Geospatial Data Integration : Panacea or Nightmare?

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Commission II

KEY WORDS: Integration, Geospatial data, Imagery, Topographic data, Ordnance Survey

ABSTRACT

Ordnance Survey®, as Britain's national mapping agency, is continually searching for ways of improving and enhancing its products and services for today's increasingly sophisticated geospatial data users. OS recognises that its ability to deliver against these targets is restricted if it continues to collect and maintain data solely using existing methodologies. It has therefore adopted a proactive approach to investigating potential alternative sources of data to complement those that it already collects.

The added value to be gained from integrating multiple geospatial data sets is illustrated, within the context of OS's business, at all stages of the data capture, maintenance, exploitation life-cycle. The value of high spatial resolution satellite imagery is shown to be at its greatest when integrated with other data sources.

If the full potential of integrated processes and products are to be realised, it is essential that appropriate storage and distribution mechanisms are developed to handle these new data. OS has already begun the process of rationalising its fundamental technical infrastructure in anticipation of the continuing growth in this area. Nationally, there are initiatives underway to proactively promote the availability and integration of geospatial products through the National Geospatial Data Framework.

There is also enormous potential for the development of comprehensive product and service delivery mechanisms through the exploitation of multiple data sources. The next decade will see an enormous growth in the provision of on-line geospatial data services, derived from multiple data sets in different source locations.

Whilst the integration of geospatial data sets has real potential to improve many data collection, management and provision processes it should not be regarded as a universal panacea. There are political and technical issues which will remain to be resolved before full advantage can be taken of the promised benefits that accrue from the wholesale integration of geospatial data sets.

1. INTRODUCTION AND BACKGROUND

Ordnance Survey® (OS) is Great Britain's national mapping agency and has been in existence for 207 years. It is responsible for the creation of the world's first large scale digital database with national coverage, equivalent to almost a quarter of a million conventional map sheets. In parallel with this enormous data capture exercise, OS's product range has extended considerably in recent years to meet the demands of the rapidly diverging geospatial data and services market. Innovations in recent years have included the implementation of automatic generalisation techniques to create mid-scales mapping, mapping on demand through approved retail outlets and web-based mapping. OS has also established a firm presence in the market for the provision of bespoke geospatial data and on-line services, such as the National Land Information Service, which is currently offering a pilot conveyancing service to solicitors in the Bristol area of the United Kingdom.

This rapidly expanding and evolving portfolio of products and services reinforces the often reported vigour with which the geospatial data industry is expanding. OS intends to continue to be a major force in this market place and is continually changing its business processes to meet this need. OS's position as a UK Government Agency means that it is also responding to economic pressures to become a self-sufficient, financially viable organisation. In the last financial year, 1997-98, it recovered 97% of its costs, representing £74.6 million.

As part of its continual efforts to maintain and improve its products and services to its customers, OS carries out regular market research. Recent results have shown that, due to maturing business needs within the geospatial data user community, the most important requirement for OS data is for more up to date information and the need to maintain and enhance the data specifications for today's increasingly sophisticated users. OS recognises that its ability to deliver against these targets is restricted if it continues to collect and maintain data solely using existing methodologies. It has therefore adopted a proactive approach to investigating potential alternative sources of data to complement those that it already collects.

Many of OS's existing products and services are created from the integration of a range of data sources. This is usually not apparent to the customer, who usually has no requirement to know its detailed provenance. It is anticipated that the integration of an ever diversifying set of source data will radically increase geospatial data provision within the next decade. OS also recognises that the accruing benefit from remotely sensed imagery does not solely derive from its use in data capture and extrapolation. Any broadening of data source provenance will also have a considerable effect on the methodologies that OS employs to manage and maintain its data holdings. It therefore follows that the adoption of diverse data must consider not only its ability to deliver additional/more economic products, but also the likely impact on OS's systems and data infrastructure.

Increasingly, customers will also view imagery as another data source to complement existing data sets, either for historical, topographical or thematic purposes. Therefore, this paper considers the impact of new and proposed geospatial data sources on the life-cycle from data availability and data capture, through data maintenance and management to the potential for application and product development. Throughout, the emphasis will be on the potential of new imagery although many of the arguments and discussions could be applied to other geospatial data sources.

