THE DIGITAL NATIONAL FRAMEWORK – UNDERPINNING THE KNOWLEDGE ECONOMY

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ABSTRACT

Providing a sustainable spatial data infrastructure creates responsibility and high demand by continually meeting and satisfying the needs of all kinds of users. It is essential to provide the right information at the right level of quality and reliability and at the right time. Geographic information (GI) is today being universally recognised as a key part of the national information infrastructure, especially by government. GI is an enabler in the knowledge economy since the power of geography can be used to underpin the sharing (and trading) of vital georeferenced information collected by all kinds of organisations. From this information reliable conclusions can and will be drawn and decisions made.

However, achieving such an environment does not just happen. It has to be led, nurtured and developed in line with user needs. Funding requires sustained investment, and it all has to be implemented and maintained whether the economy enjoys good times or bad, and through periods of political change. These are all big challenges encountered by just about every national economy.

The aim of many national governments around the world is to establish a reliable and integrated reference base for GI that can underpin the e-economy. This base needs to support government and the commercial sector who need to reference information, and potentially share it with others (eg land ownership) or link it up to form an application.(eg location based services). To achieve this a consistent method of georefererencing is required and the Digital National Framework is intended to fulfil that need in Great Britain.

This paper will describe what has been happening in Great Britain to build on the firm foundations of the past, and develop a modern and sustainable framework for geographic information for the future. In particular it will be shown that the business model adopted by Ordnance Survey in recent years (ie the users pay for the data) has played a key role in securing the ongoing funding of the modern information infrastructure that many nations are now working towards. It will also be seen that this does not mean exorbitant prices and in reality several valuable services are free of charge.

Keywords: Customers, knowledge economy, data exchange, TOID, data maintenance, spatial data infrastructures, framework for geographic information, sustainable futures, user-pays, OS MasterMap and the Digital National Framework (DNF).

1. INTRODUCTION

1.1 The Knowledge economy

Making the right decisions is more important today than it has ever been, whether it is in developing the national economy by government or by the citizen making their own plans for the future. Where do we build 20,000 new homes? ….how do we revitalise this run-down urban (or rural) area?, ….which house shall I buy?, ….is my property at risk? ….and so on.

These are vital questions that face each and every one of us in the rapidly changing world we live in. Decision making requires knowledge, knowledge requires reliable information and reliable information

requires data from several sources to be integrated - *with a known level of pedigree and assurance*. A key common factor in many of these decisions is location ie geography. Events, properties and movement of individuals, all happen somewhere. Therefore geography is the common denominator in enabling the connection of information which is related to a specific location(s) be this an address, a building, a river or a highway.

1.2 Geographic Information

Geographic information encompasses all kinds of data, generally (but not always) in a graphical form. Two forms of geographic information are commonly recognised and the distinction has been developed in the European Commission's INSPIRE initiative to develop consistent geographic information across Europe (European Commission [EC], 2003).

- Reference Data (eg the "map base")
- Thematic/User data (ie items the user will record on the map base).

Typically "Reference Data" will include topographic features (land parcels, buildings, roads, paths, rivers, etc), Digital Terrain Models (DEMs), addresses, aerial/space imagery, and administrative boundaries, transport networks, hydrological network, hydrographic charts, geological data etc. Users of this information will record their own information and assets in this reference base (eg property, gas pipes, power cables and plant, crime locations, census data, health conditions, river pollution, etc.

In the world of paper mapping it was very difficult to exchange such records as people used different scales of mapping, different coordinate systems or map projections, and different methods and approaches, often within a single organisation. Clearly integration of say gas and electricity records was at best very difficult in the vast majority of many cases in paper-based systems.

As we entered the digital world organisations largely and quite naturally used the new technology to replicate what they had done in the paper world. They digitise the same information using the same sort of map. In many cases it was easier to scan the paper map. Over the past ten years people have realised that investments in data creation and especially data maintenance are financially very significant and therefore need to be made wisely. The inability to easily integrate different records to determine the solution to a problem has been a barrier to progress.

For example the integration of an environmental order recorded at 1:50,000 scale has geometric limitations compared with property information surveyed at a 1:1,000 level of accuracy and detail. Hence answering the question: "is my property affected by the environmental order?" could be inconclusive. This is leading to the adoption of a more strategic approach and this is now being sought based on a consistent reference base and methods of georeferencing.

1.3 The position in Great Britain in the late 1990's

In Great Britain, the use of geographic information is already widespread across many market sectors, from Government (central government and local authorities), utilities and a multitude of private sector applications. An independent study (OXERA, 1999) showed that around £100 billion of the GB GDP in 1996 was underpinned by Ordnance Survey information in some way.

