Association Model

DNF Documentation Component 2.3.1

Responsibility for Content

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Change record of this document

Version	Date	Summary of change
1	30 Nov 2006	Publication following review by the DNF Expert Group

Content

This document consists of 22 pages

Location of this document

http://www.dnf.org/documentation/getdocument.asp?ID=0004

Approval for issue

This document has been approved by the DNF Expert Group

This publication

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Foreword

The Digital National Framework (DNF) is an industry standard for integrating and sharing business and geographic information from multiple sources. It is being developed for use within the United Kingdom although the concepts and principles could be applied elsewhere. It aims to be: (i) definitive by using a detailed and maintained topographic reference base, (ii) inclusive by being open and adopting industry best practice, (iii) structured and formalised to the extent that data once created can be shared and used many times, (iv) reliable through the delivery of data integrity, (v) cost-effective through reduction in the costs of data from multiple sources and (vi) flexible by enabling information exchange.

The basic principles at the core of DNF are as follows:

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

DNF is being developed and promoted by an industry body with membership drawn from data providers, system vendors and integrators and users. Both the commercial and government sectors within Great Britain are represented. All members have a common interest in the integration, sharing and utilisation of geographic information. Direction and strategy comes from an Expert Group. This in turn oversees and approves the work of a Technical Group responsible for the development of all technical documentation including this document.

This document is one of a series of technical documents being developed in support of DNF. Included in the series are data models, technical guides, guidelines, best practice, examples and case studies. Web-based services such as identifier registration are also being developed in support of this documentation.

For more information on the Digital National Framework visit http://www.dnf.org .

If you have any comments or suggestions on this document, please e-mail contact@dnf.org , your response will be acknowledged.

1 Introduction

This document lays out the logical model by which applications associate with geographic objects in a base reference layer using cross referencing techniques. More complex forms of association are also included in the model, for example, where an application refers to a geographic object within an application reference layer, which in turn is associated with geographic objects in the base reference layer.

The technical requirements for cross referencing within the model are presented in DNF0024 (Cross Referencing) this is in preparation currently.

This document should be read by practitioners in all business communities who wish to adopt the principles of DNF, these include:

- Data suppliers;
- Application developers;
- Data users.

Managers with responsibility for strategies involving the types of association described here may benefit from the discussions in the early pages, particularly 3 Definitions and 4 Background.

The association of one geographic object to other objects in a different layer of data so that the objects and their geometries are interlinked by using cross-references brings about;

- Efficiency of use – store once, use many times;
- Navigation – following links through which data sharing is achieved;
- Data Integrity – through the proper maintenance of these data relationships;
- Devolving responsibility for data management to the data owners.

To take advantage of these benefits requires a strategy for the adoption of DNF based on a model which defines the way in which data holds associations with other data by cross-referencing.

This document explains the model in the context of the Digital National Framework. A more complete overview of DNF is presented in DNF0001 (Overview).

Note: The reader needs to be aware that this document is the first version of the Association Model. It represents the current stage in development of the Model. Further work is required on some aspects in particular; the nature and complexity of the sub-type of DNF Association termed the “Qualified Association”. This includes Ancillary Geometry and its relationship to DNF Reference Object Geometry. Also time is not modelled explicitly in the current Model. This document will be updated at intervals to reflect further developments as soon as they are agreed and become available.

2 Scope

This document presents the principles and concepts used within the Digital National Framework (DNF) for associating *Business Objects*[1] and *Geographic Objects* used in applications and *DNF Reference Objects* which comprise the *DNF Reference Base.* The principles and concepts are expressed in words and diagrams. A logical not an implementation view is presented but the logical view is illustrated by examples from the real world. A formal model in a recognised modelling language (UML – Unified Modelling Language) is presented in Annex A.

The geographic objects in scope are those used to provide a location for the business information within an application. Predominantly these are objects such as land parcels, property, streets and river reaches but they can also be larger units such as census and administrative areas. The association of business information or *Business Objects* directly with the *DNF Reference Base* is also within scope. The *DNF Reference Base* is described in relation to OS MasterMap topographic objects but could be related to objects in other standard bases meeting DNF principles, for example, the offshore objects in SeaZone data[2].

The general concepts of association between the *Business Objects* and the *Geographic Objects* used in an application or group of applications and the *DNF Reference Base* are described but due to a large number of possible types of association, not all can be described in any detail. The temporal aspects of such associations are not modelled; this will be covered in subsequent versions of this document.

The way that business information or *Business Objects* are associated or referenced to *Geographic Objects* which do not form part of the *DNF Reference Base* is only in scope where those *Geographic Objects* are associated with the *DNF Reference Base* and form part of the chain of references between *Business Objects* and *DNF Reference Objects*.

Practical guidance on implementation is out of scope of this document. Readers should consult the relevant technical guide.

[1] Terms given in *italics* are defined in 3.1Terms.

[2] See http://www.seazone.com/

3 Definitions

3.1 Terms

Where definitions include terms defined elsewhere then these terms are shown in *italics*.

See http://www.dnf.org/Pages/technical%20guidance/terminology.asp for a full list of terms.

Application Reference Layer
Aggregation of *Application Reference Objects* forming a partial or complete coverage of an area

EXAMPLES

Index of Land Title extents;
Land & Property Gazetteer;
Street Gazetteer.