2. DATA AVAILABILITY & CAPTURE

2.1 Imagery at Ordnance Survey

The use of imagery (whether analogue or digital) has an established pedigree within OS's map-making heritage. Photogrammetric techniques have been employed since the early decades of this century as a fundamental part of its data capture programme and will continue to be used for the foreseeable future. Innovations within recent years have included the adoption of a digital 'monoplotting' flowline for digital update of large scale mapping. This approach uses the superimposition of digital map data upon an orthorectified image which has been scanned from conventional aerial photography. Digital monoplotting has proven to be a very successful method of carrying out rural revision work, where the need to efficiently identify and capture areas of change makes the process especially appropriate. More recently, the development of photogrammetric production techniques has been advanced with the acquisition of a Digital Photogrammetric Workstation by the corporate Research Unit.

Ordnance Survey has been researching the potential of satellite imagery to enhance its data collection processes for more than seventeen years. These studies all concluded that imagery with a resolution finer than 2m was required to be appropriate for topographic mapping at large scales (Murray and Farrow, 1988, Hartley, 1991, Havercroft and Fox, 1995)). As a direct consequence of this, Ordnance Survey, in common with much of the geospatial data industry, has been keeping a very close watching brief on the race to launch high resolution sensors, since the appropriate technology was declassified by the Russian and US governments in the early 1990's. It has shared the disappointment and frustration experienced by the successive delays and mission failures that have continued to postpone the availability of large scale imagery.

It is against this rich background of experience that OS is seriously considering the appropriateness of high spatial resolution imagery and its potential in all aspects of geospatial data exploitation.

OS believes that, due to the pre-emptive research that it has undertaken, it is in a very good position to estimate the potential impact that this data will have upon the organisation. Foremost amongst the research that it has undertaken is the successful two year major research project known as LANDMASS, (Land and National Digital Mapping from Advanced Satellite Sensors). This eighteen month project investigated the potential of the application of high spatial resolution satellite imagery to various aspects of OS's product portfolio and data capture techniques. The project was carried out in conjunction with the Department of Photogrammetry and Surveying (now Geomatic Engineering), University College London and the Department of Geography, University of Southampton, with part funding from the British National Space Centre as part of its Application Development Programme, 2nd round.

Previous research had identified six areas of potential benefit to OS's business processes resulting from the integration of high spatial resolution satellite sensor imagery with other data sets. Each of these was investigated as a separate work package. Common to each of these topics was the use of various simulations of high spatial resolution imagery, designed to be as close to the anticipated specifications of the forthcoming imagery as possible. For all but the land use investigation (see section 2.7) the imagery was simulated by scanning aerial photography at a 1m pixel resolution. An indication of detectable detail at this resolution compared to 3m and 0.2 m resolutions is shown in Fig 1, which contains images of the Albert Hall at each of the resolutions.

A summary of the research is presented here, but more detailed results have been published (Ridley et al, 1997).

2.2 Topographic Mapping

It is often assumed that the greatest potential impact of high resolution imagery is its possible use in fundamental topographic mapping. Satellite imagery is likely to be more readily available, more frequent and cheaper than commissioned aerial imagery. The larger ground coverage also means that set-up overheads will also be lower for the same area.

Monoscopic and stereoscopic techniques were used to carry out basic topographic mapping of rural and moorland areas. An evaluation of both feature identification and geometric accuracies was carried out by directly comparing the results with the existing topographic database for the sample areas. Feature detection accuracies are shown in Tables 1 and 2.

The results for the monoscopic evaluations (51% of features correctly interpreted and 55.6% of features identified) are clearly disappointing. This compares poorly with 95% success rates for both feature accuracy and identification

Fig 1. Comparison of the Royal Albert Hall and Land-Line data with 3m, 1m and 0.2m imagery

1m Imagery - Mono-scopic Methods

	Feature Type	Buildings	Road Metalling	Fences, Hedges etc	Missing Features	Total	Features Identified (%)	Features Interpreted Correctly (%)
	Buildings	43			16	59	72.9	72.9
	Road Metalling		86	2	9	97	90.7	88.6
Existing NTD data	Fences, hedges etc	15	7	135	155	312	50.3	43.3
	Additional features	18	2	30	0	50		
	Total	76	95	167	180	518		
	Features Identified (%)	76.3	97.9	77.6			55.6	
	Features Interpreted Correctly (%)	56.6	90.5	73.1				51.0

Table 1. Confusion Matrix for 1m Spatial Resolution Imagery - Mono-scopic Evaluation

