# Open Geospatial Consortium Inc.

Date:   4 September 2008

Reference number of this OpenGIS® Project Document:  **OGC 08-028r7**

Version: 1.3.0

Category: OpenGIS® Implementation Standard

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## OpenGIS® Location Services (OpenLS):

## Part 6-Navigation Service

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# i.  Preface

This OpenGIS Implementation Standard defines the interface for OpenGIS→ Location Services (OpenLS): Part 6 - Navigation Service (formerly the Full Profile of the Route Determination Service), which is part of the GeoMobility Server (GMS), an open location services platform.

This standard was produced as a result of the work done in the Location Services thread of the OGC Web Services 3 test bed initiative (2004) as well as the efforts of the OLS1.3 Revision Working Group. It also includes enhancements and fixes made subsequent to the testbed efforts by an ad hoc work group consisting of the sponsors of this standard.

The Navigation Service was formed by breaking out the Full Profile of the Route Determination Service from the basic set of LS Core Services, as developed during the testbed initiative. Likewise, the Route Service was formed from the Basic Profile of the Route Determination Service, as developed during the testbed initiative. The Navigation Service is an extended profile of the Route Service.

# ii.  Document terms and definitions

This document uses the standards terms defined in Subclause 5.3 of [OGC 06-121r3], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word "shall" (not "must") is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

# iii.  Submitting organizations

This standard was submitted to OGC by the following organizations:

Autodesk, Canada
deCarta, USA
ESRI, USA
Image Matters, USA
Intergraph IntelliWhere, Australia
MapInfo, USA
MobileGIS, Ireland
Navigation Technologies, USA
Oracle, USA
Sun Microsystems, USA
TeleAtlas, USA

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## v. Revision history

| Date | Release | Author | Paragraph modified | Description |
|------|---------|--------|-------------------|-------------|
| 28/11/2001 | 1.0 | Tom Bychowski | | Original document 03-007r1 |
| 26/02/2008 | 1.0 – new document | Gil Fuchs | | OLS1.3 Standard as 08-028 |
| 9/4/2008 | Standard | Carl Reed | Numerous | Get ready for posting as a standard |

## vi.    Changes to the OpenGIS↗ Abstract Specification

The OpenGIS® Abstract Specification does not require changes to accommodate the technical contents of this document.

# Foreword

The information in this document was substantially derived from the OGC Web Services (OWS) test bed initiatives as well as comprehensive work of the OLS1.3 RWG.

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Other standards activities that were reviewed and considered under the OpenLS initiative include related standards initiatives at ISO TC204, ISO TC211, W3C, IETF, OMA/LIF, 3GPP, AMIC, MAGIC, WAP, JAIN and Parlay, as well as other emerging and adopted OGC Standards.

# OpenGIS→ Location Services (OpenLS): Part 6 - Navigation Service

## 1  Scope

This OpenGIS Implementation Standard defines the interfaces for OpenGIS→ Location Services (OpenLS): Part 6 - Navigation Service (formerly the Full Profile of the Route Determination Service), which is part of the GeoMobility Server (GMS), an open location services platform.

## 2  Conformance

The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance, are specified in ISO 19105: Geographic information — Conformance and Testing. See section 12 concerning the requirements and procedures for OpenLS Conformance.

## 3  Normative references

The following normative documents contain provisions, which through reference in this document constitute provisions of this architecture. For dated references, subsequent amendments to these publications or revisions of any of these publications do not apply. However, parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the documents applies.

| |
|---|
| *Abstract Specification Topic 0: Overview*, OpenGIS→ document 99-100r1. |
| *Guidelines for Successful OGC Interface Specifications*, OpenGIS document 00-014r1. |
| *OpenGIS® Geography Markup Language (GML), Version 3.0*, 18 December 2002, OpenGIS Implementation Standard 02-023r4. Available [Online]: http://www.opengis.org/techno/documents/02-023r4.pdf. |
| *OpenGIS® Location Services (OpenLS): Part 1-5: Core Services, Version 0.5*, April 18, 2003, OpenGIS RFC 03-006r1. Available [Online]: <http://www.opengis.org/techno/discussions/03-007r1.pdf>. |
| *Recommended Definition Data for Coordinate Reference Systems and Coordinate Transformation*s. OGC Project Document 01-014r5. Available [Online]: <http://www.opengis.org/techno/discussions/01-014r5.pdf>. |

| |
|---|
| *OGC Units of Measure Use and Definition Recommendations.* OGC Recommendation Paper. OGC Project Document 02-007r4. Available [Online]: <http://www.opengis.org/techno/discussions/02-007r4.pdf>. |
| *OpenGIS® Simple Features Standard for SQL.* OGC Implementation Standard. Available [Online]: <http://www.opengis.org/techno/specs/99-049.pdf>. |
| *XML Linking Language (XLink) Version 1.*0. W3C Recommendation (27 June 2001). Available [Online]: <http://www.w3.org/TR/xlink/> |
| *Namespaces in XM*L. W3C Recommendation (14 January 1999). Available [Online]: <http://www.w3.org/TR/1999/REC-xml-names-19990114/> |
| *XML Schema Part 1: Structure*s. W3C Recommendation (2 May 2001). Available [Online]: <http://www.w3.org/TR/xmlschema-1/> |
| *XML Schema Part 2: Datatype*s. W3C Recommendation (2 May 2001). Available [Online]: <http://www.w3.org/TR/xmlschema-2/> |
| ISO14825 Geographic Data File (GDF) (Feb-15-2004) |

## 4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

### 4.1 Abstract Data Type (ADT)

The basic information construct used by the GeoMobility Server and associated Core Services. Consists of well-known data types and structures for location information. Defined as application schemas that are encoded in XML for Location Services (XLS).

### 4.2 Area of Interest (AOI)

A user defined area (represented by a bounding box, circle or polygon). Often used as a filter in a query.

### 4.3 (OpenLS) Core Services

The basic services that comprise the open service platform (GeoMobility Server) defined under OpenLS.

### 4.4 Directory Service

A network-accessible service that provides access to an online directory (e.g. Yellow Pages) to find the location of a *specific* or *nearest* place, product or service.

### 4.5 Geocoder Service

A network-accessible service that transforms a description of a location, such as a place name, street address or postal code, into a normalized description of the location with a Point geometry.

### 4.6 GeoMobility Server

The open service platform comprising the Core Services developed under the OGC OpenLS initiatives.

### 4.7 Location-Based Service (LBS)

A wireless-IP service that uses geographic information to serve a mobile user. Any application service that exploits the position of a mobile terminal.

### 4.8 Navigation Service

An enhanced version of the Route Service, which is a network-accessible service that determines travel routes and navigation information between two or more points while being current position cognizant.

**4.9 Point of Interest (POI)**

A location (with a fixed position) where one can find a place, product or service, typically identified by name rather than by address and characterized by type, which may be used as a reference point or a target in a location based service request, e.g., as the destination of a route.

**4.10 Presentation (Map Portrayal) Service**

A network-accessible service that portrays a map made up of a base map derived from any geospatial data and a set of ADT's as overlays.

**4.11 Position**

The state of being placed. In this context, it is the location of a mobile agent relative to a road network which is captured in a digital map database.

**4.12 Positioning**

The act of converting an externally independently and uncertainly measured location to a framing digital map database.

**4.13 Reverse Geocoder Service**

A network-accessible service that transforms a given position into a normalized description of a feature location (Address with Point), where the address may be defined as a street address, intersection address, place name or postal code

**4.14 Routing**

The act of finding an optimal path from a source to a destination.

**4.15 Route Service**

A network-accessible service that determines travel routes and navigation information between two or more points.

**4.16 XML for Location Services (XLS)**

The method for encoding request/response messages and associated Abstract Data Types for the GeoMobility Server.

# 5   Symbols (and abbreviated terms)

The following symbols and abbreviated terms are used in this document.

ADT        Abstract Data Type

API         Application Program Interface

GMLC      Gateway Mobile Location Center

GMS        GeoMobility Server

LBS         Location Based Service

LIF          Location Interoperability Forum

MLP        Mobile Location Protocol

MPC        Mobile Positioning Center

OGC        Open Geospatial Consortium

OMA        Open Mobile Alliance

OSA         Open Service Architecture

XLS         XML for Location Services

XML         eXtended Markup Language

## 6   Use Cases

### 6.1   Routing for Navigation Use Case

| Use Case Name | NA_PlanRoute | | | | |
|---|---|---|---|---|---|
| **Actors** | *End User (Driver/Passenger)* | | | | |
| **Description** | General description: The End User wishes to compute a route, with the ability to add detours and specific or fuzzy waypoints, subject to the End User's preferences. User might specify a "negative" way point (that is don't want to go via it, or even near by it, that is avoid this area kind)<br><br>1. End User requests routing after setting the origin and destination. The Navigation Server provides a route.<br><br>2. End User requests a detour re-route. The Navigation Server provides the detour re-route.<br><br>3. End User requests adding waypoint(s) while the vehicle is in transit on a route. The Navigation Server provides a re-route that includes the new waypoint(s).<br><br>4. Navigation Client provides a re-route if the End User departs from a route.<br><br>5. End User requests previous routes he has traveled. The Navigation Server provides them.<br><br>6. End User requests modifying the route with fuzzy waypoints. The Navigation Server provides the new route.<br><br>7. End User submits new preferences for route planning. The Navigation Client updates current preference settings. | | | | |
| **User goals** | 1. End User gets an optimal route based on his preferences.<br><br>2. End User gets a detour re-route in order to avoid traffic accidents and congestion.<br><br>3. End User gets a re-route to accommodate a new waypoint while the vehicle is in transit.<br><br>4. End User gets a recovery route when the vehicle strays off the original | | | | |

| | |
|---|---|
| | route. |
| **Flow** | <Main Flow> |
| | 1. End User specifies routing preferences (see Note 1). |
| | 2. End User requests the Navigation Client to create a route from origin (the current user position) to the destination. |
| | 3. Navigation Client requests current position <include NA_GetMapPosition> |
| | 4. Navigation Client notes the returned network link(s) (and possibly locations along) as the origin. |
| | 5. End User specifies the destination <include NA_RequestLocation> |
| | 6. Navigation Client notes the returned network link(s) (and possibly locations along) as the destination. |
| | 7. Navigation client requests the Navigation (or Route) Service to provide a route from the origin to the destination. |
| | 8. Navigation client informs the End User and the route guidance function when the route has been generated. |
| | 9. Navigation client displays the route <include NA_DisplayRoute> |
| | |
| | <Extends-use-case NA_RequestDetour> |
| | 10. End User requests a detour re-route after starting route guidance. |
| | 11. End User may request traffic information and Navigation client makes the request of the Navigation Server (or Traffic Service, if one such exists). |
| | 12. End User supplies the detour information, for example what is to be avoided. |
| | 13. Navigation Client requests the Navigation (or Route) Service to provide a new route based on the detour. |
| | 14. Navigation client displays the new route on the map <include NA_DisplayRoute> |
| | 15. End User accepts new route (detour re-route) |

| | 16. Navigation client informs the route guidance function that a detour route has been generated. |
|---|---|
| | <Extends-use-case NA_NewWaypointReroute> |
| | 17. While route guidance is underway, the End User sets additional waypoint(s) <include NA_RequestLocation> |
| | 18. Navigation client notes the returned location(s) as additional waypoints. |
| | 19. Navigation client requests the Navigation (or Route) Service to provide a new route, from the current vehicle location to the original destination including the new waypoint locations and any waypoints previously included but not yet visited. |
| | 20. Navigation client informs the End User and the route guidance function that a way-pointed route has been generated. |
| | 21. Navigation client displays the new route <include NA_DisplayRoute> |
| | <Extends-use-case NA_RecoveryReroute> |
| | 22. The End User travels off the current guided route. |
| | 23.The Navigation client detects that the End User is off-route <include NA_GetMapPosition> |
| | 24. Navigation client requests the Navigation Service to provide a recovery route from the current user position back onto the current route. |
| | 25. Navigation client informs the End User and the route guidance function that the recovery route has been generated. |
| | 26. Navigation client displays the recovery route <include NA_DisplayRoute> |
| | . |
| | <Extends-use-case NA_ChangeRoutingPreferences> |
| | 37. End User requests changing the routing preferences that are supported by the Navigation Server (See Note 1). |

