

Conceptual Data Model for 1:50,000 Topographic Data

Prepared by the
Working Group on 'Interoperability' chaired by
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Executive Summary

The Working Group on 'Interoperability' recommended preparation of a real-world object catalogue so as to draft a standards-based topographic data model for developing an interoperable topographic database. The model is designed to be a technology-neutral conceptual model that can (i) form the basis for the design and development of a web-based spatial data interchange format e.g. the Open Geospatial Consortium (OGC)/ International Standardization Organization (ISO) specified Extensible Markup Language (XML)/ Geography Markup Language (XML/ GML) specifications, and (ii) guide implementation of geo-spatial databases in a common conceptual framework. The intended purpose is to allow topographic information sharing between topographic map data providers/ databases and users, independent of each other's local information system implementation.

The model emphasizes topographic concepts and relationships related to information presented on a standard 1:50,000 scale topographic map of Survey of India. Design has been guided by the provisions of the revised National Map Policy announced in May 2005, documentation of existing databases/ DVD data of Survey of India (SOI), technology developments, and other standardization efforts in the Geosciences, Computer Science, and international standardisation communities (e.g. OGC and ISO implementation Specifications).

An important aspect of the above conceptual modeling is the idea that representation of the conceptual framework (ontology) that underlies topographic data must be part of the model. A controlled vocabulary defining the geographical features thus will be added to this document after the receipt of comments on the current document from the members contributing to this effort. Preparation of such a vocabulary is presently on as a part of its documentation effort. This is because the ontologies between the conceptual data models between various organizations will be the foundation for ensuring the ultimate goal of achieving semantic interoperability between the organizational data sets.

The top-level topographic classes available in the sample data used in creating the GML prototype for Survey of India are (i) communication, (ii) hypsography, (iii) hydrography, (iv) habitation (building), (v) land cover, (vi) utilities, (vii) boundaries, (viii) vital installation, and (ix) the map frame & text. Even if the vital installations are not to form a part of the open series maps, but considering the provisions in the National Map Policy that a single database should be capable of producing both the open series and defence series maps, the additional class of vital installations has been included in the Conceptual Data Model to facilitate deliberation amongst the users of the defence series maps. The Map Frame and Text (annotation) class forms a part of the model as it is considered an integral part of the existing 1:50,000 scale geo-spatial data presently available with Survey of India. Characteristics of a Digital Landscape Model (DLM) have been kept in view in designing this model so that data remains separate from the presentation style that constitutes a part of the Digital Cartographic Model (DCM) on which DVD1 is based.

1. Background

The Conceptual Model is part of a larger effort to develop standardized methodologies for the storage, manipulation, analysis, management, and distribution of digital topographic data. The effort began in October 2004 with the setting up of a Working Group on ‘Interoperability’ with the chairmanship of General M. Gopal Rao, then Addl. Surveyor General of India under the Natural Resources Data Management System (NRDMS) Programme of the Department of Science & Technology (DST), Government of India. The Terms of Reference of the Working Group has been to test the interface specifications of OGC with special reference to Geography Markup Language (GML), Web Feature Server (WFS) and Web Map Server (WMS). The Topographic Data Model builds on the Digital Vector Data (DVD) developed by Survey of India.

2. The Conceptual Data Model

The data model is designed to be a technology-neutral conceptual model that can form the basis for a web-based interchange format like XML/ GML. The intended purpose is to allow the sharing of topographic information independent of logical and physical implementations. It is a model of topographic concepts and the relationships between them with special emphasis on concepts related to information presented on topographic maps. The data model is based on the DVD 1 and NSDE formats and other standardization efforts including those of the Open GIS Consortium, International Standards Organization Geographic information/Geomatics (TC 211) etc. The Working Group on Interoperability has relied upon the OGC/ ISO standards like ISO 19109, ISO 19136 etc. for working the model.

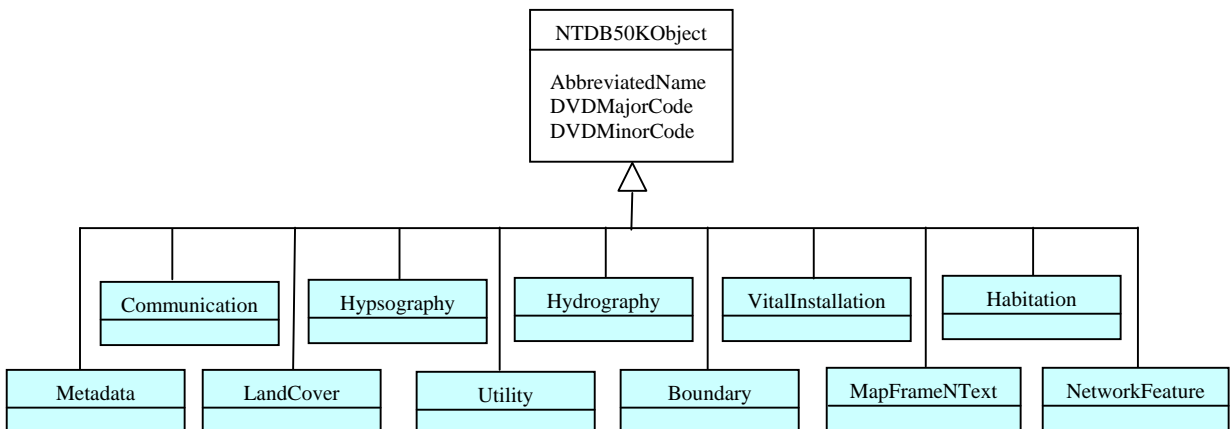


Figure: A UML class diagram for the complete 1:50,000 topographic data

NTDB50K stands for National Topographic Database objects as defined in 1:50,000 topographic maps. Details of each of the layers are given below.

