Remote sensing, LIDAR, automated data capture processes & the VEPS project

Andrew Richman, Andy Hamilton, Yusuf Arayici, John Counsell, Besik Tkhelidze
The Environment Agency for England and Wales, University of Salford, Greater Manchester, University of the West of England, Bristol
{andrew.richman@environment-agency.gov.uk, a.hamilton@salford.ac.uk, y.arayici@salford.ac.uk, john.counsell@uwe.ac.uk, Besik2.Tkhelidze@uwe.ac.uk}

Abstract

This paper discusses recent project work that has been examining how to minimise the digital 3D modelling of urban and rural environments, where remotely sensed data is available. The increasing availability of highly accurate LIDAR data offers these opportunities, but currently is not captured so often nor is yet an extensive coverage that it can be relied on to keep VR analogues of real places up to date. This places increasing importance on developing an 'urban data fusion' of different types including: LIDAR; Digital Elevation Models derived from radar altimetry and similar data (SAR interferometry); real-time video photogrammetry; and thus on standards. 3D models of proposed changes then need to comply with these standards as they emerge.

There has been research into the 3D modelling of urban settings and landscapes for visual impact assessment since the early 1980's. This started by using commercial CAD systems, but has since used GIS in order to generate 3D VR models of urban areas and integrate them with information from various sources into an overall navigable interactive whole. There is found to be an increasing need for tools for integrating different forms of representation or media, and standards for: scalability (levels of detail); movement through space and change over time; for integrating and optimising imported models of proposed change, often emanating from architectural practice; two way links for interactive exchange between a selected view and the source data; and retention of multiple different interpretations or proposals for comparison.

Keywords- LIDAR; SAR; DEM; Visual Impact Assessment; Spatial Information; GIS; VR; World Wide Web.

1. Introduction

This paper discusses recent and forthcoming project work that has been examining how to minimise 3D modelling where remotely sensed data is available. The increasing availability of highly accurate light detection and ranging LIDAR data (the basis for the forthcoming VEPS project described later) offers other opportunities. However it is currently not captured sufficiently often, nor is yet a sufficiently extensive coverage, that it can yet be relied on to keep Virtual reality (VR) analogues of real places fully up to date. This places increasing importance on developing an 'urban data fusion' of different data and media types that can then interchangeably support a common 3D urban information space. Such data types include: Conventional mapping: Satellite and aerial imagery; LIght Detection And Ranging (LIDAR); Digital Elevation Models derived from radar altimetry and similar data (SAR interferometry); and Real-time video photogrammetry.

The very range and diversity and increasing detail and accuracy of such datasets, together with increasing frequency of capture, creates problems for managing and extracting requisite data on demand. Automated capture can swiftly create massive datasets and thus creates significant problems for data management, storage and retrieval. For Virtual Reality views there are additional challenges in culling and selecting appropriate data in real-time. As these datasets become broadly available and provide overlapping descriptions and views of the same places, there is an increasing urgency for the definition of common standards and metadata. 3D models of proposed changes then need to comply with these standards as they emerge. The main issue being that while exceptional efforts in resources can produce very good 3D urban models, this effort is difficult to sustain, and needs to become commonplace and substantially automated before it can be generally useful. The INSPIRE [1] draft directive defines a need for 'a coherent combination of spatial data sets or services that represents added value, without requiring specific efforts on the part of a human operator or a machine', and this needs to be both broadly available and commonplace, in order for 3D urban models to become the norm.

2. 3D Modelling Urban and Rural Settings

There has been research into the digital 3D modelling of urban settings and landscapes for visual impact assessment since the early 1980's. This started by using commercial CAD systems, but has since developed with the use of Geographic Information Systems (GIS). The GIS have been used both to generate 3D VR models of urban areas, and to integrate them with information from various sources into an overall navigable interactive whole, in a manner still difficult to achieve with the latest commercial CAD software [2]. There is argued to be an increasing need for tools for integrating different forms of representation or media, and an increasing need for standards that address and assist in automating: Scalability (levels of detail); Movement through space and change over time; Integrating and optimising imported models of proposed change, often emanating from architectural practice; Two way links for interactive exchange between a selected view and the source data; And retention of multiple different interpretations or proposals for comparison.

