The Digital National Framework

- evolving a framework for interoperability across all kinds of information.

A White Paper by Ordnance Survey
September 2004

Interoperability - capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units.

[ISO 2382-1]

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Executive Summary

The concept of the Digital National Framework (DNF) was launched four years ago to support greater connectivity across all kinds of business information managed by separate organisations, where that information has "location" as a common dominator.

The problem of today's organisational "data silo" is well recognised across the world. The lack of connectivity between data records held by different bodies is a major barrier to the development of applications that require information from two or more organisations, especially across Government. This in turn prevents the realisation of the full potential of that information in supporting new government initiatives, new applications, innovative analysis and emerging mobile services of all kinds, especially where location has an essential role to play.

The purpose of this paper is clarify the role of DNF, provide an up to date definition of DNF for those familiar with the concept as well as those who may be new to it, to highlight the benefits of adopting a common approach, and to report what has happened since the publication of the consultation paper and public seminars four years ago.

It is recognised that DNF is a fusion of best-practice guidelines for describing and uniquely identifying spatial geographies allowing for ease of transfer of information and linking datasets between organisations. In many ways it is defines a mechanism for identifying and reusing geo-spatial information to avoid unnecessary duplication and redundancy and increase interoperability.

The paper concludes that:

- *If the true potential of geographic information is to be realised, a step change has to be recognised by all stakeholders involved in georeferencing in the required move from "digital mapping" to "geographic information". This is essential if "industrial level" and increasingly automated applications are to be successfully established and full potential in information investments achieved.*
- *Interoperability or information connectivity requires the adoption of consistent approaches in information modelling, georeferencing and data exchange. This is applicable at the macro level i.e. across national reference datasets and especially government organisations [e.g. land and marine information integration] and at the micro level i.e. within those datasets at the information record level [e.g. images connected with buildings etc].*
- *The Digital National Framework is an evolving model. It is inclusive, it is politically and commercially neutral in application and its underpinning role is to bring coherence to national geographic information datasets, interoperability, easier and consistent data integration and to promote easier and wider usage of definitive GI datasets.*

- *The more successful it is - the more significant the benefits will be, not only for users and stakeholders but it also offers significant advantages for UK plc.*

Getting involved

DNF is an open initiative, and is being developed across organisations in collaboration, led by front-line experts in information interoperability. If you wish to find out how DNF could help you improve your e-business processes, or speak to people who have implemented or are involved in implementing DNF methods or other components or want to get more involved in the evolution of DNF there is a list of people to contact in the Next Steps section of this paper.

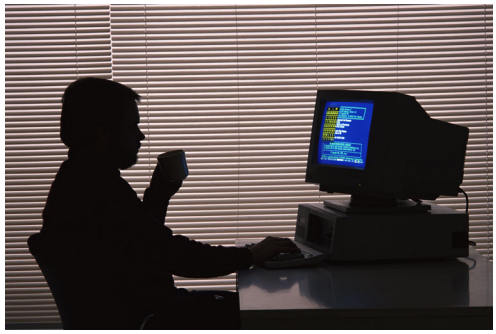
"The aim of the DNF to create standards that will support the interchange of information has parallels with the National Statistics plans to introduce standards to facilitate the handling of data. This key initiative will complement the statistical programme in the coming decade. I very much look forward to continuing our joint efforts to deliver best value to the user community from these investments"

Len Cook,
National Statistician and Registrar General for England and Wales,
Office for National Statistics

"Land Registry fully support the aims and principles of joined up geographic information across government "

Peter Collis,
Chief Land Registrar, Land Registry

"DNF offers a way forward in integrating business and geographic information"



Frank Manson,
Managing Director, Registers of Scotland

Contents

About this paper

This paper aims to:

- *Clarify the role and scope of DNF*
- *Outline the overall benefits of adopting DNF principles and methods*[1]
- *Report progress since the original consultation papers in 2000*
- *Act as a point of reference, to be supplemented with the publication of further material as it evolves*
- *Outline how the concept might evolve further in the next 3-5 years and how the GI community can contribute to this development*

Intended Audience

The paper is appropriate to anyone at senior management or strategic level who is considering information strategies, information policies and future investments involving geographic information in their organisation or who wish to better link their information with information of one or more other organisations in a consistent way.

Since DNF is primarily concerned with data and information by necessity, this paper tends towards a largely technical content. However the reader does not have to be a technical expert to understand the basic principles, concepts and benefits of the Digital National Framework.

Guide for readers:

It is possible to refer to different sections depending on the reader's interests; the following headings are offered as a guide. For a description of:

The definition of DNF – go to the section "1 .The Digital National Framework"

The benefits of implementing DNF – go to the section "2. Use and Benefits of the Digital National Framework"

Examples of implementation of DNF – go to the section "2. Use and Benefits of the Digital National Framework"

Technical description of DNF – go to the section "3. Technical Overview of the Digital National Framework"

[1] Benefits are often better defined in terms of specific user's objectives, needs and applications. It is difficult in a paper of this kind to describe specific benefits since the GI industry is so wide and organisations have different drivers for change. This document offers a starting point in developing organisational benefits, which is best achieved through dialogue with either organisations or service providers and consultants who have adopted connectivity methods [first line contacts in Ordnance Survey are listed at the end of the Technical Overview section later]

Whilst this is not a formal consultation paper, comments, feedback and views will always welcome and these should be directed to:

Mark Stileman [Mark.Stileman@ordnancesurvey.co.uk]
Corporate Office,
Ordnance Survey

Comments by the 30th November 2004 please.

Early responses will be greatly welcomed and will help in guiding the direction of the next stages of DNF.

Setting the scene

Our changing world

In the four years since the Digital National Framework Consultation Paper was published, the recognition of the potential benefits of geographic data and geographic information have grown significantly. Equally there has been a growth in the creation of digital geographic datasets and in the use of information across both the public and private sectors.

Over the past four years the most significant area of growth has been in government. This is common in most countries and in the UK we are starting to realise the power of geography in assisting decision-making at the strategic policy level, in improving operational performance, and in communication with the citizen. The use of GI in other sectors has also grown over this time, such as among utilities and in the insurance, telecoms and transport markets.

Taking a wider view than simply the UK, the prospect of a European Spatial Data Infrastructure is now much closer; and the underpinning technology powering geographic information has not only advanced considerably but has also continued to evolve – examples include the growth in broadband take-up, advances in web services, and developments in digital imaging.

Interoperability

Today the terms “interoperability” and “enterprise systems” are widely used, but the implication of adopting these approaches is often unclear and rarely explained. The e-government agenda over the past four years has done much to stimulate developments across local, regional and central government, but there are question marks about how joined-up - i.e. how interoperable - these initiatives really are, and how easily datasets from different organisations can be integrated in order to service a new application or execute a new form of analysis.

At the same time, geographic information is slowly but surely being absorbed into the mainstream of established Information & Communication Technology [ICT]. This in turn is changing customer expectations on price and quality, the need for generic information systems to handle GI thereby leading to the decline of specialist GIS. But much of what is often described as geographic information is still simply "data" and currently has limited potential in terms of "information". Current evidence relating to several initiatives and applications, both within government and in the private sector, suggests that much of the existing data cannot easily be assimilated with that of another organisation.

