A Standard European Tank?

Procurement Politics, Technology Transfer and the Challenges of Collaborative MBT Projects in the NATO Alliance since 1945

Mike Cubbin

School of Arts and Media

Salford University

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Abstract

International cooperation in weapons technology projects has long been a feature of alliance politics; and, there are many advantages to both international technology transfer and standardisation within military alliances. International collaboration between national defence industries has produced successful weapon systems from technologically advanced fighter aircraft to anti-tank missiles. Given the success of many joint defence projects, one unresolved question is why there have been no successful collaborative international main battle tank (MBT) projects since 1945. This thesis seeks to answer this question by considering four case studies of failed attempts to produce an MBT through an international collaborative tank project: first and second, the Franco-German efforts to produce a standard European tank, or Euro-Panzer (represented by two separate projects in 1957-63 and 1977-83); third, the US-German MBT-70 project (1963-70); and, fourth, the Anglo-German Future Main Battle Tank, or KPz3 (1971-77). In order to provide an explanation of the causes of failure on four separate occasions, the analysis includes reference to other high-technology civilian and military joint projects which either succeeded, or which cannot be classified as international MBT collaborative projects (such as the KNDS demonstration tank and the MBT-2000 developed by China and Pakistan). In addition to identifying the multiple causes of failure and providing an analysis of the most significant factor(s) in each case, it will be argued that the pattern which emerged during the Cold War does not necessarily provide an 'absolute principle' for future collaborative MBT projects: financial and other pressures may yet create conditions conducive to the completion of a successful collaborative MBT high-technology project. Future projects ought, however, to take note of the lessons from previous experience.

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Acknowledgements

The idea for this study came about after examining the newly donated Ogorkiewicz Papers at the Tank Museum archives and library, Bovington, and reading about the abortive MBT-70 collaboration between the USA and the FRG. It became apparent that no in-depth study had been made into international collaboration in MBT development, and Professor Alaric Searle encouraged me to tackle this subject. It has been his advice, encouragement and badgering, alongside that of my co-supervisor, Dr. Brian Hall, that have ensured that this thesis emerged without the errors and oversights that it originally contained.

I could not have begun delving into the subject of armour development without the outstanding help of Stuart Wheeler and the rest of the archive staff at the Tank Museum, Bovington, where I spent many enjoyable weeks. It was also Stuart who arranged an interview with Professor Richard Ogorkiewicz, whose papers originally sparked the whole study, and whose unparalleled knowledge and experience in the field of tank development gave my future research direction and structure. The National Archives at Kew and the *Bundesarchiv-Militärarchiv* in Freiburg im Breisgau provided the bulk of the remaining archival material, and the efficiency of the staff there ensured that my days in those archives were as productive as they could have been.

None of the research would have been possible without the generous help of The Lady Monica Cockfield Memorial Trust, whose sponsorship made it financially possible for me to undertake a full-time doctoral degree in the first place. I hope that the Trust's aim to further educational opportunities for those who would otherwise miss out, particularly in the field of European studies, has been met to their satisfaction. It most certainly has in my opinion and the completion of this thesis stands testament to the Trust's impact and success.

Finally, I must acknowledge the support that my family have given to me over the years of this PhD study and the preceding years of University education as a mature student. The support and pride expressed by both of my parents has encouraged me to keep going through some dark times. My brothers, in their own ways as only brothers can, have also made it clear that they are proud of my achievements. I also like to believe that my sons, although being teenagers they would never dream of saying so, are proud of their old dad. That my eldest son wants to be a military historian suggests that at least a little of my enthusiasm for the subject has rubbed off on him. My younger son wants a more technical job so will likely end up in a career that can support the poverty-stricken historians of the family.

Most importantly, my wife, Janet, has stood by me through the high and low times, supporting me financially, emotionally and practically through illness, injury and those times when I felt like giving up. Without her, I doubt that I would have returned to university and begun this academic journey later in life than most. I hope that she appreciates just how much her love and support have contributed to this study.

COMMON ABBREVIATIONS AND ACRONYMS

ABCT	Armoured Brigade Combat Team
AFV	Armoured Fighting Vehicle
APC	Armoured Personnel Carrier
APDS	Armour-Piercing Discarding Sabot
APFSDS	Armour-Piercing Fin-Stabilised Discarding Sabot
APDSFS	Armour-Piercing Discarding Sabot Fin-Stabilised, an alternative name for APFSDS ammunition
ARCOV	US Army's Armament for Future Tanks and Similar Combat Vehicles Committee
ATGM	Anti-Tank Guided Missile. See also ATGW (below).
ATGW	Anti-Tank Guided Weapon, often an alternative usage to ATGM
AUS(IP)	Assistant Under-Secretary of State (Intellectual Property)
AUS(Ord)	Assistant Under-Secretary of State (Ordnance)
BAOR	British Army on the Rhine
BEF	British Expeditionary Force
CE	Chemical Energy
CENTAG	(NATO) Central Army Group
CGS	Chief of the General Staff
CSA	Chief Scientific Advisor
CTR	Casemate Test Rig
DCA(PN)	Deputy Chief Advisor (Projects and Nuclear)
DCGS	Deputy Chief of the General Staff
DEPC	Defence Equipment Procurement Committee
DMGO	Deputy Master General of the Ordnance
DRAC	Director of the Royal Armoured Corps
DRDS	Defence Research and Development Staff (UK)
Dstl	Defence Science and Technology Laboratory (UK)
DUS(P)	Deputy Under-Secretary of State (Policy and Programmes)
EDA	European Defence Agency
EDC	European Defence Community
EEC	European Economic Community
ERA	Explosive Reactive Armour
FCO	Foreign and Commonwealth Office
FINABEL	A European group set up to promote greater intra-European military cooperation
FMBT	Future Main Battle Tank

FRG	Federal Republic of Germany
FVRDE	Fighting Vehicle Research and Development Establishment
GSR	General Service Requirement
GST	General Staff Target
HDS	Head of Defence Sales
HEAT	High Explosive Anti-tank
HESH	High Explosive Squash Head
HEP	High Explosive Plastic, the US term for HESH
IED	Improvised Explosive Device
IEPG	Independent European Programme Group
ISD	In-Service Date
KE	Kinetic Energy
LP	Liquid Propellant
MBT	Main Battle Tank
MC	Military Characteristics
MG	Machine-gun
MGO	Master General of the Ordnance
MICV	Mechanised Infantry Combat Vehicle
MLC	Military Load Classification
MOD	Ministry of Defence
MOU	Memorandum of Understanding
MVEE	Military Vehicles and Engineering Establishment
NBC	Nuclear-Biological-Chemical
NORTHAG	(NATO) Northern Army Group
NWPA	NATO Weapons Procurement Agency
PD/CE	Parametric Design and Cost Effectiveness.
PS	Private Secretary
PUS	Parliamentary Under-Secretary
QDG	Queen's Dragoon Guards
QMR	Qualitative Materiel Requirement
RARDE	Royal Armament Research and Development Establishment
RHA	Rolled Homogenous Armour
RHAe	Rolled Homogenous Armour equivalent
RMA	Revolution in Military Affairs
RPG	Rocket-propelled Grenade
RSI	Rationalisation, Standardisation and Interoperability
WEAG	Western European Armaments Group
WEU	Western European Union
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
VCGS	Vice Chief of the General Staff

Assumptions and Definition of Terms

Diplomacy. Potentially referring to any interactions between people; unless otherwise stated in the text, this study will use the term 'diplomacy' to describe the management of international relations between national governments.

Politics. The term 'politics' might refer to activities related to the wielding of power within any organisation, but in this study, unless otherwise stated, it will be used to refer to the activities within a nation's government and between the governments of different nations.

Superiority of Tank Design. The study does not seek to come to a conclusion on what design of tank is superior to another. Designers and users have always sought to employ designs best suited to their own philosophy of armoured warfare, and thus two different designs may be superior to one another in their own particular method of employment.[1]

Tank. What exactly defines a 'tank' (as opposed to, for example, a self-propelled artillery gun or mechanised infantry fighting vehicle), varies by commentator.[2] For the purposes of this study, a main battle tank (MBT) will be defined as being self-propelled, tracked, carrying a medium-calibre direct-fire gun in a revolving turret, and having armour sufficient to protect it in the battlefield's front line.[3]

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[1] Chapter 1, below, explains the various philosophies of tank design and how they originated.
[2] This is covered in more detail in Chapter 1, below.
[3] It is acknowledged that some fighting vehicles either fit this category but are not usually defined or employed as tanks, for example turreted tank destroyers of the Second World War, or are generally defined as tanks but do not meet the definition given, for example the earliest tanks which often had no turret, or infantry support tanks that were armed only with machine guns or small-calibre guns.

Introduction

Cooperation in defence has been a feature of diplomacy throughout the twentieth century and there are obvious advantages to both international technology transfer and standardisation within military alliances, from operational organisation and logistics through to strengthening diplomatic ties, to economic savings in both development and production.[1] International collaboration in the defence industry has, since the foundation of NATO, produced many successful weapon systems, from technologically advanced strike and fighter aircraft to artillery pieces and missiles. Despite these successes, one weapons system has appeared to be almost resistant to international collaboration – the main battle tank. Attempts to create joint tank projects have illustrated more than any other weapon the problems surrounding NATO standardisation. Given the success of many joint defence projects such as the Alphajet, Jaguar, Tornado and Eurofighter aircraft, and of the AS-30, Kormoran, Roland and Brimstone missile systems, the question arises as to why there have been no successful collaborative international main battle tank projects.[2]

The quest for a standard tank design within NATO began with the 'FINABEL' Franco-German 'European Standard Tank', 'Standard Panzer, or 'Europanzer' project in 1957, and the USA and European NATO countries have since made several further attempts towards a joint main battle tank (MBT) design.[3] At the time of writing, there is talk of yet

[1] Andrew Moravcsik, 'Armaments Among Allies: European Weapons Collaboration, 1975-1985', in Peter Evans, Harold Jacobson and Robert Putnam (eds.), *International Bargaining and Domestic Politics: Double-Edged Diplomacy* (London, 1993), p. 128; and, Matthew Ford and Alex Gould, 'Military Identities, Conventional Capability and the Politics of NATO Standardisation at the Beginning of the Second Cold War', *International History Review*, 41:4 (2019), p. 779.

[2] Alexander H. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*: *Ten Years Later - And Beyond* (The Hague, 1981), pp. 36-45. Note that Cornell's book predates both Eurofighter and Brimstone.

[3] See, for example: Richard Ogorkiewicz, *Tanks: 100 Years of Evolution* (Oxford, 2015), p. 194; Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*, p. 47; Richard E. Simpkin, *Tank Warfare: An Analysis of Soviet and NATO Tank Philosophy* (London, 1979), p. 208; and, Movavcsik, 'Armaments Among Allies', pp. 143-150.

another potential joint European tank project, this time between France, Germany and possibly Poland.[4] To date, there has been only one successful truly collaborative main battle tank design, and that was the Anglo-American Mark VIII 'International' in 1917/18.[5] Whilst the failure of NATO nations to produce a standardised main battle tank is frequently mentioned in passing, it nevertheless remains a subject on which very little has been written. It is the aim of this thesis to consider this question, with particular reference to the fact that this issue is of relevance not simply for research into the NATO Alliance, but also in relation to the continuing controversies around European defence integration. Before considering, however, some of the broader research issues, it is necessary to begin with a survey of the literature most relevant to this study.

Relevant Literature

A huge quantity of literature has appeared on the history of the tank since its first appearance on the battlefield in 1916.[6] These works concentrate on the employment of tanks and their supporting arms within the context of a particular battle, campaign, or war; or, their development in periods of peace, including the question of the theory of armoured warfare.[7]

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[4] The Franco-German conglomerate KNDS revealed a collaborative MBT venture at the Eurosatory Defence and Security Exhibition on 15 June 2018, although no Polish involvement has yet materialised in that project. Jane's 360, 'EU Tank Breaks Cover', <https://www.janes.com/article/81083/eu-tank-breaks-cover-es18d5>, accessed 2 August 2018; Defence News, 'Poland Wants to Play in Franco-German Tank Program', <http://www.defensenews.com/story/defense/policy-budget/industry/2016/08/03/poland-wants-play-franco-german-tank-program/87929202/>, accessed 17 August 2016; Jane's 360, 'Poland Reinforces Armour' <http://www.janes.com/article/72245/poland-reinforces-armour>, accessed 14 July 2017.

[5] The Mark VIII project was initiated in 1917 and the first vehicle was produced in late 1918. TNA, MUN 4/5194, 1918 Sept. 30-1919 Apr. 5, Mechanical Warfare: Mark VIII Tanks: miscellaneous departmental minutes.

[6] For general studies, which cut across countries and historical epochs, see: J. P. Harris and F. N. Toase (eds.), *Armoured Warfare* (London, 1990); George F. Hofmann, and Donn A. Starry (eds.), *Camp Colt to Desert Storm: The History of U.S. Armored Forces* (Lexington, 1999); Bruce Gudmundsson, *On Armor* (Westport, CT, 2004); and, Alaric Searle, *Armoured Warfare: A Military, Political and Global History* (London, 2017).

[7] For simply a cross-section of the literature, see the bibliographies and references in the general works in fn.6 immediately above. Considering the most recent research, Kursk provides an indication of the way in which one battle can generate several extremely well-researched studies, such as: David M. Glantz and Jonathan M. House, *The Battle of Kursk* (Lawrence, KS, 1999); Valeriy Zamulin, *Demolishing the Myth. The Tank Battle at Prokhorovka, Kursk, July 1943: An Operational Narrative,* trans. Stuart Britton (Solihull, 2011); Roman

Other historical studies explore a variety of themes, such as the history of tank production, tactics, anti-tank warfare, or attempts to elucidate particular military lessons based on case studies from different conflicts.[8] This historical literature is so vast – and includes thousands of articles in scholarly and military journals – that it would be inappropriate here to attempt to outline even a cross-section of this research. What is relevant, though, is to outline four areas in the literature which are pertinent to the issue of international collaborative tank projects. Firstly, there are some studies which do refer to, or at least mention, the question of international collaboration in tank design; while there is no study of the subject that examines more than one design in any depth, existing treatment of the subject requires reference. Secondly, it is obviously of considerable importance to make some comment on the body of work which examines tank technology.[9] Thirdly, there is some literature which falls within the discipline of Security Studies, and which considers cooperation between nations in defence, weapons projects and other forms of infrastructure planning; most of these discuss the business of diplomatic and military collaboration through technology transfer and jointinternational projects.[10] Fourthly, there is literature which deals with the subject of weapons technology with a broader focus than just tanks or armour, and examines the question of technological determinism; whether military technology drives military history or

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Toeppel, *Kursk 1943: The Greatest Tank Battle of the Second World War* (Solihull, 2018). On interwar developments, important works are: J. P. Harris, *Men, Ideas and Tanks: British Military Thought and Armoured Forces, 1903-1939* (Manchester, 1995); Robert H. Larson, *The British Army and the Theory of Armored Warfare, 1918-1940* (London and Toronto, 1984); Mary R. Habek, *Storm of Steel: The Development of Armor Doctrine in Germany and the Soviet Union, 1919–1939* (New York, 2014); Azar Gat, *British Armour Theory and the Rise of the Panzer Arm: Revising the Revisionists* (London, 2000); and, also Williamson Murray, 'Armored Warfare: The British, French, and German Experiences', in Williamson Murray and Allan R. Millett (eds.), *Military Innovation in the Interwar Period* (Cambridge, 1996), pp. 6-49.

[8] Examples are: Benjamin Coombs, *British Tank Production and the War Economy, 1934-1945* (London, 2013); Rudolf Steiger, *Panzertaktikim Spiegel deutscherKriegstagebücher 1939-1941* (Freiburg i.Br., 1973); John Weeks, *Men against Tanks: A History of Anti-Tank Warfare* (London, 1975); Kendall D. Gott, *Breaking the Mold: Tanks in the Cities* (Fort Leavenworth, KS, 2006).

[9] See, for instance: Richard Ogorkiewicz, *Technology of Tanks* (Coulsdon, 1991); Peter Gudgin, *Armoured Firepower: The Development of Tank Armament 1939-45* (Stroud, 1997); Christopher F. Foss, *Jane's Main Battle Tanks (Second Edition)* (London, 1986).

[10] See, for example: Alexander Cooley and Hendrik Spruyt, *Contracting States: Sovereign Transfers in Internal Relations* (Princeton, 2009); Peter Evans, Harold Jacobson and Robert Putnam (eds.), *International Bargaining and Domestic Politics: Double-Edged Diplomacy* (London, 1993); Karl Kaiser and John Roper, *British-German Defence Co-operation: Partners Within the Alliance* (London 1988).

vice-versa. As the subject of joint tank projects cuts across a range of different types of literature, it is necessary to consider these four areas separately.

Collaboration in Tank Design

Nations have collaborated in their employment of armour almost since the invention of the tank. During the First World War, for example, the USA had no sovereign tank design and exclusively used French and British production models.[11] Secondary works dealing principally with collaboration in tank design are limited to a handful of journal articles and conference papers, although short passages may be found in books more generally concerning tank design or defence collaboration.[12] Of those articles and papers which largely or specifically concern tank collaboration, those by Rolf Hilmes and Thomas McNaugher stand out as dealing with the subject in detail, with McNaugher in particular covering the MBT-70 project comprehensively.[13]

Collaboration in tank design has been mentioned by a number of authors looking at both the history of the tank and the technology of tanks. Elizabeth Greenhalgh and Tim Gale both examine the early development of tank designs, and how nations such as the USA were forced to use the designs of Britain and France for want of an alternative.[14] Dale Wilson, John

[11] Dale E. Wilson, 'World War I: The Birth of American Armor', in Hofmann and Starry (eds.), *Camp Colt to Desert Storm*, p. 1.
[12] See, for example: Hofmann and Starry (eds.), *Camp Colt to Desert Storm*; Ogorkiewicz, *Tanks: 100 Years of Evolution*; Simpkin, *Tank Warfare*; Glanfield, *Devil's Chariots*.
[13] Rolf Hilmes, 'Modern German Tank Development, 1956-2000', *Armor,* 110:1 (Jan-Feb 2001), pp. 16-21; Thomas L. McNaugher, 'Collaborative Development of Main Battle Tanks: Lessons from the U.S.-German Experience, 1963-1978', *Rand Note* (Rand Corporation, August 1981); and, 'Problem of Collaborative Weapons Development: The MBT-70', *Armed Forces and Society*, 10:1 (Autumn 1983), pp. 123-145.
[14] Elizabeth Greenhalgh, 'Technology Development in Coalition: The Case of the First World War Tank', *International History Review*, 22:4 (2000), pp. 806-836; Tim Gale, ' "A Charming Toy": The Surprisingly Long Life of the Renault Light Tank, 1917-1940', in Alaric Searle (ed.), *Genesis, Employment, Aftermath* (Solihull, 2015), p. 194; Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 44-45.

Glanfield and Richard Ogorkiewicz expand upon this and refer to the first, and to date the only, successful collaborative tank design, the Anglo-American Mark VIII.[15]

Among the various post-1945 attempts at international tank collaboration, none are covered in detail in the literature and, even when mentioned, they generally receive little in-depth attention. The 1957 Franco-German 'Standard Panzer' receives passing mention from Ogorkiewicz, Rolf Hilmes, and Stephen Kocs, especially in relation to the Leopard 1 and AMX-30 tanks that emerged from that unsuccessful project.[16]Amongst the NATO MBT collaborations, the US-German MBT-70 is something of a special case, receiving in-depth coverage by Thomas McNaugher who produced a RAND Note on the project.[17] The subject is also covered is far less detail in an article for the US *Armor* journal by Hilmes, and is also referred to by Ogorkiewicz.[18] The Anglo-German Future Main Battle Tank (FMBT) is more typical, receiving a brief acknowledgement from Ogorkiewicz.[19] Finally, the Franco-German 'Tank 90/Napoleon' project is once more covered only briefly by Kocs, Hilmes and Ogorkiewicz.[20]

Beyond the specifics of the NATO collaborative tank projects, the subject of NATO standardisation of MBTs is linked to collaboration, with collaboration on a design implicitly suggesting standardisation. The literature is once more sparse on the topic, but it is covered obliquely by Richard Simpkin, who examines the differing philosophies of British, French

[15] Wilson, 'World War I: The Birth of American Armor', pp. 8-9; Glanfield, *Devil's Chariots*, pp. 216-218; Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 53-54.
[16] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 190, 194; Hilmes, 'Modern German Tank Development, 1956-2000', p. 17; Stephen A. Kocs, *Autonomy or Power? The Franco-German Relationship and Europe's Strategic Choices, 1955-1995* (Westport, 1995), pp. 17-21, 69-76, 87.
[17] McNaugher, 'Collaborative Development of Main Battle Tanks'; idem, 'Problem of Collaborative Weapons Development: The MBT-70', *Armed Forces and Society*, 10:1 (Autumn 1983), pp. 123-145. This second article is drawn from the original RAND Note.
[18] Hilmes, 'Modern German Tank Development, 1956-2000', pp. 123-145; Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 169-170, 195-196.
[19] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 181-182, 196-197.
[20] Kocs, *Autonomy or Power?* pp. 159-163; Hilmes, 'Modern German Tank Development, 1956-2000', pp. 123-145; Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 192.

and US tank design.[21] McNaugher also looks at this area with more focus in his RAND Note on the MBT-70, as do Timm Meyer and Keith Hartley who concern themselves with the political and national reasons behind a lack of successful collaborative MBT projects.[22]

Literature on Tank Technology

Whilst there are numerous books that list the technical details of tanks (and most works on armoured warfare provide at least an overview of the principles of tank technology and design),[23] there are few writers who tackle in depth the technology of tanks in anything other than short articles in engineering and armour journals. Simpkin and Ogorkiewicz stand out as having authored the most important books on the subject in the English language, with Hilmes, Spielberger, and von Senger und Etterlin making significant contributions in German.[24] The debates on armoured vehicle design date back to the interwar period, and centre on the balance between firepower, mobility and protection, and on how much emphasis should be given to each significant element of the design. A subject of further debate is how the tank should be armed, with not only the types of gun under the spotlight but also whether main guns should be replaced by missiles.

The inter-relationship of tank protection and anti-tank weapons has long influenced tank design and the significance of the conflict between offence and defence in relation to

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21 Simpkin, *Tank Warfare*, p. 213.
22 Timm R. Meyer, 'Collaboration in Arms Production: A German View', in Karl Kaiser and John Roper (eds.), *British-German Defence Co-operation: Partners within the Alliance* (London, 1988), p. 252; Keith Hartley, 'Collaboration in Arms Production: A British View', in Kaiser and Roper (eds.), *British-German Defence Co-operation: Partners within the Alliance*, pp. 265, 282.
23 See, for example: Foss, *Main Battle Tanks*; idem, *Jane's Tank Recognition Guide* (Glasgow, 1996); Marsh Gelbart, *Tank: Main Battle and Light Tanks* (London, 1996); Ray Bonds, *An Illustrated Guide to Modern Tanks and Fighting Vehicles*, (London, 1980); and, B. T. White, *Tanks and Other Tracked Vehicles in Service*, (Poole, 1978). Examples of works on armoured warfare include: Harris and Toase (eds.), *Armoured Warfare*; and, Searle, *Armoured Warfare*.
24 See, for example: Rolf Hilmes, *Main Battle Tanks: Developments in Design Since 1945,* trans. Richard Simpkin (London, 1987); Walter J. Spielberger, *Die Kampfpanzer Leopard und ihreAbarten. Militärfahrzeuge, Band. 1* (Stuttgart, 1988); Walter J. Spielberger, *Von der Zugmaschinezum Leopard 2. Geschichte der Wehrtechnikbei Krauss-Maffei* (München,1979); F. M. von Senger und Etterlin, *The World's Armoured Fighting Vehicles*, trans. R. M. Ogorkiewicz (London, 1962).

tank technology is discussed by authors such as Clifford Bradley, David Fletcher, John Stone, and P.G. Griffith.[25] By the end of the Second World War, the tank appeared to be firmly established as a major battlefield weapon, yet Ogorkiewicz notes that even in 1949 influential figures were again proclaiming that the era of the tank had passed, this time due to the development of effective shaped-charge weapons such as the US 3.5" 'bazooka' and recoilless rifles.[26] Whilst tank design still currently emphasises frontal protection, the impact of improved offensive systems and munitions on the race between firepower and protection is widely covered by authors such as C. Raja Mohan, Stone, Simpkin, Ogorkiewicz, and Bradley, with each new weapons system leading to improvements in armour or other forms of protection such as active defences.[27]

In discussing the tank/anti-tank debate, Simpkin, Toase, Anker and Ogorkiewicz all address the seminal experience of the Israeli tank force in 1973, when General A.A. Mandler's armoured division lost nearly two-thirds of its tanks to an Egyptian infantry force heavily armed with RPG-7s and AT-3 SAGGER anti-tank guided missiles (ATGMs). This incident, possibly one of the most significant in terms of steering post-1945 design thinking, was another example of the assertion that tanks had become too vulnerable, this time pointing to conventional armour, and therefore conventional tanks, being rendered almost worthless in the face of modern ATGMs.[28] Despite most informed observers concluding that the Israeli experience was the result of poor tactical use of armour and a failure to use a combined arms

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[25] See, for example: Clifford Bradley, 'Historical Military Cycles', *Armor,*42:1 (Jan-Feb 1983), pp. 21-25; D. J. Fletcher, 'The Origins of Armour', in Harris and Toase (eds.), *Armoured Warfare*, p. 24; Stone, *The Tank Debate*, p. 57; P. G. Griffith, 'British Armoured Warfare in the Western Desert 1940-43', in Harris and Toase (eds.), *Armoured Warfare*, p. 71.
[26] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 150.
[27] C. Raja Mohan, 'Precision Guided Munitions in Anti-Tank Warfare', *Strategic Analysis*, 7:9 (1983), pp. 730-750; Stone, *The Tank Debate*, pp. 169-174; Bradley, 'Historical Military Cycles', pp. 21-25.
[28] See, for example: Stone, *The Tank Debate*, p. 76; Simpkin, *Tank Warfare*, p.71; F. H. Toase, 'The Israeli Experience of Armoured Warfare', in Harris and Toase (eds.), *Armoured Warfare*, pp. 180-181; Richard Ogorkiewicz, 'Armoured Fighting Vehicles', in Robert Bud and Philip Gummett (eds.), *Cold War, Hot Science: Applied Research in Britain's Defence Laboratories, 1945*-1990 (London, 2002), p. 133; Clinton J. Ancker III, 'Whither Armor', *Journal of Military Operations*, 1:2 (Autumn 2012), pp. 4-8.

approach, the recurring argument that the tank was obsolete nevertheless continued well into the Cold War,[29] and is still under debate at the time of writing.[30]

The debate over values of direct protection (for example, heavier armour) versus indirect protection (for example, greater speed and mobility) is covered in some detail by Simpkin, Ogorkiewicz and Joseph E. Backhofen, Jr., including an explanation of how modern armour can defeat shaped-charge (HEAT) rounds.[31] Backhofen also offers insight into how beyond-armour effects (the effect on the tank interior) are at least as dangerous to a tank and crew as the initial penetration,[32] whilst Ogorkiewicz describes how ATGMs may be countered by the use of more active protection systems, such as electronic jamming, the firing of fragmentation warheads at any detected incoming missile and smoke grenade projectors that create a smoke screen to blind laser-guided missiles.[33]

NATO Standardisation, Collaboration and Technology Transfer

Technology transfer of armour dates back to the First World War, when the USA accepted British and French designs for their nascent armoured force, and collaborative design began when Britain and the USA collaborated on the Mark VIII 'International' or 'Liberty' in late 1917.[34] The interwar years and Second World saw much technology transfer in the form of

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[29] See for instance: Stone, *The Tank Debate*; idem, 'The Future of Armoured Warfare: Prospects for the Tank', *The RUSI Journal*, 141:3 (1996), pp. 39-43; Ancker, 'Whither Armor'; and, Stanley C. Crist, 'The M1A2 Abrams: The Last Main Battle Tank?', *Armor,* 106:4 (Jul-Aug 1997), pp. 14-16.
[30] See for example: Defence Science and Technology Laboratory, press release <https://www.gov.uk/government/news/a-century-after-the-first-use-of-the-tank-what-does-the-future-hold>, accessed 26 September 2016; Defence of the Realm, 'Is the Main Battle Tank Obsolete?' <https://defenceoftherealm.wordpress.com/2016/03/18/is-the-main-battle-tank-obsolete/>, accessed 12 July 2016; Wealth Daily, '21st Warfare Renders the Tank Obsolete' <http://www.wealthdaily.com/articles/21st-century-warfare-renders-the-tank-obsolete/5017>, accessed 26 August 2016.
[31] Simpkin, *Tank Warfare*, pp. 67, 75, 110, 114-115; Joseph E. Backhofen, Jr., 'Armor Technology, (Part III)', *Armor*, 42:2 (March-April 1983), pp. 18-19; idem, 'Armor Technology, (Part IV)', *Armor*, 42:3 (May-Jun 1983), p. 38; idem, 'Armor Technology, (Part V)', *Armor*, 43:1 (Jan-Feb 1984), pp. 21-22; and, Ogorkiewicz, *Tanks; 100 Years of Evolution*, pp. 268-276.
[32] Backhofen, Jr., 'Armor Technology, (Part III)', pp. 18-20.
[33] Ogorkiewicz, *Tanks; 100 Years of Evolution,* pp. 268-276.
[34] Dale E. Wilson, 'World War I', in George F. Hofmann and Donn A. Starry (eds.), *Camp Colt to Desert Storm: The History of US Armored Forces* (Lexington, 1999), pp. 3, 8. For a discussion on the missed potential

tank exports and imports, and also licensed design and Lend-Lease, most notably by the Allies. With the establishment of NATO came calls for standardisation in weapons design, calls that have become more immediate in recent years with shrinking national defence budgets and a rise in world tension.[35]

Although there are undoubted benefits to interoperability (the ability to share logistics such as fuel and ammunition), there is less agreement on the benefits of standardisation and collaboration. The arguments for standardisation within NATO are given by authors such as Alexander H. Cornell, Andrew Moravcsik, Matthew Ford and Alex Gould, and Timm Meyer, citing political unity, economic savings and military homogenisation.[36] By contrast, Mark DeVore and Robert A. Bitzinger suggest that standardisation may actually result in a less effective military force and that any theoretical savings may be illusionary, with Bitzinger in particular noting that trans-Atlantic collaboration attempts are particular problematic due to the USA's reluctance to look overseas for its defence technology or to share their own.[37]

Defence collaboration projects do not exist in isolation, and many of the principles behind the collaborative design and development of a main battle tank are equally valid in the context of a non-military project. Given the main focus of this thesis, it is important that literature on general project management be taken into account. Nonetheless, Terry Adler, Thomas Pittz, and Jack Meredith have suggested that defence projects are something of a special case due to the domination of innovation in defence requirements.[38] Frinsdorf, et al.,

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for tank design collaboration between France and the UK, see Elizabeth Greenhalgh 'Technology Development in Coalition: The Case of the First World War Tank', *International History Review*, 22:4 (2000), pp. 806-836.

[35] Meyer, 'Collaboration in Arms Production: A German View', p. 246.

[36] Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*, pp. 30-34; Moravcsik, 'Armaments Among Allies', p. 128; Ford and Gould, 'Military Identities', p. 779; Meyer, 'Collaboration in Arms Production: A German View', p. 246.

[37] Marc R. DeVore, 'International Armaments Collaboration and the Limits of Reform', *Defence and Peace Economics*, 25:4 (2014), p. 416; idem, 'The Arms Collaboration Dilemma: Between Principal-Agent Dynamics and Collective Action Problems', *Security Studies*, 20:4 (2011), pp. 625-626; Richard A. Bitzinger, 'Overcoming Impediments to Transatlantic Armaments Collaboration', *International Spectator*, 39:1 (2004), passim.

[38] Terry R. Adler, Thomas G. Pittz, and Jack Meredith, 'An Analysis of Risk Sharing in Strategic R&D and New Product Development Projects', *International Journal of Project Management,* 34 (2016), p. 915.

and Philip Scranton provide rare insights into the problems surrounding collaboration in defence projects,[39] but, overall, most of the available literature is necessarily broad in scope and is rarely defence-specific. Many aspects of project management as a discipline do allow, however, an application of the basic principles to defence projects, and more general project management studies by authors such as Mazur, et al., and Dirk Klimkeit are equally valid for defence applications.[40]

Literature on Technological Determinism and RMA

The question as to whether technology drives, or is driven by, history does not form a large part of this study because the study does not examine the tank as a weapons system within history, but instead looks at particular iterations and developments of that weapon. To do otherwise, to examine the tank as weapon and its impact on historical military thinking, would be an interesting prospect but is outside the aims of this work. Nonetheless, it might be considered to be an important enough question in the wider context of weapons development to warrant a brief overview at the literature. George Raudzens looks at how previous authors have examined the impact that military technology has on warfare.[41] He highlights that problems arise in attempting to analyse the impact of weapons on warfare, and in isolating weapon technology from all the other factors involved, such as training, numbers, culture, and even simple luck. Using the tank's emergence as a 'war-winning weapon' in the First World War as just one example, Raudzens concludes that tank technology was simply one of

[39] Olivia Frinsdorf, Jian Zuo and Bo Xia, 'Critical Factors for Project Efficiency in a Defence Environment', *International Journal of Project Management*, 32 (2014), pp. 803-814; Philip Scranton, 'The Challenge of Technological Uncertainty', *Technology and Culture*, 50:2 (April 2009), pp. 513-518.

[40] Alicia Mazur, et al., 'Rating Defence Major Project Success: The Role of Personal Attributes and Stakeholder Relationships', *International Journal of Project Management*, 32 (2014), pp. 944-957; Dirk Klimkeit, 'Organizational Context and Collaboration on International Projects: The Case of a Professional Service Film', *International Journal of Project Management*, 31 (2013), pp. 366-377.

[41] George Raudzens, 'War-Winning Weapons: The Measurement of Technological Determinism in Military Technology', *The Journal of Military History*, 54:4 (1990), pp. 403-434.

many advances of an industrial war which changed the shape of warfare for the future.[42] Gervase Phillips goes further, concluding that reliance on such hastily-employed technology, often seen as an answer to stubborn military problems, might actually be counter-productive if it leads to neglect of existing military tactics.[43] Smith and Marx present several essays on the question of technological determinism,[44] and although not all cover military technology, they present a view that culture is as much as deterministic factor in technological change as the technology itself. Indeed, the essays taken as a whole suggest that society chooses which technology to adopt and that any technology 'ahead of its time' is unlikely to become common until social attitudes have reached the appropriate level. Bruce Bimber looks at the processes behind analysing technological determinism and concludes that, whilst no existing terminology or strict definition are useful in attempting to make a normative analysis of the topic, nonetheless studying technological determinism can be useful in its own right because it allows the possibility of such determinism to be excluded from any study of technology in history.[45]

The question of tanks being part of a revolution in military affairs (RMA) is intimately connected with the concept of new military technology altering the face of future warfare. Adam Grissom looks at how military innovation is studied empirically, listing four schools of thought: the Civil-Military Model, the Interservice Model, the Intraservice Model, and the Cultural Model.[46] Grissom offers a definition of innovation as being, 'a change in

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[42] Raudzens, 'War-Winning Weapons', pp. 422-424.
[43] Gervase Phillips, 'The Obsolescence of the "Arme Blanche" and Technological Determinism in British Military History', *War in History,* 9:1 (2002), pp. 39-59.
[44] Merritt Roe Smith and Leo Marx (eds.), *Does Technology Drive History?* (Massachusetts, 1994).
[45] B. Bimber, 'Three Faces of Technological Determinism', in Smith and Marx (eds.). *Does Technology Drive History?*, pp. 79-100.
[46] A. Grissom, 'The Future of Military Innovation Studies', *Journal of Strategic Studies,* 29:5 (2006), pp. 905-934.

operational praxis that produces a significant increase in military effectiveness', with such change being measured through increases in battlefield results.[47]

How closely we can apply the theories of military innovation and RMA to the development of tanks is surely something that is open to debate, to say nothing of how relevant it is to an examination of replacement tank models rather than the introduction of a revolutionary new weapons system. Innovative though some components of the tank designs to be studied might have been, James Fitzsimmons and Jan M. Van Tol make the case that simple technological innovation is not enough to announce an RMA, rather that it also takes doctrinal change and organisational adaption.[48] The German employment of the tank in 1939/40 in the so-called '*Blitzkrieg*' is certainly a case for being classed military innovation, if not indeed, an RMA,[49] but this study does not seek to examine the effect of tanks on military doctrine in any real depth.

If the development of improved tank models is classed as military innovation under Grissom's definitions then it surely falls into the category of a 'top-down' interservice innovation,[50] with the national government and army chiefs making decisions on what is to developed and when. However, given that most new tank models are merely linear progressions (whatever the designers may advertise), it is hard to classify such developments as military innovation in the sense of making a significant impact on the battlefield because they are simply incremental advances on existing technology. A tank such as the Chieftain would certainly be a hugely significant weapon on a 1940 battlefield, but was far less

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[47] Grissom, 'The Future of Military Innovation Studies', p. 907.

[48] J. R. Fitzsimmons and J. M. Van Tol, 'Revolutions in Military Affairs', *Joint Forces Quarterly*, (1994), pp. 25, 26.

[49] The invention of tanks failed to significantly alter military doctrine, despite much theorising about the future possibilities of tank warfare, until Germany demonstrated how armoured vehicles could be employed in fast-moving 'lightning' war in 1939/40. See, for example: A. Searle, *Armoured Warfare*, (London, 2017), pp. 52-53; J. Stone, *The Tank Debate*, (London, 2000), pp. 60-61; C. J. Rogers, ' "Military Revolution" and "Revolutions in Military Affairs": A Historian's Perspective', in T. Gongora and H. von Riekhoff (eds.), *Toward a Revolution in Military Affairs?*(Westport, 2000), p.27.

[50] Grissom, 'The Future of Military Innovation Studies', pp. 910, 919.

significant in Cold War terms, and whilst each tank model is best suited to a given tactical employment, wider battlefield doctrine rarely changes to a substantial degree according to which particular model of tank is employed.

A brief survey of the vast range of available literature demonstrates that, whilst many aspects of the history of armour technology have been examined – historical dimensions to collaboration, tank technology and NATO standardisation – very few authors have devoted attention to the major issue of why international tank projects 'invariably' seem to fail. There are several reasons why this subject has been ignored. Firstly, there are obvious questions of commercial sensitivities, which make access to primary source material difficult. Secondly, the international political dimensions to arms sales have proved to be especially problematic for national governments. Thirdly, any researcher attempting to explore this subject matter in more detail will quickly realise that it cuts across many disciplines, including history, technology, international defence diplomacy, and project management. Thus, any investigation into this question must necessarily be an interdisciplinary undertaking, falling within the fields of *defence technology*, *military history*, *strategic studies*, *international and NATO Alliance politics*.

Research Issues

NATO members are the countries which feature most prominently in this thesis. NATO was founded in 1949 at a time when the Cold War with the Soviet Union appeared to threaten the security of the West. This date also marked a realisation that individual NATO members would increasingly need to cooperate in both weapons' development and strategy in order to face up to the Soviet Union. The USA was the primary source of weapons for many NATO members in the immediate post-1945 era, but European nations were already planning and developing their own. With increasing improvements in technology comes increasing cost, both at the development and the production stage. Nuclear weapons initially appeared to make conventional battlefield weapons somewhat redundant, yet large conventional wars in Korea, the Middle East and Vietnam demonstrated that this was not the case.[51]

The topic of international collaboration within NATO is reasonably well covered in the secondary literature. For the most part, this is tied to the desire for standardisation and its advantages within a military alliance.[52] However, not all commentators agree that it is possible or desirable to standardise across NATO.[53] Given the differing requirements for MBTs even within NATO, with nations emphasising different aspects of the firepower-mobility-protection trinity and having different ideas about the best way to arm a tank,[54] it is difficult to see how standardisation might be agreed upon without some of the participants feeling that they have been called upon to make unacceptable compromises.

As technology becomes ever more expensive, nations are increasingly forced to compromise in the search for a future main battle tank. The design and construction costs limit the end result far more than the available technological possibilities.[55] Sophisticated compound armour, integrated command and control, local active protection systems, and automated fire systems all allow the main battle tank to remain arguably the single-most effective land weapon in a nation's armoury. However, modern defence budgets are

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[51] See, for example: Simpkin, *Tank Warfare*; and, Stone, *The Tank Debate*, pp. 40-46.
[52] See, for example: Gardiner L. Tucker, 'Standardisation and Defence in NATO', *RUSI Journal*, 121:1 (1976), p. 7; Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*, pp. 71-93; Phillip Taylor, 'Weapons Standardization in NATO: Collective Security or Economic Competition?', *International Organisation*, 36:1 (Winter 1982), p. 95; and, Ford and Gould, 'Military Identities', pp. 775-792.
[53] See, for example: Robert W. Dean, 'The Future of Collaborative Weapons Acquisition', *Survival: Global Politics and Strategy*, 21:4 (1979), pp. 159-161; Keith Hartley, 'NATO, Standardisation and Nationalism: An Economist's View', *RUSI Journal*, 123:3 (1978), p. 58; and, C. J. Davidson, 'NATO Standardisation - A New Approach', *RUSI Journal*, 122:3 (1977), p. 78.
[54] The optimal balance of firepower, mobility and protection will differ between nations where each has a different armoured doctrine and different thinking around the best tactical use of armour. See, for example: Simpkin, *Tank Warfare*, pp. 74-75; Ogorkiewicz, *Tanks; 100 Years of Evolution*, p. 259; and,Ogorkiewicz, *Technology of Tanks*, pp. 48-50, 53-55.
[55] Stone, *The Tank Debate*, pp. 169-174.

becoming increasingly tightened and, at a time when the financially-squeezed British Army, for example, once more has more horses than tanks,[56] the production of large numbers of non-collaborative domestically developed forefront-technology weapon systems such as super-powerful main battle tanks is an unlikely future, even for relatively rich nations such as the USA, UK, Germany and France.[57]

The latest Russian main battle tank, the T-14 *Armata* from Uralvagonzavod (UVZ) is a case in point. Its reported capability is impressive indeed, boasting a 125mm gun with autoloader, modular composite armour, automatic fire suppression systems and the *Afghanit* active protection system, and yet it remains reportedly capable of a 90km/h road speed with a 500km cruising range.[58] The cost of this undoubtedly remarkable specification is a reported unit cost of between 400 and 500 million roubles ($6.5 million), although the CEO of Uralvagonzavod estimated that the unit cost would fall by as much as half once full production got underway.[59] Whilst by no means the most expensive new generation main battle tank (the Japanese Type 90 is reported to cost $9.4 million per tank and the South Korean XK-2 $8.5 million),[60] it is a significant financial burden for a nation struggling with its economy yet reportedly planning to field up to 2,300 new tanks within the next four years, especially one seeking to simultaneously modernise its nuclear weapons and their control

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[56] In July 2012, the MoD reported that the British Army had 334 tanks and 501 horses (operating in ceremonial roles). BBC News, 'Why Does the British Army Have More Horses Than Tanks?' <http://www.bbc.co.uk/news/uk-scotland-highlands-islands-22951548>, accessed 08 July 2017. See also, The Independent, 'British Army Reduced to One Single Tank Regiment' <http://www.independent.co.uk/news/uk/home-news/british-army-reduced-to-one-single-tank-regiment-9644238.html>, accessed 10 July 2017.

[57] See for example: Crist, 'The M1A2 Abrams: The Last Main Battle Tank?', pp. 14-16; Stone, *The Tank Debate*, p. 174; and, Jordi Molas-Gallart, 'Which Way To Go? Defence Technology and the Diversity of "Dual Use" Technology Transfer', *Research Policy*, 26 (1997), p. 367.

[58] Army Technology, '<http://www.army-technology.com/projects/t-14-armata-main-battle-tank/>, accessed 24 April 2016. At the time of writing in 2019, it is salutary to note that the T-14 is still not in service with the Russian Army.

[59] Russia Beyond the Headlines, 'Cost of Russia's Armata T-14 Tank to Fall by Half' <http://rbth.com/defence/2015/09/25/cost_of_russias_armata_t-14_tank_to_fall_by_half_49585.html>, accessed 24 April 2016.

[60] Ibid.

systems.[61] The final purchase cost of the *Armata*, even if the unit cost should fall to an optimistic half of the current price per unit, will be around $7.5 billion before replacement, training and running costs are taken into account. For comparison, the *Moscow Times* reported that Russia's total 2015 defence budget was to be $81 billion, or 4.2% of Russia's gross domestic product (GDP),[62] although a report by the Stockholm International Peace Research Institute (SIPRI) suggested that the 2015/16 defence budget was closer to $66.4 billion,[63]and a 2017 report put it at 5.9% GDP or $69.2bn.[64] Admittedly, the cost of *Armata* was intended to be spread over four years, but even so the proposed equipping of the Russian Army with so many *Armata* tanks represents a huge proportion of the defence budget for any country, let alone one with economic difficulties. It is important to note that, apart from the report by SIPRI and the 2017 UK Defence Journal, all information on the *Armata* MBT and the Russian defence budget originally came from Russian official sources and should be viewed with that in mind.

Joint investment seems an obvious solution to the financial burden of developing and building new main battle tanks. Meyer suggested in 1988 that, 'Large-scale projects, as a rule, can now only be carried out co-operatively in Europe'.[65] The theory of joint enterprise suggests that the high expense of development and production can be split between all interested parties. Despite delivering neither the financial savings nor the technological

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[61] The Telegraph, 'Russia "Dominated" Global Defence Budget Increases in 2015, Says Think Tank'<http://www.telegraph.co.uk/news/worldnews/europe/russia/12148687/Russia-dominated-global-defence-budget-increases-in-2015-says-think-tank.html>, accessed 24 April 2016.
[62] Moscow Times, 'Russian Defense Budget to Hit Record $81 Billion in 2015' <http://www.themoscowtimes.com/business/article/russian-defense-budget-to-hit-record-81bln-in-2015/509536.html>, accessed 24 April 2016.
[63] Global Security, 'Russian Military Budget' <http://www.globalsecurity.org/military/world/russia/mo-budget.htm>, accessed 24 April 2016.
[64] UK Defence Journal, 'Is Russia Still a Threat? NATO Seems to Think So.' <https://ukdefencejournal.org.uk/is-russia-still-a-threat-nato-seems-to-think-so/>, accessed 15 July 2017. Jane's reported in March 2017 that Russia had announced a cut to its defence budget from RUB3.8 trillion (US $65.4 billion) to RUB2.8 trillion (US $ 42.5 billion), see Jane's 360, 'Russia Announces Deepest Defence Budget Cuts Since 1990s', <http://www.janes.com/article/68766/russia-announces-deepest-defence-budget-cuts-since-1990s>, accessed 28 November 2017.
[65] Meyer, 'Collaboration in Arms Production: A German View', p. 256.

advances the theory of cooperative development promises, it has worked for other advanced technology defence systems and there is no obvious practical reason why it should not work for main battle tanks. Yet for whatever reason, joint MBT development has failed in all but one instance. If the reasons for these failures can be recognised and overcome, the future possibility for joint development of MBTs should have a greater chance of success.

DeVore highlights the rise in international collaboration within the arms industry and points out that collaboration is an increasingly attractive option in the face of shrinking defence budgets.[66] International cooperation in defence is of obvious importance for defence organisations such as NATO, theoretically strengthening political bonds and multinational organisations within that alliance.[67] Allies working together can operate more efficiently if they have commonality of equipment, simplifying logistics, joint operational planning and tactical integration. Rationalisation, standardisation and interoperability (RSI) are bywords for efficiency in industry, and the principles are equally as valid for a military operating in the field as for industrial development. In addition, by sharing design and development costs, nations can develop weapon systems that they might otherwise be unable to afford. Moravcsik suggested that an estimated 27 percent, or $35 billion, was wasted in redundant military research and development within European NATO member states in 1987.[68] By involving other nations and companies, there is also the chance that a design will benefit from an increase in insights and ideas gained by widening the pool of designers working on the project.

In the main, nations clearly embark on collaborative projects seeking benefits for themselves. Each government has, after all, a duty to their own country which must outweigh

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[66] Marc DeVore, 'International Armaments Collaboration and the Limits of Reform', *Defence and Peace Economics*, 25:4 (2014), p. 415.
[67] Phillip Taylor, 'Weapons standardization in NATO: Collective Security or Economic Competition?', *International Organisation*, 36:1 (Winter 1982), p. 95.
[68] Movavcsik, 'Armaments Among Allies: European Weapons Collaboration, 1975-1985', p. 128.

any philanthropic motivations, whether this is to the population as a whole, the military or to domestic industry. Meyer suggests four main reasons behind why nations collaborate on weapons systems: military, economic, technological, and diplomatic.[69] Clearly, standardising NATO equipment makes sense from a logistical and interoperability standpoint. In theory, such joint projects should also be cheaper due to the splitting of development costs and a final saving on unit costs through larger orders. The standardisation of logistics and training should also bring savings. The theoretical technological advantages of joint projects come from shared knowledge and a greater efficiency of effort through pooling that knowledge. Finally, diplomatic advantages are seen in creating stronger ties between the involved nations.

The importance of private corporate involvement in technology transfer between democratic nations should be emphasised. Unless the nation state controls the corporations, any arms development will be done primarily by private companies with all the caveats and economic considerations that that entails. Any international project would therefore require the application of a business model. Joint collaborations require agreements on many issues such as allocation of responsibilities and workload, acceptable costs and integration of the workforce, as well as agreements on where construction and assembly take place. It appears however that in practice, many such international defence projects are more concerned with securing diplomatic relationships than with actually saving money. Where actual military requirements enter the equation and what weight military necessity carries in the failed collaborative MBT projects is something that needs to be examined. For a military project, there might also be the issue of secrecy and whilst compartmentalisation of information is an effective way to maintain security, it might also lead to problems of cooperation between departments. On an international level, language and cultural barriers and physical distance

[69] Meyer, 'Collaboration in Arms Production: A German View', p. 259.

between those departments can only increase such problems. Cornell lists four management principles that may be applied to international weapons development:

1. Coordination: Coordination at the development stage leads to better coordination at the production stage, and possibly to better success in future projects.
2. Standardisation and Economies of Scale: Interchangeable components make repair and replacement far easier, and a large number of units leads to the cost of each unit falling.
3. Cooperation in Production: If each weapon system fits a niche within alliance defence planning, it is more efficient to have each member state working on the same system rather than dispersing effort on different systems which fill the same niche.
4. Common Logistical Support: Most armies depend on their logistical trail, and standardisation simplifies and streamlines the logistical requirement.[70]

Obviously, each project member nation expects to take away a positive cost-benefit related to the investment of that nation, and disputes might occur when one or more members perceive that they are not doing so. In the case of the recent F-35 Joint Strike Fighter, for example, there were disputes regarding securing assembly facilities within member nations, the sharing of technology within the member nations, and the number of aircraft that each member nation was prepared to commit to buying.[71]

Ernst B. Haas suggests that, 'The need for collaboration arises from the recognition that the costs of national self-reliance are usually excessive.'[72] A report in 2015 showed that, overall, NATO member state defence budgets in 2014 were still short of NATO's target of

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[70] Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies,* pp. 15-16.

[71] Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program* (Washington DC, 16th February 2012), pp. 16-17, accessed online via. <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA590244>, accessed 28th September 2016.

[72] Ernst B. Haas, 'Why Collaborate? Issue-Linkage and International Regimes', *World Politics*, 32:3 (Apr 1980), p. 357.

2% of GDP, with many countries struggling to rectify the long decline in defence spending.[73] If nations decide that main battle tanks are worth pursuing, it could be that a way to reduce the cost of the tank for individual governments is going to be needed and international collaboration seems on the surface to offer a solution.

Given the choice and opportunity, a nation's indigenous MBT design will naturally reflect their own design philosophy, which encompasses a range of attitudes and experience, including specific historic approaches to doctrine for land warfare, positive and negative experiences with certain aspects of armour technology, and national defence priorities. For any potential Cold War engagement with the Soviet Union, the UK, for example, envisaged its tanks defending linear obstacles by using long-range firepower against numerically superior but technologically inferior Soviet tanks. By contrast, the FRG were wedded to using mobility to bring massed firepower to bear.[74] This led to different priorities in the triumvirate of firepower-mobility-protection, with the UK emphasising armour at the expense of mobility, and the FRG putting mobility above protection.[75] To supply the military with tanks that meet their doctrinal requirements, a nation must either collaborate with a nation that shares its doctrine, design and build the tank themselves, find a nation which has an existing design that meets the requirements, or give another nation the specifications and have them build the tank.

Of course, nations have been purchasing designs from other countries since the birth of the tank itself.[76] Yet purchasing existing designs from other countries or manufacturing those designs under licence is not the same as joint development. Collaboration usually means compromise, but not as great a compromise as purchasing a design drawn to another

[73] Alexander Nicoll (ed.), 'European Defence Spending Rises, But Well Short of NATO Target', *Strategic Comments*, 21:3 (2015), pp. viii-x.
[74] Simpkin, *Tank Warfare*, p. 66.
[75] Ibid., p. 61; and, Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 194.
[76] Perhaps most famously, during the Second World War the Allied nations bought or acquired through 'Lend-Lease' many tanks from the USA, particularly the M4 Sherman medium and M3 Stuart light tank.

nation's specifications. In addition, unless the rights to manufacture are secured, buying foreign systems has little obvious and immediate benefit to domestic industry.

Research Question

Given that the existing literature on main battle tank technology often refers to the question of standardisation in passing, but rarely offers any further explanation as to why several attempts at collaboration failed, the research question which this thesis will seek to answer is as follows: *Why have repeated attempts since 1945 to create an international production-ready MBT failed?* This question seems all the more worth pursuing when it is considered that the same European nations which failed to agree on a unified tank design were able to collaborate successfully on large-scale and complex engineering projects, such as Concorde, Jaguar, Tornado and Eurofighter.[77] The tank at its heart is simply a specialist fighting vehicle, and if international collaboration has been able to solve technical challenges in airliners, helicopters and fighter aircraft, designing a ground-based vehicle would seem to be not any more challenging.[78] The pan-European missile manufacturer, MBDA Group, reported €2.9 billion sales for 2015, with a €15.1 billion order book so clearly, joint international defence development projects can work economically as well as militarily.[79] Yet despite several proposals and projects initiated, aside from the Mark VIII back in 1917/18, there have been no examples of a main battle tank being successfully designed by international collaboration.

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[77] Donald Alfred Nelson, 'Concorde: International Cooperation in Aviation', *American Journal of Comparative Law*, 17:3 (Summer, 1969), pp. 452-467; M. Verdant and G. H. Schwehm, 'The International Rosetta Mission', *ESA Bulletin*, 93 (February 1998), pp. 39-50.

[78] Keith Hayward, 'Airbus: Twenty Years of European Collaboration', *International Affairs*, 64:1 (December 1987), pp. 11-26; J. C. Barker, 'Merlin to 2000', *Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering* (1 April 1998); Markus N. Heinrich, 'The Eurofighter Typhoon Programme: Economic and Industrial Implications of Collaborative Defence Manufacturing', *Defence Studies*, 15:4 (2015), pp. 341-360.See also DeVore, 'International Armaments Collaboration and the Limits of Reform', pp. 423-425, 430-437.

[79] MBDA website <http://www.mbda-systems.com/about-us/>, accessed 04 April 2016.

What is even more surprising about the failure of joint MBT projects is that these failures have occurred against a background of an increasing drive for collaboration within NATO. DeVore, for example, noted in 2011 that the European Defence Agency (EDA) was committed to increasing European armaments collaboration from 22% to 35%, and that in 1985 the USA had set aside funds for collaborative armaments projects.[80] Cornell sets out several approaches suggested within NATO for closer standardisation, including options such as creating a single NATO Weapons Procurement Agency (NWPA), a common research and development (R&D) programme from which all members could benefit, and a restructuring of member states' military procurement and R&D to allow better integration with the rearmament cycles of other NATO members.[81] Yet, despite this high-level political impetus, not one NATO member state has successfully collaborated on an MBT programme.

The central question will be approached by taking a broad look at international inter-NATO defence industry cooperation as a whole and examining four case studies of joint main battle tank projects within the NATO Alliance. A case-study led approach allows each project to be examined in isolation, with particular emphasis on how and why the project was initiated, what benefits the project promised the participants, what challenges were encountered and how they were dealt with, and under what circumstances the project finally failed. It is hoped that a comparison of the four case studies will improve our understanding of the difficulties faced in international collaboration in tank design, and thereby establish whether such hurdles may be overcome in any future project.

The arguments surrounding tank design and employment are relevant only in relation to how they affect the design proposals and, whilst they will be covered in Chapter One, it is not intended to look at them in any great detail. Similarly, the 'hard' engineering aspects of

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[80] Marc R. DeVore, 'The Arms Collaboration Dilemma: Between Principal-Agent Dynamics and Collective Action Problems', *Security Studies*, 20:4 (2011), p. 625.
[81] Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*, pp. 101-103.

tank design are outside the scope of this work, and will be addressed in only passing detail as they influence the decision-making processes involved. The time frame chosen, 1949 onwards, covers the formation of NATO and subsequent cooperation in defence by its member states, in essence up to the end of the Cold War. The conclusions which can be drawn from the case studies are applicable, however, to the current state of affairs in European defence cooperation.

Source Material

The key source material for this thesis is drawn from four main areas: first, archives in Europe and the USA; second, academic, military and defence industry journals, covering technical and other subject areas; third, printed material, such as company reports and specialist studies; fourth, newspapers and media sources.The sources of information available on the subject of international tank projects can be found scattered across these four broad types of source material. Beyond the disparate range of published and limited circulation material, which is now much more easily available via the world-wide-web, the archival material used for this study has to a considerable degree created the basis for this study.

Several file series held at the National Archives of the United Kingdom, Kew, have been drawn upon for this work, the files originating in several different government departments. DEFE 13/- (Ministry of Defence: Private Office: Registered Files (all Ministers)) contains the diplomatic exchanges between Britain and the Federal Republic of Germany (FRG) regarding cancellation of the proposed Future Main Battle Tank (FMBT) project between the two countries. Closer examination of the files suggests that one reason for the project's failure was a difference in mobility and protection priorities between the two countries, and also a suggestion that the main reason for the project's failure was a difference in deadline priorities between the two countries.[82]

The T225/- series (Treasury: Defence Policy and Materiel Division: Registered Files, DM and 2DM Series) gives valuable insights into the financial aspects of co-operative development, as well as highlighting areas of disagreement.[83] The Foreign Office series, FO 371/- (Foreign Office: Political Departments: General Correspondence from 1906-1966), contains material regarding Britain's experiences with international co-operation, with some files more relevant than others.[84] In particular, the FO 371 series contains correspondence regarding Foreign Office assessments of foreign economies and defence capabilities as well as international trade and technology sharing agreements.

At the Bovington Tank Museum archives, the as-yet uncatalogued papers of Professor Richard Ogorkiewicz provide first-hand insights through a variety of correspondence and documents into many aspects of both the Franco-German MBT project and the US-German MBT-70. The Ogorkiewicz papers include correspondence between the author and international figures involved in tank development projects, as well as copies of papers that Ogorkiewicz has presented at seminars for bodies such as the Royal Military Academy Sandhurst and the Royal United Services Institute (RUSI), and articles relating to the technology of tank development since 1945. This unique collection of correspondence and papers contains a wealth of technical information as well as charting decision-making processes which are difficult to identify in official documentation.

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[82] See, for example, TNA, DEFE 13/1045, Tanks and tank guns: proposals and developments, DEFE 13/1153, International co-operation and collaboration on equipment procurement, DEFE 13/1211, International collaboration in defence areas, meetings with French and German Defence Ministers, DEFE 13/1065, FMBT and associated weapons systems, 1974-7, and DEFE 13/1225, FMBT and associated weapon systems, 1977-78.
[83] See, for example, TNA, T225/85, Co-ordination of production, UK and other signatory countries, 1950, T225/101, Agreements with USA on standardisation of equipment and exchange of information on inventions and patents, 1947-1951and, T225/1571, Anglo-German co-operation in tank development, 1959-1960.
[84] See, for example, TNA, FO 371/172114, Political relations of FRG: US, 1963, FO 371/172180, FRG air force: collaboration with UK on VTOL research aircraft, 1963, and FO 371/177965, UK/FRG/US cooperation in tank development, 1964.

Beyond the United Kingdom, the Donovan Research Library at the Fort Benning Armor School in the United States holds material relating to American tank development, including projects planned and undertaken in cooperation with other nations. The US National Archives, in particular the Records of the Office of the Chief of Ordnance, likewise provide information relating to the USA's collaborative defence projects. The *Bundesarchiv-Militärarchiv* at Freiburg im Breisgau in Germany holds important files and information on projects relating to the FRG's involvement in collaborative projects. Given that the Federal Republic features in all four central case studies, this material is of particular value and cuts across each of the chapters. Additional archival material relating to the FRG's involvement can be found in the papers of two former Wehrmacht tank generals, *General der Panzertruppe* Leo Freiherr Geyr von Schweppenburg and *General der Panzertruppe* Gerhard Graf von Schwerin, both sets of papers held at the Institute for Contemporary History in Munich.

The archives of the various companies involved in collaborative programmes hold valuable documentation relating to those programmes although access to such archival material is restricted for commercial reasons.[85] Commercial sensitivity surrounding failed projects, commercial confidence and the fact that many firms have been absorbed by larger consortia make using such records for a publicly available academic work highly problematic. As an example, whilst not falling under the usual restrictions,[86] the archives for those surviving companies which comprised Britain's tank industry are now merged into BAE Land Systems, and the BAE archivists report that individual company archives have

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[85] Specifically, relevant for the purposes of this study are the legacy archives of tank manufacturing companies now held by BAE Systems in the UK, Lockheed in the USA, and the four consortium members of the German MBT-70 Joint Design Team, Krauss-Maffei, Daimler-Benz, Porsche, and Rheinmetall. Unfortunately, access to relevant private company records is extremely difficult to obtain and access could not be obtained for this study.
[86] On the issue of the sensitivity of some archives, see Brian Brivati, Julia Buxton, and Anthony Seldon, *The Contemporary History Handbook* (Manchester, 1996), pp. 223-224.

been destroyed or scattered throughout the constituent parts of BAE Systems.[87] Fortunately, there is ample material in other archives to allow a reconstruction of the course, and causes of failure, of each of the four MBT joint projects which represent each case study.

The question of international collaboration in tank design is at least as technical in nature as it is historical, with the international dimension bringing in the discipline of international politics and the developmental aspect encompassing project management and economics. The inter-disciplinary nature of this work means that a wide variety of source material has been referenced. Although still fundamentally historical in nature, this study includes news reports and other material, which is on occasion as useful as the primary material held in archives. In order to answer the main research question, sources from disciplines ranging from engineering, economics, international politics, to project management, have been as important as the historical documents used.

Research Design

In order to answer the research question as to why no international collaborative main battle tank design has succeeded since 1918, the thesis will begin with a chapter explaining key aspects of tank technology; this will be followed by the three chapters covering four international collaborative tank projects, and a fifth chapter offering an overview of other international arms and technology collaboration projects.

Framework of Analysis

In order that a qualitative comparison may be made between the four case studies featured, a framework of analysis will be used. In creating this framework, it is acknowledged that any

[87] Following a query to BAE Systems Heritage on 9 December 2016, the author was informed that information regarding commercial collaboration within BAE legacy companies such as Vickers was very unlikely to be available; this subsequently proved to be case.

such analysis framework for comparing projects is troublesome. As discussed by Todorović *et al.*, creating a unified model for project analysis is hindered by the subjective nature of determining what constitutes success.[88] Many analysis models have consequently been developed in the field of project management, and choosing a suitable one for this study is problematic due to the specific subject area. However, one framework that is suitable was developed by Joyce Fortune and Diana White in 2006, and sets out a list of 27 Critical Success Factors (CSFs) which they identify through a detailed study of the literature. These CSFs are, in turn, mapped onto a Formal System Model (FSM) which was developed to identify and predict possible failures within a project. By mapping the CSFs against the FSM, Fortune and White create a framework against which projects may be measured and thus compared. Their framework of analysis will be used in this study:

Component of FSM	Critical success factors from literature
Goals and objectives.	Clear, realistic objectives; strong business case/sound basis for project.
Performance monitoring.	Effective monitoring/control; planned close down/review/acceptance of possible failure.
Decision-maker(s).	Support from senior management; competent project manager; strong/detailed plan kept up to date; realistic schedule; good leadership; correct choice/past experience of project management methodology/tools.
Transformations.	Skilled/suitably qualified/sufficient staff/team.
Communication.	Good communication/feedback.
Environment.	Political stability; environmental influences; past experience (learning from); organisational adaptation/culture/structure.
Boundaries.	Project size/level of complexity/number of people involved/duration.
Resources.	Adequate budget; sufficient/well allocated resources; training provision; proven/familiar

[88] Marija Lj. Todorović, et al., 'Project Success Analysis Framework: A Knowledge-Based Approach in Project Management', *International Journal of Project Management,* 33:4 (May 2015), p. 774.

	technology; good performance by suppliers/contractors/consultants.
Continuity.	Risks addressed/assessed/managed; user/client involvement; different viewpoints (appreciating); project sponsor/champion; effective change management.[89]

Inevitably, some of the CSFs appear more appropriate to a national defence scenario than others, but the framework is surprising robust nonetheless.

The Chapters

Chapter 1 sketches the background necessary for an understanding of the key design and technical concepts employed in later chapters. The first part is an overview of how tanks evolved and how the tank design philosophy differs between nations within NATO. Second is an overview if the technological challenges behind MBT design, in particular addressing the triumvirate of firepower, mobility and protection. Third is an examination of how standardisation and interoperability benefit military allies, and the debates surrounding whether or not standardisation is, in, fact the best approach even within an alliance. Fourth is a treatment of the various forms of technology transfer, highlighting the differences between collaborative design and Lend-Lease, licence-building and the purchase of foreign designs. In this section is established what a collaboration means for the purpose of this study. Fifth and finally comes a brief overview of how relevant the main battle tank is for modern warfare, and thus whether it is worthwhile considering developing successors to our current models.

Chapter 2 will cover the first two case studies, the 'FINABEL' NATO Standard Tank and Tank 90/'Napoleon'. Despite the first study commencing in 1957 and the second beginning in 1979, these two Franco-German projects will be dealt with together as there are

[89] Joyce Fortune and Diana White, 'Framing of Project Critical Success Factors by a Systems Model', *International Journal of Project Management*, 24 (2006), p. 57.

obvious advantages to comparing the background and progress of two collaborations between the same nations. Problems arose in differences of opinion over the priority of the protection and weight, but the problems that ended both projects before production tanks were developed were mainly political in nature.

Chapter 3 will cover the US-German MBT-70 collaboration of the early 1960s that neither country pursued to the production stage. This study will form a major element in providing an answer to the main research question. The MBT-70 was a project initiated by Robert McNamara while he was the US Secretary of Defense but which ran hugely over-budget and was ultimately abandoned by both nations. With early disagreement over both the tank's armament and the priority given to each of the tank's three fundamental qualities (firepower, mobility and protection), a specification that was overly complex, and problems of communications, it will be shown how political enthusiasm for collaboration on the diplomatic level failed to translate into designs that satisfied the intended military customers.

Chapter 4 will cover the 1971 Anglo-German Future Main Battle Tank (FMBT). Britain and the FRG began the collaborative FMBT project looking to replace their Chieftain and Leopard 1 designs respectively. The project was cancelled in March 1977 without producing a working tank design, the official blame for the failure being attributed to different timescale priorities. However, it will be shown how priority differences in the triumvirate of firepower-mobility-protection and a failure to agree on the main armament led to a reduction of interest in the project, and how a failure to agree on the fundamental design at an early stage, resulted in a lack of focus and consequent dissipation of true collaboration. Once again, the FMBT project demonstrated that political desire for diplomatic alliances does not necessarily translate to agreement in military requirements.

Chapter 5 will look at collaborative international projects that do not fit the main criteria for the case studies thesis but are nevertheless useful as a form of contextualisation.

Included will be the SP-70 self-propelled gun, the Eurofighter, plus a variety of other aircraft and missile designs, both successful and unsuccessful. Covering a wide spectrum of international collaborative weapon systems, no single project will receive in-depth attention. Rather, the intention is to demonstrate the dynamics of such projects and to highlight any similarities or major differences between them and the main battle tank projects covered in the case studies.

The main aim of the case studies is to look at why the countries in question felt the need to enter into a joint project, what they wanted from the tank under development and to what extent the project achieved at least some of its goals. NATO countries have long professed themselves eager to develop standardised NATO military equipment. Successful aircraft such as the Sepecat Jaguar, Panavia Tornado and Eurofighter Typhoon have all been developed jointly by two or more European NATO partners, and there are more examples of successful joint projects in helicopters and missiles. By examining the collaborative programmes of non-MBT weapon systems, comparisons can be made with those programmes involving tanks. In order that a consistent analysis may be made of each study, the wider topic of international arms collaboration will be divided into several areas, looking at: the political atmosphere and interest; the technical and logistical innovations and limitations; the military reaction and how well the designs covered met the militaries' operational needs; the economic and business ramifications; and how the proposed design met (or failed to meet) the strategic requirements of the nations involved.

As far as possible these six areas of international collaboration and technology transfer will form the skeleton of the examination for all the case studies and their significance on the project will be covered. Whilst it is not intended to use a rigid system of comparison between or within the case studies, examination of these areas within the studies will allow consistency in interpreting how significant each of the different factors were within each project.[90] Each case study will be concluded by showing the final results of the project and the consequences thereof. None of the projects covered in the four case studies resulted in a successful production tank, and in each case the countries involved went on to independently design and build their own MBT shortly after the project's failure. This said, it should not be assumed at the outset that the lessons to be drawn from the case studies mean that a future international joint MBT project must necessarily fail. Indeed, from failed projects came interesting ideas and useful developments that were later used on indigenous tank designs (an example being the Rheinmetall 120mm gun developed for the US-German MBT-70 and later fitted to Germany's own Leopard 2). However, this study focuses on the projects as a whole and not the individual components or ideas developed for them, and thus it highlights the failure to design and develop a production MBT in each case rather than any side-benefits that resulted from those projects.

[90] C. R. Kothari, *Research Methodology: Methods and Techniques* (New Delhi, 2004), p. 345.

CHAPTER 1

Technology, Main Battle Tanks and Collaboration: Concepts and Theories

In addressing the question of why no international collaborative main battle tank (MBT) development projects have succeeded since 1945, it is necessary to draw from several different disciplines in order to examine various concepts and theories relevant to the study. While this thesis is intended as a contribution to the history of tank technology, the fact that international collaboration is the main focus of this study means that it is also essential that international politics, defence standardisation and technology transfer are addressed as key concepts. An in-depth study of international MBT collaboration could concentrate on any one of these fields; however, this chapter aims to provide a broad overview of key concepts surrounding tank design, the benefits and drawbacks of NATO standardisation, the question of technology transfer and the way in which the main battle tank is perceived in the contemporary defence environment in terms of its future viability.

To establish a conceptual framework for the thesis, various theories must be outlined to provide the necessary background for the subsequent case study chapters. Although this study is not in the first instance a history of aspects of tank warfare, understanding the relevance of historical background is important in order to frame the later failed efforts towards international tank collaboration. The different philosophies behind key NATO nations' tank designs will be examined briefly to explain why nations develop different design requirements for their tanks. Such variation in requirements makes standardisation more difficult and the quest for standardisation within NATO underpins many attempts for collaboration in weapons design within the Atlantic Alliance. With technology transfer at the heart of this study, it becomes important to differentiate between the most common forms of technology transfer: ‘lend-lease’, licensed production, cooperative production, and collaboration. Underlying this study is an important assumption that tanks are a core weapon for modern military forces and we will therefore finish by looking at the relevance of the main battle tank on the modern battlefield and its wider political importance. Needless to say, any study which focuses on tank technology must pay some attention to the evolution of that technology and, in particular, include some explanation of the three corners of tank design: firepower, mobility and protection.[1]

1.1. The Evolution of Tank Design: An Overview

Rolf Hilmes defines the primary purpose of a main battle tank as being ‘to provide a flat-trajectory weapon with cross-country mobility, while at the same time allowing the weapon to be used under a specified level of built-in protection.’[2] Richard Ogorkiewicz contends that tanks are ‘[a]utomotive, tracked, armoured carriers of heavy direct-fire weapons.’[3] F. M. von Senger und Etterlin defines the tank as: ‘A well-armoured vehicle, with its main armament mounted in a revolving turret, which is capable of fulfilling all the main tasks of the armoured troops on the battlefield.’[4] Although there have been variations on these definitions,[5] the modern tank is expected to be self-propelled, tracked, carry a medium-

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[1] The key design characteristics of firepower, mobility and protection are fundamental to examining how different nations design tanks. See, for example: Richard Simpkin, *Tank Warfare: An Analysis of Soviet and NATO Tank Philosophy* (London, 1979), pp. 81-83; British Army website, ‘Armoured Fighting Vehicles’, <http://www.army.mod.uk/equipment/23206.aspx>, accessed 06 October 2017.

[2] Rolf Hilmes, *Main Battle Tanks: Developments in Design Since 1945,* trans. Richard Simpkin (London, 1987), p. 9.

[3] Richard Ogorkiewicz, *Technology of Tanks, Vol. 1* (Coulsdon, 1991), p. 1.

[4] F. M. von Senger und Etterlin, *The World’s Armoured Fighting Vehicles*, trans. R. M. Ogorkiewicz (London, 1962).

[5] Although the first to be labelled as ‘tanks’, and therefore theoretically the blueprint for all tanks thereafter, the early British, French and German tanks lacked turrets. Later designs might only be armed with machine-guns

calibre direct-fire gun in a revolving turret, and have armour sufficient to protect it in the front line of a battlefield. Debates and arguments over the optimum balance between the three design elements have long accompanied arguments over how best to employ tanks on the battlefield.[6] To understand different philosophies in tank design, therefore, some consideration should be given as to how different nations expect to employ their main battle tanks.

Any tank or other armoured vehicle is a compromise between the three design elements of firepower, mobility and protection.[7] Maximum weight, cost, and the physical dimensions available to designers mean that a decision has to be made as to which of the elements receives priority. This trinity can be represented as a triangle with a different design element at each point, so that moving the design philosophy towards additional firepower and a larger gun, for example, means that the tank must sacrifice mobility and protection if it is to retain the same weight and cost. This is necessarily a simplification and Gerald A. Halbert offers a wider set of design elements, setting out eleven principles that a tank designer needs to consider: dimensions, ground pressure and weight, armour, survivability, tank layout, armament, ammunition, crew, power plant, suspension, and human engineering (crew ergonomics).[8]

For the purposes of investigating the major philosophical design factors impacting on international collaboration in tank design, however, Halbert's list of eleven principles can be simplified into the three elements of firepower, mobility and protection. Within these elements are broad design categories; the armament and ammunition affect firepower; the

(e.g. MG version of the French Renault FT-17, British Matilda I, German Panzer I) or a low-velocity howitzer (the British close-support versions of their cruiser tanks, for example).

[6]Simpkin, *Tank Warfare*, p. 74. See also: John Stone, *The Tank Debate* (Abingdon, 2013), p. 75; Hilmes, *Main Battle Tanks: Developments in Design Since 1945*, pp. 94-99; Malcolm Chalmers and Lutz Unterseher, 'Is There a Tank Gap? Comparing NATO and Warsaw Pact Tank Fleets', *International Security*, 13:1 (Summer, 1988), pp. 27-28.

[7] The firepower-mobility-protection design trinity is dealt with in more detail in section 1.2 below.

[8] Gerald A. Halbert, 'Elements of Tank Design', *Armor*, 42:6 (Nov-Dec 1983), pp. 36-42.

dimensions, power plant, suspension and weight affect mobility; and armour and survivability combine for protection. The internal layout, crew and human engineering aspects will obviously influence the overall efficiency of a tank, but do not comfortably fit any of the three categories and are largely design choices detached from considerations of cost and compromise of the three key elements.[9] Just how much emphasis each of the three elements has on the final tank design depends to a large extent on the doctrinal requirements of the nation involved in setting out the specification. A tank designed for fast manoeuvre warfare, for example, will emphasise mobility whereas a tank expected to fire from static defensive positions may compromise mobility for additional armour.

The debate over how to best use tanks has evolved alongside technology. Official military thinking was slow to change following the introduction of tanks in 1916. John Stone, for example, notes that Colonel Ernst Swinton, one of Britain's foremost proponents of the use of tanks, wrote in 1916 that tanks would be auxiliary to the infantry and would be employed primarily in breaking through the enemy defences.[10] In addition, Brigadier-General L. E. Kiggell, the BEF's Chief of General Staff wrote in 1916 that tanks were, 'Merely accessory to the combined action of infantry and artillery'.[11] In this both were correct in so far as the First World War was concerned, with mechanical and technological restrictions meaning that tanks were used primarily to support infantry attacks rather than in more autonomous mobile roles, but the potential for a more dynamic and independent employment of tanks was already being considered. New weapons always stimulate new visions of how future warfare will develop, but Bryn Hammond makes the point that the limited capabilities of those early tanks mitigated against being used as anything more than assault vehicles tied

[9] It is acknowledged that crew ergonomics may be affected by wider considerations such as the height of the tank hull, the size of the turret and the type of suspension fitted. In the main, such considerations appear to have had little overall impact in design choices during the post-1945 period, with low hulls in tanks such as the British Chieftain and Russian T-64 coming from decisions over protection, and with crew comfort being secondary to this. Halbert, 'Elements of Tank Design', p. 36.
[10] Stone, *The Tank Debate*, p. 27.
[11] TNA, WO 158/832, "Notes on the Use of Tanks", L. E. Kiggell, Advanced HQ, 5 October 1916.

to the infantry they supported, even while theoretical thinkers such as J.F.C. Fuller visualised an all-tank army exploiting deep breakthrough penetrations using fast manoeuvre in a similar fashion to ships at sea.[12]

The idea of manoeuvre warfare was certainly not new and might be traced back to ancient armies firing missiles from fast-moving chariots or, more recently, cavalry during the American Civil War employed on deep raids behind enemy lines. Yet tanks came at a time of increasing mechanisation and advances in weaponry which embraced improved explosive fillers for artillery, the use of accurate indirect fire from long-range guns, smokeless powder for small arms, and automatic weapons.[13] In the face of these advances it was no longer enough to instil soldiers with a high morale and aggressive *élan* and expect them to carry the day. David French argues that the First World War changed the doctrine of the British Army by demonstrating that an approach calling for purely human solutions to tactical problems was impractical in the face of modern weapons.[14] Born in the First World War, it was during the Second World War that the tank might be said to have come of age, and the armoured philosophies of all of the major nations evolved alongside that combat experience. In particular, by the end of the war the concept of the 'universal tank', or 'main battle tank', had largely replaced the various Infantry and Cruiser designs that had prevailed,[15] as well as the separate turreted tank destroyer concept, although parallel medium and heavy tank designs

[12] Bryn Hammond, 'Practical Considerations in British Tank Operations', in Alaric Searle (ed.), *Genesis, Employment, Aftermath* (Solihull, 2015), pp. 36-38. See also J. P. Harris, *Men, Ideas and Tanks* (Manchester, 1995), pp. 205-207.
[13] Gary Sheffield and Peter Gray (eds.), *Changing War* (London, 2015), pp. 2-3, 6-8.
[14] David French, 'Doctrine and Organization in the British Army, 1919–1932', *The Historical Journal*, 44:2 (2001), pp. 505-506.
[15] The 'Infantry Tank' concept continued thinking from the First World War that tanks should closely accompany the infantry advance in order to provide protected fire support against bunkers or other strongpoints. These tanks were consequently slow but usually well armoured against anti-tank fire. The 'Cruiser Tank' concept, by contrast, required tanks that could operate in mobile operations and independently against the enemy's rear areas in a manner akin the light cavalry of the previous century. Such tanks were usually relative fast, had a wide range of operation and carried a gun capable of tackling enemy armour.

lasted until the 1970s when the main armament of 'medium' tanks became as powerful as those on the more expensive and less mobile 'heavy' cousins.[16]

While firepower is obviously central to any main battle tank's design, its expected role may determine the type of gun fitted. Experience during the Second World War had influenced the thinking of NATO armoured warfare analysts and thus how the tanks of different NATO nations would be used, with such thinking falling into two different schools of thought. A typical Cold War scenario was predicted by NATO at the time to involve the Warsaw Pact invading Western Europe through Northern Germany with greater numerical strength but technologically inferior tanks manned by conscripts trained to a basic level. With their nations expected to be on the front line and reducing Warsaw Pact strength as they advanced against prepared positions, British and US thinkers advocating using tanks primarily using superior firepower from defensive positions at a numerically superior enemy at long range. Consequently, there was an emphasis within those nations on a tank gun that could hit hard and accurately even at long range.[17] The French and Germans, however, wanted to use their tanks to manoeuvre into positions for counter-attacks against moving Warsaw Pact formations, wearing them down and hindering their freedom of manoeuvre, and thus required tanks with greater mobility and did not require that the guns of those tanks be effective at such long-ranges as those of the UK and USA. Simpkin relates that in 1977 Field Marshal Lord Carver rated the design emphasis of the major tank producing countries as follows: the British and Israelis advocated protection over mobility, the Soviets sought a middle ground, and the French, Germans and USA (in that descending order of emphasis) stressed mobility over protection. As Simpkin notes, the USA might perhaps be better envisaged as holding a middle ground in 1977, but the point stands that in the 1970s different

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[16] See, for example: Richard Ogorkiewicz, *Tanks: 100 Years of Evolution* (Oxford, 2015), pp. 153, 167, 177-178; and Simpkin, *Tank Warfare*, pp. 29-31.
[17] M. Nicklas-Carter, 'NATO's Central Front', in. J. P. Harris and F. N. Toase (eds.), *Armoured Warfare* (London, 1990), p. 218; Stone, *The Tank Debate*, p. 48.

nations had, and indeed still have to a lesser extent, different requirements and design philosophies for their main battle tanks.[18]

A change in UK and US military thinking occurred in the 1980s. The static and linear defensive warfare doctrines designed to reduce attacking forces through the use of long-range firepower gradually altered to become a doctrine based on a more fluid battle of manoeuvre.[19] At the same time as the UK and US were moving towards more mobile employment of their MBTs, the protection and weight of the German Leopard 2 increased, with a consequent reduction in the power-to-weight ratio and thus mobility. Although still highly mobile thanks to its powerful 1500hp engine, the requirement for better armour protection added to the large and heavy engine saw Leopard 2 briefly becoming the heaviest tank in service in the world, a dubious achievement only superseded by the introduction of the better-protected British Challenger.[20] At the time of writing, the three current major NATO tank designs, Challenger 2, M1 Abrams and Leopard 2, are all so similar in external appearance and design philosophy that it requires examination of details to tell them apart. Yet despite this, while not as pronounced as it had been in the in the 1970s, the underlying and historical design philosophies are still different.