Application Reference Object
Geographic Object which may be used in an application as a means of locating directly or indirectly one or a number of *Business Objects*. It may be associated with other types of *Application Reference Objects* or it may be associated directly with one or more *DNF Reference Objects*

EXAMPLES

A Basic Land & Property Unit (BLPU) in a Land & Property Gazetteer;
A street in a Local Street Gazetteer;
An Output Area used in census analysis;
A land title extent in a Land Registry database.

In these examples, one or more applications' *Business Objects* may refer to the same *Application Reference Object* such as a BLPU.

Association
Any relationship between things or objects

NOTE In a DNF context it usually refers to a spatial relationship of some type. Associations can be simple and between two objects (e.g. this *Business Object* is related to that *Geographic Object*) or more complex and involve a number of associated *Geographic Objects*. There can a be a number of different types of association between the same types of objects e.g. a person lives at one location and works at another.

Business Object
Any piece of information or other item which is not itself a geographic object but which is modelled or processed by an application and which is related to one or more *Geographic Objects*

NOTE A business object does not itself have geometry and may or may or not be physically at the location to which it is related. Any geometry such as that used to indicate extent is derived from the *Geographic Object* or *Geographic Objects* to which it is related.

EXAMPLES

An ownership record which is associated with a land parcel;
A census record which is associated to a house.

Cross Referencing
Mechanism for holding links between objects which is expressed through the use of unique object identifiers

EXAMPLE The Unique Property Reference Number (UPRN) of a BLPU cross-referenced to one or more Ordnance Survey MasterMap object identifiers.

DNF Association
Relationship between a *Business Object* and one or more *DNF Reference Objects*, this may be a simple direct relationship or indirect through one or more *Application Reference Objects*

NOTE Where the relationship is via *Application Reference Object*s, these objects may be all of the same type such as BLPUs or different types such as BLPUs and land title extents. The key thing is that there is a path or means of linking from the *Business Object* to the *DNF Reference Object* or *DNF Reference Objects*.

DNF Ancillary Geometry
Lines or areas used to qualify the relationship between an *Application Reference Object* and a *DNF Reference Object* where the spatial relationship is not coterminous

NOTE The geometry i.e. the spatial properties in terms of points, lines and areas defined by coordinate positions must be consistent with that of the DNF Reference Base and fit to it. The Ancillary Geometry must fall entirely within a single *DNF Reference Object* geometry.

EXAMPLE Additional line geometry created where a title extends beyond the physical boundary of a land parcel as represented by the *DNF Reference Object.*

DNF Reference Object
Geographic Object that forms part of the *DNF Reference Base* which may be referenced by other objects. A DNF Reference Object can only be represented by one geometry in the DNF context.

NOTE Currently, *DNF Reference Objects* are derived from the Ordnance Survey MasterMap Topography Layer on land. It is intended to extend offshore to marine areas in the near future and in principle other types of *DNF Reference Object*s could be derived from other definitive datasets such as those used in environmental applications.

DNF Reference Base
Framework of reference made up of *DNF Reference Objects* which occupy the area of interest and to which *Application Reference Objects* and *Business Objects* may be related

Geographic Object
Abstraction or application view of a real world object which has a fixed and identifiable location on the Earth's surface

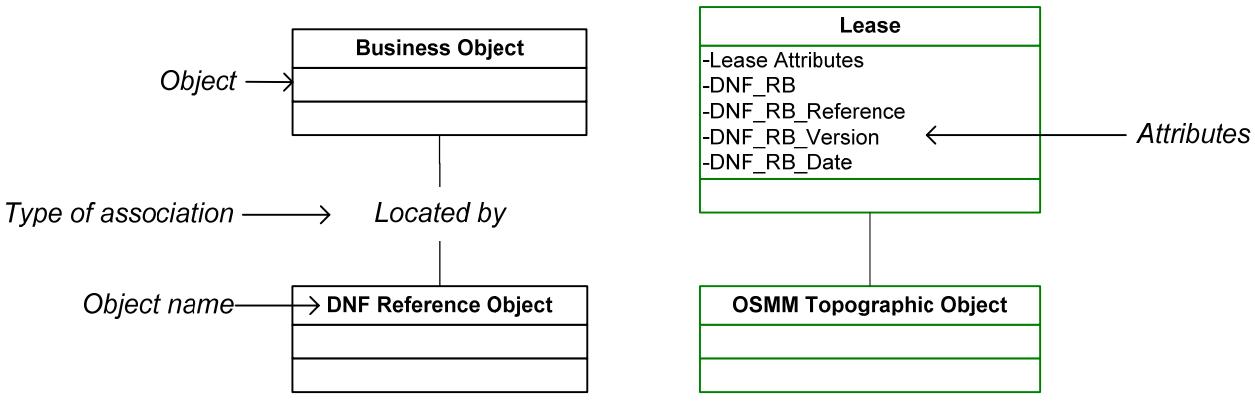
Reference Object
General term for any *Geographic Object* which is referenced by *Business Objects* or other *Geographic Objects*

3.2 Abbreviations

BLPU	Basic Land and Property Unit (in the LLPG)
DNF	Digital National Framework
ESU	Elementary Street Unit (in the LSG)
ITN	Integrated Transport Network
LLPG	Local Land and Property Gazetteer
LSG	Local Street Gazetteer
OSMM	Ordnance Survey MasterMap
TOID	Topographic Identifier
UML	Unified Modelling Language

3.3 Diagram Conventions

The diagrams in this document use the following conventions. Additionally, the **black** lined diagrams are conceptual and **green** lined diagrams are examples:



Attributes are only shown for illustration for some types of objects, they are not intended to definitive or exhaustive.