1. Communication

The Communication layer has three broad categories of information: road, railway, and road & railway.

In the DVD model, the Road category has information like ‘Road metalled 1st importance’, ‘Road metalled under construction 1st importance’, ‘Road unmetalled 1st importance’, or ‘Road 1st importance distance stone tick’ etc. An abstract class ‘RoadInfrastructure’ has been introduced to cover all types of road-related features like road, road bridge, road structure, road distance stone, cutting, and embankments on roads. The

‘RoadInfrastructure’ is a kind of ‘Communication’ object that inherits from the National Topographic Database of 1:50,000 scale (NTDB50KObject). Each of the road-related features mentioned here is a kind of RoadInfrastructure feature and thus inherits from the abstract class.

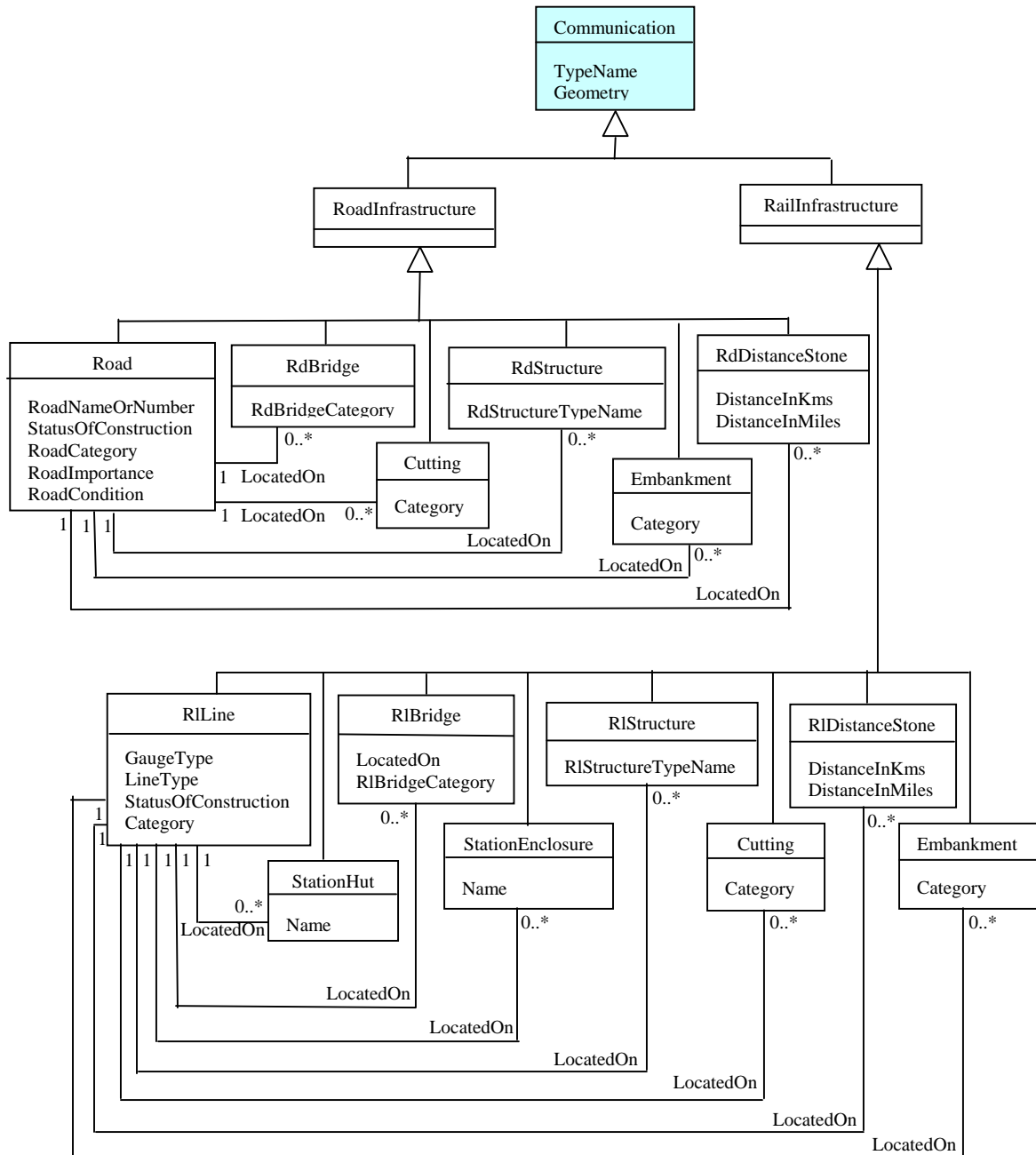


Figure: A UML class diagram of the ‘Communication’ layer

The ‘LocatedOn’ association between ‘Road’ class and another feature class has been shown to indicate that a ‘Road’ instance has either no or many (0..*) features like road bridge, road structure, distance stone, cutting or embankment etc. Details of the attributes of the concrete classes and their domains have been indicated in the tables.

