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Establishing GIS as the Prime Integrator for Roads Management

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Introduction

This paper presents the vision of GIS as the prime means of integrating road networks and information about the assets and events associated with roads, making it available for better management and public understanding. I should like to express my appreciation to the many people and organisations with whom I have discussed these issues. These organisations are tackling many of the issues presented here, and their breadth of experience has been invaluable in developing these ideas. Further detailed discussion is available at the author's web site www.highwaymapper.com.

I am solely to blame for the views expressed. As a completely independent consultant I have worked in some detail with the data under discussion. I also express a citizen's concern for the best use of public money and the best possible access to information.

The paper looks at technical issues, because in the author's experience it is tackling these "details" and developing a coherent architecture that are critical to implementing the vision. The paper suggests that Ordnance Survey's nationally coherent architecture should be supported, and that for roads, Ordnance Survey's Integrated Transport Network (ITN™) architecture within OS MasterMap® has many attributes which recommend its early and comprehensive adoption as a network base.

The Goal

Making all road-related information available as map layers in GIS is the goal. When the data is available in this way layers can be added, removed, coloured, easily classified, compared, cross-related and modelled. Management decision making across a whole range of areas is enhanced and streamlined, and public access to information is transformed. Simpler data structures can be adopted because GIS overlay methods are available. Whilst this theme is common to many GIS papers, keeping this objective in focus is essential when taking the very difficult practical decisions that either support and encourage or ultimately frustrate the GIS integration goal.

Benefits

What would achieving the goal mean in practice?

- Ordnance Survey has acquired sound knowledge of the streetnames and their latest topology and alignment, and the OS ITN layer is completely up to date. You will not need to add roads of your own. A standard process will have generated names for unnamed roads (such as "A41 between Banbury road and B4176").

- A coherent road network has been built from the OS ITN base; it fits with all the underlying OS MasterMap geography. That base is already structured in a way that supports the Bs7666-1 National Street Gazetteer (NSG) framework and can be used in the many different systems that accept NSG input. Roundabouts, dual carriageways, slip roads are identified consistently; sections of road are no longer missing, have inconsistent duplicate references across authority boundaries, or are digitised to different standards.
- So the day to day processing of streetworks notices is consistent for Utility companies and notice rework is reduced within the Highways department.
- The Street lighting department have a ready made and up to date reference for interacting with the public over lighting complaints, using a network base that everyone understands.
- Accidents and other events can be plotted against the common network base.
- Properties within the National Land and Property Gazetteer (NLPG) can be given consistent references to the street providing their access.
- The ITN base has also been separately grouped into "linear" sections which have allowed the full "chainage based" road asset inventory to be plotted and that allow defect reporting and inspections to be seen and also UK Pavement Management System (UKPMS) survey data and analyses to be presented.
- In fact data is extracted from the many systems in which it is stored and converted into geographic objects, using the standard network.
- There is pressure to constantly redefine sections so that information can be held in databases, split, for example, by carriageway construction, speed limit changes, road hierarchy etc. etc. Once the use of an integrated GIS becomes the norm, this pressure recedes because this kind of re-classification can become just a separate GIS overlay, without disrupting the underlying network structure.

This integrated GIS then opens up a range of possibilities for the more professional and cost-effective management of information.

Visualisation

Once all the information is mapped with the ability to instantly classify and reclassify using different colour schemes, management and public attention is focussed as never before on accident clusters, poor roads, properties served by roads under repair etc. etc. The author/ Jonathan Simmons' MapInfo/Mapx-based Highway Viewer product in use at Oxfordshire CC and elsewhere, provides such a tool.

Cross-referencing

Once in geographical form, previously inaccessible data (buried in separate systems needing specialist knowledge) becomes available for cross-referencing to data from other "inaccessible" systems. Once translated to a "geographic object" it does not matter that a streetwork was "related" to a Unique Street Reference Number (USRN), that defects were collected against a maintenance engineer's linear network or that surveys were performed against a different linear network representation managed within a UKPMS accredited system. The information has been lifted clear of its origins to be made more widely available.