3. Available 3D Data for Contextual Models

In the recent Interreg IIIB project proposal for a virtual environmental planning system (VEPS) it was argued that there is growing pressure to use 3D modelling and VR at the planning proposal stage to create virtual models that enable all the stakeholders to understand the proposals [3]. The 3D digital terrain data available from mapping organisations is still considered to be too inaccurate to make critical judgements about the extent to which a new structure masks or intrudes on an existing view. "Urban simulations; that is computer generated simulations of the built environment, are an effective means of improving the public 's participation in the planning process ".[[i]4] "it is well known that classified urban land cover does not bear a spectrally identifiable correspondence with urban land use. the inadequacies of self-organisation in cities necessitates some kind of intervention, and, in order to intervene, some knowledge of city dynamics is required. new, relevant, and timely lifestyles data may be 'tied' to other framework data such as those provide by remote sensing or ordnance survey's addresspoint. We believe that such approaches offer the prospect of creating vastly enhanced models of the form and functioning of systems which can be implemented into the management of 'sustainable cities'"[[ii]5]

3.1. Aerial LIDAR and Environmental Data

3D building proposal information is often now available from design practices and is inherently more inclusively understandable by all stakeholders than conventional drawings. However the contexts in which such proposals are demonstrated are often unreliable and even misleadingly inaccurate. Yet 3D contextual information is now increasingly available (at an accuracy that far surpasses commercially available mapping data) from LIDAR and it is claimed is now accurate enough to support local analysis of the visual environmental outcomes of detailed proposals. The Environment Agency for England and Wales began R&D Surveys using airborne LIDAR in late 1996, leading to operational surveys from March 1998, concentrating on surveys of river and coastal floodplains. To date they have surveyed in excess of 60,000 sq km using an Optech ALTM laser scanner. A continued R&D programme has led to the development of operational filtering routines for the separate extraction of "bare earth" (terrain models), vegetation and building (surface models) objects. These filtering routines are implemented using ESRI ArcView Spatial and 3D analyst and include: Elevation Variance analysis; Maximum vs. Minimum difference within varying spatial windows; Aspect Variance analysis; Inverse hydro-fill and edge detection; Minimum filters (varying spatial windows); Edge detection (varying thresholds) and area segmentation.

Figure 1: Example classified LIDAR objects; buildings, vegetation, bare earth. Copyright Environment Agency 2005

Combinations of different filtering techniques are applied to specific landscape types (e.g., urban, steep slopes, forested, rural, etc) along with a choice of interpolation methods, and also tools for adding breaklines and additional ground points.

The automated vegetation and building classification identifies DEM cells based on particular height differences and places a buffer around the identified objects. These objects may then be stripped out of a scene, and the bare earth terrain gap is filled by simple interpolation. The work requires some manual intervention for the finished product, which has a 1 metre grid spacing and a height accuracy of +/- 15cm. the current new and improved methods of vegetation and building classification identify unique and separate objects for all of the surface features (i.e. for each building). These individual surface objects identified can now have a height assigned to them.

The 3d raster products may then be used with a variety of environmental point and vector datasets e.g. river quality samples or verlain onto the OS 1:10k digital maps The data is also used for input into modelling Flood risk Zone maps (http://www.environment-agency.gov.uk/yourenv/)

3.2. Ground Based 3D Scan Data

In the field of surveying, ground based 3D scanning technologies are able to acquire accurate 3D data about portions of land and objects of various shapes and sizes. These instruments are commonly known as terrestrial laser scanners. While laser scanner instruments based on the triangulation principle and high degrees of precision have been widely used since the 1980's, TOF (Time of Flight) instruments have been developed for 3D survey applications only in the last 5 years (Bornaz & Rinaudo, 2004)[6[iii]].

These types of laser scanners can be considered as highly automated total stations. They are usually made up of a laser, which has been optimised for high speed surveying, and a set of mechanisms that allows the laser beam to be directed in space in a range that varies according to the instrument that is being used. For each acquired points, a distance is measured on a known direction: X, Y, and Z coordinates of a point can be computed for each recorded distance direction. Laser scanners allow millions of points to be recorded in a few minutes. Because of their practicality and versatility, these kinds of instruments are today widely used in the field of architectural, archaeological and environmental surveying (Valanis & Tsakiri, 2004). [[iv]7]

Terrestrial laser scanning offers fast 3D terrain data acquisition. It has advantages over current survey techniques including EDM, GPS and photogrammetric applications obtaining high density point data without the need for a reflector system. Merged data clouds have sufficient points to negate the need for DEM (Digital Elevation Model) interpolation techniques potentially providing the optimum representation of any scanned surface. The advantages of speed and high data point density must be viewed against the data point accuracy which may reduce instrument performance below that achievable using EDM (Electronic Distance Measurement) techniques (such techniques are, however, much more time consuming). Any Improvement to measurement range, resolution, field of view and error/accuracy would further fill the research gap relating to spatial and temporal measurement of space and change in the built and natural environment and resolve the accuracy issue with regard to EDM techniques.

The University of Salford purchased a Riegl LMS Z210 scanner in May 2002. The scanner is connected to a 12V battery and a ruggedised laptop. The high-speed scanner has the following specifications: Maximum measurement range = 300 m (in typical conditions); Minimum measurement range = 2 m; Measurement accuracy = typical +/- 25 mm; Measurement resolution = 25 mm; Beam divergence = approx. 3 mrad (i.e. 30cm beam width per 100m range); Field of view = 80° vertical angle, 333° horizontal angle; Scanning rate = 6000 points per second; Class I eye-safe laser.