The 'road & railway' features consisting of cuttings and embankments have been separated into the two abstract groups or classes of RoadInfrastructure and RailInfrastructure. Consequently, the cuttings and embankments on roads have been categorized under the RoadInfrastructure class and those relating to the railways have been put under the RailInfrastructure class.

In the DVD model, the Railway category has information like 'railway station hut', 'railway broad gauge double-line', 'railway broad gauge double-line under construction', 'railway broad gauge double line distance stone tick', 'railway broad gauge double line distance stone number' etc. The abstract class 'RailInfrastructure' has been created to cover all the features relating to the railways including the cuttings and embankments located on the railways. Similar to the roads, Rail line (RILine), Rail Bridge (RIBridge), Rail Structure (RIStructure), Rail Distance Stone (RIDistanceStone), Station Hut (StationHut), Station Enclosure (StationEnclosure), Cutting, and Embankment have been shown as kinds of the 'RailInfrastructure'. Relationships between various classes have been shown as associations marked as 'LocatedOn'. Either no or many such features (indicated as '0..*') are located on one Rail Line indicated as '1' in the association.

Road

Attribute	Domain	Cardinality	Optionality
Road Name or Number		Multiple	Mandatory
Road Category	Cart-track plains Cart-track hills/ wooded area/desert Track follows stream-bed/ boundary etc. Road in dry river bed Pack-track hills Pack-track plains Foot-path hills Foot-path plains Motorway Highway	Single	Mandatory
Road Importance	1 st 2 nd Others	Single	Mandatory
Status of construction	Under Construction Complete	Single	Mandatory
Road condition	Metalled Unmetalled	Single	Mandatory

Road Bridge (RdBridge)

Attribute	Domain	Cardinality	Optionality
Road bridge category	Track/ Footpath (C) Track/ Footpath (S) Track/ Footpath (P) Road Others (C) Road Others (S) Road Others (P) Road 1st Importance (C) Road 1st Importance (S) Road 1st Importance (P) Road 2nd Importance (C) Road 2nd Importance (S) Road 2nd Importance (P)	Single	Mandatory

Road Structure (RdStructure)

Attribute	Domain	Cardinality	Optionality
Road structure type name	Ferry Pontoon Causeway Viaduct Road Tunnel Ford Turning/ Passing Point Pass Toll Doubtful Feature Red Doubtful Feature Roman Doubtful Feature Italics	Single	Mandatory

Road Distance Stone (RdDistanceStone)

Attribute	Domain	Cardinality	Optionality
Distance In Kms		Single	Mandatory
Distance in Miles		Single	Mandatory

Rail line (RILine)

Attribute	Domain	Cardinality	Optionality
Gauge Type	Broad gauge Other gauge	Single	Mandatory
Line Type	Double-line Single-line	Single	Mandatory
Status of Construction	Complete Under Construction	Single	Mandatory
Category	As surveyed Conventional With piers	Single	Mandatory

Rail Bridge (RIBridge)

Attribute	Domain	Cardinality	Optionality
Located on	Rail line Road and Rail line	Single	Mandatory
Category	Conventional As surveyed With piers	Single	Mandatory

Rail Structure (RIStructure)

Attribute	Domain	Cardinality	Optionality
Type	Mineral line or tramway Viaduct railway Railway sidings Level crossing Railway tunnel Railway station enclosure Embankment Cutting	Single	Mandatory

Station Hut (StationHut)

Attribute	Domain	Cardinality	Optionality
Name		Multiple	Mandatory

Station Enclosure (StationEnclosure)

Attribute	Domain	Cardinality	Optionality
Name		Single	Mandatory
Type	Conventional As surveyed	Single	Mandatory

Embankment

Attribute	Domain	Cardinality	Optionality
Category	2-3 m one side 2-3 m both sides >3 m one side >3 m both sides	Single	Mandatory

Cutting

Attribute	Domain	Cardinality	Optionality
Category	2-3 m one side 2-3 m both sides >3 m one side >3 m both sides	Single	Mandatory

2. Hypsography

Each of Contours, Height Points, Mountains, High Mountains, Mud Volcanoes, and Sand Features is a hypsographic object.