Figure 1. The 1999 OXERA report – the report is available on the Ordnance Survey website.

However, as noted above, little of the electronic thematic/user information that was collected, managed and used at the time the report was written could be easily cross referenced or automatically interchanged because the goal of users at that time were largely project driven and often isolated from other developments – often within organisations. While this situation applied to Great Britain where a common metric reference base has been in developed since 1938 (Ordnance Survey, 1938) and complete national digital mapping since 1995, and it applies perhaps to an even greater extent in other parts of the world.

When a user obtains geographic data it is not uncommon for additional effort to be required, to prepare it for an application eg reformatting, or matches it with another dataset. In many countries it may be out of date or require 'cleaning' to make it fit for purpose. All of this activity is an essential, but unwelcome burden, on whoever has to undertake it. Ideally it will be undertaken only once and thereon preserved and maintained.

Data conflation and clean up adds costs and time to a project. In terms of national efficiency, and the knowledge economy, this is highly counter productive. While it may provide income for companies who spend much of their time joining up fragmented datasets, it leads inevitably to massive duplication and a major waste of energy and national potential. Very often this data preparation will be undertaken on behalf of government. Hence the taxpayer ultimately pays the price:

- through higher than necessary taxes,
- a government machine slowed down by poor quality unconnected information,
- poor strategic decision making at national, regional and local levels

The evidence therefore suggests that there is even greater potential to support the national economy by providing a more rigorous spatial data infrastructure to meet not just today's challenges, but to position the nation for tomorrow's e-economy as well.

In Great Britain, we are fortunate to have inherited firm geographic foundations (Ordnance Survey [Davidson Report], 1938) and a programme to re-map the country following the Second World War. This moved on into the first cycle of the digital era, defined as "digital mapping" (from 1980 to 1995). This established a robust foundation on which the OXERA report was based. Ordnance Survey is now developing and investing in the next generation "framework for geographic information" to better meet the needs of the information economy and this is discussed in the following sections:

- Fulfilling a national need
- Data Quality & Standards
- Financing
- Making it happen
- Other Models

2 FULFILLING A NATIONAL NEED

2.1 Digital Mapping

Ordnance Survey's direction is increasingly driven by meeting customer's needs. In the early days, like many organisations, the aim was to simply "make the data available"; almost a by-product of an internal process. Initially this was simple topographic digital map data but soon users demanded other kinds of information. These were developed, eg road centreline databases, boundaries, elevation models, addresses and so on. In some cases it also introduced collaboration with other agencies (eg Royal Mail) to create a national database of addresses each georeferenced to 10cm and in another case the private sector (Landmark Information Group) to scan all the historical maps of Great Britain.

However there was little explicit linkage across any of these rapidly evolving products. Although they are all regularly updated, they were effectively never in synchronisation from a customer perspective. For example a building may be available within 24 hours of survey, but the related address information may take 3 months to be released. The reason for this was due to the database developments required to meet short term (ie 1-2 year) product development needs and thereon the treatment of separate

products. In defence of this approach - it was impossible to design and develop an integrated database from the outset. The technology simply did not exist and time was an unaffordable luxury. Hence each product was supported by its own database in the 1990s.

2.2 Interoperable geographic information

Customers today expect more; they are themselves now much more experienced in handling geographic information, better prepared professionally and demand value for money.

To meet this challenge Ordnance Survey has embarked on several parallel developments to ensure that customers can start to concentrate on gaining greater benefits directly from geographic information. This is being achieved by making major investments in the staff, the data and IT service delivery infrastructure. Key initiatives, already underway, aim to establish new levels of customer care, supported by new customer-friendly on-line service delivery channels. Much of this is being achieved within an integrated development programme and a major output of this is OS MasterMap™ (Ordnance Survey, 2003). OS MasterMap is a layered database of geographic information (ie reference data/information) and the supporting customer selection and delivery service. OS MasterMap will, in time, supersede the existing offerings.

2.3 OS MasterMap

The first release of OS MasterMap took place in November 2001 offering Topographic information as the first layer of an integrated and consistent geographic database. The concept of the "layer" is a convenient mechanism to segment the database. Layers include Topographic Information, Height, Imagery, Digital Elevation Models and so on. The database is national and seamless across Great Britain (England, Wales and Scotland) and each layer is often broken into themes such as land, buildings, highways/paths, water in the Topographic layer etc. The customer can therefore select just those themes they need for their application and the area of their choosing.