During data acquisition, the 3D-RiSCAN software is used. It allows the operator to perform a large number of tasks including sensor configuration, data acquisition, data visualization, data manipulation, and data archiving. Numerous export functions allow the scanned data to passed to post-processing data packages for, e.g., feature extraction or volume estimation. PolyWorks software (produced by Innovmetric Software Inc.) provides comprehensive set of tools for quickly processing 3D scanned data. This software has traditionally been used in manufacturing industries with very short range scanners, but with the advent of longer range laser scanners, it has seen widespread use in surveying and architecture, especially within North America. The software can handle many millions of data points while still retaining the ability to model very fine details very accurately.

The processing of laser scanning data can be complex and since the Salford scanner was purchased, research has been conducted to investigate this complex environment for the use in the built environment. The research on the laser scanner can provide reverse engineering in construction to aid the refurbishment of buildings. Producing building design and CAD models and VR (Virtual Reality) models from existing buildings, by means of the laser scanner, will facilitate an analysis of the current conditions of the buildings. This is particularly important for historic buildings, which may have been altered and where plans no longer exist.

Besides, it even has the potential to accurately record inaccessible and potentially hazardous areas such as pitched rooftops. Consequently, it facilitates "virtual refurbishment" of the buildings and allows the existing structure and proposed new services to be seen in an effective manner. Figure 1,2 and 3 below shows the Jactin House example, which is the case study building in East Manchester. VR models were produced from the building data captured by the 3D Laser scanner. CAD models were extracted from the VR models and plastic model produced from the CAD model. This work is funded by the EU: the Intelcities FP6 IP 2004-2005.

Figure 2: Virtual Reality (VR) model produced from raw scan data

Figure 3: CAD model produced from the VR model in figure 1

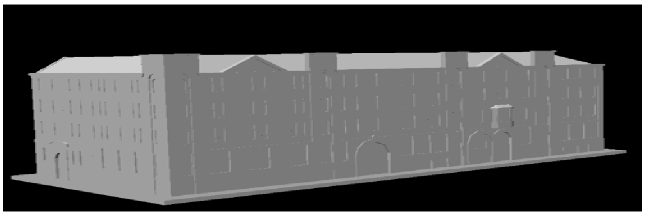

Figure 4: Plastic model produced from the CAD model

Regarding architecture and construction, architects frequently need to determine the “as built” plans of buildings or other structures such as industrial plants, bridges, and tunnels. A 3D model of a site can be used to verify that it was constructed according to specifications. When preparing for a renovation or a plant upgrade, the original architectural plans might be inaccurate, if they exist at all. A 3D model allows architects to plan a renovation and to test out various construction options.

3.3 GMES Urban Services

The European Space Agency (ESA) funds GMES Urban Services (GUS). This project aims to project from the European Space Agency to consolidate a product portfolio, based on the combination of satellite images and in-situ data, to facilitate cities and regional authorities in their implementation of European environmental policies. GUS aims to provide them with cost effective, up-to-date and homogeneous, “GIS ready” spatial environmental information mainly based on high resolution satellite image data. GUS has developed a number of products clustered into three thematic areas: Urban Land Use Mapping – with urban land use; urban change detection; urban development modeling tool and plan monitoring products; Urban Development Control - with change detection hot spots; Urban Environmental Quality – with mapping of sealed areas; Urban thermography; Road noise observatory; risk and security mapping and Brownfield mapping products.

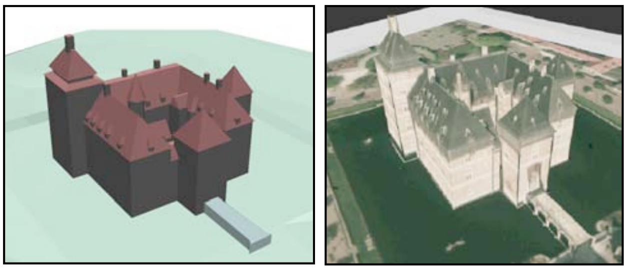

Figure 5: 3D Map of the Castle Hertogen van Brabant in Turnhout, Belgium

These products, except for the urban thermography product which is airborne, are based on IKONOS, Quickbird and SPOT-5 satellite images with scales 1:5000 to 1:25000. During 2004 GUS also developed Urban 3D Mapping product based on airborne data, which was delivered to the Belgium city of Turnhout. This is a 3D model of the historic castle, with horizontal resolution < 15cm and vertical resolution < 30sm and the product is integrated into the Turnhout City Hall geoportal to be viewed by tourists. Unfortunately, 3D modeling is not going to be developed further within GUS project during the 2005-2008 period, as the main focus is on developing generic satellite based products with highest demand and potential to cover all Europe.

