ORDNANCE SURVEY: IMAGERY APPLICATIONS IN SUPPORT OF A NATIONAL GEOSPATIAL DATA INFRASTRUCTURE

Keith Murray - Development Manager
Alison Davey - National Geospatial Database Programme
& Graham Tait - Photogrammetric Development
Ordnance Survey, Southampton, SO16 4GU, United Kingdom

Commission VI

KEY WORDS: GIS, SPATIAL, ECONOMY, THEMATIC, APPLICATION, IMAGERY, DEVELOPMENT

ABSTRACT:

Of all its 200+ year history the past five years have perhaps been the most challenging for Britain's national mapping agency. The challenges have been met with success in the completion of the national digital large scale database in 1995, the completion of a national address database in early 1996 and a national high resolution digital height model. Having prepared a continuous model of Britain's topography it would now be easy to sit back and enjoy the fruits of our labours. That will not happen if we are to retain and build our customer base for geospatial data well into the next millennium. To encourage usage of data, not just that of Ordnance Survey® (OS), but any geospatially related data in Britain, OS has proposed the concept of a National Geospatial Database. The national benefits of integrating data from various government bodies clearly has great potential and this is already being proven in the current trial of a National Land Information Service (NLIS).

The most expensive aspect in maintaining geospatial data is the data collection and update process. Imagery has played a significant role in minimising those costs over the past 40 years. Technology is now taking us into new areas where computing and networking power is starting to realise the early visions of increased automation. This paper describes areas of recent advancement and a major research investigation into the potential of high spatial resolution space sensors programmed for launch in the near future. It is already clear that imagery will play an increasing role in maintaining the geospatial databases of the future.

1. ORDNANCE SURVEY®

1.1 National Mapping Agency

The past five years has witnessed a number of major events and achievements that rank in significance even when compared with the celebration by Ordnance Survey® (OS) in 1991 of 200 years continuous operation in providing Britain with a rich mapping base. In early 1995 national large-scale digital data coverage was completed, a national on-demand plot service was launched later that year, and more recently the creation of a national address database was also completed. All this was achieved concurrently with a major internal reorganisation to refocus key elements of the organisation on specific business operations. The next five year period looks to be equally challenging! (Rhind 1995).

Ordnance Survey has been a government Executive Agency since 1990 and has been increasingly successful in improving its position as the leading supplier of geospatial data and information in Great Britain. OS revenue was £58m during the financial year 1994/95. This is equivalent to a 78% return on annual expenditure and is globally highly unusual amongst national mapping agencies (Ordnance Survey 1995b).

1.2 The database and its products

Britain now has a database which models urban areas at a nominal survey scale of 1:1 250, minor towns and rural areas at 1:2 500 scale and mountain and moorland areas at 1:10 000 scale. 1996 will also witness the completion of the digitising of a national height dataset based on photogrammetric contour surveys (5 and 10 m vertical interval). The address database holds a 1 m National Grid reference for over 23 million addresses. Further databases model road networks, administrative boundaries and various medium and smaller scale equivalents.

The main topographic database contains 230,000 data tiles and serves a wide range of customers, our own survey operation - including the work done by contractors. During February 1996 the database reached a new peak of operational performance over a three week period when an access request was serviced on average every 2.4 seconds (based on a 22 hour operational day).

The topographic database currently holds in excess of 200 million features, this includes building outlines, walls, fences and hedges, road limits, names, water features etc. which are managed together to create and maintain a continuous model of the nation.

Some success has been achieved in the past three years in the generalisation of the base topographic information to create derived graphic and raster products at output scales of about 1:10 000. The Landplan graphic to be launched later in 1996 will accompany the Superplan™ service in over 20 OS agents' premises across the country. Superplan customers are free to choose the centre, scale, orientation and other parameters of their large-scale plot of any part of Great Britain.

