



Digital National Framework (DNF)

**Using the Integrated Transport Network (ITN)
layer of OS MasterMap® for the
Oxfordshire National Street Gazetteer (NSG)**

A DNF technical white paper

Prepared by:

Dave Simmons
David C Simmons, GIS Consultants
for Oxfordshire County Council

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This document has been prepared by Dave Simmons for the benefit of users of the Digital National Framework (DNF). It presents a solution which is working well in Oxfordshire, but neither the author nor Oxfordshire County Council accept any responsibility or liability arising from its interpretation or implementation elsewhere.

Contact details	
Dave Simmons	02380-695182
	Dave_Simmons_Gis@Compuserve.com

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A DNF white paper

Summary

In February 2004 Oxfordshire implemented its decision to convert its component of the National Street Gazetteer (NSG) to the Integrated Transport Network (ITN) component of OS MasterMap. This paper explores the technical implications of that decision, and provides details relating to the implementation. It should be read in conjunction with the associated DNF Case Study

Introduction

The purpose of this report is to present a case study showing how the principles of the Digital National Framework (DNF)¹ were used in the upgrading of the street gazetteer maintained by the Oxfordshire County Council Highway Authority. The work by the County Council involved the conversion of its component of the National Street Gazetteer² (NSG) using the Integrated Transport Network (ITN) layer of OS MasterMap.

Dave Simmons (David C Simmons GIS Consultants) had been supporting Oxfordshire Highways IT for several years by providing mapping interfaces to their highways management systems, converting data for use within their corporate MapInfo GIS environment, and in seeking to improve their NSG in line with highway management needs.

But the difficulties of maintaining this network and the increasing demands to use it as a street base for Land and Property were increasing.

Work on many other networks had by this time convinced Dave that the only consistent and coherent way forward was to use the Digital National Framework (DNF) principles embodied in the newly emerging Integrated Transport Network product developed by Ordnance Survey (OS) and its links to the underlying road surface topography through OS MasterMap.

This recommendation was accepted, and the work to migrate the highway to ITN and meet Land and Property needs at the same time was completed for the whole of Oxfordshire substantially between November 2003 and February 2004, when the network was first published on the NSG web site.

¹ To find out more about DNF go to the DNF website [www.DNF.ORG].

² These and other terms and abbreviations are defined in a glossary at the end of this document

Management processes and data flows were then instituted between Oxfordshire Districts and the County Council to make any required corrections, improvements and additions to the established base, and software was evolved to process the changes and assist with maintaining the NSG network base.

Statement of the problem

In common with many highways authorities Oxfordshire faced several dilemmas.

- Districts were under increasing pressure to improve and complete their Local Land and Property Gazetteers, based around NSG streets. This has been promoted by IDeA as part of the BS7666/National Land and Property Gazetteer (NLPG) initiative along with an increasing local focus on better consistency and coordination amongst the various different systems in which addresses are stored and used.
- Meanwhile Oxfordshire highways had been following NSG guidance to produce their own digitised version of the street network, primarily to generate Unique Street References with associated names and descriptions for use in street works notice management.
- Perceived differences in the way streets needed to support property addressing within BS7666-compliant gazetteer systems and their use within highway systems were causing the street networks to diverge and were increasing tensions between district and county departments as they tried to meet their different goals.
- Meanwhile despite valiant efforts on both sides, many property addresses were missing because of the way street definitions had become a pre-requisite within LLPG software, and the many rural unnamed streets within Oxfordshire exacerbated this.
- At the same time the difficulties and effort of maintaining a gazetteer through local digitising for highways purposes was generating excessive workload in resolving street work notice queries from Utility companies.

Something had to be done.

The solution

Overview

The vision and background for this work was presented at AGI 2003 (see Ref 1). This paper presented the opportunities resulting from a common GIS-based referencing scheme for all highway management operations.

Many authorities have used Ordnance Survey's pre-cursor product, OSCAR, either overtly or covertly as the road centreline structure, but have rarely stored references (OD) to this network. ITN provided the advantages of its more consistent derivation from the road surface, its formal topological structuring into nodes, links and named streets, and its associated traffic restriction data. It also has a clear plan for future support and maintenance.

Rationalising and converting road networks is as much an art and skill as a science.

Of course techniques can be used and major sections of road converted from one reference scheme to another in bulk by automated processes. (examples are where both names and "end points" match "closely")

Once this has been done a percentage of streets inevitably remain that need to be worked through, and judgements made, on an item by item basis.