3.4 Other suitable data

“LIDAR data has a best accuracy of around 10cm in height (Z) and costs around . $500 per km2 and is best suited to applications over limited areas with high accuracy requirements. IfSAR (interferometric synthetic aperture radar) has a best accuracy of around 0.5m in Z and costs $5 per km2 LIDAR And is best suited to larger areas with lower accuracy requirements. LIDAR LAS standards have been developed in the USA and futher specification standards are being developed. (http://www.lasformat.org). IfSAR data analysis is still very much reliant upon the system operator and for bare earth filtering there will inevitably be a need for manual editing after the automatic processing. Filtering of LIDAR is probably more effective that that of IfSAR.

Spaceborne IfSAR is more established as a source of DEMs that its airborne counter part. The ESA ERS 1/2tandem missions have acquired very wide coverage of interferometric SAR pairs which have been successfully used for the generation of regional DEMs. For example the Radarmap of Germany produced by DLR.. and the Landmap project in UK... The Shuttle Radar Topography Mission (SRTM) has also produced DEMs and orthoimages between 60° North and 56° South. In addition RadarSat, JERS, and ENVISAT all produce interferometric data and in the future RadarSat 2 and ALOS PALSAR will join the ranks of IfSAR data generators. IfSAR has also had an important application in differential mode for monitoring tectonic movement and subsidence. Data fusion exploits the synergy of two or more data sets to create a new data set which is greater that the sum of the parts. “ “Although LIDAR has the potential for application in building extraction and 3D city modelling, automatic feature extraction is still not mature and therefore the output is unreliable, and manual editing is very expensive. LIDAR is also very expensive for small areas. Wider use of LIDAR may therefore have to wait until better feature extraction algorithms are available. New airborne technologies such as 3 line optical sensors could also compete with LIDAR when they become more mature and can acquire data with higher resolution than at present. Three line data avoids occlusions and adds redundancy to the data set. Multi sensor data could also do this. The use of a digital camera with LIDAR is already commonplace, but a good model for reconstruction and error analysis is needed. In order to inspire confidence in the data better theoretical models are required, both for single sensors, and for data fusion, in order that the errors can be better understood. Potential errors such as multipath and transparency effects also need to be studied much more. More comparative tests, especially with different algorithms, need to be carried out, User need to be educated more and to aid the greater use of the data, standards need to be defined for products and for data exchange."[v 8]

3.4 The difficulties in achieving automation

"Semi-automatic extraction of GIS and CAD (computer aided design) data is still mostly restricted to research and development. Implemented algorithms combine computer vision approaches with rigorous photogrammetric modelling. Some results indicate that future systems will be equipped with more powerful tools…The human-computer interface is increasingly being seen as an important factor. Efforts have been devoted to the development of systems and tools for the integrated management of large-volume heterogeneous spatial data and for enabling users to access various Earth Observation (EO) and other spatial data at regional, national and global scales. The Working group on Information Systems and Services (WGISS) of the Committee on Earth Observation Satellites (CEOS) is one of such spatial data custodian organisations. Systems and data fusion becomes increasingly important and must be addressed on different levels. The trend of using several sensors on the same platform requires establishing a common reference system for the sensors (fusion on the physical (sensor) level). Similarly, data obtained by different sensors, perhaps not on the same platform, must be merged (fusion on the data level). Not all multiple sensor data can be merged on that, however; it may be necessary to extract features independently and merge them on the feature level".[vi 9]

"SARs have difficulties in urban settings when buildings are high or if the streets are narrow… Urban areas can also be troublesome to SARs because of shadowing and layover effects… However, another particularly useful side benefit with InSAR maps is that they can detect change exquisitely, at the level of inches of vertical deflection. Each sensor technology offers other features that are useful and unique. Laser radar provides the most automated and rapid processing. EO provides the best horizontal resolution, and a great deal of qualitative information about structures. InSAR processing is reasonably well-automated, provides the best vertical resolution, and is all-weather, but it is somewhat constrained in imaging steep slopes and high depression angles. It is likely that high-quality urban mapping will depend on combining data from all three techniques in the future. Today, a number of agencies routinely produce maps combining pairs of sensor types, most frequently EO and SAR, or EO in several bands. Although this combining is usually still performed by a human operating a workstation, the operator is using tools that are rapidly increasing in sophistication."[vii 10]

"A fundamental challenge for spatial analysis tools is the need to resolve the "knowledge gap" in the process of deriving information from images and digital maps. This knowledge gap has arisen because our capacity to build sophisticated data collection instruments (such as satellite sensore, LIDAR, and GPS) is not matched by our means of producing information from these data sources. Benefits to the geographical information community would accrue from the use of open-source GIS tools. E.g. … TerraLib, an open-source GIS library that enables quick development of custom-built applications for spatial data analysis (www.terralib.org)."[viii 11]

3.5. Continuing Need for Data Fusion

"The ISPRS Journal of Photogrammetry and Remote Sensing (Vol 58(1-2), 2003), published a theme issue on multi-source data fusion for urban areas which clearly demonstrates the range and importance of data fusion. Data fusion can be used for many applications. Some of the established ones are: Assisting phase unwrapping; Eliminating errors and blunders; Atmospheric correction; Providing orientation in areas where there is no control; Terrestrial images to LIDAR; Feature extraction, such as buildings and roads; Other aspects of feature extraction and environmental analysis"