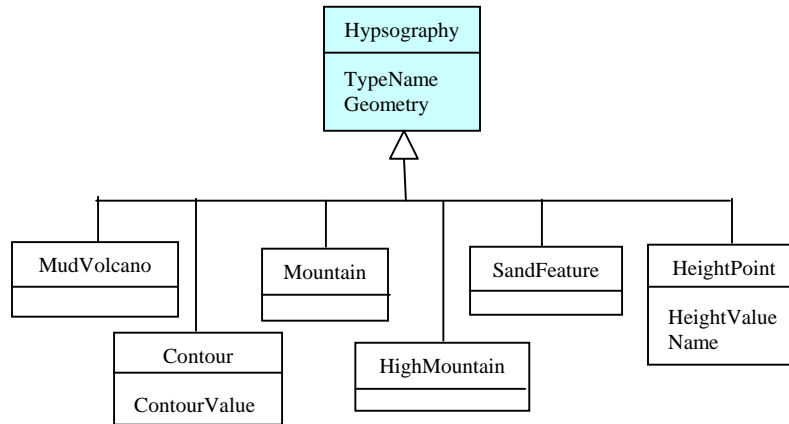


Figure: A UML Class diagram for the 'Hypsography' layer

Contour

Attribute	Domain	Cardinality	Optionality
TypeName	Index/ thick Intermediate/ thin Depression (in plains) Approximate/ unreliable thick Approximate/ unreliable thin Form line/ sub-feature broken Form line/ sub-feature continuous (pre 1905 survey) Index/ thick in snow Intermediate/ thin in snow Approximate/ unreliable in snow thick Approximate/ unreliable in snow thin Form line/ sub-feature broken in snow Bathymetric, fathom line Breakline	Single	Mandatory
ContourValue	Negative integer (m) 0 (m) Positive integer (m)	Single	Mandatory

Mud Volcano

Attribute	Domain	Cardinality	Optionality
TypeName	Crater as surveyed Pinnacles Mud vent as surveyed Mud flow as surveyed Pinnacle conventional Crater conventional	Single	Mandatory

Mountain

Attribute	Domain	Cardinality	Optionality
TypeName	Mountain depressions or devil's cauldrons broken or rocky ground scarp or cliff over 20m high scarp or cliff 6m to 20m scarp or cliff under 6m earth or gravel slide river terraces isolated rock masses sheet rock on mountain side terraced scarp rocky knob conventional rocky knob as surveyed sheet rock Boulder rock outcrop rock pinnacle (C) river gorge cutting/ broken bank in hills rock pinnacles boulder surveyed boulders in an area river fan formed by side stream	Single	Mandatory

Height Point

TypeName	benchmark geodetic benchmark tertiary benchmark canal relative height position approximate/ spot height position triangulation station triangulation point rectangular station/ point	Single	Mandatory
HeightValue	Negative integer (m) 0 (m) Positive integer (m)		
Name			

High Mountain

TypeName	Morain medial Morain lateral Morain terminal Rock couloir Scree Rock fall Pass in permanent snow Hanging glacier Ice fall Crevasses due to uneven bed Crevasses due to movement of ice stream Ice pinnacle (c) Bergschrunds Permanent snow Ice wall Glacier stream Glacier lake Ice cave Ice couloir Route over glacier Snow cornice Giants kettle Ice pinnacles	Single	Mandatory
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Sand Feature

TypeName	Ground clear of sand Steep face of sand hill Sand hill and sand dune as surveyed Shifting sand dune Elevated flat sand area Conical top of dune Flat sandy area	Single	Mandatory
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3. Hydrography

There are different types of canal infrastructures like weir, lock, aqueduct etc. Each canal infrastructure instance is located on the canal and thus has been shown as relationships in the class diagram. There are either no or many such structures (0..*) located on a canal. Similar is the situation with waterfalls as point features located on streams. For example, ‘weir and/ or lock on perennial canal(C)’ may be restated as a weir or lock with a given ID is located on a canal that has nature ‘perennial’ and type as ‘conventional’. Similarly ‘Siphon on single-line non-perennial canal’ is a type canal infrastructure ‘siphon’ located on a canal having the nature ‘non-perennial’ and LiningType ‘single-line’.