Business success requires better connectivity and joined up thinking

We need to be able to achieve easy connectivity if we are to really ***make a difference*** in developing key initiatives right across the national and local agendas in areas such as:

- Planning and Construction Lifecycle
- Property Transaction Lifecycle [seeking, buying, occupying, selling]
- Transport management and navigation applications,
- Buried Services [particularly utilities, pipes and cables]
- Citizens Democracy
- Neighbourhood renewal and regeneration
- Environmental risk management
- Personal security
- Location based & mobile services

Making that difference can be achieved by establishing a coherent set of flexible linkages within a robust geographic reference system allowing users to easily pull in other types of information or components to meet an application need. A simple case might be data of a building footprint, which has limited value until it is combined with other data, such as an address.

Through this process of data linkage, a new, higher level of "geographic information" is achieved: an "addressed real world object" to which yet more information can be recorded, maintained and published (such as the number of floors, number of rooms, construction materials and so on) and where all or part of this data can be shared, but will be maintained and distributed across those organisations who are best placed to do so.

While there is evidence that we are making some progress towards this vision, there is also evidence that in the rush towards e-government many organisations are working in isolation and we are still developing organisational information silos. This inevitably results in duplicated datasets with partial or little maintained connectivity.

This was the fear expressed in the earliest of the consultation papers:

"How ironic if, in a world of joined-up government and joined-up services, we inadvertently lose what joined-up geography we have historically had, and which provided so much economic and other benefit".

Moving into Geographic Information from Digital Mapping

Geography, while important within the GI industry, is just one element in the wider ICT and business information world - albeit a powerful component and one now widely recognised as such across the world.

Therefore geographic information does not drive the information industry and rarely will it dictate how a business will operate.It is more an enabler and a means to an end. GI will exploit the prevailing ICT environment as shown in Figure 1 below. Neverless it is becoming a powerful stimulator of new applications within the information industry [mobile sevices, planning portals, census information on line, citizen information services from local authorities and so on].

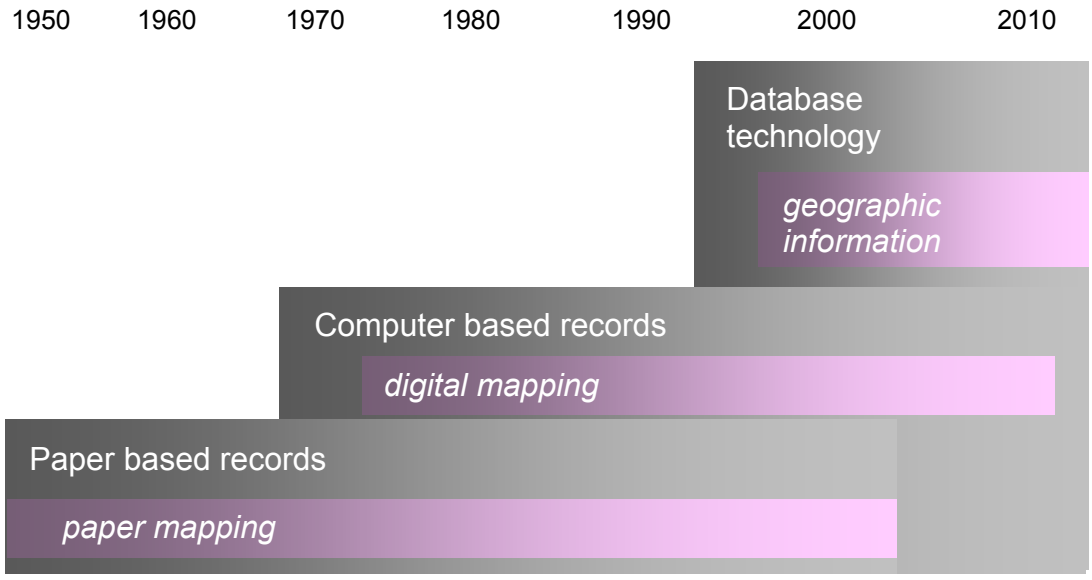


Figure 1. Step change in technological impact over the last 50 years.

Organisations adopted computers in the 1960s but it was a further 10 or more years before these systems were sufficiently mature to support digital mapping. The significance of the step change to geographic information (from digital mapping) is not always fully recognised by senior management across organisations dependent on location based information as being perhaps greater than that when we embarked on the move from paper to digital mapping. In moving up into managing mainstream geographic information,

organisations are not always aware of the need to move up a gear in terms of investment in new skills and ideas, new technology and new content to meet new business needs.

Encouragingly there is evidence that this is not always the case. For example, the SPIRE[2] programme is a major investment by DEFRA, seeking to better manage and coordinate disparate geographic data and information holdings across a wide department and several disciplines. Of course organisations will make the transition from digital to geoinformation at the time that best fits their own business plans as part of developing better services for their customers.

To achieve the potential of easier and more automatic analysis and processing of information with a geographic content, we need to establish a level of maturity more associated with banking, electronic point of sale, internet shopping and internal records management. The vision and capability has to be invested in, nurtured and developed so that the infrastructure will bear fruit.

Summary

- ***Interoperability is central to realising the business benefits that geographic information can bring***
- ***Organisations, having made the change from paper to digital mapping will make their change to geographic information when it best suits their business and operational need.***
- ***Migration from mapping to geographic information requires a step change in thinking, training and resources***
- ***A Step-Change in efficiency will be realised if unnecessary duplication in creating new geographies is avoided by identifying and registering the geographic abstractions that already exist***

[2] SPIRE: "The Spatial Information Repository (SPIRE) will deliver a consistent, managed, and 'fit-for-purpose' view of spatial information across DEFRA, its Executive Agencies and Non-Department Public Bodies (NDPB's) that underpins the Department's strategic sustainable development objectives".

1. The Digital National Framework

*This section describes **what** the Digital National Framework is, the goals, principles, components and the relationship of these.*

Definition

"The Digital National Framework is a model for the integration of geographic information of all kinds - from national reference datasets to application information at the local level".

and in its implementation:

- *"The Digital National Framework (DNF) provides a permanent, maintained and definitive geographic base to which information with a geospatial content can be referenced" [Ref A]*

- *"DNF is supported by a set of enabling principles and operational rules that underpin and facilitate the integration of geo-referenced information from multiple sources*"

It needs to be stressed that DNF is not a product owned by one particular organisation. Nor is the concept owned by one organisation. Implementation of this concept and principles requires collaboration across all GI sectors and beyond. The collaborators require some basic rules to assert a level of coherence and consistency in the implementation of the framework and in its operation; linking many distributed databases and supporting better information connectivity.

Principles

The following guiding principles have also evolved and developed to support the concept:

1. *The concept and methods shall be driven by the strategic needs of the wider GI community and the needs of the information industry.*
2. *Data should be collected only once and then re-used.*
3. *Reference information/data should be captured at the highest resolution whenever economically possible.*
4. *Such information may then, where appropriate, subsequently be used to meet analysis and multi-resolution publishing requirements.*
5. *DNF will incorporate and adopt existing de facto and de jure standards, wherever they are proven and robust.*

Hence DNF will foster an environment where users should not need to capture information that already exists. In future information can be reused and added together to form new datasets building on existing proven components.

The Goals of the Digital National Framework

Several high-level goals are evolving through practice to support the Digital National Framework. The goals are key steps in realising the benefits of the DNF model. These are to:

- Establish a coherent structural model of national reference datasets and the relationship with application information.
- Evolve and maintain a national framework based on this model to support consistent integration of geographic information and thereon enable the easy and increasingly automated exchange and analysis of application information from different sources.
- Establish and evolve a consistent approach to georeferencing and the inter-relationship of application information/data with reference information/data.
- Establish and evolve a consistent approach in the modelling, integrity and connectivity of geographic information.

Since different users employ different technologies, the DNF principles and ground rules aim to be independent of any specific technology, software application or business model.