Analysis

Once coherently represented as geographical objects all the power of GIS is available to correlate and report areas needing management attention. Once the principle of GIS as the prime integrator is accepted you do not have to pre-define the comparisons and initiate special tasks to collect and analyse the data. If you want to compare accidents to the carriageway defects revealed by UKPMS inspections (CVI data) it is there on your desk.

Achieving the goal

Common Network Referencing

BS7666 provides an excellent framework, but making it a practical reality is where the problems begin.

Elementary Street Units

The network base is the Elementary Street Unit (ESU), essentially junction to junction; it provides a route to other ESUs and into properties. It defines the underlying network routing topology. ESUs may need to be split to accommodate the rare occurrences of a streetname change between junctions.

Streets

The commonly understood “Street” is the upper level defined by BS7666 and implemented in the street gazetteer. Streets in an average town are often "well behaved", they start and end at junctions, they don’t cross address locality boundaries, and they go directly from one end to the other; BS7666 fits them perfectly. However Streets across the nation are more annoying. Often they have no definitive name; sometimes they fork, having more than one “start” and “end” point. Sometimes they continue after a gap, and will normally comprise both sides of a dual carriageway.

So in general although they can be built from a collection of ESUs you cannot trace a single “linear” path through them.

Linear Sections

Between these network descriptors and currently outside BS7666 lies the “Section”, as used by maintenance engineers and road condition surveyors. Because condition information and the like is often collected by a vehicle using an odometer, to create data with start and end “chainages”, a section has to be linear without branches or gaps. A section cannot be so small that the data collection is meaningless, nor so long that too much information is collected without a break. It essentially needs to be unlikely to change its description, as understandable as possible both “on the map” and “on the ground” and be, given “from” and “to” intersecting streetnames or road numbers to assist identification from text and phone calls. It is against such sections that the vast wealth of inventory asset data and road condition survey data is collected and maintained. But because traditionally each system, for defect, inventory or road condition has been free to define its own section scheme, getting to the underlying data has been difficult and data from different systems very difficult to correlate.

Simple, linear sections from named junction to named junction might also prove beneficial, for example, to split streets into sections by Associated Street Data (ASD) characteristics such as Reinstatement Category, for streetworks purposes

Inhibitors and possible solutions

The Network Base

Six years working with street gazetteers has made the author aware of many problems associated with the NSG build process. There appear to be different expectations and priorities imposed on the NSG, first from the Street Works Register and more recently from the National Land and Property Gazetteer. What seem to be revealed are significant incompatibilities in the guidance and practices for the NSG

and for the NLPG, and in their relationship to the underpinning BS7666 standard. Ordnance Survey's corporate status, the relationship between Ordnance Survey and Local Authorities, the ownership and costs of the data, and competition ideology are complicating factors not further discussed.

The main points are:

1. NSG is built from no standard base of digitisation and furthermore even when derived from OS; it is defined to a different precision (1m) to OS data (0.001m) making additions and "snapping" difficult. Thus NSG is creating a collection of generally incompatible digitising which is fundamentally divergent from OS.

2. NSG and NLPG (corresponding to parts 1 and 2 of BS7666) have fundamentally diverged over their expectations of street splits. NLPG is expecting locality fields to be derived from the USRN providing access to the property, and streets and ESUs to be split wherever necessary to achieve this. NSG Guidance dictates an essentially junction to junction ESU base building streets where locality specification is optional and not standardised.

3. No Ordnance Survey references are included in NSG or NLPG data. So neither ODs (Oscar) nor TOIDs (ITN) appear. The author's "Highway Mapper" built initially in 1998 using MapInfo/MapBasic to support the Portsmouth City Council level 3 gazetteer, and Mike Gearing's more recent Arc/Info-based support software for E. Sussex have both recognised the advantages of maintaining such an OD link field.

4. Naming inconsistencies currently inhibit the achievement of a coherent agreed base. OS Oscar has its base in street nameplates and local knowledge. Sometimes this appears to be inconsistent with the streetname that can be inferred from neighbouring properties. At the heart of this is the apparent lack of an administrative route by which naming information flows directly from the naming authority into Ordnance Survey for inconsistencies to be resolved. NLPG has its own view of streetnames derived for example from a combination of electoral rolls, council tax lists and AddressPoint. Consequently establishing the name to be applied to an ESU (even if one can agree where it starts and ends) is not a trivial task.