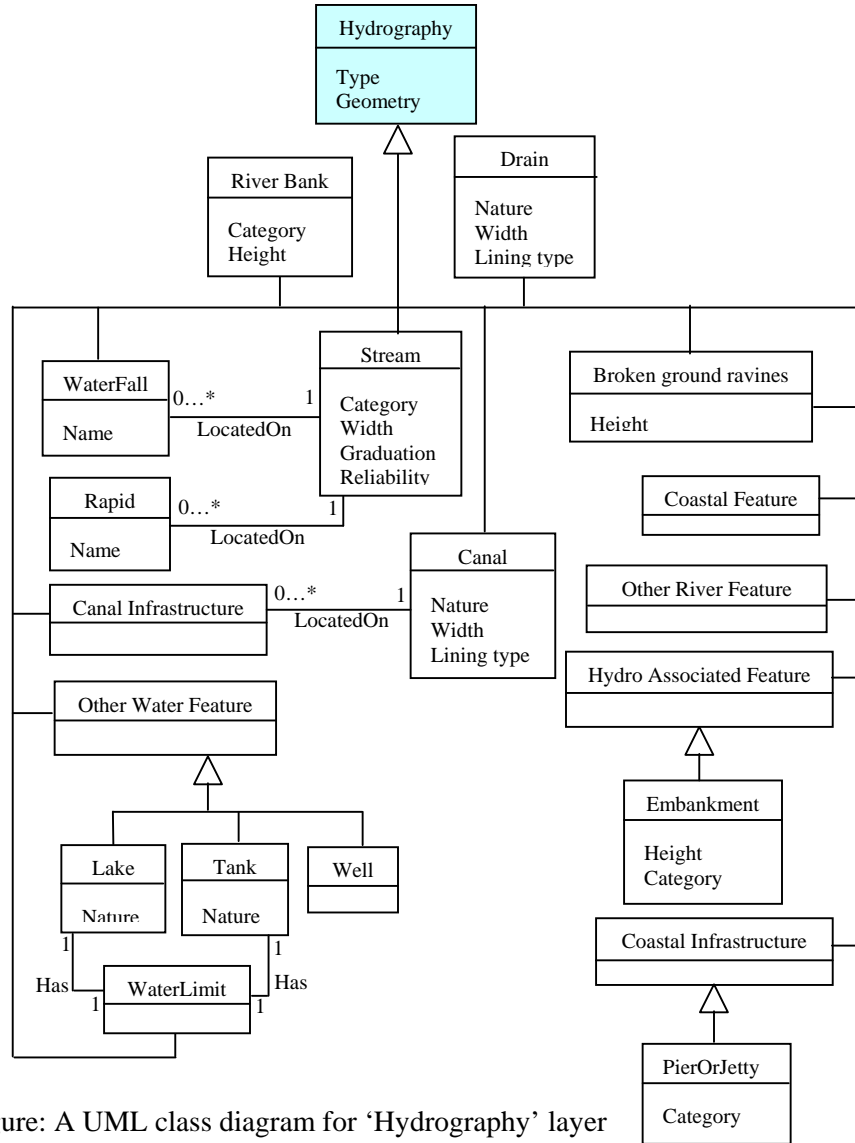


Figure: A UML class diagram for 'Hydrography' layer

Tank and Lake has water limits those are usually represented as polygons (cartographic blue wash). Since the water limit has a geometric characteristic, that has been shown separately as a class inheriting from the Hydrographic object class. There are 'lined', 'unlined', and 'dry' type of wells captured under the category 'other water features' in a topographic sheet. Therefore a separate class for 'well' has been created with an attribute 'type' inherited from higher up in the hierarchy.

Embankments categorized under the 'Hydro-associated features' consist of two types: on-tank and protective. Each has a height attribute. Such embankments have been defined as a separate class outside the 'Hydro-associated feature'. The 'category' attribute has been included to take care of the 'bridge' object that is captured to be located on 'conventional' or 'as surveyed' type of protective embankment.

'Coastal infrastructure' has a subtype 'Pier or Jetty'. Various types of Pier or Jetty include 'masonry', 'open', or 'with berth'. Categories include 'Conventional' or 'As surveyed'. The 'type' is not explicitly showing as an attribute in the diagram as it is inherited from higher up in the hierarchy.

The following are the details of the attributes of various classes depicted in the above class diagram with the domains:

River Bank

Attribute	Domain	Cardinality	Optionality
Category	Unbroken Broken Unreliable	Single	Mandatory
Height	Less than 3m 3-6m 7-15m Greater than 15m	Single	Mandatory

Other river feature

Attribute	Domain	Cardinality	Optionality
Type	River Island Water channel in dry river bed River water channel area Flow arrow in river	Single	Mandatory

Stream

Attribute	Domain	Cardinality	Optionality
Category	Dry Perennial Non-perennial	Single	Mandatory
Width	Single-line Double-line	Single	Mandatory
Graduation	1 st 2 nd 3 rd 4th and above	Single	Mandatory
Reliability	Unreliable Undefined/ Unreliable	Single	Optional

Broken ground ravine

Attribute	Domain	Cardinality	Optionality
Height	Less than 6m 6-15m Over 15m	Single	Mandatory

Canal

Attribute	Domain	Cardinality	Optionality
Nature	Perennial Non-perennial Disused/ under construction	Single	Mandatory
Type	Coventional As Surveyed		
Width	Greater than 20 meters Less than 20 meters	Single	Mandatory
Lining type	Double-line Single-line Branch Important distributary Other distributary/ minor	Single	Mandatory

Drain

Attribute	Domain	Cardinality	Optionality
Nature	Perennial Non-perennial	Single	Mandatory

	Disused/ under construction		
Width	Greater than 20 meters Less than 20 meters	Single	Mandatory
Lining type	Double-line Single-line	Single	Mandatory

Canal Infrastructure

Attribute	Domain	Cardinality	Optionality
Type	Distance stone tick Canal navigation lock (s) Sluice Weir Lock Aqueduct Viaduct Siphon Canal tunnel Flow arrow in canal Navigation lock (C) Canal milestone	Single	Mandatory

Tank/ Lake

Attribute	Domain	Cardinality	Optionality
Nature	Perennial Non-perennial	Single	Mandatory
Type	Conventional Excavated As surveyed	Single	Mandatory

Waterfall

Attribute	Domain	Cardinality	Optionality
Name		Multiple	Optional

Rapid

Attribute	Domain	Cardinality	Optionality
Name		Multiple	Optional

Well

Attribute	Domain	Cardinality	Optionality
Type	Lined Unlined Dry	Single	Mandatory

Other water feature

Attribute	Domain	Cardinality	Optionality
Type	Tube-well/ Pump house Overhead tank Hand pump Spring Reeds in perennial water Mud/ Tidal flats Swamp or Marsh Covered unlined wells/ tanks called kunds, baoris etc. Flat sand limit in lakes/ tanks	Single	Mandatory