In the early digital urban models of the 1980's and 1990's in the UK there was little consistency or agreement on scale, level of accuracy, or levels of detail. Some were of quite low levels of detail and geometric accuracy, making use of great numbers of bitmap elevations, and often based on Ordnance Survey (OS) map and terrain data. Experience in several projects showed that the OS data, while kept up to date, was too 'crude' to easily merge with data derived from total station street surveys, and the OS 3D terrain data stopped at significant man made features such as railway embankments, for which accurate 3D data was difficult or impossible to safely obtain. The OS data provided footprints at ground level but heights of buildings and the detail of roof-scapes had to be obtained from other sources. Even at that time there was therefore a need to amalgamate and meld data from different datasets at differing levels of geometric accuracy in order to construct or update an urban model [4].

Other city models were of significantly higher geometric accuracy, but perhaps consequently more difficult to keep up to date as urban change occurred. Bourdakis [5] stated that coordination of different models or part models is sufficiently difficult to manage in practice to justify a common unifying geometric structure or primary model, to which all relate or from which all are initially generated. Bourdakis had worked on both Bath and London City Models, modelled at a consistently high level of geometric detail with little or no use of bitmaps, from which lower level of detail models or part models of areas of interest were then generated on demand; (although the underlying terrain model was perhaps not so accurate, apparently being based largely on interpretation and interpolation from Ordnance Survey spot-height data).

Counsell et al [1] further argued that modelling and updating urban models takes place over a long period and that software, bandwidth, standards and detail will change over that time, rendering any fixed level of detail potentially obsolete, and hence that for effective use of resources an evolutionary approach is necessary, in which one may model the whole at a lower level of detail and then on demand introduce pockets of higher detail, as these become available from CAAD modelling or as debate and interactive use define a demand for more detail at that location.

This view of an increasing meld of different datasets in urban modelling appears to be being borne out in practice with the recent creation for example of the Heidelberg City Model, based on both LIDAR and conventional mapping data [6]. 'A range of different data sources were collected and constructed with different methods. These build a heterogeneous data source pool that needs to be homogenized and integrated to be accessible via a single 3D server. Examples of this data include several layers of digital 2D GIS data (ALK = Amtliches Liegenschaftskataster = German official digital data set for 2D-geometries) covering the whole city of Heidelberg, mostly from the land surveying office Heidelberg. Furthermore, another data source consists of laser scan data of the old town of Heidelberg that has been processed by the Institute for Photogrammetry (IfP) of the University of Stuttgart using an automated method and textured VRML models of important building and sights that have been created manually using modeling tools' [6]. There is also the increasing availability of SAR interferometry from the European Space Agency and its emerging role in identifying and mapping authorised and unauthorised development in urban areas.

A common 3D coordinate and reference system is necessary to support the melding of such data over time, and needs to be sufficiently accurate to accommodate the highest levels of detail likely to be required., However there still appears to be little consensus or agreement on levels of accuracy or levels of detail today, either in architectural CAD practice generally, or in urban modelling, except in Germany where City Modellers have agreed to use City-GML as a common standard. (City-GML was recently proposed for part of ISO standard, but rejected in case it slowed adoption of the remainder of the standard.) Thus elsewhere in Europe and in existing German modelling each digital urban model tends to be developed in an ad-hoc manner and so it is likely to remain difficult to readily take a component part of one urban model and marry it into an urban model created for a different place, until such common standards are defined and agreed.

4. European Standards for Spatial Datasets

There are moves to establish European standards relating to spatial datasets, which will eventually have an impact on common standards for urban modelling. Their goal is described as 'an open, cooperative infrastructure for accessing and distributing information products and services online' (Inspire AST) [7]. The Inspire project aims to establish 'an infrastructure for spatial information in the Community' and has published a proposed directive in this respect that was adopted by the European Commission (EC) on the 23rd July 2004 [1].

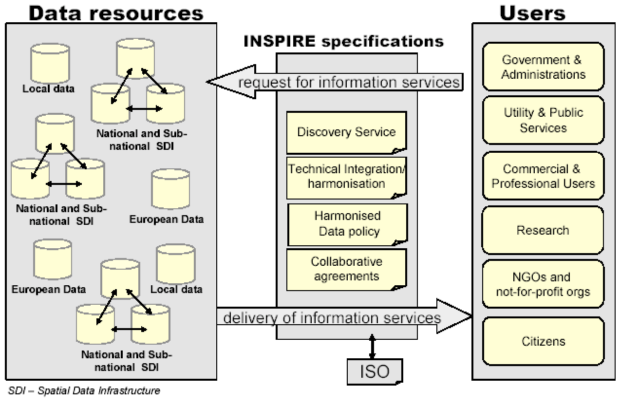

Figure 5: Diagrammatic view of the Inspire vision, (from Inspire AST 2002 p9)