Scope of the Digital National Framework

The Digital National Framework is evolving. As a better understanding of the issues also emerges, it is anticipated that the scope will incorporate[3]:

- A model of the relationship of key national geographic datasets comprising descriptions of:
  - reference information to underpin user/application information
  - the inter-relationships of reference information across organisations
  - the inter-relationships of user/application information with reference information
- Technical support to underpin geoinformation interoperability through an open resource comprising:

[3] This section may include terms the reader may not be familiar with, this is not important at this stage - specific terms are developed later in the paper.

  - Feature cataloguing & classifications
  - Unique identifier management
  - Methods of georeferencing and cross referencing
  - Feature modelling – generic cases
  - Publication at different resolutions (scales)
  - Geodetic reference system information

- Dialogue and communication:
  - Cross industry Expert Groups established to manage specific issues
  - Web resource and news centre

Relationships and Responsibilities

Within the overall concept it is expected that much of the commitment to improve today's infrastructure will continue to rest with senior management in a range of organisations, and ultimately the support of their Chief Executives. Such support will be critical in taking the lead to better improve connectivity and content to meet user's needs or to develop new applications, ***i.e. the development of the Digital National Framework will be customer driven, to meet a demand where it is needed, and will be successful where there are proven cost benefits*.**

The Digital National Framework would not have developed as far as it has today without collaboration and commitment at senior level across organisations, and the evolution of methods. These relationships are now growing and are vital in developing and extending the support required for the next evolutionary phase of the concept. Overall the relationships and communication between information providers, application-users and the wider industry needs to be further advanced.

In securing further progress, it is not expected that there will be a need for a formal committee or expansive programme structure, nor should there be any formal ownership of the Digital National Framework. Collaboration between users, providers and the wider GI industry players (vendors/consultants etc) has got us this far in this enormously challenging area and further collaboration will be even more important in the future.

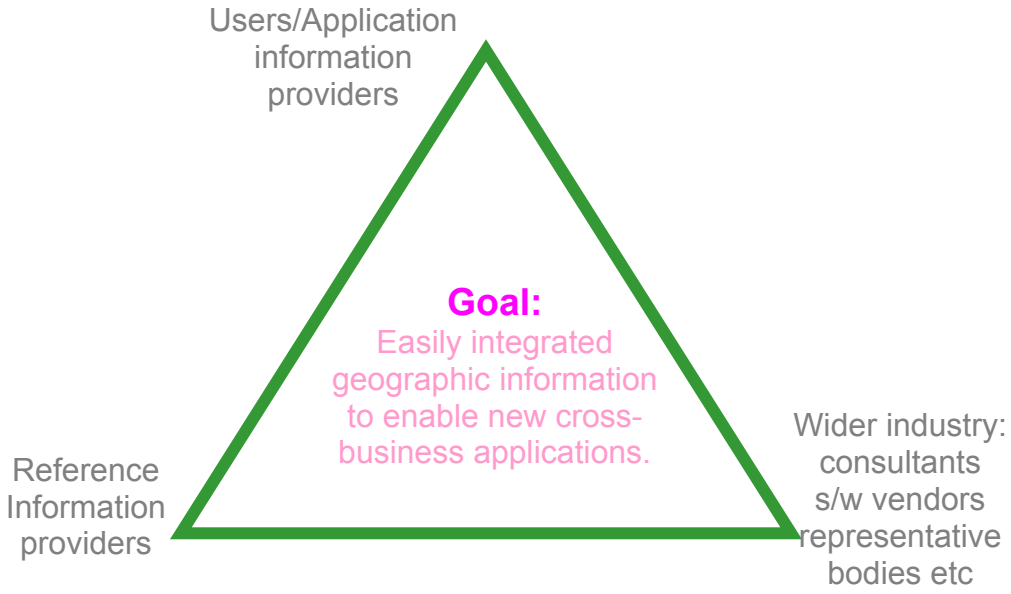


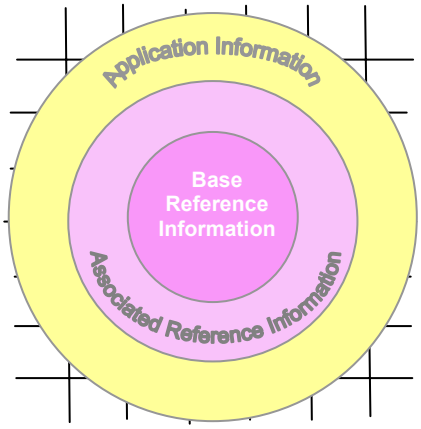
Figure 2. Relationship of the key stakeholders in development of DNF

DNF is not intended to act as a national GI strategy since it is largely concerned only with information and content. It does however perform a key role in the further development of existing spatial data/information infrastructures and therefore will complement GI strategies at local, regional, national and international levels.

Role of DNF: Enabling information integrity from national to the local level

Reference information

The DNF is a collaborative framework within which organisations that hold and manage parts of the reference information infrastructure can work together either bi-laterally or multi-laterally, to establish better linkages and standardise levels of interoperability in the reference base using a common model. Collectively they can provide a clearer and stronger foundation for application data of all kinds, where the whole has the potential to be greater than the sum of the parts.



Geodetic Reference System
The horizontal and vertical datums that all locations (coordinates) are referenced to, and coordinate transformations between such systems e.g. ETRS89 to National Grid. DNF should also address the best –practice for relating site –specific geographies to ETRS-89 and the National Grid.

Reference Information
Any geographic feature/object that is used as a locational reference for application information, or is used in geographic analysis by a number of different organisations. Reference information is formed of base and associated reference information:

- **Base reference information** (e.g. topographic features) provides complete detailed coverage of the landscape to which
- **Associated reference information** is referenced; but where this is also commonly used to support georeferencing or analysis e.g. transport networks, addresses, land parcels, SSSIs etc.

Application Information
Any business-oriented information that requires connectivity through a geographic reference of some kind (such as a building, field, road or user defined feature such as a property parcel) to enable the end-user to analyse and interpret the integrated information from different sources.

Figure 3. The main geographic information relationships.
- all based on a consistent interoperable coordinate system.

The aim is to evolve authoritative, ideally definitive, reference information of all kinds and that this should be collected and maintained at the highest resolution practicable by those organisations best placed economically and technically to achieve this.

Application Information:

At the application information level, people can create and distribute their own application components as they see fit within the overall framework, using common methods.

Technology now supports the analysis and publication of GI in different ways and forms and this is enabling multi-scale output. Graphical information can be published either at the resolution of capture or derived, although the latter is still likely to require some manual intervention. It is also now easy to display attributes by simply pointing to the object about which a user wishes to discover more information. In some cases text lists or reports may suffice.

However consistency is required here too and common methods are required to support both the providers of reference and application information – since they each face the same challenges. As generic solutions emerge, the base models and methods can be made available, along with documentation to support their greater re-use based on proven methods. This will support standardised take-up by the wider industry.

An Inclusive approach

The greater the participation by public and private sector bodies, the greater the benefit that will be realised, not only for the participants but also for third parties wishing to exploit the interoperability the framework offers. While the majority of ownership of DNF compliant datasets might lie with government bodies in delivering the reference information layers, there will clearly be significant opportunities for private sector suppliers to support these agencies at all levels of government.