Data Theme	Derived National Products
Base Topographic Information	Land-Line® Superplan™
National Height Data Model	Land-Form PROFILE™
Address database	ADDRESS-POINT™
Road centre-line database	OSCAR®: Traffic-Manager Asset-Manager Route-Manager Network-Manager
Boundaries database	Boundary-Line™
Combinations of the above	Landplan

Table 1. The major definitive Ordnance Survey datasets and their derived products.

1.3 Keeping the database up to date

Customer Requirements: Maintaining the currency of the databases is essential to meet the growing Geographic Information Systems(GIS) market. To manage this expectation the nation is divided into urban, rural and mountain/moorland areas and a revision policy is assigned to each. Urban change is surveyed within 6 months of its completion, rural areas and mountain /moorland areas undergo a 5 and 10 year update cycle respectively. Such update cycles are also linked closely Service Level Agreements (SLAs) agreed with major customer groups.

Agreements have been signed with local authorities (as a whole), utilities and some government departments to package selected data themes /products to better meet their needs. Customers are now increasingly realising that there are more applications of data that are of use to them, simply because they have access to data. Thus there is now more demand for innovative applications and new levels of service such as the integration of a wide number of datasets to support urban planning, transportation, health, environmental protection etc.

Field operations: The database is maintained through regular update using a variety of techniques based on the OS GPS control network and is supported by a network of 90 field offices and contractors. The survey field offices request, update and return data to the database using the Digital Field Update System (DFUS) which is currently being extended by pen-PC based PRISM units (Turner 1995). The maintenance of the data is the most costly item of expenditure each year and further improvement in OS cost-recovery will be *very dependent on minimising the cost of the update operation.*

1.4 The Changing World

Technology: The environment we all operate in is constantly changing as shown by the fact that technology in the survey market has changed radically over the past 10 years. GPS is now expected to have a greater impact on all our lives through the initiatives proposed by the Clinton Administration in late March 1996. Already we have witnessed combined GPS/video capabilities (Novak 1995) and other innovative approaches such as the use of GPS mounted on bikes for utility mapping (Gilton et al 1996)

Technology now offers tools and services to an increasingly wide range of potential data suppliers and users. This presents us all with a fascinating future in harnessing the power to bring benefit to everybody for all types of services: environmental planning, land development administration, visualisation, 'virtual reality' etc. The major advances in computing power, off the shelf workstations and high speed have contributed to significant the surges in technological progress. One area of disappointment is the lack of any real progress in the standardisation in operating systems.

Government and commercial factors: The environment under which national mapping agencies operate is increasingly challenging. Mapping agencies in the United States and New Zealand have experienced the winds of change during in the past 18 months. In both cases there is increasing realisation that there is a need to reduce costs and to commercialise operations so that there is a return on the investment made by the taxpayer. In Great Britain this has been the case for some years and Ordnance Survey is now driven totally by this goal.

As an Agency OS agrees challenging objectives with government at regular intervals. In its 1995 Agency Framework Document (1995a) OS has specific objectives which include " maintaining the National Topographic database " and " building a National [Geo]spatial database ".

1.5 Cartography or the real world?

Cartography: The OS digitising programme was originally implemented to improve the efficiency of the mapping and charting process. However the period from the 1970s to early '80s also witnessed the concept of flexible digital data emerge, this has had far more potential than automated chart paper mapping. A whole new industry has now developed to the development of geographic data.

A legacy remains however, the digital topographic data of many mapping agencies today bears witness to the origins of the original objective of map production. The data often resembles digital cartography rather than digital geographic information. Many digital products mimic the restraints of the paper products they supersede.

The Real World: The real world is where customers and users operate, it is where they have their problems and require solutions to those problems. Unfortunately for the digital cartographer the real world does not stop at the doors of the shopping mall, or as one disappears under a railway bridge. The real world is also three dimensional incorporating underground objects and those in which we which live and work on a daily basis.