4 Background

Applications which integrate or associate business and geographic data have often been written to satisfy immediate requirements without regard to longer-tem strategic goals. Geographic data is often extracted from a particular source by using one or more rules which meet short-term requirements. These processes almost always copy and store the information into the application alongside the business data.

Examples of the sort of mechanisms used to create the associations are:

- address matching using postcodes and house numbers;
- spatial matching – point-in-polygon, polygon-intersecting-polygon, line-near-line.

In these systems there is typically no audit of the origin of the data, and little or no verification that the matching of data is correct.

Prevalent in these types of applications is the constant replication – or approximate replication – of geometries by re-digitising the position of data for each and every object in each and every application rather than deriving the geometry directly from a reference base.

A key principle of DNF is that by creating inter-relationships between data from different sources, duplication and replication of geographic data and the consequences that follow from using such processes can be avoided.

Data Association is the mechanism that forms the links by which interoperability between datasets can be achieved.

Data Association is useful in all three of the following business communities:

- To the data suppliers, it represents efficient use and reuse of reference material avoiding dangerous replication and the elimination of errors by utilising consistent and definitive reference information;
- To application developers, it allows greater elegance and simplicity in application design through the use of core components which are suitable for multiple re-use across all tiers of the applications structure;
- To the users of the data, it gives benefits of economy of data storage, avoids duplicate data capture and associated costs, allows navigation through data layers and gives assurances of data integrity through proper maintenance.

Many local authorities who relate data to properties use OS MasterMap (OSMM) as their reference base. The real world objects defined in OSMM and their detailed geometry are the best available and most useful currently. Further, there is national coverage. For these reasons the *DNF Reference Base* is defined currently as being formed of OSMM objects but this may change over time. For users of marine data it is intended to extend the model offshore in the near future.

5 The Association Model

5.1 Overview

The DNF association model describes how *Business Objects* – for example land titles – can be associated with *DNF Reference Objects* in the *DNF Reference Base.* The association between the *Business Objects* and the *DNF Reference Objects* is termed the *DNF Association*. Such an association can be either:

- Direct – *Business Objects* are directly associated with *DNF Reference Objects* without the involvement of any *Application Reference Objects*;

- Indirect – the association between the *Business Object* and the *DNF Reference Object* is through one or more *Application Reference Objects* which may be in one or more *Application Reference Layers*.

An instance of a *DNF Association* can be of one of two types:

- **Simple** – the *Business Object* is associated with one or more *DNF Reference Object*s without needing to create any additional geometry. This is because there is either (i) a good geometrical fit between the *Application Reference Objects* and the *DNF Reference Objects* or (ii) no requirement to provide a precise geometrical relationship;

- **Qualified** - the association between the *Business Object* and one or more *DNF Reference Objects* requires the creation of additional geometry to make the relationship between the *Application Reference Objects* and the *DNF Reference Objects* more precise. In other words the relationship needs to be qualified by *DNF Ancillary Geometry.*

A simple association can be either direct or indirect but a qualified association can only be indirect because it must involve *Application Reference Objects*.

These different associations are discussed below.

5.2 Direct association

A *Business Object* carries cross-references to one or more *Geographic Objects*. By so doing it can use the geometry and position related to those *Geographic Objects*. In the simple case these will be the geometries and positioning that the *Business Object* requires. An application can make use of such for drawing or searches based on geographic relationships.

In the DNF context and in the simplest case, a *Business Object* references one or more *DNF Reference Objects* directly in what is termed here a direct association.

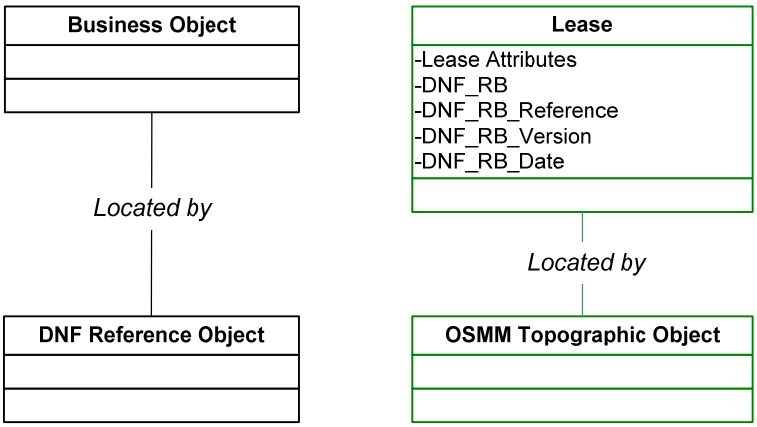


Figure 1. A direct association between a *Business Object* and a *DNF Reference Object*

If another application also refers to the same *DNF Reference Object*, an implicit relationship between the *Business Objects* exists, enabling each application to share its data with the other.