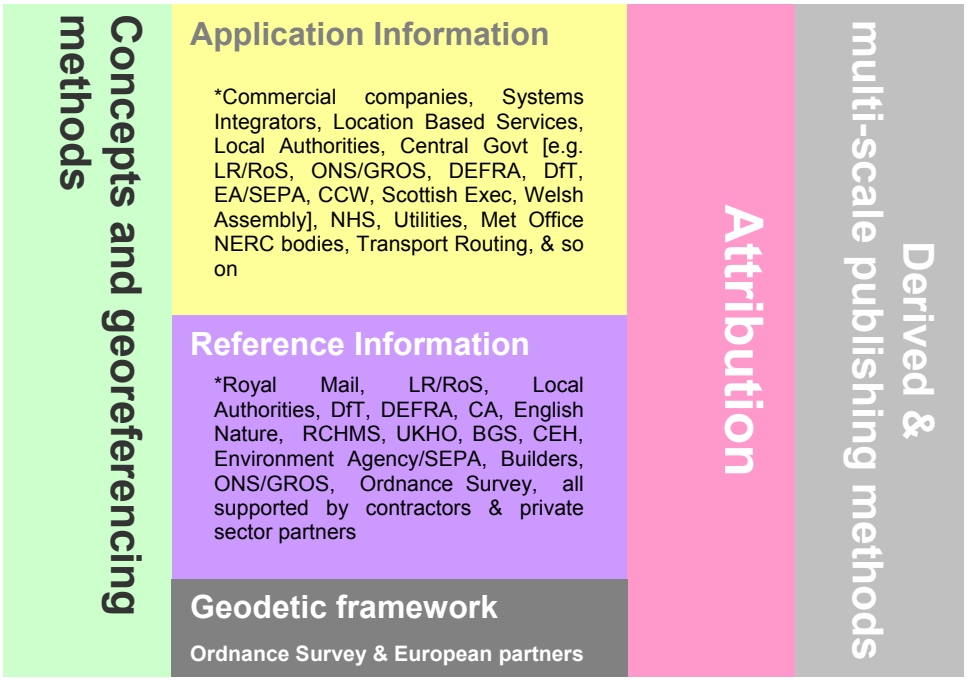


Figure 4. Components of the integrated framework and participants
See also Figure 8 later.
*Note: as regards participants, this is not intended to be an exhaustive list

Standards

As far as standards are concerned, DNF could be perceived as setting a "standard", just as the National Grid has set a standard since 1938. Establishing the DNF formally as a standard in its own right is, however, not the primary goal. In this respect DNF is better considered as best-practice guidelines. Information not adhering to these guidelines will be incompatible to simple transfer and therefore will fail in a simple adoption test. In this respect DNF is more about defining a benchmark for ease of trade – creating a simpler marketplace for the transaction of spatial information.

Proven existing standards, whether they are *de jure* or *de facto,* will play a major role in the development of the Digital National Framework. For the UK to integrate its information better, and make a strong contribution in Europe, it needs to interface and evolve national British standards in line with the ISO 19000 family of standards and other, wider European developments. Likewise

the adoption of OpenGIS interfaces is growing across Europe and at national levels. These welcome developments are likely to be incorporated into DNF modelling where they add value.

Existing standards have already been adopted for geodetic referencing in the United Kingdom and Ireland through the implementation of the European Terrestrial Reference System 1989 (ETRS89). This, and the necessary 2d and 3d transformations, not only facilitates GI data exchange across Europe, but also ensures that we are consistent with both current satellite navigation systems (e.g. GPS) as well as the emerging European Galileo system. It is clear that the transfer of positioning data at both the coordinate framework level and at the real-time positioning level for Global Navigation Satellite Systems will be an underpinning element to DNF.

The DNF is, however, primarily concerned with geospatial information and its relationship to other data and information (business and geographic). As a concept it is enabled by the adoption of electronic online services and increasingly web-served information. However as a concept it must (and can) operate across a range of technologies and this is reflected in the model.

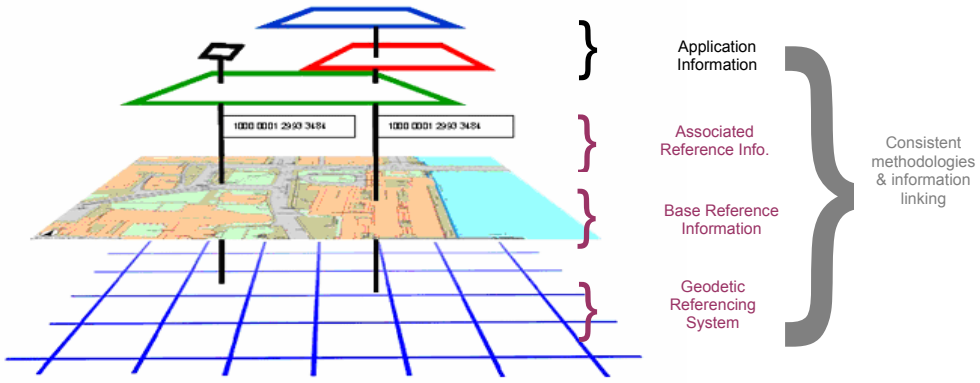


Figure 5. DNF: a framework to integrate all kinds of geoinformation.
The model supports the integration of information from multiple sources, application & reference information, linking objects & features and components by identifiers.

In the diagram above, which illustrates the model, the unique feature identifier of the geographic location [i.e. the TOID] provides the anchor in linking user application information to that location. Through cross-referencing this can be achieved by linking the geographic feature to a user's business identifier e.g. school identifier, client identifier, title number, UPRN etc. As will be seen later the user's geography can be configured in different ways to meet specific user-defined geographic "views" of the world, which, are invariably different across (and sometimes within) organisations. A key element of DNF will be defining a rule-set for creating unique feature identifiers by different organisations to allow for easy transfer and assimilation. This must maintain the principle of being both unique and maintained – re-inforcing the need for feature lifecycle maintenance across all datasets involved.

Summary

- ***DNF is supported by principles and methods based on best practice to bring about greater consistency in linking geographically-based information across organisations.***
- ***The aim is to avoid unnecessary duplication and redundancy and increase interoperability.***
- ***There are three main categories in the DNF information structure – base reference information, associated reference information and application information. These are all built on an interoperable geodetic reference system.***
- ***The Geodetic and Topographic bases are essential elements. It is important that they are accurate, maintained, comprehensive and easily accessible.***
- ***DNF requires information users, providers and the wider industry to combine forces in taking geographically-based information to a new level of maturity.***
- ***A Key Method in DNF will be rules for the creation and maintenance of unique feature identifiers***

2. Use and Benefits of the Digital National Framework

*This section summaries the experience so far, **why** it is required and describes the benefits of DNF both at national level and for organisations and users.*

Applicability of the Digital National Framework

The Digital National Framework was conceived in 1999-2000 based on wide consultation, building on existing experience within and outside the GI industry. It has since evolved, and will continue to do so. It is relevant to GI users at all levels that need to migrate their data holdings to an information environment where data integrity, currency, automation, services, fitness-for-purpose and return on investment are all key objectives.

Over the last 2-3 years several examples of better links have been developed from the national dataset level down to the local record level.

Progress 2000-2004: from concept to implementation

Progress has been made since 2000 in several areas. From Ordnance Survey, the re-engineering of the National Geospatial Database has delivered a polygon based structured database with over 440 million unique identifiers (TOIDS) maintained for all objects/features in the built and natural environment This was a major milestone in the development of the DNF since it provided the starting point for a consistent form of georeferencing. Further elements of Base and Associated Reference Information remain to be developed either by Ordnance Survey or others in the public or private sector. The new Ordnance Survey large scale mapping product family OS MasterMap is engineered on this new database foundation.