1.2. Tank Technology: Firepower, Mobility and Protection

As important as addressing how and why collaboration is seen as desirable in the modern world, is an overview of the technology involved in main battle tank design. Changes in firepower, in particular, have acted as a catalyst to tank designers who attempt to create a tank which can survive on the battlefield in the face of weapons specifically designed to

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[18] Simpkin, *Tank Warfare*, pp. 66-67.
[19] Stone, *The Tank Debate*, pp. 111, 129.
[20] Hilmes, *Main Battle Tanks: Developments in Design Since 1945*, p. 99.

destroy it. The ongoing struggle between offence and defence, between weapon systems and protection, is an area of particular interest to any study on tank design and development.

From its introduction in 1916, the tank has proven to be a versatile and potent weapon that can operate in every terrain, from Arctic to desert and from swamp to jungle.[21] Its combination of firepower, mobility and armour are unique on the battlefield. While the basic shape may be altered, the Challenger 2s and M1A1 Abrams of the 2003 Gulf War remained fundamentally the same concept of a medium calibre direct-fire gun mounted on an armoured tracked and self-propelled body that rumbled to the front line at Flers-Courcellete during the Battle of the Somme in September 1916.

The important developments of those early tanks were firepower to support attacks, mobility to carry that firepower to the point where it was required, and armour sufficient to protect the crew and to enable the vehicle to take its firepower safely over the battlefield. The early developers had little or no practical experience of armoured warfare with which to work and so mistakes were inevitably made.[22] They were also limited by the available technology. The mobility of tanks, for example, depends on powerful reliable engines, transmissions and efficient running gear, none of which had had time to mature by the time of the First World War. The only armour available in quantity was the face-hardened steel manufactured for military shipbuilding and it was heavy and difficult to work, limiting the shapes available to the designers. Although modified naval and field guns provided adequate firepower, the best method of mounting them had yet to be developed. Rotating turrets had been considered on the first designs but the high-tracked rhomboidal shape of the Mark I was deemed unsuited to a turret and the tank instead carried side sponsons, a feature that carried through all of

[21] Alaric Searle, *Armoured Warfare: A Military, Political and Global History*(London, 2017), pp. 93-112.
[22] Examples of early mistakes are seen in the French CA1 Schneider tank, introduced in 1916 and the first French design put into production. The tank had its single 75mm gun mounted on a right-side hull sponson which meant that it had a very limited field of fire and could not engage targets outside of its right-side arc. In addition, a long overhanging forward superstructure, intended to tackle belts of barbed wire, meant that the nose-heavy machine would often get stuck in heavily undulating terrain or when crossing obstacles.

Britain's early rhomboidal tank designs, and it was the small French FT-17 with its proportionally small revolving turret that pioneered such turrets to became standard for future tank designs. In the last 100 years, firepower, mobility and armour have all advanced by a phenomenal degree and the way that they have been used tactically has evolved and altered, yet it can surely be argued that the tank has remained, at its heart, the same basic concept and design - an armoured vehicle designed to carry heavy direct fire weapons to the crucial point on the battlefield.[23]

What the tank is primarily intended to engage was the cause of much debate up until, and during, the Second World War. The tank's role in the First World War was necessarily that of infantry support, its low speed, short range of action and poor contemporary communications making it unsuited to anything more independent, whatever its proponents might envisage for the future.[24] All tank-producing countries designed tanks to fulfil this infantry support role up until the Second World War, and even during the war in some cases.[25] Infantry support tanks, expected to face anti-tank weapons as they advanced with the infantry, were generally heavily armoured but traded speed for this protection. Cruiser tanks, on the other hand, were intended to exploit the breakthrough and to drive deep into enemy territory. They needed a relatively high level of mobility and a good range of operations, and many sacrificed protection to achieve this.[26] Tanks were often not even designed to fight

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[23] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 31, 45, 246.

[24] See, for example: Hammond, 'Practical Considerations in British Tank Operations', passim; Brian N. Hall, 'Development of Tank Communications in the British Expeditionary Force', in Searle (ed.), *Genesis, Employment, Aftermath*, passim; Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 40-43.

[25] Infantry tanks, that is, tanks designed to be employed for close infantry support, became less common as thinking on armoured warfare increasingly emphasised mobile actions where tanks could use their speed and shock value. See, for example: Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 64-66, 75-76, 90; Timothy K. Nenniger, 'Organizational Milestones in the Development of American Armor, 1920-40' (p. 49), and George F. Hofmann, 'Army Doctrine and the Christie Tank' (pp. 118-119), in George F. Hofmann, and Donn A. Starry (eds.), *Camp Colt to Desert Storm: The History of U.S. Armored Forces* (Lexington, 1999), pp. 49, 118-119; Azar Gat, *British Armour Theory and the Rise of the Panzer Arm: Revising the Revisionists* (Basingstoke, 2000), pp. 76-77.

[26] See, for example: J. P. Harris, 'British Armour 1918-1940: Doctrine and Development', in J. P. Harris and F.N.Toase (eds.), *Armoured Warfare* (London, 1990), pp. 41-42; Gat, *British Armour Theory and the Rise of the Panzer Arm*, pp. 74-75.

other tanks. In the USA for example, the chief of Army Ground Forces, Lt. Gen. Lesley McNair, did not believe that tanks should engage in anti-tank operations and that this should instead be left to specialised anti-tank guns and self-propelled tank destroyers.[27] It took the gruelling test of actual armoured warfare to expose the flaws in trying to design and supply different tanks to meet different tactical situations, and by the end of the Second World War most nations were pursuing a 'universal' tank, or main battle tank, that could meet all the requirements of tanks on the battlefield.

1.2.1. Firepower

The current main battle tank (MBT) is primarily a means to carry a medium calibre high-velocity direct-fire gun to the forward edge of the battlefield and engage the enemy in direct fire. The Director of the Royal Armoured Corps (DRAC) wrote in 1970 that:

> There can be absolutely no doubt that firepower is the most important characteristic of the tank. The main armament is also the factor which principally determines the dimensions and configuration of the vehicle and gives rise to the basic conflict of opinion between those who believe in an all-purpose tank and those who favour giving the antitank role to a separate vehicle. We believe that in the time-frame 1975-90 the guided weapon will continue to complement the all-purpose high velocity gun both tactically as well as in the range, but will not replace it.[28]

In 1972 the UK was heavily committed to rifled tank guns, and to its own designs in particular. After several years of being out-gunned by German tanks during the Second World War, in 1948 the excellent Vickers 20pdr (84.5mm), and later the Royal Ordnance 105mm L7, finally gave the UK domestically designed tank guns that were the best in the world. Too late for action in the Second World War, these new British tank guns were nonetheless to give the UK's arms industry a commercial lead in the decades following and

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[27] Starry, *Camp Colt to Desert Storm*, pp. 145-146.
[28] BOV, E2014.1692, HQ DRAC, Successor to Chieftain, 16 March 1970, p. 3.

would establish the UK as a centre of tank gun excellence. Married to the Vickers Centurion tank, the 20pdr was exported to 16 countries and over half the total production of the Centurion was for export. The gun's successor, the 105mm L7, was even more successful commercially, seeing service on tanks with the armies of countries such as the USA, the FRG, India, Japan and China.[29] Developed in 1957 for the new Chieftain tank then being designed, the Royal Ordnance 120mm L11A5 meant that upon its adoption in 1966 the Chieftain was NATO's most heavily-armed tank, and the 120mm calibre was to become the NATO standard for tank main guns in the following decades.

In February of 1973, less than a year after the Anglo-German Future Main Battle Tank (FMBT) joint design and development programme had been formally agreed upon, General Sir Noel Thomas, Master General of the Ordnance (MGO) suggested developing a 110mm gun as the FMBT main armament.[30] The advantages of this suggestion were queried when the UK already had an existing 120mm and 105mm design, but two experimental 110mm rifled guns, one with conventional brass cartridges and one with a semi-combustible cartridge, were nonetheless developed at the Royal Armament Research and Development Establishment (RARDE) as possible main armament for FMBT.[31]

As a result of the MBT-70 project, meanwhile, the FRG had been developing its own smoothbore 120mm gun when the USA insisted that tank-mounted ATGMs would be the next generation main armament and consequently had no interest in developing a new tank gun for MBT-70. With MBT-70's failure, Rheinmetall, a large and influential firm within the Federal Republic, was very keen to have its new gun used in FMBT as this would make the chances of it becoming the NATO standard far more likely, with all the associated export and

[29] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 178-79.
[30] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Extract from DEP 1st Meeting /77, Main Armament for the Future Main Battle Tank, 2 February 1973.
[31] Richard Ogorkiewicz, 'Armoured Fighting Vehicles', in Robert Bud and Phillip Gummett (eds.), *Cold War Hot Science: Applied Research in Britain's Defence Laboratories 1945-1990* (London, 2002), p. 124.

licensing advantages. While both the UK's Royal Ordnance Factories and RARDE were at that point government-owned, Rheinmetall was an independent privately-owned company and retained the commercial rights to their inventions, so private commercial pressures to adopt a particular gun were as important as purely military ones. Governments are, after all, more likely to allocate budgetary resources and bail out in their own in-house nationalised organisations than prop up private firms operating under purely market forces. It should be acknowledged, of course, that even poorly performing government-owned firms will be under pressure to succeed where budgets are tight.[32]

The debate between advocates of smoothbore guns and rifled tank guns had begun in the 1950s when both the USA and USSR looked at smoothbore guns to fire armour-piercing fin-stabilised discarding sabot ammunition (APFSDS) and the smoothbore concept was adopted by the FRG in the 1960s, even though the USA had since discarded the idea.[33] Rifled guns impart lateral spin to a projectile and thus increases its aerodynamic stability and hence the accuracy over longer distances, although crucially this does not hold true of fin-stabilised projectiles. This principle of rifling had been employed by firearms designers for centuries as a way to improve accuracy and effective range, and had been a feature of tank guns since the Hotchkiss 6-pounder had been fitted to the Mark I tank in 1916. With Britain wedded to its line of successful rifled guns and the FRG developing the Rheinmetall Rh120 smoothbore as a result of the failed MBT-70 programme, the main gun for the FMBT was always going to be a point of contention. One of the earliest, and arguably one of least persuasive, reasons for rifled bores emerged at a UK meeting on 2 February 1972 to discuss the main armament options for the FMBT, when it was stated that, 'The best argument for maintaining a rifled

[32] Thomas L. McNaugher, 'Problems of Collaborative Weapons Development: The MBT-70', *Armed Forces and Society*, 10/1 (1983), p. 130.
[33] Ogorkiewicz, 'Armoured Fighting Vehicles', p.125.

bore [was] that it was just as effective as a smoothbore gun up to 2000m, and the smoothbore gun would inevitably cost much more to develop fully.'[34]

Three main factors were central to the case for smoothbore guns; weight, imparted energy and ammunition. Rifled barrels require a greater thickness and therefore weight, both because of the need to cut rifling into the barrel liner and because spinning the round causes greater friction and greater heat, requiring thicker walls to dissipate and mitigate this.[35] Gun barrels are generally lined with a coating of chromium in order to mitigate this wear, but such measures delay, rather than prevent, barrel erosion.[36] In addition, spinning rounds through a rifled barrel converts some of the forward momentum into the lateral momentum for the spin and thereby bleeds forward energy from the projectile. This makes high pressure smoothbore guns somewhat more efficient at imparting muzzle velocity and means that for a given muzzle velocity the gun breach, recoil system, mounting and cartridge can be smaller and lighter. Finally, the effectiveness of any gun depends on its ammunition, and rifled and smoothbore guns impart different properties to the ammunition they fire, causing a divergence of opinion on the relative effectiveness of the various types of round when fired from each type of barrel.[37]

The key ammunition types under debate were the Armour-Piercing Discarding Sabot round (APDS), the Armour-Piercing Fin-Stabilised Discarding-Sabot round (APFSDS), High-Explosive Squash-Head (HESH), and High Explosive Anti-Tank (HEAT). The first two

[34] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Extract from DEP 1st Meeting /77, Main Armament for the Future Main Battle Tank, 2 February 1973.
[35] DTIC, AD-A440979, Clive Woodley, Ray Critchley and Dave Wallington, *QinetiQ Studies on Wear and Erosion in Gun Barrels* (QinetiQ, June 2004), esp. p. 15-2.
[36] D. M. Turley, 'Erosion of a Chromium-Plated Tank Gun Barrel', *Wear*, 131 (1989), pp. 135-150.
[37] For some of the technical arguments surrounding whether smoothbore or rifled guns are superior, see AMCP 706-242, *Engineering Design Handbook: Design for Control of Projectile Flight Characteristics* (US Army Materiel Command, September 1966), pp. 5-1 – 5-19, accessed online via <https://apps.dtic.mil/dtic/tr/fulltext/u2/801509.pdf>, accessed 20 March 2019; Richard M. Ogorkiewicz, 'Tanks and Anti-Tank Weapons', *The Adelphi Papers*, 18:144 (1978), p. 42; Simpkin, *Tank Warfare*, pp. 92-93; Erin Q. Winograd, '120 Smoothbore Favoured; Design Implications Mulled: Key Advisory Panels Recommend 110 Millimeter Cannon for the FCS', *Inside the Army*, 14:40 (October 2002), pp. 13-14.

rounds rely on kinetic energy (KE) for effect and thus require to be fired at high velocity, whereas the second two are chemical energy (CE) rounds and, far from requiring high velocity, work best within fairly low velocity ranges. KE rounds rely on their imparted velocity and mass to literally punch a hole through armour plate, damaging anything they pass through, whereas CE rounds rely on chemical explosions in contact with the armour. In addition to the immediate effect of penetration, both types of round also create spalling and possibly overpressure. Spalling is a beyond-armour effect (i.e. damage inflicted behind the armour following a successful hit) that occurs when a shock wave passing along the inner surface of the armour, be it the interior of an AFV or the wall of a structure, mechanically over-stresses the inner surface of that wall and causes it to fragment and create a 'scab' of flying shards. These shards cause death or serious injury to crew and destroy equipment, most significantly ammunition and fuel, and can disable or completely destroy the AFV. To counter spalling most modern AFVs have interior spall-liners which significantly reduce the danger, ammunition is stored in protective water jackets and crewmen can be equipped with protective goggles and clothing.[38] The goggles and face shields issued to the first British tank crews in the First World War, for example, were to protect against spalling.[39] Overpressure occurs as a shock wave and travels through the crew compartment creating a sudden flash of light and heat, even igniting flammable liquids (such as fuel or hydraulic fluids) or fine spall fragments (the 'custard power' or 'dust' explosion).[40]

By the end of the Second World War, the UK had further improved the penetration of its tank and anti-tank guns by developing APDS.[41] This KE round consisted of a sub-calibre high-density tungsten carbide 'penetrator' held within a shoe or sabot which, when the round

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[38] Joseph E. Backhofen Jnr., 'Armor Technology (Part V)', *Armor,* 43/1 (Jan/Feb 1984), p. 24. See Appendix 1 and 2 below for illustrations of spalling.

[39] Glanfield, *The Devil's Chariots*, p. 155; Hammond, 'Practical Considerations in British Tank Operations', p. 46. Note that Hammond refers to 'spalling' as 'splash', an alternative term for the same phenomenon.

[40] Dust Explosion Information, <http://www.dustexplosion.info/>, accessed 3 April 2017.

[41] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 145. For an illustration of the construction of APDS see Appendix 1 below.

was fired, fell away from the penetrator as it left the barrel.[42] The advantage of such a round is that the full calibre diameter of the sabot allows for maximum propellant charge to propel the projectile, thus achieving consequently higher velocity and potential penetration than would the smaller charge held in a round of the smaller calibre of the penetrator alone. A high density penetrator is necessary to avoid the round simply shattering when it hits armour plate at high velocity, but a full-calibre round of high density metal would be expensive, heavy and would lose velocity unacceptably quickly. Being lighter and more aerodynamic than a full-calibre round, the sub-calibre penetrator is more stable and does not lose so much velocity in its time of flight to the target. The result is that the sub-calibre tungsten carbide penetrator of APDS had significantly higher accuracy and penetration than previous armour-piercing rounds.[43]

In the 1950s both the USA and Soviet Union began further development of German research during the Second World War into an APDS round with small fins added to improve stabilisation in flight, the Armour-Piercing, Fin-Stabilised, Discarding Sabot round (APFSDS, also sometimes called APDSFS).[44] Although the UK was slow to accept the fact, APFSDS rounds were superior to APDS, but they initially required a smoothbore gun. Spinning an APFSDS projectile both reduces the energy imparted to the target and, critically, destabilises the penetrator's flight, so when the USA examined the employment of APFSDS rounds from their 152mm rifled gun/launcher during the MBT-70 project, they fitted a slipping band to the outer casing of the round to isolate the sabot and penetrator from the spin.[45] Following the failure of the FMBT project and trials of the RARDE 110mm rifled gun with APDS against the German Rheinmetall 120mm smoothbore with APFSDS, the UK

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[42] See Appendix 2 below for an illustration of the separation of the sabot from the penetrator rod.
[43] Ogorkiewicz, 'Armoured Fighting Vehicles', pp.119-20.
[44] Ogorkiewicz, *Technology of Tanks*, p. 74. For illustration of APFSDS see Appendix 1 below.
[45] Ogorkiewicz, *Technology of Tanks*, p. 81.

designed a similar APFSDS round for the Chieftain's hypothetical 120mm rifle-gun armed replacement, the proposed MBT-80, this time using isolating bearings on the sabot.[46]

An alternative to velocity-reliant kinetic energy (KE) anti-armour rounds are chemical energy (CE) rounds which rely on an explosive force applied directly against the enemy's armour. The two rounds used in the anti-armour role are the high explosive squash-head ammunition (HESH, also known as high explosive plastic, or HEP, in the USA), and high-explosive anti-tank (HEAT). HESH was originally developed by the UK in the Second World War to tackle concrete fortifications, but it proved so effective against armour that in the 1950s the UK seriously considered making HESH its standard anti-armour ammunition.[47] The HESH warhead is filled with plastic explosive within a thin metal shell which flattens on impact against the target and then detonates. The resultant shock wave passes through the armour wall to create a relatively large mass of 'spalling' fragments and very significant overpressure (with a resultant high-temperature flash) within the vehicle.[48] An early advantage of the HESH round was that it does not rely on penetration for its beyond-armour effect and so may defeat basic steel armour more effectively than an equivalent-weight standard armour-piercing shell.[49] The stress-fracturing effect HESH causes is also particularly effective against concrete or brick constructions, materials for which it was originally to tackle.[50] In addition, being metal-coated plastic explosive, the blast and secondary fragmentation effects of HESH make it very useful as a weapon against personnel

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[46] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems. Memo from CSA to Secretary of State for Defence, CSA/184/78. Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.
[47] Ogorkiewicz, *Technology of Tanks*, p. 87.
[48] See, for example: Ogorkiewicz, *Technology of Tanks*, p. 87; Simpkin, *Tank Warfare*, pp. 87-88. For details on other behind-armour effects, see, for example, Donald R. Kennedy, 'Improving Combat Crew Survivability', *Armor,* 42/4 (Jul-Aug 1983), pp. 17-19. For an illustration of spalling, see Appendix 2.
[49] DTIC, AD-389304, US Office of the Chief of Ordnance, Ordnance Engineering Design Handbook, Artillery Ammunition Series: Section 2, Design for Terminal Effects(U), 31 May 1957.
[50] Richard Ogorkiewicz, 'Armor and Future Urban Warfare', *Armor*, 53/2 (Mar-Apr 2004), p. 22.

and soft targets, around 90% as effective as a dedicated high explosive (HE) round.[51] It is, however, easily defeated in the anti-armour role by spaced armour, explosive-reactive armour (ERA) or high-hardness armour such as electroslag remelted (ESR) steel plate, and it also requires a moderately flat and vertical surface to achieve optimum effect.[52] Spall liners also mitigate the effect of HESH. Although equally able to be fired from a rifled or smoothbore barrel, being reliant on the weight of explosive for its effect, HESH rounds are less efficient when trading explosive weight for the weight of a finned tail to achieve stability (and therefore accuracy) in flight. This makes HESH a somewhat less effective round when fired from a smoothbore gun.[53]

By contrast, the HEAT round suffers significantly degraded penetrative performance when spun.[54] Using the principle of shaped charge or the 'Monroe effect', the HEAT round has a metal-lined cone, typically of aluminium or copper, in its nose, with the base of the cone facing the direction of firing and the taper pointing to the rear. Upon the fuse striking a target and detonating the charge, the conical liner collapses forward along its axis towards the cone's base to form a molten jet which penetrates armour through chemical heat and pressure to throw a stream of metal into the AFV accompanied by significant spalling. To allow this jet to form correctly, the collapse of the liner has to be triggered at precisely the correct distance from the armour and thus modern HEAT rounds have a stand-off fuse.[55] The main advantage of this form of round is that it does not rely on high velocity for its performance and is therefore used in missiles and hand-held infantry anti-tank rockets, having been developed during the Second World War for infantry anti-tank weapons such as the

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[51] I. F. B. Tytler, et. al., *Brassey's Battlefield Weapons Systems & Technology Series Volume I: Vehicles and Bridging* (London, 1985), p. 27.
[52] Ibid., pp. 26-27; Simpkin, *Tank Warfare*, pp. 87-88; Ogorkiewicz, *Technology of Tanks*, pp. 361-62.
[53] Ogorkiewicz, 'Armoured Fighting Vehicles', p.125.
[54] For a technical explanation of how spinning affects shaped-charged ammunition, see, DTIC, AD-389304,US Office of the Chief of Ordnance, *Ordnance Engineering Design Handbook, Artillery Ammunition Series: Section 2*, pp. 2-63 – 2-82.
[55] Simpkin, *Tank Warfare,* pp. 88-89.

Panzerfaust, Bazooka and PIAT. However, spinning the round degrades the formation of the charge and thus firing HEAT from a standard rifled tank gun results in poor armour penetration.[56]

Like HESH, HEAT can be degraded or defeated by high-hardness and composite or laminate armour, and by anything that disrupts the formation of the molten jet at the right time and angle, such as ERA or spaced armour.[57] HEAT rounds, using as they do a shaped charge jet for their effect, are only minimally effective against soft targets and very poor in an anti-personnel role where they have nothing hard to explode against. Although a larger HEAT warhead provides better penetration (and greater behind-armour effects), the practical limitations of incorporating a large warhead in a tank-gun calibre round means that tank-fired HEAT warheads are restricted in their potential for improvement, although shaped-charge missile warheads have less restriction on size.

1.2.2. Mobility

Ogorkiewicz defines three types of mobility: strategic, operational and battlefield.[58] Simpkin broadly agrees, although he uses the terms operational, tactical or off-road, and battlefield or cross-country.[59] Most armies, and, most significantly NATO, use similar definitions.[60] For the purposes of this discussion, Ogorkiewicz's terminology will be used (with 'battlefield' being replaced by 'tactical') as it is more in keeping with the current NATO definition of the

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[56] AMCP 706-242, *Engineering Design Handbook: Design for Control of Projectile Flight Characteristics*, pp. 5-1 – 5-19; Ogorkiewicz, *Technology of Tanks*, p. 84.
[57] Joseph E. Backhofen, Jnr., 'Armor Technology (Part III)', *Armor*, 42/2 (Mar-Apr 1983), p. 20; Ogorkiewicz, *Technology of Tanks*, pp. 369-76.
[58] Ogorkiewicz, *Technology of Tanks*, pp. 223-227.
[59] Simpkin, *Tank Warfare*, p. 100.
[60] See, for example,NATO Standard AJP-3.2, Allied Joint Doctrine for Land Operations, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/624149/doctrine_nato_land_ops_ajp_3_2.pdf>, p. 1-9, accessed 27 September 2019;USAF College of Aerospace Doctrine, Research and Education (CADRE), *Air and Space Power Mentoring Guide*, Vol. 1, <https://www.cc.gatech.edu/~tpilsch/INTA4803TP/Articles/Three%20Levels%20of%20War=CADRE-excerpt.pdf>, accessed 06 November 2019;

strategic, operational and tactical environments.[61] However defined, the need for MBTs to meet the need for mobility at each level remains important, whether it be transportation globally to an area of conflict or from one firing point on a battlefield to another. While these types of mobility are all strongly inter-related they do not necessarily require the same design answers. A high degree of mobility on the strategic level does not necessarily equate, for example, to a high tactical mobility. In addressing the problems of international collaboration in MBT design, it is important to understand why some national doctrines deem mobility to be more important than direct protection in the firepower-mobility-protection philosophy.

Fundamental to any examination of the mobility of NATO military vehicles is the concept of Military Load Classification (MLC). This NATO classification system grew from a previous British system whereby each vehicle was classified as Light, Medium, Heavy, and Super Heavy, and was noted accordingly in a table provided to the Royal Engineers to judge whether a particular vehicle was suited to given routes and bridges. This proved to be a cumbersome system and required every vehicle to be written into the table and for the table to be consulted for each vehicle in a convoy. As an alternative, therefore, each bridge and route was classified with an MLC, and the same classification was applied to vehicles. The principle stands that a vehicle can safely use a particular route if the route MLC is equal to or greater than that of the vehicle MLC. The MLC itself is a combination of weight, turning arc, load distribution and whether the vehicle runs on tracks or wheels.[62]

In the build-up to the 1991 Gulf War, more than 700 M1A1 MBTs were moved to Saudi Arabia by the USA alone, and this was in addition to the US Marines' battalion of M60 tanks, the UK 7th Armoured Brigade, and other armoured units of the coalition numbering a

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[61] NATO, British Army *ADP Land Operations (AC 71940)*, Army Doctrine Publications, p. 2-5 – 2-6.
[62] NATO uses MLC numbers; 4, 8, 12, 16, 20, 24, 30, 40, 50, 60, 70, 80, 90, 100, 120, and 150. It is useful to note that these are upper limits, so a 52 tonne tank, for example, will probably be MLC 60 (depending on the other factors as above). See, for this, Think Defence, 'UK Military Bridging – Load Classification', <http://www.thinkdefence.co.uk/2011/12/uk-military-bridging-load-classification/>, accessed 26 April 2017.

total of 3,400 tanks.[63] This sort of strategic mobility for MBTs, moving tanks from their national bases to the theatre of operations, was only possible because the designers had given thought to the necessity of building tanks that could be transported by existing ships, railway wagons and tank transporters, and even by some aircraft.[64] To achieve such strategic mobility, the dimensions of the tank need to be considered as well as the weight. Such consideration is not new and when transported by rail the early rhomboidal tanks required their side sponsons removing (or swinging into the body of the tank) to reduce the tank's width and allow the vehicles to be carried on the European railway system.[65] In the period leading up to the Second World War, British tank designers faced restriction on turret ring diameter (and consequently gun size) because tanks were again limited to being less than 2.67m wide in order that they could fit within the British railways loading gauge.[66] It is rare that tanks are produced and stored in global locations convenient for their theatre of operations, making strategic mobility an essential part of the eventual design's capability.

Once shipped to the required theatre of operations, it is the tank's operational mobility that allows commanders to position forces where they are needed for a particular campaign or operation.[67] Operational mobility on hard ground and roadways is less efficient for tracked vehicles than for those on wheels, and many attempts have been made to develop 'wheeled tanks' that would be cheaper to run and faster to deploy. As Ogorkiewicz points out, however, all these attempts have failed because the resulting vehicle has necessarily been lighter and less well-armoured in order to travel off-road as effectively as a tracked tank.[68]

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[63] William J. Taylor and James Blackwell, 'The Ground War in the Gulf', *Survival*, 33:3 (1991), p. 231; Anthony Tucker-Jones, *The Gulf War: Operation Desert Storm 1990-1991* (Barnsley, 2014), p. 9.
[64] The C-17 Globemaster aircraft, for example, can carry a single M1 Abrams MBT, with capacity for additional lighter vehicles. See Boeing Website, 'C-17 Globemaster', <http://www.boeing.com/defense/c-17-globemaster-iii/>, accessed 2 October 2017.
[65] Glanfield, *The Devil's Chariots*, pp. 144, 147.
[66] Ogorkiewicz, *Technology of Tanks*, p. 223.
[67] ADP Land Operations (AC 71940), *Army Doctrine Publications* (March 2017), p. 2-5, accessed online 22 September 2017.
[68] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 282.

Although a tank may be able to drive to where it is required on its own tracks, this is far less efficient than transportation by rail or road transporter and puts unnecessary strain on the engine and tracks, as well as being costly in terms of fuel.[69] Specialised road transporters, however, are usually in short supply and, fully laden, are obviously even heavier than the tanks they transport.[70] Ideally, then, a tank should be designed to travel at a reasonable speed on roads when required, and have the operational range to move considerable distances under its own power and on its own tracks, a feature heavily dependent on the power-to-weight ratio and thus the engine and overall weight. The tank's Military Load Classification (MLC) should also be low enough to allow it to travel over bridges and other MLC-limited structures *en-route*.

Part of the operational mobility capability for any tank is its logistical requirement, and a larger engine may mean higher speed and power but almost certainly means higher fuel consumption. Modern tanks generally have a better power-to-weight ratio than their predecessors but require an enormous amount of fuel. The current US M1 Abrams is one of the worst offenders with its thirsty AGT 1500 gas turbine engine, and the modern US Armoured Brigade Combat Team (ABCT) uses more than 100,000 gallons of fuel per day.[71] US estimates are that, in the 1991 Gulf War, a single armoured division consumed more than 600,000 gallons of fuel each day. To put this in perspective, it is almost double the fuel consumption of Patton's entire Third Army in the latter's drive across France. During the Gulf War, 350 tanks and their crews required the attentions of ninety-eight 5,000-gallon tankers plus 210 5-ton trucks per day.[72] In addition to fuel, tanks and their crews need oil, water, spare parts, ammunition, food, medical supplies and all manner of other logistical

[69] Tytler, et. al., *Brassey's Battlefield Weapons Systems & Technology Series. Volume I*, p. 41.
[70] Stone, *The Tank Debate*, p. 142.
[71] Travis Michelena, 'Protecting the Tail of the Tiger: Reshaping the Way We Train Logistics', *Armor*, 78:2 (Spring 2017), p. 4, Fig. 4.
[72] Air Force Logistics Management Agency, *The Logistics of War* (Alabama, 2000), p. 215.

support, and this is usually transported by wheeled vehicles so the longer a tank can run without such support the more operational mobility it possesses. Without timely logistical support, even the best tank becomes an expensive pillbox. In 1940, for example, fuel-hungry French Char B heavy tanks were caught and destroyed while stationary after being forced to await their fuel trucks which had been delayed by heavy refugee traffic on the narrow roads.[73]

Tactical mobility requires slightly different qualities to either strategic or operational mobility. Whereas strategic mobility requires the ability to be transported efficiently by other vehicles and operational mobility implies the ability to cover long distances over roads or other good going, tactical mobility depends on the ability to move in all manner of terrain and over soft soils.[74] The British Army's *ADP Land Operations* publication defines the tactical level as:

> … the level at which activities, battles and engagements are planned and executed to accomplish military objectives assigned to tactical formations and units. It is at the tactical level that troops are deployed directly in tactical activities, using the tactical functions.[75]

In other words, tactical mobility requires that the tank move into contact, or imminent contact, with the enemy. Simpkin categorises this as 'battlefield' or 'cross-country' mobility and it is the category of mobility which requires the highest 'sprinting' speed across rough ground.[76] While a tank's engine and power-to-weight ratio dictate its operational mobility, tactical mobility is as dependent on the suspension and the ground pressure exerted, with factors such as the length of the track (and thus the tank) and higher weight even being an

[73] Searle, *Armoured Warfare,* p. 82; Peter Caddick-Adams, 'The German Breakthrough at Sedan, 12-15 May 1940', in Brian Bond and Michael Taylor (eds.), *The Battle for France and Flanders: Sixty Years On* (Barnsley, Leo Cooper, 2001), p. 32; Karl-Heinz Frieser, *The Blitzkrieg Legend: The 1940 Campaign in the West* (Annapolis, 2012), p. 236.
[74] Ogorkiewicz, *Technology of Tanks*, p. 226.
[75] British Army ADP Land Operations (AC 71940), *Army Doctrine Publications* (March 2017), p. 2-6, accessed 22 September 2017.
[76] Simpkin, *Tank Warfare*, p. 100.

advantage.[77] Ground pressure can be kept low by carefully distributing the tank's weight over its road wheels and fitting accordingly wide tracks. The German Tiger tank, for example, was designed with interleaved wheels and wide tracks and consequently had a remarkably light ground pressure. Despite having a combat weight of 57 tonnes, the suggested method to test if the ground was firm enough to support it was to have a man, carrying another on his back, stand on one leg. If the lower man's foot began to sink then the ground was too soft for the tank.[78]

One of the features that defines a tank is that it be self-mobile. With mobility including the strategic, operational and tactical, tank designers have to consider more than simply the speed of the tank over the ground. A tank that cannot fit in long-range transport lacks strategic mobility and is highly limited in where it can be employed. A tank's operational mobility is highly dependent on its supporting logistical tail as well as its own capacity to run for considerable distances on its own tracks. Finally, tactical, or battlefield, mobility is at the heart of a tank's fighting effectiveness and its capacity for mobile warfare. Each form of mobility therefore requires a different design consideration because a tank that cannot reach the battlefield is even less effective than one which cannot move when it gets there.

1.2.3. Protection

When talking of MBT protection, there are several areas that need to be addressed. As Simpkin sets out, protection can be defined as both indirect and direct:

- *Indirect protection* concerns the chance of not being hit (under some given circumstances).

[77] Ogorkiewicz posits that higher weight is an advantage in so much as it usually corresponds to a larger tank and improves trench and ditch crossing. Obviously, this weight must not unduly increase the ground pressure exerted or reduce the power-to-weight ratio. Ogorkiewicz, *Technology of Tanks*, p. 226.
[78] David Fletcher, et. al., *Tiger Tank: Owners' Workshop Manual* (Yeovil, 2011), pp. 46, 54, 57-58.

- *Direct protection* concerns the chance of surviving a hit […].[79]

Tank designers speak of the 'survivability onion', where incoming attacks must defeat several layers of protection. The layers, in order, can be defined as; 'don't be seen', 'don't be hit', 'don't be penetrated', 'don't be killed'.[80] In simple terms, direct protection can be achieved using armour and indirect protection using camouflage, a small target area, and agility, but these concepts will be expanded upon below. As will be seen, the priority given to the balance between direct and indirect protection mirrors that between protection and mobility. Where armour is designed to prevent incoming rounds from penetrating to the vehicle's interior ('don't be penetrated'), survivability is the ability of the vehicle and crew to survive those rounds which do penetrate or otherwise inflict damage despite not penetrating ('don't be killed'). Survivability can include features such as spall liners, fire extinguishers and safe stowage of ammunition. Although an important consideration in its own right, space considerations mean that survivability and its associated design features are not dealt with here, being a substantial topic and somewhat irrelevant to the thrust of the thesis question.

A tank is primarily an offensive weapon, and thus is designed to be at the forefront of any fighting.[81] Ideally, the tank should provide fire support while avoiding returning fire. Given the direct-fire nature of the tank's main armament, to say nothing of the effectiveness of modern surveillance capabilities, avoiding both detection and incoming fire presents challenges to tank designers.

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[79] Simpkin, *Tank Warfare*, p. 110. See also Halbert, 'Elements of Tank Design', p. 41.
[80] TMARL, E2015.6, XI[th] European AFV Attack and Survivability Symposium, 11-13 June 2002, QintiQ/Bofors, 'MUSS Multifunctional Self-Protection System', p. 22; James Bingham, 'Gearing Up: European Armies Bolster the Lethality and Survivability of their AFV Fleets', *Jane's Defence Industry and Markets Intelligence Centre* (2017), pp. 8-9, accessed via. <Gearing_up_European_armies_bolster_the_lethality_and_survivability_of_their_AFV_fleets.pdf>, accessed 2 September 2018.
[81] See, for example: Simpkin, *Tank Warfare*, p. 110; Halbert, 'Elements of Tank Design', p. 35; A. C. Gadsby, 'Do We Still Need Tanks?', *The RUSI Journal*, 142:4 (1997), p. 18.

The first and most obvious way to avoid detection is to not be seen. In this, tanks have long employed visual camouflage, including suitable paint schemes and shape-altering netting and local natural materials such as foliage. Although this may be effective against the unaided human eye when stationary, any movement or enemy surveillance with thermal imaging using infra-red or similar non-visible spectrum sources will significantly reduce the utility of such measures.[82] Modern developments in the field of passive camouflage include coverings of thermal camouflage material which alter temperature to match the surroundings, and can even create a false thermal image to allow the tank to visually appear on infra-red detectors as a different vehicle.[83]

A second form of indirect protection is to reduce the target area. Small size is one of the two main forms of protection normally associated with light vehicles (the other being high mobility) but to a lesser degree it is also valid for main battle tanks. In general, this can be done by adopting a 'hull-down' stance; positioning the tank behind an obstacle or hill crest so that as little of the tank as practical is visible while still allowing it to aim and fire the main gun. Designing a tank with a lower silhouette is a method of building this form of indirect protection into the tank itself.[84] Russian tanks from the end of the Second World War tended to be low and compact and presented small targets, but such a design has drawbacks. A low silhouette presents a smaller target area but reduces the space available inside the tank. This can result in poor crew ergonomics with a consequent reduction in crew efficiency, but might also have other consequences such as a lack of hull space meaning that ammunition must be stored above the turret ring, with the risk of detonation should the turret be penetrated.[85]

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[82] Hilmes, *Main Battle Tanks*, p. 48.

[83] Google Patents, 'Thermal and Visual Camouflage System', <http://www.google.com/patents/US6338292>, accessed 30 September 2017; BAE Systems, 'ADAPTIV – Cloak of Invisibility', <http://www.baesystems.com/en-uk/feature/adativ-cloak-of-invisibility>, accessed 29 September 2017.

[84] Hilmes, *Main Battle Tanks*, p. 70.

[85] Gelbart, *Tanks: Main Battle Tank and Light Tanks*, p. 73.

Taking the idea of a low silhouette a stage further, removing a tank's turret creates a significantly lower profile. Seen in the German *Sturmgeschutz* assault guns and various tank destroyers during the Second World War, the concept of mounting the main gun directly on the hull saw a modern incarnation in the Swedish Strv. 103, more commonly known as the 'S-tank'. First proposed by Sven Berge, head of Swedish tank design in 1956, and put into service in 1967, the S-tank used an automatic loader and placed the engine and transmission at the front of the hull.[86] Aside from semantic debates over whether a 'tank' without a turret is actually a tank, siting the main gun directly on the hull restricts the tank's tactical flexibility by requiring the whole vehicle to slew in order to aim the gun. In addition to the problems of mitigating careful aiming while maintaining a stealthy stance, this tended to result in the tank slowly digging itself into the ground as it churned up the mud under its tracks. In addition, although the S-tank overcame the problem by mounting the gun high on the hull rather than within it (a 'casemate' mounting), lacking a turret usually means that a hull-mounted gun requires the vehicle to expose more of the hull to aim and fire.[87]

A third form of indirect protection is high battlefield mobility. This is usually the domain of the light reconnaissance tank and other light AFVs, but the philosophy also holds true for MBTs. Despite being relatively immune to small-arms fire, the first tanks suffered losses when hit by field guns and other artillery. Unable to armour against such heavy weapons, British thinking in 1917 was that mobility offered a surer defence than armour.[88] At that time, of course, tanks were relatively lightly armoured because their engines and power trains were insufficient to bear the weight of anything heavier, but the recurring debates over

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[86] Hilmes, *Main Battle Tanks*, pp. 79 81; Christopher F. Foss, *Jane's Main Battle Tanks (Second Edition)* (London, 1986), pp. 70-73; Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 181-182. Ogorkiewicz discusses the S-Tank with its designer, Sven Berge, in extensive correspondence covering many years; see here, TMARL, E2015.2015.13-20, Correspondence between R. M. Ogorkiewicz and Sven Berge, Malmo, 1960 to 2001.

[87] TNA, DEFE 70/467, Future Main Battle Tank, Anglo-German Symposium A, 11-29 October 1976. A Summary of the UK FMBT Simulations, March 1976; TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, p. 4.

[88] Glanfield, *Devil's Chariots*, p. 171.

tank armour's inability to defeat contemporary firepower mean that mobility as protection for MBTs has not gone away.

While ultra-high mobility might allow the evasion of some ATGMs, on a main battle tank it was found not to offer any significant protection against hypervelocity direct-fire rounds such as APFSDS.[89] Ogorkiewicz points out that there is no convincing evidence that increasing mobility by reducing the armour provides an equivalence in protection to having heavier armour at the expense of a lower mobility.[90] Nonetheless, during the post-1945 era countries such as France and Germany believed that it was impractical to try to armour tanks against contemporary anti-tank weapons and thus they emphasised mobility over protection, resulting in high mobility but relatively lightly protected tanks such as the AMX-30 and Leopard 1.[91] The experience of armoured forces during the Arab-Israeli wars showed the importance of direct armour protection despite being opposed by ATGMs and modern anti-tank ammunition, and German tank philosophy began to favour protection once more to give it more of an equal priority with mobility, a combination seen in the current Leopard 2.[92]

Finally, where armour is passive protection, active protection is the term used for a variety of active measures designed to actively intercept or degrade incoming attacks. An early proposal for such active countermeasures was the US 'Dash-Dot Device' of the 1960s which used a small radar to detect incoming threats and utilised linear charges to destroy or degrade them. No further development was made at the time, but by 1983 the Soviet Union had installed the 'Drozd' active protection system on a T-55AD tank, using radar and clusters of 107mm fragmenting-warhead rockets.[93] This system proved to be ineffective and

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[89] Hilmes, *Main Battle Tanks*, p. 51.
[90] Ogorkiewicz, 'Tanks and Anti-Tank Weapons', p. 43.
[91] Wolfgang Schneider (ed.), *Tanks of the World, 7th Edition* (Koblenz, 1990), pp. 125-126: Gelbart, *Tanks: Main Battle Tanks and Light Tanks*, pp. 31-32.
[92] Hilmes, *Main Battle Tanks*, p. 51.
[93] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 276.

expensive in practice, but the theory showed promise in defeating incoming missiles.[94] The latest Russian T-14 and South Korean K2 tanks are equipped with active protection, and future tanks may well be fitted with such systems as standard.[95]

Just as indirect protection covers several different factors which contribute to making a tank harder to hit, direct protection takes in different forms of armour which protect a tank when it get hit. Firstly, and perhaps most obviously, the physical armour carried by any vehicle is direct protection against potentially penetrating hits. Traditionally, tank armour was made of hardened steel (rolled homogenous armour, or RHA) of ever-increasing thickness, and non-steel armour such as composite or ceramic armours are generally described in terms of rolled homogenous armour equivalent (RHAe).[96] Sloping armour helps to increase the relative thickness of armour by improving the horizontal shot line thickness, that is, the actual thickness a projectile travelling on a horizontal plane must penetrate. In addition, well-sloped armour may help deflect incoming horizontal KE rounds, and also help to reduce the silhouette of the AFV and thus improve its indirect protection. Sloping armour, however, reduces the internal volume of a vehicle and creates a more cramped crew and engine space.[97]

In the race between lethality and armour, the thickness of RHA required to protect against contemporary weapons became simply too heavy for contemporary power trains and suspension units. Britain's Chieftain, for example, had excellent sloped RHA armour with a frontal horizontal shot line armour of 388mm, making it the best protected tank of any NATO country until the 1980s. However, the consequence of this protection using steel armour was that the tank weighed in at 55 tonnes, compared to its MBT contemporaries the Soviet T-62

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[94] Stone, *The Tank Debate*, p. 81.
[95] Hyundai-RotemDefense Systems, 'K2 MBT', <https://www.hyundai-rotem.co.kr/Eng/Business/Machine/Business_sub.asp?d1=2&d2=1&d3=1>, accessed 12 October 2017; Army Technology, 'T-14 Armata Main Battle Tank, Russia', <http://www.army-technology.com/projects/t-14-armata-main-battle-tank/>, accessed 24 April 2016.
[96] Chalmers and Unterseher, 'Is There a Tank Gap?' p. 38.
[97] Ogorkiewicz, *Technology of Tanks*, p. 363; Halbert, 'Elements of Tank Design', p. 37. For an illustration of the effect of sloping armour, see Appendix 2 below.

(40 tonnes), US M60A1 (52.6 tonnes) and FRG Leopard 1A4 (42.4 tonnes).[98] The heaviest tank built with RHA as its primary armour protection was again British, the 66 tonne Conqueror with frontal RHA plate 125mm thick (before the effect of sloping is taken into account).[99] With both shaped-charge warheads and larger APFSDS KE rounds able to defeat any reasonable level of RHA, it was clear that new materials to construct tank armour needed to be developed if the MBT was not to become unacceptably vulnerable on the modern battlefield.[100]

Tank armour began as thin plates of high-strength steel bolted or riveted to a framework. Hardened steel provides better protection, but it becomes brittle and liable to shatter, so early tanks used face-hardened steel where only the outer face of the armour was hardened and the inner face retained enough softness and pliability to absorb the energy of a projectile hitting. Welding plates together reduced weight and made a better join, but meant that the steel could not be as hard. An alternative to welding plates together is casting, creating homogenous components (such as turrets) without the additional preparation and weaknesses inherent in joining plates together. Unfortunately, casting requires large production facilities and creates steel of less uniform quality and hardness than rolled plates, and consequently is required to be thicker to retain the same protection levels.[101] Metallurgical research in the USA resulted in High Performance Armour, as used on the abortive MBT-70 project, made from a high quality steel harder and tougher than RHA. Other advances in steel include vacuum melted steels with nickel and cobalt, unidirectionally solidified steel and electroslag remelted (ESR). Although all these advanced steels are

[98] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 179-180, 267; Hilmes, *Main Battle Tanks*, p. 16; Gelbart, *Tanks: Main Battle Tanks and Light Tanks*, pp. 32, 80, 107, 123.

[99] Hilmes, *Main Battle Tanks,* p.14; Ogorkiewicz, *Technology of Tanks*, p.359. Ogorkiewicz also makes the point that the thickest RHA seen to that date had been the frontal plate of the 1944 72 tonne *Jagdtiger* tank destroyer, which was 250mm thick.

[100] See, for example: Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 268; Simpkin, *Tank Warfare*, pp. 111, 119; Stone, *The Tank Debate*, p. 75.

[101] Ogorkiewicz, *Technology of Tanks*, pp. 358-359. See also Hilmes, *Main Battle Tanks*, p. 72.

capable of producing stronger and lighter steel armour than RHA, their financial cost has proved to be too high for widespread adoption.[102]

Lighter armour, made of light alloys and metals such as aluminium, was developed by the USA in late 1950s for the armour of some support vehicles where mobility was considered to be more important than direct protection. To offer the equivalent protection such armour needs to be about three times as thick as the equivalent RHA, but it is considerably lighter and so provides better ballistic protection for a given weight. Although employed as armour in high-mobility armoured vehicles, aluminium alloy has never been used as the main armour for a production main battle tank.[103]

While the ability of KE rounds to penetrate the maximum thickness of RHA was becoming marginal, improvements in shaped-charge chemical energy warheads both in gun rounds such as HEAT and on ATGWs, led some to believe that attempting to effectively protect modern tanks using armour was pointless.[104] As always, developments in armour technology made such predictions somewhat premature; spaced, reactive and compound armour saw direct protection offer a counter to the new generation of such weapons.

Spaced armour consists, as the name suggests, of a second layer of armour held away from the AFV's main armour with a space in between the two layers. Although the original use was on warships to defeat torpedoes, this technology was first employed on tanks by Germany in the Second World War to increase protection on medium tanks as an alternative to bolting on an extra thickness of armour directly to the tank hull (*appliqué* armour).[105] A

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[102] Ogorkiewicz, *Technology of Tanks*, pp. 360-361.
[103] Light alloy armour has been used in the armour of such vehicles as the British CVR-T family of light tanks (the Scorpion and Scimitar, for example), the US M113 APC and M551 Sheridan light tank, and the French AMX-10 light reconnaissance vehicle. While MBT prototype designs such as the Vickers Valiant used such alloys for the hull, armour was provided using appliqué Chobham armour plates. See, for example: Rolf Hilmes, *Main Battle Tanks*, p. 77; Ogorkiewicz, *Technology of Tanks*, pp. 367-369.
[104] See, for example: Ogorkiewicz, 'The Tank and Anti-Tank Challenge', pp. 24-25, 27; Hilmes, *Main Battle Tanks,* p. 74; Stone, *The Tank Debate*, pp. 74-77, 89-90; Simpkin, *Tank Warfare*, p. 71.
[105] DTIC, AD-A954865, A. Hurlich, 'Spaced Armor', Paper Presented at Second Tank Conference, Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland, (27-29 November 1950).

slight variation of this principle was seen in the lightly armoured skirts carried to protect the running gear of some German tanks and assault guns. A projectile hitting the outer layer, if not stopped outright (and this is not the primary purpose of the spaced armour), will be distorted and deflected by the initial impact and penetration, and will therefore hit the inner layer of armour with far less penetrative power. The air gap dissipates energy and means that, for example, two layers of 4" thick RHA separated by a few inches is a more effective protection against KE rounds than a single layer 8" thick. Against shaped-charge HEAT warheads, spaced armour causes the warhead to detonate and the molten jet to form prematurely against the outer layer, and it is particularly effective against HESH as the 'scabbing' effect is confined to the outer armour layer only.[106]

Reactive armour (a.k.a. explosive reactive armour or ERA) comprises a block of two (or more) layers of armour plate with an explosive filler sandwiched in between, arranged on an AFV so that incoming rounds strike at an angle of more than 25 degrees. This explosive layer detonates when the outer plate is struck, and the force of the explosion deflects the projectile's path and degrades penetration. The force of impact required to detonate is critical, and ERA is designed not to explode due to fire, small arms, shell fragments, or fratricidally due to the explosion of the adjacent ERA block. ERA is quoted as providing between three and four times the protection against HEAT warhead as does RHAe. Although ERA would theoretically degrade long-rod KE rounds such as APFSDS if the explosive filler was of sufficient density, ERA's main value is in protecting against CE shaped-charge weapons.[107] The jet of molten metal formed by shaped charge warheads is disrupted and degraded both by

[106] For a fuller explanation of spaced armour see: Ogorkiewicz, *Technology of Tanks*, pp. 363-365; Simpkin, *Tank Warfare*, p. 88; Hilmes, *Main Battle Tanks*, pp. 74-76; Hurlich, 'Spaced Armor', passim. Note that Simpkin uniquely claims that spaced armour may actually aid HEAT, presumably due to it providing a 'stand-off' detonation and allowing the jet to form correctly, but this would depend on the HEAT fuse being set for exactly the spacing provided by the armour which would seem a highly unlikely situation.
[107] Ogorkiewicz, *Technology of Tanks*, pp. 374-376; Stone, *The Tank Debate*, p. 80.

the force of the explosion from detonating ERA and also from the outer armour plate being lifted through the jet's path.[108]

Composite, or compound, armour is armour that exploits the varying energy-diffusing properties of different materials by layering steel and such substances as ceramics, plastics and even glass.[109] Such armour relies on the combination of disruptor (or distorter) and the absorber layers, the first being hard but often brittle and relying on its hardness to slightly disrupt the path of projectile or to distort its ballistic shape. The degraded penetrator then encounters the absorber layer which absorbs and diffuses the kinetic energy remaining.[110] This principle of layering various materials forms the basis for modern armour systems.[111] In Britain, the most famous of these modern compound armours is the British development 'Chobham Armour', named after Chobham Common, the Surrey testing area where tanks were tested at the time of the armour's development. Used on British and US tanks since the 1980s, the exact composition of Chobham, now succeeded by a new armour known as 'Dorchester', is still classified, but it is presumed to be a form of composite armour incorporating steel and non-metallic materials.[112]

The principle of using different materials was seen in 1952 when the USA sought an answer to the large ATGMs then coming in to service. Their answer was 'siliceous armour', armour composed of silica glass encased in steel, glass being found to be twice as effective as steel against shaped-charge weapons. Although not adopted, the principle of layering glass with steel was to resurface in the USSR with glass-fibre composites used in the T-64 and later

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[108] See Appendix 2, below, for an illustration of ERA's effect on shaped charge.
[109] Permali Gloucester, 'Land Defence', <http://www.permali.co.uk/land-defence>, accessed 29 September 2017.
[110] M. Yong, L. Iannucci, and B. G. Falzon, 'Efficient Modelling and Optimisation of Hybrid Multilayered Plates Subject to Ballistic Impact', *International Journal of Impact Engineering*, 37 (2010), p. 605.
[111] Paul J. Hazell, 'Editorial: Special Issue on Ceramic Armour', *Advances in Applied Ceramics*, 109:8 (November 2010), p. 445.
[112] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 183-184, 269

tanks.[113] Modern armour systems also make use of ceramics to provide improved ballistic protection. The ability of ceramics to protect against ballistic projectiles was discovered in 1918 when it was found that a thin layer of ceramic applied to a steel plate improved its ability to stop projectiles.[114] A different approach was to use multiple rubber layers sandwiched between steel, often referred to as 'bulging armour'. In this case, the rubber expands as it is struck by a shaped charge jet, forcing both the metal plates and rubber layers apart and thus deforming the incoming jet of molten metal. This type of composite armour has been seen on tanks such as the Soviet T-72M.[115]

Protection and survivability are increasingly important in an age where developed nations are becoming more casualty-averse and their MBTs are becoming more expensive. No longer is it acceptable for Western nations to accept the sort of loss ratio in tanks seen by the Western Allies and Soviet Union during the Second World War.[116] Advances in technology such as ERA, compound armour and thermal camouflage all increase protection without requiring adding so much armour as to overload a tank's power train, but all increase the financial cost of the tank. Technology for active protection is still at a relatively early stage but it is possible that the near future might see the balance of firepower versus protection swing once more the way of protection, at least until the next advance in firepower.

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[113] Ogorkiewicz, *Technology of Tanks*, p. 371; idem, *Tanks: 100 Years of Evolution*, p. 268.
[114] Hazell, 'Editorial: Special Issue on Ceramic Armour', p. 445.
[115] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 269.
[116] During the Kursk operation, German losses in armour were reportedly 323 tanks and assault guns destroyed and up to 1,612 damaged, as opposed to Russian losses of 7,360 tanks and self-propelled guns. See Searle, *Armoured Warfare*, pp. 79-80. For information on how the Western Allies used superior numbers to overcome German technological superiority see: Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 144.

1.3. Standardisation: Benefits and Drawbacks

By 1990, despite NATO's push for standardisation, two out of the three major arms-producing European NATO countries of Britain, France and the FRG, had historically procured the majority of their own military equipment domestically, with France and Britain domestically producing 80% and 75% respectively. A further 15% for each nation was produced in collaboration.[117] Collaboration in weapons design within NATO is intimately linked with the concepts of rationalisation, standardisation and interoperability (RSI), and it is therefore helpful to set out in some detail why military alliances such as NATO have tried to encourage their members to standardise equipment.[118] Briefly, rationalisation encompasses all the different processes involved in encouraging standardisation and interoperability, standardisation is the adoption of common equipment and doctrine, and interoperability is the ability to share resources such as fuel and ammunition.[119] There are several arguments surrounding whether NATO standardisation is worth encouraging or not, and as to whether the perceived benefits are outweighed by the drawbacks. Setting out and briefly explaining these arguments will aid any evaluation of the question of collaborative MBT development, allowing a better understanding of why the drive for standardisation carries more influence for some involved parties than for others.

Standardisation, as opposed to interoperability, essentially means all those involved using the same equipment and procedures, or at least equipment and procedures that are so similar as to be interchangeable. In 1978, the UK Defence Ministry defined standardisation as:

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[117] Andrew Moravscik, 'The European Armaments Industry at the Crossroads', *Survival*, 32:1 (1990), pp. 65-66.
[118] See, for example: Alexander H. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies: Ten Years Later - And Beyond* (The Hague, 1981), pp. 47-48; C. J. Davidson, 'NATO Standardisation - A New Approach', The RUSI Journal, 122:3 (1977), p. 78; W. B. Williams, V. W. Perry, and H. F. Candy, NATO Standardization and Interoperability - Handbook of Lessons Learned, US Army Procurement Research Office (December 1978), p. iii.
[119] Phillip Taylor, 'Weapons standardization in NATO: Collective Security or Economic Competition?', *International Organisation*, 36:1 (Winter 1982), p. 95.

> The provision of common, and in many respects, identical weapons and equipment. It implies that the weapons and equipment of one force are in large measure interchangeable with those of another. Standardisation therefore also implies interoperability. However it is important to recognise that the converse is necessarily the case; interoperability does not imply or require standardisation.[120]

The same year, the US Army set out the following definition of standardisation:

> The process by which member nations achieve the closest practicable cooperation among forces; the most efficient use of research, development and production resources; and agree to adopt on the broadest possible basis the use of: (1) common or compatible operational, administrative, and logistics procedures; (2) common or compatible technical procedures and criteria; (3) common, compatible, or interchangeable supplies, components, weapons or equipment; and (4) common or compatible tactical doctrine with corresponding organizational compatibility.[121]

As Alexander Cornell notes, standardisation does not necessarily mean identical, just that two designs or concepts are to an agreed standard.[122] A similar definition is provided by NATO, whose definition of standardisation in 2007 was:

> The development and implementation of concepts, doctrines, procedures and design to achieve and maintain the required levels of compatibility, interchangeability or commonality in the operational, procedural, materiel, technical and administrative field to attain interoperability.[123]

By contrast, interoperability suggests that the logistical support for equipment, even if that equipment is not the same, may be shared between users. It can be noted from the above two definitions that that interoperability is the aim of standardisation. The US Army defined interoperability as: ‘The ability of systems, units, or forces to provide services to and accept

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[120] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, Head of IP2 to APS Minister of State, Adjournment Debate on the Standardisation of Weapon Systems, 8 May 1978.
[121] Williams, Perry, Candy, NATO Standardization and Interoperability, pp. 5-6.
[122] Cornell, *International Collaboration*, p. 68.
[123] Hans Kopold, ‘Standardisation of Military Equipment – The Need for Cooperation’, *European Defence Standardization Journal* (Autumn 2007), p. 10.

services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together.'[124]

Within a military alliance such as NATO, having all member states using the same (or compatible) equipment and doctrine has obvious advantages in terms of closer cooperation on the battlefield, allowing commonality of training and fully shared logistical support. Interoperability offers a lesser benefit but still gives a significant logistical advantage over having no commonality at all. During the Cold War, the Warsaw Pact had largely standardised equipment by virtue of being almost exclusively equipped by a single state, the Russian-controlled Soviet Union.[125] Although some nations within the alliance fielded a small percentage of their own vehicles or variants, an emphasis on central control by Moscow meant that the overwhelming majority of Warsaw Pact forces used identical Soviet equipment, from MBTs to small arms, which aided logistics and training but reduced flexibility in both equipment fielded and the tactics that were developed to use such equipment.[126] At the same time, by contrast, NATO was a looser confederation of independent member states and, while the USA was undoubted the most powerful member, there was no overarching political lead to make decisions on which equipment it would standardise upon. Each nation therefore made independent decisions on which equipment best suited its military doctrine and strategy, leading to a wide variety of weapon systems and tactics.

Cornell argues for standardisation, citing increased effectiveness, commonality of logistics, and commonality of training. This commonality, he suggests, helps decrease

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[124] Williams, Perry, Candy, *NATO Standardization and Interoperability*, p. 6. See also Marc R. DeVore, 'International Armaments Collaboration and the Limits of Reform', *Defence and Peace Economics*, 25:4 (2014), p. 419.

[125] Hans Kopold, 'Standardisation of Military Equipment – The Need for Cooperation', *European Defence Standardization Journal* (Autumn 2007), p. 11. For further information on how Moscow exerted political control over Soviet territories, see, for example, Philip G. Roeder, 'Soviet Federalism and Ethnic Mobilization', *World Politics*, 43:2 (January 1991), pp. 196-232.

[126] Chalmers and Unterseher, 'Is There a Tank Gap?', p. 25.

member states' domestic military expenses and 'strengthens the credibility of NATO'.[127] Hans Kopold agrees and suggests that standardisation leads to an improvement of systems and equipment, reduced logistical requirements, and an avoidance of duplication in research and development.[128] As might be expected, the *European Defence Standardisation Journal*, a journal of the European Defence Agency (EDA), promotes the idea of military standardisation and gives a fairly comprehensive list of twelve benefits, stating that standardisation:

- helps achieve Force interoperability and reduces associated risk in areas of operational, materiel and information exchange;
- enables quality of product/service/life (safety, health and environment);
- provides for economy in manufacture and servicing;
- improves collaboration e.g. between countries or contractors;
- provides a recognized yardstick against which products/processes/services can be assessed;
- ensures the supply of unambiguous technical statements for reference or contractual purposes;
- results in a reduction in the risk of dependence on specific vendors;
- ensures the avoidance of repetitive effort in producing new specifications, processes and products for each procurement;
- promotes industrial efficiency through variety control;
- reduces the need to produce project/ equipment specific components and process specifications;
- exploits best practice;
- helps to achieve and demonstrate a consistent level of equipment safety and conformity to regulations.[129]

Although some of these points may overlap in terms of the benefits they describe,[130] it is clear that the *European Defence Standardisation Journal,* and presumably therefore the European Defence Agency (EDA), believes that standardisation provides efficiency throughout the design, development, manufacture, and employment stages of military

[127] Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*, p. 68.
[128] Kopold, 'Standardisation of Military Equipment – The Need for Cooperation', p. 11.
[129] 'Benefits of Standardization', *European Defence Standardization Journal*, Issue 1 (Autumn 2007), p. 24.
[130] An example, to this author, would be the listing of the benefit of 'exploits best practice' which appears to be a rather vague concept covered by other benefits on the list.

equipment procurement. While not a NATO agency, the EDA nonetheless faces similar issues as does NATO, namely dealing with a number of independent member states, each of which has their own defence agenda and their own military doctrines.

The military and economic benefits of standardisation appear on the surface to be unarguable yet there are, indeed, arguments that mitigate against it. One problem that standardisation brings is that standardisation necessarily requires agreement on which design or doctrine should be chosen to be that standard, and partner nations may well disagree as to which design or doctrine should be adopted. For the first four decades after 1945 the most common MBTs supplied to NATO member states were designs from the USA and Great Britain, yet this situation changed with the German development and export of Leopard 1 and more significantly, Leopard 2. This design and its variants has been exported (or has had export plans confirmed) to sixteen foreign countries as diverse as Finland, Singapore and Saudi Arabia, and at the time of writing is in use by ten of the 29 NATO member states (including Germany itself).[131] While such commonality of design carries all the benefits of standardisation previously discussed, it does not follow that all NATO members would be willing to compromise their own domestic designs or particular tactical doctrine requirements to adopt a tank designed to US, British or German specifications. The MBT is a core element in most developed nation's military doctrine, and Simpkin notes that governments and militaries seem to accept a reduction in effectiveness in the quest for standardisation in some weapon systems more than in others, using the example of field artillery being rather less performance-critical than a tank or some aircraft roles.[132]

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[131] Army Technology, 'Leopard 2 Main Battle Tank, Germany' <http://www.army-technology.com/projects/leopard/>, accessed 19 September 2017. For a list of NATO member states, see: NATO website, 'NATO Member Countries' <http://www.nato.int/cps/en/natohq/nato_countries.htm>, accessed 19 September 2017.

[132] Simpkin, *Tank Warfare*, p. 206.

Cornell pointed out in 1981 that standardisation did not necessarily mean standardisation by adopting US equipment (the US being the major supplier of military hardware to NATO at that time), rather that all participants should have an equal voice in the selection.[133] In practice, however, the USA was seen as dominating arms production within NATO at the expense of its European members, creating political opposition in Europe to standardising on US equipment.[134] Matthew Ford and Alex Gould explore, for example, how, when NATO had agreed to standardise on the 7.62mm small arms round, the USA then adopted the 5.56mm and the M-16 assault rifle under circumstances that appeared to have more to do with commercial interest than military effectiveness, pushing for this round to become the new NATO standard.[135] The reluctance by European NATO members to adopt the weapons of the major producer and most powerful NATO member for reasons other than the weapon's effectiveness was addressed by C. J. Davidson in 1977, who points out that:

> Smaller NATO nations can also be induced, by economic bribery, to take a particular US weapon which in turn will mean other NATO nations adopting the weapon or equipment even if it is not the best available either in efficiency or economic sense.[136]

In these cases, the danger is that standardisation will mean adopting an inferior weapon system that happens to be championed by a politically powerful, or financially persuasive, developer. Although the USA is named in the above two examples, the developer in question could equally be any another country or even a large influential company such as General Dynamics, MBDA or BAE Systems.

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[133] Cornell, *International Collaboration*, p. 68.
[134] Alan G. Draper, *European Defence Equipment Collaboration: Britain's Involvement, 1957-87: RUSI Defence Studies* (London, 1990), p.16.
[135] Matthew Ford and Alex Gould, 'Military Identities, Conventional Capability and the Politics of NATO Standardisation at the Beginning of the Second Cold War', *International History Review*, 41:4 (2019), pp. 780-782. It should be noted that Ford and Gould make the point that the round was adopted for reasons of the political power held by the firms involved, but this author interprets the commercial drive for sales from Colt and Stoner as being behind their championing of their 5.56mm round, and any political leverage they held in the US government being driven by commercial and economic reasons.
[136] C. J. Davidson, 'NATO Standardisation - A New Approach', *The RUSI Journal*, 122:3 (1977), p. 78.

Another argument against standardisation is the loss of variety in the subsequent force arsenal, both in terms of actual equipment and in terms of military doctrine. Keith Hartley points out that standardisation removes diversification, and thus concentrating on a single design linked to a single philosophy reduces the ability of a military force to react to threats unforeseen by that philosophy.[137] In other words, an opponent only has to be able to counter a single type of force structure and tactic rather than having to deal with a variety of different weapons systems and their employment. This is an interesting idea suggesting that, like some metallic alloys, a mixture of selected separate components is stronger than any of the individual parts. The idea is furthered by Simpkin, who describes how a Cold War opponent of NATO would have had to face three different models of tank (M60, Leopard 1 and Chieftain at the time Simpkin was writing) and a variety of anti-tank missiles with different flight characteristics, guidance systems and warheads. Each weapon would be suited to a particular situation and scenario and the opponent would therefore have to counter each and every weapon in situations for which that weapon might well have been specifically designed.[138]

Standardisation within an alliance such as NATO obviously has advantages and disadvantages. The extreme positions would be for every member state to use exactly the same type of weapon and doctrine, or conversely for each to develop their own weapons and doctrine completely in isolation with no thought to interoperability or complementing those of their allies. The first situation has the advantage of efficiency in development, procurement, training, maintenance and logistics. The second approach allows innovation, a broad spectrum capability, pursuit of national engineering interests, and a measure of unpredictability for potential threats to consider. Clearly the ideal situation is an amalgam of

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[137] Keith Hartley, 'NATO, Standardisation and Nationalism: An Economist's View', *The RUSI Journal*, 123:3 (1978), p. 58.

[138] Simpkin, *Tank Warfare*, p. 207.

the two approaches. Interoperability, for example, offers logistical advantages without necessarily forcing standardisation of equipment. How far down the route towards standardisation NATO needs to travel is a question that depends on how much significance each member nation puts on the arguments set out above.

1.4. Technological Determinism, Military Innovation and RMA

Whilst the subject of this study, collaborative development of main battle tanks, concerns itself with technological innovation, this is merely a logical side-effect of studying linear progression of MBT models and no significant leap forward in military technology surrounding MBTs was evident during the period studied. Nevertheless, technological determinism and RMA do offer a wider context and starting point for discussion.

The theory of technological determinism poses the question as to whether technological innovation is driven by society and culture, or whether society and culture are driven by technology. In military terms, Raudzens asks the question, 'Do better weapons win battles?'[139] Obviously, the inventors and proponents of new weapons will argue that the introduction of a given weapon was significant in gaining victory, but this does not seem to be as clear as they would argue. Superior technology might gain its holder a tactical advantage, but it does not appear to necessarily lead to superiority at a higher level. Staying with the subject of tanks, for example, late German models such as the Tiger, Panther and Tiger II were arguably individually superior when ranked alongside equivalent Allied and Soviet machines, yet they were not capable of turning the tide of battle against Germany.[140]

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139 George Raudzens, 'War-Winning Weapons: The Measurement of Technological Determinism in Military Technology', *The Journal of Military History*, 54:4 (1990), p. 403.

140 Debates over the superiority of individual tank models focus not only on comparisons of protection, mobility and firepower, but also on mechanical reliability, availability and employment. In this study, the latter two categories are not considered as they are not factors in the argument over technology. See, for example:. A. Searle, *Armoured Warfare*, (London, 2017), pp.73-91; S. D. Badsey, 'The American Experience of Armour ,

Further evidence can be taken from the First World nations' experience of counter-insurgency warfare in conflicts from Vietnam to Afghanistan. Undoubtedly superior technology has demonstrably been unable to guarantee victory. Military technology evidently requires a commensurate change in military culture to become significant; it requires appropriate doctrinal changes to exploit any technological advantages.[141] This, then, is why technological determinism is less useful in a study examining the linear development of new tank models. Technology alone is rarely so significant as to change the patterns of warfare, so until a tank design is finalised, or even enters service, there is very little chance of its impact altering existing thinking and doctrine.

Military innovation might, on the surface, be more relevant to this study. After all, any new weapon system is innovative to an extent. Yet even here we encounter difficulty in applying the definitions of innovation to linear design development. Grissom offers a definition of military innovation that sets out three components gleaned from the extensive literature on the subject:

> First, an innovation changes the manner in which military formations function in the field.Measures that are administrative or bureaucratic in nature, such as acquisition reform, are not considered legitimate innovation unless a clear link can be drawn to operational praxis.
>
> Second, an innovation is significant in scope and impact. Minor reforms or those that have had ambiguous effects on a military organization are excluded, implying a consequentialist understanding of military innovation.
>
> Third, innovation is tacitly equated with greater military effectiveness.Only reforms that produce greater military effectiveness are studied as innovations, and few would consider studying counterproductive policies as innovations.
>
> These three elements constitute a tacit definition of military innovation that is, approximately, 'a change in operational praxis that produces a

1919- 53', in J. P. Harris and F. N. Toase (eds.), *Armoured Warfare* (London, 1990), pp.138-139; R. Ogorkiewicz, *Tanks: 100 Years of Evolution*, (Oxford, 2015), pp.128-143.

[141] Raudzens, 'War-Winning Weapons', p. 432.

> significant increase in military effectiveness' as measured by battlefield results, Correlli Barnett's 'great auditor of institutions'.[142]

Whilst a new tank model might be expected to bring greater military effectiveness, it is debateable as to how significant would be its impact on the military organisation. Some improvements might have a major impact tactically (such as anti-missile systems to counter ATGMs), but it doesn't follow that this will be reflected doctrinally. Greater protection, firepower and mobility are all desirable, but for a linear development, these will, again, be unlikely to count as significant beyond the immediate small-unit level. It is, after all, assumed that the tank design's specifications will have been drawn up to reflect the organisation's thinking and not the other way around.

If studying tank development has little in common with studying technological determinism, then the field of RMA has surely even less to offer. An RMA can be defined as:

> a major change in the nature of warfare brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine and operational and organizational concepts, fundamentally alters the character and conduct of military operations.[143]

Whilst later developments, such as the German approach to warfare in 1939/40 using fast armoured thrusts, could potentially be classed as an RMA, neither the initial development of the tank nor the linear improvements that form the basis for this study can realistically be so classified. The first tanks were simply another weapons system that slotted into existing doctrine, and no new tank model has been radical enough that it has led to 'dramatic changes in military doctrine'.[144]

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[142] A. Grissom, 'The Future of Military Innovation Studies', *Journal of Strategic Studies,* 29:5 (2006), p. 907.
[143] C. J. Rogers, ' "Military Revolution" and "Revolutions in Military Affairs": A Historian's Perspective', in T. Gongora and H. Von Riekhoff (eds.), *Toward a Revolution in Military Affairs?*(Westport, 2000), p.1.
[144] See, for example: A. Searle, *Armoured Warfare*, (London, 2017), pp. 52-53; J. Stone, *The Tank Debate*, (London, 2000), pp. 60-61; C. J. Rogers, ' "Military Revolution" and "Revolutions in Military Affairs": A Historian's Perspective', in T. Gongora and H. Von Riekhoff (eds.), *Toward a Revolution in Military Affairs?*(Westport, 2000), p.27.

Whilst it might be important to briefly look at the inter-related fields of technological determinism, military innovation and RMA, it is important only in the sense that it enables those fields to be discounted in the later analysis. Tank models are designed to specifications drawn up by military users, and they are required to fit existing needs. Those needs are largely determined by existing doctrine and military thinking, and thus it follows that it will be highly unusual for a tank designer to offer a design that is so radical as to require a completely new way of thinking.

1.5. Technology Transfer: Lend-Lease, Licensing and Collaboration

It is important for this discussion to properly differentiate between four major forms of technology transfer that feature prominently in MBT acquisition, these being *Lend-Lease*, the *purchase of foreign designs*, *licensed* and *co-production building*, and *collaborative design*. Each form of technology transfer has benefits and drawbacks, and each can be the best option in different circumstances. In discussing technology transfer it is also necessary to briefly look at the economic implications associated with developing and producing a new product. In addition, the definition of collaboration is left rather vague by most commentators and thus it is important for this study to establish a tighter definition of this form of technology transfer. By doing so, it becomes easier to judge whether or not particular cooperative projects fit this definition, and thus whether they fall into the category of collaboration or into another area of technology transfer.

Raymond Vernon's product cycle hypothesis suggests that a producer will first target a market with a nearby location and easy communication for its goods, in the case of the armaments industry this tends to be the domestic military. The next market, when the product has matured and proven itself, will often involve both export and some relocation of the industrial production facilities. Again, applying this to the weapons industry, this often means exporting the design and authorising limited licensed building. The final stage of the product cycle is the decline in profitability of domestic production of that product as foreign producers and competitors emerge, perhaps even making unlicensed copies.[145] Historically, armaments industries have tended to remain largely within their country of origin as befits important strategic assets, although the creation of many modern multinational firms such as MBDA and BAE Systems have seen former national industries become part of wider international firms through mergers and takeovers. Vernon's cycle of domestic adoption, export and then foreign copies or competition remains valid when looking at the history of tank technology development, but is perhaps less clear-cut when discussing multinational conglomerates.

Lend-Lease is famously associated with the deal between the USA and UK during the Second World War, with the US-Soviet deal almost as well known. The background to these 1940s Lend-Lease arrangements can be traced back to the economic confusion which followed the First World War and the poor financial position in which both the UK and USSR found themselves when the Second World War started. Neglect of domestic arms development and production plus a reduction in overseas trade outside of the Empire meant that the UK had little foreign currency to buy goods outright and also a shortage of domestically-produced war materiel, especially following the losses at Dunkirk. The US public was reluctant to become involved in what they saw as yet another European war so for the US government to directly supply the militaries of Britain or France would have been an unpopular move domestically Yet at the same time, the US had a surplus of manufactured goods and a president sympathetic to Britain and France's situation. The USSR was also struggling industrially at the same time that it found itself requiring large quantities of military equipment, particularly wheeled vehicles. Lend-Lease allowed the USA to export

[145] Raymond Vernon, 'International Investment and International Trade in the Product Cycle', *The Quarterly Journal of Economics*, 80:2 (May 1966), pp. 190-207.

these much-needed goods and to then accept payment in the form of loans and leasing agreements in the case of the UK, and in the reciprocal trade of rare minerals such as manganese in the case of the USSR.[146]

The more straightforward approach of buying a foreign design 'off the shelf' is usually a simple *import deal*, although the sensitivity of trading weapons means that arms deals require more political involvement than most other goods. Buying existing technology allows a nation unable to domestically design and produce weapons such as MBTs to acquire tried and tested equipment in a short space of time. Although not necessarily the most expensive form of technology transfer, buying 'off the shelf' represents the least benefit to a domestic economy as there is no associated investment in domestic industry. As a means to counter trade imbalances, therefore, such deals will sometimes have an associated offset whereby the vendor agrees to purchase other goods from the buyer, either to be fitted into the equipment being bought (a 'direct offset' such as fitting indigenous engines or main guns to tanks) or goods unrelated to the original purchase (an 'indirect offset'). The original purchaser thus buys equipment they are unable to produce domestically, and in return receives some investment in domestic industry through the sale of indigenously-produced goods as part of the offset deal. Given the otherwise one-sided nature of the 'off the shelf' purchase, it is unsurprising to learn that such deals attract the most heavily weighted trade offset deals.[147]

Licensed production is more beneficial to the buyer's domestic economy while not requiring them to invest time and money in the design and development of a product. Part or all of the components of the final product are produced domestically, or the components are

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[146] Alan P. Dobson, *U.S. Wartime Aid to Britain 1940-1946* (London, 1986), pp. 2-4, 25-28; Grigory G. Popov, 'Military-Economic Role of "Lend–Lease"for the Soviet Union' [Russian language], *Journal of Economic Regulation*, 7:1 (2016), pp. 35-37.

[147] Stephen Martin, *The Economics of Offsets: Defence Procurement and Countertrade* (Abingdon, 1996), pp. 2-3.

imported to be assembled locally. In this case the final product may sometimes also be exported by the buyer country, depending on the exact agreement with the originator. It should be noted that the terms for such licenses may differ between countries. Germany, for example, has placed tight political restrictions on which countries its weapons may be exported or licensed to, whereas the UK and French arms industries have been far more willing to export or licence on a purely commercial basis.[148] Although benefiting domestic industry to a larger extent than 'off the shelf' purchasing, licensed buying still offers little immediate benefit to the research and development sector and may not provide the end user, the military in this case, with the most suitable product for their needs.[149]

Co-production has many similarities to licensed production but it is closer to collaboration. This form of technology transfer deal gives the second country the responsibility and rights for the manufacture of a proportion of the final purchased product, even for those products destined for third party markets. The F-16 European co-production contract in 1975, for example, saw various European NATO countries share production of a total order of nearly 1,000 aircraft.[150] A more recent example of such co-production is the F-35 Joint Strike Fighter, where the USA encouraged allied investment and allowed limited production facilities in some of the nations committed to buying aircraft.[151] It should be noted that such deals rarely involve outside involvement at the design stage, and thus the product being produced represents no research or development benefits to the co-producing country.

Finally, *collaboration* is where two or more partners cooperate on a product's development. Beyond this rather vague definition we encounter problems in establishing exactly how much cooperation is required for a given project to count as a collaboration.

[148] Meyer, 'Collaboration in Arms Production: A German View', pp. 253-255.
[149] Some reports suggest that even simply importing foreign designs has benefits to the national economy. See, for example, Yi-Chung Hsu and Chien-Chiang Lee, 'The Impact of Military Technology Transfer on Economic Growth: International Evidence', *Applied Economics*, 44:19 (2012), pp. 2437-2449.
[150] Martin, *The Economics of Offsets*, p. 2.
[151] Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program* (Washington DC, 16 February 2012), accessed via. <https://fas.org/sgp/crs/weapons/RL30563.pdf>, pp. 13-17, accessed 28 September 2016.

Hartley and Martin, for example, suggest that a defence collaboration can be 'involving two or more nations sharing the development and production costs and work on defence equipment projects'.[152] Dirk Klimkeit, the Otto Group Chair of Strategic Management at Leuphana University, Germany, elaborates somewhat on this:

> Collaboration [...] requires an alignment between actors from various parts of the organization so that they show co-operative behaviour and focus on achieving the project's goals.[153]

Just how much each partner should contribute to the collaboration is not specified, and this leaves the definition unsatisfyingly vague. Asymmetry in contribution might create a situation of cooperation without necessarily leading to collaboration in the sense that each partner has a meaningful role within the arrangement. Jacques Gaillard addresses this by suggesting that the project partners should have some measure of equal standing:

> One of the determining condition[s] for successful collaboration is that the partners should be equal or at least complementary in many respects. The experience accumulated during the last decade shows that this apparent vicious circle can be overcome if the collaboration is based on a strong mutual interest and if both parties have something to gain from it.[154]

Galliard adds that, 'Project proposals should, whenever possible, be drafted jointly and each partner should be associated as much as possible to the important decisions which need to be taken,' and that, 'Each cooperating group should include a substantial number of researchers (at least 3).'[155]

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[152] Keith Hartley and Stephen Martin, 'Evaluating Collaborative Programmes', *Defence Economics*, 4:2 (1993), p. 196.
[153] Dirk Klimkeit, 'Organizational Context and Collaboration on International Projects: The Case of a Professional Service Film', *International Journal of Project Management*, 31 (2013), p. 366.
[154] Jacques F. Gaillard, 'North-South Research Partnership: Is Collaboration Possible Between Unequal Partners?' *Knowledge and Policy*, 7:2 (1994), p. 57.
[155] Gaillard, 'North-South Research Partnership.' p. 58.

It should be noted that any ‘equality’ might not be as simple as contributing equal resources at each stage of the project, Andrew Kennedy points out, for example, that asymmetry in one area might be offset by advantages elsewhere, such as where a nation gains political leverage and improved relations in exchange for investments of money and technological expertise.[156] DeVore suggests that the key to successful collaboration is ensuring that no partner feels that they are losing out relative to the other partners involved.[157] Equality of gains aside, in the case of a design and development collaboration it is suggested by this study that it is also important that all partners have significant research input as well as any other perceived benefits. In addition, Alicia Mazur, et al., conclude that all stakeholders in a project should be involved at all stages if the collaboration is to succeed.[158]

For this study, the definition for a collaborative research project will utilise all the ideas set out above: The project must involve two or more partners working in cooperation towards an agreed and predefined goal, where each partner is contributing a substantial amount of research and feels satisfied at the outset that they are gaining an advantage in proportion to the amount that they are contributing. Each partner should be involved at every stage of the project and, importantly, should have a significant input in the design of the final product.