2. NATIONAL GEOSPATIAL DATABASE

2.1 The concept

The concept of a British National Geospatial Database (NGD) was announced in late 1995 (Nanson et al 1995) and has received a positive response from all areas of the geospatial data community: The aim of the NGD is to establish an infrastructure to promote and gain maximum benefit from datasets, principally those held by Government Departments, Executive Agencies and Local Authorities. Some of this data is already accessible while other datasets are not. They all have one attribute in common - they have some form of geospatial reference - i.e. the data has a geographic coordinate or has an indirect geographic reference - through, for example, a postal address.

The benefits of data integration at the local level in a GIS are well known for a wide variety of planning aspects, infrastructure development, environmental protection etc. Considered at a national level there are benefits for citizens, government and businesses to be derived from the value adding services that can exploit a geospatial data infrastructure. The full potential benefit can clearly be significantly more productive than simply the sum of the individual data themes.

The NGD is not the sole preserve of Ordnance Survey and will require the development of a collaborative framework to establish, support, promote and develop the concept and its benefits. For the NGD to be successful, partnerships will be essential to direct, fund, motivate and realise the concept. Similar initiatives are emerging elsewhere, an early pioneer was the National Spatial Data Infrastructure (NSDI) in the United States (US Government 1995).

There are differences between the USA and Great Britain that mean that the NSDI would not export directly to Great Britain. These include factors that are cultural and legal (for example in the attitude to government information) and organisational (for example in the way in which in Britain government departments can - and do - compete). Equally in other countries there is a history of rationalisation of geography so that, for example, in France the départments and subdivisions form not only administrative but also postal, utility and other geographical units. This does not happen in Britain where as an example postal 'counties' do not exist administratively.

What therefore needs to be done to achieve the NGD vision in Great Britain ?

2.2 Standards:

Standards are necessary to provide access to data and to integrate data. For example, a land registration body will hold a unique reference number against a land parcel, the local authority will also hold data about that property - but each will have developed their own unique reference system over the years. The British Standard 7666 has been developed to support the creation of Land and Property, Street and Rights of Way Gazetteers through the assignment of unique reference identifiers. The gazetteer acts as a link between disparate datasets.

This is just one example, there are other standards issues which must be addressed if reliable conclusions are to be made from integrating two or more datasets.

2.3 Coordinate reference systems and transformations

Great Britain, like many countries has a well defined geodetic framework that dates from the 1930s. This is the base on which all the mapping has been created. New locational systems such as GPS give users much more ability to locate themselves absolutely and demonstrate the of the map framework.

Given three datasets each with coordinate resolutions to, say, 0.1 m. The combination of those datasets would not be non trivial if they had been based on different coordinate reference systems, for example, the British National Grid, ETRF89 (European Terrestrial Reference Framework 1989 used for GPS) and a local council plane grid. Proven and reliable transformation parameters are essential to merge the datasets with any confidence (ignoring the fact at this stage that the overhead of doing so over a wide area network within a geospatial query could be prohibitively expensive in terms of processing power).

There is a vast amount of data, referenced to old mapping that would be uneconomic, even with today's technology, to make compatible it with other data.

2.4 Data - populating the NGD

Currently no one knows just what geospatial information exists, how much of it is in digital form and to what extent it follows recognised standards. OS operates the SINES (Spatial INformation Enquiry Service) database on behalf of central government. SINES is a meta-database containing descriptions of nearly 600 geospatially referenced datasets. SINES is accessible on the OS website (address below). It is envisaged therefore that datasets will be gradually added to the NGD provided they meet certain criteria and as data providers wish to collaborate.

A primary motivation to join the NGD is likely to be the implementation of an application which itself may be driven by legislation, economic, commercial or "national interest" needs:

2.5 Applications of the NGD:

An NGD infrastructure would be of little value if it was inaccessible. As we have seen earlier, the provision of data encourages usage and innovation by customers. Potential applications are many; but three exciting examples are worth exploring further can come from the National Land Information Service (NLIS), Land Use Information Base - England (LUIBE) and agricultural subsidy monitoring.