It is stated that the proposal 'focuses specifically on information needed in order to monitor and improve the state of the environment', and that 'much of this information needs to be underpinned by "multi-purpose" spatial data'. It is explicit that 'in an infrastructure for spatial information, not all spatial data themes need to be subject to the same degree of harmonisation, nor can they be brought within the infrastructure at the same pace', and therefore gives different deadlines for harmonisation of different categories of spatial information. These are defined in the annexes to the proposed directive, but it makes clear that 'they do not determine how spatial information should be organised or harmonised', although it states that 'implementing measures should be … designed to make the spatial data sets interoperable' and that this should be achieved in 'such a way that the result is a coherent combination of spatial data sets or services that represents added value, without requiring specific efforts on the part of a human operator or a machine.' At the end of the proposal (pp 30 and 31) it lists a comprehensive range of data types that underpin urban modelling, to which the directive will apply. Other directives and actions also indicate a move to harmonisation and inter-operability. For example the EC have announced a GMES action plan from 2004 to 2008 aimed at achieving integration and consistency of such data [8]. While these initiatives do not specifically exclude 3D data one can find nevertheless an implicit assumption that at the scales at which data is to be collated height data is less significant.

Height data standardisation was addressed in a 2004 workshop on establishing 'Vertical Reference Systems for Europe'. In the conclusions from this workshop it was stated that significant work was still needed to achieve harmonised decimetre accuracy by 2006, although accuracy at the metre level was available now. The current problem was defined as 'Worldwide there are some hundred physical height systems, in Europe about 20, realized - by different reference tide gauges (inconsistencies within 2 m range) - by spirit levelling reduced by different theories (10-6) - at different epochs

- and as static systems' (EVRS) [9]. The Inspire AST position paper [7] made it clear that 'from the European point of view Coordinate Reference Systems (using ETRS89 and additional projections) will be used both in GIS and in geodesy. Both applications correspond to different accuracy classes (one or more meters in GIS; several decimetres or less in geodesy). At regional level also GIS information moves to smaller accuracy (like cadastre) with (adequate) regional geodetic reference systems becoming more important.'

Geographical level	Resolution range	Scale level	Scale range
European	> 100 m	Small scale	< 1:250.000
National	~ 25 m	Medium scale	1:100.000 ~ 1:250.000
Regional	~ 10 m	Medium scale	1:25.000 ~ 1:50.000
Local	< 2.5 m	Large scale	> 1:25.000

Figure 6: Diagram showing proposed 'scales' or granularity of data -Inspire RDM position paper 2002

The OpenGIS specification for locational geometry [10] refers to the need for many spatial reference systems with explicit mappings between them. In this light the common European Coordinate Reference System database contains the descriptions of national Coordinate Reference Systems of European countries and the descriptions of Transformations to European Terrestrial Reference System together with the descriptions of European Coordinate Reference Systems. (Inspire RDM) [11].

From this it may be argued that European standardisation that identifies local accuracy as potentially adequate for the range under 2.5m in X, Y, and possibly Z, needs clarification and further development to become of use in urban modelling for accurate visualisation. In practice these further standards may become defined in a de-facto manner by readily available LIDAR data of significantly higher accuracy. De-facto standards that emerge from practice often precede and establish international standards. Yet at this moment there is still be a need for those engaged in visualisable (and thus 3D) urban models as facsimiles of reality to define the most appropriate spatial reference system (that will serve all or most local requirements) while standardising their creation and maintenance, but also to provide mappings from the localised reference system to national and international reference systems. It is suggested that further research is needed in this area, and this is likely to be one focus of the VEPS project.

5. The VEPS Project

The Virtual Environmental Planning System (VEPS) project started in December 2004, with Interreg IIIB funding for 3 years. Partners include: The Environment Agency for England and Wales; the University of the West of England, Bristol; Centre Scientifique et Technique du Bâtiment; University of Salford; Manchester Digital Development Agency (a division of Manchester City Council); Clementine Media Limited; Stuttgart University of Applied Sciences; and the University of Freiburg. The primary objective of the VEPS project is to share technical competencies in the field of: 3-dimensional visualisation; ICT applications to promote public consultation; environmental modelling; data collection and use for e-Planning in territorial development in North West Europe.

It is argued in justification of the project that conventional planning systems are still substantially based on two-dimensional (2D) plans. Such 2D maps and plans are readable using taught technical interpretative skills that are inherently exclusive to those people without 'professional' qualifications and are counter-intuitive to the layman. Despite the use of taught skills 2D maps and plans also contain inherent ambiguities that lead to and support misinterpretation even by professional planners. At present there are only two possibilities for planning consultations: either - the complex information in a planning consultation is "dumbed down" for the citizen i.e. the information is reduced to a level which can be understood by the average member of the public who does not hold a qualification or diploma in planning; or - the full information is presented and the citizen must receive training in order to understand the highly accurate and highly complex information. The VEPS project is a step towards a third possibility which eliminates the need to "dumb down" the information and eliminates the need for training. An interactive three-dimensional virtual reality visualisation will allow the viewer to experience the highly complex information without the need for training because they can see and experience what the visual impacts of the planned development will be and can see the environmental impact in the associated model. [3].