In theory, such collaboration allows cost-effective development and production; the unit cost savings associated with economies of scale mean that having two or more countries buying the final product should lead to more units being manufactured and purchased, and so the cost of each unit should be reduced. However, the militaries of the states involved in collaboration will be looking to maximise features of the final design that best suit their own

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[156] Andrew B. Kennedy, ‘Unequal Partners: U.S. Collaboration with China and India in Research and Development’, *Political Science Quarterly*, 132:1 (2017), p. 84.
[157] Marc R. DeVore, ‘The Arms Collaboration Dilemma: Between Principal-Agent Dynamics and Collective Action Problems’, *Security Studies*, 20:4 (2011), p. 626.
[158] Alicia Mazur, et al., ‘Rating Defence Major Project Success: The Role of Personal Attributes and Stakeholder Relationships’, *International Journal of Project Management*, 32 (2014), p. 953.

operational philosophy. Unless all member states share an identical military doctrine, therefore, there will necessarily be compromise. In addition, if there is a senior partner within the collaboration, the final benefits are uneven. The knowledge gained by the junior partner will be greater than that of the senior, but the more senior the senior partner is within the collaboration, the less incentive there is to collaborate in the first place. Conversely, the closer the partners are in terms of technology, export potential and existing industrial capacity, the greater the possibility of friction between them as they struggle to maximise their own share of the design and development work.[159] This problem multiplies as the number of participants increases. Jocelyn Mawdsley, for example, examined the problems associated with the collaborative A400M military transport aircraft project and suggests that, while collaboration is essential to enable the benefits of larger-scale production, working with partners who all have a view on the project's development is often 'troublesome'.[160]

Although presented as separate forms of technology transfer for convenience, variations occur within all of the above project types. A licensed production deal may well include some co-operative production, and an 'off the shelf' purchase may include a direct offset allowing the buyer to licence-build a particular component for their domestic market. The abortive 1988 Jaguar MBT collaborative upgrade between China and USA, for example, was a collaboration whereby existing Chinese Type 59 tanks were to be jointly upgraded by Cadillac Gage in USA, and the China National Machinery & Equipment Import & Export Corporation in China. The deal was not a success, with political and commercial factors dooming it to failure, but it is of interest as an example of a US company collaborating and

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[159] Andrew Moravcisk, 'Armaments Among Allies: European Weapons Collaboration, 1975-1985', in Peter B. Evans, Harold K. Jacobson and Robert D. Putnam (eds.), *Double-Edged Diplomacy: International Bargaining and Domestic Politics* (London, 1993), pp. 128-133.
[160] Jocelyn Mawdsley, 'The A400M Project: From Flagship Project to Warning for European Defence Cooperation', *Defence Studies*, 13:1 (2013), p. 29.

sharing technology with China for the update of a Chinese tank design which itself was a licence-built T-55 from the USSR.[161]

1.6. Relevance of the MBT for Contemporary Warfare

There is no doubt that the modern main battle tank (MBT) is an expensive investment for any nation. But what is it that the MBT offers that nation and is it worth all the development, purchase and running costs? Is adopting a compromise MBT for financial reasons a valid course of action when it is known that the MBT does not fully fulfil the military's criteria? The military of most modern developed nations faces a wide variety of threats, from cyber warfare through international policing and asymmetric warfare, and on to the possibility of full-scale conventional warfare against a technologically equivalent opponent, or even a nuclear exchange. Jeffrey Bradford, the U.K. Defence Forum's Director of Research, wrote in April 2016 that:

> In considering the role of armour and the future of the Main Battle Tank in particular it is very clear that whilst the nature of its capabilities and contribution to military capability ("the what question?") is obvious how it will be employed ("the how question?") is not so clear.[162]

Developed with conventional warfare against a peer nation firmly in mind, is the MBT still relevant given the divergent pressures on military budgets?

A long-running and recurring debate surrounds the relevance of main battle tanks to the modern battlefield. Once its original purpose of breaking the stalemate on the Western Front in the First World War had been realised, the arguments began that the tank concept was no longer relevant to modern warfare. Each new counter to the tank, from anti-tank guns

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[161] Military Today, 'Jaguar, Prototype Main Battle Tank,' <http://www.military-today.com/tanks/jaguar.htm>, accessed 12 April 2017.
[162] UK Defence Forum, <http://www.defenceviewpoints.co.uk/articles-and-analysis/the-future-of-the-main-battle-tank, accessed 14 April 2016.

to shaped charges and then anti-tank guided missiles (ATGMs), led to a new wave of predictions that the tank was obsolete. Referring to the MBT, Richard Simpkin pointed out in 1979 that, 'Politicians, scientists and the media have been performing its obsequies every 5 years or so since the twenties.'[163]

The role of the MBT is assumed to be the application of mobile armoured firepower to the battlefield. The current view of the British Army is that:

> The role of Armour is to fix and destroy the enemy through shock action - the sudden, concentrated application of violence. Armour is the epitome of offensive spirit and the presence of Main Battle Tanks provides a psychological and physical edge in close combat operations.[164]

While the tank's role is likely to remain the same, the vehicle itself may become significantly different as technology advances. William Suttie of Dstl is quoted as saying that: 'Whatever we do, the chances are other nations will continue to field heavy main battle tanks, hence we will continue to need something that can do what current MBTs can do, even if it looks different from current vehicles.'[165] The ability to counter enemy main battle tanks is crucial. While some thinkers such as Lt. Gen. McNair, the US Army's head of Ground Forces from 1942 to his death in 1944, had argued that anti-tank artillery was the most effective way to defeat tanks, an argument later expanded by others with the introduction of ATGMs, it has been recognised by most observers since the Second World War that the best counter to an MBT is another MBT.[166]

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[163] Simpkin, *Tank Warfare,* p. 69.
[164] British Army website, <http://www.army.mod.uk/armoured/28803.aspx>,accessed 14 April 2016.
[165] Army Technology, 'What Does the Future Hold for Tanks?', <http://www.army-technology.com/features/featurewhat-does-the-future-hold-for-tanks-5688047/>, accessed 12 October 2017.
[166] See, for example: Ian G. S. Curtis, 'The Most Powerful Enemy of a Main Battle Tank...', *Defense and Foreign Affairs Strategic Policy*, 26:11/12 (Nov-Dec 1998), p. 7; Stone, *The Tank Debate*, p. 74; Simpkin, *Tank Warfare*, p. 86. For McNair's philosophy of anti-tank doctrine see, for example, Christopher R. Gabel, 'World War II Armor Operations in Europe', in George F. Hofmann and Donn A. Starry (eds.), *Camp Colt to Desert Storm* (Kentucky, 1999), pp. 145-147.

Thinkers such as McNair believed that tanks were primarily the weapons of exploitation and should not be involved in fighting other tanks. McNair's philosophy of using anti-tank guns and tank destroyers to defeat enemy armour saw a parallel in the post-1945 period when long-range ATGMs gave the infantry a real counter to armour at long range. Shaped-charge anti-tank missiles demonstrated their lethality against contemporary tanks in conflicts such as the 1973 'Yom Kippur' War, where Egyptian forces used large numbers of 3,000m-ranged AT-3 'Sagger' ATGMs against Israeli armour in the open Sinai desert. Despite most tanks in the 1973 war being knocked out by other tanks, some observers predicted the end of the tank as the dominant battlefield weapon.[167] A report from the International Institute for Strategic Studies, for example, concluded that, 'the advent of the missile suggests that the day of the main battle tank […] may be ending. The superiority of the offensive may be declining in favour of the defensive.'[168]

Rather than signalling the end of the tank, the rise of the ATGM threat instead saw new armour technology introduced. Designers made increased use of 'stand-off' or spaced armour and developed explosive reactive armour (ERA) which degraded the missile's warhead by exploding on contact and dissipating the warhead's force. Later developments included composite armour and more active measures such as firing decoys and using small anti-missile missiles to attack the incoming ATGM. Once more, the cycle of offence and defence had found equilibrium and the evolution of the MBT continues.

Despite all the questions over its relevance, the military value of the MBT has remained. The MBT is still the single most useful combination of mobile protected firepower available, and the unequalled level of protection found on MBTs is useful even when the opposition, such as insurgents employing RPGS and IEDs, does not warrant employment of the main gun. The flexibility of the tank means that it can be employed in almost any terrain

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[167] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 210.
[168] Stone, *The Tank Debate*, p. 77.

and any conditions, even when other weapon systems such as air power are significantly degraded or ineffective. Lastly, the MBT provides land forces with mobile firepower that can be deployed to the very front of the battlefield area and support the infantry while simultaneously remaining protected. No other system has yet been developed that provides all these advantages.[169]

From the first tanks that caught the imagination both of the military and the public the tank has held a special place in global culture. It has not always been a positive icon but it is undoubtedly a powerful one. As Meyer states, this symbolic importance suggests that having a sovereign tank design carries a level of national prestige which can influence the decision to collaborate with a foreign power on a new tank project.[170]Above and beyond their obvious use on the battlefield, the tank can be used to send a diplomatic message of military strength. Deploying tanks can be used as warning or statement of purpose. It might show a willingness to escalate a conflict, to employ the most powerful weapons in the arsenal short of nuclear munitions. While air power might allow more potent stand-off striking forces, aircraft do not have the same immediacy and front-line visibility as tanks. Being weapons usually employed at a distance, strike aircraft do not portray the same commitment to 'get stuck in', and thus their deployment does not carry the same immediate psychological and symbolic message as that carried by tanks and their associated armoured support vehicles.[171] As General Sir Nicholas Carter said in an address to RUSI, '"Boots on ground" is not a positive term at the moment, but our allies on NATO's eastern flank absolutely appreciate that a platoon of

[169] Clinton J. Ancker III, 'Whither Armor', *The Journal of Military Operations*, 1:2 (2012), pp. 4-8.
[170] Meyer, 'Collaboration in Arms Production: A German View', p. 252.
[171] 'Why Did China Amass Tanks at the North Korean Border? Was it simply good preparation — or was Beijing trying to send a message to Pyongyang?', *The Diplomat*, <http://thediplomat.com/2015/08/why-did-china-amass-tanks-at-the-north-korean-border/>, accessed 9 July 2016.

infantry is worth a squadron of F-16s when it comes to commitment.'[172] If a platoon of infantry shows commitment, how much more commitment is shown by a platoon of tanks?

1.7. Summary

The main research question under consideration in this thesis, why no collaborative MBT project has been successful between NATO nations since 1945, will be answered via several case studies. In order to answer the question, the introductory discussion above has sought to provide a backdrop to the consideration of the case studies. The main battle tank is a particularly complex vehicle which represents a unique combination of firepower, mobility and protection. Any study of MBT development must be based on an understanding of these factors and the multiple variations which emerge from the emphasis of one element over another. The optimum balance of these factors is a measure of the design philosophy of the end user and, thus, the relationship between doctrine (whether published or part of military traditions) and design is important to understand. As this study will demonstrate, differing national views on creating the optimal combination and balance of factors very quickly create grounds for disagreement. Nonetheless, the drive for, on the one hand, standardisation, and, on the other, technology transfer, led to extremely difficult negotiations within the context of international tank collaboration projects.

While it is the aim of this study to explain why several collaborative MBT projects failed, despite the strong political backing they initially received, this should not lead to the over-hasty assumption that all international MBT projects are somehow doomed to failure. Although it is not the intention of this study to consider likely future scenarios, it must be plain to even the most uninformed observer that the broader strategic situation of Western

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[172] General Sir Nicholas Carter, *Dynamic Security Threats and the British Army*, RUSI, accessed via. <https://rusi.org/event/dynamic-security-threats-and-british-army>, accessed 22 January 2018.

Europe, and the threats it faces, has changed dramatically since the end of the Cold War. Given the new types of threat, new budgetary constraints, and a host of other international and technological factors, such a changed set of parameters now exists that it may well be that the conditions exist now, or, may exist at some point in the near future, which may enable an international MBT project to succeed. In order that any new attempt at an international, collaborative MBT project has a chance of success, it is only logical that lessons need to be drawn from the previous, Cold War era failures.

CHAPTER 2

The Search for a ‘NATO Tank’: The FINABEL ‘NATO Standard Tank’ (1957-1963) and ‘Tank 90’ (1977-1983)

A common tank has arguably been the oldest aim of those seeking European military cooperation.[1] Although not a genuine example of a joint project, the Renault FT-17 light tank gave rise to one instance where some of the elements of a ‘joint design’ could be observed, partly caused by the chaotic international circumstances created by the First World War. First used in action on 31 May 1918, it was employed interspersed with the infantry to give support in dealing with strong-points. Although small, being only 5m long and weighing only six-and-a-half tonnes, the FT-17 was surprising well armoured. It was armed with either an 8mm Hotchkiss machine-gun or a low velocity 37mm *Puteaux* gun in a fully rotating turret, a design first for any production tank. The design was revolutionary and was adopted or copied as the first tank in the armies of countries as diverse as the USA, China and Brazil. The Russian Red Army reverse-engineered the FT-17 from a machine they had captured from White forces in the Civil War, the result subsequently being termed the ‘Russki Reno’. A direct development of this led to the MS-1, *MaliySoprovozhdeniya-Perviy* or ‘first small support vehicle’, later called the T-18.[2] What this curious case seems to demonstrate is that the possibility of ‘joint design’ emerged very early in the history of the tank. To the example of the Russian Reno, one could add the case of the German *Leichter Kampfwagen II*, of

[1] Andrew Moravcsik, ‘Armaments among Allies: European Weapons Collaboration, 1975-1985’, in Peter B. Evans, Harold K. Jacobson and Robert D. Putnam (eds.), *Double-Edged Diplomacy* (London, 1993), p. 143.
[2] Tim Gale, ‘“A Charming Toy”: The Surprisingly Long Life of the Renault Light Tank, 1917-1940’, in Alaric Searle (ed.), *Genesis, Employment, Aftermath: First World War Tanks and the New Warfare, 1900-1945* (Solihull, 2015), pp. 191, 202-203, 205-209.

which only ten were ever built; production was only given the go-ahead on 23 October 1918. The completed machines were sold to Sweden after the war; these were then used as a platform for early Swedish tank development.[3]

Of course, a number of countries bought foreign designs, licence-built machines and copied weapons from other nations in the wake of the Great War. But the 1918 Anglo-American 'International' or 'Liberty' tank designed and built by the Inter-Allied Tank Commission represented the first occasion when two allied nations became involved in a true collaboration to build a modern, tracked weapons system.[4] Yet the hurdles to creating a true collaborative tank project were so great that the next occasion when such a project was attempted was after 1945 – the 1957 'Standard Tank' project. Hence, any study of international tank collaboration must begin with this project. While it would be wrong to dismiss completely the 'International' as irrelevant to a study of contemporary tank development, the differences in technology and the international context mean that focussing on the post-1945 era is more helpful for gleaning any lessons and conclusions applicable to contemporary projects. The difficulties which the Inter-Allied Tank Commission faced were so great, and progress so slow, that the 1957 Franco-German project was effectively the first genuine collaborative tank development programme.

The 1957 Franco-German collaboration ran under various names: the 'NATO Standard Tank', 'European Standard Tank' and 'Euro-Panzer'. As the first example of an international NATO tank collaboration, the 1957-1963 project is important for any study of Cold War technology collaboration within the NATO alliance. The later Franco-German 'Tank 90' or 'Napoleon' project lasting from 1977 to 1983 bears so many similarities to the 1957 collaboration that it is useful to look at these two projects together, both to compare and

[3] DeutschesPanzermuseum Munster (ed.), *Catalogue* (Munster, 2015), entry for LK II, pp. 8-9.
[4] Dale E. Wilson, 'World War I', in George F. Hofmann and Donn A. Starry (eds.), *Camp Colt to Desert Storm: The History of U.S. Armored Forces* (Lexington, 1999), pp. 8-9.

to contrast the programmes. Aside from the obvious similarity that France and the FRG were the main collaboration partners, the two cases demonstrate just how important political patronage can be for any international collaborative project.[5]

Secondary source material covering the two Franco-German tank collaborations which goes into any depth is scarce. Andrew Moravcsik offers a useful six pages on the 1977 'Tank 90' project, briefly charting the project from beginning to end and concluding that the final collapse was down to German political and industrial misgivings.[6] Particularly useful for this overall study of international collaboration is that Moravcsik's chapter looks at several collaborative projects, and approaches each study in the same way, allowing comparison between the different programmes. Stephen A. Kocs provides essential political background to the Franco-German relationship and provides four-and-a-half pages of information specific to the Tank 90 project.[7] General works on armour occasionally mention the two Franco-German tank collaborations in passing, usually as a preface to information on the sovereign tanks projects that emerged, AMX-30 and Leopard for the 1957 'European Standard Tank' collaboration, and the Leclerc for the 1977 'Tank 90' project.[8] Wider political context is provided in several useful studies, particularly *Autonomy or Power? The Franco-German Relationship and Europe's Strategic Choices, 1955-1995* by Stephen Kocs,[9]

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[5] The 'Standard Tank' is mentioned in Richard Ogorkiewicz, *Tanks: 100 Years of Evolution* (Oxford, 2015), pp. 190, 194. But these references are perfunctory and offer very little beyond an acknowledgement that a specification had been agreed between Germany and France. A recent German official history of the Federal Army from 1950-70 contains a section on the 'Standardpanzer', and does refer to the first collaborative project, including a reference to the later involvement of the Italians. It is also acknowledged that both the AMX-30 and the Leopard 1 were products of this early attempt at a European tank project. See Helmut R. Hammerich, Dieter H. Kollmer, Martin Rink and Rudolf Schlaffer, *Das Heer 1950 bis 1970: Konzeption, Organisation, Aufstellung* (Munich, 2006), pp. 569-577, esp. 570-71.

[6] Moravcsik, 'Armaments among Allies', pp. 143-150.

[7] Stephen A. Kocs, Autonomy or Power? The Franco-German Relationship and Europe's Strategic Choices, 1955-1995 (Westport, CT, 1995), pp. 159-163.

[8] See, for example: Michael Jerchel, *Leopard 1 Main Battle Tank 1965-95* (Oxford, 1995), pp. 3-7; R. M. Ogorkiewicz, *AMX-30 Battle Tank* (Windsor, 1973), pp. 3, 5; idem, *Tanks: 100 Years of Evolution* (Oxford, 2015), pp. 184, 190, 192; Christopher F. Foss, *Jane's Main Battle Tanks (Second Edition)* (London, 1986), pp. 21, 34.

[9] Kocs, *Autonomy or Power?*; and, Ben Clift, 'The Fifth Republic at Fifty: The Changing Face of French Politics and Political Economy', *Modern & Contemporary France*, 16:4 (2008), pp. 383-398.

although a range of sources is required to grasp the contours of domestic and international politics at the time. These works provide important political background, without which any study of the NATO international collaborative projects would make little sense.

Against the background of obvious, and apparently very seductive, political advantages which could accrue from the design, manufacture and adoption of a standard NATO tank, both the 1957 'Standard Tank' and the 1977 'Tank 90' collaborations offer in many respects an obvious first case study for any consideration of the dynamics of international collaborative tank projects. The two projects possess so many similarities that considering them together makes most sense within the context of the overall analysis. This is not only because 'Tank 90' faced – more or less – the same challenges as the 'Standard Tank' project, but also since it picked up in many ways where its precursor project had left off. The alliance framework was, at the very least, similar, while Franco-German bi-lateral relations, even if they had developed further, were still affected by comparable military, technological and strategic considerations.[10]

In order to consider what appears to be one single military technological challenge, so many factors need to be considered that a multi-perspectival approach will be adopted. In doing so, there is, in fact, little in the way of accepted methodological approaches to draw on. Many of the widely used textbooks in the field of Security Studies tend, when dealing with land warfare, to refer to the 'Revolution in Military Affairs', 'divergent realities' and 'multiple paradigms', yet offer little in the way of guidance in terms of methodology.[11] But

[10] The literature on case studies is, not surprisingly, voluminous, to say the least. While there are many discipline-specific variations, many of the basic methodological considerations are similar. For studies on the approaches to case study analysis, see: John Gerring, 'What is a Case Study and what is it for?' *American Political Science Review*, 98 (May 2004), pp. 341-354; and, Hein Goemans& William Spaniel, 'Multimethod Research', *Security Studies*, 25 (January 2016), pp. 25-33. For more specific reflections on the methodological challenges of approaches in Security Studies, see Barry D. Watts, 'Ignoring Reality: Problems of Theory and Evidence in Security Studies', *Security Studies*, 7 (1997), pp.115-171.

[11] See, for example: Christopher Tuck, 'Land Warfare', in David Jordan, et al., *Understanding Modern Warfare* (Cambridge, 2008), pp. 64-121; and, Stephen Biddle, 'Land Warfare: Theory and Practice', in John Baylis, et al., *Strategy in the Contemporary World: An Introduction to Security Studies* (Oxford, 2002), pp. 91-112.

given the obvious value of considering these two joint tank projects as a single 'case study', the full complexities of alliance politics, technological challenges, organisational context and competing motives will need to be woven together in a unified analysis which extends across the 1950s, 1960s, 1970s and into the early part of the 1980s. As such, this chapter will also provide background in support of the subsequent chapters, outlining the broad inter-alliance framework in which joint tank projects were undertaken.

In pursuing a multi-perspectival approach, a range of subjects will be discussed: first, the chapter will provide some general military-historical context, including an explanation of FINABEL, one of several European military initiatives under which the initial 1957 collaboration emerged;[12] second, the fundamentals of the tank design which were agreed once the Franco-German agreement had been signed; third, the reasons behind the collapse of the 1957 'Standard Tank' programme; fourth, the second collaborative project, the 1977 'Tank 90' or 'Napoleon Tank'; fifth, the problems encountered during the 'Tank 90' project; and, sixth, the end of the Tank 90 collaboration. While the second project did not advance as far as the first, it was nonetheless taken at least as seriously politically. From the initial political enthusiasm, the mounting problems encountered led, however, to the French 'Leclerc' tank which replaced the failed collaborative MBT.

2.1. NATO, FINABEL, France and the FRG

Given the chaos of the immediate post-war period, it is perhaps unsurprising that France and Germany focussed primarily on their immediate domestic problems. Initially, de Gaulle was determined that France should regain national prestige lost during the Second World War, insisting upon equal standing with the UK, USA and USSR at the conference table. French

[12] FINABEL is the collaborative organisation set up in 1953 to promote armaments cooperation between the Ministries of Defence of France, Italy, Netherlands, Belgium and Luxembourg, with West Germany joining in 1956. FINABEL, <http://www.finabel.org/>, accessed 11 May 2018.

national policy during 1944-1945 was committed to creating an alliance with the USSR from which a French-led European coalition would stand as the Western bulwark against the possibility of a resurgent Germany, with the USSR forming the Eastern bulwark and neither power being dominant. De Gaulle distrusted the UK due to disputes over national influence in the Middle East and was sceptical of the USA's willingness to remain committed in Europe following the end of hostilities. Following de Gaulle's departure from the French leadership in 1946, a growing realisation that the Soviet Union was a greater threat than any potential German recovery led to French foreign policy changing from facing eastward to once more nurturing closer diplomatic relations in the West, including with Great Britain and the USA.[13] On 13 October 1946, the French Fourth Republic was created with a lacklustre plebiscite supported by a third of the electorate. The Fourth Republic inherited relatively powerless governmental institutions and decentralisation which weakened the grip of the national government. Decolonisation in places such as Indochina and Algeria represented military crises that occupied the attention of a newly reunified French state pressing to recover its political prestige within Europe and globally. Such rebuilding lasted until 1958.[14]

Meanwhile, Germany was divided into zones of occupation and its future as an independent state was in serious doubt. West Germany was not a political entity at the time of the original 1948 Brussels Treaty which sought a mutual European defence agreement to counter the perceived threat of the Soviet Union.[15] The new state of West Germany (Federal Republic of Germany, or FRG) only came into being on 23 May 1949 when the former German territories occupied by the UK, USA and France were merged. The first Chancellor

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[13] Frédéric Bozo, *French Foreign Policy since 1945* (Oxford, 2016), pp. 8-9, 12-13; for a greater level of detail, Alexander Werth, *France 1940-1955* (New York, 1956), pp. 293-500.

[14] Jean-Pierre Rioux, 'De Gaulle in Waiting 1946-1958', in Hugh Gough and John Horne (eds.), *De Gaulle and Twentieth Century France* (London, 1994), p. 35; David Dilks, *De Gaulle and the British* (Hull, n.d. [1994]).

[15] The Brussels Treaty was signed on 17 March 1948 by Belgium, France, Luxembourg, the Netherlands and the United Kingdom. This agreement led, in turn, to the inclusion of the USA and Canada, and thus the North Atlantic Treaty on 4 April 1949. See also; David C. Rasmussen., 'A Case Study of Politics and U.S. Army Doctrine; 1954 Field Manual 100-5: Operations', *Land Warfare Paper 122,* The Institute of Land Warfare US Army (January 2019), p. 8; and, WEU, <http://www.weu.int/>, accessed 12 December 2019.

of the Federal Republic, Dr Konrad Adenauer, set out to raise the country's standing within Europe to something approaching equality with the other powers, and to rebuild the German military to the point where it could contribute to Europe's defence. Such concerns required attention before potential international collaborations could be pursued.[16] However, as the danger presented by the Soviet Union dominated Western thinking, the future defence of Europe became directed towards a combined European Defence Community (EDC) in which Germany would be an ally rather than the projected enemy. The 1950 French proposal, the 'Pleven Plan', called for a European army in which Germany might play a role as an integrated EDC member, but the German state was still not to have independent armed forces. The rival US proposal, the 'Spofford Plan', saw European countries, including Germany, contributing their national forces to a military entity under US overall control. Both plans, and other moves towards an EDC involving German rearmament, fell out of favour as France grew less eager to see the Germany military rebuilt and any form of organisation that removed French military independence.[17]

NATO, the North Atlantic Treaty Organisation, was founded on 4 April 1949.[18] In August 1949, the Soviet Union successfully detonated its first atomic bomb; in October that same year Mao Zedong founded the People's Republic of China (PRC), which soon aligned itself with the Soviet Union.[19] With the Soviet Union now a nuclear power and with China in the Communist sphere, the new US-dominated NATO needed all the conventional military

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[16] Kocs, *Autonomy or Power?* pp. 15-16.
[17] Christoph Bluth, 'British-German Defence Relations, 1950-80: A Survey', in Karl Kaiser and John Roper (eds.), *British-German Defence Co-operation: Partners within the Alliance* (London, 1988), pp. 3-6. Although the proposed EDC did not materialise, the plan to integrate the FRG into a European defence alliance did become reality in September 1954 with the formation of the Western European Union (WEU). See; WEU, <http://www.weu.int/>, accessed 12 December 2019.
[18] NATO Key Events, <https://www.nato.int/nato-welcome/index.html>, accessed 18 February 2019.
[19] Anthony Best, et al., *International History of the Twentieth Century and Beyond* (Abingdon, 2nd edn, 2008), pp. 228-230.

strength it could muster to maintain any sort of parity.[20] Being an alliance of independent nations, NATO countries attempted to bring about some measure of standardisation through international negotiation and compromise. Coming out of the Second World War, both the USA and UK had tried and tested military doctrines and existing equipment programmes which they were understandably reluctant to abandon. France and the FRG, however, were not in the same strong position. The leaders of both countries foresaw the political and military advantages of working together, and thus both were initially willing to work within the framework of a collaborative partnership.

In October 1954, the Western allies agreed to end the occupation of the FRG and to allow West Germany to rearm and become a member of NATO. On 5 May 1955, the FRG's NATO membership was formally confirmed.[21] This move was countered by the Soviet Union proclaiming the creation of the Warsaw Pact on 14 May 1955.[22] The Cold War intensified in 1956 with Hungarian unrest resulting from a desire for political independence and popular objections to becoming part of the new Warsaw Pact, civil unrest which resulted in armed Soviet intervention.[23] France initially objected to the creation of the FRG from the three Western Allied occupation zones, but the USA insisted and France was too dependent on US military and economic assistance to offer prolonged resistance in the face of President Truman's determination that Western Germany should become part of NATO's defence against the Warsaw Pact.[24]

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[20] Alexander H. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies: Ten Years Later - And Beyond* (The Hague, 1981), p. 8.
[21] On the American attitude to German rearmament, see Robert McGeehan, *The German Rearmament Question: American Diplomacy and European Defense after World War II* (Urbana, Chicago, London, 1971); and, Kocs, *Autonomy or Power?* p. 17.
[22] Vojtech Matney, 'The Warsaw Pact as History', p. 2, and 'Document No. 1: The Warsaw Treaty, 14 May 1954', pp. 77-79, both in VojtechMatney and Malcolm Byrne (eds.), *A Cardboard Castle? An Inside History of the Warsaw Pact, 1955-1991* (New York, 2005).
[23] 'Document No. 3: Imra Nagy's Telegram to Diplomatic Missions in Budapest Declaring Hungary's Neutrality, November 1, 1956', in Matney and Byrne (eds.), *A Cardboard Castle?* p. 83.
[24] Kocs, *Autonomy or Power?* p. 15.

The governments of the French Fourth Republic had opposed the creation of a West German state, but rising tensions between the West and the Soviet Union and the resulting Cold War persuaded other European nations that a new German state friendly to what was then the North Atlantic Alliance (later NATO) would be a valuable ally and bulwark against potential Soviet aggression and expansion. France, being heavily dependent on the financial and military aid then being provided by the USA, proved unwilling to oppose the US in such an important political decision, despite their earlier objections. Thwarted in its attempt to block the formation of the German republic, the French Fourth Republic under Mendés-France next tried to control German rearmament by establishing a European centralised arms procurement authority. Following the French rejection of the European Defence Community, American sponsored negotiations began in October 1954, and the Federal Republic became a member of NATO in May 1955.[25]

Attempts to standardise NATO military doctrine and equipment had been plagued by problems from the beginning. Alexander Cornell, an American former NATO Fellow, has blamed this on 'ignorance, selfishness, and lack of willpower.'[26] A less critical explanation was suggested by Fred Mulley, the then UK Secretary of Defence, when he noted in 1978 that most of the nations that made up the NATO alliance had a long history of political and military independence, and that it was unlikely that such NATO members would be willing to compromise this independence for political, industrial and economic reasons. Highlighting the dominance of the USA within the NATO alliance, Mulley went on to suggest that the USA would have to change its position on its tactical doctrine to fit in with European

[25] For a very useful study of French policy and security concerns in the 1950s, see Dieter Krüger, *Sicherheitdurch Integration? Die wirtschaftliche und politischeZusammenarbeitWesteuropas 1947 bis 1957/58* (Munich, 2003), pp. 173-365; Kocs, *Autonomy or Power?* pp. 15-17, 73.
[26] Cornell, *International Collaboration in Weapons and Equipment Development*, p. 95.

members, and also to agree to buy more European equipment.[27] Phillip Taylor offered another perspective in 1982 when he wrote: 'Unfortunately, neither the efforts to achieve NATO standardization nor the inability or unwillingness of the member-states to progress substantially toward that goal can be explained by any of the current international integration theories.'[28]

Confusion and inefficiency within the loose NATO alliance were significant and prevalent enough that, in 1978, the British Minister of State for Defence expressed concern about the different tactical doctrines within NATO and even called for a simple definition of the terms, 'standardisation' and 'interoperability'.[29] Within NATO, many organisations were established to help promote international cooperation and standardisation both of equipment and of doctrine. By 1978, the many intra-European NATO organisations and sub-organisations dealing with European defence included: FINABEL, EUROGROUP, the Anglo-French and Anglo-German Army Equipment Commissions, EUROLONGTERM, the Independent European Programme Group (IEPG), the NATO Army Armaments Group (NAAG), and many others. Unfortunately, this plethora of organisations inevitably led to duplication of effort, blurring of responsibilities, greater bureaucracy and greater inefficiency. It was pointed out that '[i]t is an unavoidable disadvantage that there is considerable duplication of work between the various bodies.'[30]

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[27] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, Memo from Defence Secretary to Minister of State for Defence, 'Interoperability and Standardisation of Equipment in NATO', 2 March 1978.
[28] Phillip Taylor, 'Weapons Standardization in NATO: Collective Security or Economic Competition?' *International Organisation*, 36:1 (Winter 1982), p.96.
[29] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, Minister of State for Defence to DUS(P), D/MIN/JG/19/5/4, 13 December 1977.
[30] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, International Interdependence Organisation, VCGS to Minister of State, 12 February 1978. See also: FINABEL, <http://www.finabel.org/>, accessed 11 May 2018; Western European Union, <http://www.weu.int/>, accessed 11 May 2018; West German Ministry of Defence Planning Staff, 'The Eurogroup in NATO', *Survival*, 14:6 (1972), pp. 291-293; Cornell, *International Collaboration in Weapons and Equipment Development*, p. 120.

It was the FINABEL committee, comprising the army chiefs of staff from France, Germany, Italy, Belgium, the Netherlands, and Luxembourg, that was responsible for the French and Germans setting out to collaborate on the 'Standard Tank'. FINABEL met in November 1956 to set standards for a common NATO tank, specification FINABEL 3A5, and, although no immediate development resulted, the meeting led to German and French representatives meeting in 1957 independently of FINABEL to pursue a bi-lateral main battle tank design, based on the standards discussed at the FINABEL meeting.[31]

At the time of the 1956 FINABEL meeting, NATO's attempts to standardise were in their infancy and untarnished by the failures that were to come. Only two NATO members had nationally-designed tanks that could be considered modern MBTs, the USA with the Patton series and the UK with the Centurion. While the USA and UK may have had confidence in their post-war tank designs, France and the newly created FRG entered the mid-1950s with a significant gap in their tank technology. France had not designed and produced a modern main battle tank since 1940 and, although the FRG had inherited Germany's technological legacy, the last practical German tanks, the Panzer VI 'Panther' and Tiger 2, had entered production in early 1943 and early 1944 respectively.[32] All German tank development had, of course, come to a halt in 1945.[33] Given this set of circumstances, it is perhaps unsurprising that France and the FRG were the first two NATO members to undertake a serious attempt at a cooperative main battle tank programme in 1957.

The French Fourth Republic had opposed German rearmament for almost five years but was, by 1956 under René Coty, reassessing its position. France was becoming increasing disenchanted with NATO, which had done nothing to aid it in Indochina and Algeria. The

[31] Moravcsik, 'Armaments among Allies', p. 144.
[32] The Tank Museum, 'Sd Kfz 171 Panzerkampfwagen V Ausf G (E1949.338)' (Panther), <https://www.tankmuseum.org//museum-online/vehicles/object-e1949-338>, accessed 18 February 2019; and, The Tank Museum, 'Sd Kfz 182 Panzerkampfwagen VI Ausf B (E1994.81)' (Tiger II), <https://tankmuseum.org/museum-online/vehicles/object-e1994-81>, accessed 18 February 2019.
[33] Richard Ogorkiewicz, *Technology of Tanks, Vol. 1* (London, 1991), pp. 41-43, 53.

humiliation of the 1956 Suez crisis highlighted France's inferior position within the Alliance compared to that of the USA, and French politicians began to seek ways of improving their country's international standing. A collaboration and closer political relationship with the new FRG seemed to offer a way to boost France's standing within NATO, a step towards dominating European politics, and to breaking their dependency on the USA for the French Army's tanks.[34] Adenauer, the German Chancellor, was a staunch supporter of European integration and, indeed, unification. A former mayor of Cologne, Adenauer considered himself politically closer to the Rhineland and French influence than to the strong German nationalism of the NSDAP, and he had spent some time during the Third Reich as a political refugee and two years in a concentration camp. Overseeing the rebuilding of Germany, both politically and economically, he was convinced that only by building closer Franco-German political ties could a strong and secure Europe be guaranteed.[35]

At the 1957 Franco-German meeting between the German Defence Minister, Franz Josef Strauß, and the French Defence Minister, Maurice Bourgés-Maunory, it was proposed to jointly develop and produce a tank of either 30 tonnes or 22 tonnes, with both nations being interested in keeping the weight as low as possible and hoping for the lighter proposed figure. Despite some uncertainty over the final weight, the priority was to enter negotiations 'as soon as possible'. The agreement included within the contract a termination clause, whereby compensation would be paid by either government if they chose to pull out of the collaboration, a clause intended to avoid either partner being contractually tied to the

[34] Kocs, *Autonomy or Power?* pp. 18-19.
[35] See, here: Klaus A. Maier, 'Die internationale Auseinandersetzungen um die Westintegration der Bundesrepublik Deutschland und um ihre Bewaffnung im Rahmen der Europäischen Verteidigungsgemeinschaft', in MGFA (ed.), *Anfänge westdeutscher Sicherheitspolitik 1945-1956* (Munich,1990), pp. 1-234; Gero von Gersdorff, *Adenauers Außenpolitik gegenüber den Siegermächten 1954: Westdeutsche Wiederbewaffnung und internationale Politik* (Munich, 1994); Konrad Adenauer, *Erinnerungen 1945-1953* (Stuttgart, 1965), esp. pp. 398-563; Konrad Adenauer, *Erinnerungen 1953-1955* (Stuttgart, 1966), passim; and, Marcus Stadelmann, 'Konrad Adenauer', in Wilsford (ed.), *Political Leaders of Contemporary Western Europe*, pp. 2, 6.

agreement should they feel that it was no longer in their interests.[36] The new tank, classified at the time as a medium-heavy despite its proposed low weight, was to be designed in accordance with the military requirements set by the 1956 FINABEL meeting. An additional requirement was that the chassis was to be capable of conversion to a 155mm self-propelled artillery piece, the military requirements for which would be agreed by FINABEL.[37]

2.2. Franco-German Tank Concepts

One challenge for the establishment of a joint Franco-German tank project was the scepticism of some of the former generals with extensive wartime experience towards some of the assumptions around producing main battle tanks. These generals often had strong connections to both politicians and arms manufacturers, and thus could make life quite uncomfortable for officials in the defence ministries. A case in point is former tank general Baron Leo Geyr von Schweppenburg.[38] Nonetheless, he reflected the opinion of many former tank officers in the 1950s that off-road mobility across rough terrain could be achieved through tracked vehicles, whose technical characteristics had now improved considerably over the AFVs employed during the Second World War. This said, he was not prepared to write off wheeled vehicles for reconnaissance purposes since his wartime experience with them had been largely positive. At the same time, he was in agreement with the view that there was a tendency to look for technical perfection in the development of new tanks rather than to produce a less-

[36] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Niederschrift über die Besprechung vom 28. November 1957, 9.30 Uhr im BMVtdg, Bonn, Hardthöhe. 30t Standard-Panzer Frankreich, p.3.
[37] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Protokoll über Sitzung des Militär-Ausschusses am 11. und 12. Februar 1957 in Bonn, vom 12. Februar 1957. (3. Ausf.), p. 1.
[38] *General der Panzertruppe* Leo Freiherr Geyr von Schweppenburg (1886-1974): joined the Imperial German Army in 1904; promoted to Colonel, 1932; promoted to Generalmajor, 1935; military attaché for Great Britain, Holland and Belgium, 1933-37; promoted Generalleutnant in 1937, and appointed commander, 3rd Panzer Division; served during French Campaign, Russian Campaign and Western Europe; American POW, 1945-47; prolific author, journalist and critic of aspects of rearmament during 1950s and 1960s, as well as involvement in veterans' associations. Among his post-war publications: *Die Verteidigung des Westens* (Darmstadt, 1952), *Die großeFrage: Gedankenüber die Sowjetmacht* (Berlin, 1952) and *GebrochenesSchwert* (Berlin, 2nd edn, 1952). For Geyr's role in the rearmament debate, see Alaric Searle, *Wehrmacht Generals, West German Society, and the Debate on Rearmament, 1949-1959* (Westport, CT, 2003).

than-perfect but functional tank that required fewer resources and development time.[39] But, despite criticising the pursuit of technical perfection, he was at the same time critical of what he saw as a lack of understanding for technical questions surrounding the development of wheeled and tracked vehicles in the Federal Defence Ministry. Due to the connections of former officers like Geyr, which reached well into foreign armaments companies, it was fairly easy for them to complain about the lack of battlefield experience among those involved in weapons development.[40]

In the debates among former soldiers over the future of armour, the likelihood of the employment of tactical nuclear weapons formed another consideration which was discussed behind the scenes. Geyr von Schweppenburg considered it unlikely that their employment would be directed towards the main operational area for land forces. He thought that NATO airfields would be the most likely target; that these often lay close to cities he thought would have little impact on Russian decision-making. He also thought that it was unlikely that supply lines and logistics could be disrupted completely by enemy interdiction efforts.[41] In other words, those generals with the experience of commanding armoured troops during the Second World War did not question the future of the tank in a shooting war with the Warsaw Pact, even one involving nuclear weapons. At the same time, their attempts to influence members of parliament on the choice of future tanks met with, to quote Helmut Schmidt, 'only limited success'.[42]

In 1956, Germany had only a small number of tank designers and firms still familiar with designing and producing tanks, and even these were unfamiliar with modern

[39] It is interesting in this regard to recall how the German tank industry towards the end of the Second World War, when resources were stretched, began an ultimately wasteful search for 'wonder-weapon' tanks rather than concentrate on production and linear development of their existing models.
[40] IfZ, Nachlaß General der Panzertruppe Leo Freiherr Geyr von Schweppenburg, ED 91/22, Geyr to Paul R. Schaufelberger, 20 February 1956, Schaufelberger to Geyr, 10 February 1956, Geyr to Schaufelberger 23 March 1956 and 1 September 1956.
[41] IfZ, ED 91/22, Geyr to Schaufelberger, 20 February 1956.
[42] IfZ, ED 91/22, Helmut Schmidt (Member of the Bundestag) to Geyr, 6 October 1956, responding to a letter from Geyr of 30 September 1956 on types of tank.

developments.[43] At the same time, France had not designed a main battle tank since the transitional and stop-gap model, the ARL-44 of 1946 which had its roots in tank concepts from 1940 and was consequently obsolete by the time it went into production. Impressed by the designs of the German Panther and Tiger 2, the French copied many features of those tanks for their proposed 59 tonne heavy tank, the AMX-50, which had reached the prototype stage by 1949. Originally intended to carry the same 90mm gun as ARL-44, developments in armour and gun technology meant that AMX-50's planned gun was subsequently upgraded to a 120mm, which would have been compatible with the contemporary US heavy tank, the M-103, and the heavy British Conqueror. An up-armoured, 120mm prototype was also built, but this weighed 70 tonnes, 11 tonnes heavier than the original AMX-50 design. Eventually, reflecting NATO-wide thinking at the time, the French abandoned the idea of the heavy tank in the face of the increasingly widespread adoption of shaped-charge weapons by armies worldwide. The potential penetration of shaped-charged warheads such as HEAT rounds made heavy steel armour less useful and, in the French view, not worth the cost of heavy armour and the reduction in mobility due to the increased weight.[44]

Abandoning the heavy AMX-50 concept, the French military were left with former US M4 Sherman tanks of Second World War vintage and the 60 ARL-44s that had been produced. The original order had been for 300 ARL-44s, but the design had proven so outdated and inferior to contemporary medium tanks that production had been prematurely halted. Lacking a sovereign, modern, main battle tank design, France bought the US M-47 Patton which had been little used by the United States Army, but was supplied to European NATO nations in large numbers as part of the Military Aid Program.[45] France was more

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[43] BA-MA, BW1/1951, Versorgungsartikel-Fertigung, Trilaterale Erprobung, Kampfwertsteigerung, 1956-1959, Vermerk, 'Panzerentwicklung', Bonn, 28 December 1956, p. 4.
[44] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 187-188.
[45] Ogorkiewicz, *AMX-30 Battle Tank*, pp. 2-3.

successful with its AMX-13,[46] a well-armed light tank which weighed only 14.7 tons (13.3 tonnes) and was armed with a high velocity 75mm gun, later upgraded to a 90mm gun in French service and a 105mm gun for export versions. First built in 1952, the AMX-13 enjoyed impressive export sales to over twenty nations around the world, as well as being in service with the French Army.[47]

Acknowledging that Germany was lacking current expertise in tank development, the German project committee agreed that their contributions to the new Franco-German 'Standard Tank' should 'avail themselves of all accessible foreign experiences and insights', even though this might use up valuable time.[48] Although France was their collaboration partner, it is likely that the committee had US and, particularly, contemporary British designs in mind. Since 1945, while France had developed only the inadequate ARL-44, the United States had developed the M-47 Patton, a troubled design which was widely exported, and its improved successor, the M-48, also named Patton. In the same time period, Britain had developed the highly successful Centurion, a good all-round design which saw many upgrades and modifications and had a long and successful service with the armies of 14 nations around the world.[49] Nonetheless, there were still German voices in 1956 expressing worries about the purchase of Centurions, which they saw as being slower and heavier than

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[46] AMX, *Atelier de Construction d'Issy-les-Moulineaux*, became part of the GIAT group (*Groupement des Industries de l'Armée de Terre*, or Army Industries Group) in 1971, which in 2006 became the core of the Nexter group. See Nexter Group, 'History', <http://preprod.nexter-group.fr/en/our-passion/nexters-history>, accessed 3 July 2018.

[47] See, for example: Marsh Gelbart, *Tanks: Main Battle Tanks and Light Tanks* (London, 1996), pp. 135-136; F.M. von Senger und Etterlin, *The World's Armoured Fighting Vehicles*, trans. R. M. Ogorkiewicz (London, 1962), p. 24; and, Wolfgang Schneider (ed.), *Tanks of the World, 7th Edition* (Koblenz, 1990), pp. 132-133.

[48] BA-MA, BW1/1951, Versorgungsartikel-Fertigung, Trilaterale Erprobung, Kampfwertsteigerung, 1956-1959, Vermerk, 'Panzerentwicklung', Bonn, 28 December 1956, p. 3.

[49] For more information on the M-47, M-48 and Centurion, see, for example: Rolf Hilmes, *Main Battle Tanks: Developments in Design Since 1945,* trans. Richard Simpkin (London, 1987), pp. 11-12; Oscar C. Decker, 'The Patton Tanks' in Hofmann and Starry (eds.), *Camp Colt to Desert Storm*, pp. 289-323; S. Dunstan, *Centurion Universal Tank 1943-2003* (Oxford, 2003), passim.

required. Those with wartime experience thought that a heavy tank ought not to be employed in the way in which many planners assumed it would be.[50]

One of the biggest challenges for the embryonic Federal German arms industry at this stage was the need to rely on foreign companies. This made some projects vulnerable to the vicissitudes of foreign arms competition, with battles raging between, for example, the Swiss companies Bührle and Hispano-Suiza. This vulnerability led to disasters such as the HS-30 *Schützenpanzer* Infantry Fighting Vehicle, called SPz 12-3 in *Bundeswehr* service, designed by Hispano-Suiza, a project which led to press investigation into the receipt of bribes as high as 2.3 Million DM.[51]

For the Standard Panzer project, each of the two national delegations submitted a preliminary proposal for the new tank; proposals which were then further developed. Due to a need for rapid rearmament, the FRG delegation considered that the new project was of more immediate use to the *Bundeswehr* than to those of the French, and agreed that Germany would meet the greater share of the project's costs. Despite the Federal Republic thus being the primary partner from a financial viewpoint, the Germans acknowledged that the French had superior knowledge in contemporary tank technology, and agreed that German planning work would be complemented by the preparatory work which had already been carried out by the French for their own tank programmes.[52] But former German soldiers and some engineers seem to have agreed privately that there was an attempt being made to pursue technical perfection rather than realistic designs for lighter vehicles, which could then be put into production relatively quickly. There was a strong belief that light, fast machines were what

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[50] IfZ, ED91/22, Schaufelberger to Geyr, 9 January 1956.
[51] Dieter H. Kollmer, *Rüstungsgüterbeschaffung in der Aufbauphase der Bundeswehr. Der Schützenpanzer HS 30 alsFallbeispiel (1953–1961)* (Stuttgart, 2002); IfZ, ED 91/22, Schaufelberger to Geyr, 9 January 1956, as well as further correspondence and news cuttings in the same file, such as 'Zuwendungaus der Hispano-Suiza-Kasse? EhemaligerBotschafter Holzapfel sagtvordemUntersuchungsausschuß HS 30 aus', *Süddeutsche Zeitung*, 24 October 1967, and 'Hispao-Suizaklagt', *LuzernerTagblatt*, 16 December 1967. For more information on the HS-30/SPz 12-3 IFV, see: Robin Adshead and Noel Ayliffe-Jones, *Armour of the West* (London, 1978), p. 21.
[52] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Protokoll über Sitzung des Militär-Aussschusses am 11. Und 12. Februar 1957 in Bonn, vom 12. Februar 1957. (3. Ausf.), pp. 1-2.

was required since speed was a prerequisite for surprise, whereas heavy, tracked vehicles could not achieve this speed and required greater maintenance and supply.[53]

The initial discussions left it unclear as to whether production of the tank would be undertaken in the FRG or France, or divided between the two.[54] Fifteen German firms were allowed to bid for the initial Standard-Panzer contract. These were to be split into three, quickly reduced to two teams, or *Firmengruppen*, A and B, which would work on different prototypes. Meanwhile, France's DEFA (*Direction des Etudes et Fabrications d'Armements*, the weapons design and manufacturing directorate), effectively held the position of prime French contractor.[55] The initial contract of study called for each country to develop their own prototypes, which would then be assessed, followed by a decision as to which design would be pursued. It was agreed that a decision on the final design would be made a maximum of a year after the assessment of the prototypes.[56]

For the new tank, the emphasis was to be on firepower and manoeuvrability. With this in mind, the main gun was to be of either 90mm or 105mm, with both US and French-designed guns initially considered.[57] Following demonstrations for the Defence Minister at *Munsterlager*, the German military were increasingly interested in developing a tank in the 22-25 ton range using a 90mm gun accurate out to 1500m.[58] The French half of the committee pushed to use their 105mm D.1507 gun, still in development (and later designated

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[53] IfZ, ED91/22, Schaufelberger to Geyr, 9 January and 10 February 1956.
[54] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Niederschrift über die Besprechung vom 28. November 1957, 9.30 Uhr im BMVtdg, Bonn, Hardthöhe. 30t Standard-Panzer Frankreich, p.3.
[55] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 - 30.April 1958, Besprechungsnotiz vom 4.6.1957 vormittags, Standard-Panzer: Zuzulassende Teilnehmer, Preisrichter, Preise, Wettbewerbsbedingungen, p.1. It should be noted that DEFA became DMA (*la Délégationministérielle pour l'armement*) in 1961. On this, see Comité Pour l'Histoire de l'Armament, *Les Origines de la Délégation Générale Pour l'Armament* (Paris: DépartementD'Histoire de l'Armament, 2002), p. 3.
[56] BA-MA, BW1/452528, Deutsch-französisches Abkommen über die Entwicklung eines Standardpanzers (Vertrag-Nr. 899/57), 1957-1958, p. 4.
[57] BA-MA, BW1/1951, Versorgungsartikel-Fertigung, Trilaterale Erprobung, Kampfwertsteigerung, 1956-1959, Vermerk, 'Panzerentwicklung', Bonn, 28 December 1956, p. 3.
[58] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Niederschrift über die Besprechung vom 28. November 1957, 9.30 Uhr im BMVtdg, Bonn, Hardthöhe. 30t Standard-Panzer Franreich, p.1.

the 105mm *mle.*59), but the records show that the German delegation doubted the French design, especially given that the gun was still unproven.[59]

In addition to calling for a 105mm gun, the French required that the new tank carry a substantial amount of ammunition and pressed for a width of 3.25m. In justification, they pointed out that this would still be narrower than the 3.63m wide US M47 Patton, then in German service, and that some French heavy tanks were 3.4m wide.[60] The Germans countered this by pointing out that there were great difficulties in loading the 3.63m wide M47 tank onto their rail network for transportation. Transporting tanks of 3.50m and wider was only possible in theory on the German rail network because 3.5m was also the gauge of the rails and thus a wider load could easily lead to overbalancing, especially when the trains travelled around bends and when changing tracks at points. With this in mind, German proposals were for a tank with a maximum height of 2.2m from the ground to the top of the turret, not including the commander's cupola, and for the width to be no more than 3.15m. The French eventually agreed to the 3.15m width 'in principle' but noted that 'the matter would be reviewed'.[61]

Armour requirements were similarly a matter for debate. In keeping with the emphasis on manoeuvrability over direct protection, both countries agreed that the armour would be relatively light. The M47 Patton had frontal hull armour of 101mm sloped at 60 degrees, and side hull armour of between 51mm to 76mm.[62] German tests had shown that sloping was almost as important as thickness in armour protection, so German armour

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[59] BA-MA, BW1/452528, Standard-Panzer, 11. Feb 1957 – 30. April 1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, p. 11.
[60] BA-MA, BW1/452528, Standard-Panzer, 11. Feb 1957 – 30. April 1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, p. 2.
[61] BA-MA, BW1/452528, Standard-Panzer, 11. Feb 1957 – 30. April 1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, p. 2.
[62] Foss, *Jane's Main Battle Tanks* (1986), p. 155.

requirements for the new tank were 60mm at the front, 50mm at the side and 40mm at the rear, with the armour incorporating a significant slope wherever practical. Turret armour was to be 80-100mm at the front, 50mm on the sides and rear. The French representatives, however, only wanted 40mm armour on the hull side and 30mm at the rear.[63]

While rolled homogenous armour (RHA) had, by 1957, long been accepted as superior to cast amour by most tank-producing nations, the French explained that they had been considering the problem for a long time and would be using cast plates. If large casting facilities were available, casting was industrially easier than forming and joining RHA, but the resultant steel was weaker and less homogenous than RHA. The reason for the French decision was not military but instead down to the way that France regulated contractors. In France, the government did not specify a material or construction method to be used for producing the tank's armour, but rather specified the required strength and then allowed the contractor to choose how that specification was best met. While they acknowledged that there was a undoubtedly a difference between cast and rolled steel, they told the joint committee's German delegation that this difference was not thought in France to be significant.[64]

Tank direct protection was undergoing something of a transformation at the time of the 1957 collaboration. Shaped-charge warheads had revolutionised thinking on tank protection, a shaped-charge high explosive anti-tank (HEAT) round could defeat a greater thickness of RHA than could a conventional armour-piercing round of the same calibre. The 90mm gun of the M47, for example, could penetrate 147mm of perpendicular (i.e. non-sloped) RHA at 1000m with a kinetic energy high-velocity armour-piercing round (HVAP),

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[63] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, pp. 4, 16.
[64] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, pp. 4, 16.

whereas the same gun could defeat 252mm under the same conditions using HEAT.[65] In particular, shaped-charge warheads increased the lethality of lightweight anti-tank missiles and thus improved the ability of infantry, aircraft and light vehicles to defeat armour. In the race between weapons and armour, one early answer to shaped-charge warheads was spaced armour which prematurely detonated the warhead and severely degraded its effectiveness. Aware that they were compromising armour protection for reduced tonnage, the FRG delegation proposed that spaced armour should be used on the new tank. The French, on the other hand, did not believe that such armour was effective enough against shaped charges to make the increase in tank weight and width desirable. In the event, the German delegation agreed to drop their requirement for spaced armour.[66]

Other important general requirements for the new tank were that all main parts should be quick and easy to replace, that the tank have a low reflection for infra-red and radar, an exhaust system that gave off minimal flame and heat emission, and that all main parts (including the rubber road wheel tyres), were not flammable.[67] Unlike with the, albeit relatively minor, disputes over armament and armour, both the FRG and French delegations readily agreed to these more general requirements.

The Franco-German collaboration proposal demonstrated some disagreements over the military requirements for a new tank. The Germans were, at that stage, still looking to fit a 90mm gun and slightly thicker armour than the French. The French requirements were for a larger 105mm gun and thinner armour. However, compromise seemed highly likely as the differences of opinion were minor. Both countries wanted a lighter and more manoeuvrable tank than the existing NATO MBTs, and both wanted a conventional gun in the 90-105mm

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[65] Hilmes, Main Battle Tanks: Developments in Design since 1945, p. 40.
[66] BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, p. 5.
[67] Ibid., pp. 2-3.

range. There were no fundamental disagreements over the role of the tank, nor attempts to introduce radical new technology. Although some minor compromise between the two designs would be necessary, the collaborative project's future seemed secure.

2.3. Collapse of the Standard Tank Project

The political situation in France at the time of the Franco-German collaboration was lacking in stability. A long series of on-going crises had led to a general feeling that France was losing its position as a global great power. The defeat in Indochina in 1954, the Algerian crisis, the loss of former African countries as they gained independence, the 1956 Suez crisis, and internal party factionalism, all added to a general feeling of discontent within the turbulent French government, which had experienced many changes in the period 1947-58.[68] Franco-German defence relations were similarly unstable, with frequent changes of French government ministers bringing uncertainty to the bi-lateral negotiations.

Following the collapse of the Fourth Republic, Charles de Gaulle came to power in France in 1958. In contrast to his political predecessors, he believed that France was best served by maintaining political independence and becoming an influential power in international politics without compromising this independence. When de Gaulle became President, he made it clear that he was opposed to political collaboration and unity between France and other nations within Europe, was unconvinced of NATO's benefit to France, and was in particular suspicious of the USA's dominance within NATO.[69] In 1958, de Gaulle's

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[68] See, for example: François Goguel, 'Political Instability in France', *Foreign Affairs*, 33:1 (1954), accessed online via. <https://www.foreignaffairs.com/articles/france/1954-10-01/political-instability-france>, accessed 12 July 2018; Global Security, 'Fourth Republic 1946-1958', <https://www.globalsecurity.org/military/world/europe/fr-fourth-republic.htm>, accessed 12 July 2018; and, Kocs, *Autonomy or Power?* pp. 15, 18, 20-21.

[69] Andrew Shannan, *De Gaulle* (London, 1993); Douglas Johnson, 'De Gaulle and France's Role in the World', and Serge Berstein, 'De Gaulle and Gaullism in the Fifth Republic', in Hugh Gough and John Horne (eds.), *De Gaulle and Twentieth Century France* (New York, 1994), pp. 93-94, 114, 117; William C. Cromwell, 'Charles De Gaulle', in Wilsford (ed.), *Political Leaders of Contemporary Western Europe*, p. 86.

strategy was to establish a US-UK-French directorate which would have global influence and consequently place France in a more prominent international position. In particular, he saw France as taking a leading role in the future in negotiations with the Soviet Union and, thus, increasing French prestige. His military strategy was to put French sovereign interests ahead of any NATO commitments, arguing that France needed to deploy its military forces in areas of the world over which the North Atlantic Alliance claimed no influence.[70] This political belief in national sovereignty over collaborative international bodies inevitably represented a real danger for the Franco-German tank project.

For its part, Konrad Adenauer's Federal Republic was very aware that its newly acquired 'rehabilitation' and military security largely depended upon the sponsorship of the United States. Although a collaboration with France offered political advantages for the FRG within Europe, it also potentially distanced the country from the USA's influence and could have damaged German-American political relations. In addition, any increase in French power within Europe would have come at the expense of the FRG, particularly were the US-UK-French tripartite pact become a reality.[71]

Within a year of the collapse of the French Fourth Republic and the establishment of the Fifth Republic under de Gaulle, Adenauer's own political position looked under threat. Formerly lauded for his role in the West German international rehabilitation and economic recovery, Adenauer alienated many even within his own party when he attempted to stand as German President on the condition that the largely ceremonial position be equipped with new powers and that he would be able to choose his own successor. Given Germany's experience of the results of such centralisation of power only thirty years previously, such a move could not be seen as anything but ill-advised, at best, and it cost Adenauer much of the support he had built up. Later still, politically-motivated arrests of *Der Speigel* journalists caused a

[70] Kocs, *Autonomy or Power?* pp. 23-25.
[71] Ibid.,pp. 20-21, 24.

national scandal and Adenauer's support of Strauß, his Defence Minister and the man responsible for ordering the arrests, damaged both the Chancellor's personal popularity and that of his party. Perceived weakness with regards to the East German and reunification question, exacerbated by the building of the Berlin Wall in 1961, spelled the beginning of the end of Adenauer's political career. He finally stepped down in 1963 to be replaced by Ludwig Erhard.[72] To make matters worse, the great hopes which had been invested in Strauß by military men, who had hoped he would create some form of order in the Federal Ministry of Defence, proved to have been – in their opinion – unwarranted.[73]

German and French political enthusiasm for the collaboration faded quickly as the wider political situations in both France and Germany changed. Neither country's military saw an advantage in a necessarily compromised tank design and, without the political will to drive them, the motivation of the two delegations to collaborate and compromise decreased accordingly. By 1960, it was announced that the two French and German concepts could not be successfully integrated into a single design; hence, the respective defence ministries agreed to bring in an Italian chairman as a third party to break the deadlock. A competition was scheduled for September 1963 to decide which design was better. Despite this, however, the two nations announced in July 1963 that they would instead be pursuing their own national designs and that the collaboration was at an end.[74]

Given the similarity of the original project specifications, it is perhaps not surprising that the two sovereign designs from France and the FRG bore a striking similarity to each

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[72] For the period of Adenauer's Chancellorship from 1955-63, and the end of the Adenauer era, see: Jürgen Weber (ed.), *Geschichte der Bundesrepublik (V): Die Bundesrepublik zwischen Stabilität und Krise 1955-63* (Munich, 1993); Manfred Görtemaker, *Geschichte der Bundesrepublik Deutschland. Von der Gründung bis zur Gegenwart* (Munich, 1999), pp. 328-91; Henning Köhler, *Adenauer: Eine politische Biographie* (Berlin/Frankfurt am Main, 1994), pp. 1011-1221; Stadelmann, 'Konrad Adenauer', p. 3. For more details of the *Spiegel* Affair see, for example: Ralf Beke-Bramkamp, 'Franz-Josef Strauss', in Wilsford (ed.), *Political Leaders of Contemporary Western Europe* , p. 433; Gert Bergner, *Rudolf Augstein und die "Spiegel" Affäre* (Berlin, 1964); and, Stefan Finger, *Franz Josef Strauß: Ein politisches Leben* (Munich, 2005), pp. 170-245.

[73] According to former *General der Panzertruppe* Leo Geyr von Schweppenburg, rather than establishing order, 'the opposite had been the case'. IfZ, ED 91/22, Geyr to Prince Holstein, 7 March 1963.

[74] Moravcsik, 'Armaments among Allies', p. 144.

other. Both were light in weight and carried well sloped, but relatively light armour; both were armed with a conventional 105mm gun; and both emphasised speed and manoeuvrability over direct protection. It is, however, interesting that neither country managed to meet their initial proposed weight limit of 30 tonnes, although in other regards the sovereign designs bore a close resemblance to the collaborative designs. Certainly, it is difficult to see how design differences could have led to a collapse of the collaboration had the political backing remained strong.

The FRG's sovereign design became the Leopard (later renamed Leopard 1 with the introduction of the Leopard 2), although it was still occasionally referred to in the Federal Republic as the 'Standard Panzer' until officially renamed 'Leopard' on 1 October 1963. Considered by many commentators to be the best tank in its class, the Leopard underwent six major upgrades and was used as the basis for other AFVs such as the Leopard *Bergepanzer* ARV (Armoured Recovery Vehicle) and *Gepard* anti-aircraft gun system.[75] Although finally replaced by Leopard 2 as an MBT in 2003, Leopard 1 ARV variants are still in service in the German *Bundeswehr* at the time of writing. The Leopard 1 was also a major export success for Kraus-Maffei and Krupp MaK, the German contractor and main sub-contractor respectively, with nearly half of the total production exported to the seven NATO countries that adopted the design.[76]

On October 1963, Major J.H. Larminie of the Queens's Dragoon Guards was given the opportunity to inspect the new German 'Standard Panzer'; in the available documentation this would appear to refer to the prototype of the Leopard 1 although it is also possible that it was a prototype produced for the Franco-German project. While later Leopard models had

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[75] Jerchel, *Leopard 1 Main Battle Tank*, pp. 7, 17, 24-42.

[76] The Leopard 1 was exported to the NATO members Belgium, the Netherlands, Norway, Denmark, Canada, Turkey and Greece, as well as to Australia. Tanks Encyclopedia, 'Leopard', <http://www.tanks-encyclopedia.com/coldwar/West_Germany/Leopard-I.php>, accessed 12 May 2018; and, Moravcsik, 'Armaments among Allies', p. 144.

thicker armour, particularly on the turret, Larminie noted that, amongst other technical data, the armour thickness on the frontal glacis was 70mm (on a 60 degree slope) and 30mm (vertical) on the sides.[77] As the Leopard was Germany's new MBT, a comparison should be made with the contemporary US M-60A1, the most widely used tank model in NATO at the time, which had 115mm glacis armour (on a 60 degree slope) and an average of 50mm on the sides.[78] However, while the 40 tonne Leopard had a power-to-weight ratio of 20.75 bhp/tonnes, which gave it a top road speed of 65 kmph and road-range of 600 kilometres, the M-60A1 had a power-to-weight ratio of 14.24 bhp/tonnes and could only manage 48.28 kmph and 500 km on road.[79]

Unsurprisingly, the French also opted for a design that emphasised manoeuvrability over protection. The AMX-30 weighed slightly less than the FRG's Leopard, at 36 tonnes combat weight against Leopard's 40 tonnes.[80] The AMX-30 also had well-sloped glacis armour of 79mm thickness and side armour of between 57mm and 30mm. This gave it slightly better direct protection than the prototype and first production series Leopard, but, as a consequence, the power-to-weight ratio was less, at 18.91 bhp/tonnes, with a road speed of 50 kmph, and a 500-600 km road range.[81] As the Leopard was almost immediately up-armoured following its introduction, the AMX-30 became NATO's lightest-armoured MBT in service at that time. The AMX-30 was widely employed by the French Army, with over a thousand entering service and many weapon systems, including a launcher for the 'Pluton' tactical nuclear missile, utilising the same chassis. However, although bought by eight

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[77] TMARL, E2005.1990, Visit to BAOR by Maj. J. H. Larminie, QDG, Standard Panzer, October 1963.
[78] Rolf Hilmes, *Main Battle Tanks: Developments in Design since 1945*, p. 76.
[79] Foss, *Jane's Main Battle Tanks* (1986), pp. 40, 146.
[80] The combat weight refers to the weight of the tank with full ammunition, fuel and the crew on board, in other words, the weight of the tank as it would enter combat. It is generally at least a couple of tonnes heavier than the unloaded weight. BA-MA, BW1/452528, Standard-Panzer, 11. Feb. 1957 – 30. April 1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, p. 1.
[81] Foss, *Jane's Main Battle Tanks*, p. 28; and, Hilmes, *MainBattle Tanks: Developments in Design since 1945*, p. 76.

foreign nations – Chile, Greece, Iraq, Qatar, Saudi Arabia, Spain, the United Arab Emirates, and Venezuela – the AMX-30 did not enjoy the same export success in hard numbers as the Federal Republic enjoyed with the Leopard.[82]

2.4. Tank 90: The Start of a New Project

Fourteen years after the collapse of the original Franco-German collaboration, the governments of France and the Federal Republic once more sought to initiate a joint MBT programme. In the budget-strapped era of the late 1970s, most NATO members were more concerned with updating their existing equipment than in developing completely new systems in readiness for potential conflicts at least 20 years in the future.[83] Since the end of the Standard Tank programme in 1963, two further collaborative MBT programmes were attempted within NATO, neither of which had resulted in a production tank.[84] Despite this, the political attraction and potential financial advantages of collaboration were strong enough for a fourth attempt, the second between France and the FRG.

It was in 1976 when France began to consider replacing the AMX-30, which had, quite obviously, resulted at least in part from the 1957 Franco-German Standard-Panzer project. At the time, the French *Ministère de la Défense* was strongly in favour of Franco-German cooperation in armaments acquisition and development. With an eye towards financial savings as well as symbolic political gestures, French ministers initiated a tripartite meeting held on 3 and 4 November 1977 to examine the possibility of a new tank for the 1990s to be developed jointly between France, the Federal Republic and Britain.[85]

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[82] Foss, *Jane's Main Battle Tanks*, p. 29.
[83] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, Memo from Defence Secretary to Minister of State for Defence, 'Interoperability and Standardisation of Equipment in NATO', 2 March 1978.
[84] The US-FRG MBT-70 and Anglo-German FMBT projects are dealt with in chapters 3 and 4 below.
[85] TNA, DEFE 13/1153, International co-operation and collaboration on equipment procurement, Brief No. 1311.

At a meeting between the British Defence Secretary, Fred Mulley, and the FRG and French Ministers of Defence on 3 November 1977, the French Minister of Defence, Yvon Bourges, stated that France wished to give absolute priority to the European armaments industry and preferred to use the Independent European Programme Group (IEPG) to a NATO forum when discussing arms collaboration. At the same meeting, the German Defence Minister, Georg Leber,[86] stated that the FRG preferred cooperative to national projects because of the 'military, technological, economic and Alliance advantages that cooperation brought.'[87] On 9 November 1977, the British Secretary of Defence and French and German Defence Ministers issued statements of support for cooperation and commonality, including in the field of tanks, stating that, 'The Ministers declare their will to seek all possibilities of cooperation between the three countries.'[88] Despite the rhetoric, Britain quickly dropped out, having only cancelled the collaborative Future Main Battle Tank (FMBT) programme with the FRG in March 1977 and having subsequently begun its own domestic MBT-80 programme. Within the remaining two countries, the leaders, Helmut Schmidt and Valery Giscard d'Estaing,[89] were the political drivers behind the project, even though the vast

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[86] Georg Leber, a former Trades Union leader, became Federal Defence Minister in 1972, following a cabinet reshuffle by the then Chancellor, Willy Brandt. Leber was forced to resign as Defence Minister in 1978 following an espionage scandal involving FRG Defence Ministry personnel passing NATO secrets to East Germany during his time in office. Friedrich Ebert Stiftung, 'Georg Leber – eine Würdigung zum 5. Todestag, <https://www.fes.de/wuerdigung-georg-leber/>, accessed 17 February 2019. For more information about the espionage scandal see, for instance, 'Georg Leber in Bedrängnis', *Der Spiegel*, 9 January 1978, <http://www.spiegel.de/spiegel/print/d-40693706.html>, accessed 03 July 2018; 'Spionage: Wohl sehrnachlässig', *Der Spiegel*, 13 February 1978, <http://www.spiegel.de/spiegel/print/d-40616381.html>, accessed 03 July 2018.

[87] TNA, DEFE 13/1153, International co-operation and collaboration on equipment procurement, MO 25/2/72/1, Record of a Meeting between the Secretary of State and the French and German Ministers of Defence, 3 November 1977.

[88] TNA, DEFE 13/1153, International co-operation and collaboration on equipment procurement, MO 25/2/71/1, Tripartite Meeting with French and German Defence Ministers, 9 November 1977.

[89] Helmut Schmidt took over as FRG Chancellor following Willy Brandt's resignation in 1974; he saw international cooperation as a way to overcome the economic problems that plagued the Federal Republic of Germany and the rest of the world in the mid-1970s. The Federal Chancellery, 'Helmut Schmidt (1974 - 1982)', <https://www.bundeskanzlerin.de/bkin-en/chancellery/federal-chancellors-since-1949/helmut-schmidt>, accessed 17 February 2019. Valery Giscard d'Estaing had been French Finance Minister from 1969 and had overseen the financial restructuring of the Franc made necessary by the disintegration of the existing international monetary system (IMS) and the failure of the 1970 first attempt to create a unified European currency, the so-called 'European money snake'. D'Estaing became French President in 1974. CVCE,

majority of the actual negotiation was carried out by the respective Ministries of Defence armaments directors, Hans-Ludwig Eberhard and Henri Martre.[90] There can be little doubt that Schmidt and Giscard considered each other friends faced with similar political problems; moreover, that they regarded international security questions as essential components of their European policies at that time.[91]

Eberhard and Matre were apparently as enthusiastic about the collaboration as their respective political leaders, with the French arms procurement bureau seeing an opportunity to procure a modern MBT at a fraction of the price of a national tank design. France's existing tank fleet consisted of about 1,200 AMX-30s, designed in the early 1960s and thus in dire need of modernisation. The German side, however, were more interested in the political rather than the financial advantages of a collaboration.[92] At the time of the programme, the FRG was in the process of introducing the Leopard 2 and saw the proposed Franco-German tank simply as an opportunity for further development of this already existing design. Consequently, Hans-Ludwig Eberhard, the Armaments Director at the German Ministry of Defence, announced that he foresaw no great problems in running the potential 'Tank 90' alongside the Leopard 2 within the *Bundeswehr*.[93]

The German concept for armoured warfare for the 1980s had been developed during the 1970s by Ferdinand Maria von Senger und Etterlin, the son of the Second World War tank general, Frido von Senger und Etterlin. He envisaged two 'families' of vehicles, one heavy and one light. The heavy family would be based around a relatively heavy MBT, with a higher calibre gun than the Leopard (which carried a 105mm gun), and with an engine with a higher performance which would provide much greater speed and agility in open terrain. A

Biography of Valéry Giscard d'Estaing, accessed online via <https://www.cvce.eu/content/publication/2008/8/21/f18cad10-b8b5-47a2-8d1b-e706c80facd4/publishable_en.pdf>, accessed 17 February 2019, p. 2.

[90] Moravcsik, 'Armaments among Allies', p. 145.

[91] See here the comments and account in Helmut Schmidt, *Die Deutschen und ihre Nachbarn. Menschen und Mächte II* (Berlin, 1990), pp. 173-335, esp. 185-215.

[92] Kocs, *Autonomy or Power?* pp. 159-160.

[93] Moravcsik, 'Armaments among Allies', pp. 145-146.

further tank to 'accompany' the heavy tank was envisaged, which would also function as a Flak-Tank. The chassis for this lighter vehicle would be the basis for an APC, a transport vehicle and a reconnaissance vehicle, as well as communications, command and medical AFVs. It was noted in early 1973 that five arms companies in the Federal Republic had been commissioned to present suggestions for production ready tanks and their associated vehicles.[94]

The French, however, wanted a completely new tank and were aware that accepting a simple upgrade of Leopard 2 meant limited involvement from French developers and industry. The French delegation pushed for a completely new design, but the defence ministries of the two countries could not agree on a unified operational concept for a completely new tank. The impasse was only broken when, in 1979, Schmidt and Giscard d'Estaing ordered their respective delegations that an agreement *would* be reached. After this political intervention at the highest level, on 31 January 1979, a statement of intent to reach common agreement on the new tank was released by the two nations' national armaments directors. Later still, and further underlining the political importance of the project to the leaders of the two countries, at the Franco-German summit in February 1980, Schmidt and Giscard d'Estaing agreed to promote the Franco-German 'Tank 90' collaboration as a symbol of bilateral unity.[95]

2.5. Tank 90: Problems in Collaboration

Despite the political intervention and optimism, problems within the programme remained. One issue was that of export rights for the final tank. The FRG policy on arms exports was restrictive and tightly controlled by the Federal government, whereas France was prepared to

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[94] IfZ, Nachlaß General der Panzertruppe Gerhard Graf von Schwerin, ED 337/32, Schwerin to *Oberdirektor*August Schiele (Keller und Knappich, Augsburg), 10 February 1973.
[95]Moravcsik, 'Armaments among Allies', pp. 145-146.

export far more widely. Although there was no state ownership within the German arms industry, any export licenses required state agreement. Article 26 of the Federal German *Grundgesetz*, roughly translated as 'Basic Law', states that, '[w]eapons designed for warfare may be manufactured, transported or marketed only with the permission of the Federal Government'. The German government was, and still is, sensitive to lending support to military regimes deemed to be oppressive, or whose behaviour can be seen as contrary to democratic principles; thus it had long restricted its authorised arms exports to only a limited group of countries.[96] Germany saw France's potential export of a new tank to countries in Africa and the Middle East as likely to conflict with its own laws, and a collaborative tank project thus created potential legal problems given the principle espoused in Article 26.

A case in point was the problem caused by the Italian company OTO Melara, which had been allowed to continue licensed production of the Leopard 1 after the Bundeswehr had received a completed set of orders. In the early 1970s, complications in both diplomatic relations between the government and arms companies were caused when the Italian arms firm began negotiations with Kuwait and the United Emirates over the export of licence-built Leopard tanks from Italy. The first problem which emerged was that it was discovered in mid-1975 that Krauss-Maffei, who were in charge of the licence, had not been informed of this step. The board of Krauss-Maffei was taken aback when they discovered the Italian export moves. This led to the former Panzer-General Gerhard Graf von Schwerin to enquire in Bonn on behalf of the German arms company whether the Federal Government was willing to permit this.[97] The incident had already been preceded by increasing tensions in 1973 over the question of tank exports to Kuwait, given the Kuwaiti need to 'modernise the

[96] Hendrik Platte and Dirk Leuffen, 'German Arms Exports: Between Normative Aspirations and Political Reality', *German Politics*, 25:4 (2016), pp. 561-562.
[97] IfZ, ED337/32, Schwerin to Joachim Löser, 6 September 1975. For a recent biography of Schwerin, see Peter M. Quadflieg, *Gerhard Graf von Schwerin. Wehrmachtgeneral, Kanzlerberater, Lobbyist* (Paderborn, 2015).

Chieftain'.[98] Schwerin, who was still active in the 1970s as a representative of German arms manufacturers, did not himself think that the Federal Government was pursuing the correct policy, believing in 1973 that Iran, Kuwait and Saudi Arabia should be supported, not least of all due to the Western dependency upon oil deliveries from the Gulf.[99] Despite official approaches both from the Italian defence and foreign ministries to Bonn in 1974,[100] the attempt to export the Leopard to the Middle East through an Italian company failed due to the Germans' desire not to compromise Art. 26 of the Basic Law.

French diplomats acknowledged that France would export the new tank to a wider market than domestic political restriction currently gave the Federal Republic access to, but attempted to demonstrate that the intended French exports would still be of benefit to German industry and the German economy thanks to the increased overall production figures. The proposed solution was that France would inform the FRG before agreeing to any new export sales, while the FRG would have the right to 'make observations upon those intentions if she felt her interests to be affected'. This was not, it was made clear, a veto authority, but was intended to enable the problem to be addressed at the Presidential/Chancellor level should it become necessary.[101]

France's suggestion was that each country be allowed to export the tank according to its own laws, a solution that had been invoked in previous arms collaborations. However, unlike other arms developments, tank exports were seen as something of a special case. German political opinion saw tanks as politically symbolic as well as simply examples of advanced military technology. It was only at the 1980 Franco-German summit that Helmut Schmidt and Giscard finally came to an agreement. Schmidt agreed with the proposed French

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[98] IfZ, ED337/32, Schwerin to H.W. Rubin, 12 September 1973.
[99] IfZ, ED337/32, Schwerin to Rubin, 12 November 1973.
[100] IfZ, ED337/32, Schwerin to Rubin, 23 May 1974 and 12 June 1974.
[101] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation. Memo from British Embassy, Paris, to C(A&DS), 'Franco-German Tank', 26 March 1981.

special provision ensuring that bilateral discussion would take place before any export agreements were signed.[102] This provision was signed by the respective defence ministers even though the new German Defence Minister, Hans Apel, who had replaced Leber in February 1978, had opposed the whole project and only signed after being directly ordered to by Schmidt.[103]

Weight was also a bone of contention. The French still favoured a lighter tank (less than 50 tons) with consequent higher mobility, just as they had with the earlier European Standard Tank project. The Germans had, by this stage, acknowledged the importance of heavier armour and were looking for a tank weighing up to 60 tons, albeit one driven by a sufficiently powerful and robust engine and transmission to maintain good mobility. France's continued policy of insisting upon a tank no heavier than 50 tons was mainly due to a long-held armoured doctrine which emphasised tactical mobility over direct protection. But Moravcsik suggests that it might also have been influenced by potential exports to markets in developing countries where mobility was of even greater importance than on the flat European plains of the NATO-Warsaw Pact border, countries where road communications and infrastructure were poor, where even light armour could be decisive and where potential opponents were less likely to have modern anti-tank weapons.[104]

Having solved, or rather bypassed, the problem of both exports and differing military specifications by means of political diktat, the next round of disputes was industrial. For the main German contractor, Krauss-Maffei, future export sales of the Tank 90 held a couple of major commercial problems. Sales within NATO would be split with the French contractor, offering a less attractive prospect than in the case of the existing Leopard 2 sales which

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[102] Kocs, *Autonomy or Power?* pp. 161-162.
[103] Moravcsik, 'Armaments among Allies', p. 146. As mentioned previously, Georg Leber had been forced to resign from his post as Defence Minister after an espionage scandal involving FRG Defence Ministry personnel passing NATO secrets to East Germany. See 'Georg Leber in Bedrängnis', *Der Spiegel*, and 'Spionage: Wohl sehr nachlässig', *Der Spiegel.*
[104] Moravcsik, 'Armaments among Allies', p. 147. Moravcsik uses the term 'Third World countries', the then-standard description of countries now referred to as 'developing countries'.

would exclusively benefit the German firm. Secondly, with France having a more *laissez-faire* export policy, Kraus-Maffei was concerned that subsidised sales to non-NATO countries would provide the French with, what appeared to be to the Germans, a potentially unfair sales advantage. Should the French subsidise exports of the new tank to countries currently buying Leopard 2, it would still further erode Germany's export market.[105]

The threat of the new tank competing with Leopard 2 was exacerbated when Belgium declared that it was considering replacing its own Leopard tanks with the new Franco-German design. Belgium had traditionally looked to France to supply its military hardware and the possibility that they would be interested in a new Franco-German tank would have been unsurprising, if unwelcome, news for Krauss-Maffei. The French decision to enter a collaborative development with Germany had been at least as motivated by the export potential as it had for its domestic defence needs. An internal French memorandum made this clear when it concluded that a jointly produced tank would offer better export opportunities than a development of the existing French AMX-30. As a further example of the importance of potential exports to France, the French insisted that no US components be utilised. This was due to a desire to avoid US export control restrictions which would have limited any French export possibilities for the new tank.[106]

The agreement also attracted little popular support within Germany. In addition to Apel's dissention, the collaboration was not supported by the *Bundestag* Defence Committee which roundly condemned the Government's failure to consult them beforehand, insisting that they should be consulted before any substantive agreement was agreed. Communication problems were not limited to the *Bundestag* for, while German officials saw the agreement only as a study into possible collaboration, the French government portrayed it as a firm commitment to develop and build the new tank. The technical and military philosophy

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[105] Moravcsik, 'Armaments among Allies', p. 146.
[106] Ibid.

disagreements between the two sides remained substantial and German industrialists were openly sceptical about the possibility of a successful collaboration. A UK Foreign and Commonwealth Office (FCO) memo dryly noted that, 'The political desire for Franco/German tank collaboration is very high but it may still be defeated by the facts of the situation and the very real differences which exist between the two countries at the working level.'[107]

Both French and German industry experts were worried that the collaboration might turn into an unequal partnership, with France worried that they would have little to contribute and German suspicious that the French were simply gaining access to superior German technology in areas such as diesel engines, chassis development and armament. As part of a collaborative project, the French believed that they should take responsibility for major components, such as the electronics. Krauss-Maffei objected to this as they believed that German engineers had demonstrated superiority in these areas and that the Federal Republic should therefore hold responsibility in that field.[108]

The Germans had established a definite superiority over the French tank industry in the development of the Leopard 2, and the French were concerned that this would lead to a German-led programme rather than to a fully equal partnership. French industry had lobbied their government to ensure that the new tank would be a truly cooperative design rather than simply a further development of the Leopard 2. But Giscard d'Estaing had, nonetheless, agreed to a design that effectively mounted a new turret on the existing Leopard 2 chassis. The French press reported how French industry was attempting to secure more responsibility

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[107] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Procurement Executive Internal Memo, First Secretary (Defence Supply) to AUS (Ordnance), 'Franco-German MBT', 11 February 1981.
[108] Moravcsik, 'Armaments among Allies', p. 148.

within the project, but there was widespread scepticism within German over France's ability to equal their own technical contributions.[109]

Certainly, the UK Foreign and Commonwealth Office (FCO) supposition was that the next German tank would be an updated Leopard 2; and, this view was apparently shared by some German politicians in Bonn. Any potential French involvement was noted as likely to be 'marginal'. It was an open secret that the collaboration was not popular in Germany, apart from with the Chancellor, Helmut Schmidt, and that the Germans were 'paying a heavy technical and financial price for the dubious political benefit of French partnership.'[110]

A report in *Le Monde* of 23 January 1981 mentioned that that the French trade union confederation, *Confédération générale du travail* (CGT), had written to President Valery Giscard d'Estaing protesting about the inequality of the proposed joint tank project. The CGT complained that French industry's share of the project would be no more than 20%, with the prime contractors being German and the whole project regulated by German law. The CGT stated that an unequal agreement 'would endanger not only national independence, but also employment and the status of the some 130,000 civilian [workers in] arsenals and military establishments.' They also protested at efforts to recruit French workers to work in Germany on the project, comparing it to the forced labour of the Second World War.[111]

Ministries of Defence in both the Federal Republic and France continued the project despite the concerns from both German and French industry over the division of responsibility. An agreement was signed in February 1981 which sought to address the problems of different weight requirements, and of French concerns over German domination

[109] Moravcsik, 'Armaments among Allies', p. 147.
[110] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Foreign and Commonwealth Office memo, 28 January 1981.
[111] 'La C.G.T. Dénonce De Nouveau Le Projet De Char Franco-Allemand', *Le Monde*, <http://www.lemonde.fr/archives/article/1981/01/23/la-c-g-t-denonce-de-nouveau-le-projet-de-char-franco-allemand_2717122_1819218.html>, accessed 17 May 2018. See also TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Memo from British Embassy, Paris, 30 January 1981.

of the tank's hull and chassis development. The February agreement foresaw development of two different tank hulls, one heavy and one lighter in accordance with the international disagreements over the final tank's maximum weight. The collaborative project would then develop a single turret which would be fitted to both hulls. However, even this substantial compromise encountered difficulties, with concern being expressed over which of the two proposed hulls the new turret would be optimised for.[112]

By March 1981, the general position of the talks between the two sides had reached some agreements, but major hurdles to the project still remained. The French and Germans had reached agreement on the hardware development programme for a lower profile turret than was fitted to the contemporary Leopard 2, the new turret housing the German 120mm smoothbore with the possibility of also being able to accept the French 120mm. An automatic loader system and digital fire control would be fitted, with the Germans eager to include the Italians, and specifically the firm OTO Melara who, it was noted, had considerable expertise in autoloaders. The French were still undecided about this proposed Italian involvement. The French were also in disagreement with Germany over what the new tank would actually comprise, with France still wanting to develop an entirely new vehicle, while the German delegation only wanted an upgrade based on the Leopard 2. The issue of armour thickness was another hurdle and one that harkened back to the abortive 1957 Franco-German tank project, with the Germans wanting a more comprehensive armour distribution and, consequently, a heavier vehicle than the French were prepared to accept.[113]

Despite all the issues over industrial inequality, doctrinal differences, export problems, and German governmental opposition, in March 1981 the German embassy officials in Paris informed their counterparts in the British Embassy, Paris, that there was 'no

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[112] Moravcsik, 'Armaments among Allies', p. 148.
[113] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Memo from British Embassy, Bonn, to British Embassy, Paris, 'Franco-German MBT', 20 March 1981.

question of the Franco-German tank project being cancelled'. The plan was reportedly to have a Memorandum of Understanding (MOU) to cover the second phase signed, but the signing itself was to be delayed until after the French Presidential Elections, set for 10 May 1981. The expectation was that the second phase would last about two years and that it would be followed by a development phase, which would involve the building of prototypes. The in-service date (ISD) for the new tank was set for 1992, with the first deliveries going to the French Army who had the more pressing requirement. At this point, the German embassy officials believed that the collaboration only involved the turret but understood that the question of whether improvements to the chassis would be addressed once the turret design and production decisions were complete.[114]

After having withdrawn from the original tripartite agreement in 1977, the UK Department of Defence saw an opportunity in the Tank 90 project's development, wondering if the question of potential development of the tank hull might allow the UK to become involved in the collaboration again, even at this late stage. This would have been a useful exercise because the proposed MBT-80 project had been cancelled and the Challenger and Chieftain improvement programmes had recently been severely downgraded, leaving a potential operational gap with regards to the technological effectiveness of British tanks post-2000.[115] The UK's Chief of Defence Procurement noted in April 1981 that the Franco-German tank project was facing 'major problems', and pointed out that, whilst the UK should not be seen to in any way be responsible for furthering the collapse of the project, there was

[114] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Memo from British Embassy, Paris, to C(A&DS), 'Franco-German Tank', 26 March 1981.
[115] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Memo from Defence Department to AUS(IP), MoD, 'Franco-German Tank Project', 5 May 1981.

nonetheless an opportunity to join the collaboration. Germany, he reported, had already invited the UK to see some of the work they had done on the project.[116]

Restricted military budgets had thrown serious doubts on the wisdom of the Federal Republic funding a new tank project so soon after Leopard 2. On 7 March 1981, the FRG announced budget cuts which prompted President Giscard d'Estaing to seek assurance from Chancellor Schmidt that the decision taken in February 1980 to proceed with the project was still valid. A UK Embassy telegram rather cynically noted that, 'At least he needs the semblance of an assurance which will tide him over publicly until after the Presidential elections.'[117] Throughout 1981 and into 1982, three of the four major parties in the Bundestag, the CDU (and their Bavarian sister party, the CSU), SPD and FDP,[118] spoke out against the collaboration. While the military favoured allowing enough time to make a substantially better tank than the Leopard 2, the SPD and FDP objected because they saw French involvement as potentially violating the strict German arms export policy.[119]

Despite opposition from elements on the French political extreme left and nationalist right who both favoured a sovereign design, with the left also wanting the vehicles built in state-owned factories, the French continued broadly to favour a collaboration which would see a tank ready to enter service in 1991. The ISD was of more importance to France than to

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[116] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Memo from Chief of Defence Procurement to Secretary of State for Defence, 'Equipment Collaboration', 10 April 1981.

