Creating Ordnance Survey's Integrated Transport Network™

using the Digital National Framework

Before the Topography Layer of OS MasterMap® had been launched in November 2001, Ordnance Survey started work on considering the options to re-engineer other associated layers to ensure they met the demands of future applications. The choice to use Digital National Framework (DNF) principles had been established and it was only a question of how this would be done in supporting rapidly growing user needs across all parts of industry. The Integrated Transport Network (ITN), a national road centreline network with routing and restriction information, was released in 2003.

As its name suggests, the ITN is ultimately intended to cover all modes of transport along with the all the various links and interfaces between them. Currently, the road and ferry networks are included, along with details of road names and classified roads, as well as a whole range of road routing information. Prior to 2003 Ordnance Survey's main roads dataset was OSCAR®, a road centreline network with a simple structure that, while adequate for some purposes, was not extendable. By referencing the new centrelines to the Topography Layer of OS MasterMap (a seamless tessellation of map objects representing selected real-world features covering the entirety of Great Britain) the new layer would be fully interoperable and harmonised with the DNF reference base.'

The challenge

The challenge was to split the network into a series of related objects, and to reference them together using DNF principles. A suitable methodology had to be found that would create a high-quality dataset from the information already held, which was extensible in the future for Ordnance Survey and its customers.

The development of ITN represented several significant challenges, not least of which was the sheer complexity of the real-world transport network. The scope and design of the specification was in itself a considerable task, with conflicting requirements to simplify the data as far as possible while retaining all the complex connections and restrictions necessary in a large-scale road routing dataset.

The solution

The existing OSCAR roads dataset was already well established, and was an obvious starting point for the creation of the ITN. With a significant amount of filtering and restructuring, this was used as the source data for the ITN base network. Among other things, this conversion process involved making the dataset fully topological by creating nodes and referencing them to links, and changing the way road name and classification information was handled.

The fundamental reference base for ITN was the Topography Layer since the road centreline data depicted in ITN is a linear abstraction of the road surface coverage. One of the first major issues was to determine how to relate each network link to topographic area features. In order to do this it was necessary to split these underlying features at junctions so that there would always be a meaningful relationship between each road link and its corresponding road surface area

'OS MasterMap Integrated Transport Network Layer (ITN) has two data themes, the Road theme and Road Routing Information Layer (RRI) theme. ITN is structured and maintained to DNF Principles and as Ordnance Survey continues to develop the product offering we will follow DNF guidelines allowing us to manage the complex data in a structured, logical and extendable manner.'
Gavin Jackman, Senior Product Manager, ITN.

polygons. In addition, because the ITN was to be a topological network with nodes at every junction, there was also a need to create 'junction boxes' where appropriate, to which these node features could be referenced. This was a non-trivial task, and the methodology used to split the road polygons required a significant amount of manual intervention. However, once complete this process not only created a link between ITN and the Topography Layer but also enhanced the Topography Layer by making the road surface polygons more useful and meaningful in their own right. More importantly, this connection allowed change to be synchronised between the two datasets, enabling much greater consistency between data holdings.

Once the base network had been built and related to the topographic road surface polygons, higher level detail, such as road names and routing data, could be related to this base network, thus creating an extensible hierarchy of joined-up information.

Because ITN was intended to cover multiple modes of transport, with a sub-network representing each of them, a consistent way of defining the interfaces between them was needed. For example, the road network and the ferry network needed to be defined and maintained separately, but with a mechanism for moving from one to another at places where such a transition would be possible (such as at a port or quayside). This was implemented using 'terminal' objects, which are in fact cross references between connected nodes in separate networks.

After building the topological road network and relating it to the underlying topography, and having added all the ferry crossings, the final challenge was to relate a whole range of routing, restriction and other information to the network links and nodes. This needed to be done in a way that could be easily extended in the future, allowing for new content to be surveyed and published without making any major changes to the data model. To enable this, all road-related information is recorded against the base network using linear referencing.

The object model of the DNF made the solution logical and consistent by separating out the levels of detail and always building upon lower-level atomic units. The DNF requires that every item of data be considered as an object with a unique identifier and a life cycle (version number and status). Alongside this, an explicit reference to at least one lower-level object is required for every new DNF object. The adoption of this framework in the development of ITN has lead to a consistent and well-structured dataset that is fully linked to the underlying Topography Layer.

The fundamental units of the ITN are the links and nodes that make it up. Links are structured junction-junction sections of road which never cross each other, while nodes are point objects that occur at junctions and cul-de-sacs. Every one of these items is assigned a unique identifier (called a TOID® within Ordnance Survey) that persists over its lifetime, and a set of life-cycle rules is used to define this persistence. As well as having their own identifiers, links contain references to the identifiers of the start and end nodes they are connected to. This connectivity information is used in routing applications to calculate a path through the network.

One of the key enhancements in ITN over OSCAR was the separation of network links from street names and classifications. Named streets are now considered to be objects in their own right, as are classified roads. They are given unique identifiers (as with every DNF object), and contain references to the network link objects that make them up. So rather than just adding the textual attribute 'High Street' to each of the links on a high street, it can now exist in its own right, as a 'High Street' road object. The same applies to, say, the A27, which exists as a 'free-standing' road object and contains references to all the links that make it up. This is an example of how the DNF model encourages the reuse of lower-level data as building blocks to create high-level entities.

Benefits

- Having a hierarchical structure creates a good data management environment and allows the different components of the ITN to be maintained more independently.
- The structure is highly extendable, so new data layers can be added to the product in future stages without affecting what already exists.
- Cross-referencing promotes better consistency between the different OS MasterMap layers.
- Explicit referencing between ITN and the Topography Layer means that users can link ITN references with their data, and then link to the underlying topography only when necessary.
- The maintenance of the cross referencing between the Topography and ITN Layers is done by Ordnance Survey, relieving the user of the overhead of keeping the two in sync with each other.

This case study has been produced on behalf of the DNF Expert Group.

A more detailed study on this application can be found by visiting the DNF web site at **www.dnf.org**

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