NLIS is a joint collaboration between HM Land Registry, Local Authorities, the Valuation Office and OS. The principle aim of NLIS is to provide a land parcel enquiry system which can be used for conveyancing and other applications. The contributing databases are networked (via ISDN lines) and a user is able to make enquiries about specific land parcels, their value, ownership, planning constraints etc. At the heart of such a system are the land and property gazetteers discussed earlier which provide cross-referencing from one data providers dataset to anothers.

LUIBE: seeks to extend the current practice of recording land use change in England and Wales to the creation of a national survey to model and manage land more effectively for planning, statistical modelling and other purposes. Whereas land cover and land use surveys often adopt a raster/grid approach to the survey, LUIBE is based on the topographic reference base provided by OS data. This has a number of benefits, chiefly it is more accurate since polygon boundaries (such as hedges) pollute the statistics of grid based systems. Land parcel reference systems such as NLIS and other NGD applications are able to interrogate land use attributes of the polygons of interest (via the gazetteers).

Agricultural Monitoring: Even with the successful use of remote sensing - the European Community subsidy monitoring process remains a painstaking process for those that have to undertake it. As a minimum, three pieces of information are required:

- the farmers claim/record,
- a map defining the land parcels to which the claim refers and
- a 'processed' remotely sensed image.

Even with the map overlaid on the image the procedure still requires inspection and considerable manual intervention. Consider an environment where:

- each land parcel was uniquely referenced, a reference that the farmer was required to incorporate in a computer readable form,
- an on-line gazetteer of land parcels which indicated which database the land parcel polygon(s) was stored on,
- and an orthorectified remotely sensed and processed image.

Such an application could then be largely automated where the retrieved polygon would "cookie cut" the image and test against the claim for subsidy - subject to quality control and assurance sampling.

2.6 National Topographic Database

Much of the specification of OS data products has been driven by customers to meet specific requirements, some products such as OSCAR have been refocused as customers needs have become more clearly defined over time. As table 1 demonstrates there are a number of databases that service the customer and these collectively are known as the National Topographic Database (NTD). While the current databases are physically connected and coexist in harmony there is scope for improvement to eliminate data duplication, improve data consistency, data connectivity and hence the quality of the end products.

Work has therefore started in defining a target National Topographic Database which fully integrates the existing databases and will serve as a platform for new products and services from the end of the decade onwards.

The target NTD is a major piece of work and is Ordnance Survey's contribution to the National Geospatial Database. The current NTD is already a national reference framework for other data collectors/providers to tie their information to, by way of the National Grid or indirect referencing methods such as addresses.

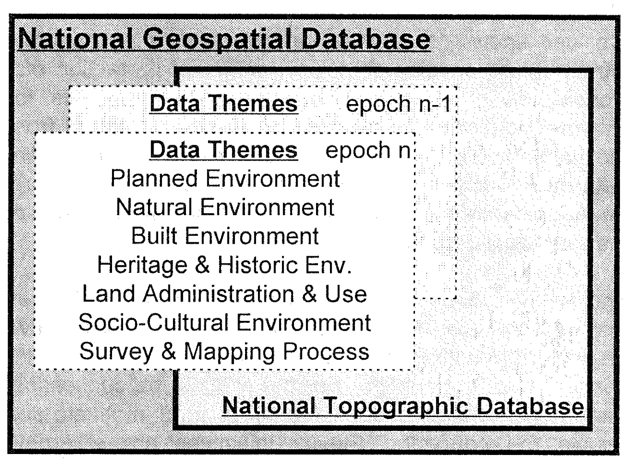

Figure 1. The potential scope, data themes and relationship of the NGD and NTD.

3. IMAGERY APPLICATIONS IN SUPPORT OF THE NATIONAL GEOSPATIAL DATABASE/NATIONAL TOPOGRAPHIC DATABASE

3.1 Introduction

Geospatial databases require careful management, quality control and quality assurance procedures to ensure data integrity and fitness for purpose. There are challenges in many areas: to reduce expenditure, to develop the product portfolio and to deliver new concepts such as the NGD. The challenge is to the technology and the people who can make it work for them. This final part of the paper will now examine the role of imagery within OS in meeting the needs of the future by populating and updating the data themes that make up existing and proposed databases.