[117] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, Telegram No. 204 to FCO, 'France/Germany: Meeting between President Giscard and Chancellor Schmidt, Joint Tank Project', 17 March 1981.

[118] The three main political parties in Germany at the time were: the Christian Democratic Union (Christlich-Demokratische Union, or CDU), allied with their Bavarian allies, the Christlich-Soziale Union (Christian Social Union, or CSU), the Social Democratic Party of Germany (SozialdemokratischeParteiDeutschlands, or SPD), and the FreieDemokratischePartei (Free Democratic Party, or FDP), which often played a part in minority German governments. See, for example: Encyclopaedia Britannica. 'Germany: Political Parties', <https://www.britannica.com/place/Germany/Political-parties>, accessed 16 April 2018; Josef Schmid, 'Parteiensystem', in Uwe Andersen and WichardWoyke (eds.), *Handwörterbuch des politischen Systems Deutschland* (Bonn, 4th edn, 2000) pp. 451-455.

[119] Moravcsik, 'Armaments among Allies', p. 149. With the exception of some of the leading figures on the right of the party, the SPD was (up until the emergence of the Green Party) the most clearly anti-militaristic party after 1945 in German politics. This stance had evolved during the rearmament debate (1949-60). On this, see Gordon D. Drummond, *The German Social Democrats in Opposition, 1949-1960: The Case against Rearmament* (Norman, Okla., 1982).

the Federal Republic, which already had the Leopard 2 in service. By November 1981, Germany questioned France's preferred ISD of 1991. France still insisted that the tank should be an entirely new design rather than an improved Leopard 2, but Germany already had a perfectly adequate tank in the Leopard 2 and had little need to replace it so soon. The Federal Republic instead favoured an ISD of 1995 or 1996, allowing sufficient future leading-edge technical improvements to be incorporated into the new design to make changing from Leopard 2 worthwhile. French elections had seen President Giscard d'Estaing replaced by François Mitterrand, the French Fifth Republic's first socialist president, on 10 May 1981. With German enthusiasm for Tank 90 seemingly waning, Mitterrand began to push Helmut Schmidt for a concrete decision on the collaboration.[120]

2.6. Tank 90: The Collaboration Ends

Mitterrand was something of a political opportunist, moving his political stance according to the mood of the time. Previously a libertarian centrist in the French Fourth Republic, the arrival of the Fifth Republic in 1958 had seen French politics become more polarised and Mitterrand had moved to a more left-wing position. One aspect of his political career that remained a constant was his antagonism towards Charles de Gaulle, with whom he had feuded since the days of the German occupation. Yet when Mitterrand became President of a Socialist coalition-governed France on 10 May 1981, in a move that bore similarities to de Gaulle's policy of 1958 which helped put an end to the Standard Panzer project, Mitterand moved France away from European and US influences and instead looked internally,

[120] Moravcsik, 'Armaments among Allies', p. 148.

increasing the public sector and nationalising French industry to tackle unemployment and inflation.[121]

German Chancellor Helmut Schmidt had faced ongoing opposition for the collaboration, not just from the parliamentary opposition but also from within his own Social Democratic Party.[122] Upon his replacement as Chancellor by Helmut Kohl on 1 October 1982, both the main German and French advocates for the collaboration had departed the political stage, so the project was effectively dead. On 30 November 1982, the French Prime Minister, Pierre Mauroy, announced that France was to pursue a sovereign design, named the 'Leclerc'. The French Ministry of Defence was thrown into some disarray, announcing that it would look to modernise the AMX-30 as a temporary measure while it continued to seek a collaboration with a suitable European partner. The French President, Mitterrand, approached Helmut Kohl in an attempt to resurrect the collaborative project, but the negotiations came to nothing and any last-minute plans for the project were finally abandoned in 1983.[123]

The Leclerc tank was not considered a success by many in the French military, General Philippe Arnold, a former Commander of France's 1st Armoured Division and Commander of the Saumur School of Cavalry, was suspended from duty after criticising the government's procurement decisions which had, in his opinion, led to France's armoured forces being inferior to that of its NATO peers. At its launch in 1987, the GIAT prototype for

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[121] John Truppen, *France under Recession: 1981-86* (Basingstoke, 1988), pp. 18, 21; 'Francois Mitterand Dies at 79: Champion of a United Europe', *New York Times*, 9 January 1996, <https://www.nytimes.com/1996/01/09/world/francois-mitterrand-dies-at-79-champion-of-a-unified-europe.html>, accessed 17 February 2019; 'François Mitterrand: France's first socialist president who championed the people - and acted like a king', *The Connexion*, 1 Feb 2016, <https://www.connexionfrance.com/People/Profiles/Francois-Mitterrand-France-s-first-socialist-president-who-championed-the-people-and-acted-like-a-king>, accessed 17 February 2019; George Ross, 'François Mitterrand', in Wilsford (ed.), *Political Leaders of Contemporary Western Europe*, pp. 325-327.

[122] Helmut Schmidt had effectively established himself by the early 1960s as the leading defence intellectual and spokesperson of his party. Arguably, it was this reputation which had allowed him to carry the project forward politically for so long. In the hands of a politician with less political weight, it may have faltered sooner. For some of his thoughts on NATO and defence policy: Helmut Schmidt, *Defence or Retaliation: A German Contribution to the Consideration of NATO's Strategic Problem* (Edinburgh & London, 1962); idem, *Beiträge*(Stuttgart, 1967), pp. 379-528; idem, *A Grand Strategy for the West: The Anachronism of National Strategies in an Interdependent World* (New Haven, Conn., 1985).

[123]Moravcsik, 'Armaments among Allies', p. 149.

the Leclerc was widely considered inferior to either the contemporary version of the Leopard 2, or the US M1 Abrams, despite those tanks entering service years prior to the Leclerc's own 1991 production schedule.[124]

This perceived inferiority of the Leclerc was highlighted when the Saudi government announced that it was looking to purchase modern tanks to upgrade its army and asked for prospective sellers. The Saudi army was at that time using the AMX-30, so the French were optimistic of the Leclerc receiving serious consideration. In the event, however, the Leclerc did not even make the shortlist of candidates. With German export restrictions ruling out the Leopard 2 from the competition, the two final candidates were the US M1 Abrams and the Brazilian Osorio, with the final decision going the way of the M1 Abrams. While geopolitics played a part in the final decision (the order from the Saudis was placed on the eve of the 1990 Iraqi invasion of Kuwait), for their newest tank not to make the shortlist of a country already using French tanks must have been demoralising, and even more so to lose out to the Osorio, the first domestic tank design from Brazil.[125]

2.7. Project Evaluation and Analysis

As we are evaluating two projects simultaneously, we will use Fortune and White's project analysis framework,[126] with the two projects side by side to enable easier comparisons between the critical success factors evident in each case:

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[124] Moravcsik, 'Armaments among Allies', p. 149.The M1 Abrams entered service with the US Army in the early 1980s, and the Leopard 2A4 variant in 1985. Steve Zaloga and Peter Sarson, *M1 Abrams Main Battle Tank 1982-1992* (London, 1993), p. 8; and, Jerchel and Schnellbacher, *Leopard 2 Main Battle Tank*, pp. 18-19.
[125] Moravcsik, 'Armaments among Allies', p. 150. The light and cheap Engesa EE-T1 Osorio was developed in Brazil specifically to meet the needs of its home country and to appeal to the export market. Unfortunately, no orders were placed and Engesa went bankrupt. See: Foss, *Jane's Main Battle Tanks* (1986), pp. 6-7; and, Richard Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 219.
[126] Joyce Fortune and Diana White, 'Framing of Project Critical Success Factors by a Systems Model', *International Journal of Project Management*, 24 (2006), p. 57.

Component of Formal System Model	***Evidence of Critical Success Factors in 'NATO Standard Tank' (1957-1963)***	***Evidence of Critical Success Factors in 'Tank 90' (1977-1983)***
Goals and objectives.	• Political ambition on the wider European stage appears to have been the primary motivation for the project. • Both countries sought a similar tank design. • Neither country had an unbalancing lead in tank development.	• Both nations sought collaboration for political and financial reasons. • Germany was looking to upgrade Leopard 2, whereas France wanted a wholly new tank design.
Performance monitoring.	• Each country kept the other informed as to their progress, and initial difficulties appear to have been negotiation.	• The negotiations between French and German design teams did not translate into agreement on a final design.
Decision-maker(s).	• Political events in each country led to a reduction in political support of the project.	• Political events in each country led to a reduction in political support of the project.
Transformations.	• Minor differences in design goals were resolved. • German lacked recent tank-building experience, and France had not designed a successful modern MBT since 1940.	• Aside from the issue of weight, little agreement seems to have been reached in design differences. • Established German superiority in tank design was a bone of contention for both nations.
Communication.	• Documents covering the project suggest that communication between the two countries was good.	• Throughout the project, French and German priorities appear to have been different and not effectively communicated.
Environment.	• The political situation in both countries became unstable during the project lifetime, and in each case led to a change of government.	• Despite working within established political and military alliance frameworks, agreement could not be reached on the design. • The historical dangers of relying heavily on political patronage to the exclusion of other factors were not realised.
Boundaries.	• Nothing about the project design was revolutionary or overly complex.	• Although France wanted a new design, Germany was only looking to upgrade their existing Leopard 2. • Significant greater German experience and technical expertise caused imbalance within the collaboration.

Resources.	• There is no evidence to suggest that the project was under-funded or suffered through lack of resources. • Starting from a position of relative inexperience in tank design, the German team made it a priority to learn from foreign designs.	• Collaboration was initially suggested as a means to conserve and maximise resources. • Imbalance between the capabilities of the two nations caused friction.
Continuity.	• Differences of opinion between the two project teams were generally minor. • Problems of differing specifications were only raised once political support had been much reduced, suggesting that the differences were being used as a convenient excuse to cancel the project.	• Each country appeared to be unaware that the national expectations of the projects differed between the two countries. • Germany was reluctant to invest in a completely new design after so recently establishing the Leopard 2. • Germany saw French foreign policy as giving them an unfair export advantage.

Even though both projects were separate, there are striking similarities between the two. Political motivation to be seen as dedicated to a European community drove both projects; in each case, a change of internal political leadership spelled the end of political support and the end of the project. In addition, the relative technical expertise and experience of the nations involved caused friction in both cases. For the 1957 project it was the French who had the most recent experience and thus expected to have the greater share of the project, in 1977 the positions were reversed and the FRG considered that they had the more advanced MBT design experience.

Unlike with the 1957 project, the 1977 collaboration had little communication of expectations between the two countries, and no firm agreement on sharing of responsibilities. Going into the collaboration, the FRG was looking for a possible upgrade to their Leopard 2, which contrasts markedly with the French understanding that the programme would result in an entirely new tank design. In addition, French export regulations were also a good deal more liberal than those of the FRG, which suggested an imbalance for future export deals.

2.8. Summary

It should be noted that the MBT projects were only two of a number of collaborative defence programmes being investigated at the time, with France and Germany seeking some measure of independence from reliance on US weapons.[127] Taken together, the two cases of the 'Standard Tank'and 'Tank 90' demonstrate just how important continued political support is to any international collaboration.[128] Although both nations were primarily seeking to improve the international standing of their respective countries in 1957, Chancellor Konrad Adenauer and President René Coty had slightly different reasons for seeking collaboration. By collaborating with France, Adenauer sought to re-establish German political influence and military power within Europe and NATO, and France sought to distance itself from US influence by collaborating with another European nation. Both programmes faced problems of industrial and minor doctrinal disagreements over the relative values of weight, firepower and protection, but it was primarily within the political arena that the projects failed.

With hindsight, the 1957 'Standard Tank' programme seemed to offer a good chance for success. France and the Federal Republic shared a doctrine of manoeuvre over direct protection, and were both seeking a conventional layout, mounting a 90-105mm gun. There was enough agreement that a formal study contract was drawn up and agreed.[129] Yet, ironically, the very political motivation that began the project was its undoing. Coty and

[127] Kocs, *Autonomy or Power?* pp. 19-20.
[128] Frinsdorf, et al., suggest that strong management support is a vital ingredient of any successful collaborative project, which can be translated into support from political leaders when talking of international projects. See on this, Olivia Frinsdorf, Jian Zuo and Bo Xia, 'Critical Factors for Project Efficiency in a Defence Environment', *International Journal of Project Management*, 32 (2014), p. 813.
[129] BA-MA, BW1/452528, Deutsch-französisches Abkommen über die Entwicklung eines Standardpanzers (Vertrag-Nr. 899/57), 1957-1958; TI3 – Commande No 899/57 – Indicateur No 2355/58, Contratd'Etude.

Adenauer and their respective Defence Ministers, Bourgés-Maunory and Strauß, strongly backed the collaboration and invested much political capital in pushing the programme forward. Identifying themselves so strongly with the collaboration, however, meant that the projects became hostage to their patrons' political fortunes.

The 1957 project certainly had minor conceptual differences of opinion between France and the FRG, notably in disagreements over the thickness of the armour and weight, but the general concept was so similar between prototypes that it is hard to believe that a compromise would not have been found. However, the troubled French Fourth Republic collapsed and was replaced by de Gaulle's Fifth Republic in 1958. De Gaulle exploited an ambiguity in the Fifth Republic's constitution to dominate foreign policy, and soon made it clear that he was uninterested in international collaborations.[130] When Strauß and Adenauer lost their respective positions as a result of the '*Spiegel* Affair' and other unwise political activities,[131] nobody was left in either French or German politics to promote the 'Standard Tank' collaboration and it subsequently collapsed. But as a result of the much larger political issues at the time, the Standard Tank issue disappeared very quickly from view.[132]

The 1977 'Tank 90' or 'Napoleon' collaboration faced far more obstacles than its 1957 predecessor. Objections from both French and German industry, political opposition and military sources left the project with support only from the German Chancellor, Helmut Schmidt, and French President, Giscard d'Estaing, backed by their Defence Ministers, Leber and Bourges. Once again, changes of political leadership spelled the end for the programme as both Schmidt and Giscard d'Estaing were replaced by leaders less interested in pursuing an

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[130] Clift, 'The Fifth Republic at Fifty', p. 385.
[131] '50th Anniversary of the "Spiegel Affair": A Watershed Moment for West German Democracy', *Der Spiegel*, 21 September 2012. Strauß made only one or two remarks about the Affair in his memoirs. Franz Josef Strauß, *Die Erinnerungen* (Berlin, 1989), pp. 376-379.
[132] Strauß does not mention the Standard Panzer in his memoirs, although he does refer to a controversy surrounding the procurement of the *Schützenpanzer HS 30.* At the time, and much later, atomic questions, the broader political canvas, and clashes with generals appeared to be more important to him. See Strauß, *Die Erinnerungen*, esp. pp. 268-334.

international collaboration. It is revealing that the official German Defence White Papers, in German, the *Weissbuch*, only referred to the collaborative *Kampfpanzer 70* (US-German MBT-70) in the 1969 edition, whereas in later editions there was no mention of collaborative tanks projects, beyond general remarks about the importance of international arms collaboration.[133]

Although it might be somewhat simplistic to blame the withdrawal of political support for the collapse of the two Franco-German MBT collaborations, particularly the 1977 'Tank 90' project, it is nonetheless evident that the end of both programmes coincided with the replacement of their primary political supporters. This suggests that collaborative projects within democratic countries must not rely solely on their political patrons but should be supported by the industry and the military of both nations. 'Tank 90' saw German military indifference, French military misgivings, and suspicion and outright hostility from the industry of both countries. Without political support there was nothing to drive the 1977 collaboration. The 1957 collaboration had greater military and industrial support, but it was, once again, politics that instigated, drove and finally finished off the 'Standard Tank'.

This all may provide an indication as to why NATO nations have not managed to collaborate successfully on an MBT. There are, of course, other, quite obvious reasons. As an official NATO publication pointed out in 1971: 'Nato, since it is not a supranational organization, does not possess mandatory powers over national governments. The responsibility for equipping and maintaining forces remains therefore a national one.'[134] Nonetheless, since its inception, NATO had at least declared economic cooperation an ideal which was to be pursued in the future, even if this was not necessarily primarily directed

[133] *Der Bundesminister der Verteidigung, Weissbuch 1969: Zur Verteidigungspolitik der Bundesregierung* (Bonn, 1969), p. 61. Later editions make no such mention, such as *Weissbuch* 1975/1976. *Zur Sicherheit der Bundesrepublik Deutschland und zur Entwicklung der Bundeswehr* (Bonn, 1976), pp. 121-131, for the section on armaments.
[134] *NATO Facts and Figures* (Brussels, 1971), p. 123.

towards collaborative arms projects. Beyond the more idealistic notions of economic growth, there was at least an awareness of the need for a more efficient use of armaments and logistics within the Atlantic Alliance. A string of committees and boards bear testament to this. The Military Production and Supply Board was set up in November 1949, followed by the Defence Production Board, then, in 1952, the Production and Logistics Committee, which changed its name to the Production, Logistics and Infrastructure Division in October 1960, becoming the Defence Support Division on 1 September 1967. It was fully acknowledged that the best early successes in standardisation were to be found in fighter aircraft production and ammunition.[135]

In essence, the countries that comprise the NATO alliance are a collection of (mostly) democratic governments with disparate military doctrines[136] and independent long-established national industrial bases, with their own standards and commercial interests. Only a strong and stable political leadership could push through an international collaboration under such circumstances, yet politicians and parties come and go within democratic national governments. True international collaborations must overcome all these obstacles to be successful, and so far, main battle tank projects have eluded such success.

[135] *NATO Facts and Figures,* pp. 123-147.
[136] The early Cold War armoured doctrine of France and Germany primarily emphasised manoeuvre and counter-attacks, whereas that of the UK and (to a lesser extent) the USA relied on long-range fire from successive defensive positions. This disparity in thinking as to how tanks would be used naturally led to a corresponding disparity in design philosophy. See, for example: Richard Simpkin, *Tank Warfare* (London, 1979), pp. 66-67; John Stone, *The Tank Debate* (London, 2000), pp. 42-43, 47,-48, 75, 83; and, Führungsstab des Heeres, *H.Dv. 100/100. FührungimGefecht* (Bonn, 28 September 1973), Ch. 27, para. 2719.

CHAPTER 3

'How Not to Design a Tank': The US-German MBT-70 (1963-1970)

Referring to the MBT-70, a contributor to a military journal asked in 1966 whether it was 'in fact possible for two world powers, any two, to arrive at agreement on a concept which will fully meet the requirements of both?'[1] His consternation was not surprising since, as an example of how not to approach an international collaboration on main battle tank (MBT) design and development, it would be hard to find a better example than the US/FRG MBT-70, also known as Kpz-70, XM-70 and the 'US/FRG Tank for the 1970s'.[2] The USA and FRG committed themselves to designing and building a tank that would be at least a generation ahead of anything in service when it was produced yet, from the start, the militaries of both sides saw little benefit in collaboration. Problems of unhelpful political interference, poor project management, two different languages, different national industrial cultures, incompatible military doctrines, and over-ambition, all conspired to make the MBT-70/Kpz-70 project's failure almost inevitable.

NATO had admitted the Federal Republic of Germany (FRG) in 1955, at least partly as an additional bulwark against the growing power of the Soviet Union.[3] With the

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[1] Nathan N. Shiovitz, 'The MBT-70: How Does the US Benefit?', *Armor*, 75 (May/June 1966,) pp. 38-39. The year was particularly significant in terms of collaboration as it was in 1966 that France chose to effectively withdraw from NATO. See: Frédéric Bozo, *French Foreign Policy Since 1945* (Paris, 2012), pp. 69-71.

[2] TMARL, E2014.3184, copy of article, Richard M. Ogorkiewicz, 'The MBT-70 or How Not to Design a Modern Weapon', *Machine Design*, 42 (1970).

[3] See, for example: William Park, *Defending the West: A History of NATO* (Brighton, 1986), pp. 3-20; Robert McGeehan, *The German Rearmament Question: American Diplomacy and European Defense after World War II* (Urbana, 1971); Saki Dockrill, *Britain's Policy for West German Rearmament 1950-1955* (Cambridge, 1991); NATO, *The North Atlantic Treaty Organisation: Facts and Figures* (Brussels, 11th edn, 1989), pp. 3-47; and, Catherine M. Keller, 'Fundamentals of German Security', in Stephen F. Szabo (ed.), *The Bundeswehr and Western Security* (New York, 1990), pp. 16-17.

requirement to build new, democratic forces, almost from scratch, Germany immediately looked to her new NATO partners for expertise in rebuilding the FRG's new tank forces, turning firstly to France in 1957 and the ill-fated 'European Standard Tank' programme.[4] With that project's collapse, the Federal Republic began development of her own tank, the Leopard (later re-designated Leopard 1 with the arrival of Leopard 2), with the first prototype phase running from 1957-1961 (as part of the 'Standard Tank' collaboration), followed by a second prototype phase, which ran seamlessly from the first phase, 1960-1963, with pre-series phase running from 1962-1964.[5] But the Leopard 1 was not as yet in production when Robert McNamara, the US Secretary of Defense, persuaded the German Defence Minister to collaborate on an entirely new tank design that would represent the very limits of current AFV technology. This project would be the US/FRG tank of the 70s, or MBT-70/Kpz-70.

The other case studies in this thesis are not dealt with other than a cursory fashion in the secondary literature, whereas the MBT-70 stands out as the one project which has attracted minor but nonetheless identifiable attention, enough indeed that in 1968 Richard Ogorkiewicz considered that 'No tank has attracted as much attention recently as the MBT-70.'[6] Whether this is because the design managed to reach the prototype stage, or because it is such an excellent example of how a collaborative project should not be run, or because the US Congress demanded an investigation into the causes of MBT-70's failure, the programme has been written about by several authors in varying degrees of detail.

By far the most important and in-depth treatment is Thomas McNaugher's study written for the RAND Corporation in 1981, detailing the MBT-70 project and subsequent

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4 Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 190. See Chapter 2, above, for more details on the Franco-German FINABEL 'Standard Tank' collaborative tank project.
5 For a useful overview of the developmental phase of the Leopard 1, see Stephan H. Essen, 'Der Kampfpanzer Leopard I: Ein Vergleich des Phasenschemas der Automobilindustrie mit der Entwicklung des Standardpanzers 30t', in Heiner Möllers & Rudolf J. Schlaffer (eds.), *Sonderfall Bundeswehr? Streitkräfte in nationalen Perspektiven und im internationalen Vergleich* (Munich, 2014), pp. 313-332.
6 R.M. Ogorkiewicz, 'A Battle Tank of the 1970s: A US-German Design with Innovations', *The Engineer*, 2 (February 1968), pp. 198-200.

developments using first-hand interviews, project documents and US Congress reports. The RAND Note 'examines that experience in search of lessons for U.S. policymakers, who now are attempting to collaborate with their European allies over a broad range of weapon systems,'[7] which makes it a noteworthy source for this case study. McNaugher not only provides details of the evolution of the MBT-70 project, but also the subsequent XM-803 and XM-1 projects which lie somewhat outside the parameters of this study. Representing as it does the most accessible evaluation of the MBT-70 project to date, McNaugher's RAND Note is most useful for an exploration of the case of the MBT-70. McNaugher also published an article in *Armed Forces and Society*, which is essentially a summary of the RAND Note.[8]

Beyond McNaugher, secondary sources do not consider the project in any real depth. A handful of authors refer to its proposed technology, usually as a reference to potential technological advances and how it was loosely connected to the development of the Leopard 2 and M1 Abrams.[9] In *Tank Warfare*, Richard Simpkin does cover the basic points of the MBT-70 programme, concluding that the 'MBT 70 project is one of the case studies that suggests that main battle tanks are not ideal candidates for standardisation, even though their increasing cost and complexity makes collaboration an attractive future option.'[10] Hoffman and Starry also give the MBT-70 project brief treatment,[11] as does Ogorkiewicz, although the latter concentrates mainly on the project's technology rather than the political or project management dimensions.[12] Although it is mentioned in several other works, these references

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[7] Thomas L. McNaugher, *Collaborative Development of Main Battle Tanks*: *Lessons from the U.S.-German Experience, 1963-1978*, Rand Note (Santa Monica, CA: Rand Corp., Aug. 1981), p. iv.

[8] Thomas L. McNaugher, 'Problem of Collaborative Weapons Development: The MBT-70', *Armed Forces and Society*, 10:1 (Autumn 1983), pp. 123-145.

[9] See, for example: Robin Adshead& Noel Ayliffe-Jones, *Armour of the West* (London, 1978), p. 69; Steve Zaloga& Peter Sarson, *M1 Abrams Main Battle Tank 1982-1992* (London, 1993), p. 3; M. Jerchel and U. Schnellbacher, *Leopard 2 Main Battle Tank 1979-1998* (Oxford, 1998), pp. 3-5; Christopher F. Foss, *Jane's Main Battle Tanks* (London, 2ndedn, 1983), p. 130.

[10] Richard Simpkin, *Tank Warfare: An Analysis of Soviet and NATO Tank Philosophy* (London, 1979), p. 208.

[11] Oskar C. Decker, 'The Patton Tanks' (pp. 312-314, 319), Robert J. Sunell, 'The Abrams Tank System' (pp. 432-434), Donn A. Starry, 'Reflections'(p. 559), in George F. Hofmann & Donn A. Starry (eds.), *Camp Colt to Desert Storm: The History of U.S. Armored Forces* (Lexington, 1999).

[12]Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 167-171, 195-196, 256, 292, 296.

tend to be brief and are almost incidental background provided to underpin the coverage of the Leopard 2 or M1 Abrams main battle tanks.

Surprisingly, given the disproportionate interest shown in the MBT-70 project compared to other collaborations, the documentary source material available has not been exploited to the full. Primary source material is to be found in the National Archives of the United Kingdom, Kew, the Bovington Tank Museum archives and the Federal German military archives in Freiburg. The National Archive files contain British Foreign and Commonwealth Office (FCO) reports on the MBT-70 gleaned from British Embassy evaluations. The documents and reports on which these evaluations were based were generally acquired unofficially as the UK was 'largely excluded' from receiving information on MBT-70.[13] In addition, the project attracted an unusually high level of secrecy, with information and updates not being freely shared within NATO but only being released annually through official NATO channels.[14] The information acquired by the British Embassy was largely down to well-established relationships with individuals from within the US project team.[15] There is also a collection of papers relating to the MBT-70 in the archives of the Tank Museum at Bovington; representing largely neutral, third-party accounts of the project; such British sources tend to be useful for their impartiality. The military section of the *Bundesarchiv* in Freiburg im Breisgau, provides valuable German source material on the MBT-70 programme.

There are several reasons why the MBT-70 project is essential for any study of international collaborative tank projects: not only is its abject failure (at least at first glance)

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[13] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970.
[14] TMARL, E2014.3069, British Embassy Information on Agreement Suspension of MBT-70, 29 September 1969.
[15] As the BritishMunitions/Fighting Vehicles Defence Research Staff newsletter put it: 'Our contacts at Detroit Arsenal show no reluctance to discuss with us the technical details of the design of the future main battle tank.' TMARL, E2014.3072, MBT-70, Munitions/Fighting Vehicles Defence Research Staff Newsletter, February 1964.

easy to employ as an argument against such projects, it raises a number of fundamental issues around international cooperation on tank design. Seen superficially, it seems to offer a perfect case study in how not to attempt an international tank design project. The hurdle of the language barrier, the distance between the two countries involved, poor project design, very divergent military philosophies in relation to tactics and the respective roles of firepower, mobility and protection conspired with an over-ambitious agenda to create less than ideal conditions for both project teams. While the main driving forces behind the project, namely, NATO standardisation and interoperability, were laudable goals,[16] it should also be borne in mind that this was the first time that such a technically ambitious joint tank development programme had been attempted. Thus, it is important not to dismiss the project out of hand at the outset.

The best way to chart and explain the birth, progress and ultimate collapse of the MBT-70 project is to consider its main phases in rough, chronological sequence. Following a summary of the MBT-70 project's background and inception, an examination of project's dual management structure will be given. This is followed by the national allocation of developmental responsibilities for the new tank and to the technology being developed and proposed. With different technological solutions being proposed and negotiated, there will be an analysis of the differences of opinion between the two development teams that bedevilled the project and led to its failure. The final stages of the project are dealt with thereafter, showing how the politicians of both nations lost faith and withdrew their support. To round off the chapter there will be a brief look at the fate of FRG/US collaboration within the two national tank design programmes which followed the collapse of the MBT-70 project.

[16] Philip Taylor, 'Weapons Standardization in NATO: Collective Security or Economic Competition?' *International Organisation*, 36:1 (Winter 1982), p. 95.

3. 1. Inception of the MBT-70 Project

NATO member states had been committed to standardisation for many years.[17] Following its entry to the alliance in 1955, the Federal Republic had begun building its armed forces in 1956 and almost immediately began a collaborative main battle tank project with France. This project had failed by 1959, with each nation subsequently adopting their sovereign design, France with their AMX-30 and the FRG with the Leopard 1. The US Army was planning the replacement to the existing M-60 tank when Robert McNamara took office as US Secretary of Defense on 21 January 1961. The M-60 was the last in a line of tanks that represented a direct linear development beginning with the prototype T-20 in 1942, and included the T-26 Pershing and the post-war 'Patton' series of M-46, M-47, M-48, and ultimately the M-60.[18] Although slow, the M-60 was heavily armoured and armed with the excellent British 105mm L7 gun, but the US acknowledged that the line was at the upper limits of what could be achieved before a completely new design was adopted.

With numerical inferiority to Warsaw Pact forces in Europe emerging as a major concern, there was a requirement for the US to meet quantity with quality.[19] The US Army was therefore in real need of a completely new tank, and one that represented the best of contemporary technology. McNamara, a former businessman and accountant, and described by Ogorkiewicz as 'that arch-apostle of cost-effectiveness',[20] decided that the answer lay in collaboration with the FRG. McNamara believed that, despite accepting that war between NATO and the Warsaw Pact might result in nuclear exchanges, a strong conventional defence

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[17] See, for example: Walter Laqueur and Leon Sloss, *European Security in the 1990s* (New York, 1990), pp. 52-53; Alexander H. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies: Ten Years Later - and Beyond* (The Hague, 1981), passim; Andrew Moravcsik, 'Armaments Among Allies: European Weapons Collaboration, 1975-1985', in Peter Evans, Harold K. Jacobson, and Robert D. Putnam (eds.), *Double Edged Diplomacy* (London, 1993), pp. 128-129.

[18] See, for example: Decker, 'The Patton Tanks' pp. 300-314; and F. M. von Senger und Etterlin, *The World's Armoured Fighting Vehicles*, trans. R. M. Ogorkiewicz (London, 1962), pp. 192, 198, 203.

[19] TMARL, E2014.3182, MBT-70/XM-803 Information Sheet, 18 June 1970.

[20] TMARL, E2014.3184, Copy of article, R. M. Ogorkiewicz, 'The MBT-70 or How Not to Design a Modern Weapon', *Machine Design,* 42:14 (1970).

would allow a flexible response and mean that NATO would not have to rely on the first use of nuclear weapons. An effective modern tank was key to such a conventional defence. From his background at Ford, McNamara was used to employing commonality and standardisation to achieve efficiency and value for money, and thus the idea of standardisation came naturally to him. Ironically, in light of the direction that MBT-70 took, McNamara was suspicious of untested technological innovations.[21] Nonetheless, he confidently stated that: 'From 1970 onwards the German Republic and the USA are going to produce the first joint wartime tank in history.'[22] Having failed in the attempt to collaborate with France on an MBT design, Franz Josef Strauß,[23] the West German Minister of Defence, was still eager to cooperate with NATO members possessing advanced weapons technology, hoping thereby to aid Germany's economy and political standing. He believed that the FRG could only be a full and equal partner within NATO if it possessed at least some advanced defence technology.[24] As the FRG had the Leopard 1 scheduled to enter full production in 1963, any collaboration on MBT development would seem to be something of a diversion and not an immediate requirement to replace existing tank models. At the same time, the US Army was eager to produce a completely new tank, having come up with a requirement in 1957. The requirement, endorsed by the Department of the Army in 1959, became the basis for work to begin on developing suitable components and such work was already in progress when the MBT-70 collaboration overtook it.[25]

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[21] Deborah Shapley, *Promise and Power: The Life and Times of Robert McNamara* (Boston, 1993), pp. 202-203, 404.
[22] TMARL, E2014.3168, typewritten translation of article, 'US/FRG Tank of the 1970s', from *Der Spiegel*, May 1965, p.1.
[23] Strauß spent six years as the FRG Minister of Defence from 1956 to 1962, but his legacy of success in building the *Bundeswehr* was overshadowed by controversy and eventually by his resignation following political scandals such as the *Spiegel* affair. See, for example: Ralf Beke-Bramkamp, 'Franz-Josef Strauss', in David Wilsford (ed.), *Political Leaders of Contemporary Western Europe* (London, 1995), p. 433; and Pertti Ahonen, 'Franz-Josef Strauss and the German Nuclear Question, 1956-1962, *The Journal of Strategic Studies*, 18 (June 1995), p. 25.
[24] Kocs, *Autonomy or Power?* pp. 74-75.
[25] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 4, 6.

For some time, the US Defense Department and Army had been eager to find opportunities for becoming involved in sharing and acquiring international research and development.[26] Upon being appointed US Secretary of Defence in 1961, Robert McNamara approached Strauß, his opposite number, with a proposal to collaborate on designing new MBTs for their respective countries. As the Leopard programme was already at an advanced stage, prototypes having already been produced by 1961, Strauß was initially more interested in persuading the USA to buy the Leopard than in entering into a collaboration.[27]

Eventually, McNamara and Strauß came to an agreement. At first, in 1962, the two countries only committed themselves to jointly developing tank components rather than full vehicle designs. At McNamara's urging, however, FRG and US tank experts entered discussions on the desired characteristics of a single future tank. These discussions soon became a more formal arrangement and in 1962, McNamara had succeeded in persuading the FRG to agree to a full collaboration on developing an entire MBT. The agreement on desired tank characteristics was accepted, after some suggested changes, by the NATO working group on main battle tanks. Following the Federal elections in January 1963, Strauß had been replaced,[28] so that, on 1 August 1963, McNamara and the new German Defence Minister, Kai-Uwe von Hassell,[29] signed an agreement on the formation and the rough pattern of a

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[26] TMARL, E2014.3149, Maj. Gen. Edwin H. Burba, 'The New US/FRG Main Battle Tank', *Ordnance Journal*, Mar/Apr 1968, pp. 475-479.
[27] McNaugher, *Collaborative Development of Main Battle Tanks*, pp.3-4.
[28] In 1962, Strauß had attempted to use his position to bring charges against the newspaper, *Der Spiegel,* which had criticised him over irregularities in the purchase of US F-104 aircraft for the Luftwaffe. The resulting scandal meant that Strauß was forced to resign as Defence Minister in October 1962. See, for instance, Beke-Bramkamp, 'Franz-Josef Strauss', p. 433.
[29] Kai-Uwe von Hassel was a reforming Minister of Defence who introduced the concept of the 'citizen in uniform' to the *Bundeswehr*. Tragically, von Hassel's son was killed flying one of the F-104 aircraft whose controversial purchase had brought down the Minister of Defence's predecessor. For further biographical material on von Hassell: Volker Koop, *Kai-Uwe von Hassell: Eine politischeBiographie* (Cologne, Weimar, Vienna, 2007); a brief biography is Andreas Grau 'Kai-Uwe von Hassell: Tropenkaufman, Ministerpräsident, Bundesminister, Bundestagspräsident, Dr.h.c.', located on the website of the Konrad-Adenaur-Stiftung, <https://www.kas.de/statische-inhalte-detail/-/content/hassel-kai-uwe-von>, accessed 12 March 2019; and, the obituary by David Childs in *The Independent*, 10 May 1997, <http://www.independent.co.uk/news/people/obituary-karl-uwe-von-hassel-1260661.html>, accessed 12 March 2018.

cooperative programme to develop an entire new MBT, officially designated 'MBT-70/Kpz-70' in March 1965.[30]

In 1965, McNamara stated that:

> I am interested in […] [the MBT-70] project because I am convinced that joint development efforts of this sort with our NATO allies […] can be highly beneficial to all concerned. The pooling of idea and sharing of costs should make for a better end product at lower expense. Identical items of equipment in our inventories simplify maintenance and support problems and exemplify that cooperation which is essential to NATO's success.[31]

However, while seeking cooperation between the Federal Republic and the United States, McNamara in particular was strongly opposed to any British participation in the new programme which somewhat undermined the stated aims of NATO standardisation. The Germans, by contrast, repeatedly assured the UK that they would welcome British involvement. In any event, the advice from the British Foreign Office was not to press for inclusion as the programme was unlikely to be successful. They predicted that the Germans were unlikely to be enthusiastic about the project, surmising that West Germany was being forced into an agreement with the US due to political pressure. Britain, in any case, had little need of joining a collaborative programme on the other side of the Atlantic at that time as it was looking to produce its own new tank, the Chieftain.[32]

The drive for NATO standardisation has always had a strong element of economic as well as military reasoning.[33] Yet, if simple NATO standardisation was McNamara's goal, it would have made sense to approach one of the other two tank-building nations within NATO, France or Britain, as a partner in the collaboration. Indeed, openly sharing technology and progress reports within the Alliance would have been a sign that NATO standardisation was

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[30] McNaugher, *Collaborative Development of Main Battle Tanks*, p. 5.
[31] Ibid.
[32] TNA, FO 371/177965, UK/FRG/US cooperation in tank development, 1964.
[33] Taylor, 'Weapons standardization in NATO: Collective Security or Economic Competition?', pp. 98-99.

the major goal, yet 'a virtually complete security ban' was placed on release of information about the MBT-70 project, with updates only being released on an annual basis through official NATO channels.[34] Several other possible motives for persuading the FRG to join a collaboration have been suggested. At the time, Britain was a major tank exporter, with Centurion being used around the world, whereas Germany had not produced an indigenous tank since the Second World War. British observers suggested that McNamara wanted to avoid commercial competition with the UK. Although the new tank would be developed collaboratively, export orders would still benefit whichever country they were placed with. By not allowing the UK into the partnership, it avoided Britain potentially gaining disproportionately high future export orders for the tank from countries already using British tanks and thus being more inclined to deal with the United Kingdom than with the United States or Federal Republic.[35]

Although not mentioned by Robert McNamara, it was noted by several observers that in the late 1950s the US had found itself in economic difficulties, with a serious problem with their balance of payments.[36] The USA had 240,000 troops in bases stationed around West Germany and was bearing the cost without any German contributions. The FRG felt that to pay towards the stationing of US troops would be politically unacceptable, raising as it did the memories of being forced until 1954 to pay punitive occupation costs to the Allies while the Federal Republic was under military occupation. As a compromise, the country agreed to buy in US military and civilian goods to offset around 75 percent of the garrison costs.[37] As the initial supposition by many US observers was that the MBT-70 collaboration would mainly use US components, it is possible that a motivation for the deal was that the Federal

[34] TMARL, E2014.3069, British Embassy Information on Agreement Suspension of MBT-70, 29 September 1969.
[35] TNA, FO 371/177965, UK/FRG/US cooperation in tank development, 1964.
[36] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 5.
[37] Kocs, *Autonomy or Power?* p. 82.

Republic would, in essence, be tied into importing US manufactured components in order to construct their own MBT.[38] A similar arrangement did, after all, exist when Italy bought the rights to construct the US M-113 APC but had to import the components from the USA, only securing rights to manufacture them within Italy in 1966.[39]

It should be noted that the August 1963 agreement was not a declaration of common requirements agreed as part of the MBT-70 programme. It was rather an acknowledgement that both the Federal Republic and the US were in broad accord with what they wanted from their new tank. Instead of setting down a single specification, the agreement therefore took the approach that the existing disagreements and divergence of opinion could be overlooked in order that the overall collaboration programme should go ahead. Up to this point (1963), the specification for the new tank was consequently remarkably vague. As the first US MBT-70 programme manager described it, the specification was 'not at the level of detail that one would normally associate with a Qualitative Matériel Requirement (QMR).' [40]

This vagueness over the specification continued. By 1965 the three officially stated goals of the MBT-70 programme were:

> 1. To develop a Main Battle Tank which meets the military characteristics agreed upon by the two governments, to be ready for production by not later than 1970 for joint use.
> 2. To make equally available to both governments the knowledge gained during the development and to insure [*sic*] each government the right to utilize the resulting knowledge.
> 3. To meet to the extent possible during the development, the criteria established by approved and accepted NATO basic military requirements.[41]

[38] McNaugher, *Collaborative Development of Main Battle Tanks*, p. 11.
[39] Shiovitz, 'The MBT-70: How Does the US Benefit?', pp. 38-39.
[40] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 3-4, 6.
[41] TMARL, E2014.3247, copy of article, Anon., 'How is the West German-American Main Battle Tank Development Program Coming Along', *Armed Forces Management*, January 1965, p. 42.

The wording of the first point, an intention to 'meet the military characteristics agreed upon by the two governments', indicated that, two years after the official start of the programme, the military characteristics were still to be agreed upon. This failure to agree was always going to cause problems throughout the programme. Even the agreed guidelines for the new tank were vague, setting out only that out that the MBT-70 would:

> Offer improvements in firepower, mobility, and protection over the M-60A1, […] be capable of operating on a battlefield where tactical nuclear weapons are employed, […] be armed with a tube-fire missile, or both a missile and a gun combination, and […] have the latest electronics for communications, navigation and fire control.[42]

Apart from stating that the new tank would be an improvement over the old ones (a worthy goal for any replacement!), the only substantive information within the guidelines was that the new tank would use a missile. As noted below, however, even this single specifically named goal was to cause many problems.

The agreed production deadline of December 1969 effectively delayed a replacement for the US Army's M-60 tank by four years, moving it from the original 1965 acceptance date. Unhappy at the delay, the US Army were still nonetheless prepared to accept the deal at the time because the agreement contained a clause allowing either party to withdraw from the project after giving two-months' notice of intent. They were, after all, potentially going to receive a more capable tank than might be expected of a unilateral design. By contrast, the *Bundeswehr* was on the verge of adopting the Leopard and, assuming this design proved successful in service, was consequently in no real hurry for another new tank until the late 1970s.[43] The problem of the failure to agree specific requirements was simply not addressed,

[42] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 6.
[43] Ibid., p. 7.

being sidelined as not as important as the political advantages of securing a collaboration agreement. While the requirements should perhaps have been established with the agreement signed in 1963, in reality the requirements process continued throughout the programme's life as new ideas were introduced at every stage.[44]

3. 2. Parallel Project Teams

As part of the 1963 agreement, an international 'Program Management Board' (PMB) was created, with one German and one US programme manager, but no further organisational arrangements were specified at that stage. The US programme manager was Major General Welborn G. Dolvin, and on the German side, Dr. Fritz Engelmann, later replaced in 1968 by General Helmut Schönefeld.[45] It is worth noting that Schönefeld[46] had been transferred in 1963 to the Armaments Office of the Army Staff, serving there when the decision to accept the Leopard design was taken. The PMB was described as regulating the 'pulse of the project', with each programme manager being authorised to act for their respective nation on all matters relating to the programme. The PMB was the highest-level joint body within the programme. Should the PMB be unable to agree or a matter arise which required diplomatic or political decisions, the PMB would pass the issue to their nation's separate political apparatus for resolution.[47]

In September 1963, Dolvin and Engelmann, the two programme managers, first met and began to organise and staff their projects while also beginning the process of refining the

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44 McNaugher, *Collaborative Development of Main Battle Tanks*, p. 3.
45 Ibid., pp. 6-7; and, Burba, 'The New US/FRG Main Battle Tank', pp. 475-479.
46 Generalleutnant Helmut Schönefeld (1916-1997): served in German Army before outbreak of war in 1939 (promoted to Leutnant on 1 April 1936); he served in the Operations Department of the General Staff of the Army; at the end of the war, he was GSO1 with a division; completed his doctorate in 1953; entered the Bundeswehr as Oberleutnant, 1956; from 1 April 1966, became head of the section military technology, FRG Defence Ministry; promoted to Brigadegeneral, 1 August 1966; promoted Generalmajor, 4 November 1968; promoted, Commander, II Korps, late 1970; retired, 1976.
47 TMARL, E2014.3247, copy of article, Anon., 'How is the West German-American Main Battle Tank Development Program Coming Along', *Armed Forces Management*, January 1965, p. 43.

rather vague specification so far laid down for the new tank. Four working groups were established, equally represented by American and German personnel, one to consider the tank concepts, one for the military requirements, one for specifications and standards, and the fourth for the legal and funding issues. The second group, the Military Requirements Working Group, was the group responsible for taking the vague operational requirements established by the August 1963 agreement and turning them into requirements precise enough to begin design and manufacture of the MBT-70.[48]

The Programme Management Board (PMB) was given complete freedom to organise the MBT-70 project. Having decided that forming a single multinational company would be impractical, not least legally, they instead decided in 1964 to approach the project by splitting responsibility down the middle and establishing two parallel national hierarchies, one American and the other German. Immediately below the PMB in the hierarchy were the two bodies that represented each respective nation as the Joint Engineering Agency (JEA). To staff the US side of the JEA, Dolvin turned to the US Army Tank Automotive Command and several other relevant technical commands. Engelmann, by contrast, had no FRG technical commands to draw from, so instead filled the German half of the JEA with experts from the FRG Defence Ministry's Federal Equipment and Procurement Office.[49]

The JEA had a single reporting body, the Joint Design Team (JDT) which was again split along national lines but was staffed by representatives of firms which had bid for the contracts to carry out the design work. Illustrating the composition of the JDT, the US required that contractor(s) of the JDT provide:

> 6x Experienced professional executive engineers and/or management personnel,
>
> 1x Experienced lawyer capable of providing counsel in matters of German civil law,

[48] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 7.
[49] Ibid., p. 8. For a diagram of the project organisation, see Appendix 3 below.

3x English-speaking secretaries,
3x English-German interpretors [*sic*].[50]

The Allison Division of General Motors (GM) won the position as prime contractor for the USA in July 1964.[51] The FRG, however, had no single contractor of a size and experience sufficient to bid for the position of prime contractor on a project the size of MBT-70, and so they instead formed a consortium, *DeutscheEntwicklungsgesellschaftGmbH* (DEG) specifically for the joint project. The consortium comprised the firms *Krauss-Maffei, Atlas MaschinenbaumbH Kiel* (MaK), *Rheinstahl AG, Daimler-Benz Stuttgart*, and *Keller and Knappich Augsburg* (KUKA).[52] It was DEG that represented the German half of the JDT.

The 1963 agreement estimated the project's development costs at $80 to $100 million, to be shared equally between the FRG and USA. The production deadline was set as December 1969.[53] The US considered that, while the administrative costs of a collaboration would be higher than for an equivalent unilateral project, each nation's share of the unit costs would still be lower than with a sovereign design. Although GM and DEG were the prime contractors, the sub-contracts on offer were substantial. One document gives a breakdown of US contracts awarded by 14 November 1967 for the tank's developmental phase, which included $393,000 for a parametric design/cost effectiveness (PD/CE) study by Lockheed's Aircraft and Missiles Company, $8 million to Philco Corporation for the Shillelagh missile system, $2.7 million to Chrysler Corporation for HET-70 (heavy equipment transport), $37.1 million to Allison Division (GMC) which subcontracted $11 million to Continental Aviation

[50] BA-MA, BW1/369131, Deutsch-Amerikanisches Programm, Gemeinsame Panzerentwicklung, Zukunftspanzer, 1964, T/Kpz70, US-Vortrag ATAC-General Motors II Phase, October 1964, Annex D.
[51] TMARL, E2014.3044, Information Sheet No. M/46/67 US/FRG MBT-70, 14/11/67.
[52] TMARL, E2014.3220, copy of article, Jacques Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', *Armies and Weapons*, year not identifiable but possibly 1975, p. 38.
[53] McNaugher, *Collaborative Development of Main Battle Tanks*, p. 6.

for the engine and $2 million to National Waterlift Company for the hydro-pneumatic suspension system.[54]

The potential problems associated with international collaboration were known, even if they were not necessarily fully addressed. As an article in the US journal *Armed Forces Management* set out in 1965:

> In addition to normal complications that arise in developing a new weapon system, there must be compounded into this venture the obstacles of language, distance and culture. Another challenge that planners face is the welding of the diverse views of the diplomat, soldier, civil servant, engineer and industrialist from both countries into a useful end product.[55]

The problem of designing a single tank which suited two different national tank concepts was certainly recognised by the PMB members, Dolvin and Engelmann. With two equal partners arguing for their own designs to be adopted, there had to be a single decision-maker who could break the tie. Consequently, in December 1964 the PMB contracted Lockheed to take all the design concepts submitted and create a virtual 'rubber tank' whose characteristics could be manipulated inside a computer. Each iteration of the tank would then be run through combat simulators to determine which design would be most cost-effective. This parametric design and cost effectiveness (PD/CE) study was intended to act as an 'impartial umpire' to adjudicate in the inevitable differences of opinion arising from different national tank philosophies and doctrine.[56]

Overall management of the MBT-70 project, and thus of the PMB, was the responsibility of the Army Materiel Command in the US, and in the FRG of the Federal

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[54] TMARL, E2014.3044, Information Sheet No. M/46/67 US/FRG MBT-70, 14/11/67.
[55] TMARL, E2014.3247, Copy of article; Anon., 'How is the West German-American Main Battle Tank Development Program Coming Along', *Armed Forces Management*, January 1965, p. 42.
[56] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 7-8.

Ministry of Defence.[57] Final project authority was held by the PMB, and Dolvin and Engelmann had complete authority over their respective national teams. This meant that all the unilateral decisions required by the programme had to be negotiated at the JDT and JEA levels, then agreed at PMB level by both Dolvin and Engelmann. If they could not reach agreement, a new round of discussion at the national JDT and JEA levels would be required before the process was repeated until an agreement was reached. Each partner team needed to be consulted at each important stage and before any major decision was made.[58]

Early signs of the bureaucratic disadvantages of having two parallel hierarchies in different countries became apparent when a decision had to be made as to where the MBT-70 programme would actually be based, the United States or the Federal Republic of Germany. Mirroring the bi-national nature of the whole project, the decision was finally made to base the programme in Koblenz in Germany until 1966 and, then, with the assumption that the prototypes would be ready by that stage, to relocate the whole management organisation to Detroit. Leadership of the JEA and JDT would fall to the nation in whose country the project was currently not based, so the USA would lead while the project was located in Germany and vice-versa. It was in September 1964, a year after the official start to the MBT-70 programme, that the JDT and JEA members first met in Koblenz. Although the delay allowed Dolvin and Engelmann time to staff their subordinate bodies and tender for JDT contractors, there was still no design requirement in place upon which to build. The process of firming up the vague list of characteristics set out at the inception of the project had been expected to take only 'five or six months' yet, a year after the project had begun, no firm specification of military characteristics had been established.[59]

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57 McNaugher, *Collaborative Development of Main Battle Tanks*, pp. 7-8.
58 TMARL, E2014.3247, Copy of article; Anon., 'How is the West German-American Main Battle Tank Development Program Coming Along', *Armed Forces Management*, January 1965, p. 45.
59 McNaugher, *Collaborative Development of Main Battle Tanks,* p. 10.

Language difficulties contributed significantly to the problems faced by the international collaborative team, especially as the project involved the use of highly technical and specialised terms. In one notable example, Dolvin records that the two sides negotiated a particular key point for two hours before realising that, due to a mistranslation, they were arguing over different things. There was obviously a requirement for interpreters to have the necessary engineering and technical knowledge to cope with the language and concepts being discussed. Unfortunately, the US team could not fill the post at the salary being offered and hence asked that the interpreter position be allocated a higher pay grade. This was initially refused because the raise would have resulted in the project interpreter being paid more than the interpreter of the US President.[60] If we assume that this problem of mistranslation was not an isolated incident, then it suggests that language problems must have added to the already extensive time spent on negotiation and hence to the deadline being extended by two years before the project finally collapsed.[61]

At a time before mobile telephones, email and instant online communication, even the disruption caused by travel and geographical dislocation was of major concern. Senior and important personnel frequently had to travel from Germany to the USA and vice-versa, and were thus unavailable at their home company for long periods. Indeed, while actually travelling, they were unavailable to anyone in the project team. While this could be disruptive when a key individual was travelling, it was a far greater problem when several members of a

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[60] TMARL, E2014.3247, copy of article, Anon., 'How is the West German-American Main Battle Tank Development Program Coming Along', *Armed Forces Management*, January 1965, p. 44.

[61] Morris, et al., note that any collaboration faces the problem of communication and interpretation, even if all stakeholders share a common language, stating: 'As project stakeholders (including the firm's local units) in different institutional settings interpret the projects' goals and business objectives differently, the communication in such organisational structures is challenging.' See here, Peter W. G. Morris, Jeffrey K. Pinto, and Jonas Söderlund (eds.), *The Oxford Handbook of Project Management* (Oxford, 2012), p.144.

team were unavailable. One US executive was heard to shout despairingly, 'Right now damned near everybody I've got is in Germany.'[62]

3. 3. Division of Responsibility

By 1962, under the terms of the agreement to collaborate on tank components, the United States and Federal Republic had agreed on the characteristics which would be needed for a new NATO tank. A NATO working group suggested some modifications which were duly integrated, and the working group approved the set of characteristics in January 1963.[63] Using these characteristics as a guide, Dolvin and Engelmann agreed the basic MBT-70 military characteristics in March 1965.[64] Simpkin suggests that that the Germans and Americans had 'little difficulty' in reaching an operational requirement for the MBT-70.[65] Given the time taken to reach the 1965 agreement, which itself had been based largely on an agreement reached two years earlier, as well as the subsequent disagreements over the tank's design features, Simpkin might have been generous in his conclusion.

The initial intention of the project was that each nation would focus on components according to their perceived particular technical expertise, with the USA tackling the weapons system, engine and primary fire-control, and the FRG responsible for the secondary armament, transmission, auto-loader and suspension. The decision was eventually made that, of the tank's 34 basic components, 18 would be developed solely by the FRG, six solely by the USA, and the remaining ten by both countries jointly.[66]

However, while the hull and turret layout remained as joint design considerations, collaborative development for the rest of the MBT-70 was in no real sense a joint effort.

[62] TMARL, E2014.3247, copy of article; Anon., 'How is the West German-American Main Battle Tank Development Program Coming Along', *Armed Forces Management*, January 1965, p. 45.
[63] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 3.
[64] Ibid., p. 14.
[65] Simpkin, *Tank Warfare*, p. 67.
[66] TMARL, E2014.3220, Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', p. 38.

Having been developing their own tank for several years at the time that MBT-70 agreement was signed, the USA already had components under development and saw little reason to discontinue these. As the FRG had been unconvinced of the effectiveness of US-developed components, such as the main armament and the diesel engine, they duplicated the work and developed their own components in parallel with the US. For example, although the USA was supposed to have responsibility for the engine, Daimler-Benz also received funding from DEG (the German JDT consortium) to develop a German engine which would be less complicated than the proposed US Continental design. Both German and US developers simply unilaterally developed their own components and then fought to include their particular design in the joint requirement agreement with little regard to the initial division of responsibility. While the project agreement had allocated responsibility for such components to the US, the FRG therefore found itself with little need to avail itself of US technology in order to build its own modern MBT. In particular, the Americans wanted the Shillelagh missile system to be the tank's main armament, although this had never been accepted by the Germans. The Americans' conciliatory attempts to modify the launcher to fire conventional 152mm shells did not convince the West Germans that the launcher would be better than a conventional 120mm gun. Neither were the Germans happy at the increasing weight of the tank. They were adamant that the new vehicle should meet a MLC-50 bridging limit; yet all the US designs exceeded that weight, partly due to their prioritising of armour over mobility.[67]

This duplication of effort was justified at the time by claiming that it was desirable to have a second design in reserve should the primary design prove to be unsatisfactory. But it

[67] McNaugher, *Collaborative Development of Main Battle Tanks*, pp. 17, 25. NATO's Military Load Classification, or MLC, is expressed in very approximate terms as the maximum weight in short tons that a particular route will accommodate. For more information on the NATO MLC classification system, see NATO Standard 2021: Military Load Classification of Bridges, Ferries, Rafts and Vehicles, accessed online via, <http://standards.globalspec.com/std/999293/nato-stanag-2021>, accessed 03 October 2017; and see also Chapter 1 above.

was likely that both sides were simply eager to advance their own political and industrial agenda by gaining valuable experience and expertise in developing the components so as to have them adopted for the MBT-70. The firms comprising the FRG's DEG consortium held the commercial patents and rights to their own designs and were naturally eager to have these designs used in a new MBT. Funding from the project allowed components to be developed, but the real money would have been in selling those components for use in a production MBT with potentially large sales within the NATO Alliance. The US firms, on the other hand, would not have kept the commercial rights to their designs, which would have been held by the government, but many had already invested time and resources in development as part of the earlier US tank replacement programme. It would have been painful to have seen such investment go to waste, especially as the components had been tailored to the specific needs of the US Army.[68]

Finally, political will to see the programme succeed ironically doomed it. With both nations looking for different military solutions, the project should have stalled before it really got going. Instead of accepting that they were looking for two different tanks, or compromising requirements for the sake of the collaboration, the project instead dealt with the impasse diplomatically, if impractically, by trying to please both parties; allowing each nation to separately develop the components that they wanted. The result was, of course, that each nation designed a different tank and the two designs bore little of the standardisation or interoperability features which had been at the heart of the collaborative ethos. The Lockheed parametric design and cost effectiveness (PD/CE) study had been commissioned to overcome the problem of two different design teams backing their own national designs and refusing to

[68] In an article on Research Joint Ventures, Gene Grossman and Carl Shapiro suggest that cooperation helps to avoid wasteful duplication of effort in research and development, and also mitigates research risk to individual companies. It should be noted, however, that in the case of the MBT-70 project, many US companies had already developed MBT components in the expectation of having them adopted by a new US MBT and so adopting new jointly-developed technology would have resulted in these previous efforts going to waste. See here, Gene M. Grossman and Carl Shapiro, 'Research Joint Ventures: An Antitrust Analysis', *Journal of Law, Economics, & Organization*, 2:2 (1986), pp. 332-333.

compromise, but this did not prevent each nation backing their own component and tank design concepts, resulting in time-consuming delays when attempting to establish the tank's specific requirements.[69]

3. 4. Technological Innovations

Hopes for the new tank were initially high. Official press reports said of the tank: 'Officially designated the MBT-70, the new weapon will outshoot, out-maneuver and outrun any known tank and, at the same time, provide unprecedented crew protection.'[70] This was quite an impressive and optimistic goal to be aiming for, but the US development team believed that the components would all be ready. The US had had their existing tank development project that they had set aside when the MBT-70 collaboration agreement was signed, and this provided several of the key design features of the new tank. The three-man crew, the provision of an auto-loader, the US-developed diesel engine, hydro-pneumatic suspension, and the Shillelagh missile system, all came from this original US design.[71] Paper projections and early prototype trials of the MBT-70 suggested that it would be 'a marked improvement' in speed, agility and on-the-move shooting accuracy.[72] An M-60 tank traversing a 'ripple course', a series of low humps set close together and resembling corrugations, was able to maintain eight mph and even this, it was noted, had resulted in an injury to the driver. The MBT-70 with its hydro-pneumatic suspension, by contrast, is reported to have 'apparently' managed the course at 25mph with no (vertical) hull movement.[73]

The MBT-70 requirement represented several major technological departures from existing conventional tank designs. While they were in use in Warsaw Pact tanks, NATO had

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[69] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 10-11.
[70] TMARL, E2014.3070, MBT-70, Allison Press Release.
[71] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 14.
[72] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970.
[73] TMARL, E2014.3049, US/FRG Tank, 8 January 1968.

not yet developed and fitted an effective autoloader and had, consequently, always had four-man MBT crews. Furthermore, new for a NATO tank was the dedicated NBC-protected turret capsule concept and the use of a hydro-pneumatic suspension, intended to adjust the height of the tank to take advantage of local terrain for firing from'hull-down' positions. This system was fitted to the revolutionary turretless Swedish Strv-103 (the 'S-tank') which was at the prototype stage in 1961, but it had not been adopted by any other armed forces at that point.[74] The power-to-weight requirement for the MBT-70 was also new, much higher than with any previous NATO tank which, as a result, required a more powerful engine.[75]

As time went on, instead of compromising on one system, competing components were simply added to the design and the weight inevitably began to increase. Although the US representatives saw higher weight as acceptable, the German team were insistent on a tank that met their 46-ton, MLC-50 limit. With neither design team able to solve the problem even at PMB level, the debate was addressed by the two national defence ministries. Their impractical – and, as it transpired, impossible – solution was to increase the MBT's specified upper weight limit at the same time as focussing on reducing further weight increases to the design, all without reducing the tank's effectiveness as specified in the agreed military requirement.[76]

The MBT-70's external dimensions were fairly conventional when compared to contemporary tanks, having a considerably lower silhouette than the notoriously tall 3.27m M-60A1, and being narrower than the equally notorious 3.63m wide M-47.[77] The width limit

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[74] See, for example: Senger und Etterlin, *The World's Armoured Fighting Vehicles*, p. 436; Foss, *Jane's Main Battle Tanks*, pp. 71-73; Rolf Hilmes, *Main Battle Tanks: Developments in Design Since 1945*, trans. Richard Simpkin (London, 1987), p. 63.
[75] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 15.
[76] Ibid., p. 18.
[77] BA-MA, BW1/452528, Deutsch-französisches Abkommen über die Entwicklung eines Standardpanzers (Vertrag-Nr. 899/57), 1957-1958, Über die Sitzung der deutsch-französischen Zusammenarbeit Unterausschuß Heer (Arbeitskreis "Panzer"), stattgefunden in Bonn, Hardthöhe, am 6. und 7. Mai 1957, 21. Mai 1957, p. 2; and, Tanks Encyclopedia, '105mm Gun Tank M60', <http://www.tanks-encyclopedia.com/coldwar/US/M60_Patton.php>, accessed 02 February 2018.

had originally specified that two tanks should be able to cross a standard NATO bridge simultaneously, and the height was to allow the tank to pass under existing underpasses. The design's width in 1967 was 3.5m (138") and the height to the top of the turret was 2.29m (90"), or 1.83m (72") with the hydro-pneumatic suspension lowered, plus an additional 0.3m (12") when the turret-mounted auxiliary 20mm gun was raised to its fullest extent. The length was 7.62m (25 foot) excluding the length of the gun.[78]

US doctrine called for engagement ranges out to 3000m, beyond the realistic capability of contemporary 105mm guns. In its eagerness to develop a completely new and sophisticated main battle tank to enter service around 1965, the US Army turned to the Shillelagh anti-tank guided missile system (ATGM) in a stabilised turret, and fed by an autoloader.[79] Following the end of the Second World War, both the French and Americans regarded shaped-charge warheads as the best anti-tank ammunition available, and this, combined with the US Army's tank doctrine of engaging at long range, led to the US Army's Armament for Future Tanks and Similar Combat Vehicles Committee (ARCOV) recommending in 1957 that future tanks should be armed with guided missiles rather than guns. This recommendation led directly to the development of the Shillelagh missile system.[80]

The XM-13 Shillelagh Combat Vehicle Weapon System, 152mm missile launcher, as later used in the M551 Sheridan armoured reconnaissance vehicle and M-60A2 support tank, was approximately half the weight and length of a 105mm gun and its infra-red (IR) guided missiles were effective out to ranges beyond that of contemporary conventional guns.[81] The term 'Shillelagh' properly referred only to the missile itself, although in casual usage the

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[78] TMARL, E2014.3044, Information Sheet No. M/46/67 US/FRG MBT-70, 14 November 1967.
[79] McNaugher, *Collaborative Development of Main Battle Tanks*, p. 4.
[80] Ogorkiewicz, *Tanks: 100 Years of Evolution,* p. 256.
[81] Decker, 'The Patton Tanks', p. 311.

whole XM-13 system was often called ‘Shillelagh’.[82] The US tested the Shillelagh against the existing 105mm of the M-60A1 and showed that the Shillelagh had improved penetration, rounds-to-kill over 500m, time-to-kill, and first-round hit probability over 500m.[83]

The FRG representatives did not agree that ATGMs were the future of tank armament and wanted a more conventional gun. As a compromise, the Americans modified the XM-13 to enable it to fire conventional 152mm high-velocity rounds with combustible cartridges. The initial XM-13 system used a barrel only 17.5 calibres long, but this short barrel length made it unsuitable for firing high-velocity ammunition which required a longer barrel.[84] The Germans requested a weapon that could fire more conventional high velocity rounds and, in 1967, the length of the barrel was increased to 30.5 calibres. This new gun/launcher was named the XM-150 (also sometime referred to as the XM-152).[85]

It was noted that the calibre of the 152mm gun-launcher design allowed for the potential firing of tactical nuclear warheads, although given the limited range of the XM-150 it would have had to be a desperate situation to do so.[86] More practically, although rifled, the XM-150 could fire armour-piercing fin-stabilised discarding-sabot (APFSDS) rounds, the best kinetic energy (KE) anti-armour round available, by using ‘slipping bands’ to steady the projectile in the rifled barrel and, thus, avoid spinning the finned dart which would have degraded its penetrative capabilities.[87] This system of slipping bands was later adopted (with modification) by the British Army to fire APFSDS rounds from its 120mm rifled guns. A British Embassy’s Defence Research and Development Staff (DRDS) evaluation of the XM-150 firing APFSDS expressed doubts about its accuracy, citing that the MBT-70 office was

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[82] TMARL, E2014.3194, British Embassy Defence Research and Development Staff, MBT-XM803, 23 March 1971.

[83] TMARL, E2014.3021, US Concepts – Future Main Battle Tank, 13 January 1965.

[84] The calibre length of a gun barrel (expressed ‘calibre L/xx’) is a multiple of the calibre of the rounds being fired. Thus, a 100mm L/45 gun would have a barrel length of 100x45mm, or 4500mm long.

[85] Ogorkiewicz, Tanks: *100 Years of Evolution,* p. 256.

[86] Decker, ‘The Patton Tanks’, p. 313.

[87] Ogorkiewicz, *Tanks: 100 Years of Evolution,* p. 259. Tank ammunition and how it relates to rifled or smoothbore guns is covered in Chapter 1 above.

being 'extremely reticent' about the accuracy figures, although their view on the Shillelagh missile itself was that it 'should be alright' following the twelve years and many millions of dollars that had been spent on its development.[88]

Although XM-13 Shillelagh missile system worked as an ATGM, attempts to convert it to fire conventional ammunition resulted in problems developing a combustible cartridge that completely burnt away and did not leave smouldering residual debris in the breach chamber. In addition, the combustible cartridge cases were found to be excessively hygroscopic, absorbing water and becoming useless.[89] The British Embassy's DRDS also highlighted several problems they believed existed with the MBT-70's autoloader.[90] There was little doubt that the autoloader was causing problems and the Germans were having many technical problems in developing it.[91] The XM-150 autoloader was only capable of loading seven or eight rounds per minute due to the combustible cartridge cases fracturing at higher rates. It also required that the gun be returned to the horizontal after each shot, and then automatically returning to the last sighting position after the round was loaded.[92] The autoloader held eight 'ready' rounds and, whilst the US developers stated that these could be replaced from the tank's 26-round magazine from inside the tank, they accepted that the lack of space would make this very difficult to achieve.[93] In practice, it is highly likely that reloading the 8-round autoloader would have had to be carried out outside the tank, requiring the crew to pull out of action and take the tank to a safer area.[94]

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[88] TMARL, E2014.3181, British Embassy Defence Research and Development Staff Report on article on MBT-70/XM-803, 24 June 1971.
[89] TNA, DEFE, 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.
[90] TMARL, E2014.3181, British Embassy Defence Research and Development Staff Report on article on MBT-70/XM-803, 24 June 1971.
[91] McNaugher, *Collaborative Development of Main Battle Tanks, p*. 18.
[92] TMARL, E2014.3054, MBT-70, December 1968.
[93] TMARL, E2014.3182, MBT-70/XM-803 Information Sheet, 18 June 1970.
[94] TMARL, E2014.3049, US/FRG Tank, 8 January 1968.

Other potential problems with the XM-150 gun/launcher were identified, such as the IR tracker, meaning that it would be unable to be fired within 7 degrees of the sun.[95] Another potential issue was that, while the system employed a 'multi-purpose' CE round (HEAT), a white phosphorous (WP) smoke round and a practice round, there was no provision for a standard HE round.[96] This meant that a ATGM-armed MBT-70 would have little ability to suppress or engage area targets outside machine-gun ranges and would consequently require external artillery support. However, the US design team persisted with the ATGM-armed tank concept even after the end of the MBT-70 programme, possibly because of the money and resources already sunk into the Shillelagh, XM-13 and XM-150 projects.[97] A covering note by a member of the British Army Staff on an 1967 article in the US *Armed Forces Management* journal suggests that the article's claim that the MBT-70's firepower had a 'better than two-to-one firepower superiority over any tank in use today' was 'misleading'. The covering note also pointed out that information from 'some quarters' responsible for US tank-crew training had expressed doubt that new crewmen could be 'adequately' instructed on the new tank within their draft period (then two years for US Army draftees).[98]

Another unique innovation was in siting of all three crewmen in the turret. The US requirement for an autoloader meant a reduction of crew from the usual NATO complement of four down to only three men. At the same time, the FRG demanded improved NBC protection for the crew. The solution was a 'crew pod' housed in the turret which contained all crew positions and could be NBC shielded at a fraction of the weight of shielding a separate hull position for the driver.[99] The driver was set in a contra-rotating capsule within

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[95] TMARL, E2014.3054, MBT-70, December 1968.
[96] TMARL, E2014.2774, Vehicle Concept and Evaluation Section, 'Proposed Joint Development of a New Main Battle Tank for 1964' (United States – Federal Republic of Germany), October 1961, p. 10.
[97] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970.
[98] TMARL, E2014.3204, covering note attached to copy of article, 'US/FRG MBT-70', *Armed Forces Management*, January 1967.
[99] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 15.

the tank turret, allowing him to maintain forward vision even when the turret rotated.[100] Tests had been successfully carried out to determine the effectiveness of using polyethylene containing boron as shielding against neutrons, with the result that the MBT-70 turret had a double skin which was to be filled with this compressed boron-enriched polyethylene.[101] As additional NBC protection, wading tubes were to be fitted to feed air to the engine only, leaving the crew to use a bottle of oxygen in the turret. The system was thought to provide about 40 minutes of breathable air, although it was noted that a similar system equipping Panzer IIIs for the 1940 operation SEALION had only managed to supply ten minutes of breathable air in practice.[102]

A 1961 UK report on the planned MBT-70 recorded that the driver-in-turret position was shown to have advantages over the usual driver-in-hull arrangement: it gave 80% better vision; was out of the mud splash; was out of any mine blast area; the commander did not always have to direct the driver; it gave higher vision in engagements particularly when in a hull-down position; and, it allowed the tank to ford depths up to the top of the turret without requiring preparation to seal the driver's position.[103] However, the driver in his own contra-rotating turret would often suffer motion sickness and nausea as the main turret moved around him.[104] In addition, having all crew positions in the turret led to a necessity to link all instruments and controls to there. One UK observer considered that there were an 'excessive' number of hydraulic and electrical links from the hull to the turret (seven hydraulic and 220

[100] TNA, DEFE 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.
[101] BA-MA, BW1/369129, Deutsch-Amerikanisches Programm, Gemeinsame Panzerentwicklung, Zukunftspanzer, 1964-1965, US-Vortrag, Experimental Confirmation of Radiological Armor Design Theory, p. 6; and, TMARL, E2014.3049, US/FRG Tank, 8 January 1968.
[102] TMARL, E2014.3049, US/FRG Tank, 8 January 1968.
[103] TMARL, E2014.2774, Vehicle Concept and Evaluation Section, 'Proposed Joint Development of a New Main Battle Tank for 1964' (United States – Federal Republic of Germany), October 1961, p. 29.
[104] Rolf Hilmes, 'Modern German Tank Development, 1956-2000', *Armor,* 110:1 (Jan/Feb 2001), p. 18.

electrical, compared with a total of 27 in Chieftain).[105] Such concern was, perhaps, justified when the entire crew was sharing the turret space with so many potential hazards because linkages were particularly prone to damage in the case of turret hits.

The US engine contractor was originally US Continental, already working on a diesel engine for the M-60's replacement.[106] Continental, however, found that their engine could not produce the required power. The US MBT-70 prototypes fitted with the beleaguered diesel engine were not only underpowered but gave off 'an appalling amount' of black exhaust smoke when the accelerator was depressed.[107] Having had doubts about the Continental diesel engine from the beginning, the Germans had developed their own Daimler-Benz diesel engine in parallel and this proved to be superior. The German diesel engine proposed for MBT-70 (and later used in Leopard 2) was rated as between 1475 and 1500 bhp, meeting the MBT-70 requirements and, significantly, being shown to work. The Germans consequently moved to use the engine on the new tank.[108] The US did not wish to have so important a component as the engine move from their sphere of responsibility to that of the FRG team and resisted the German move.

The US apparently faced a choice of continuing with an inadequate US-developed diesel engine or adopting the German one against the established division of responsibility. Instead of choosing either option they decided to move their focus to formerly obscure gas-turbine technology and introduced a gas turbine engine into the MBT-70 specification.[109] The US plan was to replace the troubled Continental diesel with a Lycoming gas turbine, although

[105] TNA, DEFE, 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.
[106] TNA, DEFE, 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.
[107] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970. In a conversation with the author, Professor Ogorkiewicz related that, when the early Continental-engined MBT-70 prototype was started up in Germany, the local fire brigade responded, believing that the smoke was the result of a huge fire.
[108] Simpkin, *Tank Warfare*, p. 104.
[109] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 18.

this plan was, in the event, not followed up by the time of the project's cancellation.[110] The UK's evaluation of the Swedish 'S-Tank' trials indicated that gas turbine engines had a tendency to produce a large heat shimmer which was judged to be worse even than producing excessive exhaust smoke because smoke only tended to be an issue when the engine was revved to move, whereas the heat shimmer hovered above even a stationary tank.[111] As the initial MBT-70 design did not include a small charging set, intended to run electrical components while the main engine was powered down, the engine would have had to run for long periods even while stationary, so the heat shimmer would have represented a major problem for concealment.[112]

While under development, the US Lycoming Army Ground Turbine (AGT) 1500hp gas turbine was promised to run at a similar level of fuel efficiency as contemporary diesels. When eventually fitted, however, it proved to have double the fuel consumption, representing a major logistical implication for any tank fleet so equipped. Indeed, even at idle a gas turbine engine could consume ten gallons of fuel per hour.[113] An attempt was made in the 1980s to demonstrate better fuel efficiency in gas turbine engines and overcome the reluctance of other nations to use such technology in their tanks. A Garrett GT-601 gas turbine engine was test-fitted to a variety of NATO tanks and proved to have a consumption only 10 percent higher than an equivalent diesel. However, to achieve this, the engine was twice as large and heavy per horsepower as the AGT-1500 and thus offered no benefits over diesel engines.[114]

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[110] TMARL, E2014.3220, copy of article, Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', *Armies and Weapons*, p. 38.
[111] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970.
[112] TNA, DEFE, 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.
[113] Richard Chait, John Lyons, and Duncan Long, *Critical Technology Events in the Development of the Abrams Tank* (Center for Technology and National Security Policy, December 2005), p. 31, accessed via <http://www.dtic.mil/dtic/tr/fulltext/u2/a476340.pdf>, accessed 24 September 2017.
[114] John L. Mason, 'Why Gas Turbines for Tanks', *International Defense Review* 11 (1980), p. 89; Ogorkiewicz,*Tanks: 100 Years of Evolution*, pp. 296-297.

Sixteen prototypes were initially planned, eight each for the US and FRG. As costs rose, though, pressures on the budget led to a reduction in the planned prototypes to only six each.[115] The first MBT-70 prototype was completed in July 1967 at the Cleveland Army Tank Automotive Plant, operated by the Allison division of General Motors.[116] By the time the prototypes were built, it was obvious that compromising designs on paper by trying to please everyone was not possible when faced with physically building a tank. The two prototypes each suited their builder nation's military requirement more than they represented a collaborative compromise.[117] By 1968, for example, the FRG team had decided that the US Continental diesel engine was simply not powerful enough and decided to simply replace it on five of its prototypes with German Daimler-Benz MTU 873 Ka multi-fuel engines. The Continental produced 1475hp at 2300rpm, the Daimler-Benz produced 1500hp at 2600rpm. Practical testing of the prototypes began in 1969. Another six prototypes were built by each country by 1969, but by the end of that year the Federal Republic had decided to cancel the project.[118]

The high level of new and complex technology demanded by the project made at least some failures probably inevitable. Installing the Shillelagh missile system was one particular area of development that did not run smoothly. Getting the system correctly installed in the turret and solving the problem of the combustible cartridges led to delays. Faced with the problems that the US were having in developing and fitting the XM-150, the Germans, never convinced of the superiority of mounting an ATGM in the tank, began working on a more conventional 120mm smoothbore gun which subsequently replaced the XM-150 on the German prototypes.[119] Although the appearance of the prototypes marked the end of the

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[115] TMARL, E2014.3044, Information Sheet No. M/46/67 US/FRG MBT-70, 14 November 1967.
[116] TMARL, E2014.617,R. M. Ogorkiewicz, 'A Battle Tank for the 1970s - A US-German Design with Innovations', *The Engineer*,2 (February 1968), p. 198.
[117] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 19.
[118] TMARL, E2014.3220, copy of article, Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', pp. 37-44.
[119] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 18.