Collectively this is more correctly described as "geographic information" rather than "mapping."

In 2002 the national georeferenced database of 26 million property addresses has been brought within the OS MasterMap environment, cross referenced to their respective building features. In 2003, and beyond, this will be augmented by the inclusion of the initial themes of the Integrated Transport Network layer, a 25cm colour Orthoimagery layer and a height layer later. Further datasets are also being readied for inclusion eg administrative, electoral and statistical geography boundaries, land and property, land use and others.

In meeting demanding government business targets the data can be ordered on-line via a map interface and delivered on-line or via media. Change only information at feature level is also supplied on line after the initial supply. OS MasterMap is recognised by government as a key vehicle in joining up government information and processes and disparate government services at local, regional and central government levels.

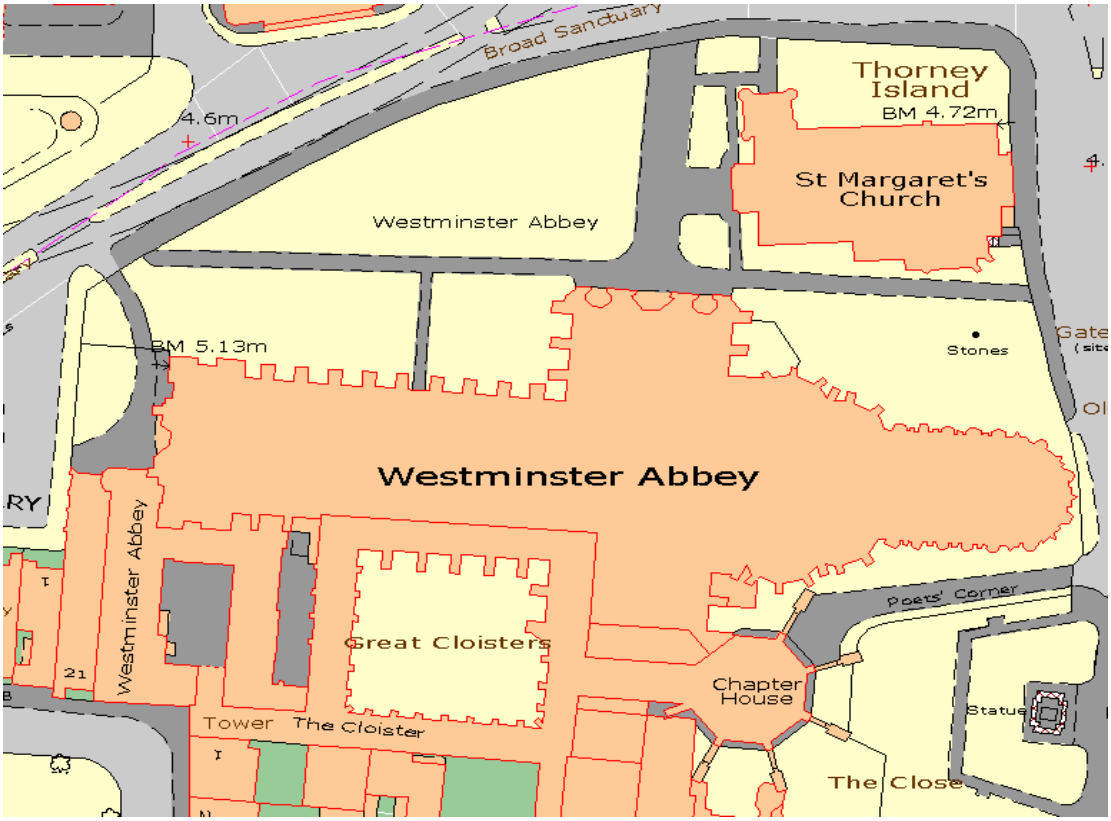

Figure 2. An extract of OS MasterMap, Topographic layer and selected themes of Westminster Abbey, London. Each feature, whether it is a point, line or area feature, has its own unique identifier known as a TOID onto which users can link and reference their own information.

OS MasterMap Topo is a truly seamless database of over 420 million topographic features (see OS MasterMap pages in the Ordnance Survey website: Ordnance Survey, 2003). Major detailed urban information is recorded in the database within six months of its construction and rural areas are updated every five years. Well over one million features are changed (added, modified or deleted) each year. This change is sourced through Ordnance Survey's surveyor network (~ 45% change) using real time kinematic GPS, through photogrammetry (internal and external resources ~ 45% change) and through the adoption and integration of design plans from builders and engineers (~ 10% change and increasing in 2001-02). This information is made available before sites are developed and is well suited for use by the utilities in planning their service routing etc.