In Oxfordshire, the five Districts were working to an early version of NSG – the NLPG base, and County were using a version that had been updated several times since that "version 1" and so had significant differences. Reconciling these two networks with no clear reference base would have been a complex and lengthy process!

So three key decisions were taken:-

- To add extra street representations purely for district use. This was to either include streets that had already become vital for LLPG management or were too new to have yet been mapped and incorporated into the ITN coverage.
- To clearly distinguish these extra streets and include the full set of streets in the NSG gazetteer to maintain synchronisation.
- To communicate regularly with Ordnance Survey so that additions and minor variations could be fed efficiently into the ITN product for the benefit of all users.

The ITN base and its relationship to BS7666

ITN was taken as the definitive base for the Level 3 Street Gazetteer with full geometry. In brief, each element of ITN has its own nationally unique identifier (a 16 digit numeric TOID). ITN is built from junction to junction road centreline elements know as "Links" with each link terminating at each end in a referenced "Node". Thus a node may have only one link (e.g. at the end of a cul-de-sac), 2 links (e.g. where a public road link joins with a private road link) 3 links (e.g. where a major road joins a side road), 4 links (e.g. at a cross-roads) and so on. The whole then forms a fully interconnected national road network topological structure.

ITN aggregates links into named streets, classified roads (Motorways, A and B roads), primary routes and trunk roads. These then form ITN “Road” TOIDs.

In effect, this means that the ITN link is a representation of a BS7666 ESU, and the ITN Road is a representation of a BS7666 street, and that the cross-referencing of ITN links to ITN Roads is very similar to the manner in which BS7666 ESUs cross-reference to BS7666 streets.

The main differences between the ITN architecture and the BS7666 specification are –

- ITN is defined to 2cm precision which has to be coarsened to 1m to fit the BS7666 specification
- Trunk roads and primary routes are not covered by BS7666
- The property aspects of BS7666 guidance have introduced splits at notional locality and administrative boundaries, whereas ITN streets are not split where the street name is continuously defined.
- BS7666 has no concept of nodes and topology and seeks to represent connectivity very crudely in terms of “tolerances”
- BS7666 and its guidance specifies that the key street identifier (USRN) is to be allocated from numeric USRN ranges administered at district level, whilst the ITN TOIDs are by definition nationally unique, coherent and consistent.

How the Conversion to ITN was done

Step 1 - Take the set of ITN Link TOIDs for the county as the definitive highway base.

For named streets

1. Take ITN Road TOIDs as the definitive base reference for BS 7666 Type 1 (named) streets
2. Using semi-automated matching, populate each ITN road record with extra columns specifying the administrative district, USRN, locality, town and county fields. Suitable values for these fields could generally be found and agreed by negotiation with property gazetteer interests, but in a few cases the property gazetteer insisted on splits, and these were accommodated through the use of “LLPG placeholders” - described later.

For unnamed Streets

1. Take ITN Link TOIDs (junction to junction) as the definitive base for BS 7666 Type 2 (unnamed) NSG streets. That means each unnamed street is a single link.

2. Populate USRN, locality, town and administrative district using geographic overlay and proximity to nearby address information in a similar manner to the methods for named streets.
3. Generate suitable descriptions for these single link unnamed roads using combinations, where applicable, of the classified road number, the road type and the names of any streets between which the link runs.

Note: In many cases the existing type 2 streets were already the familiar "Oscar section running from (x1,y1) to (x2,y2)" so these often converted readily to ITN Links. (Had BS7666 previously encouraged cross-referencing to the OSCAR identifier(OD) this conversion would have been even more straightforward)

For Classified Roads

- Take the ITN Road TOIDs as the definitive base reference for BS 7666 Type 3 (classified) streets
- Populate each ITN road record with extra columns specifying the administrative district, USRN and county fields.

Note: In Oxfordshire no type 4 streets are currently defined.

Step 2 - Supplement the highway coverage from ITN with "LLPG Placeholders"

Some extra streets were needed by Districts for property purposes (as a hierarchical component of the address within their gazetteer management systems). These tended to be:

- Terraces, Closes, Groups of houses (e.g. "Riverside Cottages"), Squares, Market Places with no highway significance
- Sub-Locality names such as small villages and hamlets
- Highway named streets that needed to be split to accommodate a separate town / locality / administration district

These were clearly identified as "LLPG Placeholder" and represented as a simple straight line using District supplied end coordinates.