MBT-70 programme, the project had never really embodied a collaboration in any real sense. Neither country had fully accepted the specifications representing the military requirements of the other. The biggest warning flag that the project was finished must have been when it was obvious that future MBT-70 models would have to use different engines and armament depending on which country they were produced to supply.[120]

The project was pioneering and ambitious in many ways, which could have been a major benefit had the technology been made to function effectively. As it was, three main areas were assessed by the UK embassy staff as being, 'unduly sophisticated, complicated and thus expensive'. These were the driver in the turret, the variable height and tilt facility offered by the hydro-pneumatic suspension, and the autoloader.[121] The components planned for MBT-70 were ahead of their time and the difficulties inherent in their development added considerably to the design's delays and increasing costs.[122] As Ogorkiewicz put it, 'The […] inherent fault of the approach exemplified by the MBT-70 program was the assumption that, once a new concept was approved on the basis of analytical studies, sufficient resources could always be mobilised to put it into practice'; and, he added that 'In principle this may be true, but thenecessary expenditure of effort and money may be unacceptably high or evenunnecessary.'[123]

3. 5. Differences of Opinion

In the circumstances of the 1960s, it would have taken strong management decision-making and significant compromise to get both design teams to agree on what was required. The US

[120] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 19.
[121] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970.
[122] Hilmes, *Main Battle Tanks*, p. 20.
[123] Richard M. Ogorkiewicz, 'Combat Vehicle Test Beds: A Study of the Use of Test Beds in the Development of Combat Vehicles', May 1983, accessed via. <http://www.dtic.mil/dtic/tr/fulltext/u2/a131652.pdf>, accessed 6 March 2018.

M-60 was the result of continual upgrades of the same basic design that dated back to the M-26 of the 1940s; and, the US Army was in dire need of a completely new tank to replace it.[124] The Americans wanted a new MBT as soon as possible, but the Germans had almost finished development of the Leopard and were therefore looking at least a decade into the future before requiring a new tank model.[125] The US half of the MBT-70 project team were committed to the US components and tank specifications that had been drawn up before the agreement to collaborate. Having invested almost six years in drawing up specifications for the M-60's replacement, the US was reluctant to abandon or compromise that work. McNaugher reported: 'Some members of the Army's Tank Automotive Command apparently assumed that the joint program would involve little more than a continuation of their component development efforts, perhaps with a certain amount of German "kibitzing" in the background.'[126]

The timescale and existing investment aside, the United States and the Federal Republic had different military requirements linked to their respective military doctrines. The FRG's tank doctrine in this period called for short-range engagements (1000 metres or less) in a highly mobile form of manoeuvre warfare.[127] Consequently, they were less concerned about long-range firepower and protection than with ensuring low weight and high mobility. The FRG was looking at a vehicle that could negotiate West Germany's secondary road network and bridges, and hence wanted a tank that met the MLC-50 limit, looking for a tank weighing a maximum of 46 tons.[128]

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[124] TMARL, E2014.3182, MBT-70/XM-803 Information Sheet, 18 June 1970.
[125] Decker, 'The Patton Tanks', p. 313.
[126] McNaugher, *Collaborative Development of Main Battle Tanks*, p. 11.
[127] Ibid., p. 12.
[128] Ibid. German doctrine did not change greatly between the late 1950s and the early 1970s, with the influence of the German Army's experience in Russia, 1941-45, still very much in evidence. In the updated doctrine manual of 1973, it was noted that in the case of armoured combat forces: 'Their particular strength is their ability to launch surprise counter-attacks which they conduct, if possible, against the enemy's flank or rear, but frontally only after attaining fire superiority.' Führungsstab des Heeres, *H.Dv. 100/100. FührungimGefecht* (Bonn, 28 September 1973), Ch. 27, para. 2719.

By contrast, the US Army's tank doctrine of the time, which was based on bringing enemy tanks under long-range fire from defensive positions, called for tanks to have a reasonable chance of hitting and destroying the enemy at ranges of between 2000 to 3000 metres.[129] This was at the upper limits or beyond the capability of contemporary tank guns and aiming systems, so the US looked to anti-tank guided missiles (ATGMs), which had longer effective range and could use infra-red guidance to hit their targets. Unlike conventional tank gun rounds, missile diameters are also not restricted by the calibre of the firing gun and can, therefore, carry a relatively large shaped-charge high-explosive anti-tank (HEAT) warhead. As a consequence of planning to fight at long range from relatively static defensive positions, US tank designs did not need to place a high emphasis on mobility, andcould thus afford the luxury of heavy armour; hence, the US design aimed for a 55-ton weight limit (MLC-60), nine tons and, significantly, one bridging class higher than the German limit.[130]

Gary Bloedon wrote at the time that the divergent tank philosophies within NATO could best be seen by comparing the contemporary MBT designs of France, the FRG and the UK (the USA's tank design philosophy largely agreed with that of the UK). The AMX-30 weighed 35.8 tons with a road speed of 40mph, the Leopard 1 weighed 42.9 tons with a road speed of 42mph, but the heavily-armoured Chieftain weighed 56.2 tons and had a 25mph road speed. The French and German tanks both had 105mm guns, but the UK had opted for the 120mm. The proponents of lighter armour cited the ability of modern weapons to defeat practically any thickness of armour, concluding that the loss of mobility associated with extra armour was not a worthwhile exchange. Bloedon pointed out, however, that there has never been a time in the tank's history when it has been invulnerable to contemporary weapons. He

129 McNaugher, *Collaborative Development of Main Battle Tanks,* p. 11
130 Ibid.

suggested that saving money by reducing the effectiveness of a tank is a false economy, noting, 'I feel that a tank that cannot do the job is more expensive than one which can.'[131]

The USA was committed to using the XM-13 Shillelagh ATGM system in the new tank. This suited their doctrine of engaging opponents at long-range from defensive positions, but the system proved expensive and highly complex. The price of the missile system would have been a hugely significant part of any tank it was fitted to, actually costing more to develop than any proposed tank design. It should be noted, however, that some in the American military were as unconvinced as the Germans of the superiority of the ATGM over the conventional tank gun, and many advocated retaining a gun for the new tank. To break the impasse, the US team decided to modify the Shillelagh to fire conventional APFSDS rounds as well as missiles. The result was the XM-150, a 152mm gun/missile launcher which was even more expensive, complicated and time-consuming than the XM-13 both to develop and produce.[132]

The FRG were primarily unconvinced by the XM-150 gun/launcher because they did not believe that the likely engagement ranges in Central Europe would be long enough to see the advantages of using the Shillelagh as the tank's main armament. In addition, the contemporary cost of the missiles at between $2500 and $3000 each compared unfavourably with the $240 cost of a conventional 105mm HEAT round. The FRG estimated that on a 1500-tank production run of a XM-150-armed MBT-70 (1500 tanks being the production numbers for their recent Leopard 1), each tank would cost them DM 2.4 million compared with DM 2.2 million for a similar run of a conventional 120mm-armed version.[133] In addition, using 152mm tank rounds meant that the tank could not carry so many reloads and manual reloading would be slow and tiring. The MBT-70 partly solved the problem of shell

[131] Capt. Gary W. Bloedon, 'How Heavy the Thunderbolt', *Armor*, 75 (May/June 1966), pp. 51-53.
[132] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 11, 15-16, 256.
[133] TMARL, E2014.617, A Battle Tank for the 1970s - A US-German Design with Innovations.

weight by using an autoloader system which held eight rounds in the autoloader and could reload from a magazine of 26 rounds.[134] However, holding only 26 rounds, let alone only 8 'ready' rounds, was a liability for an armoured doctrine which emphasised manoeuvre and mobility, although not so much of an issue for tanks that were intended to engage the enemy at long range from static positions.

US doctrine was also somewhat different to what had been issued by the *Bundeswehr* when addressing the dangers of battlefield nuclear radiation protection for the tank crew.[135] A nuclear weapon detonation involves the release of both neutron and gamma radiation, the former primarily from the initial burst and the latter from 'fallout' resulting from the gamma radiation contaminating the surrounding terrain and then being emitted from the earth. While tests showed that standard steel AFV armour gave good protection against gamma radiation even on less well-armoured vehicles, it was much less effective against neutron radiation. Adding dedicated polyethylene shielding could significantly reduce the neutron radiation passing into the tank but this was bulky and added weight.[136] The US team decided that it was not worthwhile attempting to provide significant protection against neutron radiation by adding bulky shielding to their tanks, but the FRG team were more interested in providing a higher measure of nuclear-biological-chemical (NBC) protection.[137] However, the Germans were prepared to compromise to attain a lower weight, accepting a reduction of both the NBC and armour protection, even though the radiological protection being reduced was already

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[134] Richard Ogorkiewicz, *Technology of Tanks, Vol. 2* (Coulsdon, 1991), p. 400; and, TMARL, E2014.3049, US/FRG Tank, 8 January 1968.

[135] The main manual for armoured units at the time even claimed that: 'Basic armor doctrine is generally applicable under conditions of both active and nonactive nuclear war and major changes in tactics and techniques are not required. The impact of nuclear weapons on the battlefield is considered to require, primarily, increased emphasis on dispersion and the armor protection and mobility of armor units.' HQ, Dept. of the Army, *FM 17-1. Armor Operations* (Washington DC, 14 October 1966), Ch. 2, Sect. II, para. 16.

[136] US Army Nuclear and Chemical Agency, *Nuclear Notes Number 8: Armored Vehicle Shielding against Radiation* (May 1979), accessed via. <http://www.dtic.mil/dtic/tr/fulltext/u2/a112303.pdf>, pp.8-11, accessed 10 January 2018.

[137] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 13.

'considerably less' than initially specified by them.[138] The Americans, however, did not wish to reduce the armour on their designs and thus the problem of weight remained.

Finally, in almost a parody of the difficulties faced by international collaborations, the two sides could not agree on whether the screw threads should be in metric or imperial.[139] Neither side was prepared to alter their existing industry-standard tooling for the sake of the project, believing that such a move would adversely affect their respective industrial and logistics chain. The FRG put the case that metric was becoming the standard system of measurement throughout the world, but the US countered by pointing out that the USA, UK and Canada still used imperial and that the 'unified inch' was still commonly used worldwide for screws and other fasteners, independent of the rise of metrication in other measurements. Following a year of disagreement at PMB level, the decision was passed up the political hierarchy for the respective national governments to deal with.[140] The eventual compromise reached was to use metric for FRG-produced components and imperial for those produced in the USA. Where two components joined, the thread would be metric.[141] One can only imagine the impact such an arrangement would have had on supply and maintenance teams in theatre had it been adopted.

The MBT-70's requirement as reached through the collaborative process was a compromise which did not satisfy either nation. The main armament was a major point of disagreement, with the FRG doubtful of the utility of the missile system and preferring a conventional gun. Meanwhile, the USA did not believe that the NBC-protected capsule in the turret was required and would have preferred to use the space and weight either to decrease

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[138] TMARL, E2014.3044, Information Sheet No. M/46/67 US/FRG MBT-70, 14 November 1967.
[139] BA-MA, BH1/1754, Kampfpanzer 70. – Deutsch-amerikanisches Rüstungsprojekt, 1964-1968, Dr A Schmidt, Bundesamt für Wehrtechnik und Beschaffung, Koblenz, to General Trettner, General-Inspekteur, im Bundesministerium der Verteidigung, 17 February 1965.
[140] BA-MA, BH1/1754, Kampfpanzer 70. – Deutsch-amerikanisches Rüstungsprojekt, 1964-1968, Requirement for Standardization of Threaded Fasteners (Metric vs. Unified Inch) for MBT-70 Program, 5 June 1964.
[141] TNA, DEFE 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.

the vehicle weight or, more likely, increase the armour. Some of the main points of disagreement were managed simply by incorporating both the conflicting requirements into the design. Thus, the debate over the Shillelagh missile system versus the conventional gun resulted in attempts to develop a 152mm kinetic energy (KE) round with a combustible cartridge case. The FRG's commitment to NBC shielding, with the attendant additional weight and bulk, was also added to the specification without any concomitant reduction of other components to compensate.[142]

Part of the problem was that, at the stage when the military characteristics were being drawn up, the designs existed only on paper, so the practical problem of incorporating so many different components was overlooked. Severe problems caused by the collaborative nature of the project became far more obvious once the design had moved to the prototype phase.[143] The German components were reported by the US to be, 'too heavy or didn't work very well', and the US claimed that these components were holding up the project and delaying development. US components were reported by the FRG, on the other hand, to be too expensive and complicated, and, in particular, the Germans were unconvinced by 152mm gun/launcher.[144]

Rather than acting as a final arbiter for the two conflicting national design proposals, the Lockheed PD/CE study that appeared in February 1965 appears to have simply supported proposals from both sides. Dolvin, who was jointly responsible for initiating the PD/CE study, is quoted as saying that while, 'the PD/CE Study did play an important role in the decision process […], it should be emphasized that it was not the sole source for decision.' Another participant noted: 'It appears as if the mass of data generated by the PD/CE Study

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142 McNaugher, *Collaborative Development of Main Battle Tanks*, pp. 14-16. Note that a combustible cartridge case is designed to burn up in the gun's chamber and leave no fouling residue to be removed, as opposed to the more conventional brass case which must be removed and disposed of after each firing.
143 Ibid., pp. 16-17.
144 TMARL, E2014.3182, MBT-70/XM-803 Information Sheet, 18 June 1970.

did not change greatly the design being approached by the unilateral US program which had already been initiated.'[145] Although the MBT-70 project led to prototypes in 1967, by that stage of the programme there had been significant increases in costs and lengthening of time estimates which had reduced the popularity of the whole project.[146]

3. 6. The End for MBT-70

The collaborative basis for the MBT-70 began to fall apart as the project settled into an unofficial policy of parallel development of components and disagreement over the tank's requirements, In late 1967, the first prototypes appeared and these demonstrated how far the two nations had abandoned any serious commitment to joint development. Two key areas for military interoperability and standardisation are the gun and the engine; in neither of these areas did the MBT-70 prototypes show any acceptance of the principles of standardisation. German models contained German diesel engines while US prototypes held the troubled US engine, with the new gas turbine in development and likely to replace it. Although the Shillelagh XM-150 was mounted on the prototypes of both countries, the Germans were committed to replacing the ATGM system with their 120mm smoothbore gun when it became available.[147]

Interestingly, in September 1968 MBT-70 was the sole remaining international collaborative weapons programme within NATO, following the cancellation of the US/German V/STOL fighter programme in early 1968. However, duplication of effort combined with problems associated with using new technology meant that even by 1967, the

[145] McNaugher, Collaborative Development of Main Battle Tanks*,* p. 14.
[146] Ibid., p. 1.
[147] Ibid., pp. 18-19.

schedule and cost had over-run by a significant margin. Support for the MBT-70 project started to decline both in the United States and the Federal Republic.[148]

As of 14 November 1967, the project was two years behind schedule. The MBT-70's In Service Date (ISD) had originally been December 1969 and, although the US now accepted an ISD of 1971, the FRG was happy with an ISD of 1972.[149] Pressure on the programme was mounting. The UK's Master General of Ordnance visited the USA in 1969 and ascertained that a reappraisal of the project would be completed by the end of that year. He believed that, if the FRG dropped out, which was thought 'more than likely', then it was probable that the USA would continue alone.[150] The Federal Republic did not abandon the project completely in 1969, but instead significantly reduced its involvement because they saw rising costs as well as the programme not meeting their own requirements.[151]

In particular, the Federal Republic was not as insistent as the US on the project completion date: it had already brought Leopard to near production status at the time of McNamara's approach to collaborate; the tank entering service in 1965. To fund an increasingly expensive MBT programme due to reach production five years after the Leopard was a somewhat profligate use of scarce funds at a time when the FRG was still building its armed services. Aggravating the issue was the USA's apparent willingness to increase the costs of the MBT-70 project in order to speed it up; the US having urgent need of a replacement for the existing M-60. In February 1968, Robert McNamara resigned as US Secretary of Defense following disagreements with President Lyndon B. Johnson over the United States' role in Vietnam. By 1969 the Office of the Secretary of Defense under

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[148] Walter Andrews, 'Major Investigation of MBT-70 Program', *Armed Forces Journal*, 21 September 1968; McNaugher, *Collaborative Development of Main Battle Tanks*, pp. vi-vii.
[149] TMARL, E2014.3044, Information Sheet No. M/46/67 US/FRG MBT-70, 14 November 1967.
[150] TMARL, E2014.3069, British Embassy Information on Agreement Suspension of MBT-70, 29 September 1969.
[151] McNaugher, *Collaborative Development of Main Battle Tanks*, p. vii.

McNamara's replacement, Clark M. Clifford,[152] was questioning the entire MBT-70 programme. Cost and complexity made it unlikely that replacing the entire fleet of M-60s with the MBT-70 would be practical or possible. In September of 1969 the Deputy Secretary of Defense suggested to Congress that the programme be streamlined and simplified wherever possible.[153] The German newspaper, *Süddeutsche Zeitung*, announced on 12 September 1969 that the USA had suspended development on the project although no official announcement had been made up to that point. The USA had, however, reduced the project's funding by a 'substantial but unspecified' amount.[154]

The programme incorporated the requirement for collaborative agreement at each of its key stages, yet, despite this, by 1970 the project broke down in disagreement over the required characteristics.[155] One US participant commented that:

> There could be nothing worse than one army or the other being forced to accept a piece of jointly developed equipment that did not meet its own requirements. US Army priority requirements for a piece of equipment must not be sacrificed for the sake of a politically desirable international program.[156]

If West Germany was unhappy at the way the US was pushing the MBT-70, the US Army was also unhappy with the direction the project had taken, believing that too much compromise had been agreed simply to keep the programme alive.

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[152] Clark M. Clifford replaced McNamara as US Secretary of Defense on 1 March 1968. He only held the post for 11 months and during that time was mainly focussed on US involvement in the Vietnam War. He continued McNamara's Cost Reduction Program, as indeed he did most of McNamara's other policies. Clifford's tenure as Secretary of Defense ended with the fall of the Johnson administration on 20 January 1969. See Historical Office, Office of the Secretary of Defense, 'Clark M. Clifford', <http://history.defense.gov/Multimedia/Biographies/Article-View/Article/571292/clark-m-clifford/>, accessed 10 March 2018.

[153] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 24, 26.

[154] TMARL, E2014.3069, British Embassy Information on Agreement Suspension of MBT-70, 29 September 1969.

[155] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 3.

[156] Ibid.,p. 25.

The Ministry of Defence in Bonn funded their half of the MBT-70 programme by receiving the money in block sums over a five-year period, and thus the initial allocation was negotiated in 1963 when the original project estimate was $80-$100 million. As with most parliamentary systems, once funding had been allocated it was difficult to secure further project funds from the Ministry of Finance within that same five-year period. This made the increasing estimated cost of the MBT-70 project a problem for the Federal Defence Minister and, at the time of the first increase in estimate to $138 million in 1965, the country could no longer afford to divide the costs equally. To maintain the collaboration, the USA agreed to pay the excess and thus contribute $85 million to the FRG's $53 million. When the project's estimate again rose in 1968, this time to $300 million, it marked a new five-year period and the Defence Ministry was once more in a position to enter negotiations willing to pay half of the development costs. Although able to secure the funding, the increasing cost estimates were causing concern on both sides.[157]

Unconfirmed figures estimated that eventual production figures would have been between 1000 and 1500 units for the USA and 500 for the FRG. Estimates and rumours of MBT-70 unit production costs varied between $400,000 and $750,000 per tank.[158] Such figures led the German Finance Minister in 1969 to express 'great scepticism' over the cost-effectiveness of the MBT-70.[159] How cost-effective it would have finally proved to have been will never be known, for, in January 1970, the collaborative MBT-70 programme formally ended. The US Deputy Secretary of Defense declared that the programme would instead lead

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[157] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 23-24.
[158] TNA, DEFE, 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.
[159] TNA, DEFE, 13/1368, MBT, Record of Conversation Between Secretary of State for Defence and Herr Franz J. Strauss, German Finance Minister, in Munich on 3 February 1969.

the drive towards interoperability and commonality in future tanks that each nation would design and build unilaterally.[160]

McNaugher points out that the costs surrounding the MBT-70 project are difficult to debate accurately because no production tank was produced and no parallel sovereign project took place that can be taken as a control comparison.[161] Although MBTs were certainly designed and built in the period, the plan for MBT-70 was uniquely complicated and incorporated untested and highly complex technology. Some components and subcomponents were never completed and fitted, so we will never know if they may have been value for money or an expensive failed experiment. Although each tank would obviously have had an individual unit production cost, the cost of development becomes less significant as more units are produced. It is possible that wholesale adoption by the US and FRG would have encouraged other NATO countries to buy the MBT-70, and the final production numbers might have been high enough that the initial research and development investment looked proportionately more reasonable. Another unknown question is how much the process of collaboration added to the final cost of the project, although it is difficult to see how the price could have been the same had there not been the duplication of agencies and component development, and the long and repeated periods of international negotiation.

Estimates of total project costs, to be shared equally between the USA and the Federal Republic, began at between $80 and $100 million in August 1963, with an estimated completion of the prototype by January 1967 and the first production vehicles by December 1969. It should be noted that the FRG had insisted that McNamara's starting figure of $80 million was unrealistic and had thus argued for the estimate's upper limit of $100 million. Having more recently completed an MBT programme of their own, it is possible that the FRG were simply more aware of the potential costs involved, or perhaps McNamara gave a

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[160] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 26.
[161] Ibid., p. 20.

lower estimate to make the project seem more attractive. Whatever the reason for the low initial estimate, two years later in August 1965 it had risen to $138 million. In December 1966, this rose to $200 million and the delivery of prototype and production vehicles had slipped to July 1967 and December 1970 respectively. The 1970 production vehicle delivery estimate lasted less than a year; in September 1967, it was pushed back to December 1971. This was the final delay in the estimated delivery date, but the joint project itself was abandoned in January 1970. Although the delivery schedule had seen its final change in 1967, the cost estimate was to rise again. In March 1968 it increased this time by 50% of the 1966 estimate to $300 million. In five years, the budget estimate had risen by no less than 300%.[162]

In April 1969, the FRG announced that it would be building its own tank and that it would bear little resemblance to MBT-70. It did not completely abandon the project agreement and was still willing to buy a number of MBT-70s if and when they were produced but intended to buy far fewer than originally indicated. In addition, the FRG announced that it would discontinue funding the MBT-70 programme, although both countries did agree to continue pursuing standardisation.[163] David Packard, US Deputy Secretary of Defense, declared on 15 December 1969: 'Based on information to date, I have concluded that I will not approve development of MBT-70 under the current system.'[164] Each nation in the collaboration blamed the other for failure and the problems in the project, seeing intractability over military requirements and design specifications as responsible for the rising costs and delays.[165] Following the termination of the agreement, some US officers felt that the Germans had bought '26 years of technical tank know-how.'[166]

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[162] McNaugher, *Collaborative Development of Main Battle Tanks*, Table 2: Changing Costs and Schedule Estimates for MBT-70 and MBT-70/XM803 Programs, 1961-1970, p. 21.
[163] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 25.
[164] TMARL, E2014.3150, MBT-70, January 1970.
[165] McNaugher, *Collaborative Development of Main Battle Tanks,* p. 24.
[166] TMARL, E2014.3182, MBT-70/XM-803 Information Sheet, 18 June 1970.

The total spent on the MBT-70 project was $138 million by the USA and $75 million by the FRG.[167] A major investigation into the causes of delays and cost increases was instigated by US Representative William E. Minshall, whose district included the Cleveland Tank-Automotive plant. On the subject of delays within the MBT-70 programme, Minshall suggested: 'No doubt, some are attributable to it being a joint program, but it must be some kind of a record to have a program this far behind.' Defence officials had reported the increase in the MBT-70's R&D funding was due to the additional time required, a duplication of components, major changes in the military characteristics and modifications, and developmental problems with the 'coke bottle' autoloader. The time over-runs were blamed on a lack of any proper time analysis at the beginning of the programme.[168]

After the end of the programme, the US and FRG decided to develop MBTs unilaterally while continuing to cooperate to achieve commonality.[169] It is interesting to compare this statement of intent with what actually happened during the collaboration, when each nation effectively developed unilateral tanks with little obvious commonality other than at a superficial level. After $218 million spent on the project, neither partner can be said to have benefited and the USA might even be said to have ended up in a worse position than before. It still needed, after all, to develop a replacement for the M-60 and was now several years behind schedule and $138 million out of pocket. McNaugher notes that the principle obstacle to US-FRG collaboration from 1971 onwards was US domestic politics, since members of the US Congress opposed the joint project out of fear that it would delay the introduction of a badly-needed new main battle tank into the US Army.[170]

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[167] TMARL, E2014.3220, copy of article, Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', p. 39.
[168] Andrews, 'Major Investigation of MBT-70 Program', passim.
[169] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970.
[170] McNaugher, *Collaborative Development of Main Battle Tanks,* p. viii.

3. 7. US-FRG post MBT-70 'Harmonisation'

As announced in 1969, the Federal Republic of Germany began to work on its own MBT design, later to become the Leopard 2. In 1970, the US decided to abandon the collaborative MBT-70 project entirely and instead begin development of a less technologically advanced, and consequently less expensive, version of the MBT-70 design, the XM-803, initially and unofficially referred to as MBT-75 in general conversation.[171] The XM-803 was to retain the three-man crew including the driver in the turret, the Shillelagh system, and hydro-pneumatic suspension.[172]

While the new tank was intended as a simplified and 'austere' answer to the overly complex MBT-70, in one area at least the XM-803 development team took what can be seen as a retrograde step. The inadequacy of the Continental diesel engine had been recognised and it was intended that this would be replaced in XM-803 by the Lycoming XM-1500 gas turbine, then still under development.[173] In the event, MBT-70 proved almost impossible to simplify sufficiently to satisfy the requirements of the XM-803 programme. Too many fundamental technical decisions had been incorporated into the original design in order to accommodate the advanced components. Simplifying the turret, for example, would have meant overturning all the design decisions taken to fit the Shillelagh, automatic loader and NBC pod, effectively calling for a complete redesign. A 1971 British Embassy DRDS memo reported of XM-803 that, 'Most crew positions seem to have so many switches and test panels that they look rather like the cockpit of a 747. [...] I hope they can train their soldiers to switch them all on in the right order.'[174]

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[171] TMARL, E2014.3066, MBT-70. British Embassy Munitions Group Information Sheet, February 1969.
[172] TMARL, E2014.3058, British Embassy Munitions Group Information Sheet on MBT-70 – XM-803, 11 March 1970.
[173] TMARL, E2014.3182, MBT-70/XM-803 Information Sheet, 18 June 1970.
[174] TMARL, E2014.3194, British Embassy Defence Research and Development Staff, MBT-XM803, 23 March 1971.

Improvements in kinetic energy rounds for conventional 120mm guns made mounting an ATGM system as a tank's main armament look less attractive, and the Shillelagh was in any case still proving expensive and unreliable.[175] The XM-13 missile system did see use as the M-81 on the M-60A2 'Starship', which entered service as an 'overwatch' tank in 1974, and also on the M-551 Sheridan Armoured Reconnaissance Airborne Assault Vehicle (ARAAV), or light tank.[176] Its use, despite its unreliability and limitations, may have been due to 300 XM-13 turrets having been ordered in 1966 before the missile system's problems had been rectified.[177]

XM-803 was intended to cost only a quarter of that of the MBT-70 costs to date, $585,000 per tank as against a high point of $2.4 million for MBT-70. Within a year this figure had grown to a projected estimate of $650,000 per tank for XM-803.[178] At this point, the US Congress decided that the entire programme was too expensive and the whole idea was scrapped. In December 1971, the joint House-Senate conference committee recommended:

> The committee continues to feel that the MBT70/XM803 is unnecessarily complex, excessively sophisticated and too expensive, and that the Army has failed to satisfy the recommendation of the committee report on the fiscal 1970 bill. For these reasons the Committee has recommended that all funds for the MBT70/XM803 be deleted from the budget and the program be terminated.[179]

The cost of the cancellation itself was $40 million.[180]

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[175] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. 26-27.
[176] The M-551 Sheridan was used by US Cavalry units in Vietnam where any anti-tank superiority that the Shillelagh missile system may have possessed was vastly overshadowed by a requirement to use it in a close infantry support role. The most useful feature of Shillelagh in such circumstances was the ability to fire 152mm canister rounds. See, for example: John B. Poindexter, 'The Anonymous Battle', *Armor,* 109 (Jan-Feb 2000), pp. 20, 22, 27, 29; and Adshead &Ayliffe-Jones, *Armour of the West*, p. 93.
[177] Hilmes, *Main Battle Tanks: Developments in Design since 1945,* pp. 18-19.
[178] TMARL, E2014.3220, copy of article, Baud 'MBT-70/Kpz-70: Revolutionary but Luckless', p. 39.
[179] Sunell, 'The Abrams Tank System', p. 434.
[180] TMARL, E2014.3220, copy of article, Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', p. 39.

The XM-803 programme had lasted just less than two years. Aware that time was running out for its existing fleet of tanks, upon the cancellation of the XM-803 project the USA looked instead at upgrading its existing M-60A1s. This project was designated XM-815 and the proposed tanks would eventually be known as the M-60A3. In the meantime, studies began into a completely new tank, provisionally known as XM-1 but later to become the M1 Abrams.[181] Like so many projects, both civil and defence, before and since, the original estimates for both MBT-70 and XM-803 proved optimistic. Projects that come in on budget and on time are rare, and defence projects are no exception.[182] Peter Morris and George Hough point out that project overrun is so common that it is the norm rather than an exception, with the reverse, underruns being extremely rare. Almost every project management study into the phenomenon from the 1980s and 1990s shows the same result, and more complex projects are, perhaps understandably, most liable for overrunning. Although late completion and unexpected problems are certainly not rare, the most common manifestation is cost overrun, with costs typically between 40% and 200% of the original estimate. Significantly, a survey of US Army programmes showed that they overran by up to 400%. [183]

The FRG also looked to adopt a far simpler MBT design, originating from the 1968 'Keiler Study' into MBT-70. The three-man crew and autoloader arrangement was abandoned to be replaced by a more conventional four-man crew and manual loader. The armament reverted to the FRG's favoured option of a conventional smoothbore gun and the first Leopard 2 prototype was complete by 1972. Although the early prototypes tested a wide

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[181] TMARL, E2014.3220, copy of article, Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', p. 39; Decker, 'The Patton Tanks', p. 318; Chait, Lyons and Long, *Critical Technology Events in the Development of the Abrams Tank*, pp. 5-7.

[182] For just a few examples of project overruns, see Peter W. G. Morris, *Management Projects* (London, 1994), pp. viii, 40, 70.

[183] T. Williams, 'Assessing and Moving on from the Dominant Project Management Discourse in the Light of Project Overruns', *IEEE Transactions on Engineering Management*, 52:4 (2005), p. 498. Williams draws here from Peter W. G., Morris and George H. Hough, *The Anatomy of Major Projects: A Study of the Reality of Project Management* (Chichester, 1987).

variety of options, including a 105mm rifled gun and hydro-pneumatic suspension, the production vehicle used a conventional torsion bar suspension and mounted the FRG's own 120mm gun. Ironically, following the lessons of the 1973 Yom Kippur war, the protection, and consequently weight, was increased. The Leopard 2's upper weight limit was raised from the MLC-50 limit which had frustrated the MBT-70's US designers, to MLC-60, which the FRG had vehemently resisted during the collaborative programme.[184]

After the 1971 collapse of the MBT-70 project, it was two years before the possibility of main battle tank collaboration between the USA and FRG was again mooted.[185] This time that agreement was for the US and FRG to 'make all reasonable efforts' to achieve standardisation between tanks. The study costs, up to $1 million each, would be shared. Any overrun would have to be negotiated.[186] The agreement was not without its critics in the US, who saw it as yet another potential blow to the new US tank's ISD. It was the same US Congressmen opposing collaboration who were also the main reason both the MBT-70 and XM-803 projects were cancelled. They were also prominent in establishing the XM-1 project, both by securing funding and in demanding assurances that the XM-1 would come in on budget and on schedule.[187]

Despite some objections, particularly to any potential adoption of the German 120mm, a 1974 MOU was signed which set out that the USA would examine the Leopard 2 for possible purchase and, if that did not happen, the two countries would look at bringing a measure of commonality between the Leopard 2 and XM-1 designs by sharing components. Finding commonality between the XM-1 and Leopard 2 began with no specific goals, the 1974 contained no specific outcomes, areas of collaboration or developmental cooperation.

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184 Hilmes, 'Modern German Tank Development, 1956-2000', p. 18.
185 McNaugher, *Collaborative Development of Main Battle Tanks,* p. vii.
186 TNA, FCO, 46/1371, Collaborative Procurement: Tanks, MOU between USA and FRG Concerning Harmonization of US Tank XM-1 and FRG Tank Leo II, December 1974.
187 McNaugher, *Collaborative Development of Main Battle Tanks,* p. viii.

The FRG agreed to modify and supply a Leopard 2 for the US Army to test, but US testing and development of the XM-1 was unaffected.[188]

In 1976, an amendment to the MOU committed the US Army to buy the FRG's Rheinmetall 120mm smoothbore gun to mount on the XM-1. In exchange, the FRG would test a US turbine engine and consider mounting it in the Leopard 2. This MOU caused a 120-day delay, the first such delay, in the XM-1 programme development, to allow the design to be modified and for bidding companies involved in the engine and gun mounting components to modify their submissions. Congressional criticism of the 1976 amendment to the MOU was particularly strong in the House Armed Services Committee, where there was opposition both to the delay the amendment caused and to the decision to mount the German 120mm gun. Questions were raised about both the effectiveness of the gun and its impact on the XM-1's schedule and cost.[189] At this time, it should be borne in mind, the debate was still ongoing over the relative effectiveness of a smoothbore versus a rifled gun, with many in the US Army unconvinced that a smoothbore offered the same effectiveness. Gun trials were planned and submissions invited from the FRG and UK, but a British Embassy DRDS letter of the time noted that, despite the US Army being eager to proceed slowly enough to give the British developers a chance to design and submit a new rifled 120mm gun that met US requirements, a great deal of political influence was, 'emanating from Secretary Rumsfeld [the US Secretary of Defense] …[who did] not intend things to go that way'.[190]

In September 1976, the US Congress passed the 'Hillis Resolution' which put the 1976 MOU amendment on hold for a year and ensured that future collaborative measures in

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188 McNaugher, *Collaborative Development of Main Battle Tanks,* p. vii-viii, ix.

189 Ibid., p. ix. At the time, there were high hopes for the XM-1 tank. According to one article in a defence journal, published around 18 months after the 1976 MOU: 'The XM-1 represents a fundamental moment in the history of American tanks and a conceptual and qualitative leap forward, in respect to the vehicles which preceded it in the ranks of the U.S. Army.' Anon., 'XM-1', *Armies & Weapons*, No. 40 (Dec. 1977/Feb. 1978), pp. 55-62, quote, 62.

190 TNA, FCO 46/1371, NATO: collaborative procurement of tanks; 1976. Defence Research and Development Staff, British Embassy, Washington, letter to DUS(P), Future Main Battle Tank, 17 August 1976.

the XM-1 programme had closer Congressional involvement. In November that year, Chrysler won the contract for the XM-1 and the development programme continued independently of the FRG-US collaboration agreement. A year later, the US Secretary of the Army announced in January 1978 that the US Army would adopt the FRG Rheinmetall 120mm for the XM-1, and that it would be fitted once it had undergone testing and modification to allow it to fit inside the US tank. Until the 120mm was ready, the XM-1 would be equipped with the existing 105mm.[191] In the end, greater standardisation emerged from two separate tank programmes than from a dedicated collaborative programme, and the arguments over the main gun were only solved when the political pressure to collaborate had been relaxed.

3. 7. Project Evaluation and Analysis

As before, we will use Fortune and White's project analysis framework to provide a structure of the project's critical success factors for analysis.[192]

Component of Formal System Model	***Evidence of Critical Success Factors in MBT-70 Project***
Goals and objectives.	• Both the USA and FRG saw political advantages in collaboration, and McNamara was also eager for collaboration to reduce the costs of developing a new MBT. • The US needed a new MBT design, but the FRG had less need due to having recently developed Leopard. • Despite reaching a consensus on the general characteristics of a new tank, the design process was very fluid, with neither nation agreeing a specific design goal.
Performance monitoring.	• Each nation had its own separate design team and they did not work jointly.
Decision-maker(s).	• No overall decision maker. • When the national project managers could not agree, the

[191] McNaugher, *Collaborative Development of Main Battle Tanks,* pp. ix-x.
[192] Joyce Fortune and Diana White, 'Framing of Project Critical Success Factors by a Systems Model', *International Journal of Project Management*, 24 (2006), p. 57.

	decision was made by discussion between political leaders rather than technical experts. • Political support vulnerable to internal political pressures.
Transformations.	• The US, in particular, wanted to innovate as much as possible and thus looked to new and unproven technology. • Innovative components adopted because of pressure from external contractors rather than being demand-led.
Communication.	• Language issues caused communication problems. • Two teams working in different continents with limited technology available for international communication.
Environment.	• Both nations were politically stable but subject to internal political pressures from governmental opposition. • Despite the previous Franco-German project failing largely due to a withdrawal of political support, the MBT-70 project did little to avoid the same fate.
Boundaries.	• The project attempted to bring in a large number of untested and complex technologies. • The number of people involved was inflated due to doubling the project teams to have one parallel team in each country. • FRG wanted a conventional gun, but the USA insisted on a missile launcher as the main armament.
Resources.	• Although the resources allocated by the USA were generous, Senate overview meant that they had to be seen to be justified. • The FRG was less willing to invest heavily in a new project when their existing tank programme seemed adequate for their needs. • US suppliers were eager to push new and untested technology. • FRG intention to equip MBT-70 with conventional 120mm gun, with the USA equipping theirs with 152mm missile launcher, ran contrary to aim of standardisation.
Continuity.	• Splitting the development team into two national teams limited any ability to detect or deal with differences of opinion. • Split management meant that change management sometimes had to be made at national government level.

The analysis framework presented above highlights several interesting factors which affected the MBT-70 project. Perhaps most significantly, there seems little evidence of true collaboration between the design teams. By splitting into two, separate, national teams, the MBT-70 developers compounded existing hurdles of language and culture. Whilst the USA pushed to include untested and experimental technology, the FRG appears to have been more conservative in their aims. In particular, the FRG disagreed strongly with the US insistence on equipping MBT-70 with a missile launcher rather than a conventional gun, so much so that they intended to equip their own MBT-70 with a 120mm gun, contrary to the programme's aim of standardisation.

Resources, a critical requirement of any project, initially appeared sufficient, but Senate and Federal government oversight meant that such resources were not unlimited. Concentrating on new and advanced technology inevitably meant that project costs rose faster than an equivalent project using more established components.

3. 8. Summary

What lessons can be drawn then from the ill-fated MBT-70 project? Frinsdorf, et al., suggest that the efficiency of defence projects is dependent on matching the project to the organisation's capabilities, appropriate support from senior managers, a well-defined and understood project scope, strong communication pathways and availability of appropriate resources. They also advise that periodic reviews be undertaken and any issues addressed as soon as possible.[193] There is little doubt that if MBT-70's ambitious technical goals had been attainable then the FRG and USA would have been high on the list of nations able to achieve them. While not everyone was convinced about the advisability of a collaborative MBT project, it appears that political support was at least adequate. Management decision-making must be questioned, though, and most significantly the extraordinary decision by Dolvin and

[193] Olivia Frinsdorf, Jain Zuo and Bo Xia, 'Critical Factors for Project Efficiency in a Defence Environment', *International Journal of Project Management*, 32 (2014), p. 813.

Engelman to completely split the project team. Resources were certainly available up until the project was cancelled, but the requirements for 'a well-defined and understood project scope' and 'strong communication pathways' were quite clearly lacking.

Although not specifically considering defence projects, Bresnan and Marshall's study of cooperation in engineering partnering projects found that:

> In the early stages […] client and contractor members of the team tended to relate primarily to their own groups, communications between the two groups were poor and there was some confusion about the division of roles, responsibility and authority.[194]

This obviously held true for MBT-70, even more so their second finding, which was that: 'Both project teams experienced problems due to role ambiguities and conflicts, unexpected and unplanned for duplication of effort and reversion at times to more traditional command-and-control structures.'[195] Bresnan and Marshall's findings suggest that collaborative teams prefer to work under well-defined hierarchies with clear divisions of responsibility and roles. MBT-70 blurred these distinctions by having two separate teams working to their own programme manager, but with each manager required to negotiate with his opposite number for a final decision. Where a decision could not be made by the programme management board (PMB), the problem was passed to politicians, whose primary concern was keeping the project alive by diplomatic compromise rather than reaching a hard engineering decision.

Project management failures aside, could the project have worked? The UK verdict was that the project was simply 'reaching too widely and too far ahead', and that the two partners were too far apart geographically.[196] Any project that is pushing the boundaries of technology is going to encounter problems, and to complicate this with an international

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194 Mike Bresnan and Nick Marshall, 'The Engineering or Evolution of Co-operation? A Tale of Two Partnering Projects', *International Journal of Project Management*, 20 (2002), p. 500.
195 Ibid., p. 503.
196 TNA, DEFE, 13/1368, MBT, Report for Minister of Defence, German/American Main Battle Tank (E/P.O. 55/69 of 10/02/69), 17 March 1969.

collaboration requires a highly experienced international management team to make it work. McNaugher makes the point that the USA had had limited and largely one-sided experience when it came to international collaborative arms projects, and that the majority of experience in true collaboration actually first came with the MBT-70 project itself.[197]

Marc DeVore states that international arms collaboration is an inherently bureaucratic and inefficient business and that there are specific restrictions as to how much this inefficiency can be resolved. This, he suggests

> renders it improbable that collaborative projects will ever achieve more than a small proportion of the economic and military benefits anticipated by collaboration's proponents. In fact, modest R&D savings and improvements to partners' interoperability are most likely the only benefits that states can realistically hope to achieve.[198]

Whilst McNaugher points out that 'the cost of collaboration cannot be cited with precision when the cost of not collaborating is unavailable for comparison', he agrees with DeVore in that, far from showing that collaboration in developing main battle tanks saves time or money, rather that the evidence suggests that such collaboration is actually more expensive on both counts. McNaugher goes on to suggest that the USA spent money on the project as a means to a political goal.[199] Given the differences of opinion over military doctrine, and therefore military requirements, competition from industrial concerns, a difference of priority on In Service Dates, and an ill-advised management structure, it is hard to see how the MBT-70 project could have succeeded in its stated aims of producing an MBT.

Perhaps significantly, however, MBT-70 at least managed to bring the Federal Republic and USA closer together politically and led to cooperation on subsequent tank development, with consequentially some interoperability. Arguably, this was the real – but

[197] McNaugher, Collaborative Development of Main Battle Tanks,pp. iii, v.
[198] Marc R. DeVore, 'International Armaments Collaboration and the Limits of Reform', *Defence and Peace Economics*, 25:4 (2014), p. 416.
[199] McNaugher, *Collaborative Development of Main Battle Tanks,* p. x.

unacknowledged – benefit. Within NATO, only the USA, France and Britain were well-established as tank-building nations in the early 1960s, the FRG not yet having put the Leopard into production. France and Britain were already successful exporters of tanks and this could have had an impact on competition for potential sales within any collaboration. With Britain more closely aligned with the USA on armoured doctrine, an Anglo-US collaboration would seem to have been more logical, yet McNamara not only pushed for a German collaboration but also deliberately kept Britain out of the project. Perhaps Britain's existing Chieftain tank project influenced his decision, or, perhaps, he did not wish the US to face commercial peer competition over the allocation of responsibility for components. If this were the case, then the FRG's reluctance to accept US technology must have come as an unwelcome surprise.

Whatever the reasons, MBT-70 stands as an example of how not to collaborate. Fundamental problems plagued the project from the beginning. When US General Edwin H. Burba wrote in 1968 that 'Skeptic and advocate alike have been impressed with the smoothness which has characterized the program's progress since inception',[200] it seems likely that his statement reflected the major factor which kept the project running for so long – political pressure.

[200] Burba, 'The New US/FRG Main Battle Tank', pp. 475-479.

CHAPTER 4

Unconventional Solutions:
The Anglo-German Future Main Battle Tank,FMBT/KPz3
(1971-1977)

German/UK collaboration attempts on tank design can be said to have commenced in 1959 when the Federal Republic of Germany approached the British government wanting to buy two examples of the prototype 'Medium Gun Tank No.2' (subsequently the Chieftain), an approach which came to nothing and which characterised the equally unsuccessful collaborative relationship in main battle tank (MBT) design that followed.[1] The 1971 Anglo-German FMBT project is an interesting case study into how two European NATO nations were politically driven to collaborate in designing an MBT, despite having different military priorities and with both being determined to see their own main gun design incorporated into the final tank. Following as it did the equally unsuccessful Franco-German and US-German collaborations, it is useful to examine how the Anglo-German FMBT project originated and evolved, and to identify those milestones and fundamental failings in the process that contributed to its eventual official collapse in 1977.

The end of the Second World War had seen the deliberate destruction and disposal of all German tank industry by the Allies, and the confiscation of Germany's remaining tanks.[2]

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[1] TNA, T 225/1571, Anglo-German co-operation in tank development, Ministry of Supply, Supply Attaché, British Embassy, Bonn, letters between MOD, War Office and Treasury, January-February 1959.

[2] Following the Allied victory in 1945, Germany was disarmed and forbidden from having armed forces. Its tank development facilities were destroyed, and all surviving tanks taken by the Allies to be scrapped, used in their own armed forces, on target ranges, or, sold off to other Allied or neutral countries. See here: Gerhard Wettig, *Entmilitarisierung und Wiederbewaffnung in Deutschland 1943-1955: Internationale Auseindersetzungen um die Rolle der Deutschen in Europa* (Munich, 1967); Frank Roy Willis, *The French in Germany, 1945-49* (Stanford, 1961), p. 24; CIA Memo on Syrian Arms Purchases (10 Aug 1950), <https://www.cia.gov/library/readingroom/docs/CIA-RDP82-00457R005500200002-1.pdf>, accessed 19 July

In 1955, however, the FRG was admitted to NATO with the expectation that it would provide significant elements of the NATO forces defending West Germany against the perceived threat of the Soviet Union; and, with the subsequent expansion of the *Bundeswehr* (the Federal Republic's armed forces) came the desire to develop and build a German main battle tank. Having lost so much ground, both industrially and technologically, as a result of the *Stunde Null* (zero hour) it was natural that the newcountry should look to NATO's remaining major tank-producing countries for inspiration and collaboration. Such collaboration would also improve the FRG's standing within NATO and strengthen its diplomatic ties within the Alliance.[3] In 1957, an initial approach to France to build a collaborative 'Standard European Tank' under the auspices of the European FINABEL organisation had led to two separate successful national designs, the Leopard 1 and AMX-30, but this initiative failed as a collaborative project.[4] In 1963, their second collaborative MBT project, the 'MBT-70' programme, once again failed to produce a successful design.[5] Apparently undaunted, in 1971 the FRG agreed to talks with the UK to produce the Future Main Battle Tank/*Kampfpanzer* 3, or FMBT/Kpz3.

Secondary sources mention the 1971 Anglo-German FMBT project (FMBT/KPz3, herein referred to simply as the FMBT for brevity) only in passing, if at all. While Ogorkiewicz, Simpkin, Foss and Hilmes all mention the programme, Ogorkiewicz, Simpkin and Foss only do so in passing; Hilmes devotes only a few short paragraphs to the project.[6]

2017. For more on the legal position of Germany immediately post-Second World War, see Hans Kelsen, 'The Legal Status of Germany According to the Declaration of Berlin', *The American Journal of International Law*, 39:3 (July 1945), pp. 518-526. In addition: Richard Ogorkiewicz, *Design and Development of Fighting Vehicles* (New York, 1968), p. 48; and, idem, *Tanks: 100 Years of Evolution* (Oxford, 2015), pp. 187, 200.

[3] Phillip Taylor, 'Weapons Standardization in NATO: Collective Security or Economic Competition?', *International Organisation*, 36:1 (Winter 1982), p. 95.

[4] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 190. See Ch. 2 above for the Franco-German FINABEL collaborative tank project.

[5] See Ch. 3 above for a comprehensive examination of the MBT-70 project.

[6] See, for example: Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 181-183, 197; Richard Simpkin, *Tank Warfare: An Analysis of Soviet and NATO Tank Philosophy* (London, 1979), p. 208; Christopher F. Foss, *Jane's Main Battle Tanks* (Second Edition) (London, 1986), p. 95; and, Rolf Hilmes, 'Modern German Tank Development, 1956-2000', *Armor*, 110:1(January-February 2001), pp. 18-19.

Given that no working tank design resulted from the programme, it is perhaps unsurprising that it has received so little attention from authors; moreover, there is no mention of the FMBT project in many standard works on Cold War tanks.[7] This dearth of specific secondary source material makes careful analysis of the available primary sources even more necessary. Nonetheless, on the wider subject of post-1945 tank development in the UK and FRG, rather more secondary sources are available.

Hilmes has given a broad overview of German tank development since 1956 in an article, briefly covering the Franco-German 'NATO Tank' and Tank-90 projects, the US-German MBT-70, as well as the Anglo-German FMBT. Useful though this piece is in providing a basic overview, the length of the article means that no one development is covered in any depth.[8] Ogorkiewicz has covered the post-war development of tanks of most major countries in some depth, giving the developmental background in which the FMBT project was set, with chapters devoted to both the FRG and the UK.[9] In addition, both Ogorkiewicz and Simpkin have set out in detail the engineering challenges and solutions involved in post-war tank design, allowing the FMBT project to be judged in relation to general developments in tank technology at the time.[10] Given that the problem of protection was central to the disagreement over the FMBT design, the technology of armour and survivability were obviously key to the UK-FRG discussions. Despite its sensitivity and technological complexity, Joseph Backhofen, Jr., has examined some of the principles of tank protection technology in several articles, dealing with both the physical external armour and

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7 Examples of works listing Cold War tanks that have no mention of the FMBT project include: Marsh Gelbart, *Tanks: Main Battle Tanks and Light Tanks* (London, 1996); and, I. F. B Tytler, et al., *Brassey's Battlefield Weapons Systems & Technology Series Volume I: Vehicles and Bridging* (London, 1985).
8 Hilmes, 'Modern German Tank Development, 1956-2000', pp. 16-21.
9 Richard Ogorkiewicz, *Technology of Tanks* (Coulsdon, 1991), pp. 36-41, 53-56; idem, *Tanks: 100 Years of Evolution,* pp. 176-186, 194-203.
10 Ogorkiewicz, *Technology of Tanks*, passim; Simpkin, *Tank Warfare*, passim.

other protective measures to improve a tank's survivability; this field of armour technology has also been covered by other writers.[11]

The progress of the FMBT project will, for the most part, be traced chronologically, wherever possible using information from original government papers (mainly from the UK). However, in some cases, a particular sub-theme will be examined as a subject in its own right, which will depart from the chronological approach. Some overlapping in dates is, therefore, unavoidable, but every effort will be made to explain fully the precise evolution of the project. The decision-making behind the Anglo-German tank project may be divided into three areas – political, military and technological – and each of these will be covered within the case study, with the broader military and engineering challenges inherent in designing and building any MBT (already considered in greater depth in Chapter 1).[12]

To understand the political decision-making behind the FMBT project, it is useful to summarise the wider political situation in 1971. By that year Britain had twice tried to join the European Economic Community (EEC), once in 1961 and again in 1967. On both occasions, the bid had been vetoed by France's President de Gaulle, possibly in an attempt to prevent Britain's entry eroding French influence and increasing that of the USA, the UK's closest partner.[13] Under Prime Minister Edward Heath, however, Britain's third bid (set for 1973) looked more likely to succeed as de Gaulle had been replaced as French President by George Pompidou. Heath, and to a lesser extent his Foreign Secretary in 1971, Lord

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[11] Joseph E. Backhofen Jr., 'Armor Technology (Part III)', *Armor*, 42:2 (Mar-Apr 1983), pp. 18-20; idem, 'Armor Technology (Part IV)', *Armor*, 42:3 (May-Jun 1983), pp. 38-42; idem, 'Armor Technology (Part V)', *Armor*, 43:1 (Jan-Feb 1984), pp. 21-25; Donald R. Kennedy, 'Improving Combat Crew Survivability', *Armor,* 42:4 (Jul-Aug 1983), pp. 16-22. For further discussion on the technology of tank armour, see Ch. 1 above.
[12] For more on the contemporary debate over tank gun design, see Ch. 1 above. For more information on the technical and engineering challenges see Ogorkiewicz, *Technology of Tanks*.
[13] See here: Wolfram Kaiser, '"What Alternative is Open to Us?" Britain', in Wolfram Kaiser & Jürgen Elvert (eds.), *European Union Enlargement: A Comparative History* (London & New York, 2004), pp. 10-33; GuiliaBentivoglio, 'Britain, the EEC and the Special Relationship during the Heath Government', *International Affairs*, 64:2 (1988), pp.282-283; and, European Futures, 'How Did We Get Here? A Brief History of Britain's Membership of the EU' <http://www.europeanfutures.ed.ac.uk/article-3278>, accessed 5 July 2017.

Carrington, were in favour of European integration.[14] In 1971, therefore, the UK government wished to be seen as pro-European and willing to cooperate with other European nations on major economic projects: hence, the political pressures for collaboration on a large defence programme such as FMBT were consequently very strong.[15]

In order to analyse the FMBT project systematically, some points of reference are desirable. Thus, it is useful to refer here to a note from the UK's Vice Chief of the General Staff (VCGS) of September 1980 on the logical course of future collaboration listing five key points which he believed necessary for success:

1. Political encouragement for collaborative studies.
2. Detailed military studies on Tactical Concepts required. 'Agreement on this is a first and essential step without which collaboration is bound to fail.'
3. Devise common operational requirements.
4. Give common operational requirements to the national procurement executives from which work sharing and design agreements can be negotiated.
5. Still requires a strong and sustained political and military determination to drive the project through.[16]

These requirements do in many ways mirror the factors identified in 2014 by Frinsdorf, et al., for successful military projects. These were, that: the project should match the capability of the organisation; there be appropriate senior management support; the project scope be well defined and understood; strong communication pathways be identified; and, appropriate resources will be made available when required.[17] If we equate the 'senior managers' here with politicians, the 'defined project scope' as agreement on tactical concepts and a common operational requirement, and 'availability of resources' as sustained political and military

[14] Bentivoglio, 'Britain, the EEC and the Special Relationship', pp. 282-283, 286-287.
[15] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 8.
[16] TNA, DEFE 70/586, Future Main Battle Tank (FBMT), equipment, future tank policy study, possible collaboration, Note from VCGS to CGS, Tank Collaboration, 12 September 1980.
[17] Olivia Frinsdorf, Jian Zuo, and Bo Xia, 'Critical Factors for Project Efficiency in a Defence Environment', *International Journal of Project Management*, 32 (2014), p. 813.

determination to see the project through, then both frameworks appear to be virtually the same in terms of the essential factors required for a successful international collaborative tank project. Using these two parallel frameworks, it will be possible to evaluate the progress of the FMBT project against those requirements which were deemed necessary for success at the outset.

4.1. Inception of the FMBT Project

When in 1959 the FRG requested two 'Medium Gun Tank No.2' prototypes from the UK for study in order to help the recovery of the German tank industry, Britain responded that it wanted £500K for them. The thinking behind this relatively large sum was that, although a large portion could be justified as research and development (R&D) and 'commercial' costs, the rest was to ensure some profit should the FRG decide to reverse-engineer the tanks.[18] The FRG was reluctant to pay so much to evaluate two prototypes that might not even be suitable for their needs; in order partially to offset the cost, it suggested that the UK reciprocally purchase two '30-ton prototypes of a Continental design' for evaluation, the asking price being £350K. As the Federal Republic and France were engaged in a collaborative venture to build a 'European Standard Tank' at the time, it was unclear which of the two German and one French designs the Federal Republic intended the UK to buy, although it was almost certainly intended to be one of the German ones.[19] In any case, the Director of the Chobham Fighting Vehicle R&D establishment declared that only the German 'Type B' design was of interest, and then only the hydraulic transmission and suspension.[20] Given this, the UK Treasury did not feel it worth the asking price for two 30-ton prototypes when only the

[18] TNA, T225/1571, Anglo-German co-operation in tank development. Ministry of Supply, Supply Attaché, British Embassy, Bonn, letters between MOD, War Office and Treasury, January-February 1959.
[19] For more detail on the Franco-German 'Standard European Tank' programme, see Ch. 3 above.
[20] TNA, T225/1571, Anglo-German co-operation in tank development,Treasury letter regarding a meeting, 8 May 1959.

transmission and suspension was of interest, and consequently rejected the German suggestion.[21] The Federal Republic, likewise, withdrew from purchasing and evaluating the 'Medium Gun Tank No.2' prototypes, so the deal fell through.

By 1970, the German domestic armaments industries were resurgent. The *Heer* (the Federal Army) was equipped with a mixture of their own Leopard 1 tanks and the US M48. The Leopard 2, in some ways a by-product and extension of the failed MBT-70 programme was, at that time, still under development. The FRG's policy was to only replace half its tank fleet at a time, thus keeping costs low at the expense of more complex logistics and training. In 1970 it was looking to replace both tank models, scheduling to replace the M-48 with the Leopard 2 from 1976, and to replace the Leopard 1 with an, as yet undetermined, advanced design by around 1985.[22] At the same time, the UK was planning to replace completely its own Chieftain tank fleet with a new design, also beginning the replacement in 1985. Since 1960, the UK had been studying different MBT configurations, including different weapon systems; in 1970, these studies were reviewed and the most promising designs were selected as the basis for an intensive programme of studies between design engineers and the General Staff; this study was known as 'AFV of the 80's Study Stage 2'.[23]

In 1970, informal talks between army chiefs in both countries about a collaborative development became increasing formalised, with a bilateral working party established in the same year with the aim of harmonising the Operational Requirements (ORs) between the two countries.[24] A General Staff Target (GST) agreement was signed in November 1971 and a technical symposium followed in May 1972, the idea of D. Cardwell, the Deputy Director, Specialist and Design Services (DD/S), at the Fighting Vehicle Research and Development

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[21] TNA, T225/1571, Anglo-German co-operation in tank development, Memo, 11 September 1959.
[22] Heinrich Felix Beckmann, *Schild und Schwert: Die Panzertruppe der Bundeswehr. GeschichteeinerTruppengattung*(Friedberg, 1989), pp. 153-228.
[23] TMARL, E2005.1079.4, Technical assessment of all UK and FRG concepts from '72 to '76 inclusive, p. 1.
[24] Ibid.

Establishment (FVRDE). Cardwell's aim was that the bilateral symposium should allow the two countries to show their national concepts to each other as a matter of mutual interest. However, these military and technical aims were overtaken and subverted by politics. Two days before the symposium, Lord Carrington, the UK Defence Secretary, who had been in talks with Helmut Schmidt, the FRG Defence Minister, decreed that the 'UK and FRG will collaborate on the FMBT – or there will be NO FMBT' (emphasis in original).[25] Consequently, it was agreed at the symposium that a joint design and development programme should begin.[26]

With the intention that a common General Service Requirement (GSR) and design should be agreed upon, an Anglo-German Concept Working Group was established. However, disagreement began almost immediately over the basic concepts that the designers should be working to. A fundamental difference of opinion was over the vehicle weight. NATO classifies vehicles and the routes they might safely negotiate by using sixteen Military Load Classification (MLC) numbers from 4 to 150, the MLC numbers being roughly (although not solely) based on the maximum tracked vehicle weight in US short tons, with wheeled vehicles being classed using 85% of their weight and the number and location of axles.[27] From the early days of the collaboration, the Germans felt strongly that the FMBT should be limited to an MLC of 50 to facilitate strategic and operational movement within Western Germany. For their 'AFVs of the 80s' study, meanwhile, the UK had estimated that its tank transporters would have an MLC of 80 and would carry an MBT of no more than 55 tonnes (60 US short tons or MLC 60). Britain felt that a reduction in MLC of their conventionally turreted MBT designs from MLC 60 to MLC 50 would be impossible without

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25 TMARL, E2005.1079.4, Technical assessment of all UK and FRG concepts from '72 to '76 inclusive, Marginalia on back of p. 1 by W. Beaver, 14 January 198; E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 3.

26 TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration: lessons learnt during the Anglo-German FMBT project (1971-1977), p. 1.

27 Think Defence, 'UK Military Bridging – Load Classification', <http://www.thinkdefence.co.uk/2011/12/uk-military-bridging-load-classification/>, accessed 26 April 2017.

a severe and unacceptable reduction in armour protection. For this reason, a number of more unconventional designs would be included in the coming FMBT studies.[28]

In addition to and connected with disagreements on weight, in November 1972 a strongly German-influenced report on future armoured threats noted that the projectile would always be superior to armour which should be borne in mind when developing the balance between firepower, mobility and protection. German thinking was that armour protection would never be sufficient to stop a projectile and, thus, more indirect protection in the form of manoeuvrability should be emphasised. In the marginalia of this report, the British recipient at the Ministry of Defence (signed as 'QDG') made a short, but frank and forthright, comment which left no doubt that he disagreed with this view. He also queried the assumption given in the report that stated that smoothbore projectiles are superior to those which are spun, in other words, those fired from a rifled gun.[29] British thinking at the time was exemplified by a memo from the Director of the Royal Armoured Corps (DRAC) explaining that, just because contemporary HEAT ammunition could penetrate any practical thickness of armour plate (this was before the introduction of composite and layered armour), there was no need to neglect armour thickness, and he cited the practical and psychological advantages of providing the best armour protection available.[30] This debate between firepower, mobility and protection would hinder the FMBT project throughout its life.

Whatever the arguments over the relative technical capabilities of the UK's rifled-bore and the German smoothbore and their accompanying ammunition,[31] it is clear that commercial factors played a large part in each country's championing of its own gun

[28] TMARL, E2005.1079.4, Technical assessment of all UK and FRG concepts from '72 to '76 inclusive, pp. 1-2.
[29] TNA, DEFE 70/468, Future Main Battle Tank: Anglo-German Combat Vehicles Operational Requirements (OR) Working Group, Anglo-German Concept Working Group, A Concept to Counter the Enemy Armoured Threat in the 80s, 2 November 1972.
[30] TMARL, E2014.1692, HQ DRAC, Successor to Chieftain, 16 March 1970, p. 5.
[31] For details on the arguments over the two guns see Ch. 1 above.

design.[32] Both the UK and the FRG wanted and expected that the gun selected for FMBT would become the future NATO standard, which carried with it both future sales to NATO nations and the strong possibility of sales to NATO-friendly countries. Britain's position in the West as a leader in tank gun design was threatened by the FRG developing and championing the smoothbore. The UK might have also pursued smoothbore technology if it had been convinced of it being more effective, but it had already invested heavily in rifled guns and would have had to start from a disadvantageous technological position vis-à-vis the Germans. Adopting the German gun would effectively have been acknowledging that the *Rheinmetall* option was better than any British example for potential foreign buyers. The option chosen was therefore to continue to champion the rifled-bore gun, gambling on past performance and proving (or at least convincing enough potential buyers) that rifled guns were superior. In particular, at the same time the gun for the FMBT project was being debated, the USA was looking for a gun for its XM-1, later to be called the M1 Abrams. Both the FRG and UK expected that the main gun for the FMBT would subsequently be adopted by the USA.[33] Consequently, when the Americans adopted the *Rheinmetall* Rh120 design it was acknowledged in the UK that Britain had lost its position as the centre for tank gun excellence.[34]

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[32] See for example: TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, Memo from APS to Minister of State, 7 March 1978; FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Background Equipment Brief. Anglo-German Collaboration on Future Main Battle Tank (FMBT), 14 February 1973.
[33] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Background Equipment Brief, Anglo-German Collaboration on Future Main Battle Tank (FMBT), 14 February 1973.
[34] TNA, DEFE 13/1211, International collaboration in defence areas, meetings with French and German Defence Ministers, Memo from Head of IP2 to PS/Minister of State, Pamphlet by Dr Gardiner Tucker, Interoperability within NATO, 14 December 1976.

4.2. Division of Responsibility and Design Philosophies

Following the agreement on a GST and the 1972 technical symposium to initiate the joint FMBT programme, an early political agreement was sought for a broad division of responsibilities, 'so that wasteful competitive development could be minimised.'[35] From the beginning of the FMBT project it was obvious that the main gun was going to be a key feature of the new tank and that both countries were eager to have their own design adopted. Consequently, the division of design systems would be critical. While there was recognition in the UK that developing a new British gun to replace the L11A5 of the Chieftain would be prejudicial to any acceptance of the FRG's Rh120 as the future standard, it was still considered by the UK that they should develop the FMBT's main gun.[36] The UK's thinking behind the intended division of responsibilities is well illustrated by a Foreign and Commonwealth Office (FCO) note of 9 February 1973 which emphasised the need to avoid being seen as the 'supporting partner' in any such collaborative tank project:

> Morale and National Standing. In the popular understanding a tank is a machine consisting of two major items, the gun and the power train, mounted in an armoured hull. Thus to be seen to be equitable the distribution of development should give the gun to one nation and the power train to the other.[37]

The armour for FMBT was also felt in the UK to be best designed by them because Britain's composite armour development, Chobham, was more advanced than any armour

[35] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Background Equipment Brief, Anglo-German Collaboration on Future Main Battle Tank (FMBT), 14 February 1973.
[36] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Defence Department to WOD, The Future Main Battle Tank: Armament, 1 February 1973; TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Extract from DEP 1st Meeting /77, Main Armament for the Future Main Battle Tank, 2 February 1973.
[37] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Basis for the Bilateral Division of Work on FMBT. 9 February 1973.

development in the Federal Republic.[38] In return for the UK having responsibility for the design of the main armament and armour, it was considered that the FRG should concentrate on the engine, running gear and suspension, something they had in any case been working on for the MBT-70 and the abortive SP-70 collaborative self-propelled artillery project.[39] Given the problems being faced by the Chieftain's engine at the time, giving the Germans responsibility to develop the FMBT's automotive train was probably a wise decision, even if it was made primarily to allow the UK to develop the main armament.[40] The British view was that such a division of responsibility would enable each nation to preserve and work to its national capability. Each country was viewed as having strengths and weaknesses which needed to be taken into account; the Germans were expected to have advanced automotive developments stemming from the MBT-70 project, but the British believed that it had superior gun and ammunition designs and that these would be 'lost or severely impaired' if foreign designs were chosen.[41] In the event, and ominously reminiscent of the failed MBT-70 project, no agreement on work sharing was reached.

The proposed production split of the FMBT was easier to agree on. Each country was to set up a separate production line and the number of tanks to be produced was intended to be weighted towards the nation which actually bought the most units. The initial domestic production figures were estimated at 2,000 vehicles for the FRG and 1,000 for the UK, with

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[38] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT). Extract from DEP 1st Meeting /77, Main Armament for the Future Main Battle Tank, 2 February 1973; FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Basis for the Bilateral Division of Work on FMBT, 9 February 1973.
[39] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Extract from DEP 1st Meeting /77. Main Armament for the Future Main Battle Tank, 2 February 1973.
[40] TNA, PREM 16/1972, Defence, Chieftain tanks: alleged shortcomings in tank engine; replacement of Chieftain tank; proposed collaboration with the USA and Germany, start of development work on new tank, 1975 Mar 05 – 1979 Apr 27.
[41] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Basis for the Bilateral Division of Work on FMBT, 9 February 1973.

third party sales, expected to be considerable within NATO and NATO-friendly states, to be split evenly between the FRG and UK production lines.[42]

While the sharing of production might have been easily agreed upon, fundamental problems remained over work-sharing agreements at the design stage, with the disagreement over which nation would develop the main gun only part of the problem (if a major part). In addition to a failure to agree the division of responsibility for systems design, there was also the problem of agreement on the overall balance of the tank itself. The FRG and the UK foresaw very different tactical employment scenarios for the FMBT, and thus had different priorities when it came to the allocation of priority to the firepower-mobility-protection triumvirate of main battle tank design.[43] Britain, like the USA at that time, emphasised long-range firepower, with protection coming a very close second, and mobility third. The British Army on the Rhine (BAOR), operating as part of NATO's Northern Army Group (NORTHAG) defending northern Germany and the critical North German Plain, expected to defend a series of forward defensive positions with long range gunnery and relatively little manoeuvring against a fast-moving Soviet armoured thrust. The tank Britain needed, therefore, was typified by the Chieftain with its 120mm (rifled) main gun and heavy well-sloped armour. Mobility was still important, of course, but it was deemed acceptable to sacrifice or compromise this in favour of firepower and direct protection.[44] Indeed, it was noted that the major differences between the 1971 joint Anglo-German GST and the UK's own guidelines, drawn up in 1969, were that the MLC of the new design should not exceed

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[42] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Basis for the Bilateral Division of Work on FMBT, 9 February 1973.
[43] TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration: lessons learnt during the Anglo-German FMBT project (1971-1977).
[44] TMARL, E2014.1692, HQ DRAC, Successor to Chieftain, 16 March 1970, p. 5.

50 (the UK had been working to an MLC limit of 60) and that the FMBT should have a higher level of agility than the UK was planning for.[45]

By contrast, the *Bundeswehr* was expecting to defend the entirety of West Germany as part of both NORTHAG and CENTAG (Central Army Group) and had traditionally relied on mobility and manoeuvre in employing its armoured forces.[46] This, combined with a belief that modern tank guns were able to penetrate any practical thickness of armour, meant that the FRG had previously emphasised mobility over both firepower and armour protection, an approach typified by the German Leopard 1.[47] By 1974 this had altered, with German doctrine changing from a mobile defence to holding ground, so the MBT design priority moved towards an emphasis on firepower with mobility and protection having equal importance, as illustrated by the eventual Leopard 2 design.[48] In 1971, however, the FRG were still committed to a design with low weight and high mobility, as well as using the *Rheinmetall* smoothbore gun. To meet their needs in terms of mobility, the FRG were reluctant to use a UK engine and suggested that they might use a US design. Given an expectation that either Germany or the USA would produce the automotive system, and with the FRG not prepared to adopt the UK's rifled main armament, this left the Britain in a distinctly inferior position within the project. If they agreed, then neither the FMBT's gun nor the engine were likely to be British, leaving an 'uneven split of design responsibility'. The UK would be left manufacturing components mainly designed elsewhere and the final design

[45] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 4.
[46]Simpkin, *Tank Warfare*, pp. 66-67; Global Security, 'Cold War NATO Army Groups' <http://www.globalsecurity.org/military/world/int/nato-ag.htm>, accessed 12 March 2017.
[47] See for example: TMARL, E2014.1692, HQ DRAC, Successor to Chieftain, Military Attaché at British Embassy, Bonn, 'Battlefield Tactical Doctrine in the German Army', 13 Feb 1974, p. 2; Thomas L. McNaugher, 'Problems of Collaborative Weapons Development: The MBT-70', *Armed Forces and Society*, 10:1 (Autumn 1983), p. 129; TNA, DEFE 70/468, Future Main Battle Tank: Anglo-German Combat Vehicles Operational Requirements (OR) Working Group, Anglo-German Concept Working Group, A Concept to Counter the Enemy Armoured Threat in the 80s, 2 November 1972.
[48] TMARL, E2014.1692, HQ DRAC, Memo from Military Attaché to British Embassy, Bonn, 'Battlefield Tactical Doctrine of the German Army', 13 February 1974, p. 2.

would consequently be more German or US/German than British. It was noted within the UK that this would not represent true collaboration.[49]

It should be borne in mind that the participants in the FMBT project were not unaware of potential difficulties in reaching compromise between different design philosophies and tactical doctrines. The FRG had recently encountered the same problems regarding failed collaborations with both France and the USA and a long project timescale was believed necessary in order to bring British and German ‘conceptual thinking’ into line.[50] Awareness that the French at that stage gave even greater emphasis to mobility over protection than did the Germans also led to a British FCO memo advising that any approaches by the French to join the FMBT programme should ‘not be encouraged’.[51] It should be noted that the French, like Britain and West Germany, altered their priorities as doctrine changed. A 1973 communication from the British Military Attaché in Bonn stated that the French at that time saw their defence policy as purely defensive and saw no need for their tanks to undertake strategic or large tactical (‘operational’) movement. Consequently, the French described their tank philosophy as being more in line with that of the British (protection at the expense of mobility) rather than that of the Germans, a reversal of their previous position.[52]

4.3. Evaluation of Concepts

By the end of 1971, a joint GST had been agreed for FMBT and this was followed by the joint UK/FRG technical symposium in May 1972, held at the UK’s Military Vehicles and

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[49] TNA, FCO 46/1372, NATO, collaborative procurement of tanks, Minute from AUS(IP) to Secretary of State. Future Main Battle Tank, 22 September 1976.
[50] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, CSA/38374, CSA [Chief Scientific Advisor] to Minister of State for Defence, Future Main Battle Tank, 5 August 1974.
[51] TNA, FCO 46/1082, Collaboration between the UK and Federal Republic of Germany on Future Main Battle Tank (FMBT), Background Equipment Brief. Anglo-German Collaboration on Future Main Battle Tank (FMBT), 14 February 1973.
[52] TMARL, E2014.1692, Military Attaché, British Embassy, Bonn, ‘Study of National Tank Warfare Philosophies’, 29 November 1973.

Engineering Establishment (MVEE) at Chertsey. The UK already had several concepts that had been submitted as part of their existing unilateral 'UK AFVs of the 80s' study, and now attempted to find a shortlist of those designs that met the new Anglo-German GST. The concepts considered for the shortlist, and presented for evaluation to the 'UK AFVs of the 80s Studies Stage 2' committee in February 1972, were:

1. Conventional turreted:
    a. Meeting MLC 50 limit.
    b. Meeting MLC 60 limit.
2. External pedestal gun meeting MLC 50 limit:
    a. With external magazine.
    b. With internal magazine.
3. Semi-fixed casemate gun, with MLC 50/60 dependant on armour:
    a. With stabilised crew and weapon 'pod'.
    b. Without stabilised 'pod' with three different power/weight ratios.

At the joint Anglo-German symposium in May, both countries presented their concepts which were then discussed in detail by the specialist groups attending. The UK designs shortlisted and submitted were the turreted MLC 60, external gun MLC 50 and one each of the two semi-fixed gun designs. All the UK concepts were fitted with the newly developed rifled FVDRE 110mm gun. From the FRG came four designs, all but one of which met their requirements of MLC 50: an external gun design, a turreted driver-in-turret design (similar in concept to the aborted MBT-70) with limited traverse of +/- 90°from forward, a twin-gun concept with guns externally mounted and semi-fixed either side of the crew compartment, and a non-turreted design, with gun and crew mounted in an oscillating pod which gave stabilisation on all three axes, this design having two armour options to meet either the MLC

50 or MLC 60 limits.[53] All the FRG designs submitted were armed with the *Rheinmetall* 120mm high-velocity smoothbore gun.[54]

The turretless casemate or hull-mounted gun concept had been influenced by the success of the highly effective German wartime tank destroyers and *Sturmgeschütz* (StuG) series of turretless assault guns; but also by the radical Swedish 'S-tank' design which had appeared in the early 1960s.[55] A turretless AFV has several advantages over turreted designs. Without a turret they could be built with a lower weight and a lower silhouette, but they also came with drawbacks. The lower height, whilst it meant that the tank was easier to conceal from the enemy, resulted in the commander and crew having reduced observation as compared to that from a turret.[56] A turret also offered greater flexibility in the installation of equipment for the commander and gunner, giving as it does additional dedicated space for the crew.[57] Finally, although semi-fixed guns allow some independent movement of the gun, aiming beyond the limited traverse or elevation of this mounting necessitates the entire vehicle to be moved to lay the gun on the target. This was considered by the UK to be unsuited to fast-moving mobile warfare where a target may need to be tracked whilst the tank is on the move.[58] It should be noted that the semi-fixed gun differed from the design of the turretless Swedish 'S-tank' in that it had some degree of independent movement, whereas the gun on the 'S-tank' was completely fixed and the vehicle had to be moved for even the slightest adjustment to the gun's aim.

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[53] TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, pp. 2-4; E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 2.
[54] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 5.
[55] Rolf Hilmes, *Main Battle Tanks: Developments in Design Since 1945,* trans. Richard Simpkin, (London, 1987), pp. 79-81; Christopher F. Foss, *Jane's Main Battle Tanks (Second Edition)* (London, 1986), pp. 70-73; Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 181-182.Ogorkiewicz discusses the S-Tank with its designer, Sven Berge, in extensive correspondence covering many years. See here TMARL, E2015.2015.13-20, correspondence between R. M. Ogorkiewicz and Sven Berge, Malmo, 1960 to 2001.
[56] TMARL, E2014.1841 RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 11.
[57] TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, p. 2.4.
[58] Ogorkiewicz, *Tanks: 100 Years of Evolution,* p. 182.

The two variations on the turretless semi-fixed gun theme submitted for evaluation in 1972 were the FRG's experimental *Versuchsträger* tank (VT-1) which mounted twin semi-fixed main guns outside and either side of the main crew compartment but within armour plate, and the UK's Casemate Test Rig (CTR), a semi-fixed gun in a heavily armoured hull.[59] The FRG's twin-gun design was proposed in order to improve the hit rate while the vehicle was weaving, firing a volley using both guns simultaneously. In keeping with the German emphasis on mobility, the VT tanks also offered a very high power-to-weight ratio.[60] As subsequent exercises showed, however, twin guns were actually little better than a single gun (as fitted to the UK experimental CTR) and required almost twice the amount of ammunition.[61]

First seen on the UK's experimental COMRES 75 in 1968, the external pedestal-mounted gun, on the other hand, offered the rotation of a turret but required an auto-loader, a system used in the Soviet Union but one which Western nations were not yet employing in their designs as they could not overcome the technical difficulties posed. Pedestal guns give a smaller frontal 'turret' area, but again remove the tank commander's turret and deny him the height and 360^{o} vision which he enjoys in a turreted tank. The external gun is not within the tank's main armour and is thus more vulnerable to being destroyed or damaged, rendering the entire tank ineffective in its main purpose. In addition, the exposed position means that crew cannot access the gun or autoloader to perform minor repairs or address malfunctions on the battlefield.[62] Lower crew numbers, something that many designs such as the pedestal mounted gun sought to incorporate, also came with the operational disadvantage that fewer crew operating the tank meant fewer crew for other tasks around the vehicle, such as standing

[59] Hilmes, *Main Battle Tanks: Developments in Design since 1945*, pp. 33-34; Richard M. Ogorkiewicz, 'Tank Test Beds', *Armor*, 75:2 (Mar-Apr 1984), p. 18.
[60] TNA, DEFE 15/2210, A joint UK / FRG study prepared by RARDE Fort Halstead and IABG Ottobrunn of a new German concept for a future Main Battle Tank, 1st-30th September 1973.
[61] TNA, DEFE 70/467, Future Main Battle Tank, Anglo-German Symposium A, 11-29 October 1976, Resumé of RARDE War Games, 19 March 1976.
[62] Hilmes, 'Modern German Tank Development, 1956-2000', p. 19.

guard in picket, readying and stowing camouflage netting, refuelling and loading, and minor (but urgent) maintenance, such as track repairs. The Director of the Royal Armoured Corps (DRAC) pointed out that a future conflict might require that tank crews operate continuously for long periods, and thus reducing the number of men in a crew was 'not sensible'.[63] After the 1972 evaluation, the UK's ACGS (OR) (Assistant Chief of the General Staff of the Ordnance) discarded with no detailed explanation any design mounting an external gun, as well as the concept of a conventional tank meeting the MLC 50 limit.[64]

Both countries quickly acknowledged that many of the submitted designs were flawed. Two of the UK's designs did not meet the new MLC 50 target and, even those which did would have had to sacrifice even more armour to meet the FRG's demand for higher agility. The least affected would be the 'CTR' semi-fixed gun design, followed by the external pedestal gun and finally the conventional turreted design which would have had to lose between 50% and 75% of its armour, the exact amount depending on the agility to be achieved. For their part, the Federal Republic's limited traverse turreted design, as noted, was very cramped and ergonomically poor for the crew, with one German commentator arguing that the loader would have to be a 'Bavarian gorilla'. The oscillating pod design was noted as being very complex and not meeting the protection requirements of the FMBT's GST.[65]

At the time of the 1972 symposium, the UK view was that external gun tanks were 'unfightable' (suggesting that they believed the design was not fit for combat operations) and that the German turreted pod design was unnecessarily complicated. They also maintained that MLC 50 conventional tank designs left the tank inadequately protected, which left the concepts most worth pursuing those of a 55-ton (MLC 60) conventional turreted tank and casemate semi-fixed gun. Disagreements persisted between the two countries and it was

[63] TMARL, E2014.1692, HQ DRAC, Successor to Chieftain, 16 March 1970, p. 7.
[64] TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, p. 2.
[65] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, pp. 4-5.

noted that ‘some differences’ were resolved at the symposium through argument and agreement, others by compromise on both sides, but that still others were left unresolved to be carried forward to the feasibility study stage.[66] Britain had previously been largely committed to a conventional turreted design and the feeling was that such a design should still be ‘seriously considered’ for FMBT, noting that using theoretical performance estimates of unproven concepts alongside the existing empirical data for conventional designs might result in unreliable comparisons favouring the theoretical concepts.[67] It was noted within the UK that the recent developments ‘considerably altered’ the outlook for FMBT. Two years previously (1970), the UK had been looking at a solution based on the evolutionary development of existing conventional tank designs, but thanks to a combination of strong political pressure stemming from Britain’s forthcoming entry into the EEC (scheduled for January 1973), theoretical economic advantages and potential military advantages within the NATO alliance, the UK was now committed to bilateral feasibility studies into unconventional designs such as semi-fixed guns.[68]

Neither side were encouraged by the conventional MLC 50 concepts, but both had been attracted to the semi-fixed gun designs. It was agreed, therefore, that the direction of future main study should be into designs with semi-fixed gun configurations, with a reserve study into turreted designs, including those with limited traverse should this prove to be advantageous. At the same time, both countries proposed that they would continue with their own unilateral studies, specifically that the FRG would continue to pursue an external gun concept and the UK would pursue their heavier MLC 60 designs. Although unilateral, these

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[66] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, pp. 3, 6.
[67] TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from ’72 to ’76 Inclusive, p. 2.2.
[68] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 8.

national studies would be available for inspection by the other country at the end of the Joint Feasibility Study Stage of the project, planned for March 1975.[69]

In 1973, the year after the Anglo-German FMBT symposium, there was what was described as a 'rapid escalation of interest in the problems of short and long term standardisation of tank guns in NATO involving the US as well as FRG and UK'. The USA, after being committed to arming its future tanks with ATGMs, had finally decided against this and was now looking to replace its existing 105mm guns. The expectation was that whichever gun the US chose would become the NATO standard tank armament, with obvious implications for large export opportunities for the nation which designed it. Coming as it did just as new FMBT concepts were being pursued by the UK and FRG, this new debate distracted and diverted the FMBT programme and the project began to lose impetus.[70]

By August 1974, two years since the technical symposium and four years since the first tentative discussions between the Army Chiefs, the UK Defence Equipment Procurement Executive (DEPC) endorsed further funding for the FMBT project, expecting to produce a tank which could enter service by the late 1980s. There was officially 'total commitment' to the FMBT programme beginning in earnest by March 1976 with costs estimated at £14.5M, with the engine alone costing £2.5M. The government's Chief Scientific Advisor (CSA) wrote that:

> The desirability of such a collaborative project was agreed by Herr Leber and Lord Carrington some three years ago with the aim of equipping the NATO alliance, particularly on the central front, with a standardised tank, thus ensuring logistic unity and enabling us to share the expertise available and the development costs between the two countries.[71]

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[69] TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, pp. 2-5, 7-8.