1m Imagery - Stereo-scopic Methods

	Feature Type	Buildings	Road Metalling	Fence, Hedges etc	Missing features	Total	Features Identified (%)	Features Interpreted Correctly (%)
	Buildings	89		2	13	104	87.5	85.6
	Road Metalling		115	9	2	126	98.4	91.3
Existing NTD Data	Fences, hedges etc	12		325	196	533	63.2	61.0
	Additional features	8	2	30		40		
	Total	109	117	366	211	803		
	Feature capture accuracy (%)	92.7	98.3	91.8			68.7	
	Correct feature capture accuracy (%)	81.7	98.3	88.8				65.9

Table 2. Confusion Matrix for 1m Spatial Resolution Imagery - Stereo-scopic Evaluation

using current monoscopic production techniques (digital monoplotting) with aerial imagery at OS. Positional accuracy was found to vary between 3 and 4m RMSE, depending on the feature surveyed.

Accuracies achieved from stereoscopic techniques were much better than the monoscopic results (65.9% correctly interpreted, 68.7% identified). The positional accuracy achieved (1.6 – 2.3m RMSE) is marginally acceptable for OS's 1:2500 scale mapping standards, but is more suitable for some of the 1:10000 'mountain and moorland' requirements.

These results show that the 1m imagery has potential for topographic mapping for those areas mapped at 1:10,000 scale which comprises c.10% of the area of Great Britain. Interpretation and geometric accuracy may also be improved by the real, as opposed to simulated, imagery. A re-evaluation will be necessary, as imagery becomes available, to achieve a definitive assessment of the use of high resolution imagery for 1:2500 mapping.

2.3 Automatic Change Detection

OS's surveying operations are dependent upon the availability of appropriate intelligence on topographic change. This currently relies heavily upon the planning process and other manual techniques, which do not readily identify all appropriate change. The theoretical ability of high resolution imagery to automatically identify change is of obvious attraction to OS. Research within the LANDMASS project concentrated on the use of Digital Elevation Models (DEMs) derived from the simulated imagery. Two DEMs were created from current and five year old imagery. The difference between these two models was calculated as a third DEM and integrated with vector data to try to identify significant change. Results showed that change was detectable, but compared with benchmark imagery at 0.2m, the change was poorly pronounced and very difficult to separate out from noise within the DEM. It was concluded that it would be very difficult to automate the detection of change to a meaningful level for derivation of survey 'intelligence'.

2.4 Completing the National Height Database (NHD)

One of the major source datasets for OS products is the National Height Database (NHD) which was derived from 5m vertical interval contours on 1:10,000 scale conventional mapping. However, the accuracy and consistency of the NHD is affected by gaps in information along roads, railways and similar features where contours were originally omitted for cartographic purposes. The effect is particularly severe where there are embankments or cuttings.

As part of the LANDMASS project, two dimensional vectors from OS's topographic database, representing the centreline of these poorly defined areas, were integrated with DEMS created from 1m imagery. Heights were then interpolated along the length of these vectors. Unfortunately, the interpolated heights had a worse RMSE than the original NHD (5.66m cf. 4.85m), when compared against a terrain model captured with analytical plotter from conventional photography. These results would indicate that the integration of vector and imagery data in this process would create a localised deterioration of accuracy in the NHD, for those areas where there is a recognised problem.

2.5 High Accuracy Digital Elevation Models

The accuracy of the current NHD is not sufficient for many of today's more sophisticated geospatial data users. The availability of very detailed terrain information is especially important to the insurance sector for flood risk assessment purposes. Accuracy measures from DEMs created from the 1m simulated imagery indicate that respectable results (Z RMSE of 1.5 - 2m) are achievable. Preliminary results also indicate that these results can be improved further by the integration of extra intelligence in the form of 2D vector breaklines. Further investigations will be made once real imagery is available, to ascertain the scope for producing an automatic production system.

2.6 3D Building Modelling

The availability of detailed height information for topographic features, such as buildings, fences and vegetation canopies is of great interest to a diverse market, such as the telecommunications and military sectors. The desirability of heighted features being maintained within OS's topographic database is beyond doubt, but unrealistically expensive to capture via more traditional photogrammetric techniques. The prospect of the use of new high resolution imagery for this purpose is therefore especially attractive. The LANDMASS project evaluated the feasibility of the creation of a national 3D building database from DEMs derived from 1m imagery.

The automatic identification of building objects from imagery is not well enough developed to be applied to the creation of a national database. However, when the imagery is integrated with building polygons built from OS topographic mapping, it is possible to calculate the minimum, mean and maximum heights within these restricted areas. Results were influenced by the complexity of the roof morphology, but generally for buildings with a planimetric area greater than 5m by 10m the maximum height value was proven to be the most reliable. This value gave errors of the order of an RMSE in Z of 1.5 - 3m, which is acceptable for most purposes. More importantly, this process is far more likely to be commercially viable than manually intensive alternatives.