| | 38. Navigation client provides the list of preferences that are supported by the Navigation Server.<br><br>39. End User selects some items and submits them.<br><br>40. Navigation client verifies them and establishes them as the new current settings, requesting Navigation Service to re-plan route if necessary. |
|---|---|
| **Dependencies** | Main flow extended by:<br>   NA_RequestDetour<br>   NA_NewWaypointReroute<br>   NA_RecoveryReroute<br>   NA_PreviousRoutes<br>   NA_ModifyPlannedRouteWithFuzzyWaypoints<br>   NA_ChangeRoutingPreferences<br>Alternate flow extended by:<br>   NA_PlanRouteWithWaypointCandidateSets<br>   NA_PlanRouteWithMultipleAlternateRoutes<br>   NA_PlanRouteWithMultipleDestinations<br>Includes:<br>   NA_GetMapPosition<br>   NA_DisplayRoute<br>   NA_RequestLocation<br>Used by:<br>   NA_GuideDriver |
| **Preconditions/ Postconditions** | |
| **Notes** | 1. End User wants the following as preferences for route planning.<br>-Shortest Time<br>-Shortest distance<br>-Avoids pass of highway/toll road and specified streets/areas.<br>-Using scenic route or sightseeing tour routes.<br>-Using traffic information<br>-Applies time period traffic restriction by estimate passing time and daylight saving time.<br>2. Despite the absence of a MapService call, this use case is significant in that the NA is assumed to retain previous routes.<br>3. End User wishes to plan a route from an origin to a destination with one |

| | |
|---|---|
| | or more waypoints, but the waypoints are not specific points or links, but rather areas. For example, the End User may want to indicate a region through which the route should go, in order to specify a preference for one highway over another (without bothering to click exactly on the highway), or in order to specify going around an obstacle like a body of water or a mountain on one side rather than the other (without bothering to choose a particular highway on that side of the obstacle). |

| Use Case Name | NA_GetMapPosition | | | | |
|---|---|---|---|---|---|
| **Actors** | *End User (Driver/Passenger)* | | | | |
| **Description** | 1. End User presses a button which is tantamount to asking "show me on the map, where am I?" | | | | |
| **User goals** | 1. Since the map might be different then the real world that the End User sees around him/her, the End User wants to know where in the map he/she is. | | | | |
| **Flow** | 1. Current lat, long is obtained from external device<br>2. history of previous position and direction of motion is consulted<br>3. a unique Link is picked as current map element that the user is on.<br>4. location along this element is figured out (fractional)<br>5. lat, long is snapped to element at proper place and made available | | | | |
| **Preconditions/ Postconditions** | [Pre] World Positioning knows where End User is now<br><br>[Pre] either history, or "summed" history is stored<br><br>[Pre] End User is assumed to be on the navigable network relevant to this map | | | | |
| **Alternative flow** | Instead of current external device position an End User manual click on the map is used (cast as new step 1) | | | | |
| **Notes** | 1. History of position and direction of motion is needed, if map matching is required. | | | | |

## 6.2 Positioning for Navigation Use Case

### 6.2.1 Get Position on Map

| Use Case Name | NA_GetMapPosition | | | | |
|---|---|---|---|---|---|
| **Actors** | *End User (Driver/Passenger)* | | | | |
| **Description** | 1. End User presses a button which is tantamount to asking "show me on the map, where am I?" | | | | |
| **User goals** | 1. Since the map might be different then the real world that the End User sees around him/her, the End User wants to know where in the map he/she is. | | | | |
| **Flow** | 6. Current lat, long is obtained from external device<br>7. history of previous position and direction of motion is consulted<br>8. a unique Link is picked as current map element that the user is on.<br>9. location along this element is figured out (fractional)<br>10. lat, long is snapped to element at proper place and made available | | | | |
| **Preconditions/ Postconditions** | [Pre] World Positioning knows where End User is now<br>[Pre] either history, or "summed" history is stored<br>[Pre] End User is assumed to be on the navigable network relevant to this map | | | | |
| **Alternative flow** | Instead of current external device position an End User manual click on the map is used (cast as new step 1) | | | | |
| **Notes** | 1. History of position and direction of motion is needed, if map matching is required. | | | | |

**6.2.2    Information Utilities (aid to Positioning) – Get Features which are nearby to current position**

| Use Case Name | NA_GetNearbyMapFeatures | | | | |
|---|---|---|---|---|---|
| **Actors** | *End User (Driver/Passenger)* | | | | |
| **Description** | 1. Description:  User presses a button which is tantamount to asking "what am I near on the map?" | | | | |
| **User goals** | 1. Given a world position, the End User wants to know what other map features he is next to (or area he is within) | | | | |
| **Flow** | 1. Current lat, long is obtained from external device<br>2. How many items to be returned to user is known by preferences.<br>3. if classification type is be filtered (or chosen) this is obtained {point, line, area} of features are segregated by geometrical classification (point, line, area, complex) as well as increasing "distance" from current position. Then ADTs (or handle to them) are returned | | | | |
| **Preconditions/ Postconditions** | [Pre] World Positioning knows where End User is now | | | | |
| **Alternative flow** | Instead of current world position an End User manual click on the map is used | | | | |
| **Notes** | End User or Nav App may specify filters on the feature type | | | | |

## 7    Requirements

### 7.1    Schema Conformance (Normative)

A server implementation *shall* return a valid XML document of the type corresponding to a valid XML document request according to the following table:

| Request Document Type | Response Document Type |
|---|---|
| DetermineRouteRequest | DetermineRouteResponse |
| GetPositionRequest | GetPositionResponse |
| GetNearbyMapObjRequest | GetNearbyMapObjResponse |

All other information and requirements in this document exclusive of Annex A are informative.

### 7.2    Terminology

All OGC Standard related documents *shall* use the following terminology as defined in Subclause 5.3 of [OGC 06-121r3], which is based on the ISO/IEC Directives, Part 2: Rules for the structure and drafting of International Standards

1.   shall – verb form used to indicate a requirement to be strictly followed to conform to this standard, from which no deviation is permitted

2.   should – verb form used to indicate desirable ability or use, without mentioning or excluding other possibilities

3.   may – verb form used to indicate an action permissible within the limits of this standard

4.   can – verb form used for statements of possibility

5.   informative – a part of a document that is provided for explanation, but is not required

6.   normative – a part of a standards document that is required

Note: Other standards organizations also use the term "MUST".  For the work of the OGC, the term MUST is equivalent to the term SHALL. Note that only the *Italic* versions of these terms are to be interpreted as above.

### 7.3    Routing for Navigation Requirements

The service *shall* support the planning of routes according to the following simple route, waypointed route, and co-routing parameterization:

> Start at the origin, go to the destination, while passing through the via points (in some order), and avoid the regions specified by avoid list.

The result returned to the application is an abstract route object reference, which provides access to a list of link references and perhaps other data. This minimal or basic route object supports data-object-level utility functions, which allow subsequent client-side application functionality such as rendering a highlighted version of the route geometry on a displayed map.

Optionally, the route object *may* also contain a collection of additional connected and/or nearby link references to support client-side access to a larger collection of map data elements for subsequent application access to Positioning and (static or dynamic) Route Guidance API functions. This optional "route buffer" capability is particularly important to minimize data request roundtrips when the service is implemented in a distributed fashion over slow and/or less robust networks.

Some possible types of additional map data elements returned in addition to the basic sequence of links (ordered by data size):

> Data sufficient to provide a guidance-oriented trip itinerary or "route preview" (mainly street names and sign text)
> All links directly connected to nodes along the route not already returned in the sequence of links comprising the route
> Networks of navigable links extending away from all nodes along the route limited by driving time or distance forming a connected buffer whose extent is constant driving time (or distance) from the planned route
> Spatial buffers of all map elements (connected as well as unconnected links plus cartographic elements) at a prescribed distance from the route

The returned data extent options shall be specified as input or configuration parameters to the route planning service request.

Regardless of returned data extent, this route object abstraction implies a rich enough backing data structure in the implementation underneath the service to support data-oriented utility functions providing geometric, topological, and/or attribute-level "views" — at potentially multiple generalization levels — to the application derived from this underlying data content. This content is intended to be represented in various generalization levels and physical formats in an implementation specific manner.

### 7.4    Positioning for Navigation Requirements

#### 7.4.1    Introduction

The Positioning service is used to determine "map DB location", for example, given latitude and longitude return the appropriate navigable network entity. Positioning is further enhanced by Map Matching.  Map Matching is the method of determining where the "mobile device" has moved in the navigable network based on the device's previous location{s} and data about the device's motion from external inputs (such as, but not limited to GPS).

#### 7.4.2    Functional Description

"Positioning" seeks a relative position and orientation of a mobile device to the transportation network with respect to the map data representing the real world. An application may dynamically determine the device's current position while the device is in motion.  Map Matching in the background of the application (which might be just tracking of positional history) can continue even while other functions are being performed so the device always "knows where it is."  Map Matching algorithms are beyond the scope of this service, and are not meant to be standardized. For the purpose of positioning, the following are the requirements:

1.  For a given observed lat-long coordinate, return the best POI on the navigable network.
2.  For any specified POI on the navigable network, return a single (corrected) lat-long coordinate.
3.  For a given observed lat-long coordinate, return the best link on the navigable network.
4.  For a given observed lat-long coordinate, return position along (fraction along) the best link on the navigable network.
5.  For any specified link on the navigable network and a fraction of the distance along it, return a single (corrected) lat-long coordinate.
6.  For any specified link (or sequence of connected such) on the navigable network, return the Geometry of said items.
7.  For any requested specified rectangle, return the Geometry of all navigable network features.
8.  For any specified link on the navigable network, return the set of topologically connected links on the navigable network.
9.  For any requested specified rectangle, return all POIs and links on the navigable network.
10. Provide positioning related *Attributes, Conditions* and *Relationships* (i.e. *Prohibited Maneuvers, Direction of Traffic Flow*) for an application-specified link *on the navigable network.*
11. Provide the entry and exit angles for the set of *Transportation Elements* connected to an application-specified *Intersection* or *Junction*.
12. The service shall allow a pre-fetch area of interest to be specified by a rectangle for retrieving Positioning data.

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13. Only one coordinate system can be used in a service invocation.
14. Identification of the coordinate system provided by the service with a single identifier.
15. Turn on and off background map matching
16. Where appropriate, provide QoS measure.

### 7.4.3 Interaction of Positioning Service and other Services (informative)

Positioning may provide position information to other services (directly) to perform the following tasks:

1. When an application tracks progress along the route and provides maneuver instructions at appropriate points to the end-user. [IE routing service would make direct requests to Positioning Service]
2. When an application determines whether the mobile device has left the planned route. [same as above]
3. When an application calculates a route to the requested destination from the mobile device's current position. [same as above]
4. When an application scrolls the displayed map.
5. When an application selects services by geographic proximity.
6. When an application is displaying the navigation system's position on a map. [Presentation Service]
7. When an application displays a map around a location relative to the mobile device's current position
8. Positioning Service may receive planned route information from the Routing Service for use in map matching.