A more relaxed approach to incorporating fields that are likely to be of future use might help. This would allow best practice to evolve along sensible lines, rather than be overly constrained. Such fields as AddressPoint reference and locality/town references within the Land and Property Identifier (LPI) record to define a property as "unique" or to correlate its postal address would give an alternative way to provide essential locality and/or town address components. NSG changes introducing extra complexity compared to its BS7666-1 role would then not be needed.

Current digitisation

- Raster maps (Os 1:10000 or old county series) rasters provide no "lines to follow" just pictorial representations.

- Landline- provides road centrelines to follow but these have no attributes and have arbitrary start and end points.

- Oscar provides ESU lines with more "meaning" - a street name and/or number and start and end points, but no way beyond inference to distinguish different streets of the same name.

Unfortunately NSG has been digitised by reference to all these sources and others, across the 200 or so highway authorities. In the process of line following and then rounding to 1m the ability to easily add or replace OS sections by "snapping" into the existing base has become difficult.

Proposed future base

OS Integrated Transport Network (ITN) component of OS MasterMap provides further "meaning" for the data and offers the most advanced option to build a common base for all network data.

1. ITN defines Road Links, which equate to BS7666.NSG ESUs, but at a higher level of precision.
2. ITN further defines Roads that are built from non-linear collections of Road Links to define Named Streets or Numbered Roads (e.g. A41) these equate to the BS7666/NSG street types 1 &3.
3. ITN defines Routes that are built as linear collections of directed Road Links. Already in the standard product these define the correct direction for dual carriageways, roundabouts and slip roads, and furthermore could be readily extended to define the linear sections discussed above, but in a standardised manner.
4. The ITN references to underlying OS MasterMap Polygon TOIDs provide further possibilities for interrelating data for example to establish carriageway and footway coverage.

Adopting this base would in effect mean that NSG and Sections would include a set of "TOID cross-references", with geography definition, and possible global shifts (as in the PAI exercise), no longer being a problem for the individual Highway and Street Naming Authorities.

UKPMS and Maintenance Section addressing

Historically Sections are geared to on-the-ground interpretation. End points descriptions can refer to intersecting roads at junctions, but often degenerate into nearby house numbers, current business names, lamp post numbers or "to 300m north of junction" etc. making map-based interpretation difficult, time consuming, or at worst impossible.

It has been the author's privilege to work with Steve Batchelor of Data Collection Ltd. (DCL) to define sections for surveys more rationally as "Linear collections of ESUs" and several Highway Authorities now have these sections as their survey base. Derivation of this coherent base can be automated to some extent, and once in place allows not only original survey condition data, but also derived road condition indices to be classified on the map.

Data buried in individual systems

Most Highway Authorities will have their data held in a variety of systems. The supplier naturally wants to keep control of the data to show it to advantage in his own system. But using the kinds of tools and techniques described in www.highwaymapper.com it can indeed all be mapped in the integrated GIS. The author's work with Oxfordshire County Council using an OS ITN base, and with other authorities in the Highway Mapper Group illustrate what can be achieved.

Addressing within Maintenance Systems

Storing data in a database as "chainage and offset" and manipulating those fields when splitting, joining and re-referencing sections is a pseudo-geographic approach. Measure is not a reliable locator for data since it depends on start point, route followed along the highway, accuracy and consistency of odometers etc. In the author's opinion these measures should be used for the once-off creation of geographical objects, but should then be effectively discarded, and all further processing channelled into the GIS.

Streetworks data suffers from addressing by a variety of different "clues" imbedded in location text. Little standard practice exists , " j/o", "jct". "Jnct with", being arbitrary ways to refer to an intersection whilst often o/s (outside) house number or "l/p" (lamp post) number appear in location text. A reasonable hit rate in locating streetworks by interpreting the location descriptions within incoming ETON notices was achieved using the author's Highway Mapper software in conjunction with EXOR

processing at Portsmouth City Council. The recent, but long overdue proposals for the Streetworks Act requiring notices to be issued with coordinates is a big step forward.

UKPMS commercial secrecy

The commercial secrecy surrounding UKPMS does not encourage imaginative uses of the wealth of data being collected annually at great public expense (estimated at £20m nation-wide). From this data we deserve much more than this year's "overall performance indicator", based on this year's "algorithm" - subject to commercial confidentiality and not in the public domain.