[70] TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977), p. 1.

[71] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, CSA/38374, CSA to Minister of State for Defence, Future Main Battle Tank, 5 August 1974.

With such high-level backing it appeared that the FMBT project had a bright future, at least from the UK's point of view. However, little of substance had been agreed. The UK was still under the impression that the Germans would design the automotive systems and the British would design the weapons system, even though the FRG had given no indications that it was prepared to accept such a division of labour. Indeed, the two countries were working on separate concept studies with the expectation that an agreed single concept could be reached by the following year, the reasoning presented to the public being that by presenting two or more competitive designs they could then take and use the best system from each design, although the suspicion must be that it was actually due to wanting to keep control of the final MBT design. The work-sharing on the final design had still only been discussed tentatively, with negotiations on which nation would design which system only expected to be agreed by 1977, at which point the decision would be made whether or not to enter full collaborative development and production.[72] It is useful to note at this stage that one of the most critical stages of collaborative MBT design, that of reaching agreement on the design's eventual tactical qualities, was only now (1974) being planned to happen in 1977, which would be five years after the initial 1972 technical symposium.[73]

At the same time as the UK and the Federal Republic were attempting to agree possible future design-sharing for the FMBT, Germany was in negotiation with the USA. Following considerable Congressional criticism as a result of the failed MBT-70 programme, which many blamed on the collaborative nature of the project, it is perhaps surprising that the USA was so soon to look once more at European MBT collaboration.[74] The failure of the US-FRG MBT-70 project had left both nations to pursue their own domestic MBT designs

[72] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, CSA/38374, CSA to Minister of State for Defence, Future Main Battle Tank, 5 August 1974.
[73] TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977), p. 2.
[74] Thomas L. McNaugher, *Collaborative Development of Main Battle Tanks*: *Lessons from the U.S.-German Experience, 1963-1978,* Rand Note (Rand Corp., August 1981), p. 37.

resulting in prototypes for the German Leopard 2 and the US XM-1 (later to become the M1 Abrams).[75] However, both countries were still ostensibly committed to the concept of a standardised NATO tank, particularly in NATO's CENTAG area of southern West Germany where the bulk of both the US Army and *Bundeswehr* armoured formations were assigned, and they had mooted a possible harmonisation programme between the Leopard 2 and XM-1. A Memorandum of Understanding (MOU) between the US and FRG drawn up in December of 1974 officially stated that both countries wished to make 'all reasonable efforts' to standardise between tanks.[76] Consequently, in August 1974, the German National Armaments Director, Herr Wahl, informed the UK that Germany was 'overstretched' on work both towards the Leopard 2 and with the USA on a 'hybrid of Leopard 2 and the XM-1'. He said that Germany required a 'pause for reflection' of about three years regarding the FMBT project.[77] This 'pause for reflection' became an indefinite halt when, on 8 October 1974, Germany informed the UK that it was going to have to put the FMBT project on hold as its resources were becoming too stretched.[78]

Although the FRG participation was temporarily on hold, in March 1975 the Feasibility Study trials were held at the Royal Armament Research and Development Establishment (RARDE) at Fort Halstead, Sevenoaks.[79] Three UK and two German FMBT concepts were evaluated, these concepts being the results of national developments based on the 1972 symposium decision to concentrate effort on semi-fixed guns with turreted designs as reserve options. No attempt had yet been made to work on a joint design, although there

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[75] See Ch. 2 above for more detail on the MBT-70 project.
[76] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, MOU between the USA and FRG Concerning Harmonization of the US Tank XM-1 and the FRG Tank Leopard, 2 December 1974.
[77] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, CSA/38374. CSA to Minister of State for Defence, Future Main Battle Tank, 5 August 1974.
[78] TNA, FCO 46/1229, Collaboration between UK, France, Federal Republic of Germany and USA on Future Main Battle Tank (FMBT) project, Memo from Head of IP2 to FCO, Defence Department, FMBT, 14 October 1974.
[79] For literature on the discipline of simulation and defence modelling, see, for example: Reiner K. Huber (ed.), *Systems Analysis and Modeling in Defense* (New York, 1984); J. W. Gibson,'Systems Analysis in British Defence Policy Making: Some Achievements and Limitations', pp. 88-104, in Laurence Martin (ed.), *The Management of Defence* (New York, 1976).

had been regular bilateral meetings to coordinate the national studies, and the designs submitted for testing reflected the different military priorities of the two countries. The designs submitted were:

UK1	A semi-fixed gun in casemate (CTR).
UK2	Turreted conventional AFV with V12 engine.
UK3	Turreted conventional AFV with V16 engine.
FRG1	Twin semi-fixed, externally mounted guns (VT-1).
FRG2	Driver-in-turret with +/-90° turret traverse.[80]

The evaluation was mainly a paper exercise but also included armour performance data derived from practical firing trials. In April 1975, following the evaluation there was a comprehensive exchange of data, including technical descriptions, drawings, weight analyses and data sheets. Each country validated the other's data and the results were initially planned to be completed by January 1976. However, the FMBT Joint Steering Group issued an Additional Studies Directive ordering that additional studies be carried out starting November 1975. The directive was that work should end on the twin-gun concepts and should instead look towards harmonising the turreted designs, something of a reversal of emphasis from the 1972 symposium.[81] It is worth reflecting that this change of direction back towards a more conventional turreted design, a design that the UK had been championing over more unconventional concepts, came at a time when the Germans were showing a lack of interest in pursuing the joint tank design with the UK, having asked for their 'pause for reflection' the previous year.

On 19 March 1976, RARDE conducted war games to test the effectiveness of three different potential FMBT designs from the UK. The war games presented three scenarios to

[80] TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, p. 7.
[81] Ibid., pp. 5, 8-9.

be played out, with the tanks tested playing the part of the Blue force, as usual in NATO simulations:

1. Red advance into contact and Blue fighting withdrawal.
2. Blue engaging Red in a killing zone.
3. Blue attacking Red under covering fire.

The three UK designs evaluated the previous year were tested: a semi-fixed gun casemate design (UK1, the CTR), a conventional turreted tank with V12 engine (UK2) and a conventional turreted tank with a V16 engine and lighter side armour to improve mobility (UK3). The conclusions reached from the tests were that the CTR non-turreted design was, in fact, more vulnerable than the turreted designs because it needed to expose more of itself to fire its main gun over obstacles and cover from a defensive position, the most likely scenario for BAOR tanks in predicted Cold War engagements. UK3, with the larger engine and lighter side armour, was found to be no more vulnerable than the slower and heavier UK2 as the armour sacrificed was from the side, which was rarely targeted in the scenarios. UK3 was also faster and spent more time engaging the enemy because it spent less time moving into position.[82]

These conclusions suggested that the UK's emphasis on protection over mobility might require something of a compromise, with mobility to be given more consideration in the FMBT or future sovereign MBT-80 design. Ironically, the USA had concluded from the lessons of the Yom Kippur War that their future tanks required more protection and survivability, and this was a key factor in the design of the XM-1.[83] The 1976 RARDE trials suggested that, in defence in open country, protection was not as important at long range as

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[82] TNA, DEFE 70/467, Future Main Battle Tank, Anglo-German Symposium A, 11-29 October 1976, A Summary of the UK FMBT Simulations, March 1976; TMARL, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, p. 4.

[83] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 170.

attackers acquired only a few targets and those were mostly hull-down, and that direct protection was of most use in defence in close country where engagements were short-ranged. This was significant because another conclusion was that effective long-range gunnery was invaluable in defence and whilst in open country in good visibility, but otherwise (i.e. in attack or in close country) long-range gunnery was less useful. The trials also showed that high speed was most advantageous when conducting a linear defence, but only when the enemy was out-ranged. Greater mobility and a longer effective range allowed vehicles to fire and then reposition efficiently, but any form of defensive weaving or 'jinking' was of negligible advantage in such circumstances as the vehicle was likely to be out of direct enemy observation.[84] The conclusion drawn from the trials was that the UK's future tank requirement, be it FMBT or MBT-80, would be met with a tank that was turreted, with a main gun effective to longer-range than the likely opposition, was mobile and manoeuvrable, and had armour thickest at the front. In October 1976, a bilateral symposium was held at which the 'essential characteristics' of FMBT were finally agreed.[85]

4.4. Enthusiasm Wanes

In 1974 the West German Army was still using Leopard 1 tanks, introduced in 1965, alongside the older and less capable US-designed M-48s which had originally been introduced into US service in 1952, and which had been operated in the *Heer* since late 1957.[86] The FRG hoped that FMBT might lead to a replacement for Leopard 1 and had originally stated that this would begin happening by 1985. The UK's 'In Service Date' deadline for FMBT was the late 1980s. The older M-48 design was clearly in more urgent

[84] TNA, DEFE 70/467, Future Main Battle Tank, Anglo-German Symposium A, 11-29 October 1976, Resumé of RARDE War Games, 19 March 1976.
[85] TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977), p. 2.
[86] Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 164, 194. Appendix 6, below, shows the main battle tanks employed by France, the FRG, UK and USA during the period.

need of replacement and the FRG was looking to replace these by 1976; initially, the Leopard 2 was planned as the replacement, but this design had still not been finalised in 1974; and, the FRG let the UK know that at that time it considered that it had three options for the 1976 replacement:

1. More Leopard 1s (although these were considered to be deficient in armour and fire control by contemporary standards).
2. Introduce the Leopard 2 when it was ready.
3. Develop a hybrid Leopard 2/XM-1, for example a German engine in an XM-1 body and/or US fire-control in a Leopard 2.[87]

Especially given the usual problem of overruns seen in other collaborative projects, it was unlikely that a new tank would be ready within two years, even if it were a 'harmonised' development based on two tank designs that were almost ready for production. Leopard 2 was therefore by far the most likely option presented, although political considerations favoured the international hybrid. Timely replacement was important to counter potential new Soviet MBTs that were known to be in development, with the T-72 having entered service in 1973, and the T-80 due to be ready three years later in 1976.[88] Even in Britain there was acknowledgement that an improved version of Chieftain could be developed before the FMBT project would result in a production vehicle.[89] The Chief Executive of the Procurement Executive (PE) believed that the delay to the FMBT programme caused by the 'pause for reflection' would be 'at best' two years. But he did not believe that Germany

[87] TNA, FCO 46/1229, Collaboration between UK, France, Federal Republic of Germany and USA on Future Main Battle Tank (FMBT) project, Memo from Head of IP2 to FCO, Defence Department, FMBT, 14 October 1974.
[88] Ogorkiewicz, *Tanks: 100 Years of Evolution,* p. 158.
[89] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, CSA/521/74, Chief Scientific Advisor to Secretary of State for Defence, 25 October 1974.

would have the funding to restart the FMBT programme in so short a time; he predicted that the delay would probably therefore be much longer.[90]

With the FMBT project on hold, if not officially cancelled, the UK had to look at other alternatives to replace its fleet of Chieftains. The proposed theoretical new design was given the project name MBT-80, the designated Chieftain replacement's original name before it became FMBT in 1972. The Germans already had the Leopard 2 design at a fairly advanced stage, having produced sixteen prototypes by 1972, although no decision had been taken to bring the new tank into production at this point; this decision would not be taken until 1977.[91] With the USA and Federal Republic having recently been in partnership in the abortive development of the MBT-70, and already in negotiation to create a hybrid of the XM-1 and the Leopard 2, which would possibly become a replacement for the FRG's M-48, the UK believed that the negotiations would also lead to a US-FRG collaboration on the successor to the Leopard 1, the role that FMBT was intended to fulfil.[92] The UK's Head of Defence Sales (HDS) also stated that he believed that the USA and Germany were involved in denigrating UK equipment in Iran to sabotage future UK-Iran arms deals. He believed that the German 'pause for reflection' was because Germany wished to sell the Leopard 2 to Iran.[93]

In 1974, the UK was developing the *Shir* (or 'Lion') MBT for Iran. Iran was then the major importer of Chieftains, being the largest foreign operator of the type, and the *Shir* tank was an improved Chieftain being developed to Iranian specifications.[94] The resources

[90] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, Memo from Chief Executive of Procurement Executive to Secretary of State for Defence, 25 October 1974.
[91] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 196.
[92] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, Memo from Chief Executive of Procurement Executive to Secretary of State for Defence, 25 October 1974.
[93] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, Record of meeting held in Minister of State's Office on Wednesday 26th March 1975 to discuss the XM-1 Tank Project.
[94] The *Shir,* or Khalid, MBT was a development of the Chieftain Mk.5 P with a more powerful engine, greater mine protection and improved shock absorbers. The *Shir 2* was to have been a further improved *Shir* with

demanded of the *Shir* programme, combined with the implications of the German decision to halt its commitment to the FMBT project, caused a reconsideration of the UK's own position with regards to the FMBT collaboration. Whilst there was political regret at the uncertainty over the FMBT project's future, it was also noted that the halt would benefit the *Shir* programme. In particular, there was now no urgent need to use resources to develop the 16-cylinder engines that the FRG had wanted in its quest for emphasising manoeuvrability in the FMBT. Instead, the 12-cylinder engine that Britain believed was sufficient could be used both for the new Iranian tank and for the UK's own MBT-80 programme.[95] However, direct adoption of the *Shir* as Chieftain's replacement was rejected as the *Shir* was not considered to be as advanced as either the T-64 or the T-72, and was also considered to fall short of the General Service Requirements (GSR) for the MBT-80 in terms of protection, fire control, night-fighting and mobility. In light of the RARDE trials which showed the advantages of mobility, even in defence, *Shir* was also believed to be too heavy at 60 tonnes. Linear development of the *Shir* design was a possibility, but it was considered that any such development to meet the GSR would be so extensive a project as to constitute a completely new tank.[96] In addition to problems of meeting the MBT-80's GSR requirements, any linear development of the *Shir* would result in an MBT that was radically different to either the FRG's Leopard 2 or the USA's XM-1. The Vice Chief of the General Staff (VCGS) acknowledged that whilst the UK could certainly produce 'world-beating tanks', there were still powerful military and political arguments for standardisation within NATO.[97] Lord Carrington, the then Secretary of State for Defence, had considered back in 1972 at the start

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Chobham armour. See here Mark Hewith, 'Challenger and Khlaid – the British FV4030 Family of Main Battle Tanks', *International Defense Review,* 13 (1982), p. 13.

[95] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, CSA/521/74, Chief Scientific Advisor to Secretary of State for Defence, 25 October 1974.

[96] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, Memo from CSA to Secretary of State for Defence, CSA/184/78, Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.

[97] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, Record of meeting held in Minister of State's Office on Wednesday 26th March 1975 to discuss the XM-1 Tank Project.

of the project that it was essential to have a single Anglo-German tank for military, political and economic reasons, and the FMBT remained the UK's primary focus for a new tank even as the Germans were displaying a considerable lack of enthusiasm.[98]

Another possibility for the Chieftain's replacement was to purchase the USA's XM-1, a design believed to be superior to the Leopard 2 which itself had not being considered for reasons of its smoothbore gun and emphasis on mobility over protection.[99] It should be noted that the decision on the main gun for XM-1 had not been officially made at this point and the UK still believed that its own RARDE experimental 110mm rifled gun could be chosen. The XM-1 had the advantage that it was considered that it would be available at the 'right price', being something of a relatively low-budget tank due to the US Administration facing strong Congressional pressure to keep the XM-1 project's costs down. However, it was also noted that the XM-1 (like Leopard 2) was essentially an older design that had originally been conceived before the experiences of the Yom Kippur War, a conflict which had caused a global rethink of tank design, especially how to deal with ATGMs and handheld RPGs.[100] In light of this conflict and its illustration of how infantry armed with modern shaped-charge warheads could defeat conventionally armoured tanks, by the time of the German announcement that it wished for a 'pause for reflection' concerning the FMBT, the US had adopted the UK's Chobham composite armour; it was also temporarily fitting the XM-1 with the US derivation of the British L7 rifled 105mm, with the UK still pushing for its rifled 110mm gun to be adopted as the main armament.[101] However, the AGT-1500 gas turbine engine of the XM-1 had a particularly high fuel consumption, as much as twice that of a

[98] TNA, FCO 46/1372, NATO, collaborative procurement of tanks, minute from AUS(IP) to Secretary of State. Future Main Battle Tank, 22 September 1976.
[99] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from Chief Scientific Advisor (CSA) to the Minister of State, Chieftain Replacement (MBT 80), 26 July 1977.
[100] TNA, DEFE 13/1065, Future main battle tank and associated weapon systems, Record of meeting held in Minister of State's Office on Wednesday 26th March 1975 to discuss the XM-1 Tank Project.
[101] TNA, DEFE 24/1143, Future main battle tank, memo from Master General of the Ordnance (MGO) to the Secretary of State for Defence, Future Tank Main Armament, Current Position and Proposed Actions, 4 February 1977.

Leopard 2, and the British assessment was that gas turbines were inferior to more conventional diesel engines for that reason.[102]

4.5. The End for FMBT (and UK Tank Guns?)

In March 1976 the Soviet journal, *Krasnaya Zvezda* (or 'Red Star', in essence, the official Soviet MOD organ), reported on NATO's manoeuvrings for a 'uniform tank' and suggested that NATO's European members were taking revenge on the USA for the imposition of the F16. In return, the journal went on, the USA were trying to sabotage the Anglo-German FMBT agreement by persuading the Federal Republic to accept the Leopard 2/XM-1 hybrid. Given the failure of the FMBT programme, *Krasnaya Zvezda* claimed that Britain's future prospective tank sales were 'questionable'.[103]

Destabilising propaganda though the intention behind the article might have been, it was certainly accurate in so far as the USA-FRG agreement signified the end of the FMBT project, even if the major problems had been there from the beginning, so the harmonisation programme between the Leopard 2 and the XM-1 might be more accurately described as a symptom of the loss of German enthusiasm rather than the cause of FMBT's demise. It was likewise true that the UK was in the process of losing its position as a major exporter of both tanks and tank guns. Though the fundamental disagreement on the relative values of smoothbore versus rifled were highly significant, the problems within the FMBT collaboration went much deeper.[104] Following the 1976 Fort Halstead trials the 'essential characteristics' of FMBT were finally agreed at a symposium, although there was still

[102] Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 170.
[103] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, Research Department of the Soviet Section to Defence Department, Soviet Comment on the New NATO Tank of the 1980s, 25 March 1976.
[104] TNA, FCO 46/1372, NATO, collaborative procurement of tanks, minute from AUS(IP) to Secretary of State. Future Main Battle Tank, 22 September 1976.

disagreement over the gun and other system details.[105] However, the FRG had found that its Leopard 2, originally intended to replace the aging M-48 and not to be an alternative to Leopard 1, was a very capable design. Indeed, there was a 'strong body of German opinion' that considered the Leopard 2 to be the ultimate in conventional tank design, meaning that its successor would have to be a 'significant' improvement, something made clear to the FMBT project team.[106]

In the meantime, the debate over the best tank gun continued.[107] The initial trilateral trials to determine which gun the US would adopt for the XM-1 were held in 1975, pitting the US rifled 105mm against the UK's rifled 110mm and the FRG's smoothbore 120mm. As a result, the US decided to adopt the 120mm calibre using one-piece ammunition, even though many in the US military had doubts about the Federal Republic's gun which prompted the UK to begin hurried development of a new rifled 120mm to meet those requirements.[108] In July 1976, the USA announced new trilateral gun trials for 1977, and that it was willing to adopt for the XM-1 whichever 120mm gun was agreed upon to be the standard in Europe; specifically it wanted France, the FRG and UK to agree on a standard gun. However, France had no 120mm tank weapon in development, and the UK had only taken the decision to develop its 120mm M13A following the 1975 trilateral trials. Since the FRG had already stated that would use its own *Rheimetall* 120mm smoothbore and was not interested in the UK's rifled-bore guns, it was unlikely that the US were expecting anything but the German

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[105] TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977), p. 2.
[106] TNA, FCO 46/1372, NATO, collaborative procurement of tanks, minute from AUS(IP) to Secretary of State, Future Main Battle Tank, 22 September 1976.
[107] As mentioned earlier, the debate over tank guns in this period largely revolved around accuracy and the ability to destroy enemy armour, particularly other main battle tanks. Britain (and, to a lesser extent, the USA), favoured the rifled gun whereas Germany and the USSR had chosen to pursue smoothbores. As set out in Ch. 1 (above), the arguments largely revolved around which ammunition could be effectively fired by smoothbore and rifled guns, as well as the relative accuracy of each type at typical tank engagement ranges. See, for example: Ogorkiewicz, *Tanks: 100 Years of Evolution*, pp. 238-239; Hilmes, *Main Battle Tanks: Developments in Design since 1945*, pp. 36-37.
[108] Richard Ogorkiewicz, 'Armoured Fighting Vehicles', in Robert Bud and Philip Gummett (eds.), *Cold War Hot Science: Applied Research in Britain's Defence Laboratories 1945-1990* (London, 2002), p. 124.

weapon to be adopted. Indeed, the Congressional XM-1 Tank Panel themselves noted that the new requirements for the gun had been written in such a way as to exclude the British M13A and leave the German Rh120 as the only real choice.[109]

More evidence for chicanery in the US decision-making process came from Dr. Malcolm R. Currie, US Director of Defense Research and Engineering, who reportedly stated that, 'Rumsfeld [US Secretary of Defense] was very keen to take a decision on the new gun on purely political grounds before the US election [November 1976], and was not likely to be swayed by technical arguments.' All the evidence pointed to the US having already made the decision to adopt the German 120mm, possibly as part of US/FRG deals which included many future weapons and the trade offset for US troops based in Germany.[110] Indeed, at the end of July 1976, the same month that the USA had publicly announced that it would hold trials and adopt whichever 120mm gun the Europeans agreed upon, there was an 'off the record' announcement that the USA and FRG had reached an agreement on harmonisation between the XM-1 and Leopard 2.[111] A minute to the UK Secretary of State for Defence noted that the FRG had 'probably' given a political commitment to buying the US AWACS and was prepared to accept the US fire control and engine in return for the USA accepting the FRG smoothbore gun. This created grave concern in Britain for the future adoption and sales of both the Nimrod AEW and for the future sales prospects of UK tank armament (and consequently tanks).[112]

Despite strong evidence that the US had already made the decision to adopt the *Rheinmetall* gun, diplomatic efforts were still made to withhold any final US official decision until after the UK's new 120mm rifled gun was tested in the new round of trilateral trials to

[109] McNaugher, *Collaborative Development of Main Battle Tanks*, p. 51.
[110] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, memo from DCA(PN) to PS/Secretary of State, 23 July 1976.
[111] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, Bonn Telegram 738, UK Embassy, Bonn, to FCO, 30 July 1976.
[112] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, PUS/76/503, Minute to Secretary of State, Collaborative Equipment Projects, 4 August 1976.

be held in 1977.[113] The British Embassy in Washington had managed to get hold of a copy of the addendum to the original US/FRG MOU on the Leopard 2/XM-1 harmonisation programme. The obtaining of this document by Her Majesty's Government was noted to be on a, 'strictly private and confidential basis' and with a caveat that the FRG should not know that the UK had a copy. This placed the UK's diplomatic efforts towards persuading the US to hold a decision in a fairly awkward position, as they were obliged to negotiate using information obtained from the MOU addendum without letting slip that the document had been seen.[114] At this point, with the US and FRG in agreement on Leopard 2/XM-1 harmonisation, and the FRG declaring that FMBT needed to be 'significantly better' than Leopard 2, a failure to agree on work sharing with FMBT, and the UK struggling to have its M13A gun adopted, there was official recognition in Britain that the FMBT project was effectively finished. The situation was described as being the 'worst of all possible worlds': there would be no FMBT and the FRG gun was to be used in the XM-1, with a probable reduction of UK sales of its own rifled-bore gun as a consequence.

Although the UK had further major arms projects in development relating to NATO standardisation, there was no doubt that the failure of both the FMBT project and the sale of the M13A 120mm gun were major setbacks. Such a high-profile weapon system as an MBT would have helped retain the UK's global position in the international arms trade. There was now concern that UK might end up with a 'disproportionately small share' of future international development and production programmes, especially as the UK was more reluctant to buy from abroad than others were to buy from the UK. The ideal potential export markets were seen as European countries, especially Germany, so it was still considered important to involve Germany in future collaborative projects. Although the USA was a

[113] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, Bonn Telegram 738, UK Embassy, Bonn, to FCO, 30 July 1976.
[114] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, Memo from DUS(P) to Secretary of State, The Future Tank Gun, 6 August 1976.

larger single market, it was recognised that the UK had little to offer the US in terms of weapons technology and, conversely, was being (politically) pressured into accepting the US AWACS and the Harpoon and TOW missile systems.[115] A government pamphlet on the subject of defence collaboration wryly noted that the US approach was heavily influenced by its large and powerful industrial lobby pushing for the sale of US equipment. The USA appeared to be in favour of NATO standardisation, but only if the agreed standard equipment was American, to the detriment of the European arms industry. Indeed, the French were apparently especially sceptical of the US balance of arms trade within the NATO alliance.[116]

The agreement between the USA and FRG on harmonisation between the Leopard 2 and XM-1 was seen in the UK as the 'last nail in the coffin' of the FMBT project, even though it ultimately failed to result in an improved tank for either side.[117] Although full disengagement would have been difficult politically, it was advised that spending any more time, money and effort on the FMBT programme was now a waste of resources.[118] The UK had two realistic options for the Chieftain's replacement: either to buy a foreign design or to go ahead and design unilaterally the MBT-80 in the face of increasing calls for NATO standardisation. Buying a foreign design was seen as a poor option for British industry as such a move would be damaging for any future domestic tank-building capability. Whilst collaboration was not a perfect solution, it would at least have provided the opportunity to maintain expertise in the various engineering fields required for designing and building a main battle tank. By sharing the development process and foreign sales, a collaborative

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[115] TNA, FCO 46/1371, NATO, collaborative procurement of tanks, PUS/76/503, Minute to Secretary of State, Collaborative Equipment Projects, 4 August 1976.
[116] TNA, DEFE 13/1211, International collaboration in defence areas, meetings with French and German Defence Ministers, memo from Head of IP2 to PS/Minister of State, pamphlet by Dr Gardiner Tucker, Interoperability within NATO, 14 December 1976.
[117] Ibid.
[118] TNA, FCO 46/1372, NATO, collaborative procurement of tanks, minute from AUS(IP) to Secretary of State, Future Main Battle Tank, 22 September 1976.

partner would at least have retained a share of the experience and exports.[119] However, apart from the Federal Republic, no other nation within NATO was planning to replace its current MBT within the time-frame which had been laid down for MBT-80.

The UK Secretary of State for Defence was advised on 14 March 1977 that the Expenditure Committee be informed that the FMBT programme had encountered problems and that the UK and Germany were in contact over future prospects; and, a decision 'should be ready soon.' The outcome was not really in doubt, but as the political, industrial and military consequences were significant, the advice was that any announcement of the project's cancellation be played down.[120] In a draft communication for the UK military theatre commanders (BAOR, UK, Northern Ireland, and Hong Kong), it emerges that the VCGS was to make them aware of the forthcoming official announcement of the failure and cancellation of the FMBT project. He put the official blame on the timescales involved as the Chieftain's replacement was required by 1989 at the latest; moreover,'it has become quite clear that the collaborative project would not have achieved this.' The VCGS pointed out that the Federal Republic was not tied to the same deadline in seeking to develop an improved Leopard 2 and were, in any case, not convinced that FMBT would be significantly better than the Leopard 2, an assumption that the VCGS disagreed with.[121]

Official confirmation of the end of the Anglo-German FMBT project came on 24 March 1977 in a letter from Fred Mulley, the UK Secretary of State for Defence, to his counterpart in the West Germany, Georg Leber. After four and half years of joint study on the project, Mulley wrote that:

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[119] TNA, DEFE 13/1211, International collaboration in defence areas, meetings with French and German Defence Ministers, memo from Head of IP2 to PS/Minister of State, pamphlet by Dr Gardiner Tucker, Interoperability within NATO, 14 December 1976.

[120] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from AUS (Ord) to PS/Secretary of State, FBMT,14 March 1977.

[121] TNA, DEFE 13/1045, Tanks and tank guns, proposals and developments, draft, VCGS to Theatre Commanders (CinC BAOR, CinC UKILF, GOC NI, CBF HK).

> I think we are agreed that although our two countries have found the joint study of considerable value it has not gone as either of us would have wished in agreeing on a co-operative tank programme […] It is against this background that we have just formally announced the end of our work on FMBT to our NATO partners.[122]

Like the VCGS, Mulley diplomatically blamed the timescale for the failure of the programme, not mentioning the inability of either country to compromise on the issue of the main gun or the differing priorities over protection or mobility. Nor was there any mention of the German talks with the USA over the Leopard 2/XM-1 harmonisation programme, although he did allude to the FRG's wish to adopt an improved Leopard 2 as their future new MBT:

> The threat we face is the same; the requirements our two staffs formulated to meet the threat were almost identical; two essential pre-conditions of a successful collaborative project between our two countries were therefore present. Nevertheless[,] as a result of our divergent replacement time-scales, you will, no doubt continue developing the Leopard 2 tank while we concentrate our resources on introducing a replacement for Chieftain starting certainly no later than 1989.[123]

In his reply, Leber confirmed the FRG's position that that the FMBT programme had been halted but was more open about the question of the main gun, writing that: 'the promising work for a joint concept of weapons systems ideally requires certain assumptions which did not exist when we started on our programme in May 1972.' The letter contained a final attempt to persuade the UK to adopt the German 120mm smoothbore for MBT-80, even noting that adopting the gun would not imply any UK export plan restrictions on a new MBT.[124] Mulley's response was that the UK still considered the rifled 120mm the better gun and that, although the Anglo-German FMBT/KPz3 steering committee had been disbanded,

[122] TNA, DEFE 13/1045, Tanks and tank guns: proposals and developments, MO 26/4/2, letter, UK Secretary of State for Defence to FRG Minister of Defence, 24 March 1977.
[123] Ibid.
[124] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, translation of letter from Georg Leber to Secretary of State for Defence, 4 March 1977.

the UK was nonetheless still open to possible future collaboration with the Federal Republic.[125]

4.6. MBT-80: A Blow to Standardisation?

The MBT-80 project followed directly from the failure of the FMBT collaboration and after the possibilities of other collaborative development had been 'fully explored.'[126] The project name 'MBT-80' was actually the original name given to the Chieftain's replacement when this was being investigated by the 'UK AFVs of the 80s' study. It had been superseded by 'FMBT' when the collaborative project had been initiated, so the project name's restoration can be seen as symbolic.[127] The possibilities considered for replacing the Chieftain MBT were either buying the Leopard 2 or XM-1 ('off the shelf', alternatively to be built in the UK under licence), or a UK national development, possibly including foreign components.[128] The option of using foreign components was suggested as an opportunity to bring a greater harmonisation of components with the French, US and FRG tank fleets; while not true 'standardisation' it would have been a step in that direction which would have improved NATO logistics. The purchase of an 'off the shelf' foreign tank, it was predicted, would have led to the direct loss of 2,000 UK jobs after 1986, and 10,000 indirectly as regards the suppliers of components. Licensed building was seen as a better route than buying a foreign design as it would at least have maintained British industrial capacity. But it was still believed that such a move could affect future UK design and development capability and

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[125] TNA, DEFE 13/1045, Tanks and tank guns, proposals and developments, MO 26/4/2, letter, UK Secretary of State for Defence to FRG Minister of Defence, 24 March 1977.
[126] TNA, FCO 46/1749, NATO, collaboration on tanks and tank guns, Chieftain Tank replacement, 2nd Draft of MBT Memorandum – The Successor to Chieftain, 10 July 1978.
[127] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 1.
[128] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from APS/Minister of State to DUS(Army), revision of draft memo, MBT-80, dated 17 July, 20 July 1978; DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from CSA to Secretary of State for Defence, CSA/184/78, Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.

overseas sales markets.[129] In any case, a foreign design would not have been designed and built to meet the British Army's particular requirements and was, therefore, seen as a bad choice for both the Army and the UK's domestic tank industry.[130] MBT-80's requirements were to be (in order of priority): firepower, and then equal priority for protection and mobility, with a much greater emphasis to be placed on reliability than in the past. No European tank was considered to meet those requirements.[131]

Intelligence estimates in 1978 indicated 'substantial' advances in Soviet tank design. The T-64 (designed in 1976) was replacing or supplementing the older T-62,[132] and the T-72 (designed in 1977) was also gradually being introduced. The M1980 (later designated T-72A) was known to be in the early stages of development.[133] Both the T-64 and T-72 tanks were considered a generation ahead of any NATO tank of the time and were believed to have laminate armour and advanced control systems.[134] With this intelligence in mind, the Operational Requirements (ORs) for the MBT-80 were: the ability to 'withstand and overcome' the new Soviet tanks entering service in terms of firepower, mobility and protection, but also to have the ability to operate for longer periods without a break than Soviet tanks. The ORs dictated a crew of four and 'maximum possible' fuel and ammunition load, a 55 tonne limit (MLC 60) to negotiate German bridges, a conventional turret, a 120mm gun and Chobham armour.[135]

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[129] TNA, FCO 46/1749, NATO, collaboration on tanks and tank guns, Chieftain Tank replacement, 2nd Draft of MBT Memorandum – The Successor to Chieftain, 10 July 1978.

[130] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from Chief Scientific Advisor (CSA) to the Minister of State, Chieftain Replacement (MBT 80), 26 July 1977.

[131] TNA, DEFE 24/1144, Future main battle tank, MBT-80, Presentation to Minister of State by GS(OR)17, 23August 1977.

[132] For a contemporary Western view of the new tank, see J. Gratzl, 'T-64: Some Thoughts on the New Soviet Battle Tank', *International Defense Review*, 1 (1976), pp. 24-26.

[133] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from CSA to Secretary of State for Defence, CSA/184/78, Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.

[134] For technical information on T-64 and T-72, see: Hilmes, *Main Battle Tanks: Developments in Design Since 1945*, pp. 21-22, 70 (T-72), 95-96 (T-64); Wolfgang Schneider (ed.), *Tanks of the World, 7th Edition* (Koblenz, 1990), pp. 600-607 (T-64), 608-617 (T-72).

[135] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from CSA to Secretary of State for Defence, CSA/184/78, Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.

In 1977, the argument for a 120mm gun was that each main gun round stowed within the tank, smoke excluded, should be capable of killing a tank. There was also a balance to be found between the physical weight and size of a round and the explosive content of chemical energy (CE rounds). Possible future developments in armour protection were also to be considered, especially given that Soviet tanks in the 1990s might be invulnerable to 105mm KE rounds striking their frontal armour. Nonetheless, there remained the view that KE rounds should be regarded as the primary tank killer and that CE should become the domain of ATGWs, a view reinforced by the development of Chobham armour, designed specifically to defeat CE and, reportedly, capable of defeating HESH and HEAT from 120mm guns. A UK requirement for rounds to tackle soft targets and strongpoints meant that HESH was preferred to HEAT, a key operational point in favour of retaining rifled guns over smoothbores.[136]

Although closer to the UK's requirements than Leopard 2, as the US shared the UK's priorities on firepower and protection, the XM-1 was still not considered to meet the MBT-80's GSR in firepower, protection and survivability. It was also criticised for the inability of its commander to acquire targets and indicate them quickly to the gunner, and also for its inadequate armour protection compared to Soviet tanks' capabilities – the frontal armour was believed to be defeatable by the 125mm round beyond 4,000m. In addition, storage of single-piece ammunition in the turret bustle was considered riskier than storage below the turret ring, the UK method with its two-part ammunition. Although the turret bustle used in XM-1 was designed to vent any explosion away from the crew compartment, it had not at this stage been tested with 120mm ammunition, and was in any case deemed vulnerable when in action as the armoured doors were often opened. Fuel storage in the crew compartment and high-pressure hydraulic fluids in the gun control equipment were also considered unacceptable hazards present in XM-1. It should be pointed out that the XM-1 was still under development

[136] TNA, DEFE 24/1144, Future main battle tank, memo from ACGS(OR) to MA/VCGS, Main Armament for the MBT-80, 9 June 1977.

and, although rejected by the UK as a replacement for the Chieftain, it was noted that the design might be improved upon in the future.[137] Finally, the British Army still preferred the rifled gun over the *Rheinmetall* Rh120, or, indeed, the US development of the German smoothbore gun which was to be fitted to the XM-1.[138]

With a second attempt at collaboration unlikely in the near future, and the purchase of available foreign designs rejected, a domestically-designed MBT was the only remaining option.[139] An initial budget of £14M was allocated for the MBT-80 project, a sum that should be seen in relation to the £8.5M already spent on the FMBT.[140] The development of the MBT-80 was considered to be £175M as of September 1977; the final cost of replacing the Chieftain fleet of 1029 vehicles (numbers as of July 1978) by the 1989 In Service Date (ISD) was projected to be between £1100M and £1200M (at December 1977 prices).[141] The new design would build upon work, in particular on the transmission and running gear, already undertaken for the *Shir* Iran, which it was believed would be in production by the early 1980s.[142]

The engine choice was initially between the US AGT-1500 gas turbine as used on XM-1, and the Rolls-Royce CV12 (with the expectation that a 16-cylinder version was to be developed later).[143] Gas turbine engines had lower vibration, were quieter, easier to start, were more reliable and required less time between maintenance, but created a noticeably heat haze and, crucially, were very demanding of fuel. The intended eventual engine for MBT-80

[137] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from CSA to Secretary of State for Defence, CSA/184/78, Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.
[138] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from APS to Minister of State, 7 March 1978.
[139] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from AUS(OP) to PS/Secretary of State, MBT-80 – Draft DOP paper, 20 July 1978.
[140] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from Chief Scientific Advisor (CSA) to the Minister of State, Chieftain Replacement (MBT 80), 26 July 1977.
[141] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from CSA to Secretary of State for Defence, CSA/184/78, Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.
[142] TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from Chief Scientific Advisor (CSA) to the Minister of State, Chieftain Replacement (MBT 80), 26 July 1977.
[143] TNA, FCO 46/1749, NATO, collaboration on tanks and tank guns, Chieftain Tank replacement, 2nd Draft of MBT Memorandum – The Successor to Chieftain, 10 July 1978.

was, therefore, to be a Rolls Royce 16-cylinder CV16, a projected development of the new CV8 and CV12 designed for the MICV (later called Warrior) and *Shir* respectively. This requirement for a 16-cylinder engine is particularly interesting in light of the previous belief that a 12-cylinder engine would be sufficient for FMBT; it might be noted that the 16-cylinder engine was never developed. MBT-80's main gun was intended to be the UK's M13A rifled 120mm originally developed with the XM-1 in mind.[144]

The theoretical advantages of standardisation on the FRG smoothbore gun for the UK were considered to be outweighed by the operational advantages of the rifled-bore gun; and the adoption of a foreign gun design was also considered to have negative implications for both British industry and future foreign sales of UK guns and equipment. Any national development of the UK's own smoothbore gun was considered likely to cause an unacceptable delay to the MBT-80 programme and to disrupt existing productionand R&D. With the controversy and arguments surrounding the relative advantages or disadvantages of smoothbore versus rifled, combined with the growing pressure for NATO to standardise its weapons, the decision to go with a rifled gun was considered to require a carefully worded announcement. MBT-80 might, after all, be seen as a blow to standardisation.[145] However, the UK's position was summed up in a memo pointing out that, '[f]or the UK, the advantages of standardisation are in any case outweighed by operational considerations.'[146] It was also noted that, having so recently introduced new national tank projects of their own, neither the US nor the FRG were in any position to criticise a national UK tank project, despite all the calls for NATO standardisation.[147]

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144 TNA, FCO 46/1751, NATO, collaboration on tanks and tank guns, Chieftain Tank replacement, FCO Draft Guidance Telegram to be sent to NATO posts – Chieftain Replacement, 1 September 1978.
145 Ibid.
146 TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from APS/Minister of State to DUS(Army), Revision of draft memo, MBT-80, dated 17 July, 20 July 1978.
147 TNA, DEFE 13/1225, Future main battle tank (FMBT) and associated weapon systems, memo from CSA to Secretary of State for Defence, CSA/184/78, Replacement of Chieftain (MBT-80/GSR 3572), 4 June 1978.

When the ISD for MBT-80, originally set for 1989, slipped by two years, the Army were instead offered the Challenger. Challenger was essentially a UK-requirement modified *Shir*-2, itself a development of the original *Shir* developed for Iran, but delivery of which had been stopped following the Iranian Revolution and overthrow of the Shah in 1979. Development costs of the Challenger had, therefore, effectively already been met by Iran, although each tank still cost more than £1M, almost as much as MBT-80 was projected to have cost taking development costs into account. This price was a sobering warning that MBT-80's final unit costs might have been far greater than originally estimated.[148] Challenger was only supposed to be a temporary replacement, intended to cover a UK capability gap for the 'latter half of the decade', and, 'tide BAOR over into the 1990s'.[149] The UK was now looking at an immediate quarter fleet replacement with Challenger, and a further quarter replacement with an 'improved version' of Challenger by the late 1980s, thus putting the UK on a half fleet replacement cycle like other nations within NATO.[150] Buying Challenger would give the UK the opportunity to collaborate with the French and Germans on production of a new MBT for the 1990s, an aim that the UK Secretary of State for Defence indicated that he set great store by.[151] Regardless of the intention for Challenger to be a stop-gap, its adoption made the chances of a new national UK-made battle tank for the

[148] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, memo, Tanks, Franco-German Collaboration and MBT-80, 8 February 1980.
[149] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, memo, Tanks, Franco-German Collaboration and MBT-80, 12 February 1980.
[150] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, brief for the Secretary of State, Future Tank Collaboration with FRG and France, 3 July 1980.
[151] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, memo from Department of Defence to the PS of Sir A. Acland (DUS FCO), Tank and Armoured Personnel Carrier (APC) Procurement, 11 July 1980.

1990s ‘extraordinarily weak’.[152] Consequently, on 8 July 1980, the decision was made to abandon MBT-80 entirely in favour of adopting Challenger.[153]

4.7. NATO Discussions on Collaboration after the Failure of FMBT

In March 1978, *Lessons Learnt during the Anglo-German FMBT Project (1971-1977),* was published. The report highlighted six main areas which had led to the project’s failure:

1.) There were ‘markedly different’ technical solutions to the FMBT’s developmental requirements, exacerbated by differing tactical philosophies for the design and use of armour.

2.) There had been a failure to agree on the main gun, the decision on which was to be delayed until both guns could be properly evaluated. This delay was then compounded by the involvement of the USA in pushing for a standard NATO tank gun and the consequent involvement of a US gun in the trials. When trilateral tests were finally conducted, there was considerable controversy over the interpretation of the results and the final decision. The report noted that the momentum behind the project had evaporated in the face of this inability to agree.

3.) By the time the need for a further twelve-month joint study to provide better project definition was realised (to be known as Concept Study Two), it was too late for such a study to be implemented as the project had already been terminated.

4.) The harmonisation programme between the Leopard 2 and the US XM-1 created a further delay to the FMBT project. It also made the requirement for FMBT as a standardised NATO tank somewhat less significant.

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[152] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, memo, Tanks, Franco-German Collaboration and MBT-80, 12 February 1980.

[153] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, memo from Department of Defence to the PS of Sir A. Acland (DUS FCO), Tank and Armoured Personnel Carrier (APC) Procurement, 11 July 1980.

5.) The Germans did not believe that FMBT would offer a significant enough advantage over the Leopard 2 to make the FMBT programme worth pursuing.

6.) Although further development might have resulted in a more advanced design to meet the FRG's requirements of being a 'significant improvement' over Leopard 2, such a development would have created further delay to the introduction of FMBT, and would have been unacceptable to the British who were seeking the replacement of Chieftain by 1989 at the latest.[154]

The most commonly stated reason for the cancellation of the FMBT remained the timescale, exacerbated by delays in the project which pushed the likely production date for a common tank after 1989, a delay the UK could not accept due to its urgent need to update or replace Chieftain.[155]

However, the official report made clear that political disagreements over the main gun, a belief in the Federal Republic that FMBT would offer little significant improvement over Leopard 2, and the distraction of the FRG/US harmonisation programme, were at least as much to blame as any 'timescale' issues. A lack of agreement on what is the main feature of any modern MBT, the main gun, as well as the best balance between firepower, mobility and protection was unlikely to lead to a successful collaboration. Neither side was prepared to compromise on what they saw as the best solution, an attitude summed up in a memo to the UK Secretary of State for Defence which pointed out that: 'We are always in favour of standardisation and rationalisation until it is required of us! But standardisation and rationalisation do not make sense for their own sake if the resulting product is inferior.'[156]

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[154] TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977), p. 1.

[155] TNA, FCO 46/1749, NATO, collaboration on tanks and tank guns, Chieftain Tank replacement, 2nd Draft of MBT Memorandum – The Successor to Chieftain, 10 July 1978.

[156] TNA, FCO 46/1749, NATO, collaboration on tanks and tank guns, Chieftain Tank replacement, memo to Secretary of State, Replacement for the Chieftain Tanks, MBT-80, 29 June 1978.

With the failure of the MBT-70, the Franco-German 'European Standard Tank',[157] and the Anglo-German FMBT project, in addition to the failure to harmonise the Leopard 2 and XM-1, a series of tripartite meetings was organised between the UK, French and German Defence Ministers in early November 1977, which sought to identify specific components which could be 'harmonised to the mutual benefit of each country'.[158] M. Bourges, the French Defence Minister, stated that France not only wished to give absolute priority to the European armaments industry, but also preferred to use the Independent European Programme Group (IEPG)[159] as opposed to a wider NATO forum when discussing arms collaboration, such a move excluding the USA from those talks. Herr Leber, the German Defence Minister, stated that the FRG preferred cooperative to national projects because of the 'military, technology, economic and Alliance advantages that cooperation brought.'[160] All three ministers present gave statements of support for cooperation and commonality in matters of defence, including in tanks, stating: 'The Ministers declare their will to seek all possibilities of cooperation between the three countries.'[161]

Standardisation was noted as carrying several potential advantages: improving NATO military effectiveness, economic savings for unit costs, savings for research and development and logistics (including training), and a pooling of knowledge. However, it was also recognised that there were disadvantages and hurdles, such as, differing national doctrines and regional requirements, a lack of diversity in weapon systems which made developing counter-measures easier to implement, industrial rigidity and a stifling of innovation, and a

[157] For further information on the Franco-German 'European Standard Tank', see Ch. 3 above.
[158] TNA, DEFE 13/1153, International co-operation and collaboration on equipment procurement, Brief No.B11, Tripartite Meeting with French and German Defence Ministers, 3-4 November 1977.
[159] The IEPG was set up on 2 February 1976 as a forum to discuss greater European armaments cooperation. It was dissolved on 4 December 1992 when its functions were moved to the Western European Union (WEU) and the new Western European Armaments Groups (WEAG), See here, UIA Website, 'Independent European Programme Group (IEPG)' <https://uia.org/s/or/en/1100006524>, accessed 18 March 2019.
[160] TNA, DEFE 13/1153, International co-operation and collaboration on equipment procurement, MO 25/2/72/1, Record of a Meeting between the Secretary of State and the French and German Ministers of Defence, held at the *Ecole de l'Air*, Salon de Provence, France on 3rd November 1977 at 2.45pm.
[161] TNA, DEFE 13/1153, International co-operation and collaboration on equipment procurement, MO 25/2/71/1, Tripartite Meeting with French and German Defence Ministers, 9 November 1977.

growth of a few large monopoly suppliers, with all the problems of lack of diversity and competition associated with such a situation.[162] One possible alternative to full standardisation was the suggestion of an emphasis on interoperability, instead.[163] In response to a request to define the difference between the terms, the UK Defence Ministry's head of Intellectual Property defined 'standardisation' as:

> The provision of common, and in many respects, identical weapons and equipment. It implies that the weapons and equipment of one force are in large measure interchangeable with those of another. Standardisation therefore also implies interoperability. However it is important to recognise that the converse is necessarily the case; interoperability does not imply or require standardisation.[164]

Thus, interoperability might be illustrated by having two different weapons which use the same ammunition, an example being the modern US M4 carbine (a shorter and lighter version of the M16 assault rifle) and the UK's L85A2 assault rifle. Both are designed to do the same job, but are very different weapons, and the two are hence not standardised. They do, however, use the same ammunition, 5.56×45mm NATO rounds, and are therefore *de facto* interoperable. This makes logistical support much easier as only one type of ammunition need be transported, and the British and American armies (and others using the same ammunition) could share a common pool of ammunition if required.

David Owen, the UK Foreign Secretary in 1978, was particularly keen to promote the idea of standardisation within NATO. But he also recognised that potential European customers were now looking to Germany and the USA because their own forces were largely based on existing FRG and US equipment, thereby making replacement schedules dependent

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[162] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, Head of IP2 to APS Minister of State, Adjournment Debate on the Standardisation of Weapon Systems, 8 May 1978.
[163] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, D/MIN/JG/19/5/4, Minute from Minister of State for Defence to DUS(P), 13 December 1977.
[164] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, Head of IP2 to APS Minister of State, Adjournment Debate on the Standardisation of Weapon Systems, 8 May 1978.

on the FRG and US's own developments.[165] If NATO standardisation was going to mean an increasing reliance on German and US equipment, then the best that the UK might be able to hope for was collaboration with one or the other country, although Owen did suggest the possibility of collaboration with the French. If collaboration and standardisation were to be achieved, he felt, then NATO's different tactical requirements needed to be overcome. He suggested that the FRG and UK should work to bring their requirements closer together.[166] But, at the time, there were at least eight different groups within Europe and the NATO umbrella that were working to better integrate European and NATO weapon systems and defence doctrines. These included: NATO and EUROGROUP; Anglo-French and Anglo-German Army Equipment Commissions; EUROLONGTERM; Independent European Programme Group (IEPG); NATO Army Armaments Group (NAAG); EURONAD; SAC of WEU; and, FINABEL.

With so many groups all working along roughly similar lines, it was inevitable that there would be much duplication of effort, something noted as being an 'unavoidable disadvantage'.[167] A second Franco-German MBT collaboration had begun in 1979, the Tank 90, or, 'Napoleon' project, and this might have presented the UK with a second opportunity to collaborate on an MBT with European NATO allies. However, a Foreign Office memorandum in February 1980 stated that there was 'no question' of the UK joining the Franco-German collaboration, although it did not elaborate on the grounds for this.[168] The reasoning may have been that France's tank philosophy emphasised mobility over protection even more than the Germans did, or it may have been a belief that such a collaboration with France on an MBT was unlikely to succeed. Having just seen a collaboration with the FRG

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[165] TNA, FCO 46/1750, NATO, collaboration on tanks and tank guns, Chieftain Tank replacement, David Owen (Foreign Secretary) to Prime Minister, Replacement of Chieftain Tanks, 24 July 1978.
[166] Ibid.
[167] TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO, VCGS 100-1, memo from VCGS to the Minister of State, International Interdependence Organisations, 13 February 1978.
[168] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, memo, Tanks, Franco-German Collaboration and MBT-80, 12 February 1980.

fail over differing priorities, philosophies and an inability to agree on a standard main gun, the likelihood of now finding common ground while facing the hurdles magnified by France's inclusion seemed remote. This did not stop Sir Clive Rose, the UK's Permanent Representative to NATO (1979-82), writing in July 1980 that, were Britain to approve the adoption of an improved *Shir* (now called Challenger) as a temporary measure, and halt the MBT-80 project, it 'could provide a unique opportunity' for collaboration with the Federal Republic and France for a standard NATO tank.[169] The UK's adoption of Challenger did, of course, come to pass, but recent experience had shown that the reality of collaboration could appear unattractive, whatever the initial political advantages. Nonetheless, there was strong political pressure from her NATO allies for the UK to standardise.[170]

At this time, there was also discussion in both the UK and elsewhere surrounding the future relevance of the tank in its conventional form. The Yom Kippur War had demonstrated the vulnerability of tanks to shaped-charge missiles, yet there was simultaneously a belief that Soviet tanks by the 1990s might be invulnerable to frontal attack by conventional guns.This doubt about the future of the MBT thus made any major governmental investment a risky prospect.[171] The UK Secretary of State for Defence defined a 'tank' as 'that part of our anti-armour capability which provides direct fire from positions which are adequately protected yet mobile, and at the same time provides the ability to counter-attack.' He defended the need for an AFV to fill the tank role, citing the ability to destroy Soviet tanks with direct fire

[169] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, Telegram from Sir Clive Rose (UK delegation to NATO) to PUS, British Tank Programme, 3 July 1980.
[170] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, Draft Memo from Secretary of State to Francis Pym (Secretary of State for Defence), Tanks, Cooperation with France and FRG, 17 July 1980.
[171] TNA, FCO 46/2220, NATO, collaboration on tanks, tank guns and ammunition, Note, Tanks, Essential Facts, n.d.

would 'remain crucial' with both ATGMs and very high velocity tank guns. But he also stated that the exact form of any future weapon system in that role had yet to be decided.[172]

Three months after MBT-80 was abandoned, Britain was once more in the position of having to choose between buying a foreign design, a collaboration, or developing a national design to have an MBT to replace Challenger (and its likely immediate successor) to face potential future Soviet armour developments. A list of options was drawn up and the advantages and disadvantages for each option noted.[173] The conclusion drawn was that, if the UK wanted a replacement to the Challenger's immediate successor in the short to medium term, it would have had to compromise. Margaret Thatcher, the British Prime Minister in 1980, expressed her interest that a future tank should be produced collaboratively.[174] If a European collaboration were to succeed, to the advantages of collaboration within NATO for spreading the cost, maximising production capabilities, and the advantages of commonality within the alliance, would be added to in large measure through European independence in the face of US dominance in arms production. Collaboration with the USA, on the other hand, was thought to be 'always difficult', and the relative numbers of tanks purchased would mean that the UK would be a very junior partner. In any collaboration, the actual realities might mean this option would not work out any cheaper; a 'rule of thumb' guideline was that such collaborative projects cost around 30% more than national ones. The timescales involved in full collaboration projects were also expected to take much longer due to the need to reach agreements on essential points before any development commenced. In addition, the

[172] TNA, FCO 46/2220, NATO, collaboration on tanks, tank guns and ammunition, Covering minute from Secretary of State to Prime Minister, Tank Policy, October 1980; FCO 46/2220, NATO, collaboration on tanks, tank guns and ammunition, note from Defence Minister to Prime Minister, Tank Policy, 16 October 1980.
[173] See here Appendix 6 below.
[174] TNA, FCO 46/2220, NATO, collaboration on tanks, tank guns and ammunition, covering minute from Secretary of State to Prime Minister, Tank Policy, October 1980.

advantages of national tank development included prospective third-party sales and design control besides.[175]

4.8. Project Evaluation and Analysis

As with the other case studies, we will use Fortune and White's project analysis framework to provide a structure of the project's critical success factors for analysis.[176]

Component of Formal System Model	*Evidence of Critical Success Factors in FMBT/KPz3 Project*
Goals and objectives.	• Both FRG and UK were, at the time, looking to design and produce a new MBT. • FRG and UK were looking to emphasise their European credentials with collaboration. • UK wanting a heavier armour-protected tank than did the FRG. • FRG looking for a faster tank which would necessarily have less armour protection than the UK preferred. • Each country looking to install their own main gun design, with an eye to future exports.
Performance monitoring.	• Joint committees agreed concepts to test, but in most cases the concepts presented met national, rather than bi-national, requirements. • The question of tank gun standardisation within NATO distracted and diverted FMBT project. • Disagreement over splitting of responsibilities. • Both countries working on separate designs with an expectation that one would be chosen.
Decision-maker(s).	• Political support was initially very strong. • Long delay (5 years) in planning agreement on the critical design factors regarding the design's eventual tactical qualities. • FRG simultaneously in negotiation with the USA over possible cooperation on Leopard 2 and XM-1.
Transformations.	• Each development team worked in isolation to design and produce prototypes. • Although conferences jointly agreed which designs to test, there was no cooperation in actual development.

[175] TNA, FCO 46/2220, NATO, collaboration on tanks, tank guns and ammunition, note from Defence Minister to Prime Minister, Tank Policy, 16 October 1980.
[176] Joyce Fortune and Diana White, 'Framing of Project Critical Success Factors by a Systems Model', *International Journal of Project Management*, 24 (2006), p. 57.

Communication.	• Poor communication led to, for example, misunderstanding as to the work-sharing for the final product. • No agreement on the final main gun, with each nation wanting to use their own design.
Environment.	• The FRG and UK were both stable democracies subject to internal political oversight from political opponents and domestic bodies. • The USA and FRG began to cooperate on greater standardisation between MBTs, at the expense of the FRG-UK project. • USA opened competition to choose main gun for XM-1, which further disrupted the FMBT project. • FRG's interest waned as time passed with no sign of UK-FRG agreement on a design.
Boundaries.	• Disagreements from the start over the division of responsibilities. • Each country to produce tanks separately, with numbers produced weighted by national purchases.
Resources.	• Both the FRG and UK governments had budgetary limits and were subject to democratic governmental oversight. • Both countries were looking to replace existing MBTs and had budgeted accordingly. • No radically new technology was proposed, although the UK introduced its 'Chobham' composite armour. • Both countries looking to use their own domestically designed and produced main gun. • FRG's resources and attention split when it entered agreement with USA to look at standardising MBTs. • USA's announcement of competition to choose new main gun for XM-1 focussed and diverted both UK and FRG on that issue.
Continuity.	• Project saw no real attempt to address differing views on main gun or tactical requirements. • Separate national teams and development saw duplication of effort. • Pressure to adopt domestic main gun by both nations, especially following USA's announcement with regards to XM-1 gun.

Analysis using the above framework strongly suggests that the project lacked specific aims and therefore lacked a clear direction. Although political support was strong, this did not translate into agreement of a final design, with each country wanting something different in their new MBT. It is hard to see how the programme could have succeeded when no clear goal was established; any agreement on the main gun would have meant a significant compromise by one or the other partners and a severe blow to that nation's tank gun industry. The domestic industries of both the FRG and UK wanted their own main gun design to be adopted for the final MBT, something that became more critical when the USA announced that it was looking for a main gun design for the XM-1. Indeed, the USA's influence on the FMBT programme should not be overlooked but was, perhaps, a symptom of ongoing disagreement rather than any cause of the failure. At a time when the FRG and UK were struggling to agree an MBT design and on which main gun to use, the USA approached the FRG to collaborate on standardisation plans between Leopard 2 and XM-1, as well as announcing the competition to find a new main gun. This distracted the FRG's resources at a time when they might have been concentrating on the FMBT project. How likely it is that the UK and Germany would have agreed a design and main gun is open for speculation, but it seems unlikely given the problems encountered. The USA's approach, therefore, might have been a welcome excuse for Germany to bow out of the FMBT programme given that the FRG was no closer to a successful MBT design with the UK and was, in any case, happy to stick with its Leopard 2.

4.9. Summary

The 1978 joint Anglo-German paper, *FMBT/KPz3 Equipment Collaboration: Lessons Learnt during the Anglo-German FMBT Project (1971-1977)*, detailed three principles that its authors stated were the lessons learned for future collaboration: that a project must be feasible, likely to succeed and be of benefit to both sides; that a common aim should be established, and competition and duplication avoided; and, that information should be exchanged in a timely and effective manner.[177] The fundamental requirements for the success of a project as established by the UK's Vice Chief of the General Staff – and Frinsdorf, et al., (adapted to the FMBT project in the introduction above) – are having initial political support, an agreement on a common scope or design, good communications between the participants, and sustained support to see the project through.[178]

Looking at the principles contained in these lists in relation to the FMBT project shows that only the political encouragement for initial collaborative studies was successfully applied. The project set up national feasibility studies to arrive at a common design concept based on the tactical requirements, but these came to nothing and a General Staff Requirement was never arrived at. Without a GSR, there was no chance of achieving unity on work-sharing agreements because each side knew that the other would likely design a system based on their own requirements. Communication was sporadic, and generally consisted of telling the other party what the designers of a nation were working on, rather than any attempt at bringing together ideas and establish a common design. There was a lack of faith in reaching compromise which resulted, in turn, in a lack of enthusiasm to work towards a successful project, while the armies of both nations were not prepared to accept the designs of the other.

Beyond the multiple failures within the broad project structure as set out above, two specific and highly significant points of disagreement stand out: the early failures to both agree on a main gun and the different priorities over the balance of firepower-mobility-protection. Although widely quoted as the reason behind the project's failure, the different

[177] TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977, p. 2.

[178] TNA, DEFE 70/586, Future Main Battle Tank (FBMT), equipment, future tank policy study, possible collaboration, Note from VCGS to CGS, Tank Collaboration, 12 September 1980; and, Frinsdorf, et al.,'Critical Factors for Project Efficiency in a Defence Environment', p. 813.

timescales for ISD do not appear to be as significant as assumed by some observers.[179] The Federal Republic had always intended that FMBT replace the Leopard 1 tank starting in 1985, while the UK had a similar initial ISD in mind for Chieftain's replacement. The UK's proposed ISD was subsequently extended to 1989 at the latest, which was certainly a later deadline than initially suggested for FMBT, but unlikely to have been impossible for the FRG to agree to. However, whilst the FRG might have been able to extend the ISD for FMBT beyond 1989 due to its proposed introduction of Leopard 2 to run alongside the existing Leopard 1 tanks, this would have been unacceptable to the UK which was looking to replace its entire, ageing Chieftain MBT fleet. However, many of the delays in the FMBT project were themselves due to a failure to agree on tactical concepts from the start, leading to duplication and additional work.[180]

Of course, the potential for further overrun is always present in any development project, and in collaborative projects in particular, something that the Germans had discovered only too recently with the MBT-70. However, blaming different timescales was a convenient political excuse to mask the fact that the FMBT project had been doomed by a lack of agreement and compromise in tactical design concepts, with neither country willing to compromise its own position in the mobility-versus-protection debate, or to threaten its domestic arms industry by adopting the other's tank gun design.[181] In addition, in the Leopard 2 design the FRG found that it had a tank that might potentially give it a leading position vis-à-vis international arms exports, something which would have been compromised by the development and adoption of FMBT.

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179 For some examples of the blaming of timescale, see: TNA, DEFE 13/1045, Tanks and tank guns, proposals and developments, MO 26/4/2, letter, UK Secretary of State for Defence to FRG Minister of Defence, 24 March 1977; DEFE 13/1045, Tanks and tank guns, proposals and developments, draft, VCGS to Theatre Commanders (CinC BAOR, CinC UKILF, GOC NI, CBF HK); WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977), p. 2.

180 TNA, WO 362/54, Future Main Battle Tank (FMBT)/KPz3 equipment collaboration, lessons learnt during the Anglo-German FMBT project (1971-1977), pp. 2-6.

181 See, for example: Hilmes, 'Modern German Tank Development, 1956-2000', p. 19; and, Ogorkiewicz, *Tanks: 100 Years of Evolution*, p. 182. The tank gun debate is covered in some detail in Ch. 1 above.

The fact that the FRG was convinced of the superiority of the Leopard 2 design and its own smoothbore gun – and, conversely, that the UK was likewise convinced that its own rifled gun was superior – must therefore be seen as more significant than any differences in ISD. For the Federal Republic, developing a radically different MBT in collaboration was a less attractive option than linear development and the export of a domestic design. The strong possibility of persuading the USA to adopt the *Rheinmetall* smoothbore gun further reduced any enthusiasm for FMBT when the UK was still insisting on using its own rifled-bore gun. Clearly, neither the FRG nor the UK wanted to be seen as the junior partner in any collaboration, and both had future foreign arms sales firmly in mind. The adoption of the main gun was of vital significance for the tank gun industry, and indeed the wider tank industry, of whichever country could persuade the other to compromise.

Perhaps the lesson to be drawn from the FMBT project is that MBT collaboration should be first and foremost a military decision based on necessity, with agreement on the tactical requirements essential to allow later political decisions on work-sharing and foreign export sales.[182] In other words, agreement is vital on the military role, as determined by a nation's armoured doctrine, not to mention its own future 'threat perception', that the new MBT is expected to fill. Although both (or all) partners must obviously also be politically committed to the design, it is doctrine that should determine the final design. Sharing design responsibilities can only be agreed when both parties are working towards the same goal, both military and political, and without this focus any project will be highly likely to fail. A comment made at the Royal Armoured Corps (RAC) conference of November 1972 on the progress of the FMBT is instructive in this regard:

> The successful outcome of a bilateral project is dependant to a large extent on the two countries identifying and facing up to differences at the start.

[182]McNaugher, *Collaborative Development of Main Battle Tanks*, pp. 71-72.

> Failure to do so can only result in bitter and costly arguments, even breakdown later on.[183]

Based on the experience of the FMBT project, it can be argued that political engagement on MBT collaboration may be useful to boost the standing of individuals and governments, but if the planners cannot agree on what tactical requirement the MBT will meet, much less find a final design that meets their national military requirements, then the project will inevitably stumble towards failure. As Lord Carrington, the UK Foreign Secretary, wrote in 1980 to Francis Pym, the Defence Secretary, 'one does not buy tanks purely as a matter of political convenience.'[184] Tanks have a symbolic and political impact for a nation over and above their military value.[185] Yet they remain, first and foremost, a weapon system, and their design might best be led by defence experts and the soldiers who will operate them rather than simply using their development and acquisition as political capital.

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[183] TMARL, E2014.1841, RAC Conference 1972, FMBT Progress Report, 14 November 1972, p. 6.

[184] TNA, FCO 46/2219, NATO, collaboration on tanks, tank guns and ammunition, draft memo from Secretary of State to Francis Pym (Secretary of State for Defence), Tanks, Cooperation with France and FRG, 17 July 1980.

[185] See, for example: Dmitry Evstafyev, 'A Song About a Tank, or Reflections on Russian Military Strategy', *Security Index: A Russian Journal on International Security*, 18:2 (2012), p. 105; Alaric Searle, *Armoured Warfare: A Military, Political and Global History* (London, 2017), pp. 193-208; Wright, Patrick, *Tank* (London, 2000), passim.

CHAPTER 5

Placing MBT Collaboration in Context: Other Defence and Technology Projects since 1945

The apparent advantages of international collaboration make it an attractive option for any new development where cost and statements of political unity are more important than the sovereignty of the design.[1] Large projects such as airliners, next generation fighter aircraft and complex missile systems might be beyond the economic and technological capability of single nations, especially those with smaller budgets and research and development (R&D) resources. Joining an international collaboration offers the opportunity to develop such weapon systems without bearing the entire cost or R&D burden. While this study is directed primarily towards NATO collaborations in the design and development of MBTs, such a study cannot exist in isolation, and it is useful to examine briefly other collaborative projects. In other words, given the complex, technical, technological and organisational issues surrounding MBT collaborative projects, it is only logical to consider other projects not involving MBTs as a means of placing the material examined in this thesis within a broader context.

Chapter 1 explained the differences between collaboration and other forms of technology transfer, but it seems appropriate to revisit these definitions in order to look at some of the wider problems of collaboration. Hartley and Martin suggest that European defence collaboration consists of programmes 'involving two or more nations sharing the

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[1] Andrew Movavcsik, 'Armaments among Allies: European Weapons Collaboration, 1975-1985', in Peter Evans, Harold Jacobson & Robert Putnam (eds.), *International Bargaining and Domestic Politics: Double-Edged Diplomacy* (London, 1993), p. 128.

development and production costs and work on defence equipment projects'.[2] Although collaboration thus appears to be deceptively easy to identify, the main problem with defining real-world projects comes when the balance of responsibilities is highly asymmetric. In the definition provided above by Hartley and Martin, for example, there is no indication of any sort of equality in the division of costs and work. Dirk Klimkeit, the Otto Group Chair of Strategic Management at Leuphana University, Germany, used the following definition:

> Collaboration [...] requires an alignment between actors from various parts of the organization so that they show co-operative behaviour and focus on achieving the project's goals. Apart from differing interests and priorities as impediments to collaboration, the organizational context into which projects are embedded varies in how conducive it is to international collaboration.[3]

This definition again sets outs that the development work ought to be shared between the involved parties, but once again avoids suggesting any measure of parity in the work-sharing or responsibilities.

Andrew Kennedy, using the example of the United States' R&D collaborations with India and China, notes that asymmetry in one area might be offset by advantages elsewhere. In the case of the US-India-China collaborations, the USA was gaining political leverage and improved relations in exchange for investing money and technological expertise in Indian and Chinese projects.[4] The balance of gain from such asymmetric deals is highly subjective, it being almost impossible to quantify such 'soft' benefits as political influence. This makes any hard evaluation very difficult. Rather, it must be for the partners involved to judge how satisfied they are with the arrangement. As DeVore points out, the prospect of losing out

[2] Keith Hartley and Stephen Martin, 'Evaluating Collaborative Programmes', *Defence Economics* 4:2 (1993), p. 196.
[3] Dirk Klimkeit, 'Organizational Context and Collaboration on International Projects: The Case of a Professional Service Film', *International Journal of Project Management*, 31 (2013), p. 366.
[4] Andrew B. Kennedy, 'Unequal Partners: U.S. Collaboration with China and India in Research and Development', *Political Science Quarterly*, 132:1 (2017), p. 84.

relative to the other partners involved is a strong deterrent to any potential collaboration.[5] Jacques Gaillard addresses the problems of asymmetry in international collaborations and concludes that:

> One of the determining condition[s] for successful collaboration is that the partners should be equal or at least complementary in many respects. The experience accumulated during the last decade shows that this apparent vicious circle can be overcome if the collaboration is based on a strong mutual interest and if both parties have something to gain from it.[6]

Thus, Gaillard is in broad agreement with Kennedy in that apparent asymmetry in one area can be balanced out if there is a clear gain elsewhere. However, he also suggests that two of the prerequisites for a successful collaboration are that 'Project proposals should, whenever possible, be drafted jointly and each partner should be associated as much as possible to the important decisions which need to be taken,' and furthermore that, 'Each cooperating group should include a substantial number of researchers (at least 3).'[7] Alicia Mazur, et al., would also seem to conclude that all stakeholders in a project should be involved at all stages if the collaboration is to succeed.[8]

The literature suggests that a key factor for successful collaboration is that all parties believe themselves to be gaining advantage in approximate proportion to the contribution they are investing. However, this also holds true for non-collaborative international transactions, even simply purchasing a foreign design 'off the shelf' might be seen as an equitable exchange while, self-evidently, not being collaboration in any real sense. Thus, it is it acknowledged here that the exact definition of a 'collaboration' is vague at best, and that the theoretical ideal of two or more parties investing equally in development and

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[5] Marc R. DeVore, 'The Arms Collaboration Dilemma: Between Principal-Agent Dynamics and Collective Action Problems', *Security Studies*, 20:4 (2011), p. 626.
[6] Jacques F. Gaillard, 'North-South Research Partnership: Is Collaboration Possible Between Unequal Partners?', *Knowledge and Policy*, 7:2 (1994), p. 57.
[7] Ibid., p. 58.
[8] Alicia Mazur, et al., 'Rating Defence Major Project Success: The Role of Personal Attributes and Stakeholder Relationships', *International Journal of Project Management*, 32 (2014), p. 953.

manufacturing may not survive contact with actual projects. Nonetheless, the principle of involving all partners in the development process seems to differentiate 'true' collaborations from projects where one partner develops a product independently, and later invites others to simply invest money in it or to produce an already-developed system under licence.

A number of successful international collaboration projects, both military and civilian, are relevant to investigating the question of collaboration, and could have been included, but space limits both the number of case studies and the depth of coverage. With the thesis focussed on NATO MBTs, a decision was made to concentrate on other military projects for these smaller studies, although the civilian BAC/Aerospatiale *Concorde* airliner is obviously a significant departure from this. The projects covered are divided into three broad categories: tanks and ground vehicles, aircraft, and weapon systems. Three examples of international collaboration for each of these three categories have been chosen, with the expectation that examining a broad range of programmes will reveal a pattern pertinent to our study of MBTs. The Mark VIII 'International' tank has already been mentioned earlier in the thesis as the only historical example of a collaborative tank project to result in a production vehicle. Given its significance, the Mark VIII is dealt in more depth than the other case studies in this chapter and appears towards the end of the chapter rather than in the section on tanks and other ground vehicles since it was a collaboration which predates the Cold War. Other projects not covered here that are, nevertheless, worthy of a brief mention include the Indonesian-Turkish PT/FNSS/CMI *Tiger/Harimau* medium tank,[9] the Lockheed Martin F-35

[9] See, for example: Jane's 360, 'IDEF 2017: Prototype Kaplan MT Medium Weight Tank Completed', <http://www.janes.com/article/70297/idef-2017-prototype-kaplan-mt-medium-weight-tank-completed>, accessed 31 January 2018; and, Jane's 360, 'Indonesian Army's Tiger Medium Tank Programme Moves Ahead', <https://www.janes.com/article/84825/indonesian-army-s-tiger-medium-tank-programme-moves-ahead>, accessed 28 November 2018.

Lightning II,[10] the Austrian-Spanish ASCOD Fighting Vehicle,[11] and the 'Black Night' upgrade to Challenger II.[12]

Finally, in order to highlight how programmes which involve cooperation may not be collaborative in the sense of co-development and joint responsibility, two significant defence programmes, the Sino-Pakistani MBT-2000/*Al-Khalid* MBT and the F-16 Falcon combat aircraft have been chosen for brief examination. By showing how the dynamics within these cooperative projects differ significantly from those illustrated in the main MBT case studies above, a better critical comparison between types of technology transfer can be made in the conclusion.

5.1. Tanks and other Ground Vehicles

Main battle tank collaborative projects have generally taken place between NATO nations, even if Warsaw Pact nations produced Soviet tanks under licence. Any collaboration within the Warsaw Pact was, though, very far away from the intentions which lay behind NATO nations' efforts at collaborative AFV projects. The Sino-Pakistani MBT-2000/*Al-Khalid* likewise does not fit the model of a genuine collaborative AFV project. Thus, this section will consider two collaborative AFV projects: first, the case of the Franco-German KNDS EMBT, which was a demonstrator tank, developed as an exhibition vehicle to showcase KNDS as a company; second, the SP-70, which was Italian-German-British self-propelled artillery piece,

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[10] See, for example: F-35, 'F-35 Lightning II', <https://www.f35.com/>, accessed 23 December 2018; and, Gertler, Jeremiah, *F-35 Joint Strike Fighter (JSF) Program* (Washington DC: Congressional Research Service, 16 February 2012), accessed via. <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA590244>, accessed 28 September 2016.

[11] Army Technology, 'ASCOD (Pizarro /Ulan) Armoured Fighting Vehicle', <https://www.army-technology.com/projects/ascod/>, accessed 29 September 2018.

[12] See, for example; BAE Systems, 'Black Night Unveiled, <https://www.baesystems.com/en/black-night-unveiled>, accessed 1 January 2019; and, Army Technology, 'BAE Systems unveils Black Night Challenger 2 MBT for British Army', <https://www.army-technology.com/news/bae-black-night-challenger-2-army/>, accessed 10 October 2018.

which failed as a project due to technical difficulties. These two examples provide variations on the main theme of this thesis.

Franco-German KNDS EMBT

On 15 June 2018, the Franco-German KNDS Group, comprising Krauss-Maffei Wegmann (KMW) and Nexter Defense Systems, unveiled its new tank demonstrator at the Eurosatory Defence and Security Exhibition. This demonstrator was not a completely new tank but was instead a KMW Leopard 2A7 MBT chassis fitted with the turret of the Nexter Leclerc MBT. Despite calling their vehicle the 'European Main Battle Tank' (EMBT), KNDS were not actually suggesting the EMBT as a finished tank but rather promoting it as evidence that they were capable of producing a next-generation MBT.[13] This new project is particularly interesting as it may signal a possible collaboration between French and German companies to produce a new MBT for NATO countries. Whilst it is too early, especially in light of the history of such collaborations, to state that a post-1945 collaborative project will lead to a new NATO tank, the EMBT demonstrator is certainly a significant enough development to warrant some examination.

The origins of EMBT must surely be traced back to the 1977 Franco-German 'Tank 90/Napoleon' project.[14] After several disagreements and re-evaluations of the aims of that project, a late proposal was for a new, collaboratively developed, turret to be mounted on an improved Leopard 2 chassis.[15] The Tank 90 project was eventually cancelled in 1983, cancellation having also been the fate of the earlier 1957 'FINABEL' Franco-German attempt. Evidently two failed collaborative proposals had not dampened enthusiasm for another attempt between these two major continental European countries because another

[13] Jane's 360, 'EU Tank Breaks Cover', <https://www.janes.com/article/81083/eu-tank-breaks-cover-es18d5>, accessed 2 August 2018.
[14] See Ch. 2, above, for more details of the 1977 Franco-German project.
[15] TNA, FCO 46/2775, NATO: Franco-German Tank Cooperation, memo from British Embassy, Bonn, to British Embassy, Paris, 'Franco-German MBT', 20 March 1981. See also Ch. 2 above.

tank collaboration project was announced in 2012. The French and German governments agreed to cooperate on a new Main Ground Combat System (MGCS) to potentially replace both the Leclerc and Leopard 2A7, as well as a related range of AFVs and support vehicles.[16] On 20 June 2018, Germany's KMW and France's Nexter announced the creation of new bi-national company, KMW and Nexter Defense Systems (KNDS), to develop new land combat vehicles.

Nexter and KMW have been exploring the possibility of a collaboration for some years. In an interview on 22 July 2016, the Polish Defence Minister announced that Poland wanted to be part of any international collaboration between the two firms, although no Polish involvement has yet been revealed in the KNDS consortium.[17] Such interest in a new development is prescient, especially for a country close to an area of current conflict.[18] Yet the Cold War vintage that underlies the design of the current MBT fleets of NATO member states' means that widespread replacement is going to be required within NATO in the next 20 years. Many Western countries have neglected their MBTs in the face of reduced defence budgets and contemporary conflicts which predominantly involve counter-insurgency and low-intensity warfare. Urgent replacement of obsolete tanks is likely to be met with progressive upgrades rather than with the development of new models, but upgrades can only offer limited technological improvements and new models will inevitably be required in the longer timeframe. KNDS's EMBT demonstrator may thus be a sensible first move towards meeting the requirements of several NATO members within the next couple of decades.[19]

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[16] Jane's 360, 'Design Concepts Emerge for Possible New French-German Main Ground Combat System', <https://www.janes.com/article/80463/design-concepts-emerge-for-possible-new-french-german-main-ground-combat-system>, accessed 6 June 2018.

[17] Defence News, 'Poland Wants to Play in Franco-German Tank Program', <http://www.defensenews.com/story/defense/policy-budget/industry/2016/08/03/poland-wants-play-franco-german-tank-program/87929202/>, accessed 17 August 2016.

[18] At the time of writing, the Ukraine is still fighting Russian-backed separatists on its eastern borders and tensions with Russia are mounting over navigation rights in the Sea of Azov, amongst several other disputes.

[19] IISS, 'France and Germany: on the right tank tracks?',<https://www.iiss.org/blogs/military-balance/2018/07/france-and-germany-tank-tracks>, accessed 20 July 2018. For an example of how governments

According to a study by Frinsdorf, Zuo and Xia, there are five main factors that should be taken into account when assessing a potential project's efficiency: the organisational capability should be sufficient to meet the project's scope; the project should enjoy sufficient support from senior management; the project's aims and objectives should be well-defined and understood; communication pathways should be well-established, and; sufficient resources should be available to meet the project's requirements.[20] For many national government-led projects not all of these requirements can be guaranteed. Elected politicians support projects for only so long as they remain in office, and an election or governmental reshuffle can leave projects without strong political support. With strong management identified as a particularly important factor in successful project management, politically-driven projects within democracies can therefore be at a severe disadvantage in relation to those undertaken within the private commercial sector (or, indeed within a dictatorship).[21] Resources depend on budgetary allocations, something that may be reduced or withdrawn at any time according to political necessity or changing priorities. A politically-driven project might be overseen by diplomatic forces with political goals but without a clear and defined military target. Commercial collaborations, by contrast, are far more likely to begin projects with a set goal in mind, with allocated resources and with a strong management structure. Obviously even commercial collaborations can run over budget or fail, but the incentives to succeed commercially are stronger than with a programme under governmental supervision, where the consequences of failure are perhaps not as commercially catastrophic.

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upgrade older MBTs, see UK Defence Journal, 'BAE Unveils "Black Night" – the First Fully-Upgraded Challenger 2 Tank' <https://ukdefencejournal.org.uk/bae-unveils-black-knight-the-first-fully-upgraded-challenger-2-tank/>, accessed 3 December 2018.

[20] Olivia Frinsdorf, Jian Zuo& Bo Xia, 'Critical Factors for Project Efficiency in a Defence Environment', *International Journal of Project Management*, 32 (2014), p. 813.

[21] Stephen B. Johnson, 'Technical and Institutional Factors in the Emergence of Project Management', *International Journal of Project Management*, 31 (2013), p. 677.

The most recent international defence collaboration, the KNDS EMBT may signpost the future of such programmes. Multinational consortia are commonplace in the field of high value large projects and having the single management structure and development team allows for fewer disagreements over specifications and direction. Whilst this might also restrict developmental input to a single team, being a commercial concern means that such consortia are theoretically going to be developing to a fixed governmental tender. At the time of writing, KMW itself might be acquired by *Rheinmetall*, which could affect the future of the KNDS collaboration.[22] With few nations having the budget, facilities or resources to develop new sovereign MBTs, it will be interesting to follow the fortunes of KNDS and similar international consortia and discover if such private sector international collaborations are the future for MBT development within NATO.

The Italian-German-British SP-70 Self-Propelled Artillery System

The SP-70 was intended to be the self-propelled variant of the 155mm FH-70 howitzer, covered below, which was jointly developed in the late 1960s by Britain, the FRG and Italy. The towed FH-70 howitzer officially entered service with those countries in 1978, although it was not operational until two years after that.[23] The SP-70 was subsequently accepted as a NATO project in 1973 on the basis of the success to that point of the FH-70.[24] Whilst it is acknowledged that covering the SP-70 before the FH-70 project is not the logical sequence, as an armoured vehicle the SP-70 belongs in this section and knowledge of one project does not really depend on knowledge of the other.