## 8   Top-Level Architecture

Figure 1 shows how the concept GeoMobility Server relates to the other elements of an LBS architecture. The GeoMobility server is an element offering basic functions on which location-based applications are built (the OpenLS Core Services). This server uses open interfaces to access network location capacity (provided through a GMLC, for instance) and provides a set of interfaces allowing applications hosted on this server, or on another server, to access the OpenLS Core Services (see definition of Core Services in section 9).

The GeoMobility Server also provides content such as maps, routes, addresses, points of interest, traffic, etc. It can also access other local content databases via the Internet.

In summary, the GeoMobility Server contains:

- The Core Services and their OpenLS interfaces;

- The OpenLS Information Model, consisting of ADTs;

- Possibly, a set of local applications build upon the Core Services and accessing them through OpenLS interfaces;

- Content such as map data, points of interest, routes, and so on used by the Core Services. This content can also be hosted on other servers and accessed through the Internet; and

- Possibly other supporting functions for personalization, context management, billing, logging, etc.

# Role of the GeoMobility Server
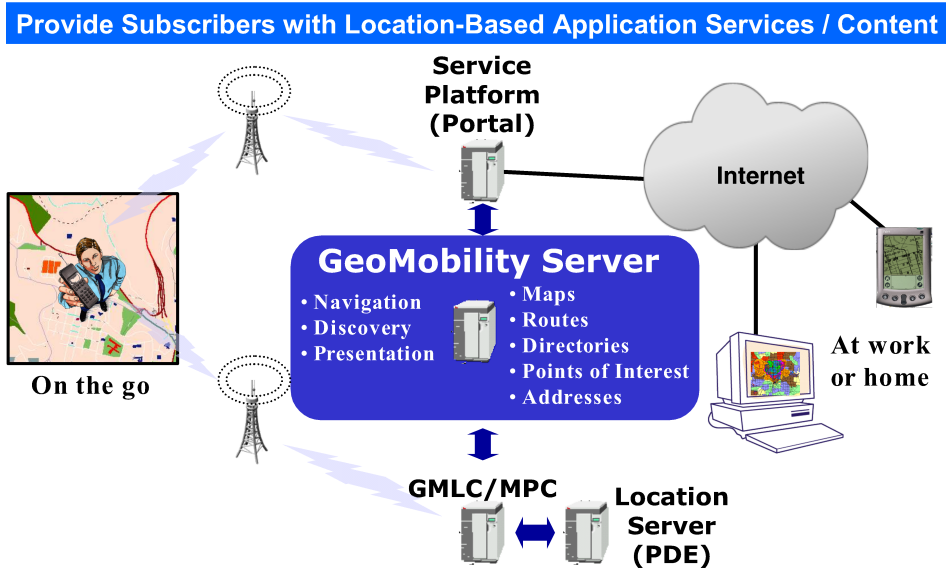


**Figure 1. Role of the GeoMobility Server**

## 9    OpenLS Core Services

The Core Services are location-based application services that form the Services Framework for the GeoMobility Server. See the associated standards for these services (this reference is listed in section 3).

# The GeoMobility Server
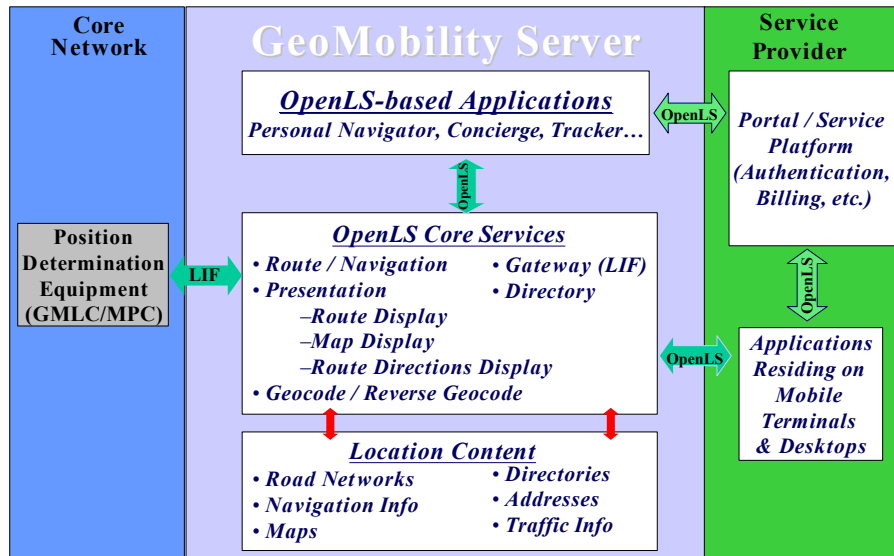


**Figure 2. The GeoMobility Server**

Note: It is not necessary to specify a Coordinate Reference System for Point geometries that are used by these services because the default for all coordinates used by the GeoMobility Server is WGS 84 as specified in the EPSG database. The coordinate conventions are as follows:

- Default Coordinate Reference System - WGS 84 (srsName='4326');

- Coordinate Order - Latitude, Longitude;

- Value Type - Decimal Degrees;

- Latitude Sign is +90 at North Pole to -90 at South Pole;

- Longitude Sign is -180 west from Greenwich at the International Dateline to +180 east from Greenwich at the International Dateline.

## 10  Navigation Service

### 10.1  Description of an Example

**Use Case 1:** The user wants to know: *Which route should I take?* The user has specified the endpoints, and optionally some waypoints, in some manner, or these points have been specified for the user. The starting point is either defined from a GPS or cellular network measurement or entered manually by the user. This information is then fed to a service that determines the route. Optionally, the user may specify route determination criteria. These criteria might be: fastest, shortest, least traffic, most scenic, etc. and can also specify the preferred mode of transport of the user. The routing algorithm might default to a single criterion, such as fastest. The route can also be optionally stored on the terminal or application server. The user may store it for as long as needed, thus requiring the means to also fetch a stored route.

### 10.2  Request and Response Parameters

#### 10.2.1  Navigation DetermineRoute Request Parameters and Attributes

| Determine Route Request Parameters | | | |
|---|---|---|---|
| **A collection of one or more of the parameters below** | | | |
| **Name** | **Mandatory?** | **Data Type** | **Description** |
| RouteHandle | Y (must choose one of these two) | RouteHandleType | Reference to a previously determined route.  Used to request additional information about the route, or to request an alternate route. |
| ExtendedRoutePlan | | RoutePlanType | Specifies the criteria upon which a new route is determined [an extension of the base Route Service parameter]. |
| BoundingBox | N | gml:EnvelopeType | Rectangular area of route for which the answer is requested.  If not specified, defaults to full route. |
| RouteGuidanceRequ | N | RouteInstructionsR | Requests the return of turn- |

| est | | equestType | by-turn route instructions and travel advisories in a text, voice, or other presentation format. |
|---|---|---|---|
| FirstBucketSize | N | integer | If not there, or zero, then don't get first bucket, Else if some positive integer, then get that many objects in the first bucket. |
| | | | |
| Priority | Y | PriorityType | Priority of the request (as compared to other requests which need to be handled out of order). |
| provideRouteHandle | N | Boolean | Requests the return of a route handle. Default = "false" |
| distanceUnit | N | DistanceUnitType (UOM) | Specifies the unit for measuring distance. Default = "M" |

nav:RouteHandle

nav:ExtendedRoutePlan

DetermineRouteRequestType

attributes

nav:BoundingBox

Rectangular area of route for
which the answer is
requested. If not specified,
defaults to full route.

nav:RouteGuidanceRequest

nav:FirstBucketSize

If not there, or zero, then
don't get first bucket. Else if
some positive integer, then
get that many objects in the
first bucket.

| RoutePlanType: Defines the criteria upon which a route is determined. | | | |
|---|---|---|---|
| **Name** | **Mandatory** | **Data Type** | **Description** |
| WayPointList | Y | RoutePointSequenceType | List of waypoints along the route. There must be at least two points, one for the origin and one for the destination. They are the first and the last point in this sequence. Intermediate waypoints, if there are any, are defined in the middle of the sequence. |
| AvoidList | N | AvoidListType (ADT) | List of areas, locations, and features in which the route should avoid passing through. |
| ExtendedRouteControl | Y | RouteControlType | The criteria upon which a route is determined. |
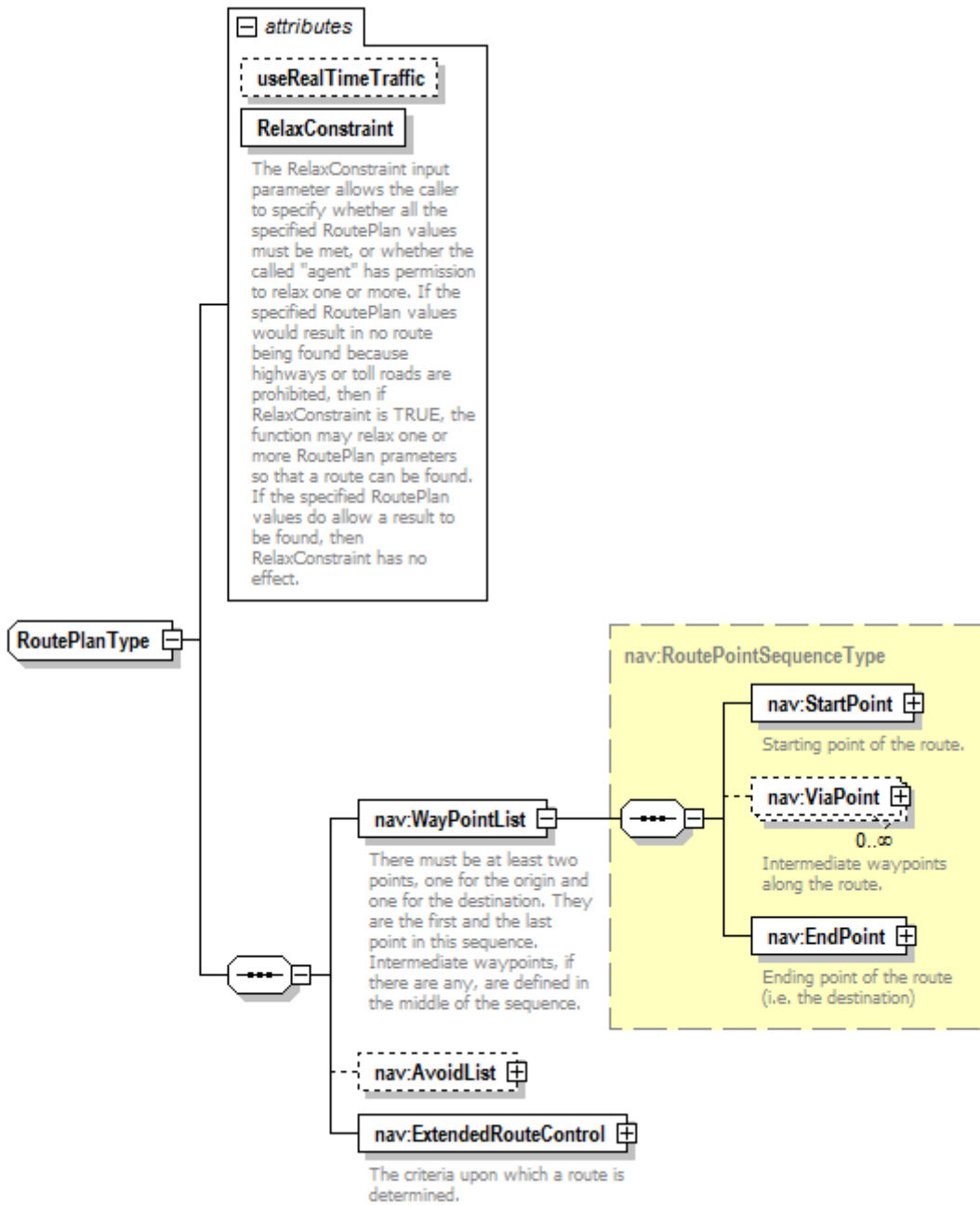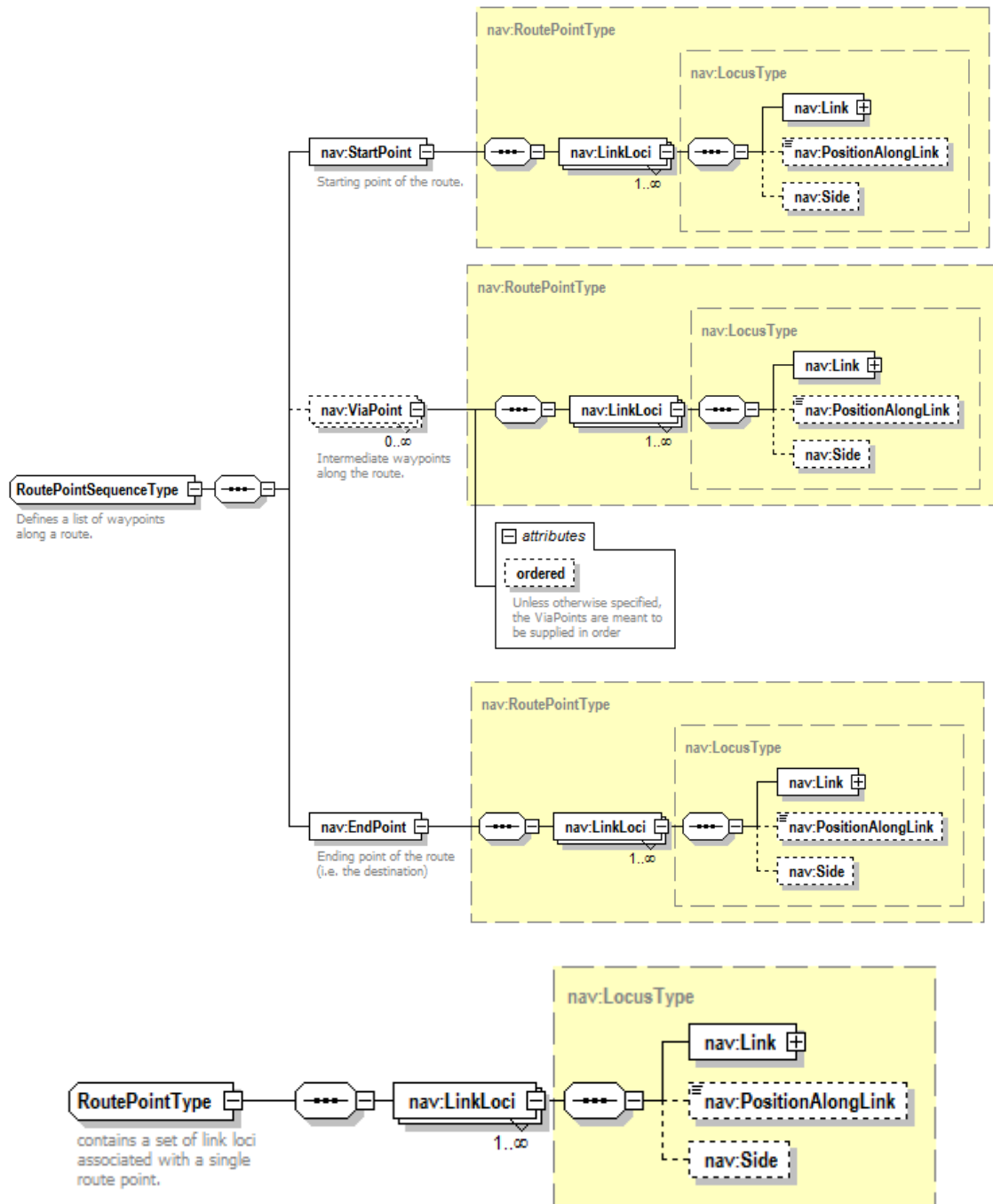
**RouteControlType**: This structure contains the criteria to be used by the DetermineRoute request:

The cost criteria includes the following information:
➔ Should travel time or travel distance be minimized?
➔ Should highways be used?
➔ Should toll roads be used?
➔ Should a scenic route be preferred?
➔ For which vehicle type(s)?
➔ For what starting and/or ending time?

| Name | Mandatory | Data Type | Description |
|---|---|---|---|
| CostCriteria | Y | RouteCostModel Type | Cost Criteria |
| Vehicle | N | VehicleType | Vehicle type(s) |
| VehicleCompositionLogic | N | string | If more then one vehicle listed, should they be considered as disjuncts or conjuncts (AND or OR) |
| RouteStartDateTime | N | DateTimeType | Route "start" date and time |
| RouteEndDateTime | N | DateTimeType | Route "end" date and time |
| | | | |
| useRealTimeTraffic | N | Boolean | Specifies whether to use real time traffic information when determining the best route.<br><br>Default is "false" |
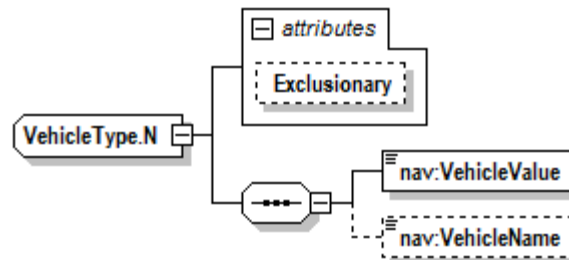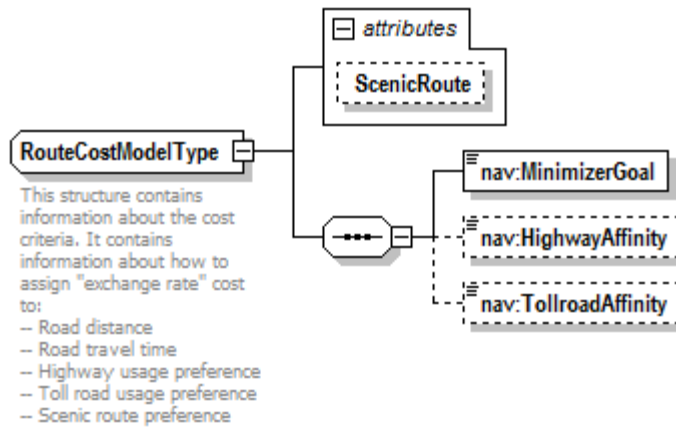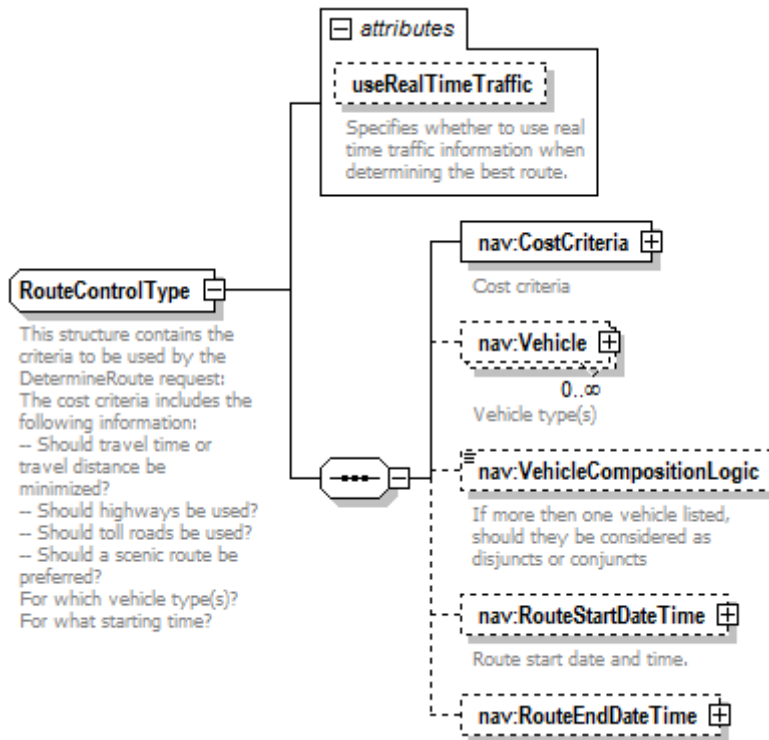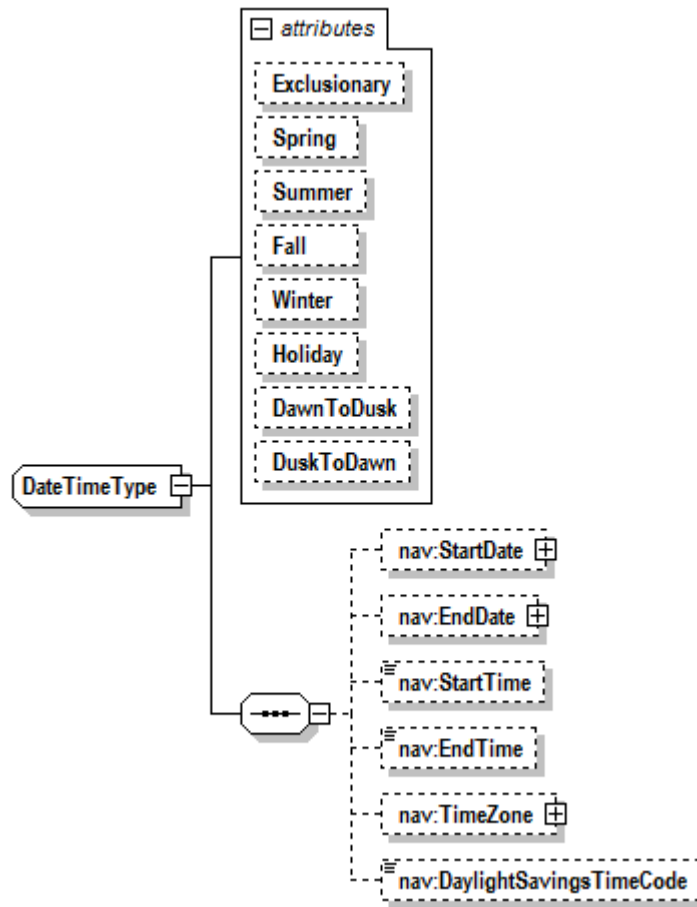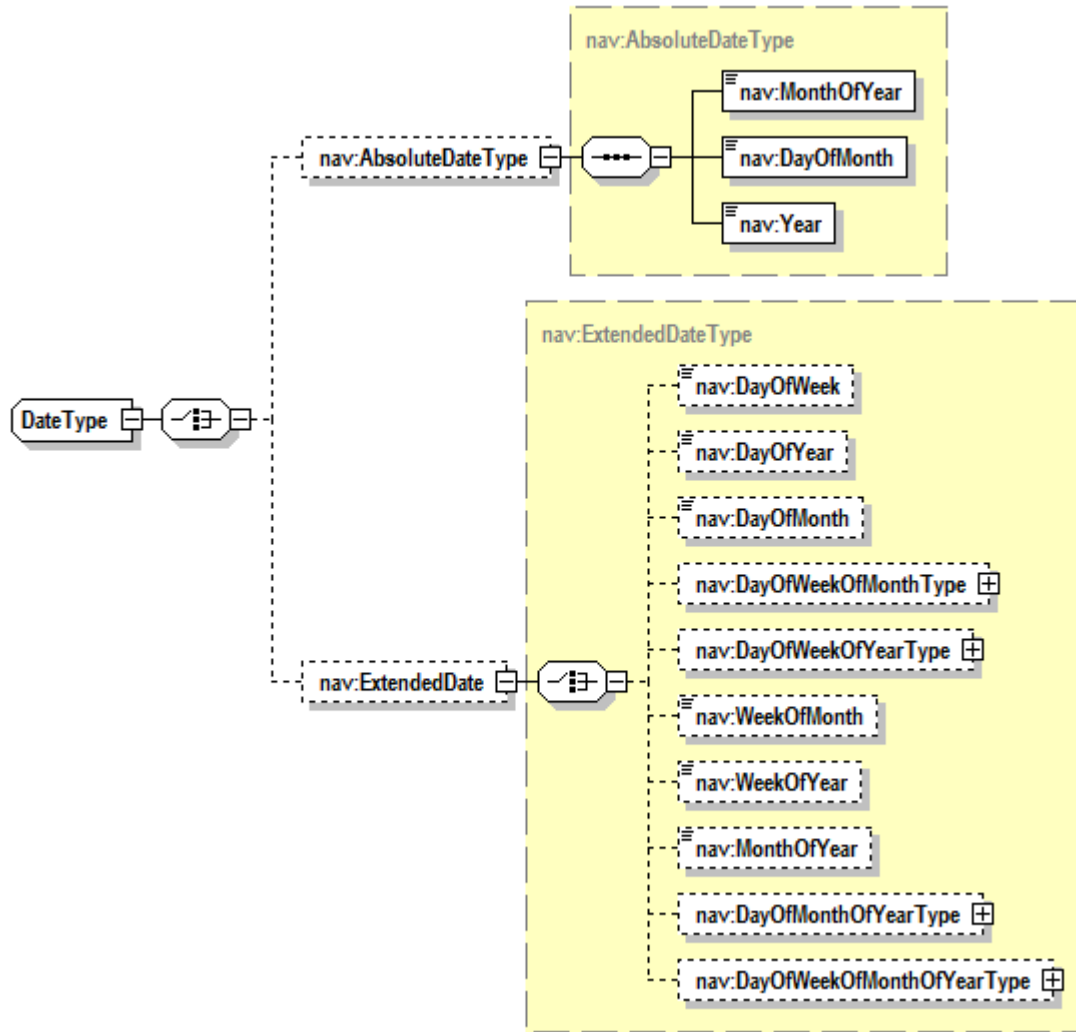
### 10.2.2 Navigation Response Parameters