The DNF concept is starting to encourage the development of definitive joined-up datasets, maintained by the originators in a distributed network of servers, based on a framework of a few basic rules and methods to support interoperability, easy access and use. Implementation is a medium to long-term goal, which will reflect an organisation's position on the technology ladder, and its business plans. The example of SSSIs earlier illustrates some of the changes still required and with over 160 such different area geographies, the challenges of implementation should not be underestimated.

At the national level: Work has been successful in securing the better integration of coastal zone information by agreeing some definitions, standards and transformations between the UK Hydrographic Office [UKHO], the British Geological Survey and Ordnance Survey [Ref I]. In the not too distant future, applications in the coastal zone will be able to use UKHO data, which will be aligned with OS MasterMap in terms of features (High Water Mark) and in the same coordinate system (horizontally and vertically). See Figure 6 below.

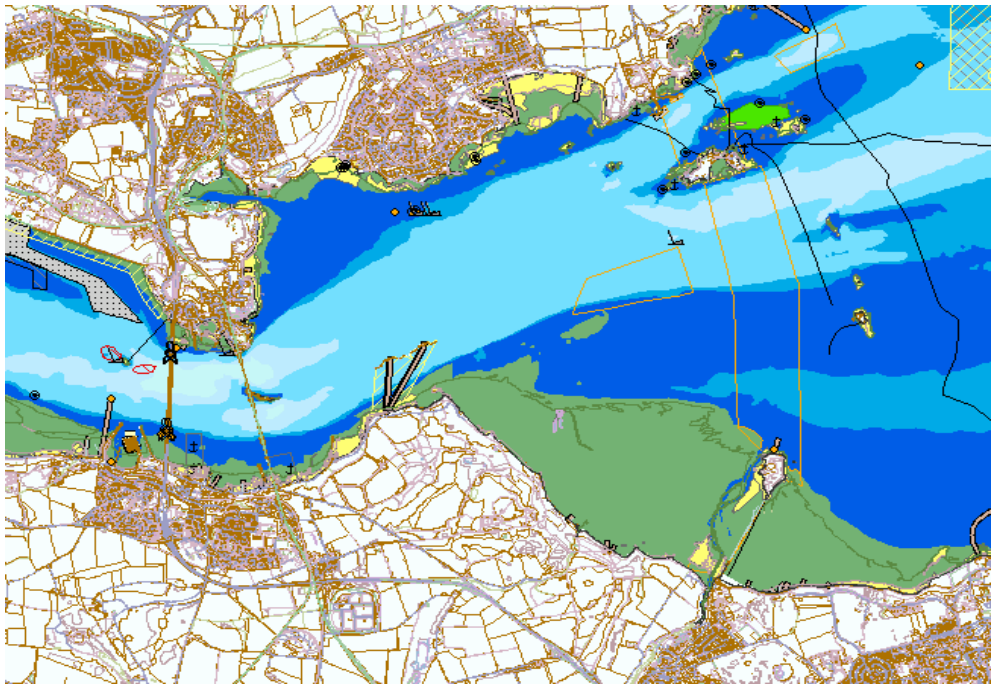


Figure 6. Example from the Coastal Zone information integration pilot.

Work has also taken place to investigate the linking of address, land and property information across government [Ref G]; and there has also been continuing dialogue between Great Britain, Northern Ireland and the Republic of Ireland on the harmonisation of national base reference information [Ref F].

On the wider European scene, the emerging European Spatial Data Infrastructure has stimulated several initiatives such as EuroSpec [Ref J] for pan-European Reference Information.

The DNF model has been presented in several workshops and is acknowledged within initiatives such as INSPIRE [Ref M], as a complementary model to support consistent GI interoperability [Ref K].

At the record level: Easily the most significant implementation of DNF principles has been undertaken in the definition of access land by Black and Veatch for the Countryside Agency [Ref L]. This has involved referencing over 1.3 million hectares of land to the physical ground features as part of an extensive programme to assess its suitability for inclusion as access land under the Countryside & Rights of Way Act 2000. This has involved several scrupulous consultation stages and is backed up by an extensive electronic audit trail.

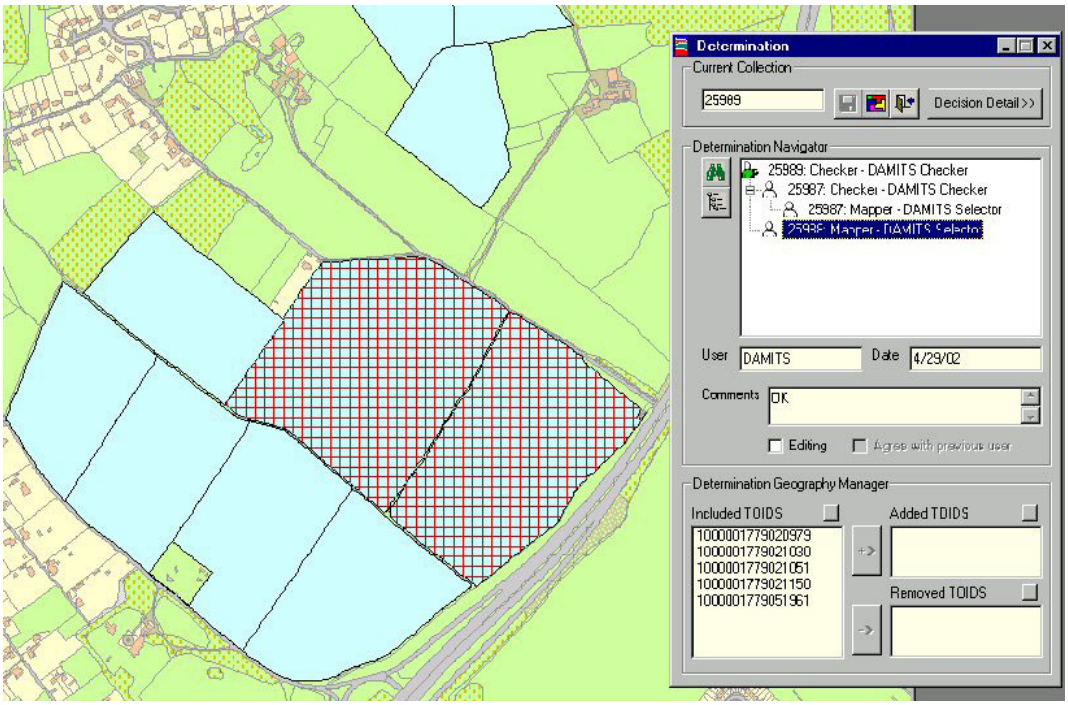


Figure 7: Access land data being prepared for consultation.
Image courtesy of Black & Veatch and the Countryside Agency.

The need for common standards for information processing is also recognised in the National Statistics Code of Practice which has an underlying principle to use common statistical frames, definitions and classifications. The Statistical Integration Protocol that supports the Code underlines the importance of common georeferencing and coding standards. The National Statistics Group that is responsible for developing standards has endorsed the DNF as a key part of its policy to support a consistent approach to georeferencing across all organisations collecting information for statistical analysis. The link with the DNF is an important step on the path to creating a Geographic Referencing Framework to underpin the collection, processing and analysis of statistical information.

Benefits for stakeholders at the organisational or national level

Savings and benefits through the re-use of definitive information

- **Investing in the future.** Such is the pace of change that investments in new systems and information supply will be incurred by most organisations over the next 5-7 years. Greater benefits and direct cost savings will accrue to those investing in a common approach that supports re-use and connectivity. This applies to the wider information industry as much as it applies to the GI industry.
- **Minimising risks and saving costs.** Through a coherent framework, with greater participation, definitive interoperable datasets will emerge through increasing integration of existing information and convergence

to a common model. Thus today's duplication should largely start to disappear (although data silos cannot be legislated against).