2.7 Land Use Mapping

Amongst the array of promised satellite sensor launches are several which have a multi-spectral capability at a spatial resolution as fine as 4m (Fritz, 1996). The imagery produced by these sensors has great potential to automatically derive a national land use database, especially within rural areas. An increase in resolution will also mean that, compared to the much coarser multi- spectral imagery available until now, far smaller land use units will become mappable. This will increase the usefulness and applicability of the data to land management professionals.

Within the LANDMASS project, Compact Airborne Spectrographic Imager (CASI) data was specified and acquired to closely simulate the spatial and spectral resolutions of proposed sensors. The imagery was classified using several per-pixel techniques and then by integrating the imagery with OS's topographic vector data to create an assisted per-polygon classification.

The per-polygon methodology was found to be superior to any of the per-pixel methods, firmly illustrating a direct positive benefit of geospatial data integration during data capture processing.

The promising results for automatic land use database creation from high resolution imagery has prompted OS to continue investigations within other projects. OS has conducted its own internal research into the feasibility of using imagery as a fundamental part of a land use product, which is discussed further in section 4.2.

A more recent award of research funding has come from the European Union, where OS is part of an Anglo-German-Israeli consortium examining the potential of a proposed high resolution, multi-spectral sensor. The consortium includes a variety of organisations, from OS who represent the potential end users of such information to satellite hardware specialists who are responsible for designing and building the sensor equipment. It is anticipated that this sensor with its 5m spatial resolution and 12 narrow wavebands will provide data unavailable from other proposed sensors which will provide high resolution OR multi-spectral capabilities. The conclusions of the LANDMASS project indicate that this imagery will provide high quality thematic information for applications such as the capture of detailed land usage to complement the large scale topographic mapping offered. The project is planned to run between May 1998 and May 2000.

2.8 LANDMASS Conclusions

The results from the LANDMASS project have been very useful in directing OS to those areas of its business which are likely to accrue the greatest potential benefit from the adoption of high spatial resolution imagery. It is apparent that *ab initio* surveys of topographical detail will not be economically practical and will be technically difficult. There is undoubtedly a technical challenge still to be met to increase survey accuracy, but current techniques do not make the process commercially viable to OS.

In contrast the most successful evaluations in the LANDMASS project involved the integration of the raw satellite imagery with other geospatial data, namely topographic vector detail. The promise shown by the evaluations into building heighting and land use mapping is illustrative of the benefits to be gained from the combination of different sources of geospatial data. Typically, these data sets cannot alone satisfy processing requirements, but together they create an appropriate information source. In both cases, the essential process is an increased attribution of an existing geospatial data source.

OS believes that the results of the extensive, eighteen months LANDMASS project clearly indicate that high spatial resolution imagery will have a role to play in its geospatial data strategy, but that the areas of benefit are currently restricted to value-adding contributions to existing data.

3. DATA MANAGEMENT AND MAINTENANCE

Whilst high resolution imagery is clearly not the panacea to all of OS's current data capture requirements, it will be of undoubted value to some aspects of the business. It is therefore essential that OS develops mechanisms to ensure that image data is stored in the most appropriate and efficient manner. The technology employed must facilitate the integration of imagery and other new geospatial data sources with OS's existing topographic database. This will ensure their availability through a portfolio of products and services.

The opportunity to make best use of imaged data comes at a most opportune time. OS is currently undergoing a massive rationalisation of its systems and data infrastructure. The existing National Topographic Database (NTD) is an amalgam of data sets which supply OS's wide ranging portfolio of national data products, such as large scale topographic mapping (Land-Line®), road centreline network (OSCAR®) and address database (ADDRESS-POINT™). As an indication of the size of these data sets, Land-Line currently contains well over 200 million mapped features. This data is collected at nominal survey scales of 1:1250 for urban areas, 1:2500 for minor towns and rural areas and 1:10000 for mountain and moorland areas. This data is currently held in almost a quarter of a million dataset tiles.

The diverse development of these different products over the last twenty years has led to a complex data infrastructure which has data held in many locations and incompatible databases. Individual systems have been very specifically developed to create a particular product. Data integration between different OS datasets is therefore often a very complex process and one which mitigates against the efficient adoption of additional geospatial data sources.