| Determine Route Response Parameters | | | |
|---|---|---|---|
| **A collection of one or more of the parameters below.** | | | |
| **Name** | **Mandatory** | **Data Type** | **Description** |
| RouteLinkAndCost | Y | CursorType of type RouteLinkAndCost | Here is returned an ordered list of links and node travel costs for the computed path. The computed path is the path for the specified compute control values in the request call |
| FirstBucket | N | CursorFetchResponse of type RouteLinkAndCost | If we asked for 1st bucket to be returned in the Request |
| RouteHandle | N | RouteHandleType(ADT) | Contains a reference to the route stored at the Navigation Service server. Can be used in subsequent requests to the Navigation Service to request additional information about the route, or to request an alternate route. |
| RouteSummary | N | RouteSummaryType (ADT) | Describes the overall characteristics of the route. |
| ConstraintRelaxed | N | Boolean | The ConstraintRelaxed output parameter shows whether one or more RoutePlan (input parameter) values has been relaxed |
| WhichConstrainWas Relaxed | N | | Shows which constraint was/were relaxed |
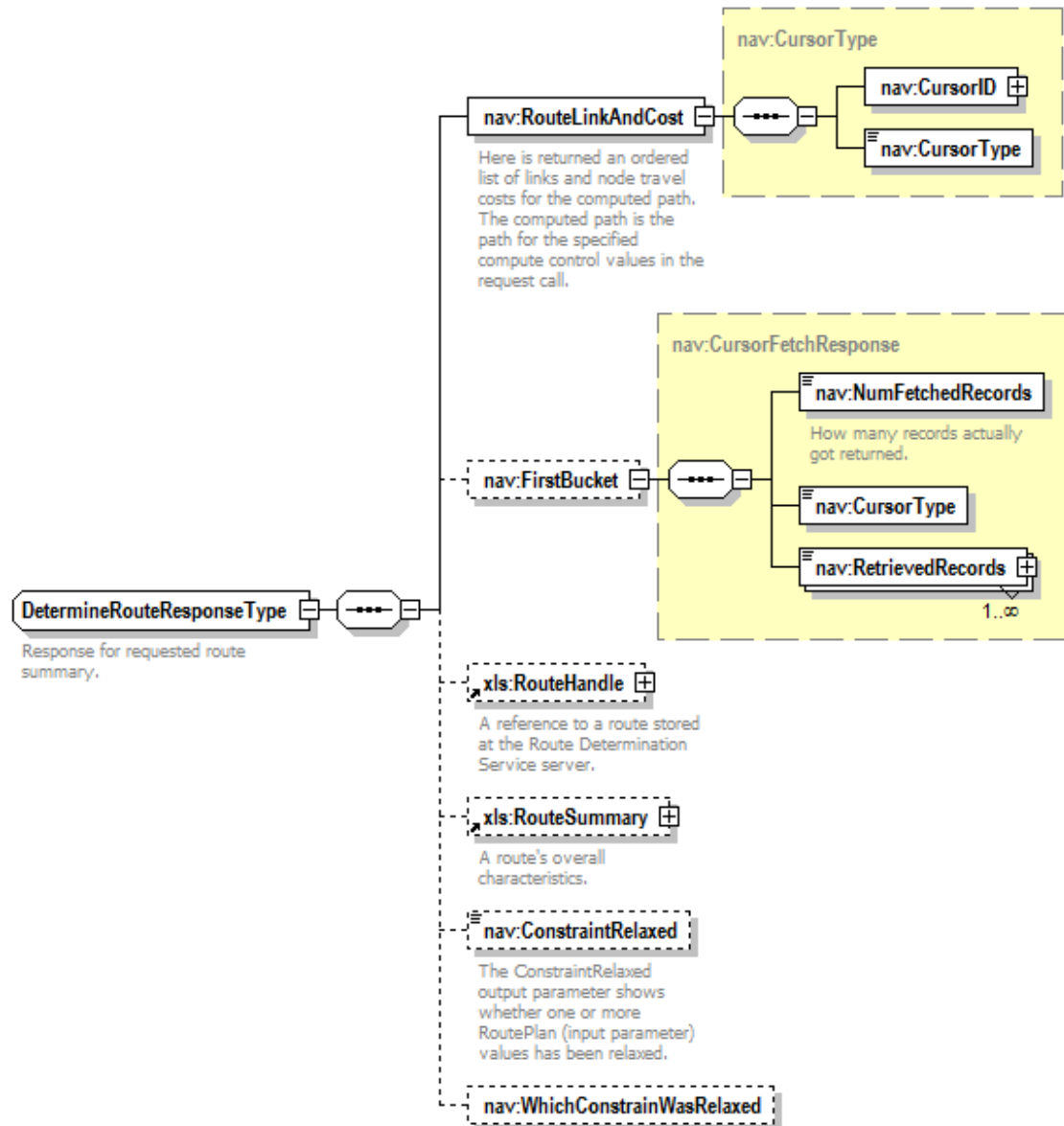
## 11 OpenLS Information Model

The OpenLS Core Services exchange content in the form of well-known OpenLS Abstract Data Types (ADTs). Collectively these ADTs comprise the OpenLS Information Model (Figure 3).

| The OpenLS Information Model | |
|---|---|
| Position ADT | Point location in well-known coordinate system |
| Address ADT | Street address or intersection |
| Point of Interest (POI) ADT | The location where someone can find place, product or service |
| Area of Interest (AOI) ADT | A polygon, bounding box or circle used as a search template |
| Location ADT | A location (Position, Address or POI) |
| Map ADT | The portrayal of maps and feature overlays (routes & POI) |
| Route Summary ADT | Metadata pertaining to a route |
| Route Geometry ADT | Geometry data for a route |
| Route Maneuvers ADT | Navigation maneuver data for a route |
| Route Directions ADT | Turn-by-turn navigation instructions for a route |



**Figure 3. OpenLS Information Model**

## 12  Conformance Requirements and Procedures

### 12.1  Compliance Testing

Compliance testing for this Implementation Standard *shall* be based upon the normative schema in Annex A.

The sponsors of this standard have devised the following conformance test requirements and procedures.

### 12.2  Abstract Test Suite

The server *shall* respond to each of the valid XML request document types itemized in section 7.1 with a valid XML document of the corresponding type.

# Annex A.1: OpenGIS Location Services (OpenLS) Navigation Service Schema and Positioning Service (Normative)

The XML for Location Services (XLS) schema for Navigation Service, Version 1.3 is presented below.

**nav-RouteService.xsd**

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2008 sp1 U (http://www.altova.com) by Gil Fuchs (Tele Atlas) -->
<!-- edited with XMLSpy v2006 sp1 U (http://www.altova.com) by Marwa Mabrouk (ESRI) -->
<schema xmlns:gml="http://www.opengis.net/gml" xmlns:xls="http://www.opengis.net/xls"
xmlns:nav="http://www.opengis.net/ols/nav" xmlns="http://www.w3.org/2001/XMLSchema"
targetNamespace="http://www.opengis.net/ols/nav" elementFormDefault="qualified"
version="1.3">
    <import namespace="http://www.opengis.net/gml" schemaLocation="GML4XLS.xsd"/>
    <import namespace="http://www.opengis.net/xls" schemaLocation="XLS.xsd"/>
    <import namespace="http://www.opengis.net/xls" schemaLocation="RouteService.xsd"/>
    <include schemaLocation="nav-Positioning.xsd"/>
    <include schemaLocation="nav-CursorUtil.xsd"/>
    <include schemaLocation="nav-UOM.xsd"/>
    <!--Copyright (c) 2003 OGC, All Rights Reserved - This OGC document is a draft and is
copyright-protected by OGC. While the reproduction of drafts in any form for use by participants in
the OGC Interoperability Program is permitted without prior permission from OGC, neither this
document nor any extract from it may be reproduced, stored or transmitted in any form for any other
purpose without prior written permission from OGC.-->
    <!-- ============================================= -->
    <!--DetermineRouteRequest                                    -->
    <!-- ============================================= -->
    <element name="DetermineRouteRequest" type="nav:DetermineRouteRequestType"
substitutionGroup="xls:_RequestParameters"/>
    <complexType name="DetermineRouteRequestType">
        <complexContent>
            <extension base="xls:AbstractRequestParametersType">
                <sequence>
                    <choice>
                        <element name="RouteHandle" type="xls:RouteHandleType"/>
                        <element name="ExtendedRoutePlan" type="nav:RoutePlanType"/>
                    </choice>
                    <element name="BoundingBox" type="gml:EnvelopeType" minOccurs="0">
                        <annotation>
```

```
                        <documentation>Rectangular area of route for which the answer is
requested.  If not specified, defaults to full route.</documentation>
                    </annotation>
                </element>
                <element name="RouteGuidanceRequest"
type="xls:RouteInstructionsRequestType" minOccurs="0"/>
                <element name="FirstBucketSize" type="integer" minOccurs="0">
                    <annotation>
                        <documentation>If not there, or zero, then don't get first bucket, Else if
some positive integer, then get that many objects in the first bucket.</documentation>
                    </annotation>
                </element>
            </sequence>
            <attribute name="priority" type="nav:PriorityType" use="required"/>
            <attribute name="provideRouteHandle" type="boolean" use="optional"
default="false">
                <annotation>
                    <documentation>Requests the return of a route handle.</documentation>
                </annotation>
            </attribute>
            <attribute name="distanceUnit" type="xls:DistanceUnitType" use="optional"
default="M">
                <annotation>
                    <documentation>Specifies the unit for measuring
distance.</documentation>
                </annotation>
            </attribute>
        </extension>
    </complexContent>
</complexType>
<complexType name="RoutePlanType">
    <sequence>
        <element name="WayPointList" type="nav:RoutePointSequenceType">
            <annotation>
                <documentation>There must be at least two points, one for the origin and one
for the destination. They are the first and the last point in this sequence.  Intermediate waypoints, if
there are any, are defined in the middle of the sequence.</documentation>
            </annotation>
        </element>
        <element name="AvoidList" type="xls:AvoidListType" minOccurs="0"/>
        <element name="ExtendedRouteControl" type="nav:RouteControlType">
            <annotation>
                <documentation>The criteria upon which a route is
determined.</documentation>
            </annotation>
        </element>
```