- **Unlocking the latent potential in current datasets.** At the national level, over time, we will see both government policy enabled and a stronger knowledge economy emerge, based on the strong information infrastructure that enables the kinds of applications that the GI industry has promoted for several years, if not decades.

Savings and higher value of user information through the re-use of definitive information

- **Increasing the value of your information.** The emergence of information with greater connectivity and authority will be of greater value, whether this is simply in the eyes of users who will use it before anything else, or in commercial terms. Both are relevant to different sectors of the industry.
- **Increasing the revenue potential of your information.** As greater unity and integration emerges we should expect some very specific advantages to be realised to a) the benefit of the information provider, third parties building applications [who might provide revenue returns back to the information provider], and b) the end users in terms of better services and lower costs.

Easier integration, data exchange, sharing and better reliability

- **Link once and use many times.** One of the greatest barriers faced by both the public and private sectors at the moment is the cost of data integration. Whether one is developing a programme to address social exclusion ills, or a location based service application on a 3G system - the start up data integration costs are significant as are maintenance costs. ***Indeed, they are often so significant as to be prohibitive.***
- **Minimise costs and start up times for new applications.** Today an organisation might repeat the conflation that another body performed only a week before. There is merit, therefore, in each organisation building in their own connections once and reusing these, which can lead to the "whole being much greater than the sum of the parts".
- **Link your geographic information into new mainstream ICT initiatives.** The term 'plug and play' geography is widely used and while it is a challenge to achieve, the goal has been realised in other ICT industries and has the potential to liberate many geographically-based innovative developments and help grow the market for GI.

Assurance for investment

- **Invest with greater confidence.** We need greater clarity. Today someone developing a new application does not have a clear view of

how the constituent datasets relate to each other. If they invested in joining up some of these, would they be able to bear the cost of maintaining these links? [unlikely perhaps] and would their investment be undermined by a new development in the near future?

- **Invest in an extensible infrastructure.** A clearer framework of authoritative information, developed by those organisations responsible for specific geographic information records, taking control of their own records and georeferencing these in a consistent way, will establish the step change required by those that wish to develop new services with assurance.

Summary

- ***DNF was launched in 2000 after extensive consultation.***
- ***DNF is an essential element of the spatial data/information infrastructure of Great Britain (and may be applicable elsewhere)***
- ***Adopting the principles and methods of DNF will deliver major benefits for government, businesses and citizens.***
- ***Good progress has been made in the last 3 years but much more can be done.***
- ***There are short-term significant investments required but these will be more than offset in the longer term by the benefits.***

3. Technical Overview of the Digital National Framework

*This section provides an overview of **how** the information components and high-level relationships in the DNF model operate and fit together and outlines potential future developments.*

Information relationships – macro model

Earlier in the paper the relationship of application and reference information was described. Figure 8 below illustrates the different kinds of information that need to better inter-relate to establish a more coherent and consistent model and operating environment across the GI industry.

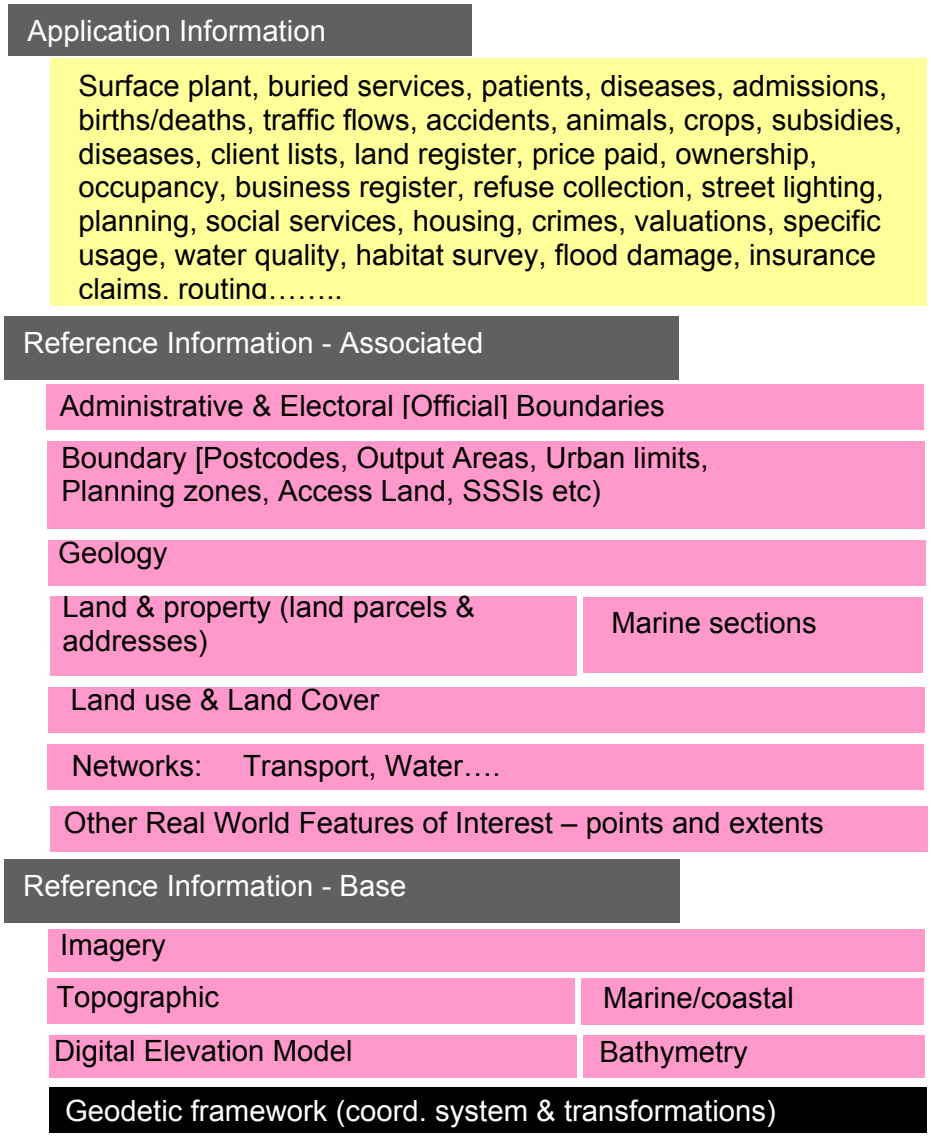


Figure 8. Structure of Definitive Reference Information and Application information. This is an expansion of Figure 4 earlier. Note these lists are not

necessarily exhaustive and attributes may be added to information in any one of the three categories.

The entire reference information infrastructure requires contributions from several players across local and central government and beyond. The logic of the structure was first developed in Ref A and mirrors developments elsewhere in Europe and builds on the INSPIRE initiative [Ref M] and earlier initiatives. Logically it breaks down into base and associated reference information. This does not infer any level of importance of one over the other; "importance" will always be driven by the user's application at any one time.

Base Reference Information. Ultimately all location-based information refers to real world physical features in the landscape be these discrete buildings, fences, streams (or parts of streams) etc. That landscape transcends the jurisdictions of the mapping agency or hydrographic department. Together topographic and marine information represent that physical and in a sense "neutral" landscape. The landscape is also three-dimensional and imagery completes the base since it incorporates millions of features that could not economically or sensibly be surveyed.

Of course this simple base information is not always suited to all purposes, hence other kinds of information, which more closely reflects real-world features of interest (e.g. schools, residential properties, airports etc) can be developed to which application information can be more conveniently attached. For interoperability, consistency and internal integrity, this [associated reference information] needs to be referenced to the base information.