Several of the new layers demand close collaboration with customers/users or third parties in government, for example Royal Mail continue to provide address information and HM Land Registry surveyors now feedback minor changes to property boundaries. A collaborative project with the UK Hydrographic Office and the British Geological Survey is working on joining up the land and, marine information both horizontally, vertically and semantically (Whitfield & Pepper, 2003). Similar joining up initiatives are also evident at the national level eg harmonisation collaboration with sister organisations in Northern Ireland and Ireland (Murray, Bray & Steenson, 2001).

From the National Geospatial Database (ie the master database) all future products such as OS MasterMap and other derived datasets will eventually flow, as much by automation as is possible (Lilley, 2003).

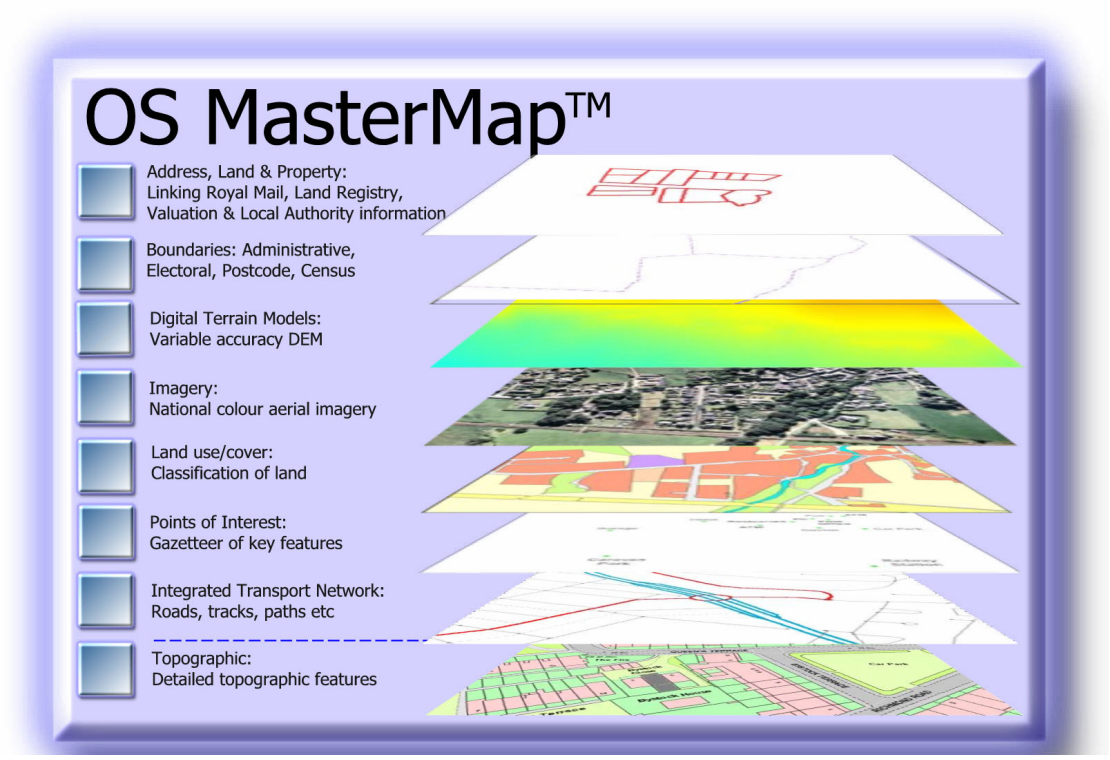

Figure 3. OS MasterMap – the vision for the main information layers. These will be interoperable based on DNF methods and standards. It will provide the underpinning reference base for location-based information inside and outside government.

3 DATA QUALITY AND STANDARDS

3.1 Data Quality

An integrated information infrastructure upon which fundamental decisions will be made, or where lives are at risk, demands proven standards. The information and data must be maintained to acceptable data quality levels (AQL's) and this will determine whether data is fit for purpose in terms of accuracy, completeness, currency and consistency. When billions of £ are being invested annually by users of the spatial data infrastructure, it is absolutely necessary to reassure those users that their foundations are secure. Ordnance Survey has always maintained tight control over all these parameters regarding the national database and has earned an enviable worldwide reputation for quality.