Some streets were unrepresented in ITN and LLPG Placeholders were generated as a temporary expedient to hold these (and communicate the need for their inclusion to OS)

It was clear that some streets defined in ITN had different extents, and extra unnamed ITN links should be associated with them. These were fed though to Ordnance Survey as candidate changes to the ITN "link to road" cross-referencing base.

Step 3 - Generate Associated Street Data

Associated street data (ASD) represents the highway characteristics of the street for communication with Utility companies and others concerned with street works. The decision was to include only highway in the ASD - not the non-highway "LLPG Placeholders".

So only streets identified as 1:1 with ITN Named Road TOIDs or 1:1 with ITN Link TOIDs (for parts of the highway that are not officially named) are included. The purpose of this was to prevent these non-highway streets being the subject of streetworks notices. This strategy has been successful.

On-going District-County Communication

At the beginning of the project relationships between districts and county had become strained over the different perceived needs for street representation in the different property and highway gazetteers. ITN was independent of either network view and it became clear that with some amendment and addition it could meet the needs of both districts and county. The fine details were implemented as follows:-

1. A series of meetings, initially monthly, but more recently quarterly, were set up to agree and refine communication procedures and processes and discuss the progress of the project. This included representatives from each district, county highways and independent contractor with guest visits from other interested parties (IdeA, Intelligent Addressing, Ordnance Survey, and Royal Mail).
2. An agreed file format to communicate required changes from district to county to maintain the LLPGs and County NSG in step. This allowed communication of additional highway, additional placeholder streets for property, and changes in the geometry of existing streets.
3. Programs run by the County to interpret the change file, map against the latest version of ITN, and make alterations to the network base.
4. Three monthly generations of required NSG and ASD files by the external consultant to generate a level 3 NSG update.
5. Feedback of differences identified between the County highway representation and ITN to improve the ITN product.

Making the level 3 gazetteer

This was the most important of all where DNF had the most vital role to play. ITN TOID references (to ITN roads for named streets and classified roads and to ITN Links for unnamed sections) were maintained and shipped with the level 1 data, through the use of the BS7666 AliasDescription field. If the street was not highway then the designation "LLPG Placeholder" was put in the same field to create a classification

Level 3 was generated programmatically and automatically solely from the architecture of ITN which already holds more than enough information to build the BS7666 type 12, 13 and 14 records.

DNF technical architecture

At a national level, NSG is currently based on a collection of local digitising largely following Ordnance Survey road centrelines as they have appeared over the years on raster maps, Land-Line and OSCAR. This is a direct consequence of BS7666 inspired management of local coordinates to represent lines. It aggregates component street gazetteers from over 100 highway authorities built to different standards, to different resolutions, to different levels of completeness and with different ideas of road representation and classification.

The Oxfordshire NSG component is subtly, but radically different. Instead of “following” centrelines it directly uses and references the centreline information contained in the ITN component of OS MasterMap which is “Base Reference Information” in DNF terminology. These ITN road centrelines having in turn been derived from the road surface features of the MasterMap base reference geometry for real world (surface) topographic features.

This means that the Oxfordshire NSG is not only built from ITN but is able to supply these ITN TOID references as well. It currently achieves this by populating the BS7666 Alias description field with the TOID reference. This is a non-standard use of this field, but does no harm. It is consistent with the modifications to BS7666 currently under public consultation which seeks to permit and encourage cross-referencing to an underlying geographic base, and to allow classification schemes. .

The implications of this are that any organisation accessing the Oxfordshire NSG has a way of referring not just to street names and vague locations, but to the nationally unique ITN TOID reference, and hence to the precise road centreline geometry and underlying surface polygons if that organisation also uses OS MasterMap.

Thus Oxfordshire has achieved DNF cross referencing, and has established a sound base for inter-operability in the transmission of road related information.

Results

For named streets

In the majority of cases a single locality, administrative district and USRN could be inserted without difficulty against the ITN –defined named Roads.

Any cases where streets had to be logically split by locality have been successfully resolved through the use of LLPG Placeholders to cater for this type of street.

Note: The reasons for these splits are complex, they come about through the way BS7666 has been interpreted and the way LLPG software has consequently developed to insist that a “street” is a logical and hierarchical component of a property address rather than a highway connection.