Associated Reference Information. This kind of information more closely models real world objects. As an example a road database will consist of a real world view of the road network (often topologically structured). Similarly one might build and maintain school, hospital, university campus features and so on [see figure 9],

Geology is recognised as "associated information" because it needs the physical features to reference to on the surface of the land – both man made and natural. The British Geological Survey (BGS) do ensure as far as possible that their information fits the topographic feature and the terrain (which, in turn, is obviously influenced by the geology).

Likewise addresses (which are far more complex than most people imagine) are a device for locating and attaching other information, and in many models are an attribute of a specific "view" of the real world (e.g. a registered land title, occupied property, taxable property etc).

Hence the model suggests that the associated reference information needs, in some way, to connect or interoperate with the base physical geography to ensure integrity and internal consistency. This is increasingly managed by information providers using DNF principles and models. The need to transfer information from one form of reference information to another is growing. For

example planned road excavations are better managed as referenced works against the physical [surveyed] features they will apply to. Equally, in their execution, there may be a need to divert traffic away from the site using a street network. Linkage across these physical street objects and the network is therefore essential. Similar models are also required in river management.

Reference Information – current status. From Figure 8 above, it is clear that several (largely) government bodies are responsible for the collection and maintenance of the Base and Associated Reference Information. Currently little of this is easy to connect across organisations, but progress is being made. The base reference information provides the most detailed national cover, to which the associated reference information should integrate and interoperate with. This in turn will often be used either for referencing or analysis of some kind.

Application (or Business) Information. A wider, and potentially infinite, number of organisations and bodies may collect and reference business information for their applications. It is quite possible that some application information – if it is of widespread interest and use – could become part of the reference information over time; for example utility plant or street lights (and their locations) may be shared across several organisations and different business information attached by a wide group of parties (e.g. the local authority and the citizen).

Therefore the boundary between reference information and application information will never be fully defined or static. Each kind of geographic feature or object, whether it is reference or application information, should ideally be formally described and classified within a national feature catalogue.

Record relationships – information connectivity levels

At the more detailed level, the DNF model is underpinned by flexible record connectivity, sufficient to meet different applications and user views of the world. A generic set of methods linking application information with geographic features and objects are evolving and are being documented. As part of this evolution, over the last two years ***a stepped approach to information linking has evolved*** and this is briefly outlined below:

Level 1 – Linked identifiers

This base level of connectivity is the simplest and relies on simply cross-referencing identifiers e.g. from an application dataset to the reference base. As an example an organisation may have a library of digital photographs of buildings, each with their own identifier. These could be matched with the geographic feature identifier of the building. Thereon a third party collecting different information about the same building [e.g. age and nature of the building materials] could similarly attach information to the building feature. Since each user is employing the same techniques, they have an immediate information link to each other's data.

This level is not concerned with any geometry or location information other than a representative point and where applicable this has to be managed separately.

Implementation examples are: PointX, 3's 3G LBS application services, linking Local Street Gazetteers to the national road geography [e.g. Oxfordshire County Council].

Level 2 – Integrated Geography

Geometry is introduced at this stage and provides a way of referencing application information to either a) a discrete object or feature in the real world [such as a building, woodland, river stretch etc] or b) to an abstraction of real world features that define the user's geography [such as access land, land ownership, land occupancy, planning zones etc.]

Abstractions can be defined by the user using linear referencing of bounding features or area features. Where the base reference information is incomplete [as far as the user information is concerned] user defined geometry can be added and given a user assigned identifier [a TOID from the user's own list] and used in the same way as the other base mapping features. If that new feature has universal benefit then there may be merit in permanently incorporating it in the base reference information.

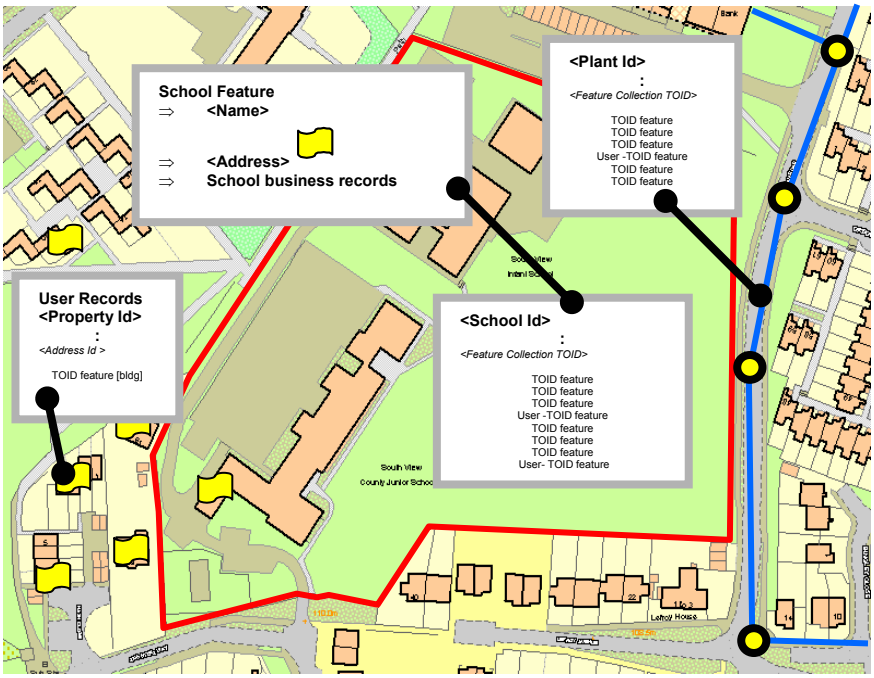


Figure 9. Simple examples of point, line and area geographic referencing

Point level referencing:

- In the above example several point features are referenced as  for example addresses against their respective building features.

Line referencing

- To the right in Figure 8 an underground utility network is referenced against the features it transects, thus enabling a user to click on a feature such as a pavement and determine what plant is below it.

Area feature referencing

- Finally a school (area feature) is defined using a combination of base reference map features and user-defined features (this can build on area or linear features). In the case of such features the user-defined identifier (such as a School Identifier or Title Number or UPRN etc) can be linked to a "Feature Collection Identifier" [an identifier at the feature level that references internal components of the feature] on a 1:1 basis and thereon to the individual features and components.

Since the user would store the reference data and their own geography on their own system (using level 2) there is a need to keep the two synchronised. The integrity of the user information, as far as geographic fidelity with the underlying base information is concerned, can be maintained through such an identifier and feature reference linkage. With this method the user information can be stored and referenced or built dynamically.

Implementation examples are: Access Land [Countryside Agency with Black and Veatch Ref L], Local Authorities – land parcels [Dudley MBC Ref N - the Dudley approach is Level 3 enabled].

Level 3 – Dynamic Linking

As the information age develops, with associated increases in data volumes, we are already witnessing a growing trend in the need to scale up data management capacity and capability. In the future, it is likely that geographic information, as with some consumer information, will increasingly be supplied when the user requires it. This has great attractions in relieving the need to store and manage high volumes of reference information by application users. All the user would need to hold are their own references (as in Level 2) and their own information could be built dynamically when required. There is still an issue of users synchronising their own information with changes to the base information, but there are benefits in reducing duplication in data management, better consistency and integrity and hence potential cost savings. This is very much a technology dependent solution (web feature serving) and requires rock solid network and server resilience. The benefits would clearly need to outweigh the costs and risks for those concerned.