```
                    </sequence>
                    <attribute name="useRealTimeTraffic" type="boolean" use="optional" default="false"/>
                    <attribute name="RelaxConstraint" type="boolean" use="required">
                        <annotation>
                            <documentation>The RelaxConstraint input parameter allows the caller to specify
whether all the specified RoutePlan values must be met, or whether the called "agent" has
permission to relax one or more. If the specified RoutePlan values would result in no route being
found because highways or toll roads are prohibited, then if RelaxConstraint is TRUE, the function
may relax one or more RoutePlan prameters so that a route can be found. If the specified RoutePlan
values do allow a result to be found, then RelaxConstraint has no effect.</documentation>
                        </annotation>
                    </attribute>
                </complexType>
                <complexType name="RoutePointSequenceType">
                    <annotation>
                        <documentation>Defines a list of waypoints along a route.</documentation>
                    </annotation>
                    <sequence>
                        <element name="StartPoint" type="nav:RoutePointType">
                            <annotation>
                                <documentation>Starting point of the route.</documentation>
                            </annotation>
                        </element>
                        <element name="ViaPoint" minOccurs="0" maxOccurs="unbounded">
                            <annotation>
                                <documentation>Intermediate waypoints along the route.</documentation>
                            </annotation>
                            <complexType>
                                <complexContent>
                                    <extension base="nav:RoutePointType">
                                        <attribute name="ordered" type="boolean" use="optional"
default="true">
                                            <annotation>
                                                <documentation>Unless otherwise specified, the ViaPoints are
meant to be supplied in order</documentation>
                                            </annotation>
                                        </attribute>
                                    </extension>
                                </complexContent>
                            </complexType>
                        </element>
                        <element name="EndPoint" type="nav:RoutePointType">
                            <annotation>
                                <documentation>Ending point of the route (i.e. the
destination)</documentation>
                            </annotation>
```

```
            </element>
        </sequence>
    </complexType>
    <complexType name="RoutePointType">
        <annotation>
            <documentation>contains a set of link loci  associated with a single route
point.</documentation>
        </annotation>
        <sequence>
            <element name="LinkLoci" type="nav:LocusType" maxOccurs="unbounded"/>
        </sequence>
    </complexType>
    <complexType name="RouteControlType">
        <annotation>
            <documentation>This structure contains the criteria to be used by the DetermineRoute
request:
The cost criteria includes the following information:
-- Should travel time or travel distance be minimized?
-- Should highways be used?
-- Should toll roads be used?
-- Should a scenic route be preferred?
    For which vehicle type(s)?
    For what starting time?</documentation>
        </annotation>
        <sequence>
            <element name="CostCriteria" type="nav:RouteCostModelType">
                <annotation>
                    <documentation>Cost criteria</documentation>
                </annotation>
            </element>
            <element name="Vehicle" type="nav:VehicleType.N" minOccurs="0"
maxOccurs="unbounded">
                <annotation>
                    <documentation>Vehicle type(s)</documentation>
                </annotation>
            </element>
            <element name="VehicleCompositionLogic" minOccurs="0">
                <annotation>
                    <documentation>If more then one vehicle listed, should they be considered as
disjuncts or conjuncts</documentation>
                </annotation>
                <simpleType>
                    <restriction base="string">
                        <enumeration value="AND"/>
                        <enumeration value="OR"/>
                    </restriction>
```

```xml
            </simpleType>
        </element>
        <element name="RouteStartDateTime" type="nav:DateTimeType" minOccurs="0">
            <annotation>
                <documentation>Route start date and time.</documentation>
            </annotation>
        </element>
        <element name="RouteEndDateTime" type="nav:DateTimeType" minOccurs="0"/>
    </sequence>
    <attribute name="useRealTimeTraffic" type="boolean" default="false">
        <annotation>
            <documentation>Specifies whether to use real time traffic information when
determining the best route.</documentation>
        </annotation>
    </attribute>
</complexType>
<complexType name="RouteCostModelType">
    <annotation>
        <documentation>This structure contains information about the cost criteria. It contains
information about how to assign "exchange rate" cost to:
-- Road distance
-- Road travel time
-- Highway usage preference
-- Toll road usage preference
-- Scenic route preference</documentation>
    </annotation>
    <sequence>
        <element name="MinimizerGoal" type="nav:RouteMinimizeOptionEnum"/>
        <element name="HighwayAffinity" type="nav:RouteHighwayUsageEnum"
minOccurs="0"/>
        <element name="TollroadAffinity" type="nav:RouteTollUsageEnum"
minOccurs="0"/>
        <!--<element name="ScenicRoute" type="boolean" minOccurs="0"/>-->
    </sequence>
    <attribute name="ScenicRoute" type="boolean" use="optional"/>
</complexType>
<!-- ========================================= -->
<!--DetermineRouteResponse                -->
<!-- ========================================= -->
<element name="DetermineRouteResponse" type="nav:DetermineRouteResponseType"
substitutionGroup="xls:_ResponseParameters"/>
<complexType name="DetermineRouteResponseType">
    <annotation>
        <documentation>Reference to the route stored at the Route Determination Service
server.</documentation>
        <documentation>Response for requested route summary.</documentation>
```

```
            </annotation>
            <complexContent>
                <extension base="xls:AbstractResponseParametersType">
                    <sequence>
                        <element name="RouteLinkAndCost" type="nav:CursorType">
                            <annotation>
                                <documentation>Here is returned an ordered list of links and node
travel costs for the computed path.  The computed path is the path for the specified compute control
values in the request call.</documentation>
                            </annotation>
                        </element>
                        <element name="FirstBucket" type="nav:CursorFetchResponse"
minOccurs="0"/>
                        <element ref="xls:RouteHandle" minOccurs="0"/>
                        <element ref="xls:RouteSummary" minOccurs="0"/>
                        <element name="ConstraintRelaxed" type="boolean" minOccurs="0">
                            <annotation>
                                <documentation>The ConstraintRelaxed output parameter shows
whether one or more RoutePlan (input parameter) values has been relaxed.  </documentation>
                            </annotation>
                        </element>
                        <element name="WhichConstrainWasRelaxed" minOccurs="0"/>
                    </sequence>
                </extension>
            </complexContent>
        </complexType>
        <complexType name="RouteLinkAndCost">
            <sequence>
                <element name="Link" type="nav:AbstractIDType"/>
                <element name="EstLinkTravelTime" type="unsignedLong">
                    <annotation>
                        <documentation>Link traversal time, in tenths of seconds.</documentation>
                    </annotation>
                </element>
                <element name="NodeTravelTime" type="unsignedShort">
                    <annotation>
                        <documentation>Estimated node travel cost to the link above, units of
measurement are in tenths of seconds.</documentation>
                    </annotation>
                </element>
            </sequence>
        </complexType>
</schema>
```

**nav-Positioning.xsd**

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSPY v2004 rel. 3 U (http://www.xmlspy.com) by Gil Emanuel Fuchs (Tele Atlas) -->
<!--Generated by XML Authority. Conforms to w3c http://www.w3.org/2001/XMLSchema-->
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:gml="http://www.opengis.net/gml" xmlns:xls="http://www.opengis.net/xls"
xmlns:nav="http://www.opengis.net/ols/nav" targetNamespace="http://www.opengis.net/ols/nav"
elementFormDefault="qualified" version="1.3">
    <xsd:import namespace="http://www.opengis.net/gml" schemaLocation="GML4XLS.xsd"/>
    <xsd:import namespace="http://www.opengis.net/xls" schemaLocation="XLS.xsd"/>
    <xsd:include schemaLocation="nav-CursorUtil.xsd"/>
    <xsd:include schemaLocation="nav-UOM.xsd"/>
    <!-- ========================================= -->
    <!--        Positioning functions       -->
    <!-- ========================================= -->
    <xsd:element name="GetPositionRequest" type="nav:GetPositionRequestType"
substitutionGroup="xls:_RequestParameters"/>
    <xsd:element name="GetPositionResponse" type="nav:GetPositionResponseType"
substitutionGroup="xls:_ResponseParameters"/>
    <xsd:element name="GetNearbyMapObjRequest" type="nav:GetNearbyMapObjRequestType"
substitutionGroup="xls:_RequestParameters"/>
    <xsd:element name="GetNearbyMapObjResponse"
type="nav:GetNearbyMapObjResponseType" substitutionGroup="xls:_ResponseParameters"/>
    <xsd:complexType name="GetPositionRequestType">
        <xsd:complexContent>
            <xsd:extension base="xls:AbstractRequestParametersType">
                <xsd:sequence>
                    <xsd:element name="UseHistory" type="xsd:boolean"/>
                    <xsd:element name="CurrentPosition" type="xls:PositionType"/>
                </xsd:sequence>
                <xsd:attribute name="priority" type="nav:PriorityType" use="required"/>
            </xsd:extension>
        </xsd:complexContent>
    </xsd:complexType>
    <xsd:complexType name="GetPositionResponseType">
        <xsd:complexContent>
            <xsd:extension base="xls:AbstractResponseParametersType">
                <xsd:sequence>
                    <xsd:element name="Locus" type="nav:LocusType"/>
                </xsd:sequence>
            </xsd:extension>
        </xsd:complexContent>
    </xsd:complexType>
```

```xml
<xsd:complexType name="GetNearbyMapObjRequestType">
    <xsd:complexContent>
        <xsd:extension base="xls:AbstractRequestParametersType">
            <xsd:sequence>
                <xsd:element name="CurrentPosition" type="xls:PositionType"/>
                <xsd:element name="Delta" type="xsd:unsignedLong"/>
                <xsd:element name="GetFirstBucket" type="xsd:integer" default="0" minOccurs="0">
                    <xsd:annotation>
                        <xsd:documentation>If not there, or zero, then don't get first bucket, Else if some positive integer, then get that many objects in the first bucket.</xsd:documentation>
                    </xsd:annotation>
                </xsd:element>
            </xsd:sequence>
            <xsd:attribute name="priority" type="nav:PriorityType" use="required"/>
        </xsd:extension>
    </xsd:complexContent>
</xsd:complexType>
<xsd:complexType name="GetNearbyMapObjResponseType">
    <xsd:complexContent>
        <xsd:extension base="xls:AbstractResponseParametersType">
            <xsd:sequence>
                <xsd:element name="MapObj" type="nav:MapObjType"/>
            </xsd:sequence>
        </xsd:extension>
    </xsd:complexContent>
</xsd:complexType>
<xsd:complexType name="MapObjType">
    <xsd:sequence>
        <xsd:element name="Cursor" type="nav:CursorType"/>
        <xsd:element name="FirstBucket" type="nav:CursorFetchResponse" minOccurs="0"/>
    </xsd:sequence>
</xsd:complexType>
<xsd:complexType name="LocusType">
    <xsd:complexContent>
        <xsd:extension base="xls:AbstractWayPointType">
            <xsd:sequence>
                <xsd:element name="Link" type="nav:AbstractIDType"/>
                <xsd:element name="PositionAlongLink" minOccurs="0">
                    <xsd:simpleType>
                        <xsd:restriction base="nav:FractionType">
                            <xsd:minInclusive value="0"/>
                            <xsd:maxInclusive value="1"/>
                        </xsd:restriction>
                    </xsd:simpleType>
                </xsd:element>
```

```
                    <xsd:element name="Side" minOccurs="0"/>
                </xsd:sequence>
            </xsd:extension>
        </xsd:complexContent>
    </xsd:complexType>
</xsd:schema>
```