Embankment

Attribute	Domain	Cardinality	Optionality
Type	On tank Protective	Single	Mandatory
Height	2-3 m >=3 m Steep	Single	Mandatory
Category	Conventional As surveyed	Single	Optional

Hydro associated feature

Attribute	Domain	Cardinality	Optionality
Type	Field bund across stream Sheet rock in river-bed/ coast Rounded rocks in river-bed/ coast Edged rocks in river-bed/ coast Rock ribs in river-bed/ coast Flat sand limit in sandy river-bed Dam (Masonry or rock filled) Dam (Earthwork) Weir Shaded sand in sandy river-bed Weir on single or narrow double-line stream Protective embankment distance stone tick Bridge on protective embankment (C) Bridge on protective embankment (S) Rocky knob along/ off coast conventional Rocky knob along/ off coast as surveyed	Single	Mandatory

Coastal feature

Attribute	Domain	Cardinality	Optionality
Type	Shingle/sand not submerged Cliff along coast Broken ground along coast Submerged rock with danger line Submerged sand Mangrove swamp Coast-line shown as high water line Coast-line shown as low water line Island formed by high water line Coral reef Rann/salt waste wet Rann/salt waste dry Shoal Tidal river double line perennial Tidal river single line perennial Tidal creek Tidal river double line non-perennial Tidal river single line non-perennial Tidal water limit Ocean/sea/gulf/bay areas Flat sand along coast/ sea, submerged Shaded sand along coast/ sea, submerged Flat sand along coast/ sea, not submerged Shaded sand along coast/ sea, not submerged	Single	Mandatory

Coastal infrastructure

Attribute	Domain	Cardinality	Optionality
Type	Anchorage Beacon, steamer signal, navigation mark unlighted Buoy unlighted Beacon, steamer signal, navigation mark lighted Lighthouse Lightship Buoy lighted Steamer service (double-line river)	Single	Mandatory

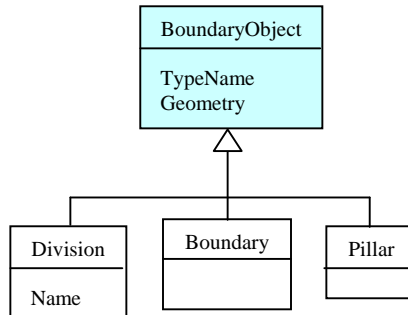
PierOrJetty

Attribute	Domain	Cardinality	Optionality
Type	Masonry Open With berth	Single	Mandatory
Category	Conventional As surveyed	Single	Mandatory

4. Boundary

Each of the boundary features in a topographic sheet is a kind of NTDB50 object. Its attributes 'TypeName' and 'Geometry' describe the type of boundary each feature is and the type of geometry the feature has.

'Division', 'Boundary', and 'Pillar' are different kinds of boundary objects. While 'Division' has an additional attribute 'Name', the other two classes inherit the attributes from the class 'BoundaryObject' located higher up in the hierarchy. Division refers to an administrative division like a country, state, district etc. Domains of the attributes of the classes with cardinality and optionality for each of them have been in the tables.



Division

Attribute	Domain	Cardinality	Optionality
Type Name	Village Municipality Subdivision/Tahsil / Taluk District State Country	Single	Mandatory
Name	Division name	Multiple	Mandatory

Boundary

Attribute	Domain	Cardinality	Optionality
Type Name	International Boundary without pillars International Boundary with pillars State boundary demarcated State boundary undemarcated Paragna boundary in U.P. Line of control Line of actual control Cantonment boundary Open limit Wall or permanent fence	Single	Mandatory

Pillar

Attribute	Domain	Cardinality	Optionality
Type Name	Boundary pillar main as surveyed Boundary pillar subsidiary Boundary pillar unlocated Trijunction pillar	Single	Mandatory

5. Utility

Transmission lines like power line, telephone line, telegraph line, ropeway and pipelines like oil or gas pipelines constitute the Utility objects in a topographic sheet. Power or telephone