While the gains are potentially the most significant of the three models, further proving of the technologies, underpinning IT infrastructure and piloting is required before most users would feel comfortable with committing fully to this approach for operational services currently.

Implementation examples are: Trials and research [e.g. GiMoDig Ref O].

Supporting infrastructure for the Digital National Framework

To support the development of the Digital National Framework further work is taking place to reinforce and further develop current literature, documentation and practices. This is outlined below:

The Digital National Framework identifiers [TOIDs]

Terminology

- The term TOID has been widely adopted through the OS MasterMap infrastructure and is now widely quoted and adopted through many media. This is a 16-digit identifier without intelligence.
- A small number of further terms may be required to better reflect the modelling and aggregating of individual features into a school as illustrated earlier. There we used the term “Feature Collection” which is an OpenGIS term. Further terms, if any, will be developed with DNF users and experts to ensure that the model remains as simple, logical and unambiguous as possible.

TOID allocation

- Early in the life of DNF, blocks of TOIDs were allocated to several organisations and an agreement made with Ordnance Survey Ireland and Ordnance Survey of Northern Ireland. This ensured that there was no overlap or duplication in the identifier while making it an open system for all to use.
- A proposal has been made to move away from the allocation of blocks of identifiers and to use the four-character namespace afforded and mandatory in GML, as a tag to differentiate the unique number for example <namespace><TOID identifier>.
- In such a case a user would simply register their namespace and start assigning identifiers from 1-9999,9999,9999,9999. Consultation with users will take place before any changes are made.
- The adoption of a four character namespace and the widespread adoption of assigning identifiers will be a major step forward for the DNF principles.

Creating and maintaining your own geography

To provide the flexibility in referencing described above to meet the different views of users and to support reliable data integration across organisations the following definitions have evolved:

Feature

- A feature is a digital representation of a real world entity. A feature comprises a unique identifier (TOID) and one or more data components that describe the information known about the real world entity. For example a residential building will have a TOID, a classification, an address and a geographic representation (point centred or footprint). Clearly much more will be known about the building, which can be, added e.g. floor plan, materials, images and all kinds of application information.

Real world entity

- Real world entities are the things like roads, buildings, schools, administrative areas, reservoirs, sites of rare flora. Real world entities are therefore anything that exist, have existed or will exist in the future (either physically or through legal or other abstract definition) that have a locational element.

Collection feature

- A collection feature represents a collection of other features. A school will comprise the school buildings, the playgrounds, paths and surrounding walls, hedges and fences and so be represented by a collection feature that references the contained features.

Data Component

- A discrete piece of information and its metadata that represents something known about a feature, for example a building's footprint geometry, an address, classification, occupancy details for a property and so on.

Therefore the model accommodates different user "views" of the real world while providing consistent linkages to support integration, integrity and data sharing.

The DNF Registry

To publicise and promote the principles of DNF and to help and facilitate the integration of geo-referenced information it will be necessary to establish some sort of repository of documents relating to DNF. Increasingly, this will provide a means of registering and disseminating information about data that conforms to the DNF principles. It is therefore proposed that a DNF Registry should be established and thereon developed to meet the prevailing DNF community needs. The DNF Registry would be the main organisational component of DNF – a form of secretariat.

The role of a DNF Registry could be to:

- provide an authoritative source of current documents about DNF, accessible to all, this would include explanatory material, high-level definitions and models of DNF, feature catalogue and a glossary

- act as the repository for all technical documents about DNF including relevant standards and guidelines
- hold examples of good DNF practice
- allocate name spaces or identifier blocks and maintain a record
- register and disseminate information (metadata) about data that conforms to the DNF principles. This would allow definition of, for example, new area geographies that could avoid unnecessary duplication and encourage reuse and thereby faster growth using proven existing datasets.
- provide administrative support to DNF – to maintain documentation and a website and manage the registration process.

For the Registry to succeed it would have to be developed in a collaborative way offering some form of mutual benefit to the parties involved. It could be developed in stages from a simple information source to a web service for online querying and transactions. On-going discussions regarding the DNF Registry are currently taking place.

Communication and industry engagement

DNF is an inclusive initiative and much of the progress to date has been managed through dialogue with users of information, organisations that wish to re-engineer their data, and experts and consultants who have developed DNF-based applications.

It is, therefore, anticipated that stronger communication will flow, and perhaps a few more formal links will be forged, as experience starts to be shared and proven methods reused.

The proposed DNF Registry will provide a repository and points of contact but other developments such as dedicated web pages and workshops are anticipated.

Feedback on the methods and documentation from experts who have implemented applications is being encouraged through the formation of an Expert Group.

Proposals by stakeholders and the wider user community on developing channels of communication will always be welcome.

Collaborative applied research may be required in some areas.

Summary

- ***No one organisation holds all parts of the reference information – collaboration is required to achieve interoperability.***
- ***DNF does not aim to define "a new Standard" but common adoption of best practice and consistency has the potential to evolve a standardised approach.***
- ***Adoption of de facto and de jure standards is essential, as is metadata, particularly at feature level.***
- ***There are three levels of information linking offering a flexible approach to improve the integrity and consistency when relating disparate datasets; and longer-term\extensibility.***
- ***A collaborative DNF 'Registry' is required.***
- ***DNF enables the integration of different user views and geographies.***
- ***Promotion of datasets based on common referencing methods will encourage reuse and growth.***
- ***Further evolution of the DNF principles and methods is required - your help and involvement is needed.***

Conclusions

In summary we can conclude that:

- If the true potential of geographic information is to be realised, a step change has to be recognised by all stakeholders involved in georeferencing in the required move from "*digital mapping"* to *"geographic information*". This is essential if "industrial level" and increasingly automated applications are to be successfully established and full potential in information investments achieved.

- Interoperability, or information connectivity, requires the adoption of consistent approaches in information modelling, georeferencing and data exchange. This is applicable at the macro level i.e. across national reference datasets and especially government organisations [e.g. land and marine information integration] and at the micro level i.e. within those datasets at the information level [e.g. images connected with buildings etc].

- The Digital National Framework is an evolving conceptual model. It is inclusive, it is neutral in application and its underpinning role is to bring coherence to national geographic information datasets, interoperability, easier and consistent data integration and to promote easier and wider usage of definitive GI datasets.

- The more successful it is - the more significant the benefits will be, not only for users and stakeholders but it also offers significant advantages for UK plc.

Getting closer to the DNF - Next Steps

There are several ways to better understand or to be more closely involved in developing DNF further:

National datasets

There is further work required to develop Base and Associated Reference Information and organisations that hold definitive information may wish to explore how this can be integrated into and possibly form part of the DNF model.

Local information

At the information record level you may wish to better integrate your existing information or new datasets you wish to create. By drawing on the experience of others and obtaining advantage from the growing number of technical document you can short cut the pitfalls and adapt proven methods to meet your own specific needs.

Communication

You may simply wish to discuss some of the issues described in this paper further.

Expert Groups

If you have implemented an application using DNF methods you might wish to get involved in an Expert Group [e.g. methods, research] or propose some other forum.

Further papers

It is intended that this paper will be followed by several short specific White Papers in 2005 focussing on specific areas of DNF: DNF Registry, DNF Methods etc. If you identify further topic areas please contact one of the individuals below.

Getting in touch….

Should you wish to take advantage of any of these suggestions, or if you have ideas of your own - don't hesitate to get in touch with:

Technical perspective and experience of implementing DNF methods:

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Carl St John Wilson, Ordnance Survey
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Or for more information on the DNF Registry:

Sally Cooper, Ordnance Survey
[Sally.Cooper@ordnancesurvey.co.uk]

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