The second objective of VEPS is to develop a common architecture and methodology to enable citizens to view and respond to planned changes via home PCs. (The third objective of VEPS is to refine and implement a test-bed system and to evaluate and refine the methodology and the system architecture. In the final system, we anticipate that users will be able to examine the underlying raw data, and thus it will also promote e-Learning.) A key action of VEPs will be the analysis of large data sets, including high resolution 3 dimensional height data from LIDAR, for use within Virtual Reality (VR) visualisation software and the subsequent delivery of the VR environment via the internet and world wide web. The virtual environment used in VEPS can look extremely realistic as the LIDAR images demonstrate. These images are compiled by overlaying different data sets, LIDAR data , and for example, Compact Airbourne Spectographic Imager (CASI) data, which records the colour of the underlying ground [3].

Among the partners, researchers in the Department of Remote Sensing and Landscape Information Systems at Freiburg University have developed methods and software to calculate and to extract and visualize information automatically from LIDAR and multi-spectral data. Work on two projects, Highscan and the still running Natscan [12] has enabled them to automatically extract and distinguish between vegetation, streets and buildings. In the Highscan project they showed that, (with the Laser scanning technology then in use,) the DTM accuracy obtained with the laser scanner varied from 15 cm to 1m depending on terrain slope[13]. The focus of the Natscan project is a survey of comprehensive methods of laser scanning technology and their adaptation to the specific requirements of environmental monitoring. In the second phase aerial laser scanner data and terrestrial laser scanner data will be integrated into a closed system for multiple data use.

5.1. Alternative User Generated Proposals

The VEPS product will be based on interactive 3D visualisation. As such it represents a technology leap in the modernisation of the planning process. The visualisation would also allow the user to explore alternatives such as before and after scenarios. Other types of data can also be overlaid according to the user requirements. All the data would be underpinned by mapping data. The user will be able to explore this virtual world and click on features to see the environmental model. In some cases the environmental model might be dynamic e.g. for properties in a flood plain the model might show the water gradually inundating the planned development. In addition, the VEPS product challenges existing practice in that it would allow a two-way consultation process. It would allow citizens to upload their own alternative planning scenarios and view the results in terms of visual and environmental impact as well as download and view the details of the planned development. The user could also manipulate the planned development and see the impact of their own suggestions [3]. This poses the question (as yet unanswered) of which media will acceptably and credibly present user's own suggestions in this context. It might be argued that 2D images billboarded into the 3D context might adequately convey a proposal from a specific set viewpoint. There is certainly a truism that systems that exclude methods or approaches that are found useful and relevant become bypassed and consequently risk obsolescence. An effective versatile and lasting system should accommodate approaches and methods not envisaged by its designers. In this respect the VEPS project will examine, define and integrate standards for incorporating other media into the same spatial referencing system.

Conclusions

There is still a pressing need to develop better means of integrating and fusing data from different datasets to automate digital urban and landscape models that are at present highly resource intensive. There is also a need to re-examine and define in such standards the data to be recorded with media such as images and video. It should then eventually become possible to limit the resource intensive 'manual' modelling tasks to proposals for change that have yet to exist, or to interpreting historic events and contexts that no longer exist. While currently emerging European Standards for 2D data and 'vertical data' provide a context, there is still within this context an apparently as yet un-addressed need to define digital urban model standards that define data and urban modelling outcomes, at scales / resolutions that enable critical tasks such as visualisation and construction to be adequately supported. The VEPS project will need to address these issues in attempting to define a usable pan-european standard approach to uploading proposals for change and alternative scenarios into the context of such increasingly available highly accurate datasets as those derived from LIDAR.

Acknowledgements

The VEPS project work presented in this paper is co-financed through the INTERREG IIIB North West Europe programme.

References

[1] INSPIRE Project (2004) (www.ec-gis.org/inspire)

[2] Counsell, J. Brkljac, N. & Smith, S (2002). GIS based Urban Information Systems as a basis for the Generation of Complex 3D VRML Models, in Proceedings of DMUCE, London, November 2002.

[3] VEPS (2004) Proposal document submitted in support of VEPS project bid to Interreg IIIB North-West Europe, 2004.