A recognition that integration of these existing and imminent geospatial data sources will become increasingly common, along with the rapidly increasing data volumes being handled, has led to the current development of the next generation National Topographic Database, known as the Geodata Environment Management System (GEMS) (Murphy, 1998, Murray, 1997).

GEMS is being developed at OS using leading edge geospatial database methodologies. Whilst the fundamental object-oriented technology is available there is no proven vehicle for the appropriate management of large geospatial databases. Therefore prototype object-oriented databases and their high level architecture have been developed, which identified modularity of development as being a critical requirement. This will allow the progressive migration of all systems from the NTD to GEMS. The model developed will allow the inclusion of large and small scale data, in-house and third party data and vector and raster data, including imagery, within the same data model. Most importantly the complete object model will be independent of all of the products that it creates. Any number of products and individual solutions can then be defined and 'served' from this object model with little disruption and relatively little development. The commensurate savings are expected to be enormous and will liberate the ability to define almost any data solution within the confines of one data architecture.

In parallel with the development of GEMS, the specification for basic topographic data in the current NTD is being radically enhanced to ensure a more realistic, topologically structured representation of real world objects as opposed to cartographic abstractions of reality. Intelligence is also being added to the data in a number of ways, to assist with data integration and exploitation.

A relevant example to illustrate the benefits of object orientation within the data and additional intelligence is shown in Fig 2, which represents a farm house comprised of several buildings located within a field. Under the present data specification the field boundary would be represented by four unassociated vectors (A to D) and independent text describing Ten Acre Field. Similarly there would be six vectors (1 to 6) and independent text describing Folly Farm.

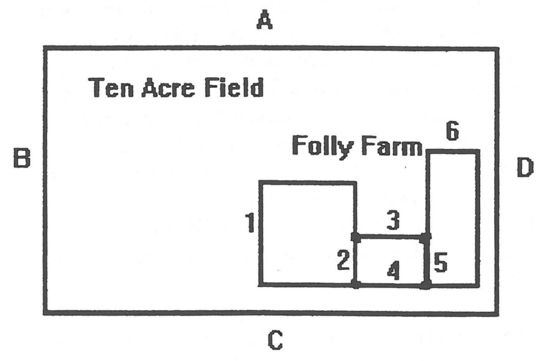

Figure 2 Example data structure

Within the new data model Ten Acre Field would be represented by one field polygon with a direct association to its describing text. The data is immediately of more use, for example in linking to agricultural or land and property gazetteers and in readily defining field parcels for per-parcel land use classification of imagery. Similarly the complex building structure that is Folly Farm is a manageable object with similar benefits accruing, including ready definition of building polygons for height extraction from imagery-derived DEMs.

However, the radical improvement of systems and data currently underway is not without risk. The object-oriented technology is relatively untested in this environment and with the volumes of data (as many as 1.5 billion) that it is estimated that GEMS will be asked to handle. OS considers that it is a risk that it cannot afford not to take if it is to remain competitive.
Whilst OS has been undertaking radical changes in its systems infrastructure and data specifications, to capitalise on advances within the geospatial data industry and market sector, the UK geospatial community have been preparing for similar advances via the National Geospatial Data Framework (NGDF). The NGDF's mission is 'to provide a framework to unlock and improve geospatial information for the benefit of the citizen, business growth and good government through enabling viable, comprehensive, demand led and easily accessed services.' It is established to enable greater awareness of existing data; improve accessibility of that data and improve data quality through the use of standards to greatly enhance the prospects for data integration. It is likely that this access, integration and dissemination will be via the internet. Notable advances made by the NGDF thus far include the definition of Discovery Metadata guidelines for Geospatial data (NGDF, in press) and the development of two prototype metadata services established to use these guidelines, by Intergraph and ESRI.

The realisation of NGDF will create a far better service to all in the geospatial data community - end users, system suppliers and data producers. Readily integratable data sets will enable greater flexibility of use and liberation of information from a diverse data base. High spatial resolution imagery will have an important role to play in this framework, not least by offering the potential for enhanced attribution of other data sets and as such is recognised as a significant potential contributor to the NGDF.

There are still an enormous number of technical, political and infrastructural challenges to be overcome before the NGDF can be deemed a success. Members of NGDF will be conscious of the relatively slow development of the National Spatial Data Infrastructure (NSDI) in the United States and anxious to learn from their experience.

This section has highlighted the advances in geospatial data management and maintenance that are taking place at Ordnance Survey and in the wider UK geospatial data community. The development of both initiatives contain significant risk, but the perceived benefit in both cases is so large that it is deemed to be a venture worth undertaking. If and when they are successful the entire UK geospatial data using community will be the beneficiaries.