Some highway was more recent than the ITN map coverage and in some cases the ITN extents did not match the expected extents of the street in terms of contained links. In a few cases the road names were not as expected – often down to poor signage resulting in difficulties during OS survey of the roads.

These cases were handled by feedback of information to Ordnance Survey to investigate and if necessary correct the base reference information.

For unnamed Streets

The decision to associate each unnamed street (type 2 USRN) with a single link was based on the lack of any consistency or formal method by which links could be aggregated together to form a “street” whose name would often be incapable of identification or verification either from the ground or on the map.

This decision provides streetworks users with a fine level of detail at which to specify works. Indeed it is ironic that a finer level of detail is possible now for unnamed streets than for named ones which can span many junctions. This suggests that the streetworks regime should be improved to allow link level referencing. (See ref 2. for a fuller discussion)

For property purposes, LLPG placeholders were again allowed in cases where districts wished to associate two end points to a described type 2 street, such as “road through culham”.

No attempt in these cases was made to associate links, which remained as separate single link USRNs for highway purposes.

For classified Roads

No problems were encountered in matching the 61 classified road sections crossing Oxfordshire to the previously allocated USRN numbers, and ITN was used without modification to create the association with the links making up these Motorways, A and B roads.

No “C” class roads have yet been inserted into the Oxfordshire data

No footpaths have yet been inserted into the Oxfordshire data.

But note that the methodology for making these local extensions is being evolved as part of the recently documented DNF Architecture for Highways. This methodology is already beginning to be applied in other highway authorities.

Benefits

These are some quotes from the key users:

Steve Egan – Oxfordshire Highways senior technician *“ITN is the most accurate highway network we have ever worked with. Since it has come into full operation for street works, queries from Utilities have fallen almost to nothing for all named streets”.*

Dennis Young – Oxfordshire GIS Manager *“ITN is providing us with a coherent highways network for the first time, and we are developing links and exploring ways to use it as widely as possible across the county as the definitive street base”*

Brian Whittaker – Skanka *“Working with Oxfordshire to manage street works on behalf of BT has improved markedly since the network was upgraded”*

These give a clear indication of the benefits being derived from the approach. The benefits can be listed as:

- Street gazetteer is now built on an up-to-date, and consistent base;
- Improved data quality: specifically - positional accuracy, completeness, thematic accuracy and logical consistency resulting in reduced errors;
- Up-to-date and regularly maintained base data;
- Providing a secure base to record and cross-reference all data about the road network, whatever its source,

There is now the potential to share information with other bodies such as national and regional utilities if they also base their information on DNF rather than having to deal with a plethora of local and incompatible networks which are all inconsistent in detail.

Better Location of Street works

The consistent NSG base built from ITN Links provides a further benefit. An improvement to the MayRise streetworks software developed to take advantage of better network referencing can now accurately place streetworks in a high (70%) percentage of cases simply from the location description present in the notice.

This is possible because it is now certain to which street the notice refers, and a separate exercise has related all properties in the county to the ITN link which serves them. Thus the true connection between property and highway, often obscured within the LLPG use of USRN, is made through DNF and

streetworks with either an address or a junction between two streets in its location description can be automatically placed by the software. This makes future inspection and verification much more reliable.

Lessons learned

There are a number of lessons to be learned from this exercise both at the business and technical level.

The different perceived needs of Districts to have a hierarchical property address structure including a street, and highways administration which needs only highway can lead to confusion and discord.

In our project the use of regular face-to-face meetings and the clear distinction (in the data) between highway streets (defined by ITN) and additional LLPG Placeholders where they are believed to be needed for incorporation into district property gazetteers has effectively defused and managed this situation.

What is “definitive”? Ordnance Survey (the national mapping agency) have used a consistent national survey technique and relied heavily on on-the-ground evidence from street name plates to inform the ITN network. Address data often supplies indications of the extent of a street through adjoining property addresses. Districts have a statutory street naming function, but this often does not rigorously inform the building of their property gazetteers. The woolly specification of street extents as simple end coordinates, even if correctly specified, often do not in themselves convey the fine detail of which parts of the highway are, or are not to be included as part of a given street.

The ITN project has brought about improved communication between Districts, County and Ordnance Survey to use local knowledge to improve the national base map.

Next steps

Creating and maintaining a sound road network base is a vital investment. It brings life to “inter-operability” across the range of highway applications and beyond.