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[22] Defence News, 'Tank Maker Takeover: Germany's Rheinmetall Eyes Acquisition of Rival KMW' <https://www.defensenews.com/global/europe/2018/11/27/tank-maker-takeover-germanys-rheinmetall-eyes-acquisition-of-rival-kmw/>, accessed 27 November 2018.
[23] R.G. Sawhney, 'Field Artillery Today and Tomorrow', *Strategic Analysis*, 7:11 (1984), p. 931. FH-70 is dealt with in more detail below.
[24] Alan G. Draper, European Defence Equipment Collaboration: Britain's Involvement, 1957-87: RUSI Defence Studies (London, 1990), p. 89.

Self-propelled artillery has several advantages over towed guns. It is faster to get into action, is about as mobile as any armoured units it is supporting, and it usually provides some protection both for the crew and the gun. By contrast, disadvantages include the additional expense, the fact that its mobility relies on its own internal engine which is not easily replaced in cases of mechanical breakdown, less efficient operational mobility than a towed gun, and greater weight than an equivalent towed gun which consequently reduces its strategic mobility in comparison.[25] In the years following the Second World War, armoured warfare was predicted to remain an important feature of any potential European Cold War conflict. Most NATO countries therefore saw a need for self-propelled medium artillery to complement the existing self-propelled light pieces.

The successful progress of the FH-70 towed howitzer encouraged the trilateral collaboration of Britain, the FRG and Italy which had developed it, so that they took the decision in 1973 to use this gun as the basis for a new self-propelled version, to be known as SP-70.[26] Development was split between the three participating countries, with Britain taking responsibility for the turret, ammunition handling system and sights; the Federal Republic contributing the ammunition, chassis and main engine; and Italy the elevating mechanism, hull and auxiliary power unit (APU). With the aim of improving both interoperability and reliability, the FRG used components from several existing vehicles such as Leopard 1 and the Marder Infantry Fighting Vehicle (IFV). The gun, as mentioned, would be the FH-70, further improving interoperability.[27]

In 1973, the trilateral group completed the SP-70's Project Definition Phase and then went on to conduct exhaustive validation trials which included the production of five prototypes by 1976. These trials were extensive and included operation in the freezing

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[25] J. B. A. Bailey, *Field Artillery and Firepower* (Basingstoke, 1989), p. 11.
[26] For more information on the FH-70 towed howitzer, see below.
[27] R. C. F. Craven, 'A 70 for the 90s', *Field Artillery Journal,* 51:3 (1983), p. 28; and Military Today, 'SP-70', <http://www.military-today.com/artillery/sp70.htm>, accessed 10 September 2018.

conditions of northern Norway and the hot, dry conditions of Sardinia. Crucially, mobility was found to be equal to that of the new US M1 tank (then still under development) and of all contemporary NATO's tracked personnel carriers. The system proved itself capable of negotiating rocky conditions and firing with consistent accuracy; and it was successful enough in the trials that the project moved on to Phase B.[28] With the Phase B trials set for 1983, SP-70, also known as PzH-70 in the Federal Republic, was expected to enter service in 1988.[29]

However, various technical problems emerged during the Phase B trials, including reliability issues with the turret and the ammunition handling system. As these problems continued to delay the programme and with rising costs, the Federal Republic took the decision to withdraw from the collaboration in 1985. As the major partner, this effectively doomed the project. With the collapse of the SP-70 project, Britain, the FRG and Italy were still left in need of a replacement for their existing US-built M109 SPGs. It was highly unlikely that another European self-propelled howitzer collaboration was going to be proposed within the required time frame, even had the three countries been eager to enter another such project so soon after the failure of SP-70. With the USA looking to a linear upgrade of, rather than replacement for, their own existing M109s, Britain, the FRG and Italy instead chose to develop their own sovereign mobile artillery systems. Britain subsequently developed the AS-90, Germany the PzH-2000 and the Italians the *Palmaria*.[30]

The SP-70 collaboration demonstrates an important consideration when entering such partnerships, be they international or not, in that any partnership is reliant on continued cooperation between its members. When one partner withdraws from the collaboration, the consequences can be disastrous. The Federal Republic's decision to withdraw effectively

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[28] Craven, 'A 70 for the 90s', p. 29.
[29] Sawhney, 'Field Artillery Today and Tomorrow', p. 931.
[30] Christopher F. Foss, *Jane's Armour and Artillery 2011-2012* (Coulsdon, 2011), pp. 809, 823, 854; and, Military Today, 'SP-70', <http://www.military-today.com/artillery/sp70.htm>, accessed 10 September 2018.

spelled the end of the project, forcing the other two participants to choose between substantially reallocating and restructuring the existing resources and responsibilities, or also withdrawing in turn. Of course, such a consideration might also act to dissuade a partner from withdrawing, even whilst facing unfavourable financial circumstances. Dooming a project to failure by withdrawing support might result in negative political consequences, something which could be deemed more important than the potential financial disadvantages of staying part of the programme.

5.2. Aircraft

This section is slightly different in that a civilian collaborative project has been included. This is because it is a good example of an Anglo-French joint aircraft project, established with the intention of a combined effort being deemed the best way of solving major technical challenges. It seems obvious that the timing of the project coincided with Britain's intention of attempting once again to join the EEC. The second project – the Eurofighter Typhoon – deserves inclusion as it could be seen as an example of successful high-technology aircraft project conducted by four NATO nations. Finally, this section will consider A380/A400M because this project was driven almost entirely by political considerations to produce a military airlift aircraft.

Concorde

Described by BAE Systems as an example of "what can be achieved when 'great minds think alike' ", the Anglo-French BAC/Aerospatiale *Concorde*[31] emerged from separate studies by

[31] Through a long sequence of mergers and eventual nationalisation, the British Aircraft Corporation (BAC) became one of the companies inherited by BAE Systems. The company Aerospatiale is similarly the inheritor of Sud-Aviation. See BAE Systems, 'BAC Concorde', <https://www.baesystems.com/en/heritage/bac-concorde>, accessed 18 September 2018; and Reference for Business, 'The Aerospatiale Group',

both Britain and France in the mid-1950s to examine the possibility of a practical supersonic transport aircraft.[32] The project history is interesting for several reasons, most notably the point that political enthusiasm over-ruled any economic realities which would likely have otherwise hindered or even halted the aircraft's development. As an example of international collaboration, *Concorde* can be viewed as an attempt by two major European nations, both with a recent history of being global superpowers, to regain global prestige with a ground-breaking scientific and technical project and, in particular, to gain a technical lead in commercial aviation over the USA.[33] As a commercial venture, *Concorde* was a financial failure but it certainly achieved the political aim of highlighting British and French technical expertise to the world.[34]

In 1954, the future of Britain's commercial aircraft industry looked bleak. The much-vaunted Brabazon project, a large luxury airliner intended to attract rich passengers, had failed to attract orders in the face of increasing mass-market commercial air travel. The British Comet, the world's first jet-powered airliner, had just been grounded following a series of accidents and issues with metal fatigue and structural weakness reportedly due to the shape of the windows.[35] The French, meanwhile, had produced the Sud-Aviation *Caravel* sub-sonic airliner, but were very aware that the years of German occupation during the Second World War had stagnated their airliner technical expertise, especially compared to the USA whose increasing industrial dominance in Europe de Gaulle particularly resented and

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<https://www.referenceforbusiness.com/history2/15/The-Aerospatiale-Group.html>, accessed 10 November 2018.

[32] Donald Alfred Nelson, 'Concorde: International Cooperation in Aviation', *The American Journal of Comparative Law*, 17:3 (1969), p. 453.

[33] Lewis Johnman& Frances M. B. Lynch, 'The Road to Concorde: Franco-British Relations and the Supersonic Project', *Contemporary Military History*, 11:2 (2002), pp. 229, 235.

[34] Annabelle May, 'Concorde – Bird of Harmony or Political Albatross: An Examination in the Context of British Foreign Policy', *International Organizations*, 33:4 (1979), pp. 483-4.

[35] Johnman& Lynch, 'The Road to Concorde', p. 231.

sought to counter.[36] Since being elected to head the French Fifth Republic, de Gaulle had committed France to a series of *grands projets* to further the country's global standing. The quest for a supersonic airliner that would result in the *Concorde* was only one of these prestige projects.[37]

Both Britain and France came to the same conclusion, that in order to regain lost prestige in the global airliner industry they needed to develop a supersonic passenger aircraft. The technical problems were considerable; and, both nations had encountered similar obstacles. As a consequence of the aerodynamic forces encountered, supersonic aircraft must have smaller wings than aircraft designed for slower flight, but small wings produce less lift, particularly at slower speeds. This lack of lift means a very long run is required to achieve take-off speed and, conversely, it results in a frighteningly high landing speed. These drawbacks meant that supersonic airliners remained technically impractical until Britain's Royal Aircraft Establishment at Farnborough developed the concept of the 'slender-delta planform' wing shape which overcame most of the problems.[38]

Both France and Britain sought collaboration as a means to reduce development time, reduce costs and to pool technical expertise.[39] Each had slightly different aims, with Britain holding an uncertain middle ground between wishing to dominate the global aeronautical industry and pursuing cooperation with the USA, and with France looking to dominate politically and industrially in Western Europe. Yet the governments of both nations recognised that the costs of these ambitions would be prohibitive for their respective national

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[36] May, 'Concorde – Bird of Harmony or Political Albatross', p. 490. Charles de Gaulle, who was eager to reduce US influence in Europe and increase that of France, returned to power in France following the 1958 collapse of the Fourth Republic. See here Michel Winock, 'De Gaulle and the Algerian Crisis 1958-1962', in Hugh Gough and John Horne (eds.), *De Gaulle and Twentieth Century France* (London, 1994), pp. 71, 83-85.

[37] Serge Berstein, 'De Gaulle and Gaullism in the Fifth Republic', in Gough and Horne (eds.), *De Gaulle and Twentieth Century France*, p. 115.

[38] BAE Systems, 'BAC Concorde', <https://www.baesystems.com/en/heritage/bac-concorde>, accessed 18 September 2018.

[39] Martin Edmonds, 'International Collaboration in Weapons Procurement: The Implications of the Anglo-French Case', *International Affairs*, 43:2 (1967), p. 254.

economies. The apparent answer was collaboration. France lagged behind Britain in the fields of engine manufacture and metallurgy (the required special steels cost three times as much to make in France as compared to Britain), so collaboration with Britain offered solutions to both of these problems.[40] Britain, for its part, primarily saw collaboration with France as an opportunity to reduce the cost of the development and simultaneously improve its relationship with the EEC, which organisation Britain was negotiating to join at the time of the decision to collaborate on *Concorde*, making the first unsuccessful attempted to join in 1963.[41]

In 1959, the British Government had awarded a contract for study of preliminary designs to Hawker Siddeley Aviation and Bristol Aeroplane Company (BAC). In France, the equivalent contract was awarded to Sud-Aviation with their *Super-Caravelle* proposal. The decision to collaborate began in April 1960 when the Sud Technical Director approached BAC and discovered that the two teams were broadly in agreement with the proposed design. Rather than form a simple commercial partnership, however, the strategic implications behind developing the world's first supersonic airliner led the respective governments to insist on forming the partnership at an international level. Britain and France signed the draft 'Treaty Agreement Regarding the Development and Production of a Civil Supersonic Transport Aircraft' on 29 November 1962.[42]

Despite some disputes over the name, whether the aircraft would be the British *Concord* or the French *Concorde*, an ironic disagreement given that the name was supposed to represent harmony and agreement between the nations, the project went ahead smoothly and first of the two prototypes (one French and the other British) made its test flight on 2 March 1969. It took seven years of testing and further development before *Concorde* first

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40 Johnman& Lynch, 'The Road to Concorde', pp. 229, 233
41 May, 'Concorde – Bird of Harmony or Political Albatross', pp. 486, 493.
42 Nelson, 'Concorde: International Cooperation in Aviation', p. 457; and, BAE Systems, 'BAC Concorde', <https://www.baesystems.com/en/heritage/bac-concorde>, accessed 18 September 2018.

entered commercial service on 21 January 1976.[43] Sadly, the aircraft proved an economic failure almost from the start. Sales were very poor, with British Airways and Air France buying a handful of machines, and Singapore Airlines and Braniff International Airways (operating from Dallas, Texas) each leasing a single aircraft for less than a year. Political disputes regarding overflight privileges and airport access severely restricted the routes on which *Concorde* could operate. In particular, the USA was reluctant to allow *Concorde* to fly from its airports and only Dulles International in Washington DC was eventually opened to the model. Energy and environmental concerns were cited as influencing the decisions to disallow the supersonic airliner freedom to operate, but political motives were strongly suspected to be a major factor. The USA, for example, had attempted its own supersonic airliner project but this had failed, and *Concorde* undoubtedly represented a threat to its own domestic aerospace business.[44]

The *Concorde* programme shows what can be achieved with strong political support, even in the face of economic hurdles. As an international collaboration it was successful, but, as Martin Edmonds points out, 'decisions about what to build, how many and at what cost are of paramount economic importance'.[45] The *Concorde* programme showed off the engineering talents of Britain and France at a time when both countries were eager to regain some international prestige globally. Yet it also demonstrated that international collaborations driven so strongly by political factors are in danger of losing sight of economic advisability in

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[43] BAE Systems, 'BAC Concorde', <https://www.baesystems.com/en/heritage/bac-concorde>, accessed 18 September 2018.
[44] May, 'Concorde – Bird of Harmony or Political Albatross', pp. 506-508; BAE Systems, 'BAC Concorde', <https://www.baesystems.com/en/heritage/bac-concorde>, accessed 18 September 2018; Airways, 'The Other Concorde Airlines: Braniff International and Singapore Airlines', <https://airwaysmag.com/uncategorized/concorde-airlines-braniff-international-singapore-airlines/>, accessed 02 December 2018.
[45] Edmonds, 'International Collaboration in Weapons Procurement', p. 262.

the face of a desire to succeed ‘at all costs’ and against sound economic objections.[46] Some comparison can be made with the MBT-70 project which was similarly motivated primarily by politics and also proved economically disastrous, albeit that project was cancelled before reaching the production stage.[47] The *Concorde* programme stands as an example of how even successful collaboration does not necessarily lead to a successful end project. A marvel of engineering, *Concorde* sadly proved to be economically flawed.

Eurofighter Typhoon

The Eurofighter Typhoon project has been, to date, the largest European military aircraft programme. Despite much criticism aimed at the collaboration, it has resulted in a wide range of employment and technical benefits to the nations involved, and produced a highly effective fourth-generation multi-role combat aircraft that is in use, or on order, with nine nations around the world.[48] With a four-nation NATO collaboration involving Britain, Germany, Italy and Spain, the Eurofighter programme demonstrates that such international consortia are able to successfully develop and produce highly technical weapon systems.

In the late 1970s, NATO’s European-built fighter aircraft were beginning to look inadequate when compared against both those of the USA (F-15 and F-16) and the Soviet Union (Su-27 and MiG-29). Developing and building a fourth generation fighter aircraft was going to be an expensive proposition and so, whilst some governments bought US equipment, Britain, Germany and France instead considered the collaborative development of a ‘European Fighter Aircraft’ or ‘Eurofighter’. Britain’s British Aerospace (BAE) and

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[46] For examples of contemporary warnings about the inadvisability of the project, see, for example; Johnman& Lynch, ‘The Road to Concorde’, p. 235; May, ‘Concorde – Bird of Harmony or Political Albatross’, pp. 506-508; and, Nelson, ‘Concorde: International Cooperation in Aviation’, p. 464.

[47] For more on the MBT-70 project, see Ch. 3 above.

[48] See, for example; Keith Hartley, ‘The Industrial and Economic Benefits of Eurofighter Typhoon’, *Independent Academic Study Commissioned by Eurofighter PR& Communications Office* (June 2006), p. 3, accessed via <http://www.defense-aerospace.com/dae/articles/reports/Typhoon_studyJune2006.pdf>, accessed 16 July 2017; and, Eurofighter, ‘Eurofighter Typhoon’, <https://www.eurofighter.com/>, accessed 11 December 2018.

Germany's Messerschmitt-Boelkow-Blohm (MBB) discussed an Anglo-German collaboration in 1979 and produced a design for a 'European Collaborative Fighter' (ECF) which was later renamed the 'European Combat Aircraft' (ECA). Although initially showing interest in joining the collaboration, France, and particularly Dassault, finally withdrew from discussions in 1980 over disagreements regarding their prominence in any such coalition, instead beginning development of their own aircraft (eventually to become the Dassault *Rafaele*).[49]

The proposed new ECF aircraft project was almost abandoned due to funding cuts and differing government priorities. However, BAE turned to the old Anglo-German-Italian Panavia consortium which had produced the Tornado MRCA (Multi-Role Combat Aircraft) and managed to persuade them to work on a new 'Agile Combat Aircraft' (ACA). Italy was particularly interested in the project as it was looking to update its aging F-104 Starfighters, but the German government was reluctant to wholeheartedly support either the Anglo-Italian ACA initiative or the French programme, believing that to choose either side would incur diplomatic displeasure from the other. However, MBB had not abandoned the idea of the new ACA aircraft, despite their government's official position. In May 1983, they aided BAE and Italy's *Aeritalia* in creating a demonstrator known as the 'Experimental Aircraft Programme' (EAP). Significantly, the EAP greatly impressed the pilots who flew it, one comment being that, 'It goes like a ferret with a firework up its bum!' [50]

On 29 April 1983, just a month before the BAE/MBB/*Aeritalia* EAP demonstrator, the air staffs of Britain, France Germany, Italy, and Spain had met to discuss a 'Future European Fighter Aircraft' (FEFA) project collaboration. Following this meeting came the Turin Agreement in August 1985, a formal invitation to participate in what had by then

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[49] Carlos J. Sancho Gonzales, *NATO Armaments Cooperation: The Case of the European Fighter Aircraft*, MSc. thesis for Air Force Institute of Technology (December 1990), pp. 32-33.
[50] Airvectors, 'Eurofighter Typhoon', <http://www.airvectors.net/aveuro.html>, accessed 11 December 2018.

become the 'European Fighter Aircraft' (EFA) programme. Britain, Germany and Italy all signed together, with Spain joining a few weeks later. However, France would not join the partnership unless it was the predominant partner and unless the EFA was based on the Dassault *Rafaele*, something that the other partners rejected. Even those remaining were not completely in agreement over the direction of the new aircraft, with Britain and Spain wanting the 'European Fighter Aircraft' (EFA) to be a multi-role machine, capable of ground strikes as well as air superiority, whereas Germany and Italy only wanted an air superiority fighter. Discussion and compromise allowed agreement to be reached on a final design by September 1987, and the EFA programme was given the go-ahead in January 1988.[51]

The Eurofighter consortium completed prototypes based on the BAE/MBB/*Aeritalia* EAP in 1989 and the four partners agreed to divide responsibility for setting up manufacturing of their allocated components for future production aircraft. The exact division on production responsibility was not finalised until 1996. Following extensive testing, the first aircraft entered service with the air forces of the four participating nations between 2003 and 2005. At the time of writing, Eurofighter Typhoon is in service with Germany, Italy, Spain, United Kingdom, Austria, the Kingdom of Saudi Arabia and the Sultanate of Oman. Ordersfor the aircraft have been placed by both Kuwait and Qatar.[52]

Criticisms of the Typhoon project include questions about its relevance in a post-Cold War world, the escalation of costs, and the delays taken in development and production. The relevance of any military system is only highlighted when it is required, but that requirement might come at any time and place, and history has shown that few conflicts wait until all participants are prepared. The cost escalation seems to be standard for all collaborations, and indeed most complex projects. On 16 June 2006, Keith Hartley presented a report on the

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[51] See, for example; Flight Global, 'Coming Together', <https://www.flightglobal.com/news/articles/coming-together-52567/>, accessed 12 December 2018; and, Airvectors, 'Eurofighter Typhoon', <http://www.airvectors.net/aveuro.html>, accessed 11 December 2018.
[52] Eurofighter, 'Eurofighter Typhoon'. <https://www.eurofighter.com/>, accessed 11 December 2018.

industrial and financial benefits of the Eurofighter Typhoon, concluding that the collaboration had saved the European combat aircraft industry, as well as providing around 100,000 jobs and various technology spin-offs.[53] The overall costs were undoubtedly higher than had the project been handled by a single nation indigenously, but this should be seen in relation to the splitting of the budget between the four participants and the advantages of increased economies of scale. Despite the escalation of overall costs, therefore, each participant spent less on their share of Eurofighter than had they pursued their own designs.[54]

The Eurofighter programme is a good example of how international collaborations can successfully produce complex defence technology. Whilst both over-budget and over schedule, it is hard to recall a defence development that has done otherwise and this should not be seen as a fault of collaboration, even though these over-runs were considerable in the case of Eurofighter.[55] With collaboration, at least, such costs are shared. The political strain that such projects come under is perhaps magnified within collaborations because each partner is at the mercy of domestic political opinion, no matter which partner (if any) is actually responsible for any problems, and domestic political opponents can trumpet any delay or additional cost as examples of governmental mismanagement or poor decision-making.[56] On a wider stage, international cooperation requires that all partners share a single goal. Both the refusal of the French to enter the Eurofighter programme unless it was dominated by France, and the negotiations required to agree on the future role of the EFA, show how different countries bring different opinions to any coalition and thus demonstrates how any successful collaboration must ensure that such differences are taken into consideration and overcome from the outset.

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[53] Hartley, 'The Industrial and Economic Benefits of Eurofighter Typhoon', pp. 23-26.
[54] C. R. Cook, et al., *Final Assembly and Checkout Alternatives for the Joint Strike Fighter*, RAND (Santa Monica, CA, 2002), pp. 32-33.
[55] Jocelyn Mawdsley, 'The A400M Project: From Flagship Project to Warning for European Defence Cooperation', *Defence Studies*, 13:1 (2013), p. 15.
[56] Cook, et al., *Final Assembly and Checkout Alternatives for the Joint Strike Fighter*, p. 2.

A380/A400M

Inspired by the commercial Airbus A380, the A400M project was a multinational collaborative programme to produce a military airlift aircraft meeting a requirement between the tactical/operational capability of the Lockheed C-130J Hercules and the larger strategic capability of the Boeing C-17 Globemaster.[57] Following the cost and time over-runs of the Eurofighter programme, A400M was intended to be an example of how European collaboration could produce good results to a budget and deadline.[58] Unfortunately, the programme actually reinforced how such international collaborations rarely manage to meet such targets.

The Airbus consortium had developed and built the A380, a project that has its roots in the 1960s and a desire to compete with the USA, and especially with the Boeing 747 'Jumbo Jet'. The supersonic BAC/Aerospatiale *Concorde* was proving a commercial failure,[59] and politicians in Britain, France, the FRG, and the Netherlands met in July 1967:

> For the purpose of strengthening European co-operation in the field of aviation technology and thereby promoting economic and technological progress in Europe, to take appropriate measures for the joint development and production of an airbus.[60]

A coalition of manufacturers, *Airbus Industrie GIE*, was formed in 1970, and Spain joined in 1971 with the first Airbus aircraft, the wide-bodied A300B being launched in 1972. Although it took nearly 35 years for a single multinational company to form, in 2001 the Franco-Germany EADS and British BAE Systems finally established Airbus as a company in its own right. In 2003, Airbus overtook McDonnel-Douglas and Boeing as the world's largest

[57] Jean-Michel Guhl, 'At Last, the A400', *Avionics Magazine*, 34:3 (2010), p.2, accessed online via <https://search.proquest.com/docview/224673436?accountid=8058>, accessed 12 December 2018.
[58] Mawdsley, 'The A400M Project', p. 15.
[59] For more information on the *Concorde* project, see above.
[60] Financial Times, 'Airbus–the European Model', <https://www.ft.com/content/c9a9a77c-db07-11e3-8273-00144feabdc0>, accessed 12 December 2018.

supplier of aircraft. In 2006, BAE sold its share in the collaboration to EADS, with a proposed return to the consortium in 2012 blocked by German Chancellor Angela Merkel, who feared that such a return would threaten the strong German position within Airbus.[61]

The Airbus A380 was the largest commercial airline in service at the time of its first flight on 27 April 2005 and remains so at the time of writing, possessing a wide body and double-decked fuselage. This made it suitable for use as the basis of a new military transport aircraft, something that the management of Airbus was aware of and, in 1999, planned to take advantage of. As a European coalition, Airbus was uniquely positioned to develop and build an operational military airlift aircraft to supply both NATO and non-NATO European countries. After consultation with potential customers, in 2005 Airbus began work on the A400M Atlas.[62]

Partly in response to the excessive delays and cost overruns of the Eurofighter Typhoon programme, on 12 November 1996 the Defence Ministers of Britain, France, Germany and Italy signed an agreement forming the procurement agency, *Organisation Conjointe de Coopérationenmatièred'Armement* (OCCAR), or the Organisation for Joint Armament Cooperation. This organisation was given legal status on 28 January 2001, with the intention that it could award defence contracts and supervise international defence programmes on a commercial basis and avoid undue political and national influence.[63]

OCCAR oversaw a new military airlifter contract awarded to the Airbus Military Company, a subsidiary of the larger EADS-owned Airbus firm. Having learnt from the Eurofighter programme, this contract was intended to run to a fixed price, with penalty clauses to penalise the primary contractor for late delivery. This, it was hoped, would transfer

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[61] Financial Times, 'Airbus–the European Model', <https://www.ft.com/content/c9a9a77c-db07-11e3-8273-00144feabdc0>, accessed 12 December 2018; and, Christopher Bronder& Rudolf Fritzl, 'Developing Strategic Alliances: A Conceptual Framework for Successful Co-operation', *European Management Journal*, 10:4 (December 1992), p. 414.
[62] Stephen J. Mraz, 'Airbus Builds a Military Airlifter', *Machine Design*, 77:4 (2005), p. 98.
[63] OCCAR, <http://www.occar.int/>, accessed 14 December 2018.

the financial risks to Airbus rather the involved governments meeting such costs. It highlighted a growing interest in allowing national governments to distance themselves from the running and financial risks of such projects, which would instead be run on commercial lines.[64] A deadline for the new airlifter was set that envisaged a first test flight in 2008 and delivery of the first production aircraft in 2009.[65]

Almost inevitably, the A400M project ran into delays, in particular regarding the engines. Airbus sub-contracted much of the work on the aircraft, including the development of the engines. The requirements for the A400M were that it would be agile, fuel-efficient, able to climb and takeoff steeply and also able to descend and slow down quickly. These last requirements resulted from consultation from the military users who needed the airlifter to operate on short and rough runways in hostile environments where slow descents and climbs would increase the time the aircraft was vulnerable to short-ranged surface-to-air anti-aircraft fire.[66] The engine requirements suggested an extremely powerful eight-bladed turboprop, but no Western manufacturer had yet developed such an engine. Bids were received for the tender from the Canadian Pratt-Whitney and the European Europrop International (EPI) consortium, led by Rolls Royce and France's *Safran*. The Pratt-Whitney bid was the cheapest but political pressure from France and Britain persuaded Airbus to allow EPI to resubmit their bid. With the Pratt-Whitney bid now known and with Britain promising to subsidise development funding for Rolls-Royce engines, the resubmitted bid was unsurprisingly lower than the original one from Pratt-Whitney and thus secured the contract.[67]

The delays and problems developing the new engines put pressure on the A400M project that almost saw it abandoned. Despite the original contract placing any financial risks onto Airbus, in 2010 the participating governments were pressured into 'bailing out' the

[64] Mawdsley, 'The A400M Project', p. 15.
[65] Mraz, 'Airbus Builds a Military Airlifter', p. 98.
[66] Ibid.
[67] Mawdsley, 'The A400M Project', p. 20.

programme. Although EADS, Airbus's owner, offered to absorb some €3.2bn of the costs associated with the overruns, they insisted on renegotiating the original contract and that the partner nations invest a further €7bn. Both France and Germany resisted any changes and made clear that they expected Airbus to both absorb the additional costs and pay the penalty fines as contracted.[68] Despite their objections, however, all partners of the Airbus project eventually realised that EADS's threat to simply cancel the programme should additional funding not be forthcoming, around a third of the original sum agreed in the contract, was simply too serious to reject outright. The project came into that category of being 'too big to fail', where the consequence of cancelling is deemed to be more disadvantageous than meeting additional financial commitments to keep it going.[69] As a result of the potential political and financial implications of a failed programme, the partner nations eventually agreed to bail out the A400M as demanded by Airbus, and the project continued. The first test flight of the A400M was on 11 December 2009, a year later than scheduled.[70] The first delivery of a finished production aircraft, to the French Air Force, was in August 2013, fully four years later than originally agreed.[71]

The A400M project stands as an example of how such collaborations can primarily serve a political purpose. Initially intended as statement of European capability and unity, several decisions made during the project's lifetime suggest that the continuance of that aim was seen as being more important than commercial efficiency. The shenanigans surrounding the awarding of the engines contract to EPI show a desire for keeping the project as European as possible. In 2000 in the face of cost over-runs and delays, the British government publicly

[68] See, for example: Guhl, 'At Last, the A400', p. 4; and, Reuters, 'Update 2-EADS Wants A400M Contract Change, Adds Delay', <https://www.reuters.com/article/eads/udpate-2-eads-wants-a400m-contract-change-adds-delay-idUSL915166620090109>, accessed 13 December 2018.
[69] Mawdsley, 'The A400M Project', p. 21.
[70] Guhl, 'At Last, the A400', p. 1.
[71] Reuters, 'Update 2-EADS Wants A400M Contract Change, Adds Delay', <https://www.reuters.com/article/eads/udpate-2-eads-wants-a400m-contract-change-adds-delay-idUSL915166620090109>, accessed 13 December 2018.

supported Airbus over a US alternative, meaning that a reluctant Germany would have appeared to be politically isolated and anti-European had it then opted out of the Airbus project. Conversely, in 2002 Portugal left the A400M programme in favour of the Lockheed C130J during the controversy over the Iraq conflict, a move widely seen as political and a desire to reinforce the Portugal-US relationship at a time of heated diplomatic debate and widespread anti-US rhetoric over the legality and advisability of a US-led coalition invading Saddam Hussein's Iraq.[72]

5.3. Artillery and Anti-Armour Weapons Systems

In addition to AFV and aircraft programmes, it is worth taking into account projects dedicated to specific weapons systems (the three examples explored here cover anti-armour missiles and medium artillery systems), which are in essence the smallest size of weapons systems which justify international collaboration. This section will consider the MILAN Anti-Tank Guided-Wire Missile, the Brimstone dual 'fire-and-forget'/laser-guided air-to-ground anti-armour weapon, and the FH-70 155mm towed howitzer (an Anglo-German collaboration, joined later by Italy). The two missile projects in particular seem to point to a much brighter future for international, collaborative weapons projects, as a result of their being conducted an international consortium. The FH-70 likewise succeeded, but for different reasons to the two anti-armour projects.

The MILAN ATGM

MILAN (Missile d'Infanterie Leger ANtichar, or Light Anti-Tank Infantry Missile) had its origins in the decision by both France and Germany in the early 1960s to develop new anti-tank and anti-aircraft missile systems. The contemporary cost of developing and producing

[72] Mawdsley, 'The A400M Project', pp. 20-21.

advanced missile systems was prohibitive, and so the two NATO allies made the decision to collaborate in order that costs might be reduced for each country.[73] MILAN, together with the longer-range HOT missile and the anti-aircraft missile, Roland, both also developed by the collaboration under the same programme, were the products of a Franco-German consortium, *Euromissile*, set up specifically for that purpose. The success of this collaborative consortium suggests that complex military technology can be developed in international collaboration so long as the project aims are clear and the development team are in agreement.

In 1963, France's Ministry of Defence procurement directorate, DTIA, awarded a joint development contract to France's *Aerospatiale* and FRG's *Messerschmitt-Bolkow-Blohm* (MBB) to develop a second generation guided anti-tank missile system to meet the requirement of both countries. Second generation missiles allowed the operator to guide the missile by keeping the cross-hairs of his eyepiece trained on the target, a marked improvement over the first generation where the operator guided the missile in the manner of flying a remote-control aircraft.[74]

Initially, the collaboration was led by France. The Committee of Directors was French and the initial project contract had been given to *Aerospatiale* who sub-contracted half the work to MBB. The committee comprised members of both firms, and the project managers came from both companies. Whilst this superficially gave both parties equal responsibility, France's *Aerospatiale* was definitely the lead partner, with the French Committee of Directors making final decisions that affected the joint project. Significantly, German governmental export restrictions meant that MBB had to organise future exports through the less prohibitive French government export control. This decentralised project development

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[73] Terrell G. Covington, Keith W. Brendley, and Mary E. Chenoweth, 'A Review of European Arms Collaboration and Prospects for its Expansion under the Independent European Program Group', *RAND Note,* (July 1987), p. 53.
[74] Gayford D. Evan-Hart, 'Tactical Simulation of Second Generation Anti-Tank Guided Weapons', *The RUSI Journal,* 125:1 (1980), p. 69.

structure was satisfactory at the initial stages, but it became obvious that a tighter hierarchical system would be needed for future development and to organise production, sales and exports.[75] In 1972, as MILAN was accepted for service by the French Army, *Aerospatiale* and MBB formed *Euromissile*, an international *groupement d'interet economique* (GIE), or Economic Interest Group, which represented an equal partnership between the two firms and thus the two countries.[76] The partnership held obvious economic and technical advantages for *Euromissile*'s future stakeholders. By forming a single business hierarchy, the consortium was more streamlined and efficient than the previous decentralised system.

An industrial alliance with Germany held political advantages for France; de Gaulle, a strong advocate of European self-reliance (led by France) to counter what he saw as undue US influence, had stepped down in the spring of 1969 and was succeeded as president by Georges Pompidou who had been his prime minister and shared many of de Gaulle's political beliefs.[77] A joint Franco-German defence company could only help to strengthen the position of Europe's position within NATO, as well as reducing Europe's reliance on imports of American weapons. Neither Willy Brandt, FRG chancellor in 1972 when *Euromissile* was established, nor Ludwig Erhard, chancellor in 1963 when the initial collaboration agreement between *Aerospatiale* and MBB had been signed, were as publicly concerned as de Gaulle about US influence in Europe. Instead, Erhard was primarily concerned with rebuilding Germany's economy and Brandt with strengthening NATO. Ludwig Erhard, the Federal Republic's chancellor from 1963 until 1966, has been credited by many commentators with

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[75] Covington, Brendley, and Chenoweth, 'Review of European Arms Collaboration', p. 53. It is interesting to contrast this approach with that of the MBT-70 and FMBT projects where the management structures remained separate throughout.

[76] See, for example; Covington, Brendley, and Chenoweth, 'A Review of European Arms Collaboration', p. 54; Global Security, 'Euromissile', <https://www.globalsecurity.org/military/world/europe/euromissile.htm>, accessed 3 December 2018. Note that some sources quote the two founding companies as *Aerospatiale* and *Deutsche Aerospace AG* or *Daimler-Benz Aerospace* (DASA), but DASA did not buy MBB until 1989, long after the 1972 formation of *Euromissile*. At the time of writing, the MILAN family of missile systems has been produced and developed by MBDA, the successor of *Euromissile* through various mergers and acquisitions.

[77] Frédéric Bozo, *French Foreign Policy Since 1945: An Introduction*, trans. by Jonathan Hensher (New York, 2016), pp. 81-83.

putting in place the post-war West German economic recovery. Although initially close to the French leader, he disagreed vehemently with de Gaulle over the latter's plans to negotiate with the Soviet Union on Germany's behalf, and Erhard considered himself a personal friend of the US President, Lyndon B. Johnson.[78] Willy Brandt, although a socialist and in favour of negotiation with the Soviet Union over the status of East Germany, was a strong supporter of US forces in Europe as part of NATO, also putting him at odds with Gaullist French position.[79]

Despite his support of US influence within Europe, Erhard acknowledged that closer strategic ties with France were important both for European and German military security, and also for Germany's reconciliation following the Second World War. Charles de Gaulle and Konrad Adenauer, the president and chancellor of France and the FRG respectively, had signed the Elysée Treaty on 22 January 1963 which signalled closer Franco-German cooperation and which was a significant gesture signalling a closer political relationship. The proposed Franco-German tank project had failed,[80] and there had been few circumstances where France and Germany could cooperate on major programmes, so the MILAN collaboration represented an important opportunity to implement the terms of the Elysée Treaty.[81]

Strategy for *Euromissile* was determined by the six-man Assembly of Members, effectively the board of directors, comprising three each from *Aerospatiale* and MBB. France's BPFA and Germany's BLBM, the two respective government programme offices,

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[78] Despite Erhard's optimistic views of his relationship with Johnson, the latter apparently treated Erhard badly when the German Chancellor refused to provide military aid to the USA in Vietnam. Nonetheless, Erhard remained both suspicious of de Gaulle's ambitions and a supporter of the USA, and its role within NATO and Europe. See Alfred C. Mierzejewski, *Ludwig Erhard* (London, 2004), pp. 186-187, 199-201, 209.
[79] See, for example: Klaus Harpprecht, *Willy Brandt: Portrait and Self-Portrait*, trans. Hank Keller (London, 1971), pp. 282-286; and, Mark Bartholomew, 'Willy Brandt', and Rudolf Wildenmann, 'Ludwig Erhard', in David Wilsford (ed.) *Political Leaders of Contemporary Western Europe* (London, 1995), pp. 47-48, 119, 123.
[80] For more information on the Franco-German 'European Standard Tank' project, see Ch. 2 above.
[81] Stephen A. Kocs, *Autonomy or Power? The Franco-German Relationship and Europe's Strategic Choices, 1955-1995* (Westport, 1995), pp. 88-89.

issued the contracts to *Euromissile* who then subcontracted as required. The two parent companies, *Aerospatiale* and MBB, retained their own independent manufacturing and industrial capabilities, but production coordination and sales were the responsibility of *Euromissile* itself.[82] In particular, this arrangement allowed MILAN to be more widely exported than it could have been had the company been more subject to tight German weapons export restrictions. By classifying German-made components as French, the consortium managed to greatly increase the number of countries to which it could sell MILAN, eventually exporting to 41 countries.[83]

The modern incarnation of the *Euromissile* consortium is the international group, MBDA, created from several mergers and acquisitions of European aerospace and missile companies. MBDA is jointly owned by three companies; Airbus (with 37.5%), BAE Systems (37.5%) and Leonardo (25%).[84] The MILAN anti-tank guided-wire missile system is now in its third incarnation and has sold over 360,000 missiles worldwide.[85] By any measure, then, the collaboration that created *Euromissile* and MILAN has been a success. Missile systems are technologically complex and expensive to develop, but perhaps the project succeeded where tank projects failed because there was little or no disagreement over the specification of the system, and management of the project was streamlined at a crucial time by creating the *Euromissile* consortium rather than running two national teams in parallel. A guided missile and a main battle tank are obviously very different development prospects, yet MILAN stands as an example of how complex international defence collaboration can

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[82] Covington, Brendley, and Chenoweth, 'A Review of European Arms Collaboration', pp. 54-55.
[83] See, for example: Global Security, 'Euromissile', <https://www.globalsecurity.org/military/world/europe/euromissile.htm>, accessed 3 December 2018; and, Army Technology, 'MILAN Anti-Tank Missile System', <https://www.army-technology.com/projects/milan/>, accessed 30 November 2018.
[84] For further information on the various companies that became part of the MBDA consortium, see, MBDA website, <https://www.mbda-systems.com/about-us/>, accessed 4 April 2016. The formation of MBDA is covered in more detail below.
[85] Army Technology, 'MILAN Anti-Tank Missile System', <https://www.army-technology.com/projects/milan/>, accessed 30 November 2018.

succeed, perhaps suggesting how possible future main battle tank collaborations could improve their chances of success by forming a single management structure.

Brimstone Air-to-Ground Anti-Armour Missile

The Brimstone missile is an aircraft-launched, multi-purpose, anti-armour weapon which has been developed by the multinational defence consortium, MBDA. To quote from MBDA's website:

> Brimstone provides a combat proven, low collateral, close air support weapon offering to the fast jet operator the unique capability of engaging a wide range of target types, including fast moving vehicles/vessels in both land and naval environments and in both direct and indirect modes.[86]

Originally based on the US Hellfire missile but with so extensive a redesign that it is essentially a new weapon, the missile came from a development and production contract awarded by the British Ministry of Defence in December 1996, and entered service with the RAF nine years later.[87] With Brimstone 2 already in service and Brimstone 3 in development, the missile is undoubtedly a successful multinational collaboration.[88]

The origins of the MBDA group are, like many such modern consortia, a history of takeovers and mergers that encompass some well-known companies of several European nations. Now represented by Airbus (37% share), BAE Systems (37%) and Leonardo (25%), firms such as BAE Dynamics, EADS Aerospatiale, GEC-Marconi Radar and Defence, and Matra Defence have merged or joined to create the consortium, giving MBDA a multinational background which has drawn upon the expertise and experience of established

86 MDBA, 'Brimstone', <https://www.mbda-systems.com/product/brimstone/>, accessed 16 December 2018.
87 Air Force Technology, 'Brimstone Air-to-Ground Missile', <https://www.airforce-technology.com/projects/brimstone-air-ground-missile/>, accessed 16 December 2018.
88 Jane's 360, 'MBDA to Develop "Brimstone 3" ', <https://www.janes.com/article/78861/mbda-to-develop-brimstone-3>, accessed 19 December 2018.

defence companies.[89] Necessarily working closely with the governments and armed forces of potential customer nations, MBDA is nonetheless a multinational commercial concern and thus its priorities are profits and reputation rather than international diplomacy.

The contract for an advanced anti-armour missile had been awarded to MBDA by the British Government in 1996, but the origins of the requirement can reasonably be traced back to 1978. In that year, at the height of the Cold War, the VJ291 steerable cluster bomb project was cancelled. This project had been intended to provide the RAF with a more efficient stand-off anti-armour weapon that gave aircraft a more effective capability against Soviet tanks and IFVs than existing bombs or unguided rockets.[90] On cancelling VJ291, the options for the British MoD were to purchase the US Maverick missile system or to improve the existing BL755 unguided cluster bomb. The decision was taken to improve the BL755 as an interim measure and to pursue development of a stand-off missile under Staff Requirement (Air) 1238. SR(A) 1238 commenced in 1982, but it was not until 1988 that the MoD narrowed down the contenders to Brimstone (at that date a Marconi/Rockwell tender) and the Hunting/Honeywell Smart Weapon Anti-Armour Missile (SWAARM).[91]

In 1990, with all the signs suggesting that the Cold War was over and that NATO would no longer be required to face massed Soviet armour, Britain's 'Options for Change' Defence White Paper cancelled SR(A) 1238, thus wasting a great deal of both government and industry funding that had been invested to this point. The 1991 Gulf War, however, showed that, while any threat of the Soviet Union invading Europe may have been (at least temporarily) nullified, unstable global geopolitics and potential future opponents meant that air-launched precision anti-armour missiles were still needed in the RAF's inventory. Thus,

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89 MDBA, 'History', <https://www.mbda-systems.com/about-us/history/>, accessed 16 December 2018.
90 Flight Global, 'Air-to-Ground', <https://www.flightglobal.com/FlightPDFArchive/1980/1980%20-%202055.PDF>, accessed 19 December 2018.
91 Think Defence, 'Brimstone', <https://www.thinkdefence.co.uk/uk-complex-weapons/brimstone/>, accessed 15 December 2018.

in 1994, SR(A) 1238 was resurrected as a requirement for an Advanced Anti-Armour Weapon (AAAW).[92]

In 1996, the AAAW contract was awarded to the Brimstone missile programme, which had by then become the product of GEC-Marconi. As noted above, this missile was originally a development of the US laser-guided AGM-114 Hellfire missile, but the redevelopment and changes to the original were so extensive as to make Brimstone a completely new weapon system. The primary change to the Hellfire was in the guidance system. Whereas the laser-guidance of the AGM-114 required both line-of-sight and for the operator to keep the aiming crosshairs on the target until impact, Brimstone used a millimetric wave (MMW) radar and a digital autopilot to seek out and destroy targets within its programmed area of activation. This enables Brimstone to act in a 'fire-and-forget' role, with sophisticated algorithms allowing the operator to specify a limited area within which the missile seeks targets whilst ignoring those outside of this zone. To reduce the danger of collateral damage, especially in a counter-insurgency role, an alternative and complementary guidance was fitted. This is semi-active laser (SAL) guidance, where an operator 'illuminates' the target with a laser and the missile homes in on the beam, in a similar fashion to the original AGM-114 Hellfire.[93] The advantage of using both systems in parallel is that Brimstone may be used either against targets in the vicinity of neutral or friendly forces with less risk of 'friendly fire' or 'collateral damage', or as a fire-and-forget missile against peer enemy armoured formations in a more conventional 'free-fire' battlefield.

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[92] Think Defence, 'Brimstone', <https://www.thinkdefence.co.uk/uk-complex-weapons/brimstone/>, accessed 15 December 2018.

[93] Army Technology, 'Brimstone Advanced Anti-Armour Missile', <https://www.army-technology.com/projects/brimstone/>, accessed 15 December 2018.

As a successful missile, with MBDA receiving in 2018 a £400m contract to develop Brimstone 3,[94] built by a multinational commercial coalition, Brimstone has distinct similarities to the MILAN project examined above. Where Brimstone differs significantly, however, is in the overt involvement of the British Government with delays and cancellations that came from vacillation over policy. It is interesting to note that MBDA's own involvement appears to have been relatively trouble-free once the MoD decided to once again procure the missile after initially cancelling its development. The political dimension appears to have been far more significant in the final length and cost of the programme than any commercial or technical concerns, something that might be of interest in comparisons with other collaborative programmes.

FH-70 155mm Artillery System

The FH-70 155mm towed howitzer was the result of a collaborative agreement between Britain and the FRG in the early 1960s. Italy later joined the collaboration, making the FH-70 programme the first of a series of trilateral programme between those three countries, later examples being the SP-70 self-propelled howitzer (examined above) and the Tornado Multi-Role Combat Aircraft (MRCA). The FH-70 programme resulted in a successful product, with over a thousand howitzers built and seeing service with the militaries of eleven nations, including several outside of NATO.[95] It also formed the basis for the self-propelled howitzer, SP-70, although, as noted above, that project did not succeed.

In the early 1960s, the USA, FRG and Britain were looking to replace their existing towed medium howitzers, these being the venerable US M-114 155mm in the case of the USA and Federal Republic, and the equally venerable Ordnance 5.5" gun (140mm) in the

[94] Jane's 360, 'MBDA to Develop "Brimstone 3" ', <https://www.janes.com/article/78861/mbda-to-develop-brimstone-3>, accessed 19 December 2018.
[95] Foss, *Jane's Armour and Artillery 2011-2012*, p. 956; and, Army Guide, 'FH70', <http://www.army-guide.com/eng/product1176.html>, accessed 4 December 2018.

case of Britain.[96] In 1963, NATO's 'Basic Military Requirement 39' had agreed a standardised NATO medium artillery calibre of 155mm, this giving the optimum balance of firepower to range.[97] The USA decided upon an indigenously developed product and eventually produced their M-198 howitzer, but in 1967 the Federal Republic and Britain instead took the decision to cooperate on a multinational design, with a Memorandum of Understanding (MOU) signed in 1968. The British firm Vickers Shipbuilding and Engineering Ltd. (VSEL), and Germany's *Rheinmetall* both had many decades of experience in artillery design and quickly produced six prototypes for evaluation by 1970.[98]

At this point, Italy's OTO Melara joined the collaboration and a further eight prototypes were produced by 1973. Italy agreed to accept a quarter-share of project expenses from that point, changing the balance of financial responsibility to 50% for the FRG and 25% each for Britain and Italy.[99] Italy's inclusion was also politically significant because it marked a departure from the Italian military dependency on the USA for its equipment, and instead signalled a move towards stronger intra-European ties. In spite of frequent periods of domestic political instability, Italy offered the alliance a strong industrial base and, like Vickers and *Rheinmetall*, OTO Melara had a long history of designing and producing successful artillery pieces.[100]

The new MOU to develop the FH-70 in light of Italian participation divided the project responsibility between the three countries. The Germans developed the ammunition

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[96] The M-114 dates from 1942 and the 5.5" gun from 1941. Both had seen extensive service during the Second World War and later, with the M-114 still in service with some militaries at the time of writing. See, for example; Military Factory, 'M114 155mm (155mm Howitzer M1)', <https://www.militaryfactory.com/armor/detail.asp?armor_id=439>, accessed 4 December 2018; Military Factory, 'Ordnance BL 5.5-inch', <https://www.militaryfactory.com/armor/detail.asp?armor_id=412>, accessed 4 December 2018.

[97] Military Factory, 'FH-70 (Field Howitzer 1970)', <https://www.militaryfactory.com/armor/detail.asp?armor_id=1090>, accessed 2 December 2018.

[98] Pierre Dussauge& Bernard Garrette, 'Determinants of Success in International Strategic Alliances: Evidence from the Global Aerospace Industry', *Journal of International Business Studies*, 26:3 (1995), p. 511.

[99] Military Today, 'FH-70' <http://www.military-today.com/artillery/fh_70.htm>, accessed 10 September 2018.

[100] Alan G. Draper, *European Defence Equipment Collaboration: Britain's Involvement, 1957-87, RUSI Defence Studies* (London, 1990), pp. 59-60.

primers, the loading system, auxiliary propulsion system, suspension, and the sights and associated aiming system. Britain developed the carriage and traversing gear, and Italy took responsibility for the gun cradle, the recoil system, sights bracket and elevating gear. All three countries shared responsibility for the ammunition except that, as noted, Germany produced the primers.[101]

The final design was intended to be towed by a tractor unit, but had an Auxiliary Power Unit (APU), an 1800cc small auxiliary engine which provided hydraulic and electrical power and also allowed the gun to be independently driven at up to 16.5kph by its crew for short distances in emergencies.[102] In fact, it was the early requirement for this APU that helped dissuade the USA from participation in the FH-70 programme in 1965. The US wanted their new howitzer to be transportable by helicopter and the APU added considerable weight and was seen by the US as unnecessary.[103]

Officially entering service with Britain, the FRG and Italy in 1978, numerous minor problems meant that the FH-70 did not actually become operational until 1980.[104] Even after this time there were a plethora of reliability issues with the FH-70, with some commentators suggesting that there had been too little testing in order to meet the operational deadline. Many problems were found to be as a result of inappropriate operation by its crews, and were consequently solved by updating the operator's technical manual. The howitzer has been commercially successful, having been accepted for service by Estonia, the Lebanon, Malaysia, Morocco, Norway, the Netherlands, Oman, and Saudi Arabia, as well by as Britain (where it is known as the L121), the FRG and Italy. Even Japan adopted the FH-70,

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[101] Global Security, 'FH-70 – 155mm Howitzer', <https://www.globalsecurity.org/military/world/europe/fh-70.htm>, accessed 4 December 2018.
[102] Army Guide, 'FH70', <http://www.army-guide.com/eng/product1176.html>, accessed 4 December 2018.
[103] Military Today, 'FH-70' <http://www.military-today.com/artillery/fh_70.htm>, accessed 10 September 2018.
[104] Sawhney, 'Field Artillery Today and Tomorrow', p. 931.

becoming the largest single user, and licence-built the design locally. Nonetheless, the FH-70 attracted criticism for minor design flaws and problems throughout its career.[105]

With over 1,000 units built before production ended in 1989, as an international weapons collaboration the FH-70 must be viewed as a success. The US disagreement over the inclusion of the APU showed how an international collaboration can fail due to differing requirements, but in this instance the disagreement came before the project really began in earnest and the withdrawal of US interest did not hinder the FH-70's development. Italy's late involvement signalled a diplomatic move away from reliance on the USA and towards Europe, something that highlights the political significance of such alliances for any study of international collaborations.

5.4. Other Technology Transfer Projects

The final section in this chapter looks at two projects involving technology transfer which do not fit so easily into this study's defined concept of collaboration. As has been noted during this study, international collaborations potentially offer diplomatic advantages which make them attractive to politicians wishing to demonstrate the strength of international diplomatic ties. This can lead to projects being announced as 'collaborations' when they might more fit more naturally or obviously into a different definition of technology transfer. Other forms of technology transfer usually emphasise the commercial or technological aspects of international cooperation over the political although, as this section will demonstrate, the boundary between the different forms of technology transfer may be ill-defined in practice. Two short case studies, the Sino-Pakistani MBT-2000/*Al-Khalid* and the US F-16 aircraft, will be covered here. Whilst necessarily brief overviews of only two examples, these studies will serve to demonstrate how not all projects described as collaborations fit within the

105 Military Today, 'FH-70' <http://www.military-today.com/artillery/fh_70.htm>, accessed 10 September 2018.

definitions established. This will reinforce the rarity of the main MBT case studies examined in the chapters above, and show how future projects publicly described as collaborations should be examined carefully to determine just how much actual design collaboration is involved. Such ‘collaborations’ might be more accurately described as, for example, licensed or cooperative production.

MBT-2000 / VT-1/Al-Khalid

The main battle tank known variously as MBT-2000, VT-1 or *Al-Khalid* (‘eternal’), is a modern MBT developed by China and Pakistan and currently in service with the Bangladeshi, Moroccan, Myanmar, Sri Lankan, and Pakistani armies. China does use the MBT-2000 but only for training purposes.[106] The project has been described as a joint development but, as will be seen, it does not fit our definition of a collaboration in the sense of co-development throughout the programme. The tank is known as MBT-2000 or VT-1 in China, with both names referring to very similar designs, both marketed for export. In Pakistani service, the tank is called the *Al-Khalid* after various historical figures of the same name.[107]

The project can be traced back to January 1990 when Pakistan and China signed an agreement to develop a new MBT to meet Pakistan’s requirements.[108] Pakistan had had experience of armoured warfare from its conflicts with India and consequently had a good idea of the qualities it wanted in a new tank. With Chinese help, Pakistan had set up *Heavy Industries Taxila* (HIT) which licence-built the Chinese Type 85-IIAP MBT and was

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[106] Military Factory, ‘HIT Al Khalid (MBT 2000) Main Battle Tank (MBT)’, <http://www.militaryfactory.com/armor/detail.asp?armor_id=181>, accessed 23 July 2016; and, Tank Encyclopedia, ‘Al Khalid’, <http://www.tanks-encyclopedia.com/modern/Pakistan/al-khalid.php>, accessed 28 December 2018.

[107] Foss, *Jane’s Armour and Artillery 2011-2012*, p. 88; and Sino Defence, ‘MBT-2000/VT-1’, <http://sinodefence.com/mbt-2000-vt1/>, accessed 20 December 2018. The name ‘Khalid’ translates as ‘eternal’, and was the name of several prominent figures in Arabic history, including the 7th Century military leader, Khalid ibn al-Walid, and two different early and significant religious figures.

[108] Richard Ogorkiewicz, *Tanks: 100 Years of Evolution* (Oxford, 2015), pp. 239-239.

therefore the obvious choice to be involved in any new tank programme.[109] The basis of the new tank was to be the new *China Ordnance Industries Group Corporation Limited* (NORINCO) Type 90-II, itself a linear development in a series of Chinese MBTs that can be traced back to the Type 59, a Chinese copy of the Soviet T-54A and first produced in 1958.[110] The Type 90-II appeared to mark a change in Chinese military tank doctrine and was markedly heavier and better protected than its predecessors, but was nonetheless rejected for Chinese service.[111]

The new MBT-2000/*Al-Khalid* was tailored to Pakistan's particular requirements, although publicly available information is vague as to the exact alterations made to the Type 90-II. However, at least two improvements were demanded by Pakistan, an improved fire-control system and a more reliable engine than the Chinese-built diesel. Power was initially going to be supplied by a British Perkins CV12, as installed in Challenger II, with the French supplying a SESM ESM500 transmission, as used in the Leclerc. However, when in 1998 Britain and France joined the arms embargo imposed upon Pakistan for its nuclear testing, plans were changed, and the final design used a Ukrainian 6TD-2 engine, as used in Ukraine's own T-84 MBT. Production of the *Al-Khalid* tank was licensed to HIT in Pakistan although the engines were imported directly from the Ukraine. The MBT-2000, which differed little from the *Al-Khalid* in most respects, was built in China and offered for export. The VT-1 was similarly built in China for export but was specifically tailored to allow it to be more easily customised to a potential customer's requirements.[112]

MBT-2000/*Al-Khalid* was not a collaboration in the sense that we have established for this study. Whilst Pakistan certainly specified what it wanted from the new tank, no Pakistani

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[109] Military Factory, 'HIT Al Khalid (MBT 2000) Main Battle Tank (MBT)', <http://www.militaryfactory.com/armor/detail.asp?armor_id=181>, accessed 23 July 2016.
[110] Rolf Hilmes, *Main Battle Tanks: Developments in Design Since 1945*,trans. Richard Simpkin (London, 1987), p. 14; and, Wolfgang Schneider (ed.), *Tanks of the World* (Koblenz, 7th edn, 1990), pp. 74-75.
[111] Foss, *Jane's Armour and Artillery 2011-2012*, p. 88.
[112] Sino Defence, 'MBT-2000/VT-1', <http://sinodefence.com/mbt-2000-vt1/>, accessed 20 December 2018.

developers were involved in the fundamental design. The tank was a NORINCO Type 90-II with minor modifications and a Ukrainian engine; no significant Pakistan-designed components formed the final model. Therefore, the MBT-2000/*Al-Khalid* should perhaps be viewed as an existing Chinese tank slightly modified to meet an export customer's requirements and license-built in Pakistan. By building the *Al-Khalid*, Pakistan received valuable experience in manufacturing and constructing tanks, but little or none in developing them. However, with no domestic tank industry from which to build, expecting Pakistan to be any more involved in the development would perhaps have been unrealistic. Instead, with Chinese help, HIT has formed the basis of an emergent Pakistani tank industry that may, in future, look to develop its own designs.

F-16 Aircraft

In Cornell's *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*, he describes the F-16 as a 'stellar example of a multi-national consortium set up to pursue selection and production of a replacement aircraft on a multi-national basis.'[113] Examination of this project suggests that it is by no means a co-developmental collaboration and instead shows an asymmetric partnership with licensed production. Whilst the political significance for NATO standardisation is undeniable, the ramifications of the F-16 for the European combat aircraft industry were at least as significant. As with other US partnerships such as the F-35, the F-16 stands as a good example of how the USA's reluctance to share technology or involve other nations, even allies, in developmental work makes any cooperation with them highly asymmetric at best.[114]

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[113] Alexander H. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies: Ten Years Later - And Beyond* (The Hague, 1981), p. 28.
[114] Gertler, *F-35 Joint Strike Fighter (JSF) Program*, pp. 12-17.

By the 1970s, fighter aircraft had become less agile as a result of military planners predicting that missiles alone would determine future air conflicts. Early Cold War fighter aircraft designs, relying mainly on short-range missiles, emphasised speed over agility and were typified by such aircraft as the English Electric Lightning (first flight 1957), MiG-21 (first flight 1955) and F-104 Starfighter (first flight 1956). Experience of air-to-air combat in Vietnam and the Middle East showed that agility and 'dog-fighting' had not been entirely eclipsed by aircraft loosing volleys of missiles, and so a group of US designers and analysts pressed for a more agile aircraft that would be smaller and cheaper than the large and very capable F-15 Eagle, then in development to be the US interceptor replacement. This requirement for a small and affordable dogfighter led to General Dynamics designing the F-16 in 1975.[115]

In the 1970s, NATO nations in Europe were primarily using US aircraft such as the F-4 Phantom, F-104 Starfighter and F-5 Freedom Fighter. Modern combat aircraft were highly technical and expensive to both develop and produce, and it was easier for countries without indigenous combat aircraft industries to buy 'off the shelf' than to develop their own. Only France was still using fighters of its own design, with even Britain replacing their English Electric Lightnings with F-4 Phantoms in the late 1960s. However, NATO's stated goal was interoperability and standardisation, and having so many different aircraft models, whatever their common national origin, clearly ran counter to this ideal.[116]

A competition was run to determine which aircraft would replace the myriad of models as a NATO standard. *Dassault* entered the Mirage III and Saab-Scandia the Viggen, but the General Dynamics F-16 won in what was described then as a 'tempestuous contest [...] marked by political pressure, economic one-upmanship, promotional hoopla, some

[115] Lockheed Martin, 'F-16 Fighting Falcon, History', <https://www.lockheedmartin.com/en-us/news/features/history/f16.html>, accessed 27 December 2018.
[116] Phillip Taylor, 'Weapons Standardization in NATO: Collective Security or Economic Competition?', *International Organisation*, 36:1 (1982), p. 97.

influence peddling and, at least in the early stages, financial skulduggery.'[117] Consequently, the USA pressed its European allies to adopt the F-16 and, in what was described as the 'contract of the century', offered an arrangement in 1975 whereby European NATO nations could share the production of the F-16 as well as purchase aircraft. A consortium was formed, described by Cornell as 'a partnership in the truest sense of the term.' In fact, the 'partnership' of European Participating Governments (EPG) merely gave limited production rights to the participants in return for those in the EPG not only having the right to buy the F-16, but additionally paying the US a 'significant portion' of the research and development costs involved in designing it, costs that would normally have been recouped through the normal sales process.[118]

The adoption of the F-16 was not universal throughout NATO and it was criticised, especially by French observers who had long resented what they saw as excessive US influence within NATO. Although creating a limited level of standardisation, the F-16's fuel was incompatible with existing NATO aircraft fuel and thus ran counter to NATO's aim of interoperability, the very reason that the competition for a standard NATO aircraft had been held in the first place.[119] The Belgian Senator, Etienne Duvieusart, described the decision to adopt the F-16 as, 'not only to renounce all advance technology in aeronautical matters, but also to found security on an American "mirage".' Such criticisms were not in any way countered by the US insinuation that a refusal to adopt the F-16 might be seen as 'lack of gratitude' for US investment in Europe and might lead to a reduction in the US military presence.[120]

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[117] New York Times, 'The F-16 and How It Won Europe', <https://www.nytimes.com/1975/07/27/archives/the-f16-and-how-it-won-europe-the-f16-and-how-it-won-europes-orders.html>, accessed 28 December 2018.
[118] Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies*, pp. 27-28; and, Stephen Martin*, The Economics of Offsets: Defence Procurement and Countertrade* (Abingdon, 1996), p. 2.
[119] Taylor, 'Weapons Standardization in NATO', p. 97.
[120] New York Times, 'The F-16 and How It Won Europe', <https://www.nytimes.com/1975/07/27/archives/the-f16-and-how-it-won-europe-the-f16-and-how-it-won-europes-orders.html>, accessed 28 December 2018.

Although Cornell includes the F-16 as a successful collaborative project, even a casual examination of the US contract with the EPG highlights that any 'collaboration' was extremely asymmetric. General Dynamics developed the aircraft without input from external partners and designed it to a specification that owed nothing to any explicitly stated requirements from their final customers. Instead, an indigenous fully-developed US aircraft was offered for sale with strong political influence and implied threats encouraging its adoption. In return for granting licensed production agreements, General Dynamics ensured that the partners not only bought its product but also separately reimbursed a large part of the development costs, whilst not gaining access to potential future technological benefits of that development, a fairly common feature of US defence partnership agreements.[121] In return, however, the partner countries gained a ready-made capable combat aircraft at a fraction of the cost of developing one by themselves, as well as reinforcing diplomatic ties to NATO's largest member nation.

5.5. Mk.VIII International/Liberty Tank

The Mark VIII 'International', or 'Liberty' tank was, as been mentioned above, the first and, to date, the only example of a successful international MBT collaboration. Consequently, although outside this study's post-1945 time period, no study of collaborative tank development is complete without an examination of the Anglo-American Mk.VIII International/Liberty. The particular circumstances surrounding the Mark VIII project's initiation are perhaps too specific to their time to draw broad conclusions for future projects, but nonetheless there are lessons to be learned. As the only successful collaborative tank project to date, the Mark VIII will be examined in some detail, as it may throw some light on

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[121] Robert W. Dean, 'The Future of Collaborative Weapons Acquisition', *Survival: Global Politics and Strategy*, 21:4 (1979), p. 161.

why later projects failed to achieve their declared goals. In fact, for any comparative study of international tank collaboration it would be peculiar if it were excluded

When the USA entered the First World War by declaring war on Germany on 6 April 1917 it had no armour of its own. In June of that year, the commander of the American Expeditionary Forces (AEF), General John J. Pershing, read a report on the use of tanks by the British and French Armies. He was sufficiently impressed to establish a board of officers to study the viability of setting up a US Tank Corps, the board recommending on 1 September 1917 that a new and separate Tank Department be established, equipped with more than two thousand tanks with a 10-to-1 mix of light to heavy tanks.[122]

AEF tank crews received training in two separate tank schools: the Light Tank School in France, and a training camp in Britain for training in heavy tanks. Initially, instructors were provided from the respective countries, France and Britain, but US personnel increasingly became involved. Whilst the UK-based heavy tank training camp concentrated on training US crews to operate the heavy British tanks, the Light Tank School had the advantage of being situated close to both an AEF infantry training centre and to the fighting front itself. As a consequence, the US crews trained at the Light Tank School not only learnt how to operate the FT-17 tanks, but also the rudiments of tank tactics and operations in something approaching real battle conditions. Whereas the light tanks operated with the AEF, the British felt that they were too short of heavy tanks in their own army to freely allocate tanks to the Americans. In consequence, whilst the AEF formed four heavy tank battalions before the end of the war, only one was used in combat and this was kept under the control of British commanders in the British sector. This was significant for US post-war military thinking

[122] Dale E. Wilson, 'World War I: The Birth of American Armor', in George F. Hofmann and Donn A. Starry (eds.), *Camp Colt to Desert Storm: The History of U.S. Armored Forces* (Lexington, 1999), pp. 1-3.

which concentrated on those offensives where the AEF dominated, such as St. Mihiel and Meuse-Argonne.[123]

In September of 1917, the sources of either heavy or light tanks for the USA were limited. Britain and France between them were producing only five tank models; the British Mark IV and Mark V heavy tanks, the French Schneider and St.-Chamond heavies, and the Renault FT-17 light tank. Having secured French permission to construct the light FT-17 under licence, a US evaluation team, Majors James A. Drain and Herbert W. Alden, reported to the Chief of Ordnance that none of the current heavy tanks were suitable for adoption and recommended that a new joint US-British design be considered instead.[124]

As Britain had, by this stage, two years' experience of designing and producing heavy tanks of the lozenge shape with sponson guns, they took responsibility for the hull and armament of the proposed new tank. Meanwhile, the USA had more experience with gasoline-powered engines and took responsibility for the tracks, engine and transmission gear. At that time, the US 'Liberty' V-12 aero-engine that the US intended to install in their own tanks and which gave their tank version its name, was reported to be the most powerful engine in the world for its weight at the time.[125] With an historical reliance on steam power for its heavy haulage, including road haulage, Britain at the time of the First World War had struggled to develop a petrol engine of sufficient power to give its tanks a speed much greater than a man could walk. Indeed, the 14-ton Medium A 'Whippet' tank, specifically designed to offer improved speed and mobility, used two British 4-cylinder Tylor 45hp engines

[123] Robert S. Cameron, *Mobility, Shock, and Firepower: The Emergence of the U.S. Army's Armor Branch, 1917-1945* (Washington, 2008), pp. 3-4.
[124] Cameron, *Mobility, Shock, and Firepower,* pp. 2, 8. It should be noted that Britain had already also constructed several prototypes of their Medium A 'Whippet' tank, but this tank was not in full production in September of 1917. See Elizabeth Greenhalgh, 'Technology Development in Coalition: The Case of the First World War Tank', *The International History Review*, 22:4 (2000), p. 824.
[125] IWM, 60/101/1, Thornycroft Papers [uncatalogued at time of writing], *Daily News*, press clipping of 5 August 1918.

originally developed for double-decker omnibuses, yet still only reached 8mph.[126] For the Mark VIII, Britain turned to the new 150hp engine designed by Harry Ricardo and used in the 1918 Mark V tank, the Ricardo engine having recently replaced the less efficient Daimler engines that had powered British heavy tank models to date.[127] The estimated cost of this new tank was £6,920 per unit. With shipping of components across the Atlantic included, the financial shares were about equal, with the USA responsible for £3,150 and the UK for £3,770.[128]

In Britain, the diversion of work to develop the Mark VIII disrupted development the Mark V, Mark V* and Medium B tanks, which work was consequently moved to the Metropolitan company in Birmingham. Sir Albert Stern, the new Commissioner for Mechanical Warfare (Overseas and Allies Department), Ministry of Munitions, identified in October 1917 that Britain's mechanical warfare readiness for the 1918 fighting season was wholly inadequate. Stern, a man described by Harry Ricardo, the engine designer, as a 'difficult man' but 'a most superb organiser and team leader', had been the head of the Mechanical Warfare Supply Department within the Ministry of Munitions, which had been led from July 1917 by Winston Churchill. Stern had been sacked from that post after becoming involved with one fight and one argument too many within the department.[129]

The USA in 1917 was still in the process of increasing its industrial output and the sudden increase in demand as a result of the USA's rapid armament programme inevitably meant that output targets were not always met. In February 1918, delivery of the first two hundred Liberty V-12 engines for the new tanks was delayed until May of that year. Part of the problem was that the Liberty engine was only manufactured by one supplier, Trego

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[126] John Glanfield, *The Devil's Chariots: The Birth and Secret Battles of the First Tanks* (Stroud, 2001), p. 294.
[127] David Morrison, 'Harry Ricardo – A Passion for Efficiency', in Fred Starr, Edward L. Marshall and Bryan Lawton, (eds.), *The Piston Engine Revolution: Papers from a Conference on the History of Reciprocating Internal Combustion* (London, 2012), pp. 156, 160.
[128] TNA,MUN 4/5194, Mechanical Warfare: Mark VIII Tanks: miscellaneous departmental minutes. Letter from the controller Mechanical Warfare Department (MWD) to Sir S.Dannreuther, 3 February 1919.
[129] Glanfield, *Devil's Chariots*, pp. 202-214, 226.

Motors, and the Mark VIII had to share the engine production run with the aircraft that were the Liberty's original intended recipients. Altering the aero-engine for use in tanks also caused delays, with the designers encountering many unforeseen problems with a conversion that had appeared to be simple in theory.[130] The engines intended for tanks, for example, used cast-iron cylinders rather than the steel ones in the aero-engines and thus the two engines were not interchangeable and required slightly different production facilities.[131] Due to the delays the May delivery date was extended, in April the projected figures were altered to 365 engines to be delivered by the end of August. Two months later, in June, the delivery date was again put back until October, and then only one hundred engines were expected to be ready.[132]

Britain's manufacture of the Mark VIII was similarly delayed. In fact, the only production tank that left British factories before the war's end rolled out from the British Locomotive Works in October 1918. The delays on both sides of the Atlantic meant that no Mark VIII saw action in the First World War, although they remained in US service, for the want of a suitable replacement, until 1932, when they were placed in reserve.[133]

Despite finally resulting in a working tank, therefore, the Mark VIII collaboration was not an unqualified success. It certainly gave the USA valuable experience of tank design and cemented closer ties between the US and Britain, but the aim had been to produce a single model heavy tank for the armies of Britain, France and the US to fight Imperial Germany. In this respect it failed and also caused diplomatic friction with France, with the agreed allocation of Mark VIII tanks favouring the other two allies at France's expense.[134] The Mark VIII collaboration must be seen in the context of its time. In 1917, very few countries had any

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[130] Glanfield, *Devil's Chariots*, p. 250.
[131] J. Edward Schipper, 'The Liberty Engine', *Flight*, 11:1(January 1919), p. 6.
[132] Greenhalgh, 'Technology Development in Coalition: The Case of the First World War Tank', p. 828.
[133] Ibid.; and, Richard Ogorkiewicz, *Tanks: 100 Years of Evolution* (Oxford, 2015), p. 80.
[134] Glanfield, *Devil's Chariots*, p. 252.

experience or expertise in tank design or possessed any suitable production facilities. The new tank was required urgently, with the war predicted to last into 1919. These circumstances were unique and so the Mark VIII offers only limited insights into modern tank collaborations. Yet Britain's dominance of the design process did help avoid design disagreements, even if this made the collaboration somewhat one-sided. It is interesting to compare the Mark VIII collaboration with later defence projects involving the USA, where the US generally held a monopoly on design and any collaboration was limited to financial investment and licensed production facilities.[135]

5.6. Summary

Clearly, the lines between collaboration and other forms of technology transfer are poorly defined both theoretically and in practice. Many commentators agree that cooperation is required, but few suggest at which stage of the project such cooperation needs to occur, nor what the relative weighting of effort needs to be. Some projects, such as the F-16, are obviously asymmetrically weighted in favour of a single partner (the USA in this case), with the other partners only involved after all research and development was complete. Whilst a collaboration in so much as the US granted licensed co-production rights to its partners, there was no co-development and no full sharing of US technological research. The MBT-2000/*Al-Khalid* project shows that Pakistan had an influence on the final tank design, but that their input was minor on a tank design that had, in essence, already been developed by China. However, while Britain also undoubtedly dominated the Mark VIII International/Liberty tank project due to its previous experience, the programme also involved US personnel at the earliest development stages. This can usefully be contrasted to the US producing the French

[135] See, for example, the US F-16 Falcon project, above in this chapter.

FT-17 under licence, a technology transfer of a very different type and one which gave the USA nothing in the way of design input or experience.[136]

Bitzinger has identified that NATO has suffered continuous setbacks in its drive for weapons collaboration. Whilst some successful international projects stand out as exceptions, he suggests that the general trend shows that collaborative development ventures are likely to fail.[137] Even some projects held up as successful examples of international collaboration show that the partners and contributions are not equal; the F-35 programme, for example, was developed largely by Lockheed Martin in the USA, with various other nations contributing research and development (R&D) funding under a Memorandum of Understanding (MOU), but not participating in the actual R&D.[138] Bitzinger notes that transatlantic arms collaboration has its own particular problems, citing the USA's disproportionate defence and R&D budget, as well as the protectionist natures of governments dealing with security technology. He suggests, however, that these problems may be over-emphasised and that the real problems lies in the fact that, 'US corporate indifference to the defence industry globalisation process in general and to transatlantic arms collaboration in particular has been matched by a general lack of responsiveness and commitment on the part of the US government.'[139]

Each partner within a collaboration is seeking an advantage, what Moravsik calls the 'win-set'.[140] The size of this win-set is the key to how successful each partner feels a given collaboration has been, and thus how likely it is that the project will succeed. Sometimes this

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[136] Dale E. Wilson, 'World War I: The Birth of American Armor', p. 8.
[137] Richard A. Bitzinger, 'Overcoming Impediments to Transatlantic Armaments Collaboration', *International Spectator*, 39:1 (2004), p. 84.
[138] Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program* (Washington DC: Congressional Research Service, 16th February, 2012), pp. 8, 14, accessed online via <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA590244>, accessed 28 September 2016.
[139] Bitzinger, 'Overcoming Impediments to Transatlantic Armaments Collaboration', pp. 87-88, 92.
[140] Movavcsik, 'Armaments among Allies', p. 160.

win-set might simply be a lack of alternatives, a partnership of necessity.[141] By studying and comparing the projects illustrated here, three major conclusions can be drawn. Firstly, it becomes obvious that governmental politics is a major force in international collaborations, often at the expense of economic prudence. In their guide to project management, Morris, et al., state that:

> Politicians, or others intimately involved with and investing political capital in a project, have a tendency to overestimate results and benefits, whilst simultaneously underestimating potential problems or costs. This optimism bias has the effect of increasing support for a project.[142]

FH-70, SP-70, Eurofighter Typhoon and A400M are good examples of international projects championed to further coalition politics. *Concorde* was likewise primarily a political ambition, but in this case Britain and France were at least as interested in promoting the 'superiority' of their civilian aviation as demonstrating any diplomatic alliance.

An interesting development in the field of international defence collaboration is the commercial multinational group, with good examples being the MBDA and KNDS groups, suggesting that establishing an international project on purely commercial grounds might improve the chances of success for any future international weapon system. While even indigenous industrial projects can fail, run over budget, or be delayed, the factors contributing to friction and failure are multiplied when the number of partners increases.[143] When the partners are from different countries and have different native languages, industrial standards and expectations, such problems are inevitably compounded. The study by Frinsdorf, et al., on the subject suggests that maximising the success of collaborations depends on factors that

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[141] Dean, 'The Future of Collaborative Weapons Acquisition', p. 160.
[142] Peter W. G. Morris, Jeffrey K. Pinto, and Jonas Söderlund (eds.), *The Oxford Handbook of Project Management* (Oxford, 2012), p. 328.
[143] Mawdsley, 'The A400M Project', p. 29.

are associated with single management and corporate structures.[144] This is certainly borne out by the evidence of studying collaborative projects, and may well be the key to any successful future MBT collaborations, with the fate of the KNDS EMBT programme being of particular interest for those hoping to establish any new international MBT collaboration.

[144]Frinsdorf, Zuo, and Xia, 'Critical Factors for Project Efficiency in a Defence Environment', p. 813.

Conclusion

This study has investigated four specific case studies in failed international main battle tank collaborative projects: the NATO 'Standard Tank' (1957-63), 'Tank 90' (1977-83), the MBT-70 (1963-70), and the FMBT/KPz3 (1971-77). It has also included some consideration of projects which do not quite fulfil the definition of international MBT collaboration projects: the Franco-German KNDS EMBT (a tank demonstrator), the Italian-German-British SP-70 (a self-propelled artillery system) and the MBT-2000/Al-Khalid (a Sino-Pakistan cooperation, falling therefore outside the focus on the leading European/Western NATO nations). If each of the main case study projects had, arguably, some positive outcomes, as was to be anticipated, each project – in terms of its stated goal, the creation of a jointly designed and manufactured MBT, quite clearly failed. That these projects failed spectacularly, unlike a number of other high-profile collaborative weapons projects between NATO nations, is well documented. The research question under investigation in this thesis was, however, *why* these collaborative MBT projects, undertaken in pursuit of a standard European tank, failed.

The reasons for failure were, needless to say, many, often predictable, and sometimes more complex than the initiators originally anticipated. The four main case studies were drawn, however, from the period of the Cold War (1949-1989), which raises the question as to whether changed international, financial and other circumstances in the post-Cold War and post-9/11 world may have changed the dynamics governing collaborative US and European defence technology projects. But before considering this question, it is necessary (1) to reflect on the main and peripheral case studies, (2) draw some general conclusions as to what they reveal about collaborative MBT projects, (3) discuss where these conclusions leave the hypotheses reached hitherto in the academic and professional literature and, finally, (4) reflect on what these conclusions might tell us about the future for international MBT collaboration.

Observations on the Case Studies

To identify what lessons might be drawn from the four main case studies and three 'peripheral' case studies, a summary of five key areas affecting the projects will be undertaken: *political*, *technical*, *military*, *industrial/economic*, and *strategic*. Each of the summaries will include reference to each of these five factors. The following section will then seek to create a 'matrix' which conveys the distilled experience of why MBT joint projects fail, but then identifying those factors which are the major prerequisites for success.

The initial 1957 European Standard Tank project emerged from the FINABEL group concept of a standardised European tank and was pushed *politically* by René Coty and Konrad Adenauer as a tool to reinforce Franco-German relationships. Coty was looking to distance France from reliance on the US while Adenauer sought to re-establish German influence within Europe and in NATO. When de Gaulle took power in France following the collapse of the Fourth Republic, and Ludwig Erhard was elected Chancellor after Adenauer was forced to step down following a number of political miscalculations and scandals, the Standard Tank project was wound up. De Gaulle did not wish France to be involved in collaborations and Erhard was looking for a new political direction elsewhere.[1] Whilst the official reason for the project's failure was stated to be a difference in specification, even a

[1] Adenauer was eventually forced to step down following his part in supporting Franz-Josef Strauß, his Defence Minister, throughout the '*Spiegel* Affair'. See, for example: Gert Bergner, *Rudolf Augstein und die "Spiegel" Affäre* (Berlin, 1964); and, Stefan Finger, *Franz Josef Strauß: Ein politisches Leben* (Munich, 2005), pp. 170-245. Meanwhile, de Gaulle had taken power after the collapse of the Fourth Republic and believed that France should maintain a political independence which defence collaborations threatened. See: Andrew Shannan, *De Gaulle* (London, 1993); Douglas Johnson, 'De Gaulle and France's Role in the World', and Serge Berstein, 'De Gaulle and Gaullism in the Fifth Republic', in Hugh Gough and John Horne (eds.), *De Gaulle and Twentieth Century France* (New York, 1994), pp. 93-94, 114, 117.

casual look at the prototypes and, indeed, the two sovereign designs that followed, Leopard and AMX-30, shows that the national concepts were almost indistinguishable.

The proposed designs for the Standard Tank should not have proved to be a challenge for the standards in the contemporary *technology* of the time. It is true that the main gun was to be new, and hence unproven, but the basic vehicle design required little in the way of major new technology. The 90-105mm gun calibre was in common use, or in development, at that time and the only real question was who would supply it, with France favouring their own design and the Federal Republic looking elsewhere. German requirements for well-sloped RHA armour were no more challenging than what could be seen on contemporary tanks, such as the British Centurion or US Patton series and, indeed, could be seen in the design of the old Soviet T-34.[2] The call for spaced armour, rejected by France, was not anything which was not already in use on armour design.

The main *military* needs for both the German and French armies in 1957 were for a main battle tank to replace those then supplied by the USA; both countries agreed that the tank should rely on firepower and mobility over direct armour protection; both required that the weight be kept to a minimum. Indeed, aside from minor disagreement over the maximum weight, the specifications for the Standard Tank from each nation were remarkably similar, as the similarity in design of the subsequent Leopard 1 and AMX-30 demonstrated. Possibly the weight disagreement made any final agreement less likely, yet the requirements of the two countries were so close that it is difficult to see how compromise could not have been reached had the military specification been the only, or at least a major, hurdle.

The *economic* ramifications surrounding the Standard Tank were in no way as significant as the issues seen in the case of the second Franco-German project, the Tank 90,

[2] The development of armour had seen rolled homogenous armour (RHA) replace face-hardened armour in the 1930s, but cast armour became an alternative as it was easier to produce complex shapes, such as turrets, without requiring welding or riveting. See on this subject, Richard Ogorkiewicz, *Tanks: 100 Years of Evolution*, (Oxford, 2015), pp. 266-267.

or Napoleon Tank. The Federal Republic had, in 1957, no tank-building industry and France had only just begun to rebuild its own. Unlike the later programme, therefore, while France did have the infrastructure in place, neither country had established industry or available designs that would be aided or threatened by collaboration. In fact, the FRG recognised that France at that time had more recent experience with tank building and would, therefore, take the lead. They also believed that a collaborative MBT project was going to benefit the *Bundeswehr* more than it would the French armed forces and so agreed to invest the bulk of the funds. There was some confusion over where the final tank would be built, but this was an issue which could have been discussed later and was certainly not significant during the project's lifetime.