The position of the UKPMS processing algorithms as commercial secrets of a few accredited suppliers has the following negative consequences –

- It is made difficult for a Highway Authority or external auditors to independently verify that the road condition results properly derive from the base data collected.
- Frequent algorithm change makes year on year comparison difficult.
- Extracting condition data from the UKPMS systems is a daunting task, because it is in the system suppliers' interests to maintain control.

A possible approach to breaking this logjam is to encourage more openness on the part of the supplier, and in this regard I am grateful to WDM Ltd. for help in mapping the road condition output they generate to present in an external integrated GIS being built for Oxfordshire CC.

A second approach is to leave central statistics production to Dft and the UKPMS accredited suppliers. The mapping of road conditions to include in our integrated GIS could be based on much simpler publicly available algorithms applied directly to the original survey data. An example of this is the mapping of CVI data using the spreadsheet approach developed by DCL at the request of its customers.

A Possible Solution scenario

Steps to Success

Recognition that national standards for geographical data need to be agreed, set, and applied by a competent national agency. Ordnance Survey's remit should be to provide nationally unique identifiers (TOIDs) as required in collaboration with the user community to identify real-world objects. This seems the best way to ensure topological consistency for the road network, as it evolves to include footpaths, alleyways etc. together with their precise intersection points.

Recognition that privatisation, data ownership and payment issues have to be resolved with the aim of supplying basic attributes such as streetname and locality - which the public at large would expect not only to be "in the public domain" but also to appear correctly on the maps they buy.

Local Authorities should move as far as possible away from local digitising over a background map. This is time consuming and expensive and always contributes to the problems of a divergent geographical base. Wherever possible they should build entities from TOIDs and maintain cross-references to TOIDs, which avoid local rework every time some change like PAI, road realignment etc. is noticed.

They should ensure that Ordnance Survey is supplied with timely information on the basic public domain attributes such as Streetname, which it is their role to define. They should then demand up to date geographical alignments from the Ordnance Survey. There seems little point in having a process to supply more frequent, customised updates for OS MasterMap ITN if the basic information flows are

not agreed and in place to avoid the local digitising of, for example, new housing estates. OS data needs to be one step ahead in identifying change and incorporating it into maps which then form the base to correlate and cross-reference local data.

This solution scenario is being implemented at Oxfordshire County Council making as full use as possible of the structure of OS ITN data. Experience from this project as it evolves will be available on the www.highwaymapper.com site.

Migration

The current methods for network build by upwards aggregation of data from many incompatible local systems seem unlikely to succeed, whilst being highly resource intensive to the extent that many ESUs, streets and sections are being individually hand-crafted.

One of the many benefits of a move to OS ITN is the potential to replace most of this resource-intensive activity. Migration from the current base to OS ITN along the lines discussed above should be supported by GIS-based migration programs to complete the task of "lifting" current knowledge from NSG/ ASD/ NLPG and presenting it for verification and inclusion where verified into the ITN geographic base.

Conclusion

This paper has sought to present the benefits that flow from access to GIS layers for all the information pertaining to roads, wherever it is stored and managed.

At the heart of all this is a common representation of the network for use in all circumstances. Current projects show that it can be done for a rural county the size of Oxfordshire on the one hand and an urban area like the London Borough of Waltham Forest on the other.

The level of effort and commitment amongst all parties involved in NLPG and NSG is self-evident when one sees the work being done to collect good property information.

Such a national base underpinned by the BS7666 standard is a vital and remarkable national asset with far-reaching benefits.

But in the author's opinion there is an illusion being promoted that we are moving to completion.

In good software development there comes a time to take stock of all the lessons learnt and from that experience build a completely new architectural base. NSG has been built over the past 5 years. There is still a 5-year spread of data currency on the NSG web site. More fundamental change is currently being stimulated by NLPG. For the reasons already given no coherent national structure is yet evident. These facts provide ample evidence that the time is ripe for change much more radical than just adjusting local roles and responsibilities.

Accepting the value of GIS as the "prime integrator for road information" firmly rooted in Ordnance Survey ITN architecture would allow us to move forward from resolving incompatibilities to reaping real management benefits.