The ITN junction to junction links (or ESUs in BS7666 language) are the fundamental base element against which road related assets can be mapped, defects recorded and managed, and road condition surveyed and monitored.

The freedom to choose different application suppliers for these aspects of highway management make a common base architecture even more essential.

Oxfordshire has chosen Mayrise to manage street works and street lighting – systems for which ITN is thus automatically the base through NSG USRNs, and we have already noted above the benefits in streetworks positioning that DNF has enabled. EXOR currently provides the system for highways maintenance and WDM the UKPMS service. Ensuring these, and other,

separate applications refer to a common interoperable base is an essential next step.

Conclusions and Recommendations

The Oxfordshire conversion to ITN was not overly complex, but it required the right environment, management support, will and determination.

The same process could be followed nationally, and this would lead to a coherent and consistent NSG largely automatically updated through Ordnance Surveys own update procedures. Critically such a network would be better informed by information flows between OS and local authorities, as already underway in Oxfordshire.

Where NSG is seriously out of date this conversion can only be of benefit. It is a single jump to an up-to-date highway representation.

There are obvious and significant benefits for national or regional Utilities who have to deal with multiple authority networks, and in relation to the Traffic Management role defined in the Traffic Management Act which would presently have to deal with hundreds of local networks all mutually incompatible at a detailed level.

But there are difficulties, and not everyone shares the same perspective.

The Improvement and Development Agency (IDeA) agent of the Local Government Association has for the past five years been promoting through BS7666 a geography that is divergent from Ordnance Survey data. Such a stance has encouraged the local digitising and lack of consistent cross-referencing which underlies many of the problems in NSG today. It is good therefore to note that the BS7666 revision process is now swinging towards a better classification of data and cross-referencing to base geography. Though only an appropriate management structure for NSG will actually encourage these BS7666 improvements to take effect.

Where authorities already have well developed, but locally digitised networks, it will be a wrench to cut over to what might be perceived to be no better. It will be argued that the previous investment needs to be protected. But this is a short-sighted view and ignores cross-authority compatibility as well as future maintenance problems and costs.

References

Ref 1: D. Simmons, AGI 2003, Enabling GIS as the Prime Integrator for Roads Management.

Ref 2: D. Simmons, Streetworks 2005, Migrating to a National Street Gazetteer based on the Digital National Framework

Glossary

The following terms and abbreviations are used in the text. They are defined or expanded here.

Terms

Associated Street Data	Data supplied for each Street Gazetteer entry (USRN) to specify highway characteristics.
Digital National Framework	An overall architecture for the sharing of UK geographical information.
Elementary Street Unit	Continuous length of street between adjacent junctions or a junction and the end of the street. Defined and used in BS 7666
Integrated Transport Network	An OS MasterMap component which replaces OSCAR and provides a structured representation of road centre lines.
Land-Line	Ordnance Survey large scale digital mapping at either 1:1250, 1:2500 or 1:10,000 scale depending on the type of landscape (urban, rural or mountain and moorland). Features are represented as either points or line vectors.
Level 3 Street Gazetteer	A street gazetteer which includes Elementary Street Units and where the coordinates of intermediate vertices are included.
National Land and Property Gazetteer	A national aggregation of local land and property gazetteers conforming to BS 7666.
National Street Gazetteer	A national aggregation of street gazetteers maintained by Local Authorities using BS7666 as the common framework.
OS Centre Alignment of Roads	ITN pre-cursor product (OSCAR) which provides junction to junction road elements
OS MasterMap	A fully topological digital map designed by Ordnance Survey for use with geographical information systems (GIS) and databases. Based on the National Grid, it includes topographic information for many real world features – buildings, roads, phone boxes, post boxes, landmarks. Information is presented by themes in a series of layers.
Ordnance Survey TOID	Identifiers that provide unique references for all features in OS MasterMap.
Unique Street Reference Number	An 8-digit number unique for each local authority defined street in ranges allocated to local districts

Abbreviations

BS 7666	British Standard 7666 Spatial datasets for geographical referencing – Part 1: Specification for a street gazetteer
ESU	Elementary Street Unit as defined in BS 7666
IDeA	Improvement and Development Agency

ITN	Integrated Transport Network
LLPG	Local Land and Property Gazetteer
NLPG	National Land and Property Gazetteer
NSG	National Street Gazetteer
OSCAR	Ordnance Survey Centre Alignment of Roads
TOID	Topographic Identifier
USRN	Unique Street Reference Number