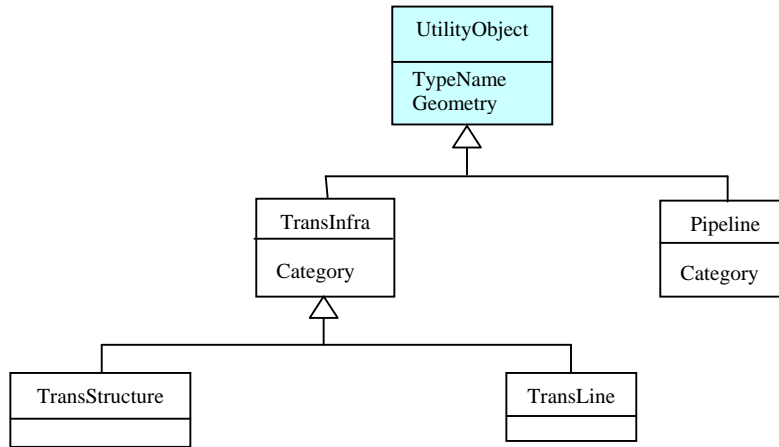


Figure: A UML class diagram for the 'Utility' layer

lines etc. have been categorized as transmission infrastructure and inherit from the abstract class Utility object with attributes 'TypeName' and 'Geometry'. With the inheritance arrow, the relationship may be read as 'Transmission Infrastructure is a kind of utility object' and similarly 'pipeline is a kind of utility object'. In the transmission infrastructure, similarly there are transmission structure (geometry type 'point') and transmission line (geometry type 'line') classes. The inheritance arrow here may be read as 'TransStructure is a kind of transmission infrastructure' and also 'TransLine' is a kind of transmission infrastructure'. Domains of various attribute fields of the classes like TransStructure, TransLine, and Pipeline have been defined in the tables below the diagram.

TransStructure (Transmission Structure)

Attribute	Domain	Cardinality	Optionality
Category	Main power line pylon Ropeway terminus	Single	Mandatory

TransLine (Transmission Line)

Attribute	Domain	Cardinality	Optionality
Category	Telephone and Telegraph Line Main power line conventional Main power line on pylon surveyed Power line conventional Ropeway	Single	Mandatory

Pipeline

Attribute	Domain	Cardinality	Optionality
Category	Oil Gas Water Karez Karez disused	Single	Mandatory

6. Habitation

HabitationObject is a kind of NTDBObject and has attributes ‘TypeName’ and ‘Geometry’. In a topographic sheet, there are different types of building like ‘Hut permanent’, ‘Hut oblong permanent’, ‘Hut Temporary’ etc. Thus the ‘Building’ class is a kind of HabitationObject and has attributes ‘Typename’ and ‘CategoryName’. Domains for ‘TypeName’ and ‘CategoryName’ have been defined in the table. Since there are different types of huts, forts, and caves as Habitation objects, those have been defined as separate classes with their TypeName domains specified in the tables.

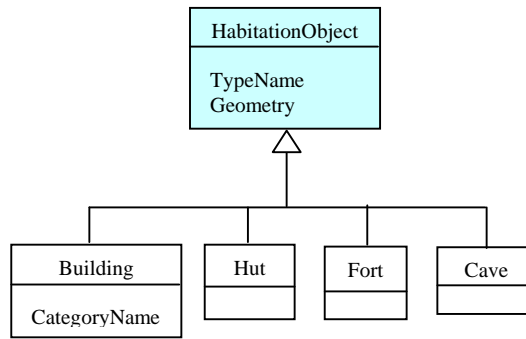


Figure: A UML class diagram for the ‘Habitation’ layer

Building			
Attribute	Domain	Cardinality	Optionality
TypeName	Block Village/ town Temple Chhatri Church Christian Memorial Buddhist kyaung Idgah Gopuram Mosque Pagoda Gurudwara Tomb Moghal Kos Pillar/ Kos Minar Monument Village in ruin Watch-tower Chimney Deserted site Piquet or post	Single	Mandatory
CategoryName	Residential Religious Antiquities Others	Single	Mandatory

Hut			
Attribute	Domain	Cardinality	Optionality
Type Name	Permanent Oblong permanent Temporary Oblong temporary	Single	Mandatory

Fort			
Attribute	Domain	Cardinality	Optionality
Type Name	Conventional As surveyed In ruins	Single	Mandatory

Cave

Attribute	Domain	Cardinality	Optionality
Type Name	Antiquity Inhabited Uninhabited	Single	Mandatory

7. Land cover

Under the Land Cover category, three different features – land cover, vegetation, and land use - are captured and mapped. Different types of each feature are surveyed. For example, forest, scrub, plantation, tea/ coffee garden etc. are surveyed under the land cover category. Different types of trees, bamboo, casuarina, palm, and grass etc. are captured under the vegetation category of features. Kiln, oil well, oil tank, camping ground, burial ground etc. are depicted under the land use feature category.

A LandCoverUse abstract class has been defined with attributes ‘TypeName’ and ‘Geometry’. Each of the concrete classes LandCover, Vegetation, and LandUse inherit from the LandCoverUse abstract class. For example, this inheritance may be read as ‘LandCover is a kind of LandCoverUse’ or ‘Vegetation is a kind of LandCoverUse’ etc. Domains of the attributes for each of the concrete classes have been defined in the tables.