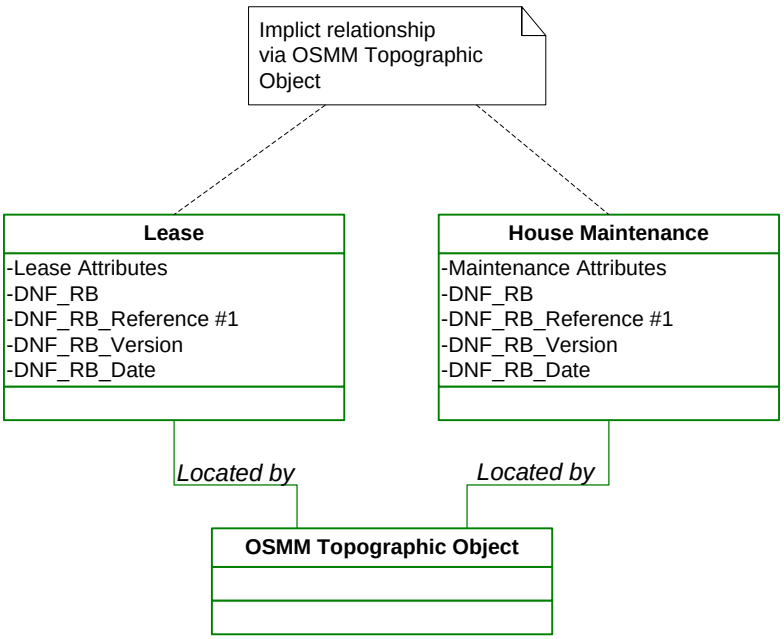


Figure 2. Direct association allowing interoperability between *Business Objects*.

This demonstrates the power of using objects defined using DNF principles where a devolved reference layer provides perfect interoperability at the application level.

5.3 Indirect association

In many existing applications *Business Objects* are associated with *Geographic Objects* specifically defined for that application or they are derived from some other application, for example a land and property or street gazetteer. In a DNF context, it is often useful to create intermediate layer of *Geographic Objects* for applications to refer to:

- When multiple *DNF Reference Objects* are used to create the geometrical extent required by a *Business Object* – for example the road elements making up a route;
- Where several applications may want to create their geometrical extents using the same business rules – for example a property reference or a land title.

These *Geographic Objects* created in the context of a particular application are referred to as *Application Reference Objects* and they aggregate into what is termed an *Application Reference Layer*:[3].

Figure 3 illustrates how a *Business Object* may have a direct association with a *Base Reference Object* or an indirect relationship through an *Application Reference Object*.

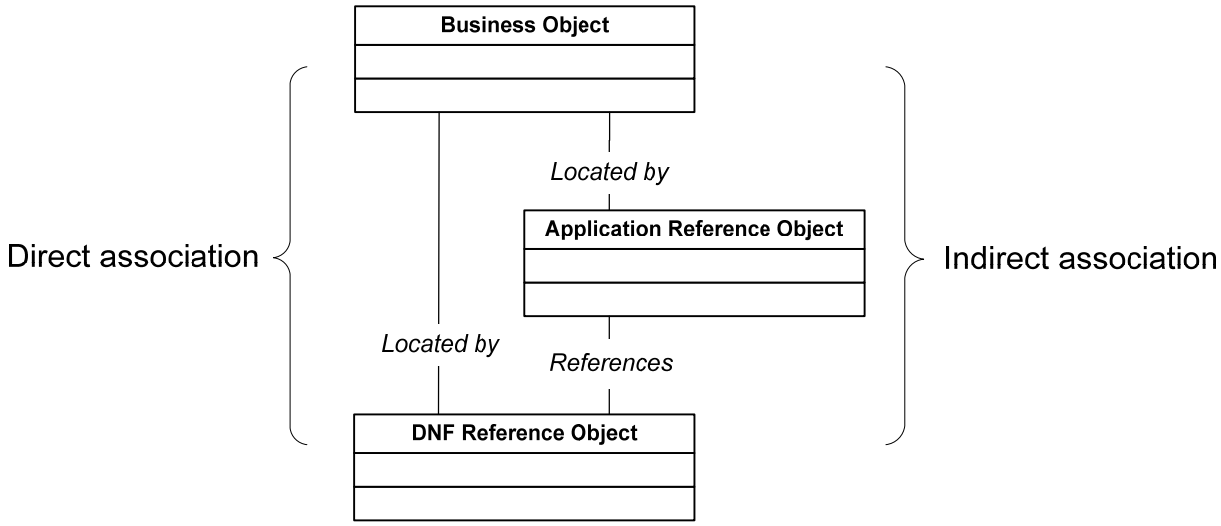


Figure 3. Direct and indirect associations between *Business Object* and *DNF Reference Object*

[3] The use of an *Application Reference Layer* enables data maintenance routines to be concentrated within the appropriate levels of the model. It is best to allow the application the simple relationship - in most cases a one-to-one relationship – of referencing the *Application Reference Object*, concentrating the administration of the more complex relationships of the *Application Reference Objects* to the *DNF Reference Objects* in a separate operation with its own administration

Examples of direct and indirect associations are contrasted below. Figure 4 shows how planning and building control applications are located directly to an OS MasterMap Topographic Object in a direct association and indirectly via an intermediate layer of BLPUs.