4. PRODUCT & APPLICATION DEVELOPMENT

As highlighted earlier, the benefits arising from geospatial data integration are not solely restricted to data capture and management improvements. Ordnance Survey's involvement in a rapidly increasing range of services and applications, as well as an expanding product range, indicate that the integration of its data with third party data is usually required either for additional attribution or contextual information.

The value of integration is illustrated in this section with two outline case studies, one with and one without the inclusion of high resolution imagery. Experience in these and other current projects indicate that the main obstacles to the successful exploitation of integrated data are political and legal issues. The ownership and exploitation rights to composite data become complicated when the source data is owned by distinct organisations. Similarly the accuracy and quality of integrated is much harder to define and describe when different provenances are used.

4.1 National Land Information Service (NLIS)

The National Land Information Service (NLIS) is a collaborative venture between HM Land Registry (HMLR), Ordnance Survey and Bristol City Council (BCC). The aims of the service are to make spatial data from the participating organisations available on-line, in a consistent format to allow end users to make more timely and efficient use of data from more than one organisation simultaneously.

The first live pilot application was launched in April of this year and has been acclaimed a success. The application provides participating solicitors in the Bristol area with an efficient property conveyancing process by utilising on-line land and property searches. The participating solicitors are able to access property ownership details direct from HMLR and locational information from an underlying land and property gazetteer created and maintained by OS. These details are then sent to other participating data providers, such as the British Geological Survey, BCC and the National Coal Authority.

This application is demonstrating the positive benefit to be obtained from on-line geospatial data integration involving data from multiple organisations. There is no doubt that more and more services will be offered in this way in the near future and that it is exactly the type of service that the NGDF is seeking to facilitate. The use of imagery in this kind of application is also likely to increase as a provider of basic contextual information. However, if true 'information' is required, such as feature type, age, ownership etc., imagery is inappropriate and conventional topographic data is still needed.

4.2 Land Use Database Evaluation

OS has been involved in ongoing research over the last five years, investigating the feasibility of creating a large scale national coverage land use map. Establishing a detailed database of land use across 50+ categories is potentially a very intensive and time consuming process if traditional non-automated techniques are used.

Research projects within OS have recently concentrated on the feasibility of creating this comprehensive data base from a combination of a number of independent data sources. A simple combination of classified high resolution imagery and OS large scale vector data was shown to provide the necessary information.

The study concluded that it would be feasible to create a national land use data set by integrating OS large scale vector data with classified large scale satellite imagery. Although 100% classification of land use was achieved using this methodology, the results were of variable quality and were considerably enhanced by integration with additional third party datasets.

One issue highlighted by this project was the importance of recognising the different provenance of the varied data sets that have been combined to produce an integrated product. If data of differing currency and quality are combined the quality of the eventual product is compromised.

The value of metadata at the data set level is widely recognised but the value of metadata at the feature level was also considered in this project. The varying influences of different data sets on each individual feature needs to be assessed to give an objective level of confidence in data quality at the feature level. These indicators would then be of relevance, were this data set to be subsequently integrated with others.

5 CONCLUSION

The added value to be gained from integrating multiple geospatial data sets has been illustrated to be of some use, within the context of OS's business, at all stages of the data capture, maintenance, exploitation life-cycle

Indeed, the value of high spatial resolution satellite imagery is at its greatest when it is integrated with other data sources. Use of this imagery in isolation is limited to presenting a very graphic representation of an area and, other than for small scale mapping purposes, has little inherent information value. The truly synergetic value from the use of this imagery is derived when it is combined with a vector mapping data base.

If the full potential of integrated processes and products are to be realised, it is essential that appropriate storage and distribution mechanisms are developed to handle these new data. OS has already begun the process of rationalising its fundamental technical infrastructure in anticipation of the continuing growth in this area. Nationally, there are initiatives underway to proactively promote the availability and integration of geospatial products through the National Geospatial Data Framework.

There is also enormous potential for the development of comprehensive product and service delivery mechanisms through the exploitation of multiple data sources. The next decade will see an enormous growth in the provision of on-line geospatial data services, derived from multiple data sets in different source locations.

Whilst the integration of geospatial data sets has real potential to improve many data collection, management and provision processes it should not be regarded as a universal panacea. There are political and technical issues which will remain to be resolved before full advantage can be taken of the promised benefits that accrue from the wholesale integration of geospatial data sets.

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