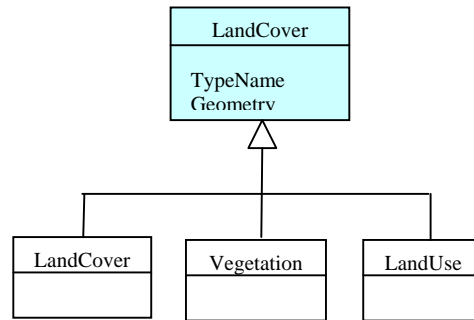


Figure: A UML class diagram of the ‘Land cover’ layer

LandCover

Attribute	Domain	Cardinality	Optionality
TypeName	Forest reserved Forest protected/ others Open or dense wooded area Forest fire line Forest Riband Scrub Area Scrub (Dot for undergrowth) Scrub (Curve for scrub) Orchard Plantation (walled/ fenced) Orchard Plantation (not walled/ fenced) Tea or coffee garden (walled/ fenced) Tea or coffee garden (not walled/ fenced) Betel or vine on trellis (walled/ fenced) Betel or vine on trellis (not walled/ fenced) Vegetable/ pineapple garden (walled/fenced) Vegetable/ pineapple garden (not walled/ fenced)	Single	Mandatory

Vegetation

Attribute	Domain	Cardinality	Optionality
TypeName	Surveyed tree Other tree small	Single	Mandatory

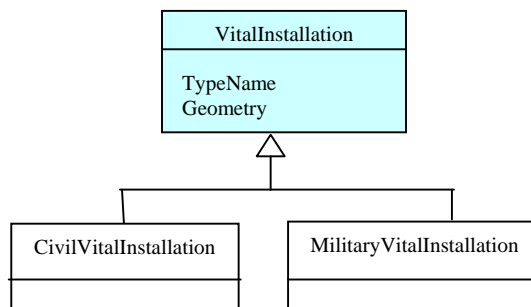
	Other tree big Bamboo Casuarina Conifer (pine, fir etc.) Cactus or aloes High grass Palmyra Palm upright Palm inclined Plantain Betelnut Cane-brake Avenue of tree Surveyed tree (Betelnut) Surveyed tree (Casuarina) Surveyed tree (Conifer) Surveyed Tree (Palm) Surveyed Tree (Palmyra) Bamboo (thin) Grass		
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Landuse

Attribute	Domain	Cardinality	Optionality
TypeName	Brick/Lime kiln conventional Brick/lime kiln as surveyed Oil-well Oil-tank Mine-shaft Rifle range head Air bombing/firing range Air bombing target Air firing target Wireless station conventional Wireless station as surveyed Air mooring or tall telegraph / wireless station mast Quarry Cultivation Camping ground Camping ground-shepherd's Grave Burial ground Salt pans Barren/ fallow/ habitat land Rifle range (surveyed) Wind turbine	Single	Mandatory

8. Vital Installations

Vital installations fall into two broad types: civil and military. Civil vital installations have several categories like dam important, reservoir, helipad, micro-wave tower etc. Domains of the attributes of various classes have been defined in the tables.



CivilVital Installation

Attribute	Domain	Cardinality	Optionality
TypeName	Dam important Reservoir Helipad Microwave tower/Air mooring or Tall telegraph/Wireless station mast Wireless station conventional Wireless station as surveyed Oil-well Oil-tank Oil pipe line Water pipe line Gas pipe line Piquet or post Air bombing/firing range Air bombing target Telephone and telegraph line Line of control Line of actual control Aerodrome limit (walled/fenced) Aerodrome limit (not walled/fenced) Aerodrome Landing ground/landing strip limit (walled/fenced) Landing ground/landing strip limit (not walled/fenced) Landing ground/landing strip	Single	Mandatory

MilitaryVital Installation

Attribute	Domain	Cardinality	Optionality
TypeName	Piquet or post Air bombing/firing range Air bombing target Telephone and telegraph line Line of control Line of actual control	Single	Mandatory

9. Map frame and text

In this layer, there are three important categories of features: map frame, cartographic symbol, and cartographic text. Various features included in these categories are all types of items on the margin or border, names like locality names, tribal names, grids in metric and FPS, index to sheets, administrative index, and compilation index etc. Geometry is also associated with some of these features.

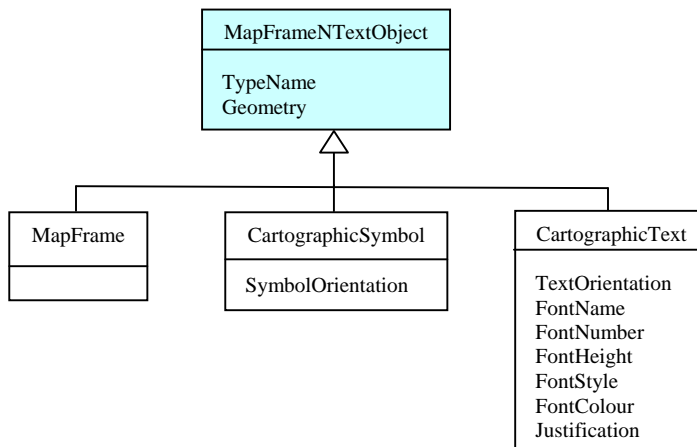


Figure: A UML class diagram for the 'Map frame and text' layer

Map frame

Attribute	Domain	Cardinality	Optionality
TypeName	Thick map border line Thin map border line Map graticule line	Single	Mandatory

Cartographic symbol

Attribute	Domain	Cardinality	Optionality
Symbol orientation		Single	Mandatory

Cartographic text

Attribute	Domain	Cardinality	Optionality
Text orientation		Single	Mandatory
Font name		Single	Mandatory
Font number		Single	Mandatory
Font height		Single	Mandatory
Font style		Single	Mandatory
Font colour		Single	Mandatory
Justification		Single	Mandatory