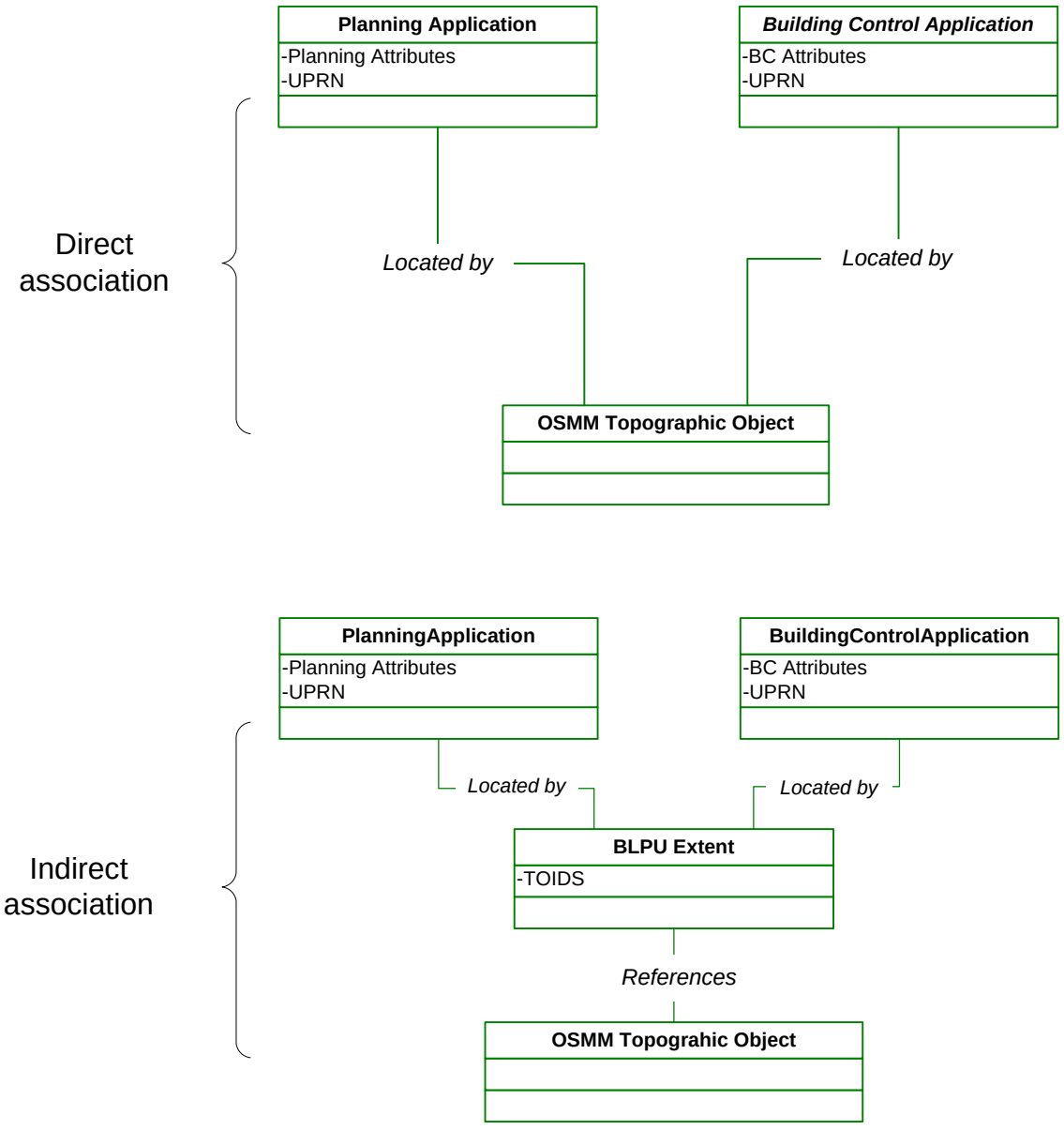


Figure 4. Examples of direct and indirect associations where area-based objects are referenced

Figure 5 shows how street cleaning and highway maintenance can be located directly to an OS MasterMap Topographic Object, or indirectly via two intermediate layers (Elementary Street Units and ITN Road Links). Both the Local Street Gazetteer (LSG) and the Integrated Transport Network (ITN), an OS product, are defined as *Application*

Reference Layers. ITN is a collection of *Application Reference Objects* since each object refers down to the underlying *DNF Reference Base* made up of OSMM topographic objects.