3.2 The Digital National Framework

The new OS MasterMap environment will be consistent with a new set of geospatial data standards and methodologies, known collectively as the Digital National Framework (Ordnance Survey, 2000). The components of DNF are being developed in conjunction with other mapping agencies and a wide number of users. Within the DNF conceptual model features such as buildings, land parcels, roads etc *each* hold a unique identifier known as a TOID – this is a simple 16 digit integer with no intelligence. The TOID will support discrete feature referencing, essential in a seamless database. The TOID also supports data linking to underpin data sharing by users who have georeferenced their information about a specific and common location. Features are versioned and hold metadata eg date of last change, reason for update etc and features in different layers are cross referenced eg road center-lines with topographic road features, buildings and addresses.

Each uniquely identified feature describes a specific location in Great Britain. Each building has a unique number; this enables several users to record information against this feature identifier and if they do this consistently in future they will be able to link their information and perform automated

data conflation tasks impracticable today. Information interoperability is seen as business critical today (Murray & Mahoney, 2003).

The DNF model also supports interoperability of features, whether these are in the reference data such as OS MasterMap or the information that users collect and reference to OS MasterMap. For example the linkage between land parcel information eg ownership or occupancy information, can be made explicit through the TOID (see Figure 4). This has several advantages in terms of data reliability, maintenance and future web services.

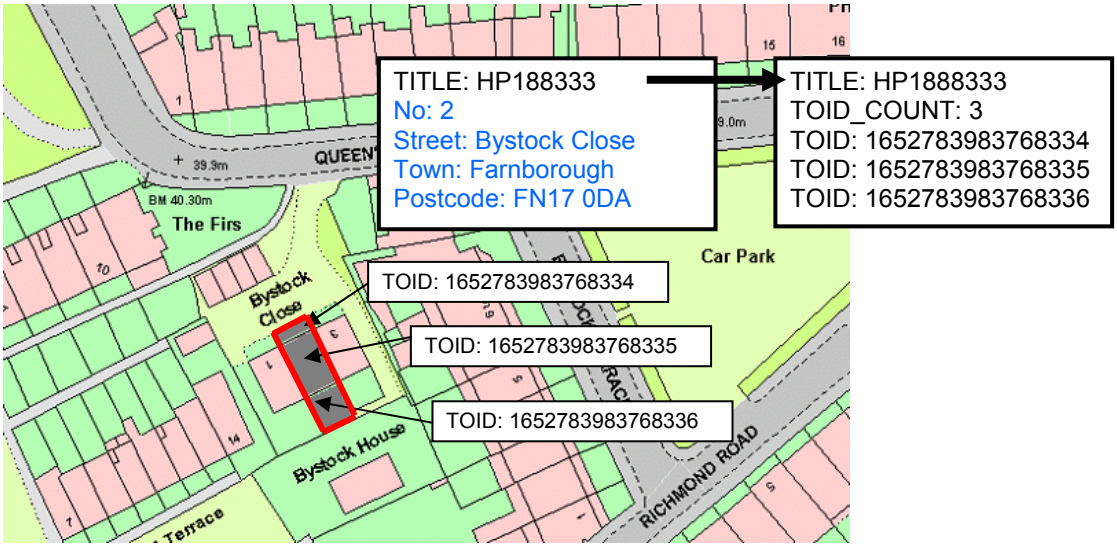

Figure 4. Explicit linking of the reference Topographic Information, Address and the user Land Ownership or Occupancy information. The parcel is made up of three topographic features (building and land to front and rear). These features are referenced by TOID and the parcel can therefore be defined simply as a TOID list. Third parties may only reference the building but the common use of the TOID means that their data already can be automatically linked with that of third parties.

3.3 Evolving Best Practice and Standards

This conceptual information framework (DNF) has been designed to meet national needs (Ordnance Survey, 2000) but is well placed to support wider initiatives such as the emerging European spatial data infrastructure known as INSPIRE (EC, 2003) and other commercial pan-European datasets. DNF will incorporate as many existing and proven standards as possible whether these are de jure (eg ISO), agreed standards such as EUREF or emerging standards through pragmatic testbed research (eg OpenGIS). For example OS MasterMap data is available only in GML, (Geography Markup Language) from the OpenGIS Consortium. The decision to use GML was mandated by users and industry technology players in several stakeholder seminars when OS MasterMap and the Digital National Framework were being developed.

4 FINANCING

Since its inception in 1791, Ordnance Survey, was a substantially government funded department but that changed from the mid 1970s with the introduction of revenue based financial targets. These targets have risen from an initial 25% cost recovery to achieving an average of 9% Return on Capital Employed over five years to 31st March 2004. This follows the transfer to Trading Fund Status in 1999, since when Ordnance Survey has received no direct funding from government (Parliamentary Vote).