**nav-CursorUtil.xsd**

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSPY v2004 rel. 3 U (http://www.xmlspy.com) by Gil Emanuel Fuchs (Tele
Atlas) -->
<!--Generated by XML Authority. Conforms to w3c http://www.w3.org/2001/XMLSchema-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:xls="http://www.opengis.net/xls"
xmlns:nav="http://www.opengis.net/ols/nav" targetNamespace="http://www.opengis.net/ols/nav"
elementFormDefault="qualified">
    <import namespace="http://www.opengis.net/xls" schemaLocation="XLS.xsd"/>
    <include schemaLocation="nav-UOM.xsd"/>
    <!-- ======================================== -->
    <!--Large Result Set Utilities (requests) -->
    <!-- ======================================== -->
    <complexType name="CursorFetchRequest">
        <annotation>
            <documentation>get a bucket from the cursor (of requested size)</documentation>
        </annotation>
        <complexContent>
            <extension base="xls:AbstractRequestParametersType">
                <sequence>
                    <element name="CursorID" type="nav:CursorIDType"/>
                    <element name="FetchDirection" type="nav:FetchDirectionType"/>
                    <element name="NumRecordsToFetch" type="xsd:unsignedLong"/>
                </sequence>
                <attribute name="priority" type="nav:PriorityType" use="required"/>
            </extension>
        </complexContent>
    </complexType>
    <complexType name="GetCursorInfoRequest">
        <complexContent>
            <extension base="xls:AbstractRequestParametersType">
                <sequence>
                    <element name="CursorID" type="nav:CursorIDType"/>
                </sequence>
                <attribute name="priority" type="nav:PriorityType" use="required"/>
            </extension>
        </complexContent>
    </complexType>
    <complexType name="GetCursorPositionRequest">
        <annotation>
            <documentation>The cursor is considered to be positioned in a gap between records.
Gap number 0 is the gap before the first record.  Gap number J is the gap between the Jth and (J+1)st
```

records.  If there are N records in total, gap number N is the gap after the last record. The value returned by this request is the current cursor position.</documentation>
        </annotation>
        <complexContent>
            <extension base="xls:AbstractRequestParametersType">
                <sequence>
                    <element name="CursorID" type="nav:CursorIDType"/>
                </sequence>
                <attribute name="priority" type="nav:PriorityType" use="required"/>
            </extension>
        </complexContent>
    </complexType>
    <complexType name="SetCursorPositionRequest">
        <annotation>
            <documentation>This request positions a large result set cursor current position (CP) to a specified record within the complete result set. The action of this request  can be described in two steps as follows, although there is no implication that the actual implementation of the request must be implemented in this way: First, if the "CursorStartPosition" element is RESULT_SET_START, the CP is moved to the gap before the first record; if the "CursorStartPosition" element is RESULT_SET_END, the CP is moved to the gap after the last record; and if the "CursorStartPosition" element is CURRENT_POSITION, the CP is not moved.  Second, if NumOfPositions is positive, the CP is moved forward (toward the end of the result set) by NumOfPositions records; if NumOfPositions is negative, the CP is moved backward (toward the beginning of the result set) by NumOfPositions records; if NumOfPositions is zero, the CP is not moved.  However, if this movement would move the CP before the gap at the beginning of the large result set  or after the gap at the end of the large result set, the CP is instead left at that gap.
</documentation>
        </annotation>
        <complexContent>
            <extension base="xls:AbstractRequestParametersType">
                <sequence>
                    <element name="CursorID" type="nav:CursorIDType"/>
                    <element name="CursorStartPosition" type="nav:CursorOriginEnum"/>
                    <element name="NumOfPositions" type="xsd:long" default="0"/>
                </sequence>
                <attribute name="priority" type="nav:PriorityType" use="required"/>
            </extension>
        </complexContent>
    </complexType>
    <complexType name="ProcessCursorRequest">
        <annotation>
            <documentation>This request is for the server to process all of the records in the result set starting with the first record regardless of where the cursor's current position is currently positioned. Upon completion of this request, the cursor current position is positioned at the end of the complete result set.

The action function's first parameter is a pointer to a structure of the type contained in the cursor's records.  The second is an application-defined structure, or NULL. In processing each cursor element, the third element  of ProcessCursorRequest is passed in as the second argument of ActionFunc.  If ActionFunc yields a negative result value, processing will be aborted. ProcessCursorResponse returns the number of records processed.</documentation>
                </annotation>
                <complexContent>
                    <extension base="xls:AbstractRequestParametersType">
                        <sequence>
                            <element name="CursorID" type="nav:CursorIDType"/>
                            <element name="ActionFunc" type="xsd:anyType"/>
                            <element name="ActionFuncParam" type="xsd:anyType"/>
                        </sequence>
                        <attribute name="priority" type="nav:PriorityType" use="required"/>
                    </extension>
                </complexContent>
        </complexType>
        <complexType name="CloseCursorRequest">
            <complexContent>
                <extension base="xls:AbstractRequestParametersType">
                    <sequence>
                        <element name="CursorID" type="nav:CursorIDType"/>
                    </sequence>
                    <attribute name="priority" type="nav:PriorityType" use="required"/>
                </extension>
            </complexContent>
        </complexType>
        <!-- ========================================== -->
        <!--Large Result Set Utilities (responses) -->
        <!-- ========================================== -->
        <complexType name="CursorFetchResponse">
            <complexContent>
                <extension base="xls:AbstractResponseParametersType">
                    <sequence>
                        <element name="NumFetchedRecords" type="long">
                            <annotation>
                                <documentation>How many records actually got
returned.</documentation>
                            </annotation>
                        </element>
                        <element name="CursorType" type="nav:CursorTypeEnum"/>
                        <element name="RetrievedRecords" type="xsd:anyType"
maxOccurs="unbounded"/>
                    </sequence>
                </extension>
            </complexContent>

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```xml
        </complexType>
        <complexType name="GetCursorInfoResponse">
            <complexContent>
                <extension base="xls:AbstractResponseParametersType">
                    <sequence>
                        <element name="CursorInfo" type="nav:CursorInfoType"/>
                    </sequence>
                </extension>
            </complexContent>
        </complexType>
        <complexType name="GetCursorPositionResponse">
            <complexContent>
                <extension base="xls:AbstractResponseParametersType">
                    <sequence>
                        <element name="CursorPosition" type="xsd:long"/>
                    </sequence>
                </extension>
            </complexContent>
        </complexType>
        <complexType name="SetCursorPositionResponse">
            <complexContent>
                <extension base="xls:AbstractResponseParametersType">
                    <sequence>
                        <element name="GapNum" type="long">
                            <annotation>
                                <documentation>the number of the gap at which the cursor is
left</documentation>
                            </annotation>
                        </element>
                    </sequence>
                </extension>
            </complexContent>
        </complexType>
        <complexType name="ProcessCursorResponse">
            <complexContent>
                <extension base="xls:AbstractResponseParametersType">
                    <sequence>
                        <element name="NumRecordsProcessed" type="long"/>
                    </sequence>
                </extension>
            </complexContent>
        </complexType>
        <!-- ===================================== -->
        <!-- Cursor Types                     -->
        <!-- ===================================== -->
        <complexType name="CursorType">
```

```xml
        <sequence>
            <element name="CursorID" type="nav:CursorIDType"/>
            <element name="CursorType" type="nav:CursorTypeEnum"/>
        </sequence>
    </complexType>
    <complexType name="CursorIDType">
        <complexContent>
            <extension base="nav:AbstractIDType"/>
        </complexContent>
    </complexType>
    <complexType name="CursorInfoType">
        <sequence>
            <element name="CursorBufferStart" type="xsd:long">
                <annotation>
                    <documentation>Number of the gap before the set of records in the server's
buffer, ready to be returned.</documentation>
                </annotation>
            </element>
            <element name="CursorBufferEnd" type="xsd:long">
                <annotation>
                    <documentation>Number of the gap after the set of records in the server's
buffer, ready to be returned.</documentation>
                </annotation>
            </element>
            <element name="ResultsSetComplete" type="xsd:boolean">
                <annotation>
                    <documentation>Indication of whether last result record is ready to be returned.
This field is true if and only if CursorBufferEnd describes the gap after the last bucket record.
</documentation>
                </annotation>
            </element>
            <element name="CurrentCursorPosition" type="xsd:long">
                <annotation>
                    <documentation>Current cursor position, as a gap number.  Reading forward
will start after this gap; reading backward will start before this gap.</documentation>
                </annotation>
            </element>
        </sequence>
    </complexType>
    <simpleType name="CursorTypeEnum">
        <restriction base="xsd:string">
            <enumeration value="RouteLinkAndCostType"/>
            <enumeration value="MapObjType"/>
        </restriction>
    </simpleType>
    <simpleType name="FetchDirectionType">
```

```xml
        <restriction base="xsd:string">
            <enumeration value="FetchForward"/>
            <enumeration value="FetchBackward"/>
        </restriction>
    </simpleType>
    <simpleType name="CursorOriginEnum">
        <restriction base="xsd:string">
            <enumeration value="CURRENT_POSITION"/>
            <enumeration value="RESULT_SET_START"/>
            <enumeration value="RESULT_SET_END"/>
        </restriction>
    </simpleType>
</schema>
```

**nav-UOM.xsd**

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!-- edited with XMLSpy v2008 sp1 (http://www.altova.com) by Gil E. Fuchs (TeleAtlas) -->
<!-- edited with XMLSPY v2004 rel. 3 U (http://www.xmlspy.com) by Gil Emanuel Fuchs (Tele
Atlas) -->
<!--Generated by XML Authority. Conforms to w3c http://www.w3.org/2001/XMLSchema-->
<schema xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:xls="http://www.opengis.net/xls"
xmlns:nav="http://www.opengis.net/ols/nav" targetNamespace="http://www.opengis.net/ols/nav"
elementFormDefault="qualified" version="1.3">
    <import namespace="http://www.opengis.net/xls" schemaLocation="XLS.xsd"/>
    <!-- ======================================= -->
    <!--UOM for navigation                       -->
    <!-- ======================================= -->
    <complexType name="DateTimeType">
        <sequence>
            <element name="StartDate" type="nav:DateType" minOccurs="0"/>
            <element name="EndDate" type="nav:DateType" minOccurs="0"/>
            <element name="StartTime" type="unsignedShort" minOccurs="0"/>
            <element name="EndTime" type="unsignedShort" minOccurs="0"/>
            <element name="TimeZone" type="nav:TimeZoneType" minOccurs="0"/>
            <element name="DaylightSavingsTimeCode" type="unsignedShort" minOccurs="0"/>
        </sequence>
        <attribute name="Exclusionary" type="boolean" use="optional" default="false"/>
        <attribute name="Spring" type="boolean" use="optional"/>
        <attribute name="Summer" type="boolean" use="optional"/>
        <attribute name="Fall" type="boolean" use="optional"/>
        <attribute name="Winter" type="boolean" use="optional"/>
        <attribute name="Holiday" type="boolean" use="optional"/>
        <attribute name="DawnToDusk" type="boolean" use="optional"/>
        <attribute name="DuskToDawn" type="boolean" use="optional"/>
    </complexType>
    <complexType name="DateType">
        <choice>
            <element name="AbsoluteDateType" type="nav:AbsoluteDateType" minOccurs="0"/>
            <element name="ExtendedDate" type="nav:ExtendedDateType" minOccurs="0"/>
        </choice>
    </complexType>
    <complexType name="ExtendedDateType">
        <choice>
            <element name="DayOfWeek" type="nav:DayOfWeekEnum" minOccurs="0"/>
            <element name="DayOfYear" type="unsignedShort" minOccurs="0"/>
            <element name="DayOfMonth" type="unsignedShort" minOccurs="0"/>
```