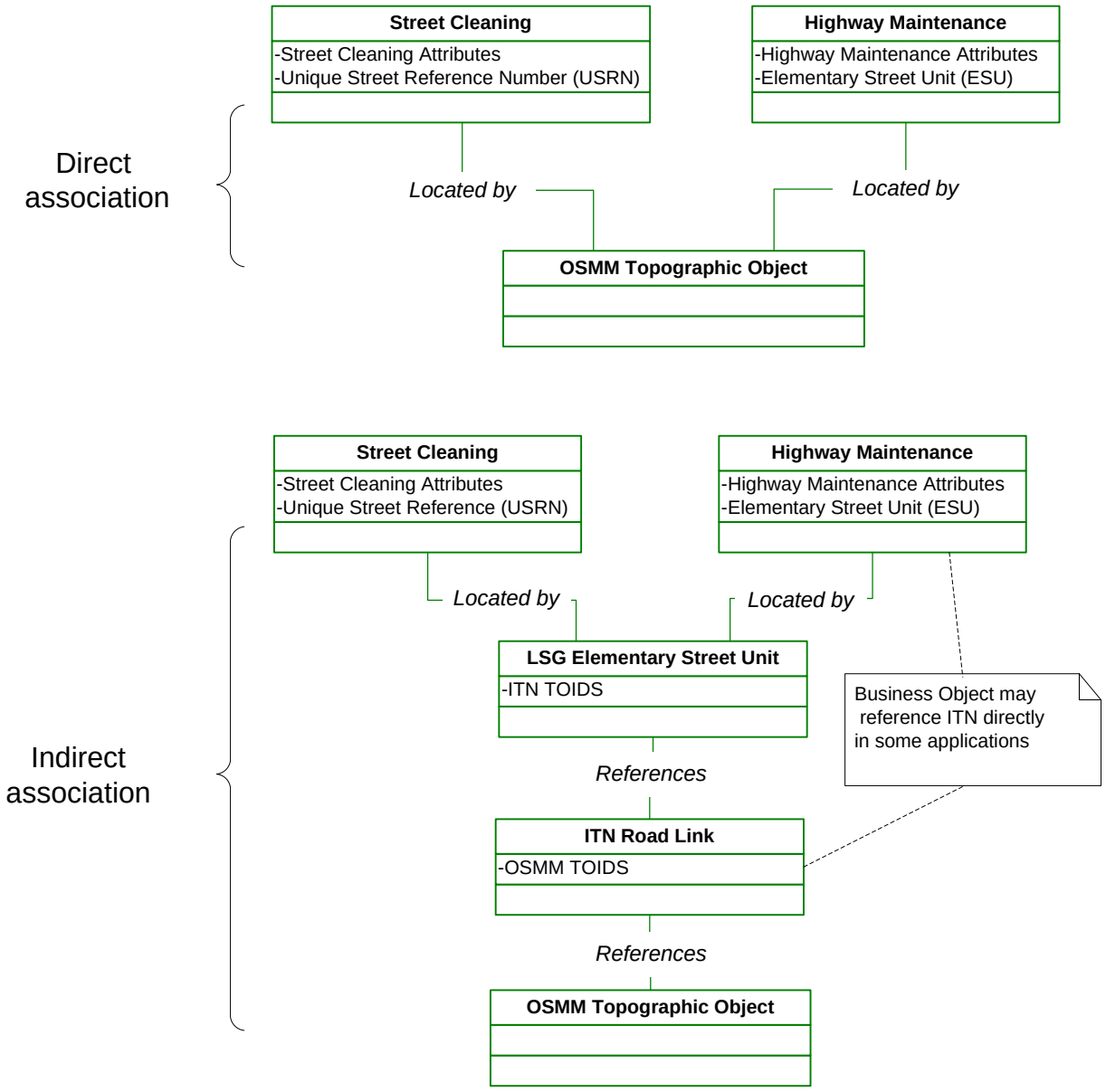


Figure 5 Examples of direct and indirect associations where linear-based objects are referenced in the indirect association

As a working example of interoperability related to the above model, it is possible to navigate from a Street Cleaning application entry, retrieving the highway surface composition from the Highway Maintenance application object, and draw the highway envelope in an appropriate rendering from geometries retrieved from the *DNF Reference Base*.

5.4 DNF Ancillary Geometry

Other than in direct associations between *Business Objects* and *DNF Reference Objects*, the geometry defining the extent of the *Geographic Object*s used by the application and that of the reference objects in the base may not be coincident in every instance. Depending on the nature of the association, this may require the capture and maintenance of additional or ancillary geometry to adequately define or qualify the association.

Two types of *DNF Association* are recognised, simple and qualified, depending on whether ancillary geometry is needed to qualify the association.

- The **simple association** does not involve any ancillary geometry. Either there is a good fit between the geometries of the *Application Reference Layer* and the *DNF Reference Layer* or an exact fit is not needed to adequately define the association. It may be sufficient to base it on polygon intersection or, if the *Application Reference Object* is represented by a point, on point-in-polygon where the polygon in question is that representing the DNF Reference Object.

- The **qualified association** involves ancillary geometry, here termed *DNF Ancillary Geometry*. It is used to relate the geometry of the *Application Reference Objects* and *DNF Reference Objects* with some precision and overall limits or qualifies the relationship between the *Geographic Objects*.

OS MasterMap Topography which is likely to form the reference base has its origins in a cartographic product. It presents a neutral view of the landscape based predominantly on physical objects. Extents are mainly representations of physical boundaries (e.g. fences and hedges). OS MasterMap Topography has introduced some inferred boundaries which have been created using sets of rules to subdivide certain area extents. Actual property ownership, for example, may not coincide with the physical boundary or the inferred boundary in OS MasterMap and additional geometry will have to be captured to adequately define it. Path networks and streets as represented in OS MasterMap may also require additional ancillary geometry.

In representing the location of *Business Object*s through DNF techniques of data association to other geometry layers, there have to be mechanisms which allow the user's own geometries to be managed.

Any *DNF Ancillary Geometry* must "fit" to the geometry of the reference base. It must be consistent with the base geometry and "snap" to it where the ancillary geometry follows the base geometry.

In Figure 6, the BLPU Extent Polygon is not coterminous with the polygons from OS MasterMap Topography which have to be split thus creating BLPU/ OSMM Ancillary Geometry which fits to the OS MasterMap geometry. The cross-references to the original *DNF Reference Object*, in this case an OS MasterMap topographic object, needs to be maintained but it is qualified or constrained by the ancillary geometry.