This growth in the business has primarily been achieved by significantly expanding the use of geographic information based on non-exclusive licensing of data and not by imposing arbitrary price

increases in excess of inflation. Ordnance Survey therefore operates a fully user-pays business model to collect, maintain, invest in and disseminate the national mapping database of Great Britain.

It is the total dependence on customers that has brought a sea change in thinking across the organisation. Everyone now has to think about customers as a priority, if we do not provide the customer with what they want the customer can, and will, go somewhere else. There is no longer the financial safety as in the days of the Vote, though even then fortunes regularly changed with economic and political priorities. Equally customers continually expect more for less which in turn demands an ongoing critical reassessment of costs incurred and transfer of the same pressure to our own suppliers to reduce their costs.

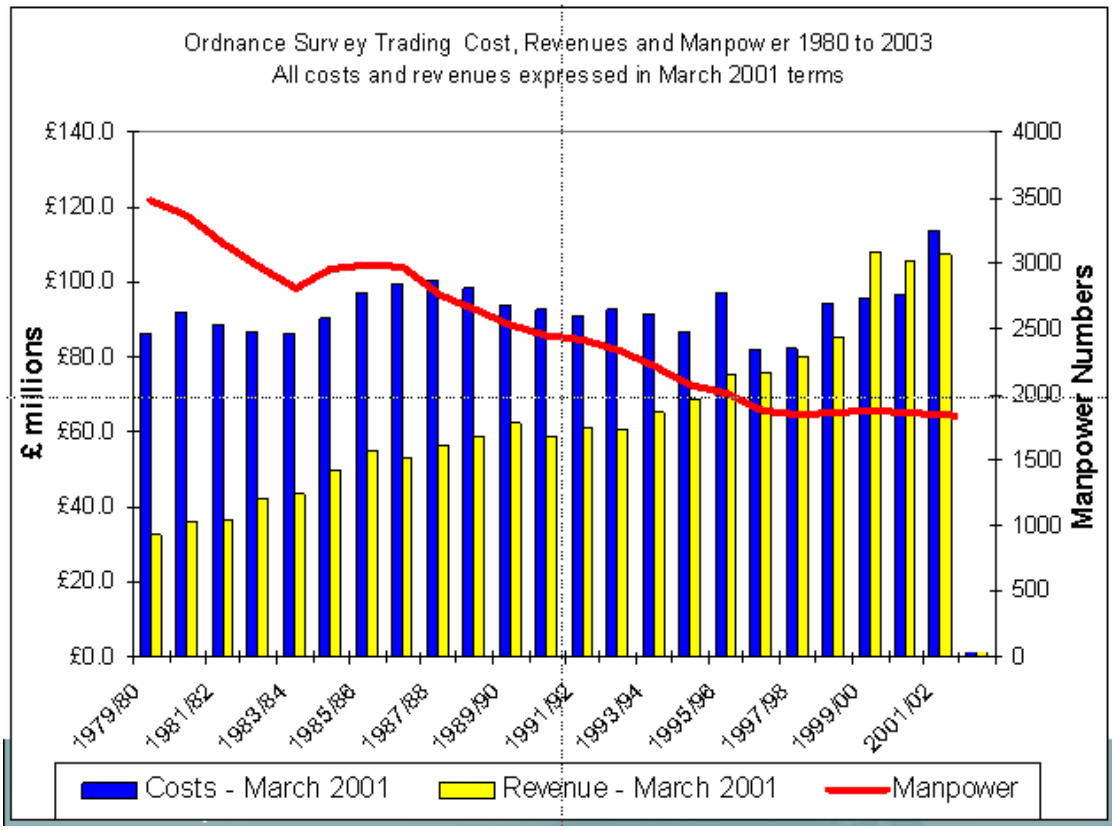

Figure 5. The Ordnance Survey's performance over the last 22 years. Costs are total operational costs for each year including any external spends. (Ordnance Survey, 2002).

Figure 5 demonstrates that broadly over the past twenty years total costs (these include all costs plus a small return on investment) have been held within +/-10%, revenues have tripled and the manpower has reduced by 50% (the staff figures do not reflect the use of contractors for map updating but contracting costs are included in the total costs). In the last 24 months significant investments have been made in OS MasterMap and the organisational infrastructure thereby deploying the surplus revenues of the previous two years. By any measure these figures demonstrate significant benefits of the user-pays model, especially when put together with the detailed datasets that are available and their multitude of uses in the economy as described in the OXERA report.