The last 10-15 years we have witnessed some major photogrammetric advances and successes to migrate from the 1950's analogue technology to the analytical instrumentation and more recently their digital equivalents (Farrow & Murray 1992). Annually the base topographic information database accommodates an equivalent of 900,000 units of update (these may be houses, roads, forestry etc. - all features are measured in a common measure of units of change). Of this number approximately 20% is surveyed by photogrammetric means, by simple graphic tracing from single images to analytical instrumentation. Superimposed vector mapping over imagery is a very effective update mechanism.

3.2 Imagery applications in OS

The main area of recent investigation and development has been the development of the digital mono-plotting system based on the existing editing system. The threshold of a production digital image system has now been crossed and further investigations are planned.

The major reason for the adoption of a digital solution in the past 12 months is more to do with the technological infrastructure than with photogrammetric software availability. Earlier OS research showed that both the software and hardware environments were immature in the early 1990's. The latter has progressed significantly during the past 3-4 years with off the shelf workstations commonplace and local area network operation speeds increasing by a magnitude. Such is the pace of progress that automation of basic utilities, e.g. roll film scanning and high productivity are basic expectations that sit at the top of the buyers' list of requirements.

3.3 The use of digital imagery in OS

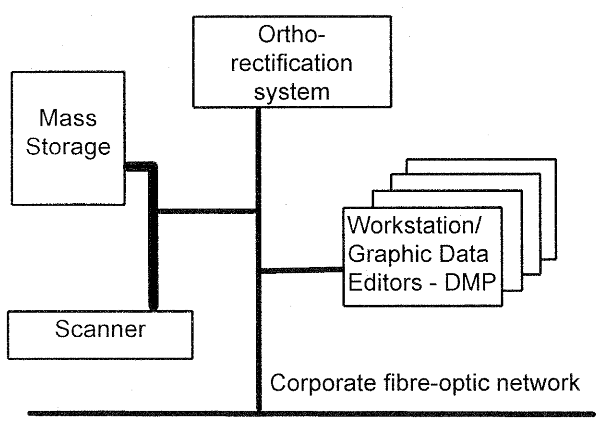

Figure 2: The OS Digital Mono-Plotting System

A digital image capability has now been established in production. Following successful trials and a production pilot a full production system is now in operation.

The system is primarily employed on the update of rural mapping using a single orthoimage matched centrally to National Grid kilometre square and is referred to as DMP (Digital Mono-Plotting system). DMP replaces some of the graphic aerial photographic methods, successfully employed by OS for over three decades. It will also replace some of the current OS analogue instrumentation.

It was a primary requirement of the development that OS use proven techniques and software where possible since the process involves modifying the primary asset of the organisation, i.e. the base topographic information. Consequently modifications were commissioned to the existing edit system and the process is a simple extension of the existing photogrammetric production system.

3.4 Investigation of the potential of space imagery

OS has invested extensively in research into the potential of space imagery over the past 15 years (Hartley 1991). This did not produce usable results until image resolution improved with the launch of SPOT-1 in 1986. OS then undertook the world's first extensive topographic mapping project in the civilian sector. Stereo SPOT imagery was employed to map over 25,000km^2 of north-east Yemen (Murray & Farrow 1988). Other investigative work and production projects followed. More recently this has involved a collaboration between OS and the National Remote Sensing Centre Ltd (NRSCL) to produce an image map of Christmas Island (Havercroft & Fox 1993).

Benefits of space imagery: The major cost benefit of the Yemen project was directly related to the reduction in the number of stereo models involved. In terms of data processing and labour it was estimated that this contributed to an overall cost saving of approximately 10% on the (substantial) project costs (Murray 1990). Timely data availability is a further advantage; if data can be acquired within hours or days rather than weeks then project planning can go ahead with confidence. Sadly the skies over Great Britain are not always clear and improvements in cloud penetrating techniques are always warmly welcomed!