If either of the objects changes for any reason then there is an audit trail allowing data maintenance procedures to "warn" the application that perhaps something of importance has changed the geometry of the *Geographic Object* which locates the *Business Object.*

How the ancillary geometry is stored is an implementation issue but it is essentially a property of the association between the *Application Reference Object* and the *DNF Reference Object*.[4]

If applications are going to be able to relate their *Business Objects* with those of other applications using location then the *DNF Ancillary Geometry* from each application needs to be generally accessible and available together with the *DNF Reference Base.*

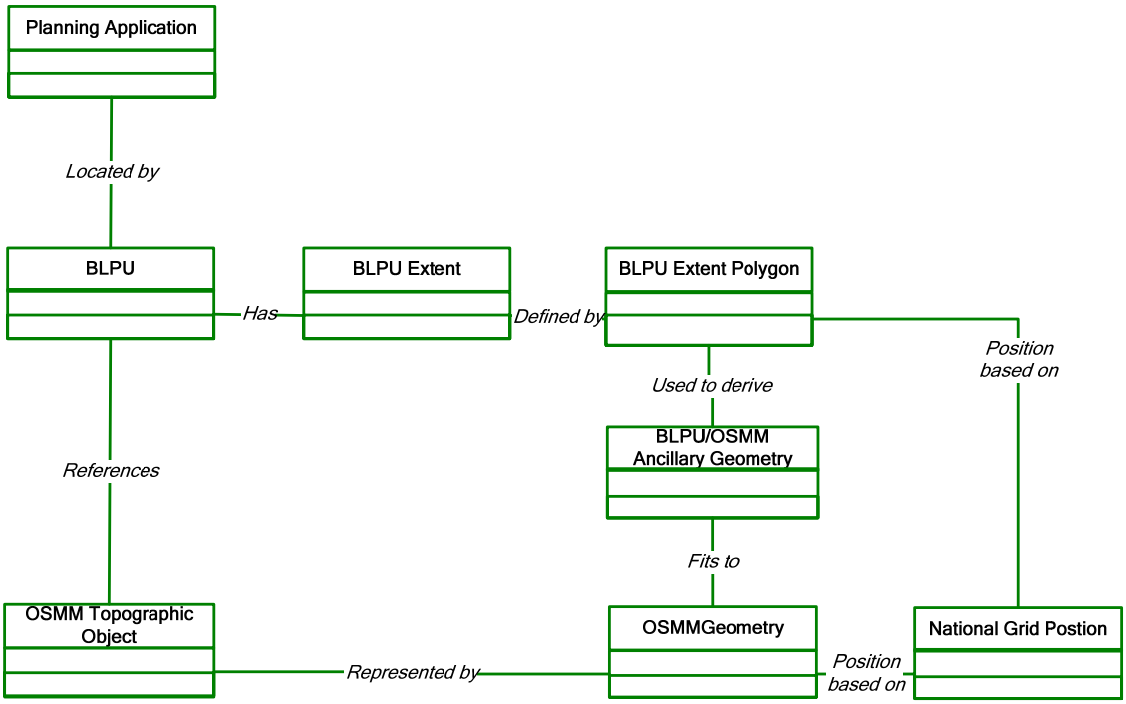


Figure 6. Example of where DNF Ancillary Geometry may need to be created and maintained

[4] Where application specific or temporary geometries are required – i.e. these geometries will never be made available to a wider user base – there is no case for DNF principles and the geometries may be held for private access by the application

6 Cross-referencing

In order to implement the model, a mechanism for interlinking objects is required. Cross-referencing is used in this context and this performs the various associations. Each cross-reference carries attributes or metadata qualifying or defining the link such as dates, object versions. For DNF to work, it is imperative that the integrity of these links is preserved by proper maintenance of the data.

Cross referencing will be discussed in DNF0024 which is in preparation.

Annex A: UML class diagram summarising the DNF Association Model

The following is a UML (Unified Modelling Language) class diagram providing a summary of the DNF Association Model. Readers should consult a UML text for an explanation of the standard conventions used in the model.

The notes below the diagram give the natural language version of what the diagram means.