```xml
            <element name="DayOfWeekOfMonthType" type="nav:DayOfWeekOfMonthType"
minOccurs="0"/>
            <element name="DayOfWeekOfYearType" type="nav:DayOfWeekOfYearType"
minOccurs="0"/>
            <element name="WeekOfMonth" type="unsignedShort" minOccurs="0"/>
            <element name="WeekOfYear" type="unsignedShort" minOccurs="0"/>
            <element name="MonthOfYear" type="unsignedShort" minOccurs="0"/>
            <element name="DayOfMonthOfYearType" type="nav:DayOfMonthOfYearType"
minOccurs="0"/>
            <element name="DayOfWeekOfMonthOfYearType"
type="nav:DayOfMonthOfYearType" minOccurs="0"/>
        </choice>
    </complexType>
    <complexType name="TimeZoneType">
        <sequence>
            <element name="Code" type="long"/>
            <element name="MinutesFromGMT" type="short"/>
            <element name="Description">
                <simpleType>
                    <restriction base="string">
                        <length value="4"/>
                    </restriction>
                </simpleType>
            </element>
        </sequence>
    </complexType>
    <complexType name="AbsoluteDateType">
        <sequence>
            <element name="MonthOfYear" type="unsignedShort"/>
            <element name="DayOfMonth" type="unsignedShort"/>
            <element name="Year" type="unsignedShort"/>
        </sequence>
    </complexType>
    <complexType name="DayOfWeekOfMonthType">
        <sequence>
            <element name="DayOfWeek" type="nav:DayOfWeekEnum"/>
            <element name="WeekOfMonth" type="unsignedShort"/>
        </sequence>
    </complexType>
    <complexType name="DayOfWeekOfYearType">
        <sequence>
            <element name="DayOfWeek" type="nav:DayOfWeekEnum"/>
            <element name="WeekOfYear" type="unsignedShort"/>
        </sequence>
    </complexType>
    <complexType name="DayOfMonthOfYearType">
```

```
            <sequence>
                <element name="DayOfMonth" type="unsignedShort"/>
                <element name="MonthOfYear" type="unsignedShort"/>
            </sequence>
        </complexType>
        <complexType name="DayOfWeekOfMonthOfYearType">
            <sequence>
                <element name="DayOfWeek" type="nav:DayOfWeekEnum"/>
                <element name="WeekOfMonth" type="unsignedShort"/>
                <element name="MonthOfYear" type="unsignedShort"/>
            </sequence>
        </complexType>
        <complexType name="AbstractIDType">
            <annotation>
                <documentation>This is an entity's full ID. This type must provide a unique ID across
all databases accessible by a service during any open session.</documentation>
            </annotation>
            <sequence>
                <element name="ID" type="xsd:integer"/>
            </sequence>
        </complexType>
        <simpleType name="RouteMinimizeOptionEnum">
            <annotation>
                <documentation>This enumeration is used for route minimization
option.</documentation>
                <documentation>shortest road distance.</documentation>
                <documentation>shortest road travel time.</documentation>
            </annotation>
            <restriction base="xsd:string">
                <enumeration value="SHORTEST_DISTANCE"/>
                <enumeration value="SHORTEST_TIME"/>
            </restriction>
        </simpleType>
        <simpleType name="RouteHighwayUsageEnum">
            <annotation>
                <documentation>This enumeration is used for route minimization
option.</documentation>
                <documentation>shortest road distance.</documentation>
                <documentation>shortest road travel time.</documentation>
            </annotation>
            <restriction base="xsd:string">
                <enumeration value="PROHIBIT_HIGHWAYS"/>
                <enumeration value="AVOID_HIGHWAYS"/>
                <enumeration value="PREFER_HIGHWAYS"/>
                <enumeration value="NO_PREFERENCE"/>
            </restriction>
```

```xml
        </simpleType>
        <simpleType name="PriorityType">
            <annotation>
                <documentation>Priority of this request (as there may be other ones invoked at the same
time).</documentation>
            </annotation>
            <restriction base="unsignedShort">
                <minInclusive value="0"/>
                <maxExclusive value="256"/>
            </restriction>
        </simpleType>
        <simpleType name="RouteTollUsageEnum">
            <restriction base="xsd:string">
                <enumeration value="PROHIBIT_TOLLROADS"/>
                <enumeration value="AVOID_TOLLROADS"/>
                <enumeration value="NO_PREFERENCE"/>
            </restriction>
        </simpleType>
        <simpleType name="DateTimeEnum">
            <restriction base="xsd:string">
                <enumeration value="MAP_DAY_OF_WEEK"/>
                <enumeration value="MAP_ABSOLUTE_DATE"/>
                <enumeration value="MAP_DAY_OF_YEAR"/>
                <enumeration value="MAP_DAY_OF_MONTH"/>
                <enumeration value="MAP_DAY_OF_WEEK_OF_MONTH"/>
                <enumeration value="MAP_DAY_OF_WEEK_OF_YEAR"/>
                <enumeration value="MAP_WEEK_OF_MONTH"/>
                <enumeration value="MAP_WEEK_OF_YEAR"/>
                <enumeration value="MAP_MONTH_OF_YEAR"/>
                <enumeration value="MAP_DAY_OF_MONTH_OF_YEAR"/>
                <enumeration value="MAP_DAY_OF_WEEK_OF_MONTH_OF_YEAR"/>
            </restriction>
        </simpleType>
        <simpleType name="DayOfWeekEnum">
            <restriction base="xsd:string">
                <enumeration value="Monday = 0x1"/>
                <enumeration value="Tuesday = 0x2"/>
                <enumeration value="Wednesday = 0x4"/>
                <enumeration value="Thursday = 0x8"/>
                <enumeration value="Friday = 0x10"/>
                <enumeration value="Saturday = 0x20"/>
                <enumeration value="Sunday = 0x40"/>
            </restriction>
        </simpleType>
        <complexType name="VehicleType.N">
            <sequence>
```

```
            <element name="VehicleValue" type="nav:VehicleTypeValue"/>
            <element name="VehicleName" type="nav:VehicleTypeName" minOccurs="0"/>
        </sequence>
        <attribute name="Exclusionary" type="boolean" use="optional" default="false"/>
    </complexType>
    <simpleType name="VehicleTypeValue">
        <restriction base="xsd:integer">
            <enumeration value="0"/>
            <enumeration value="11"/>
            <enumeration value="12"/>
            <enumeration value="13"/>
            <enumeration value="14"/>
            <enumeration value="15"/>
            <enumeration value="16"/>
            <enumeration value="17"/>
            <enumeration value="18"/>
            <enumeration value="19"/>
            <enumeration value="20"/>
            <enumeration value="21"/>
            <enumeration value="22"/>
            <enumeration value="23"/>
            <enumeration value="24"/>
            <enumeration value="25"/>
            <enumeration value="26"/>
            <enumeration value="28"/>
            <enumeration value="29"/>
            <enumeration value="30"/>
            <enumeration value="31"/>
            <enumeration value="32"/>
            <enumeration value="33"/>
            <enumeration value="34"/>
            <enumeration value="35"/>
            <enumeration value="36"/>
            <enumeration value="37"/>
            <enumeration value="38"/>
            <enumeration value="39"/>
            <enumeration value="40"/>
            <enumeration value="90"/>
            <enumeration value="91"/>
            <enumeration value="92"/>
            <enumeration value="93"/>
            <enumeration value="94"/>
            <enumeration value="95"/>
            <enumeration value="96"/>
            <enumeration value="97"/>
            <enumeration value="98"/>
```

```
                    <enumeration value="99"/>
                </restriction>
            </simpleType>
            <simpleType name="VehicleTypeName">
                <restriction base="xsd:string">
                    <enumeration value="All Vehicles">
                        <annotation>
                            <documentation>0</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="Passenger Cars">
                        <annotation>
                            <documentation>11</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="Residential Vehicle">
                        <annotation>
                            <documentation>12</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="High Occupancy Vehicle">
                        <annotation>
                            <documentation>13</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="Car with Trailer">
                        <annotation>
                            <documentation>14</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="Emergency Vehicle">
                        <annotation>
                            <documentation>15</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="Taxi">
                        <annotation>
                            <documentation>16</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="Public Bus">
                        <annotation>
                            <documentation>17</documentation>
                        </annotation>
                    </enumeration>
                    <enumeration value="Private Bus">
```

```
            <annotation>
                <documentation>18</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Military vehicle">
            <annotation>
                <documentation>19</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Delivery Truck">
            <annotation>
                <documentation>20</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Transport Truck">
            <annotation>
                <documentation>21</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Motorcycle">
            <annotation>
                <documentation>22</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Moped">
            <annotation>
                <documentation>23</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Bicycle">
            <annotation>
                <documentation>24</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Pedestrian">
            <annotation>
                <documentation>25</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Farm Vehicle">
            <annotation>
                <documentation>26</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Vehicle with water polluting load">
            <annotation>
```

```
                <documentation>28</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Vehicle with explosive load">
            <annotation>
                <documentation>29</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Vehicle with other dangerous load'">
            <annotation>
                <documentation>30</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Trolley Bus">
            <annotation>
                <documentation>31</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Employee Vehicle">
            <annotation>
                <documentation>32</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Light Rail">
            <annotation>
                <documentation>33</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Facility Vehicle">
            <annotation>
                <documentation>34</documentation>
            </annotation>
        </enumeration>
        <enumeration value="School Bus">
            <annotation>
                <documentation>35</documentation>
            </annotation>
        </enumeration>
        <enumeration value="4 Wheel Drive Vehicle">
            <annotation>
                <documentation>36</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Vehicle carrying snow chains">
            <annotation>
                <documentation>37</documentation>
```

```
            </annotation>
        </enumeration>
        <enumeration value="Mail Vehicle">
            <annotation>
                <documentation>38</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Tanker">
            <annotation>
                <documentation>39</documentation>
            </annotation>
        </enumeration>
        <enumeration value="Vehicle for disabled persons">
            <annotation>
                <documentation>40</documentation>
            </annotation>
        </enumeration>
        <enumeration value="User defined 00">
            <annotation>
                <documentation>90</documentation>
            </annotation>
        </enumeration>
        <enumeration value="User defined 01">
            <annotation>
                <documentation>91</documentation>
            </annotation>
        </enumeration>
        <enumeration value="User defined 02">
            <annotation>
                <documentation>92</documentation>
            </annotation>
        </enumeration>
        <enumeration value="User defined 03">
            <annotation>
                <documentation>93</documentation>
            </annotation>
        </enumeration>
        <enumeration value="User defined 04">
            <annotation>
                <documentation>94</documentation>
            </annotation>
        </enumeration>
        <enumeration value="User defined 05">
            <annotation>
                <documentation>95</documentation>
            </annotation>
```

```
            </enumeration>
            <enumeration value="User defined 06">
                <annotation>
                    <documentation>96</documentation>
                </annotation>
            </enumeration>
            <enumeration value="User defined 07">
                <annotation>
                    <documentation>97</documentation>
                </annotation>
            </enumeration>
            <enumeration value="User defined 08">
                <annotation>
                    <documentation>98</documentation>
                </annotation>
            </enumeration>
            <enumeration value="User defined 09">
                <annotation>
                    <documentation>99</documentation>
                </annotation>
            </enumeration>
        </restriction>
    </simpleType>
    <simpleType name="FractionType">
        <restriction base="xsd:decimal">
            <maxInclusive value="1.0"/>
            <minInclusive value="0.0"/>
        </restriction>
    </simpleType>
</schema>
```