3.5 New Space Sensors

For space imagery to be successful in Britain we concluded that an image resolution of 2 m or better was required to support the applications required to maintain the existing database. This threshold is now close to being realised with the declassification of military technology by the Clinton administration. There are now a number of high spatial resolution sensors being prepared for launch over the next few years. Table 2 provides an overview of some of the systems proposed.

System	Launch	Pixel-Nominal Ground Resolution	System
EarthWatch - Earlybird - Quickbird	 1996 1997	 3 m 1 m	Stereo Fore/Aft Panchromatic Panchromatic
Space Imaging -	1997	1 m	Stereo Fore/Aft Panchromatic
Orbview	 1998 1998	 8 m 1 & 2m	Stereo Fore/Aft Multispectral Panchromatic
SPOT 5a	2001	5 m	Stereo Fore/Aft Panchromatic

Table 2: High spatial resolution sensor systems planned for 1996-2001

3.6 Testing the potential

OS, in collaboration with the Department of Photogrammetry and Surveying at University College London and the Department of Geography at the University of Southampton, has embarked on a project to investigate the potential of the new high spatial resolution systems. The project is part funded by the British National Space Centre through their second Application Demonstration Programme.

The project is very much focused on seeking solutions to problems, for example:

- seeking more cost-effective/efficient ways of updating certain geospatial data themes,
- assessing the potential of greater automation in those processes,
- employing economies of scale, where say one or more update processes can be combined and utilise a image to minimise production overheads.

A common benefit the areas under investigation enjoy is that OS has extensive a priori knowledge in a digital form readily available to assist the process. This can be valuable in determining a ground surface DEM, for example, to minimise nugatory effort in populating areas where the desired height values are inaccessible.

Test Sites: The project has various facets: topographic mapping, enhancement of Digital Elevation Models, 3D urban modelling and land use/cover determination. Test sites have been established in Lincolnshire (low lying coastal), the Lake District (mountainous) and Hertfordshire (rolling agricultural land). Unfortunately there is no suitable space imagery currently available, simulated or otherwise. OS is therefore creating simulated imagery from recent aerial photography and is acquiring imagery from one or more of the following sensors: ERS-1/2, Wide Angle Optoelectronic Stereo Scanner (WAOSS) and the Compact Airborne Spectrographic Imager (CASI) systems.

Where possible airborne system parameters will be matched as closely as possible to one of the proposed space platform systems. It is hoped that by the completion of the work (early 1997) at least one of the new high spatial resolution systems will be acquiring data from which we can validate the results of simulated test data. Specific areas of investigation are:

Topographic Mapping An important issue when planning the deployment of survey staff and resources is to know what change exists and where it exists. Although OS already employs several approaches to solve this problem, it is believed that change detection methods can be improved. The nature and importance of change varies by topography and geography, e.g. a new fence dividing a rural land parcel may be much more important than the erection of a similar structure in an urban public park. Although urban change is often well reported, rural change is often more difficult to detect and hence is rarely fully documented.

Mapping, whether new surveys or revisions are considered, is also being examined within the project using mono and stereo image techniques.

Digital Elevation Models Now that the national high resolution terrain model digitising programme is coming to an end attention has focused on improving the maintenance and enhancement of that surface. Three areas of investigation within the investigation are:

- automatic detection of changes in terrain surfaces,
- remodelling the surface following major engineering works (highways etc.) and
- improving the surface resolution where the environment is sensitive to floods etc.

It is expected that existing topographic data will aid the process - for example, highway topography can be employed as breaklines and polygons defining buildings and woodland can be employed as masks either to prevent automated terrain modelling or as edit tools to remove spurious surface heights.

Building and 3D Urban Modelling There is growing demand to model the world as we recognise it in three dimensions for specific applications. It is safe to say that the next generation of data users who have been introduced to realistic 3D PC games systems at an early age are unlikely to tolerate anything other than an interactive model to test urban planning scenario, concepts or environmental impact assessments.