The *strategic* aim of both France and the Federal Republic at the time of the Standard Tank project was simply for a locally-produced tank to equip their armed forces. In the case of the FRG this was to replace the recently delivered US M-47 and M-48 tanks that had been imported following the US-led decision to rearm the West German military in the face of the perceived threat of European invasion from the Soviet Union. France's army was also largely equipped with US tanks, the venerable M4 Sherman in this case, and both countries initially wished to break their military reliance on the United States. The strategic goals of both nations were therefore in alignment in looking for a new, at least partly indigenous, tank to enter service as soon as possible.

In the case of the 1963 MBT-70, once again *politics* was a driving force, this time in the face of military and industrial advice. Robert McNamara, the US Secretary of Defense, initiated, drove and championed the project, even if his underlying intentions were almost certainly as much economic as political, with the deal potentially cheaper than a sovereign development. A further intention was to redress an uneven balance of payments by forcing the Federal Republic to buy US components for the new tank. Nonetheless, the Federal

Republic and Franz-Josef Strauß, the Defence Minister, had to be persuaded to enter the collaboration rather than simply to sell the USA their own Leopard tank; at the same time, senior officers and representatives of the defence industries of each nation believed they were simply sharing ideas and concepts until told that a collaboration would be commenced. Throughout the MBT-70 programme, McNamara's influence is plainly visible, even over-riding reservations from the two armies and a lack of control over industry. But a poor management structure combined with communication problems conspired to waste millions of dollars in fruitless duplication of development efforts. Following McNamara's departure in February 1968, US political support for MBT-70 weakened considerably and the Germans, never as committed to the project as the US had been, did not take long to reduce funding for, and eventually cancel, the programme.

Coupled with the influence of political figures was the confused and disjointed management structure which was created for the MBT-70. The Program Management Board (PMB) was, in effect, two separate management teams that had some interaction with their opposite numbers, but fundamentally each team was concerned with its own national programme. That two separate design paths subsequently emerged should have been a surprise to nobody, but the political desire to keep the project going meant that higher authority stepped in to bring the two teams together by forcing a compromise over their respective ideas.

The *technological* issues with MBT-70 are the most pronounced in any of the case studies. Hilmes, for example, concludes that the complexity and over-optimistic specification of the MBT-70 design led to its failure.[3] From the outset, the USA wanted the tank to be better in all areas than anything else in service and was consequently eager to use any new technology, technology that had yet to be properly developed. The US industrial lobby

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[3] Rolf Hilmes, *Main Battle Tanks: Developments in Design Since 1945,* trans. Richard Simpkin (London, 1987), pp. 18-20.

pressed for the management team to adopt innovation in vital components such as the engine, suspension, and crew protection, while the US Army was committed to a programme of using the troubled 'Shillelagh' ATGM instead of a direct-fire main gun. Not only did demanding untried and undeveloped technology add to the delays and cost of MBT-70, there was no guarantee that the technology would function. The case of the proposed diesel engine is a case in point; a US diesel could not be developed to produce the required power and so untested gas turbine technology was to be adopted instead of using the German diesel engine which did meet requirements but was, of course, not American.

A major *military* disagreement over MBT-70's direction was in the main armament. The USA was, at that time, eager to use ATGMs as the primary anti-tank weapon on the new tank, whilst the FRG was unconvinced by this and preferred to keep using direct-fire guns. Even supposing the rest of the project had gone smoothly, the fact that each country was intending to mount a completely separate weapon system (with resulting changes to the interior of the turret and ancillary systems) meant that the MBT-70 would not have represented either standardisation or interoperability, primary goals of NATO generally and the collaboration in particular.

The lack of *industrial* standardisation between the two countries meant that even more mundane construction and development encountered hurdles. The German half of the project did not believe that the US-made components were satisfactory, while the American side believed the same of the German components. A sense of national pride, combined with a desire to protect the reputation of its industrial expertise, means that any tank-building nation is understandably reluctant to adopt a foreign design – a move that would imply acknowledgement that potential competitors are producing a superior vehicle. A general reluctance by the USA to accept foreign designs could not have helped any form of collaboration and, coupled with the division of the management team into two parallel, national teams, it was perhaps inevitable that each country would follow its own path and hence make compromise less likely. The failure to agree on a universal standard for screw threads is indicative of how these two established industrial nations were reluctant to compromise their own industrial culture and standards. Possibly even more serious, because US firms saw opportunities for lucrative defence contracts they tried to push emerging and even as-yet undeveloped technology, leading to additional delays and cost overruns that adopting tried and tested ideas might have avoided, as well preventing disagreement between the partners as to the advisability of such untried technology.

As far as the *strategic* ramifications are concerned, whilst neither the USA nor Germany ended up with a production-ready tank from the project, both sides subsequently went on to develop sovereign designs that are still in use, the M1 Abrams and the Leopard 2. The two countries also entered a technology-sharing programme with the intention of improving interoperability between the two new tanks. In fact, the USA ended up buying the German smoothbore 120mm gun but on the other hand chose to adopt its own newly-developed gas turbine engine, thus improving interoperability in gun ammunition but not in either fuel or automotive components. McNaugher notes of the MBT-70 programme that:

> Part of the problem was political: the initial requirement had become the basis for work-sharing arrangements whose renegotiation would likely have involved high-level officials, public scrutiny, and possible diplomatic embarrassment. Part was organizational: there was no unity command, no way to enforce clear-cut trade-offs. But behind both problems lay the differing tank concepts each army had originally brought to the project. Under these conditions money and time were perhaps the only negotiable issues.[4]

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[4] Thomas L. McNaugher, 'Problem of Collaborative Weapons Development: The MBT-70', *Armed Forces and Society*, 10:1 (Autumn 1983), p. 141.

The *political* situation surrounding the 1971 Anglo-German FMBT was, once again, that of politicians driving the collaboration forward despite reservations from both industry and the military. In the case of FMBT it was the UK's Defence Minister, Lord Carrington, who decreed that the collaboration with Germany was the only option for a new MBT for the British Army, the UK at that time being eager to join the EEC and thus wanting to establish its credentials as a European partner. At the same time, the Germans were in negotiation with the USA over integrating their XM-1 and Leopard 2 tank programmes which effectively precluded development of an Anglo-German MBT unless this was somehow incorporated into that programme. The political priorities of the Federal Republic were to work with the US and this overshadowed any genuine enthusiasm for FMBT that they might have had. MBT-70 had shown that German tank designers were committed to their own designs, even though they might be willing to test other technologies in collaboration with other NATO members. Regardless of any other problems that the FMBT programme encountered, the fact that the FRG was never fully committed to developing a new tank in partnership with the UK was a major handicap from the start.

Rather than seriously looking to FMBT to produce a new tank, it appears more likely that the FRG saw the programme as an exercise in *technical* experimentation. For the failure of FMBT, Hilmes puts the blame on disagreements over weight, protection, logistical support, and cost, noting that Britain insisted on a turreted design in the face of various innovative German turretless concepts.[5] Certainly, a wide range of different designs were examined within the project, notably in the potential for future turretless tanks, although British tests suggested that more traditional designs were still superior at that time, and the British were consequently still in favour of pursuing conventional turreted designs. FMBT

[5] Hilmes, 'Modern German Tank Development, 1956-2000', pp. 18-20.

also highlighted the contemporary debate over rifled guns verses smoothbore, a debate that severely hindered any real chance of collaboration.

The armies of both countries were certainly looking towards a future replacement tank when they entered the FMBT programme. Yet, while thanks to Lord Carrington's pronouncement, Britain had invested a great deal in the FMBT programme, eventually producing their new tank, the Federal Republic were already developing Leopard 2 and was unlikely to wish to pursue the two designs in parallel. The *Bundeswehr* was also committed to a lighter and more manoeuvrable tank design than the one sought by the British Army, not to mention using a smoothbore gun as opposed to the rifled bored gun that was the favoured option of the British. Thus, for the project to have succeeded, one nation or the other would have had to buy into an MBT that did not meet the stated needs of its end user.

The *economic*, or more accurately, the commercial competition between the British rifled bore and German smoothbore gun is a key factor as to why the collaboration failed. Quite aside from any military preference and political ramifications, each country was expecting their gun to become an important export. Losing the argument over which would be fitted to a new Anglo-German MBT would have effectively been an admission that the other design was better, with obvious consequences for the export market. This single factor, therefore, made it highly unlikely that any agreement or compromise would have been made on the main gun, and so any final design would have failed to further interoperability, let alone standardisation, within these two major NATO members and for any countries adopting their MBT design.

Both Britain and the FRG were major exporters of main battle tanks at the time when the FMBT programme commenced and future exports were a *strategic* consideration. Leopard 1 had proved a successful export for the Federal Republic, and Britain's recent export history included both Centurion and, to a lesser extent, Chieftain. Britain was undoubtedly dominant in exporting tank guns, with the 105mm L7 being used even in Leopard 1. However, the consequences for a successful FMBT were that future MBT exports would be shared with the collaboration partner, with the question of which gun was adopted resulting in either further export success for Britain or a new export market for Germany. A jointly developed gun would have somewhat alleviated this problem but neither country was prepared to compromise on the relative advantages of smoothbore over rifled. With an eye to future exports, therefore, it is hard to see how either country could have been satisfied with a jointly developed tank.

The 1977 Tank 90, or 'Napoleon', project was the result of both France and the FRG needing to replace or upgrade their existing main battle tanks. France's Minister of Defence, Yvon Bourges, saw the collaboration as a means to reaffirm France's *political* commitment to cooperation with France's European allies as opposed to the wider NATO Alliance, while Germany's Defence Minister, Georg Leber, also used it as an opportunity to strengthen the Germany's political ties within Europe. Although the political personalities changed, the leaders of both France and Germany championed the Tank 90 collaboration throughout its lifetime, despite political dissent within Germany, notably from the *Bundestag* Defence Committee and Hans Apel, who became the new German Defence Minister in February 1978. In October 1982, both the Federal Republic and France had seen a change of leadership and, with industry in both nations raising concerns about work sharing, enthusiasm for the Tank 90 project effectively ended.

It is difficult to identify any major *technological* hurdles to the Tank 90 programme, but it should be pointed out that the French were looking for innovation where the Germans were simply seeking an upgraded Leopard 2. This alone caused problems for the collaboration, with France unwilling to become simply a partner in the development of what would have essentially been a new German tank. Towards the end of the project it became likely that the collaboration was to become simply a programme to develop a new turret for Leopard 2, something the French politicians agreed with but which upset French industry and the military, both of whom had been expecting a completely new tank to be developed.

The *military* needs of the two partner nations differed slightly, as they had in 1957, on the weight of the final vehicle. Germany was, by this stage, designing the Leopard 2 with more of an emphasis on direct protection than it had been seeking in 1957, while France was still unwilling to compromise weight for this additional protection. Hilmes argues that the Franco-German Tank 90 programme collapsed due a failure to agree on weight and cost, but also points out that Germany was already largely satisfied that its Leopard 2 design and was seeking a linear development in its tanks rather than a radical new design.[6] It is interesting to compare the Tank 90 debate with that of the Standard Tank because the weight difference was once more the only real military disagreement, with both sides happy to use a 120mm smoothbore main gun. However, Tank 90 experienced far more industrial and political objections than had its predecessor; perhaps this is why the later programme stalled at an earlier stage than the 1957 project.

The *economic and industrial* ramifications of Tank 90 caused at least as much trouble for the programme as did the political background. The influential French industrial unions did not want be a junior partner to German tank building and the French were determined that a new tank would be a completely new design rather than an upgraded Leopard 2. The German firms, by contrast, believed that they were allowing inferior French tank-building expertise to benefit from that of the Germans, and appeared to believe that the new tank would essentially be a Leopard 2 with some improvements. French industry struggled to be a greater part of the collaboration, but the Federal Republic had established a self-belief that it was superior in just about every field of tank building, something that was borne out by the

[6] Hilmes, 'Modern German Tank Development, 1956-2000', pp. 18-20.

comparison between the eventual French sovereign design, the Leclerc, and the Leopard 2. Such uncertainty and unrest from the firms that were expected to design and build the new tank did nothing to improve the Tank 90 programme's chances of succeeding.

At the *strategic* level, the strict Federal Republic export laws were always going to cause problems for any arms collaboration with a country with a more open policy. However, this was partly side-stepped by an agreement that any exports by France would be submitted to the Germans for prior agreement and discussion. The ramifications, however, would inevitably have had a deleterious effect on German tank exports, with shared MBT exports to NATO nations reducing exports that Germany's Leopard 2 enjoyed at that time, while the French would have been able to exploit a larger market, given the countries for which the FRG refused to authorise exports. Having established themselves as major exporter of MBTs, neither nation was likely to compromise over lucrative markets by sharing them with an economic competitor.

Given these observations on each of the case studies, the table below summarises the difficulties faced by each MBT project. Although this conveniently highlights the major factors that led to each project's failure, there were minor areas of dispute which have not been listed as they were not as significant as these central factors.

Joint MBT Projects: Factors Leading to Failure				
	Standard Panzer 1957-1963	MBT-70 1963-1970	FMBT 1971-1977	Tank 90/ Napoleon 1977-1983
Political				
Politically driven	✔	✔	✔	✔
Separate management structure		✔	✔	
Failure coincides with change of political leadership or direction	✔	✔	✔	✔
Technical				
Early lack of specification		✔	✔	
Over-ambitious expectations		✔		
Military				
Different tank philosophy	✔	✔	✔	✔
Differing priority for new tank		✔	✔	✔
Industry/Economic				
Lack of work-sharing agreement		✔	✔	✔
Different industrial standards	✔	✔		
Commercial competition (components)		✔	✔	✔
Strategic				
Competition for export market (finished MBTs)			✔	✔
Incompatible In-Service Date		✔		
Number of Identified Factors	4	11	9	7

As can be concluded from the table, the major areas which have caused problems for MBT collaboration have been: changes of political leadership or direction (such as the FRG choosing to work more closely with the USA at the expense of the UK); differing military requirements over the design philosophy of MBTs; a lack of strong management and/or an agreed design specification; commercial disputes over either work sharing or components; and, strategic, national considerations over future tank exports.

Finally, and in light of the above, it is useful to refer briefly to the three peripheral case studies: the Sino-Pakistani MBT-2000, KNDS Demonstrator, and SP-70 self-propelled artillery system. MBT-2000 was essentially a tank design built by the Chinese, modified to better suit Pakistani specifications and licence-built in Chinese-funded Pakistani factories. This approach clearly favours the originating nation in terms of political influence, industry and innovation, but does nonetheless provide the buyer with an MBT without having to develop tank-building infrastructure and research. This approach has been used by non-tank building nations since the invention of the tank itself, but it cannot be said to be a collaboration in the sense that we have established for this study. Pakistan may have been able to specify its own requirements, but it had no influence in the design of the vehicle and was thus merely modifying an existing MBT design, the Type 90-IIM.

The KNDS Demonstrator was built by an international consortium to demonstrate that those involved were capable of producing a next-generation MBT. Such consortia have, of course, long been established in the fields of military and civil aircraft, missile and other weapons systems. In this way, the major hurdles to MBT collaboration such as reliance on national government support, divided design philosophies, disjointed management structures, and questions over exports are largely avoided. Whilst such consortia still require nations to invest in development and to buy the completed vehicles, they are not as tied to individual governments or political figures as are national projects. Instead, they operate as commercial interest groups and may seek customers globally, or represent the future for MBT development.

SP-70 saw Britain, West Germany and Italy working together to develop a self-propelled artillery system based on a successful howitzer which had been developed and built by those same three countries. Given that there were no obvious differences of opinion over what SP-70 was expected to achieve in the field, such a joint development seems to have been, on the surface, a relatively easy goal. Yet technical issues led to cost and time overruns which persuaded the Federal Republic to abandon the programme. Given that the FRG had been SP-70's major investor, the remaining countries had little choice but to discontinue the project. This case study demonstrates a key factor in joint tracked vehicle projects – all partners within the collaboration are dependent on the others; so, the project is likely to succeed or fail according to the unity of purpose of each member. This dependency, and thus the fragility of the project, increases the more the number of partners involved.

The Case Studies: What Lessons Can Be Learned?

What do these case studies tell us, then about MBT collaboration? In the first instance, the most obvious conclusion is that success will require certain basic prerequisites. These can be considered to be as follows: political/management support throughout the project; an understanding and agreement of the project scope or requirements; good communication throughout the project; and, that sufficient resources be made available.[7] While adhering to theoretical project management guidelines may appear straightforward in principle, when dealing with large international industrial projects, many different and often conflicting influences make it unlikely that the theory will survive contact with two national partners.

Governmental politics within a democracy is notoriously fickle. The very power a politician holds, the power that enables him or her to initiate and support a collaborative project, is dependent on the popular support of the electorate. It is understandable, therefore, that politicians are more eager to lend support to projects which offer short-term political advantage. Politicians, or others intimately involved with and investing political capital in a project, have a tendency to overestimate the probable results and benefits, while simultaneously underestimating potential problems or costs. This 'optimism bias' has the effect of increasing support for a project.[8] Yet, projects that look attractive from a political viewpoint might not be as attractive to the military end-user, or the engineers and designers

[7] See, for example, Olivia Frinsdorf, Jian Zuo, and Bo Xia, 'Critical Factors for Project Efficiency in a Defence Environment', *International Journal of Project Management*, 32 (2014), p. 813; TNA, DEFE 70/586, Future Main Battle Tank (FBMT), equipment, future tank policy study, possible collaboration, Note from VCGS to CGS, Tank Collaboration, 12 September 1980.

[8] Peter W. G. Morris, Jeffrey K. Pinto and Jonas Söderlund (eds.), *The Oxford Handbook of Project Management* (Oxford: Oxford University Press, 2012), p. 328. It should be noted that, when discussing military procurement, there is a significant difference between the governmental politics and military procurement executive phases of the process.

who are faced with the problems of agreeing on a single concept. The MBT-70 and FMBT projects offer good examples of how conceptual differences hinder collaborations despite strong political support, while the Standard Tank and Tank 90 show that a change in domestic politics may end even a project that otherwise has a good chance of success. The partners in any future European MBT collaboration are likely to remain democratic governments in the future; hence the problem of changing political personalities and priorities is unlikely to disappear. However, if lessons of past history are to be learned, support for future collaborative tank projects should be shared among the government or national parliament as a whole rather than being maintained by a single party or politician.

National differences in design philosophy have been major hindrances to a successful collaboration in the past. Arguments over the optimal balance of the firepower-mobility-protection triangle have meant that nations would have had to compromise their own military requirements in order to develop jointly a new MBT. To a large extent this issue seems to be no longer as significant in modern tank design, with advances in technology and the experience of modern armoured warfare refining and defining what the optimum MBT design should be. While some differences still exist at the time of writing, the debate over rifled versus smoothbore guns being an example, it is less likely that such differences should be a major factor in any future collaboration.

While it is not easy to make predictions, the rise of multinational conglomerates within the defence industry is very likely to solve the problem of export and industrial arguments. Previous projects saw difficulties both in maintaining domestic industrial advantage for the involved nations, as well as arguments over responsibility for components. Decisions as to who, for example, takes responsibility for the main gun, or who may export the final product, are somewhat moot when the developer is a multinational conglomerate. In addition, such an infrastructure allows for a defined and agreed project scope and requirements, in other words an agreement on exactly what is to be built. The case studies examined in this thesis show that not one of the four reached agreement because sovereign states were backing the projects.

Examination of the case study projects allows the identification of essential requirements, the absence of which reduced the chances of success for any potential international MBT collaboration project:

- Continued Political Backing. International defence projects, by their nature, involve governments and diplomatic agreement. Government funds are required to fund such projects, and a measure of diplomatic cooperation is essential for any sort of agreement to be reached. It is advisable, however, that such agreements are not tied to a single political entity, be that a politician or government in power, but are supported and governed independently once the initial agreement has been reached.
- Agreed Military Specification.An established specification gives a project needed focus, but that specification must be drawn up through military studies in consultation with the end-user, in this case the national armed forces, in most cases the army. Tanks are an integral part of military organisations and doctrine, and the military user might expect any new MBT to be designed to their own requirements. While it is true that a compromised design is better than no new tank at all, an MBT project is a multi-billion pound investment in a nation's future military effectiveness and should not simply be viewed as a means to political or diplomatic gain. After all, national security and the lives of soldiers may be dependent upon having an optimal MBT design every bit as much, or more so, as an advanced MBT enhances national or governmental prestige.
- A Single Management Structure. Should each partner run their own management team in isolation, as was seen in the cases of MBT-70 and FMBT, then the likelihood of

developing a single unified design becomes more improbable. Efficient and effective management must be in place to ensure that an agreed specification is adhered to, or that any required changes to it are made as efficiently and effectively as possible. This also encompasses having a clear and effective system of communication, both from the top down and also in the other direction.

- A Realistic Goal and Sufficient Resources.When setting project targets it is essential that those targets are realistically achievable with the resources and capability available. Overruns in collaborative projects, and complex defence projects in particular, appear to be unavoidable. This fundamental fact needs to be taken into account when establishing completion dates and budgets, with some agreed system in place to encourage both contractors and management to keep such overruns to a minimum.
- Awareness of Commercial and Strategic Concerns. Export of MBTs and their components is both lucrative and politically advantageous, especially should that model become the standard MBT with an alliance such as NATO. Exporting MBTs is not only a business decision but also a diplomatic one, and many export deals are made for political rather than military reasons. Established tank-exporting nations are going to view with concern any compromise to their existing market share by jointly producing an MBT with another country: this must be taken into consideration either before a collaborative deal is sought, or before any investment in development is made. Strategic concerns involve the 'soft' power diplomatic prestige held by a nation as well as the 'hard' power capability and potential of its armed forces. By choosing to buy a foreign design, or even allowing a collaborator to dominate a deal, a nation risks compromising their prestige by acknowledging that the other design is better than their own.

Revisiting Contemporary Theories of International Collaboration

In the light of the conclusions reached as regards the case studies as to why collaborative international MBT projects have largely failed to date, it is useful to examine the hypotheses and conclusions of previously published works on the subject. Very little of the existing material deals exclusively with MBT projects, so this study may allow for some adjustments to existing thinking on international collaborative projects.

Alexander Cornell is in favour of integration of systems within the Alliance, and uses three major case studies to reach his conclusion that collaboration and integration is the most beneficial way for member states to develop new weapon systems.[9] His choice of case studies, the E3A-based Airborne Early Warning and Controls System (AWACS), the Roland surface-to-air missile (SAM) and the F-16 fighter aircraft, do not include a main battle tank, or even a ground vehicle, and the extent of true cooperative development in either the AWACS or F-16 projects is highly debatable. In addition, he does not consider the military benefits of having a broad range of weapon systems within an alliance, nor the benefits to the countries themselves of developing their own weapons. His politically-focussed approach is interesting to note in light of the conclusion that international MBT collaborations often fall victim to political ambitions which mask practical obstacles to success such as failure to meet military requirements.

Marc DeVore suggests that whilst – in theory – weapons development collaboration ought to provide economic and military benefits, in practice these theoretical advantages are rarely achieved. The inherent problems of private industry working with an international competitor evidently do not prevent other armaments collaboration projects from succeeding, examples of joint weapons development include the Panavia Tornado, Milan anti-tank missile and Eurofighter Typhoon, but DeVore argues that the international aspect of such projects

[9] Alexander H. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies: Ten Years Later - And Beyond* (The Hague, 1981), pp. 30-34.

mitigates against the theoretical financial savings and technological advancement that a collaborative model suggests. Indeed, he suggests that joint international projects often cost more in absolute terms and take longer to mature due to their inherent additional bureaucracy, casting considerable doubt on the wisdom of collaboration on larger projects:

> Thus, intrinsic limits to the extent to which the arms collaboration process can be reformed exist. This renders it improbable that collaborative projects will ever achieve more than a small proportion of the economic and military benefits anticipated by collaboration's proponents. In fact, modest R&D savings and improvements to partners' interoperability are most likely the only benefits that states can realistically hope to achieve. Moreover, even these benefits come at the price of a slow and inflexible decision-making process. Equipped with a better understanding of the limited benefits and trade-offs inherent in collaboration, scholars and policy-makers can examine when it is in states' interest to collaborate and when they would be better served by other policy options.[10]

DeVore believes that economic factors hinder international defence cooperation, pointing out that: 'As with international cooperation in other domains, fear of suffering losses relative to one's partners provides a powerful deterrent to states or firms investing in the specific assets needed to render collaboration efficient.'[11]

DeVore's conclusions are certainly borne out by studying MBT collaborations, where national economic and strategic considerations were significant in the failure of three of the four case studies, with only the 1957 Standard Panzer avoiding these problems, probably because neither France nor the FRG had, at the time, invested heavily in their domestic tank industry and had no existing export expectations. By contrast, the other three case studies saw

[10] Marc R. DeVore, 'International Armaments Collaboration and the Limits of Reform', *Defence and Peace Economics*, 25:4 (2014), p. 416.
[11] Marc R. DeVore, 'The Arms Collaboration Dilemma: Between Principal-Agent Dynamics and Collective Action Problems', *Security Studies*, 20:4(2011), pp. 625-626.

national tank industries reluctant to compromise their own established designs and export markets in favour of an international collaboration.

This factor of national self-interest on the part of existing industry is reinforced by Moravcsik, who suggests that the most widely encountered explanation for the failure of collaborative weapons projects is national interest, quoting Kenneth Waltz in stating that 'States do not willingly place themselves in situations of increased dependence'. He notes that those running national governments rarely have the power to interfere significantly in economic decisions made by private firms and it is domestic private industry that often determines the success or failure of co-operative arms development.[12]

Any collaborative project must overcome organisational hurdles, and when such collaboration is on an international level those hurdles are multiplied. DeVore notes, for example, that 'many empirical examinations of collaborative programs reveal gross inefficiencies', but adds that identifying the causes of these inefficiencies is more problematic.[13] Morris, et al., note that any collaboration faces the problem of communication and interpretation, even if all stakeholders share a common language, stating that 'As project stakeholders (including the firm's local units) in different institutional settings interpret the projects' goals and business objectives differently, the communication in such organisational structures is challenging.' [14] These management problems can be seen in all of the MBT case studies but are most noticeable in the MBT-70 and FMBT projects. In these two studies, a lack of communication and duplication of effort made any final agreement on a single compromised design highly unlikely, with both MBT-70 and FMBT leading to parallel design efforts that would have given little interoperability advantage, let alone

[12] Andrew Moravcsik, 'Armaments among Allies: European Weapons Collaboration, 1975-1985', in Peter Evans, Harold Jacobson and Robert Putnam (eds.), *International Bargaining and Domestic Politics: Double-Edged Diplomacy* (London, 1993), pp. 129-130, 155-156,160.
[13] DeVore, 'International Armaments Collaboration and the Limits of Reform', p. 416.
[14] Morris, Pinto and Söderlund (eds.), *The Oxford Handbook of Project Management*, p.144.

standardisation, had the tanks entered production. Indeed, the two FMBT design paths bore so little resemblance to each other that the casual observer would have been unlikely to guess their 'common' origins.

The study by Frinsdorf, et al., notes that defence projects tend to comprise large value multi-disciplinary contracts with many sub-contracted component projects, and thus their very complexity makes any judgment of effectiveness or efficiency problematic.[15] Stephen B. Johnson also investigates the subject of complexity and notes that novel and complex technology development historically leads to cost and time overruns. He points out that a technology that is complex but established has already become familiar enough to the design teams that the complexity is less of a hurdle, and a technology that is novel but simple is easily understood and developed.

The combination, however, of complexity and novelty means that it is not easy to understand and there are few, if any, historical precedents to enable developers to follow a recognisedmodel.[16] Philip Scranton puts this in perspective regarding defence projects during the Cold War, citing the continuous redesign and uncertainty attached to new technology which led to both cost and schedule targets frequently being overrun as a matter of course. As any innovative design alters according to both technological necessity and customer revisions of requirement, it leads to dislocating changes in production and consequent changes to the requirements of all the affected components. Scranton quotes the apocryphal defence engineer defending a project's delays by telling a complaining air force general that, 'If you want it bad, you'll get it bad.'[17] While most of the MBT case studies do not obviously show overly complex technology to be a major influence in the failure of projects, it was a

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[15] Frinsdorf, Zuo and Xia, 'Critical Factors for Project Efficiency in a Defence Environment', p. 803.
[16] Stephen B. Johnson, 'Technical and Institutional Factors in the Emergence of Project Management', *International Journal of Project Management*, 31 (2013), p. 678.
[17] Philip Scranton, 'The Challenge of Technological Uncertainty', *Technology and Culture*, 50:2 (April 2009), p. 516.

significant factor in the case of the MBT-70. Over-ambitious technology brought uncertainty, time delays and additional expense to the programme, which undoubtedly contributed significantly to the eventual disillusionment of the national governments.

Mazur, et al., suggest that the improvement of a project's chances of success can be directly concomitant to the relationship between the project stakeholders, noting there is an improvement in a project's outcome if the stakeholders are both committed to the project goal and mission, and are thus involved in the decision-making at all stages.[18] Dirk Klimkeit also points to a collaborative project's success being dependent on 'drivers for collaboration', and elaborates by citing interdependency and an interest in the project being successful as among such drivers. Klimkeit argues that sufficiently robust informal drivers for the success of a collaborative project may even overcome the absence of established institutional and formal mechanisms.[19] In many ways, it was these 'commitment drivers', in the form of national political will, that finally contributed to the end of the MBT projects explored in the case studies. Although political drivers are essential to any international defence project, Western democracies provide relatively unstable political bedrock for long-term projects because they are subject to changes both of personnel and political parties. Every one of the case studies saw their political support shrivel and die as their initial champions were replaced, suggesting that such support must have a broader political support than simply the party leader or defence minister in post at the time.

Meyer pointed out in 1988 that, despite NATO managing to collaborate successfully on other weapons projects, the successful collaborative main battle tank project had so far eluded them. He suggested three reasons for this failure in relation to projects in and before the 1970s: differing military priorities in regards to the balance between firepower, mobility

[18] Alicia Mazur, et al., 'Rating Defence Major Project Success: The Role of Personal Attributes and Stakeholder Relationships', *International Journal of Project Management*, 32 (2014), p. 953.
[19] Dirk Klimkeit, 'Organizational Context and Collaboration on International Projects: The Case of a Professional Service Film', *International Journal of Project Management*, 31 (2013), p. 376.

and protection; a lack of political will; and, concerns about national prestige surrounding the abandonment of sovereign tank designs.[20] Keith Hartley defines the process of defence collaboration as the establishment of an exclusive club of member governments who create a 'protected market for one or more items of defence equipment', but who remain part of that club only as long as they believe it to be worthwhile. His conclusion as to the failure of joint tank projects is that they are due to 'a political preference for national domestic interests ... distinctively different tank philosophies ... industrial and technology considerations, and because of domestic electoral factors.'[21]

This study's conclusions broadly do at one level support those found within published works on the subject of international defence collaboration. Political drivers were the major factor in the failure of the case study projects, with support for collaboration dwindling as costs rose and political figures moved from office. All the projects examined, with the exception of the 1957 Standard Panzer, saw the domestic national tank industries reluctant to compromise their own potential exports by sharing with those of another country, this phenomenon being particularly significant in the case of the battle for the FMBT's main armament. Each project also struggled to overcome the basic fact that the military of the nations involved wanted different qualities in their new tanks, usually manifesting as differences of opinion over weight and manoeuvrability versus armour protection but being most obvious in the debate over ATGM or gun for the MBT-70's armament. Confused project management and a lack of agreement over a single specification were compounded by the political prevarication and national differences in tank philosophies, which amplified the usual project cost and time overruns. As the projects threatened to cost more and miss their deadlines, political support was withdrawn and each project was cancelled.

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[20] Timm R. Meyer, 'Collaboration in Arms Production: A German View', in Karl Kaiser and John Roper (eds.), *British-German Defence Co-operation: Partners within the Alliance* (London, 1988), p. 252.

[21] Keith Hartley, 'Collaboration in Arms Production: A British View', in Kaiser and Roper (eds.), *British-German Defence Co-operation*, pp. 265, 282.

However, few of the published works deal with the requirements of the armed forces, focussing instead on the economic and logistical advantages of collaboration and standardisation. The military is the organisation which dedicates itself to studying and analysing how MBTs are used in practice, and thus we can assume that they are the organisation best placed to decide what they need any new MBT to do. As the end-user, the military ought to be the best judge of what they require from a new MBT and, while a compromised new tank design is certainly better than no new tank at all, the whole point of developing and supplying any national army with modern MBTs is to increase their effectiveness. Supplying MBTs that do not suit an army's doctrine is clearly going to compromise this effectiveness.

The main battle tank is fundamentally different to the aircraft and missiles that have formed the basis of previous, successful, international collaborations. Most military thinkers agree on the role of a particular missile or aircraft, albeit the Eurofighter Typhoon saw some disagreement over whether the aircraft was to be a pure fighter or a multi-role fighter-bomber.[22] The most effective way to employs tanks, though, has been the subject of debate since the tank's early days, suggesting that there is no single 'best' tank philosophy, or at least not one that has been identified to date. With NATO nations previously divided over their tank philosophy, a split that appears to be narrowing with modern NATO-nation MBT models now being more similar,[23] it might be unsurprising that any previous collaborative design would need to overcome significant hurdles in persuading the involved parties to compromise their own ideas of where the balance between firepower, mobility and protection

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22 The Eurofighter Typhoon project is covered in Chapter 5, above.

23 Exact data for modern MBTs is, of course, classified, but the US M1A3 Abrams upgrade (still under development at the time of writing), Germany's Leopard 2A6 and the UK's Challenger 2 are all very similar in design and shape, use diesel engines and 120mm main guns. Although Challenger 2 uses a rifled-bore gun, the possibility of moving to smoothbore was suggested as part of the LEP upgrade package although this was subsequently dropped for financial reasons. Global Security, 'M1A3 Future Tank', <https://www.globalsecurity.org/military/systems/ground/m1a3.htm>, accessed 5 April 2019; Defense News, UK Surges Ahead with Challenger 2 Upgrade, <https://www.defensenews.com/land/2016/01/16/uk-surges-ahead-with-challenger-2-upgrade/>, accessed 7 February 2017.

should lie. Only by solving this fundamental issue of a new MBT's basic specification will any collaboration hope to overcome all the other hurdles associated with complex multi-national defence collaborative projects.

The Future for MBT Collaboration

How future programmes might succeed is, after all, at least part of the reason for studying past examples. It is unlikely that Western politicians or political systems will change to the point that they are no longer attracted to potential savings in the cost of development or in securing diplomatic advantages through initiating collaborative projects. With the end of Tank 90 in 1982, the international situation has advanced considerably in many key areas that may affect the chances of success in the case of a new MBT collaborative project. Advances in communications technology, a rise in 'globalism'[24] and the formation of multi-national defence conglomerates appear to have increased the chances of success for any new international collaboration within NATO (or at least within the nations that comprise the Alliance), while new military threats (or possibly the rebirth of old ones), and increased pressure on national defence budgets, coupled with a reduction in national tank-building capacity within many European NATO member nations, now increase the attraction of the potential benefits of collaboration over sovereign tank design.

Recent conflicts in the Middle East, the Ukraine and other current global tensions suggest that the potential for peer conflict redolent of the Cold War did not vanish with the fall of the Soviet Union, and that MBTs are by no means obsolete in the modern world. Meanwhile, Europe is seeking greater integration of its members states, with the European

[24] At the time of writing the UK is planning to leave the EU, which might be seen as something of a reversal of the wider move towards globalisation. However, whilst the UK may have chosen to withdraw from close political union with the EU, this is, at best, a minor diversion from the more general move towards closer international collaborations on large and complex commercial projects.

Union (EU) established as a continental legislative power. While not all European nations agree with this quest for greater integration, it is impossible to ignore the military, strategic and industrial implications of a move towards European unity. In particular, there have been calls for a 'European Army' with greater integration of command and equipment.[25] Such increased integration, especially in light of signs of diplomatic fracture between NATO members and most significantly between the USA and other NATO countries,[26] increases the possibility of the European NATO nations agreeing on a single, European, MBT design: this raises the chances of success for a future European MBT collaboration, which would almost certainly involve Germany.

As mentioned above, it is in the field of communications that there have arguably been the greatest advances since the most recent failed joint MBT projects. The use of English as an international language of business has become more widespread.[27] The internet and digital communication networks have made it far easier to form and run international collaborations. International data-sharing is now possible almost as fast as voice communication, with translations easy to access even if language barriers still exist. The only barrier to such communication is imposed by companies or governments themselves, and not the available technology. Internationalism, aided by easier communication, has made possible the formation of large international consortia such as BAE Systems, KNDS, MBDA and Airbus. It is perhaps these commercial organisations rather than governments which hold the key to future international MBT development although, as the Eurofighter and Airbus 380/400M projects demonstrate, international consortia are not immune to the delays and cost

[25] Modern Diplomacy, 'Defence: Is the EU Creating a European Army?', <https://moderndiplomacy.eu/2019/06/24/defence-is-the-eu-creating-a-european-army/>, accessed 24 June 2019.
[26] New York Times, 'Trump Discussed Pulling US from NATO, Aides Say amid New Concerns over Russia', <https://www.nytimes.com/2019/01/14/us/politics/nato-president-trump.html>, accessed 23 June 2019. See also, for example, BBC, 'Turkey defies US as Russian S-400 missile defence arrives', 12 July 2019, <https://www.bbc.co.uk/news/world-europe-48962885>, accessed 12 July 2019.
[27] Sandra Lee McKay, 'English As An International Language: What Is It and What It Means for Pedagogy', *RELC Journal*, 49:1 (2018), pp. 9-23.

overruns that plague almost every joint project.[28] Interested parties should take such overruns as unfortunate but almost inevitable aspects of complex projects, and make decisions as to how much overrun can be tolerated before cancelling a project, absorbing all costs up to that point.[29]

The Future of the Main Battle Tank

It is a fact that not every defence commentator or government official views main battle tanks as either a priority or, indeed, a necessity for modern warfare. Indeed, in conversation with a senior member of staff from Britain's Atomic Weapons Establishment (AWE), the author was asked whether tanks were still necessary in the age of nuclear weapons, 'drones' and precision-guided air-launched munitions.[30] Most military thinkers, however, agree that tanks, perhaps in a slightly different form,[31] are still the best weapon system to perform the role of land-based highly mobile tactical shock engagement; no other single vehicle can yet do all that a main battle tank can do, and so far no alternative has been developed that is cheaper yet is as effective in the primary battlefield role of bringing armoured and mobile firepower directly to the point of decision. Until and unless such a replacement can be found or

[28] Mawdsley, for example, makes this point in relation to the A400M project. Jocelyn Mawdsley, 'The A400M Project: From Flagship Project to Warning for European Defence Cooperation', *Defence Studies*, 13:1 (2013), p. 29. The Eurofighter, A380 and A400M projects are discussed in Ch. 5, above.

[29] When MBT-70 was cancelled, for example, it is estimated that the project had cost $213 million, money that ultimately saw no tangible benefit for either nation. TMARL, E2014.3220, copy of article, Jacques Baud, 'MBT-70/Kpz-70: Revolutionary but Luckless', *Armies and Weapons*, year not identifiable but possibly 1975, p. 39.

[30] This conversation took place in 2018 at the Shrivenham Defence and Security Doctoral Symposium. It should be noted that questioner was not, in fact, in a directly defence-related role.

[31] Possible future developments for a revolutionary MBT design are presented by Rahman et. al., suggesting that the future MBT may need to address improved 'survivability, cruising range, ISTAR, tactical mobility, trafficability and ease of adaptability.' See here A. Hafeezur Rahman, Ameer Malik Shaik, J. Rajesh Kumar,V. Balaguru and P. Sivakumar, 'Design Configuration of a Generation Next Main Battle Tank for Future Combat', *Defence Science Journal*, 67:4 (July 2017), pp. 343-353.

developed, the MBT will continue to be a vital part of NATO armies for the foreseeable future.[32]

The tank as an armoured vehicle to bring firepower to the point of contact is unlikely to change soon. However, the form that such an AFV may take in the future is the subject of much debate and radical thinking. The idea of a turretless tank allows for a cheaper vehicle that may be easier and faster to build, whilst also allowing for the mounting of a larger main gun than a rotating turret would accommodate. This concept was thoroughly tested by Germany during the Second World War with their range of both tank destroyers and assault guns. The turretless tank destroyer concept lasted beyond 1945 and saw its final practical application in the Swedish ***Stridsvagn 103***'S Tank', designed in 1950s, and the West German *Kanonenjagdpanzer* JPK-90, first produced in 1965.[33] The Anglo-German FMBT project of 1971 also toyed with the idea of mounting the gun directly in the hull or on a pedestal, but eventually discarded the turretless idea as not being fit for the modern battlefield tank.[34]

Another popular suggestion is using wheels instead of tracks, creating the 'wheeled tank' alternative.[35] Tracked vehicles are expensive and difficult to maintain, and are usually

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[32] Debates and arguments surrounding the future of the main battle tank may be found in, for example: Sir Richard Swinburn, 'Future Armoured Warfare: The Case for the Tank', *The RUSI Journal*, 137:3 (1992), pp. 35-37; Clinton J. Ancker III, 'Whither Armor', *The Journal of Military Operations*, 1:2 (Autumn 2012), pp. 4-8; Richard P. Geier, 'A View of a Future Tank' (letters page), *Armor,* 44:2 (Mar-Apr 1985), pp. 44-45; Jane's 360, 'Heavy armour heritage: The evolution of the MBT and the search for its successor', <https://www.janes.com/images/assets/280/82280/Heavy_armour_heritage_The_evolution_of_the_MBT_and_the_search_for_its_successor.pdf>, accessed 26 May 2019.

[33] Hilmes, *Main Battle Tanks: Developments in Design Since 1945*), pp. 79 81; Christopher F.Foss, *Jane's Main Battle Tanks (Second Edition)* (London, 1986), pp. 70-73; Wolfgang Schneider (ed.), *Tanks of the World, 7th Edition* (Koblenz, 1990), pp. 214-218.

[34] Richard M. Ogorkiewicz, 'Tank Test Beds', *Armor*, 43:2 (Mar-Apr 1984), pp. 16-19; TMARL, E2005.1079.4 Technical Assessment of All UK and FRG Concepts from '72 to '76 Inclusive, 6th Steering Group Meeting, 14 November 1975, p. 2:55; William Suttie, *The Tank Factory: British Military Vehicle Development and the Chobham Establishment* (Stroud, 2015), pp. 152-155; Robin Fletcher, 'Trunnions on the Move: Advantages and Disadvantages of the Tank Turret', *Armor*, 45:1 (Jan-Feb 1986), pp. 33-43.

[35] Wheels have, of course, been used for armoured cars almost since the birth of the motor vehicle. Where a heavy armoured car becomes a 'wheeled tank' is subjective but most easily lies with the use for which it is intended. If an AFV is designed, built and employed in the role of main battle tank then it might be viewed as a 'wheeled tank'. Examples of wheeled AFVs that carry medium calibre main guns (in the 90mm to 120mm range) include the Cadillac Gage LAV-300, Consortium IVECO-OTOBREDA Centauro B1 Tank Destroyer, and the Reumech OMC Rooikat Armoured Car. It should be noted that no current wheeled AFV has the same

slower and more expensive to run than an equivalent-weight wheeled AFV. As Ogorkiewicz points out, however, although wheeled AFVs offer increased mobility on roads and flat firm terrain, once off-road the tactical mobility of wheeled vehicles is inferior to that of tracks. Advanced wheel and suspension arrangements allow improved off-road mobility but the vehicle weight must be kept lower than that of a tracked AFV, compromising protection and possibly firepower.[36] While mounting a direct-fire gun of 90-120mm on a wheeled armoured vehicle offers many of the benefits of a tank at a fraction of the cost and offering more operational mobility than a tracked vehicle, such AFVs are generally described as fire-support vehicles or tank destroyers and there is an acknowledgement that their lesser protection means that, limited and counter-insurgency conflicts aside, such 'wheeled tanks' cannot operate on the front line of a modern war in the same way as an MBT can.

Unmanned fighting vehicles can save on crew spaces and remove most of the danger to the operator, an important consideration in modern defence thinking where the public's acceptance of casualties is apparently much lower than it once was. Unmanned Ground Vehicles (UGVs) are in use or in current trials for investigating and tackling explosive devices such as IEDs, bringing logistical supplies to the front lines, in infantry support roles such as mounting and carrying heavy weapons, demolitions engineering, and in urban reconnaissance and combat.[37] It is, of course, important to note that 'unmanned' is not the same as 'autonomous' and the vast majority of UGVs have a human controller. It is this controller that limits the effectiveness of UGVs in an MBT-like battlefield combat role; the

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firepower or protection levels as modern MBTs. See here; Christopher F. Foss,*Jane's Tank Recognition Guide,* (Glasgow, 1996), pp. 372-373, 384-385; pp. 398-399.

[36]Ogorkiewicz, Tanks: 100 Years of Evolution, p. 282.

[37] Jane's 360, 'Follow the Leader: US Army Unmanned Ground Vehicle Programmes', <https://www.janes.com/images/assets/925/87925/Follow_the_leader_US_Army_unmanned_ground_vehicle_programmes.pdf> accessed 26 May 2019; UK Defence Journal, 'Robot Wars Becomes Reality as MBDA and Milrem Robotics to Develop Anti-Tank Unmanned Ground Vehicle', <https://ukdefencejournal.org.uk/robot-wars-becomes-reality-as-mbda-and-milrem-robotics-to-develop-anti-tank-unmanned-ground-vehicle/>, accessed 10 August 2018; UK Defence Journal, 'UK to Explore Unmanned Logistics Vehicle Use', <https://ukdefencejournal.org.uk/uk-explore-unmanned-logistics-vehicle-use/>, accessed 15 April 2018.

effective range of control in anything but open areas is limited by line of sight or the length and vulnerability of a control wire. Remote wireless control works well for UAVs (Unmanned Aerial Vehicles) because the sky does not block signals as do trees, buildings and terrain fluctuations. For a ground battlefield, the controller would have to remain close enough to the vehicle that any advantages of removing the crew from a frontline AFV would be largely negated and might possibly require a second armoured vehicle for the remote crewmen if he is to remain in an area close to the combat zone. In addition, there are potential tactical problems from failed or delayed signals, slowing firing or reaction in the often split-second decision-making of the battlefield of modern ground-based close combat. Indeed, Russia encountered just these problems when it combat-tested its Ural-9 unmanned ground combat vehicle (UGC) in Syria, where, as well as delays and failure of the 30mm autocannon armament, and problems with the suspension and optical sensors:

> in carrying out of combat missions, the average range of sustainable management from the advanced control point was 300-500 m in the conditions of the settlement with low-rise buildings, […] while also were recorded 17 cases of short-term (up to 1 min) and 2 cases of long (up to 1.5 hours) loss of Uran-9 control.[38]

Richard Greier predicted in 1985 that the future of tank armament would be a highly computerised (although still human-crewed) future tank armed with an electro-magnetic (EM) gun, firing hyper-velocity rounds, backed up by two lasers for engaging personnel and softer targets.[39] Ogorkiewicz suggests that the main drawback with EM guns is the large power pack required, although he acknowledges that it is possible that future EM gun

[38] Defence Blog, ‘Combat Tests in Syria Brought to Light Deficiencies of Russian Mini-Tank’, <https://defence-blog.com/army/combat-tests-syria-brought-light-deficiencies-russian-unmanned-mini-tank.html>, accessed 10 December 2018; Popular Mechanics, ‘Russia’s Tank Drone Performed Poorly in Syria’, <https://www.popularmechanics.com/military/weapons/a21602657/russias-tank-drone-performed-poorly-in-syria/>, accessed 16 May 2019.

[39] Richard Greier, ‘A View of a Future Tank’ (letters page), *Armor,* 44:2 (Mar-Apr, 1985), pp. 44-45.

systems may reduce the size of power pack required or use a more compact energy source.[40] He concludes that current EM technology means that they are not as efficient as a conventional 140mm high velocity gun, as well as being unproven technology.[41] However, Ogorkiewicz does accept that conventional guns have reached a design plateau where technology has made them as effective as they are going to be without increasing calibre once more, but that increasing calibre will force designers into equipping tanks with autoloaders as larger rounds will be too heavy for a human to load efficiently.[42]

While these new technological possibilities continue to offer opportunities to significantly adjust the standard configuration of the main battle tank, experience cautions that the trade-offs required may well reduce the positive advantages offered by the traditional MBT.

*   *   *

Tanks remain a vitally important part of the armies of most countries of the world, and all the indications are that they will remain to be vital for conducting warfare on the modern battlefield. The cost of tanks is escalating as new technology is developed to make them safer, faster and more potent fighting vehicles, potentially making developing new tanks too expensive for nations with restricted defence budgets. It is easy to create the 'ultimate tank' by investing in all the latest technology, but the cost of producing and maintaining enough models to equip an army, and to allow for losses through mechanical failure or combat, makes it necessary to compromise what could be built for what can be afforded. Collaboration between tank-building nations offers one solution, albeit one beset by the

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[40] Ogorkiewicz, *Technology of Tanks*, pp. 92-94.
[41] Ogorkiewicz, *Tanks; 100 Years of Evolution*, pp. 263-265.
[42] Ibid., pp. 259-260.

problems detailed in this study. Decisions must be made as to whether a government wants to gamble national security and the lives of its military personnel by clinging to outdated technology, invest a significant amount of resources into developing a new sovereign design, or potentially compromising what its military want from a new tank in order to save money and further both political alliances and military standardisation. Hard decisions, indeed.

APPENDICES

APPENDIX 1: Tank Ammunition

1.1 APDS round showing the core penetrator within its sabot.

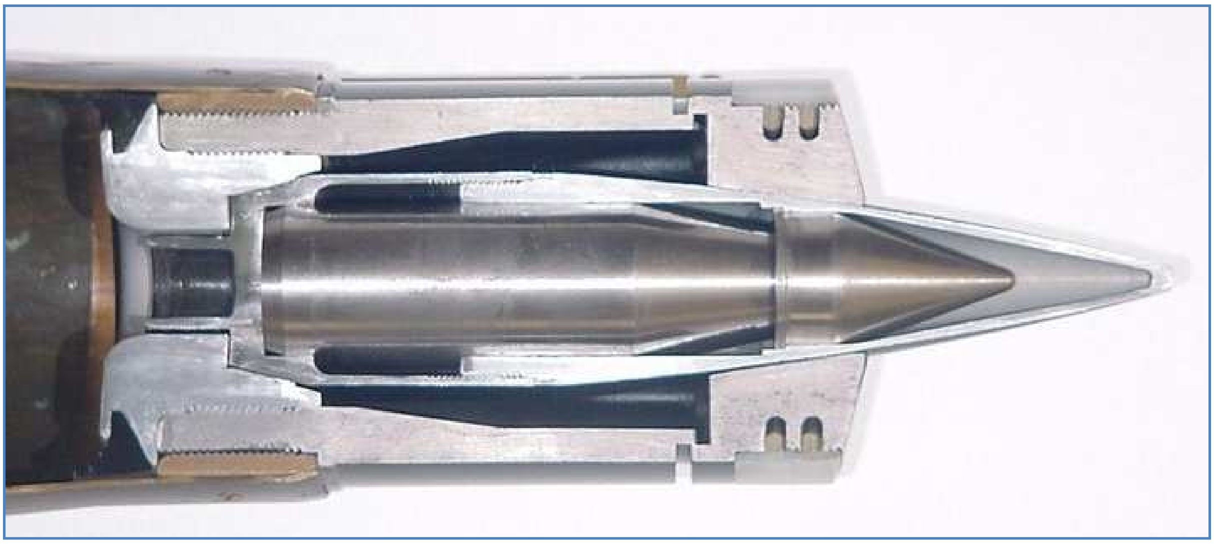


Image reproduced from Norfolk Tank Museum website: <http://norfolktankmuseum.co.uk/types-of-ammunition/>, accessed 03 April 2017.

1.2 APFSDS round showing the sabot being discarded after firing.

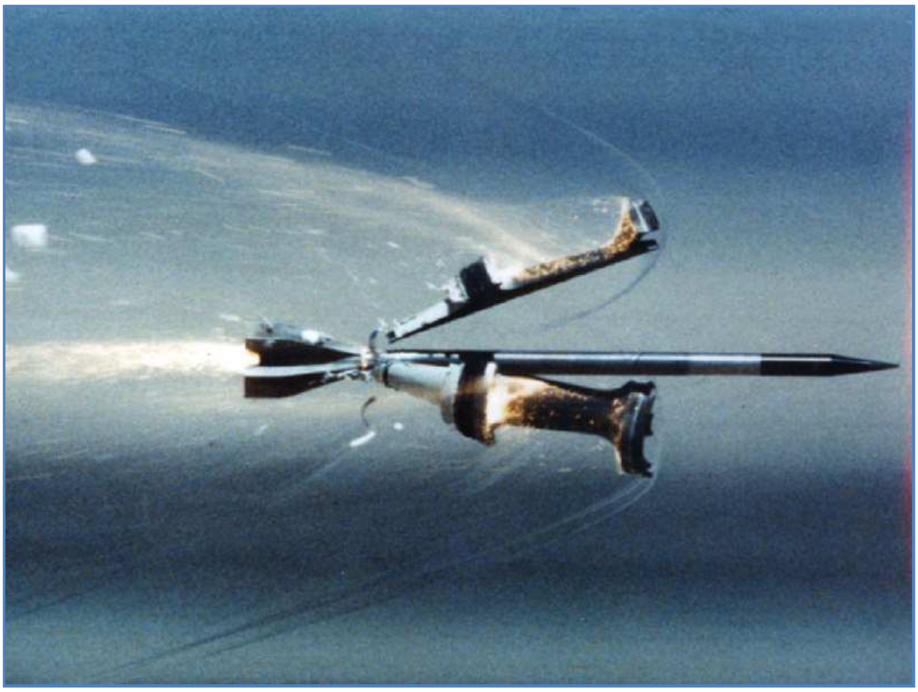


Image reproduced from Deagel website: <http://www.deagel.com/library/M829-APFSDS-T_m02006120700244.aspx>, accessed 03 April 2017.

Graphical illustration of effects from HEAT, HESH and APDSFS. Note that the secondary spalling effect is not shown (see below).

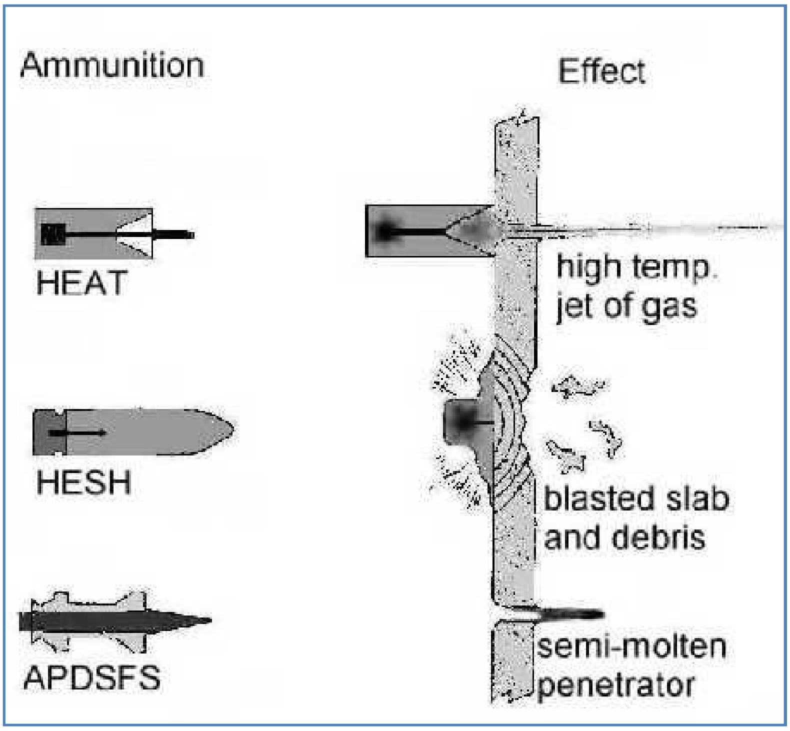


Image reproduced from Military Engineering Overviews Tumblr website: <https://militaryengineeringoverviews.tumblr.com>, accessed 03 April 2017.

1.3 Spalling and molten jet caused by HEAT round striking from left to right.

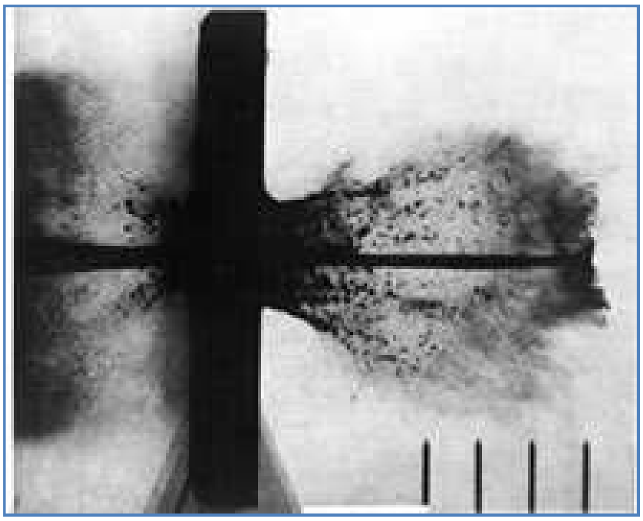


Image reproduced from Defence Update website: <http://defense-update.com/features/du-2-05/IED-1.htm>, accessed 03 April 2017.

APPENDIX 2: ARMOUR

2.1 Effect of sloping of armour

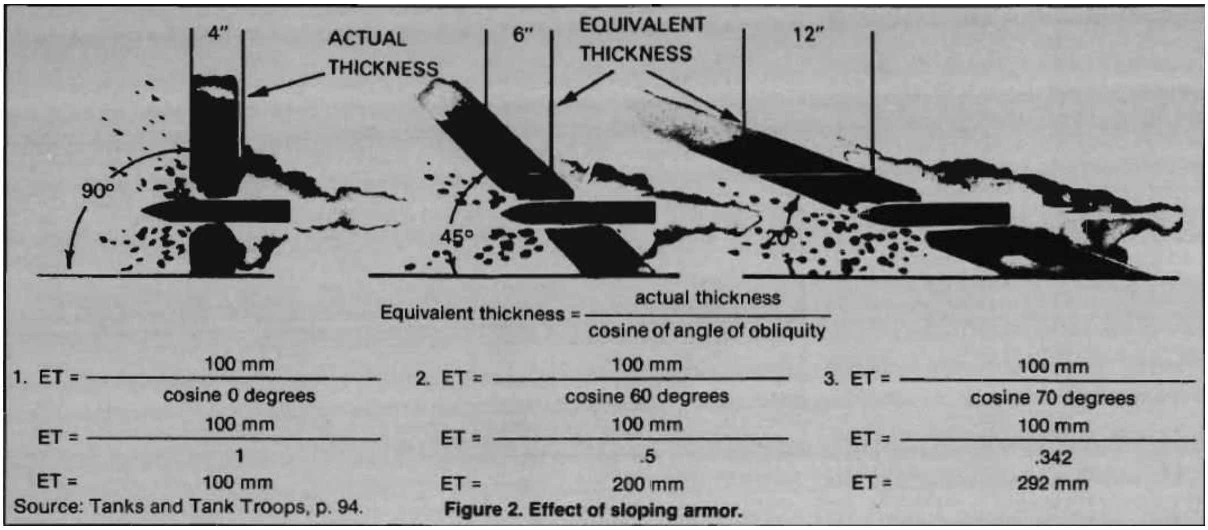


Image reproduced from Gerald A. Halbert, 'Elements of Tank Design', *Armor*, 42:6 (Nov-Dec 1983), p. 38.

2.2 The effect of explosive reactive armour (ERA) on shaped charge jet

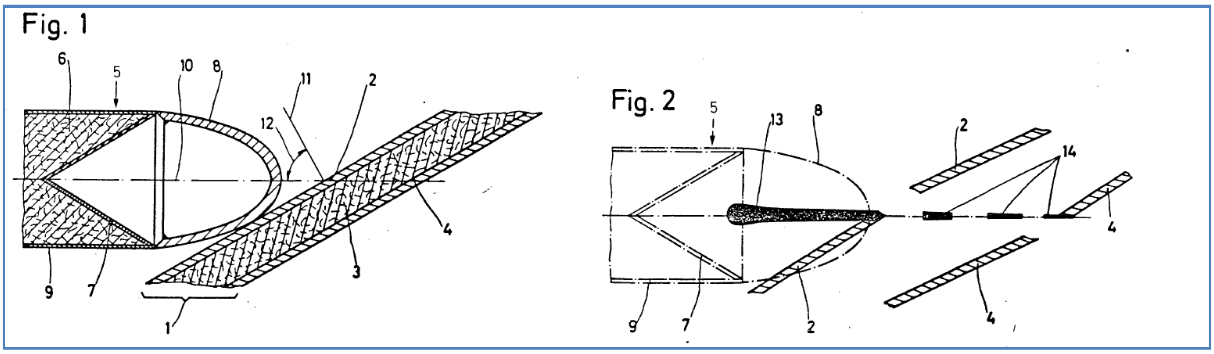


Image reproduced from Google Patents, 'Protective arrangement against projectiles, particularly hollow explosive charge projectiles: US 4368660 A': <http://www.google.com/patents/US4368660>, accessed 27 September 2017.

2.3 Effect of spall liner on spalling

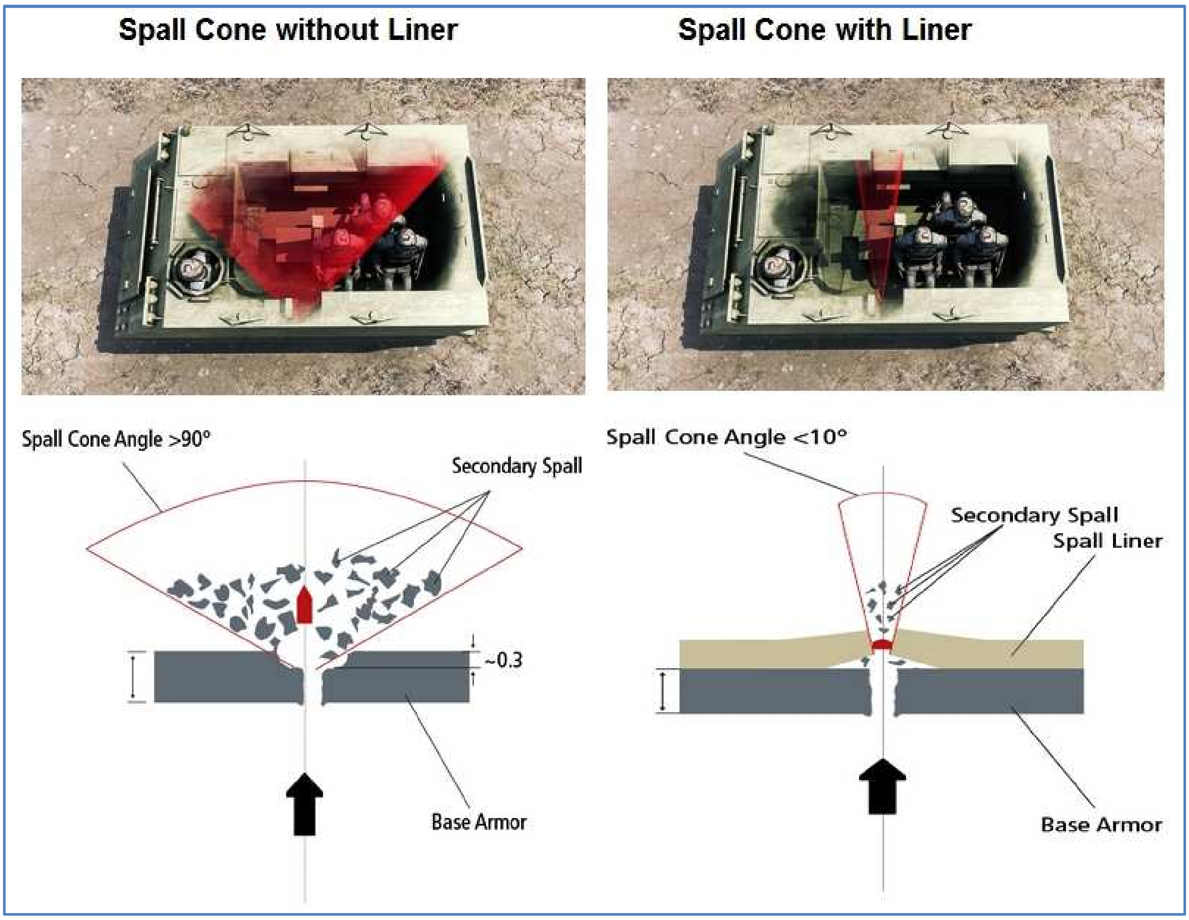


Image reproduced from Think Defence website, 'Vehicle Protection',<http://www.thinkdefence.co.uk/2012/02/vehicle-protection/>, accessed 22 September 2017.

APPENDIX 3: MBT-70 PROJECT HIERARCHY

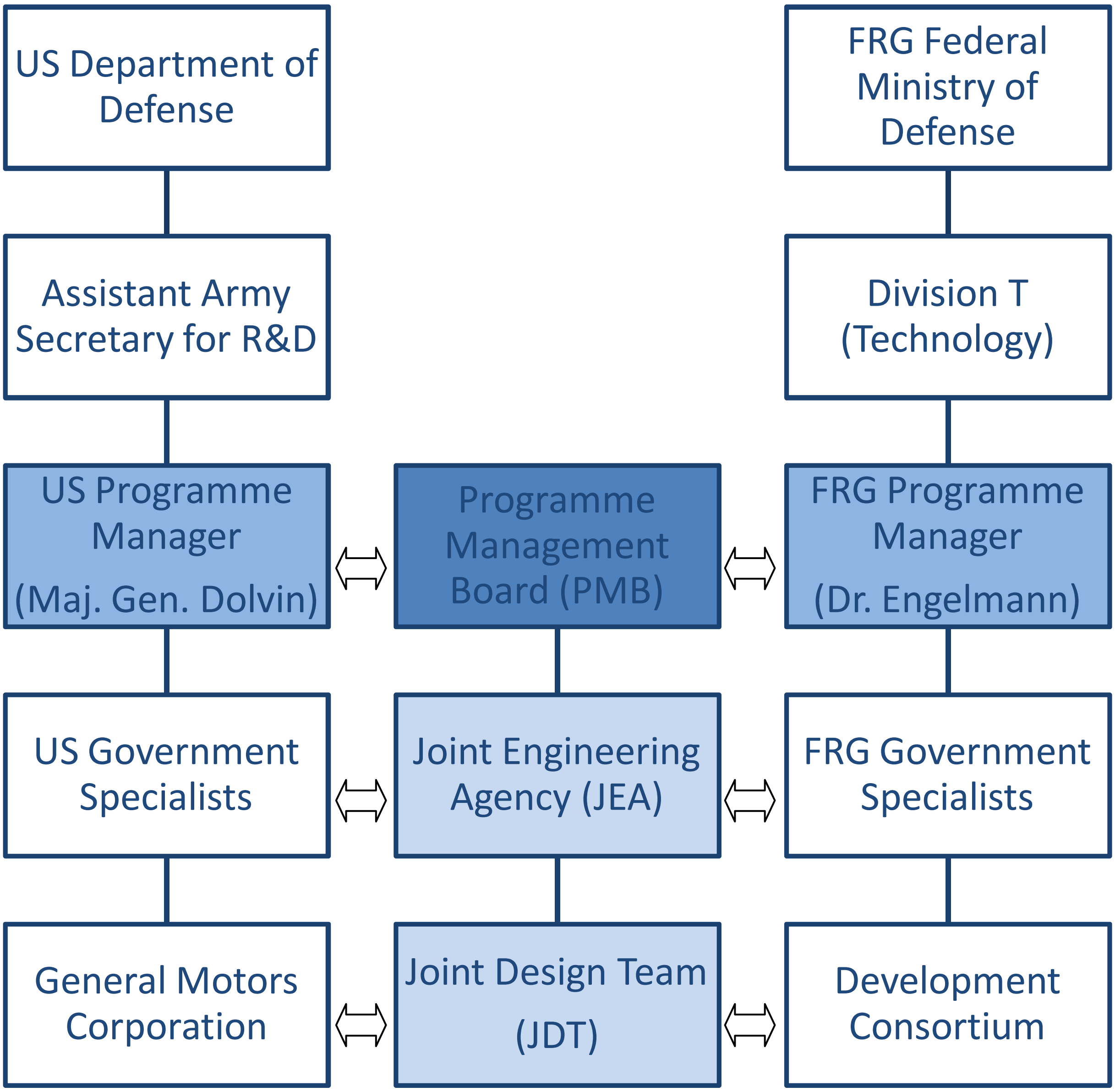
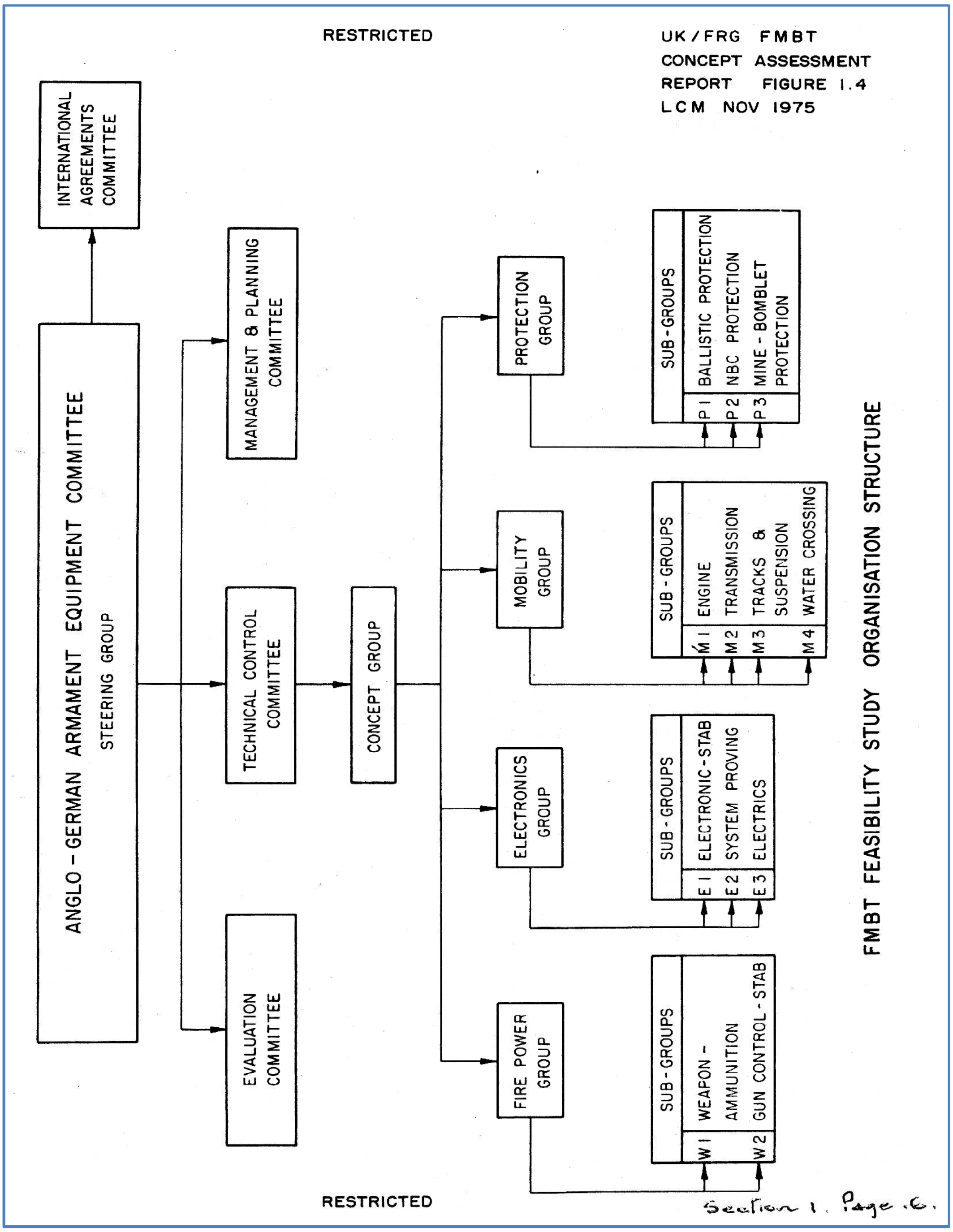


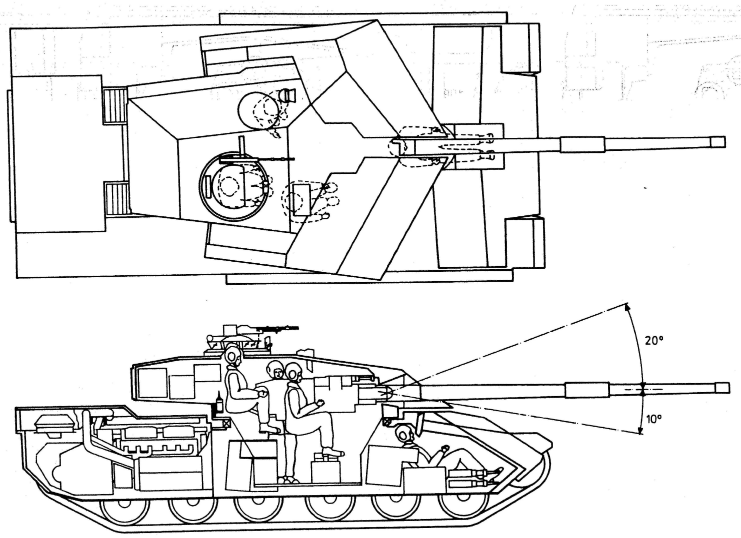
Table extrapolated from BOV, E2014.3247, *Armed Forces Management* Journal. 'How is the West German-American Main Battle Tank Development Program Coming Along,' January 1965, pp. 42-45, and;Thomas L. McNaugher, 'Collaborative Development of Main Battle Tanks: Lessons from the U.S.-German Experience, 1963-1978', *Rand Note* (Rand Corporation, August 1981), Figure 1, p. 9.

APPENDIX 4: FMBT Anglo-German Steering Committee

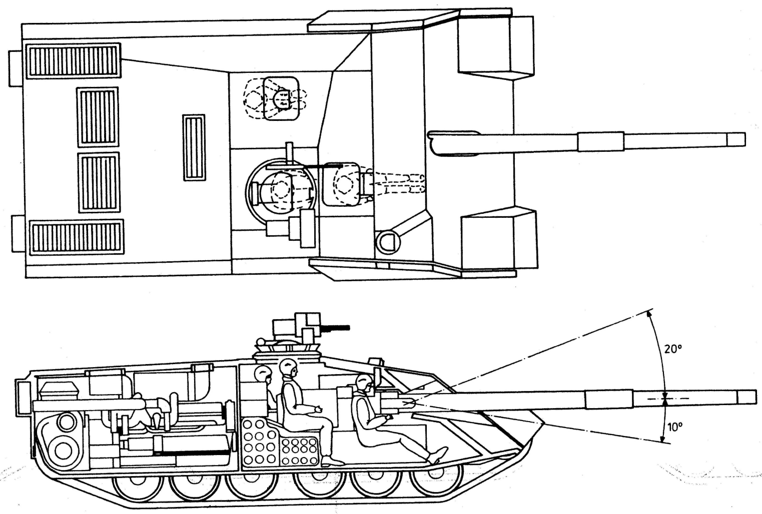


Reproduced from BOV, E2005.1079.4, Technical Assessment of All UK and FRG Concepts from ’72 to ’76 Inclusive.

APPENDIX 5: FMBT Design Concepts For 1975 Assessment



DRIVER IN HULL UNLIMITED TRAVERSE TURRET



SEMI-FIXED GUN

SECRET UK/FRG EYES ONLY

Reproduced from BOV, E2005.1079.4 Technical Assessment of all UK And FRG Concepts from ’72 To ’76 Inclusive.

APPENDIX 6: Major MBTs used by UK, USA, FRG and France, 1950-2000

Note that these tables only represent main battle tanks used in the gun tank role; that is, excluding tanks retained as the basis for self-propelled artillery, engineering, training or other ancillary roles. The date range chosen ends in 2000. In most cases (exceptions being the FRG Leopard 1 and UK Challenger 1), the MBTs in service as gun tanks in 2000 remain in front-line service at the time of writing. When referring to MBTs, this category includes tanks designated 'medium' in the early part of the period covered, and excludes heavy tanks such as the British Conqueror and US M-103.

Data compiled from various sources listed in the bibliography. Note that different sources are often vague, unclear or contradictory on years of service, listing dates which include, for example, dates expressed as 'late 1950s', or service by non-MBT AFVs built on MBT chassis (such as armoured recovery vehicles or self-propelled artillery) or use as training vehicles or range targets.

To save space and retain clarity, no attempt has been made to divide basic MBT models by versions. The British Centurion, for example, ran from the Centurion I through to the final Centurion XIII within this time period, and the latest Leopard 2 is the Leopard 2A7+.

France

Model	of Origin	Dates	1946	1948	1950	1952	1954	1956	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000
M-4 Sherman	*USA*	1943-1954																												
ARL-44	*France*	1950-1953																												
M-47 Patton	*USA*	1954-1970																												
AMX-30	*France*	1966-																												
Leclerc	*France*	1993-																												

FRG

Model	of Origin	Dates	1946	1948	1950	1952	1954	1956	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000
M-47 Patton	*USA*	1955-1967																												
M-48 Patton	*USA*	1957-1993																												
Leopard 1	*FRG*	1965-2003																												
Leopard 2	*FRG*	1979-																												

UK

Model	of Origin	Dates	1946	1948	1950	1952	1954	1956	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000
Centurion	*UK*	1946-1972																												
Chieftain	*UK*	1956-1995																												
Challenger 1	*UK*	1983-2001																												

USA

Model	of Origin	Dates	1946	1948	1950	1952	1954	1956	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988	1990	1992	1994	1996	1998	2000
M-4 Sherman	*USA*	1942-1957																												
M-26 Pershing[1]	*USA*	1945-1953																												
M-46 Patton	*USA*	1949-1957																												
M-47 Patton[2]	*USA*	1952-1959																												
M-48 Patton	*USA*	1953-1990																												
M-60 Patton	*USA*	1960-1997																												
M-1 Abrams	*USA*	1993-																												

[1] Although originally designed as and designated a heavy tank, the M-26 was re-designated as a medium in May 1946.

[2] Although widely known as the M-47 'Patton' or 'Patton II', the M-47 was never officially given that name, unlike the others of the M-4x series.

APPENDIX 7: Britain's Future Options for a New MBT in 1980

Future options considered in 1980 for a new MBT to replace Challenger and its likely immediate linear successor (Challenger 2). All information collated from, *TNA, FCO 46/2220, NATO: collaboration on tanks, tank guns and ammunition. DPN081/6. Note. Future Tank Policy, 28 October 1980.*

1. UK Development of Challenger 3.
   - \+ Cheapest option.
   - \+ All work would go to UK industry.
   - \+ Financial gains from parity with Challenger 2.
   - – No gain to NATO standardisation.
   - – Probable poor sales.
   - – Reduction of BAOR would result in higher unit cost due to reduced economy of scale.

2. Cooperative development with France and Germany
   - \+ Political boost.
   - \+ A trilateral tank would probably become the standard in much of NATO.
   - \+ UK would have a share in world sales. Especially valuable in Europe where the UK had lost many sales to the FRG.
   - \+ Possible future joint projects and more stable future for the Royal Ordnance Factories.
   - – Probably not a Franco-German tank, let alone a France/German/UK one.
   - – Germany looking at a linear development of Leopard 2.
   - – UK would struggle to get an acceptable share if it joins the project late.
   - – The unit cost would probably be 'substantially' higher than a national tank, aggravated by a need for a whole new logistics structure.

3. Cooperative development with France.
   - \+ It would be a partnership of equals.
   - \+ A design would be built from scratch and therefore has greater scope for UK components than a UK/FRG collaboration.
   - – French described as being 'not best partners'.

– The French and UK requirements were different.
– It was unlikely that agreements would be reached where the France/FRG deal failed.
– The result would be a brand new tank with a small market.
– It would be more expensive than a national tank.

4. Cooperative development with USA.

+ The vast US domestic requirement and industrial reserves would ensure a technologically advanced and cheap tank.
+ A potentially large world market.
– The difference in required numbers would make the UK very junior partners.
– The UK's small development contribution would mean the end of UK tank production.
– The US described as 'extremely unreliable partners', with examples such as the JP233, the 81mm mortar and attempts to negotiate licenced production of the Bradley IFV.
– US vested interests and Congress were too powerful to ensure that the US would stick to any deal.

5. Cooperative development with USA, French and FRG.

+ It would mean maximum standardisation within NATO.
– Unlikely to be attractive to the French or Germans who would see little prospect of getting good shares of high-tech research and development.
– France and Germany prioritised European defence industrial base.
– No attraction for the US who would continue to develop the XM-1.
– It would represent a small UK share.
– It would be more expensive than a national tank.

APPENDIX 8: NATO European Members Defence Organisations

Name	Year Founded	Remit	Members
Western European Union (WEU)	1948	Defence cooperation and mutual military aid. Promotion of economic and political integration and growth within Europe.	Belgium, France, Luxembourg, The Netherlands, United Kingdom. FRG and Italy joined 1954.
FINABEL	1953	Promote military cooperation.	France, Italy, The Netherlands, Belgium, Luxembourg, United Kingdom (1956), FRG (1973).
EUROGROUP	1969	Cooperation in weapons production and logistics.	Belgium, Denmark, FRG, Greece, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Turkey, United Kingdom.
Independent European Programme Group (IEPG)	1976	Promote defence standardisation and interoperability, maintain the European defence industry, unity in negotiation with USA.	Belgium, Denmark, France, FRG, Greece, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Turkey, United Kingdom.
Western European Armaments Groups (WEAG). A subsidiary of the WEU.	1993	Greater European arms cooperation with the aim of creating a European arms agency.	Belgium, France, FRG, Italy, Luxembourg, The Netherlands, United Kingdom. (All of the WEU members).

Information taken from: Robert Zweerts and Kelly Campbell, 'The Search for Integrated European Programme Management', in Jane Davis Drown; Clifford Drown; and Kelly Campbell (eds.), *A Single European Arms Industry: European Defence Industries in the 1990s* (London 1990), pp. 75-89; UIA Website, 'Independent European Programme Group (IEPG)' <https://uia.org/s/or/en/1100006524>, accessed 18 March 2019; and, TNA, DEFE 13/1167, Interoperability and standardisation of equipment in NATO. VCGS 100-1, Memo from VCGS to the Minister of State. International Interdependence Organisations. 13th February 1978.

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