In late 2002 Ordnance Survey announced that a further 355 permanent posts will be phased out over by March 2004 owing to the advantages new technology is bringing. Revenue has been relatively flat in the last couple of years due to our ability to hold prices and in some cases make significant price reductions to maximise utilisation eg small scale digital products ('business geographics') and the georeferenced address product (ADDRESS-POINT).

NIMSA (National Interest Mapping Services Agreement) is a non profit contract with Government to support non-commercial services such updating rural areas, the immediate provision of services in an emergency, scientific work etc. NIMSA focuses on the database and other national interest activities

(not product supply) and currently accounts for ca 14% of the budget. NIMSA is expected to reduce significantly over the next 3 years.

In summary, the approach to funding we now have in operation imposes an internal discipline in line with the private sector.

5 MAKING IT HAPPEN

5.1 From theory to reality

The vision for Ordnance Survey provides the focus which is:

Ordnance Survey and its partners will be the content provider of choice for location based information in the new information economy.

This statement recognises that Ordnance Survey needs partners, that national mapping agencies are encountering increased competition and that knowledge of location in the new economy is a powerful asset in many applications. "Making it happen" calls on change and new ways of working, these are:

5.2 Partners

Ordnance Survey made a conscious decision to withdraw from the applications market about three years ago and to concentrate in providing a quality, robust foundation for the spatial data infrastructure. Partners are vital in taking the geographic information Ordnance Survey creates and maintains and develop applications adding value in the process. Such partnerships are essential in developing the use of geographic information across a wide span of dynamic new markets. Partners also have the expertise and industry knowledge to develop specific markets exploiting the same detailed and maintained geographic information, for example:

- companies such as Tele-Atlas incorporate regularly updated highway network data into their navigation applications which they combine with other data and sell on to vehicle manufacturers.

- the Landmark Information Group use detailed mapping in several applications – such has checks for contaminated land when purchasing property.

- Hutchison 3G with the new "3" brand of 3G mobile services incorporate OS MasterMap conflated with other data in their location/navigation mobile phone applications.

Ordnance Survey's role is therefore now clearer – it is not to engage in these kinds of applications, but to concentrate on providing a high quality geographic information framework for others to exploit and making this accessible in innovative ways.

5.3 Easy access to information

Several service level agreements have been established over the years. The main ones being with central and local government, utilities and others to ensure that organisations have easy access to the data thereby assisting everyone to obtain the maximum benefits from the data.

The most recent and exciting of these is the Pan Government Agreement (PGA) which makes Ordnance Survey detailed mapping available to nearly 600 government bodies. When the new agreement was piloted in April 2002 there were just 40 bodies taking the data, this trebled in just 6 months and an agreement is now secured for the next three years.

Users of Ordnance Survey's web-site will have noticed that a lot of information is free, including the Get-a-Map service. Many customers who license Ordnance Survey data provide free to view services through their web-sites eg local authorities in the communication of local plans to the citizen.

5.4 Cultural change

There has also been a major overhaul at Director and senior manager levels to ensure that staff are able to meet the new demands the emerging knowledge economy is bringing. It is also necessary to attract and retain key staff and several programmes are in place to ensure that the organisation is ready to respond to future demands.

6 OTHER MODELS

While most countries have established national mapping agencies the national structures vary significantly. It is quite common for countries to incorporate one of the land agencies (ie cadastre and or the land register) with the mapping agency – especially those nations visited by Napoleon in the 19th century. In others such as the United States or Australia there are different levels of operation such as state and federal level. Therefore direct comparisons are not entirely possible and cursory comparisons can be misleading. Whilst bearing this in mind it is possible to review the overall approaches and compare four leading countries at a high level.

France
The mapping agency Institut Géographique National – France (IGN-F) recovers some of its costs (less than 50%) from the sale of its data. Its largest scale of survey is ca 1:20,000 scale (BD-Topo). This is a new photogrammetric survey. The 25-year programme commenced in the early 1990's, however the demand for its completion has been acknowledged. This is currently being accelerated by updating and integrating existing datasets.

Germany
The states (Lander) in Germany are responsible for the national survey at 1:10,000 to a common specification (ATKIS) for Topographic data, DEMs and Imagery. The topographic information does not include land or buildings that are in the cadastral database. The national mapping agency Bundesamt für Kartographie und Geodäsie (BKG) is responsible for drawing together the national dataset and also for derived smaller scale products. The need to create a national data infrastructure (SDI) is recognised at federal level but some Lander have established their own SDI services eg Nordrhein – Westfalen.

Sweden
The National Land Survey of Sweden Lantmäteriet (NLS) is both a national mapping agency and the national cadastral authority for Sweden. The NLS provide a wide variety of modern data and consultancy services with revenue of 1.3bn Swedish Krone (SEK) of which 900m SEK was earned from the sale of data and services in 2001.