The benefit of an existing 2D dataset, and a supporting terrain surface, is seen as a major asset from which to start 3D or perhaps more realistically at this stage 2.5D modelling. Techniques are being explored to provide an upper building surface height and to more realistically model upper surface planes and structures.

As with any project the data population phase is relatively trivial compared with ongoing maintenance. Currently demand does not warrant the conversion of all survey OS techniques to capture 3D coordinates universally and therefore more pragmatic maintenance techniques are being sought.

Land Use The final aspect of the project will examine the potential of the new forms of imagery in populating and maintaining a land use inventory. Clearly there is little scope to accurately determine land use in urban areas from remote images but a high success rate in rural areas is expected. Again the investigators will benefit from a priori knowledge in the form of land parcel polygons.

4. CONCLUSIONS

If successful national economies rely on sound decision making then robust and timely information is essential to that process. Where much of the national infrastructure planning and development has a geospatial basis and to support this there is a need for comprehensive, high quality data.

Much of these data will be captured by different organisations. OS, in its role of providing the national topographic framework that underlies most other data, needs to provide data that are timely, accurate and affordable. High spatial resolution imagery whether from satellites or aerial platforms will contribute to this.

Computing power, networks, sensors and the technological infrastructure supported by wide collaborative research is already having a significant impact in realising the longer term aim of maximising automation in the data collection process.

In parallel with the developments in technology, standardisation, commercial and legal developments will ensure that the National Geospatial Database becomes reality and there will be a virtual model of Great Britain.

References:

Farrow, J.E. & Murray K.J, 1992. Digital photogrammetry - options and opportunities. International Archives of Photogrammetry and Remote Sensing, Comm. II pp397-403.

US Government 1994 Coordinating Geographic Data Acquisition and Access: National Spatial Data Infrastructure. April 1994 Executive Order 21906

Gilton M.B, Milam, D.R, Philbrook, M.L. & Reynolds G.R., 1996. GPS by bike: collecting utility data on two wheels. GPS World, March 1996, pp36-43

Hartley W.S, 1991. Topographic mapping and satellite remote sensing: is there an economic link?. International Journal of Remote Sensing Vol. 12 pt 9 pp1799-1810.

Havercroft M. & Fox D., 1995. The creation of processed satellite imagery products compatible with Ordnance Survey digital mapping. Association of Geographic Information 1993 Conference Proceedings, pp 3.9.1-3.9.4.

Murray K.J & Farrow J.E., 1988. Experiences producing small scale line mapping from SPOT imagery International Archives of Photogrammetry and Remote Sensing, Comm. II pp407-421.

Murray K.J., 1990 Stereo SPOT imagery: Applications in overseas mapping projects by Ordnance Survey of Gt. Britain Proceedings of the 10th EARSeL Symposium, New European Systems, Sensors and Applications, Toulouse pp77-86.

Nanson, B.W., Smith N.S & Davey. A.J., 1995. What is the British National Geospatial Database?. Association of Geographic Information 1995 Conference Proceedings, pp1.4.1-1.4.5.

Novak, K., 1995. Mobile mapping technology for GIS data collection. Photogrammetric Engineering and Remote Sensing, Vol. 61 No: 5 May 1995, pp493-501.

Ordnance Survey (1995a) Ordnance Survey Executive Agency Framework Document 16 pages

Ordnance Survey (1995b) Ordnance Survey Annual Report and Accounts 1994/95. 32 pages

Rhind D.W., 1995. Ordnance Survey to the Millennium: the new policies and plans of the National Mapping Agency. Association of Geographic Information 1995 Conference Proceedings, pp1.2.1-1.2.6.

Turner, J., 1995. The use of Pen Computers in the Update of Large Scales Mapping at Ordnance Survey. GIS'95 Conference Proceedings

Ordnance Survey is on the Internet at:

http://www.ordsvy.govt.uk/