[4] Bulmer, D. (2001), How can computer simulated visualizations of the built environment facilitate better public participation in the planning process? Online Planning Journal, (http://www.casa.ucl.ac.uk/planning/articles61/complanning.pdf)

[5] Harris, R. Longley, P. (2000) "Data-Rich Models Of The Urban Environment: RS, GIS and 'Lifestyles'" GISRUK 2000 Conference, York, England (www.casa.ucl.ac.uk/urgent/DataRich.doc)

[6] Bornaz, L. Rinaudo, F. (2004) Terrestrial Laser Scanner Data Processing. In proceedings of XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey, http://www.isprs.org/istanbul2004/comm5/papers/608.pdf)

[7] Valanis A. Tsakiri M. (2004) Automatic Target Identification for Laser Scanners, In proceedings of XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey, Commission 5 (http://www.isprs.org/istanbul2004/comm5/papers/512.pdf)

[8] Dowman, I. (2004) Integration Of Lidar And Ifsar For Mapping, Invited paper In proceedings of XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey Commission 2, (www.isprs.org/istanbul2004/comm2/papers/104.pdf)

[9] ISPRS Annual Report 2000 - Technical Commission Reports

[10] Vick, A. et al: (2000) Enabling Technologies For Urban Aerospace Operations chapter 6 of 'Aerospace Operations in Urban Environments: Exploring New Concepts' MR1187 ISBN: 0-8330-2851-0 published by Rand Corp, Santa Monica, CA, USA. (http://www.rand.org/publications/MR/MR1187/)

[11] UNESCO Report on the International Workshop on Open Access and the Public Domain in Digital Data and Information for Science 10/11 March 2003, ICSU/ UNESCO (http://www.codata.org/wsis/FinalReportUNESCO31July.pdf)

[12] Phillips, R.J. & Counsell, J. (1997), Appropriate Data for Navigable 3D Cityscape Interfaces to Urban Information Systems, in proceedings of Joint European Conference on Geographical Information, Vienna, April 1997, published by IOS Press, Amsterdam, pp 298-308.

[13] Bourdakis, V. (1996) 'From CAAD to VR, Building a VRML model of London's West End.' Proceedings of 3rd UK VR-SIG conference, DeMonfort University, Leicester July 1996 (http://www.cms.dmu.ac.uk/VRSIG)

[14] Zipf, A. and Schilling, A. (2003): Generation of VRML City Models for Focus Based Tour Animations. Integration, Modeling and Presentation of Heterogeneous Geo-Data Sources. In proceedings of the 8th International Symposium on Web 3D Technology. Web3D 2003. March 2003 Saint Malon. France.

[15] Inspire AST (2002) INSPIRE Architecture and Standards Position Paper, European Commission, Joint Research Centre, 2002

[16] GMES (2004) (Establishing a GMES capacity by 2008 (Action Plan (2004-2008))

[17] EVRS (2004) Workshop on Vertical Reference Systems for Europe, Frankfurt Main 5-7 April 2004 (http://gi-gis.jrc.it/ws/evrs)

[18] OpenGIS (1999) Open GIS Consortium Abstract Specification Topic 3: Locational Geometry (http://www.opengis.org/docs/99-103.pdf)

[19] Inspire RDM (2002) Position Paper of the Reference Data and Metadata working group, European Commission, Joint Research Centre, 2002

[20] NATSCAN (2004) Ending October 2004, (www.natscan.de)

[21] Diedershagen, O. Koch, B. Weinacker, H. & Schütt, C. (2003) Combining LIDAR- And Gis Data For The Extraction Of Forest Inventory Parameters, Proceedings of the ScandLaser Scientific Workshop on Airborne Laser Scanning of Forests, Umeå Sweden, September 2-4, 2003: pp.157-165.

---

[i] Bulmer, D. 2001, How can computer simulated visualizations of the built environment facilitate better public participation in the planning process?, Online Planning Journal, Available at: http://www.casa.ucl.ac.uk/planning/articles61/complanning.pdf

[ii] Data-Rich Models Of The Urban Environment: RS,GIS and 'Lifestyles' Rich Harris, Paul Longley University Of Bristol, Gisruk 2000 Conference, York, England

[iii] Bornaz, L. Rinaudo, F. Terrestrial Laser Scanner Data Processing. In proceedings of XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey, Commission 5 on line at: http://www.isprs.org/istanbul2004/comm5/papers/608.pdf

[iv] Valanis A. Tsakiri M. Automatic Target Identification for Laser Scanners, In proceedings of XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey, Commission 5 on line at: http://www.isprs.org/istanbul2004/comm5/papers/512.pdf

[v] Dowman, I. Integration Of Lidar And Ifsar For Mapping, Invited paper In proceedings of XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey Commission II, WGII/2 (www.isprs.org/istanbul2004/comm2/papers/104.pdf)

[vi] ISPRS Annual Report 2000 - Technical Commission Reports

[vii] Enabling Technologies For Urban Aerospace Operations chapter 6 MR1187

[viii] International Workshop on Open Access and the Public Domain in Digital Data and Information for Science 10/11 March 2003, UNESCO FinalReportUNESCO31July.pdf