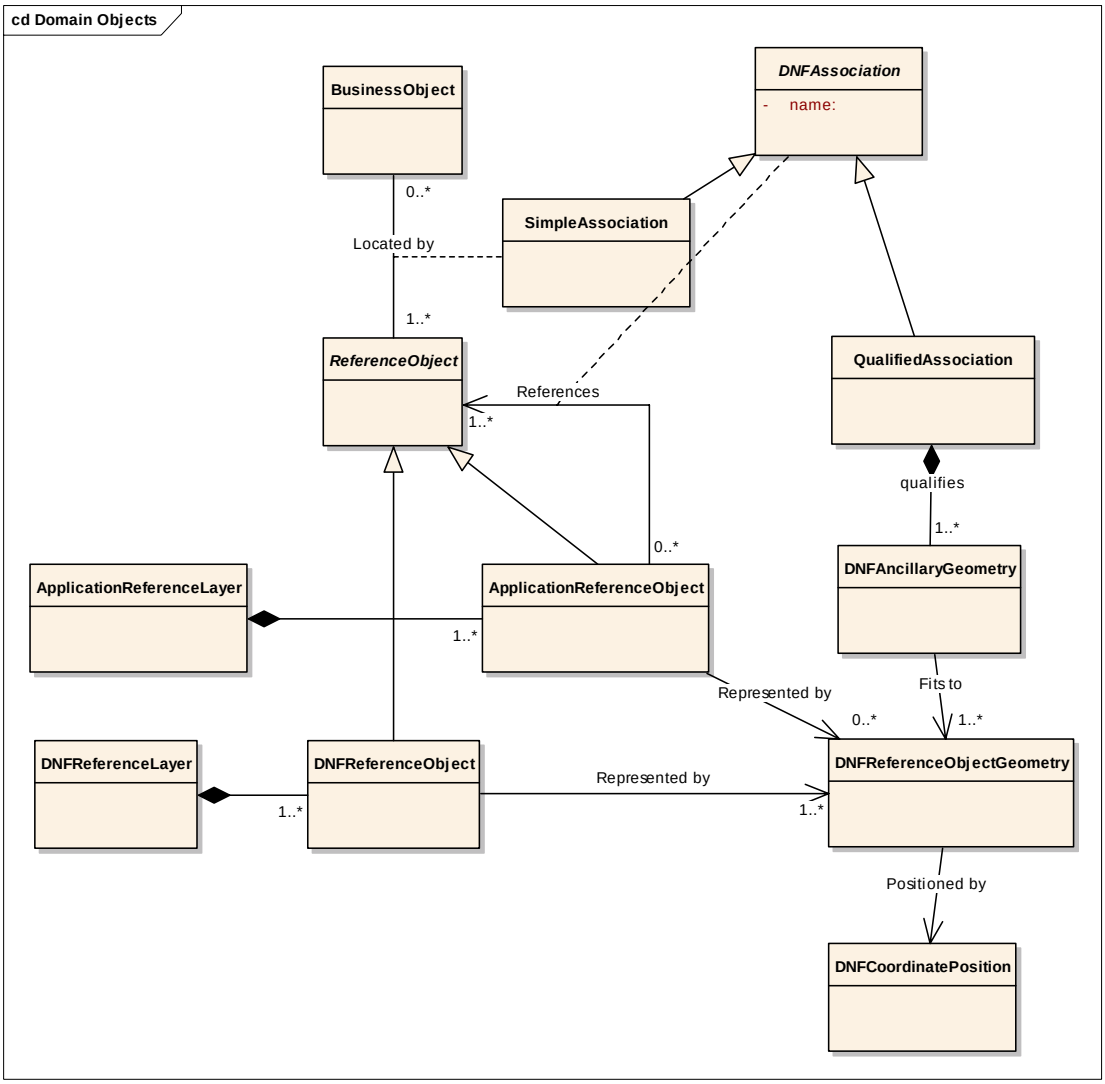


Figure A1: DNF Association Model expressed as a UML class diagram

The diagram represents in UML the following statements. These statements must always be true for any individual instance of the classes shown in the diagram:

- A *Business Object* is located by a *Simple Association* to one or more *Reference Objects.*
- A *Reference Object* may be referenced by any number of *Business Objects* or none.
- A *DNF Association* has a name. This will indicate the meaning of the association. For example, a business object representing a person could be linked to a building by an association named “resident at” and to another by an association named “works at”.
- There are two kinds of *DNF Association*: *Simple Association* and *Qualified Association*. i.e. *DNF Association* is the general term for both *Simple Association* and *Qualified Association*. Each instance of *DNF Association* must be either a *Simple Association* or a *Qualified Association.*
- There are two kinds of *Reference Object*: *Application Reference Object* and *DNF Reference Object*. Each instance of *Reference Objec*t must be either a *Application Reference Object* or *DNF Reference Object*
- An *Application Reference Object* references one or more *Reference Objects* (each of which may be either *DNF Reference Object* or *Application Reference Object*)[5].
- An *Application Reference Objec*t may optionally be represented by a number of *DNF Reference Geometries*. (This is in addition to being located by associations to one or more *Reference Object*).
- A *Reference Object* is referenced by any number of *Application Reference Objects* or none.
- A *Qualified Association* is qualified by one or more *DNF Ancillary Geometry*. A *DNF Ancillary Geometry* is part of a *Qualified Association* i.e. it cannot exist without being part of a *Qualified Association*.

[5] An *Application Reference Object* must reference at least one other *Reference Object*. A consequence of this is that ultimately the chain of references must lead to a *DNF Reference Object*. This means that it is not possible to have an *Application Reference Layer* which is not linked to a *DNF Reference Layer*. Any candidate to be an *Application Reference Layer* within DNF must be linked, either directly or indirectly, to a *DNF Reference Layer*.

- The *Application Reference Objects* themselves compose an *Application Reference Layer* (which may or may not exhaust space and may have only local coverage).

- The *Qualified Association* must use *DNF Ancillary Geometry*, that is geometry which needs to be created to qualify the relationship between the *Application Reference Object* and the *Reference Object* where the geometries are not coterminous (e.g. where an OS MasterMap object has to be divided because of differences with the geometry of the *Application Reference Object*);

- The *DNF Ancillary Geometry* must fit to the *DNF Reference Object Geometry*.

- The *DNF Reference Objects* compose a *DNF Reference Layer*;

- A *DNF Reference Object* is represented by a *DNF Reference Object Geometry* (which represents its spatial properties in terms of points lines and areas defined by coordinate positions);

- A *DNF Reference Object Geometry* is positioned by *DNF Coordinate Positions*.