United States
The United States Geological Survey (Mapping Division) is responsible for federal mapping in the United States. Data is supplied to users at the cost of dissemination. Several national datasets are held at 1:24:000 scale (eg Topographic, DEM, Imagery, Hydrology) with most sheets nearing 20 years since their last revision. The USGS is now driving a new initiative to establish an integrated layered database of the US called "The National Map" and are currently exploring how this might be developed, maintained to a high level and funded.

From these four prominent NMAs and Ordnance Survey we can see how different operations are. The level of detail (mapping scale) varies as does the current availability of up to date information and the interoperability of that information. Some agencies are very advanced in developing their national infrastructures while others are in different stages of planning and redevelopment. The e-revolution is having a dramatic effect on NMAs as was predicted in a workshop in 2000 (Gower, 2001).

There is however there is a strong correlation between those agencies that have commercially oriented business models and the provision of complete, yet always developing, national information infrastructures. This is of course very much related to the national culture and way of doing things. What may work on one country may not work in another.

As a footnote here is worth recording that some NMAs in Europe have suffered significant budget cuts in recent years (eg Denmark & Norway), as national governments continually readjust their priorities. Clearly the continued development of the national geospatial information infrastructure becomes very difficult in those circumstances.

7 CONCLUSION

In conclusion the paper provides evidence to support the approach that Ordnance Survey has taken, driven by the UK Government in providing a modern framework for geographic information along the lines of a commercial model. This in turn has the potential to enable and advance the knowledge economy. How successful this will be will not be answered for some years since ways of working require time to adapt.

The new infrastructure in Great Britain is being achieved rapidly while maintaining the organisation's reputation for quality, innovation and as a leader in the GI world. This approach is underpinned by substantial experience in several key business and technical areas:

Customers: The successful operation of a mapping agency such as Ordnance Survey is dependent on understanding and tuning the organisation's activities to meet customer needs, today and tomorrow, in a coherent way that supports the national economy.

- This in turn drives everything else in the organisation.
- Government, as a customer, values information that they "pay" for.
- Consequently the customer is now more involved in process of evolution of the database.

Information: It is clear that the revolution in the use of GI in the last 5 years has placed high demands on national mapping agencies and most are re-engineering or redeveloping their databases to service the e-commerce model.

- The right information at the right time is key to meeting customer's needs (which can and do vary considerably).
- OS MasterMap is seen as a pragmatic and evolutionary development to underpin the massive variety of user applications with a common reference framework.
- The commercial model ensures that funds are available to invest in developing the database – but priorities are essential.

Technical consistency: In the electronic world, more than ever, it is important to set and work to common methods and specifications, in time these will become standards.

- The absence of common methods of georeferencing led to users to adopting method common with paper mapping processes.
- When we wish to link and exchange this information we find that it does not lend itself to automated conflation.
- Hence the gradual evolution of the Digital National Framework to support greater consistency in georeferencing and internal integrity of the national data assets.

Commercial approach: There is an instant appeal to the notion of free infrastructures, such as free public transport etc, but we all know that someone has to pay and that generally this should be the primary beneficiaries ie user(s).

- All stakeholders then benefit from a focused model where cost, product, service quality and delivery are tuned to the (paying) customers needs.
- Volume usage keeps prices as low as possible through the economies of scale then available.
- The user-pays model serves to incentivise all those who engage in it and ensures that the products are fit for purpose and priorities set and met.

Cost control: The commercial model also acts to ensure that there is a constant pressure to keep data production and support costs as low as possible.

- Minimising the costs while retaining the delivery high quality maintained information in a customer friendly way is a critical objective for all stakeholders in the national information infrastructure.

Partners: As the market for GI grows, not only is a professional approach to all aspects required, but greater is the reliance on others. Whether this involves partnership with contractors, collaborative engagements across government, the private sector or value-adding partners who focus on applications in key parts of the wider information industry, all are essential stakeholders in achieving the national vision for integrated geographic information and derived benefits.

Ordnance Survey is not unique in operating a successful user-pays model, especially in Europe. The value added partners in Europe often start from a stronger base compared with other parts of the world. Greater opportunities to *add real value* then exist and are already being exploited.

Finally, without such a model it is clear that many innovative Ordnance Survey developments over the past five years would not have got this far. The new products now emerging for the next generation user are essential in positioning a nation at the forefront of the global knowledge economy and in maximising the outputs of its valued resources, be those people and/or materials.

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