

Title: A7.6-D3 Profiles for risk management

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This document contains a revised version of the HS-ERiskA common data model. In addition, it looks at the wider context and takes into consideration the application domain the Scenario belongs to, i.e. the more general risk management domain, describing relevant information items and existing data models.

Keywords:

profiles, risk management, ERiskA, data model

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1 Introduction

The purpose of the previous version of this document (A7.6-D2) was to stay close to the use cases defined in the ERiskA Scenario. In the A7.6-D2 document, datasets needed for the ERiskA use cases as well as the harmonisation issues arising from those were described and a first ERiskA common data model was drafted. This final version, A7.6-D3, contains a revised version of the ERiskA common data model. In addition, it looks at the wider context and takes into consideration the application domain the Scenario belongs to, i.e. the more general risk management domain.

The European Risk Atlas (ERiskA) Scenario aims at developing a cross-border disaster management application case for the Lake Constance Region which includes Swiss, Austrian and German territories. This application can be used as an add-on to existing emergency operation systems at command and control (C&C) centres dealing with the different steps in the disaster management cycle (e.g. prevention, preparedness, response) in the case of floods. ERiskA will facilitate cross-border cooperation between the agencies responsible for disaster management in the Lake Constance Region by easing the exchange of information on potentially flooded areas and inundation of infrastructure like roads and railways. For this purpose a number of interoperability and data harmonisation issues are addressed within the Scenario. The use cases and functionality are described in detail in the documents A7.6-D2, A9.6-D1 and D9.6-D2.

2 Scope of the Profile

2.1 The ERiskA Scenario Common Data Model

The ERiskA common data model (see figures 1 to 7) was designed based on

- a) the limited scope of the ERiskA use cases
- b) the requirements concerning the ERiskA demonstrator's functionality,
- c) the available datasets and
- d) the relevant INSPIRE Data Specifications.

Thus it does not cover the whole application domain of risk management.

The ERiskA use cases focus on creating a harmonised information base concerning infrastructure like roads, railways and hydrographic features like watercourses in the Lake Constance region as well as providing access to current water level measurements and pre-calculated flood extent features.

The main use case "Information Exchange" can be summarized as follows:

- Information on potentially flooded areas and resulting inundation of infrastructure like roads and railways has to be exchanged between employees of the C&C centre and end users of other agencies or the public in different parts of the cross border Lake Constance Region (in case of actual flood event or in simulation / preparedness exercise).
- The end user requests information if roads or railways in his area of interest are still passable, already flooded or probably flooded soon.
- The C&C centre employee selects the gauges relevant for the area of interest and accesses information on the current water level at these gauges. Based on this information, a

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corresponding flooded area extend feature is chosen and overlaid or spatially intersected it with the road and / or railway features (for each gauge, pre-calculated potentially flooded area extends for different water levels are stored.

Feature types of the following INSPIRE Data Specifications have been re-used in the ERiskA data model (by importing the respective packages of the INSPIRE data model):

- Hydrography (V 3.0): HydroObject, SurfaceWater, Watercourse and StandingWater from the Hydro - Physical Waters package; IndundatedLand (candidate type for Annex III Natural Risk Zones)
- Transport Networks (V 3.0): TransportLink, RailwayLink, RoadLink, FormOfWay, FunctionalRoadClass, RoadSurfaceCategory, RoadName, NumberOfLanes, RoadWith, VerticalPosition, ConditionOfFacility, OwnerAuthority, MaintenanceAuthority, NumberOfTracks, RailwayType, RailwayElectrification, RailwayUse
- Geographical Names (V 3.0): data type GeographicalName

The process of creating the data model is described in Fichtinger et al. [2010].

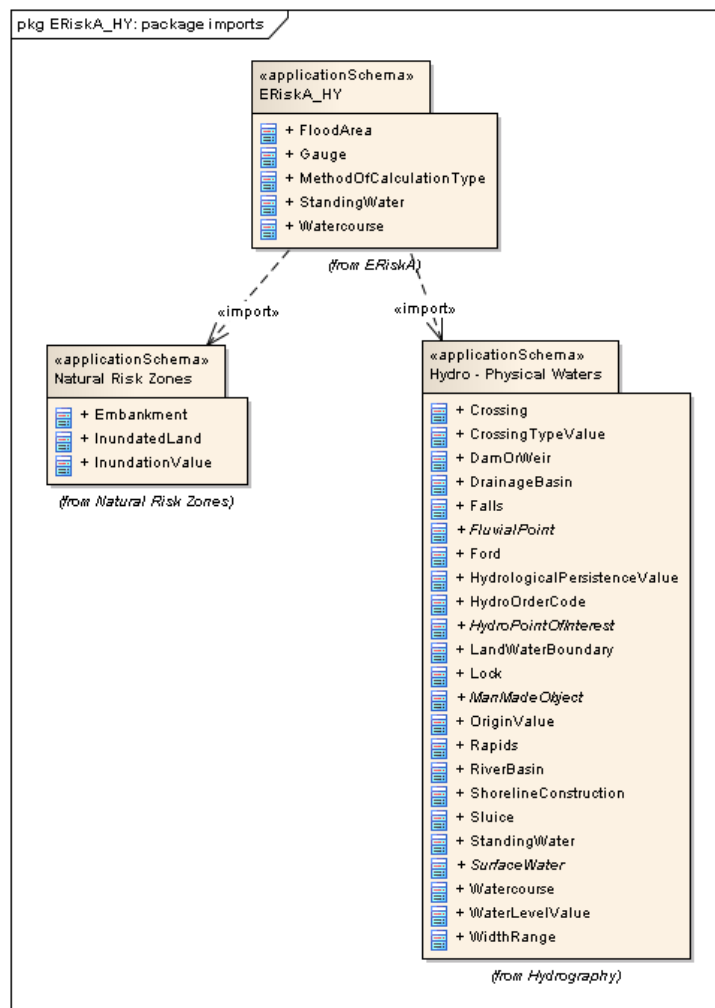


Figure 1: ERiskA data model "Hydrography" package imports

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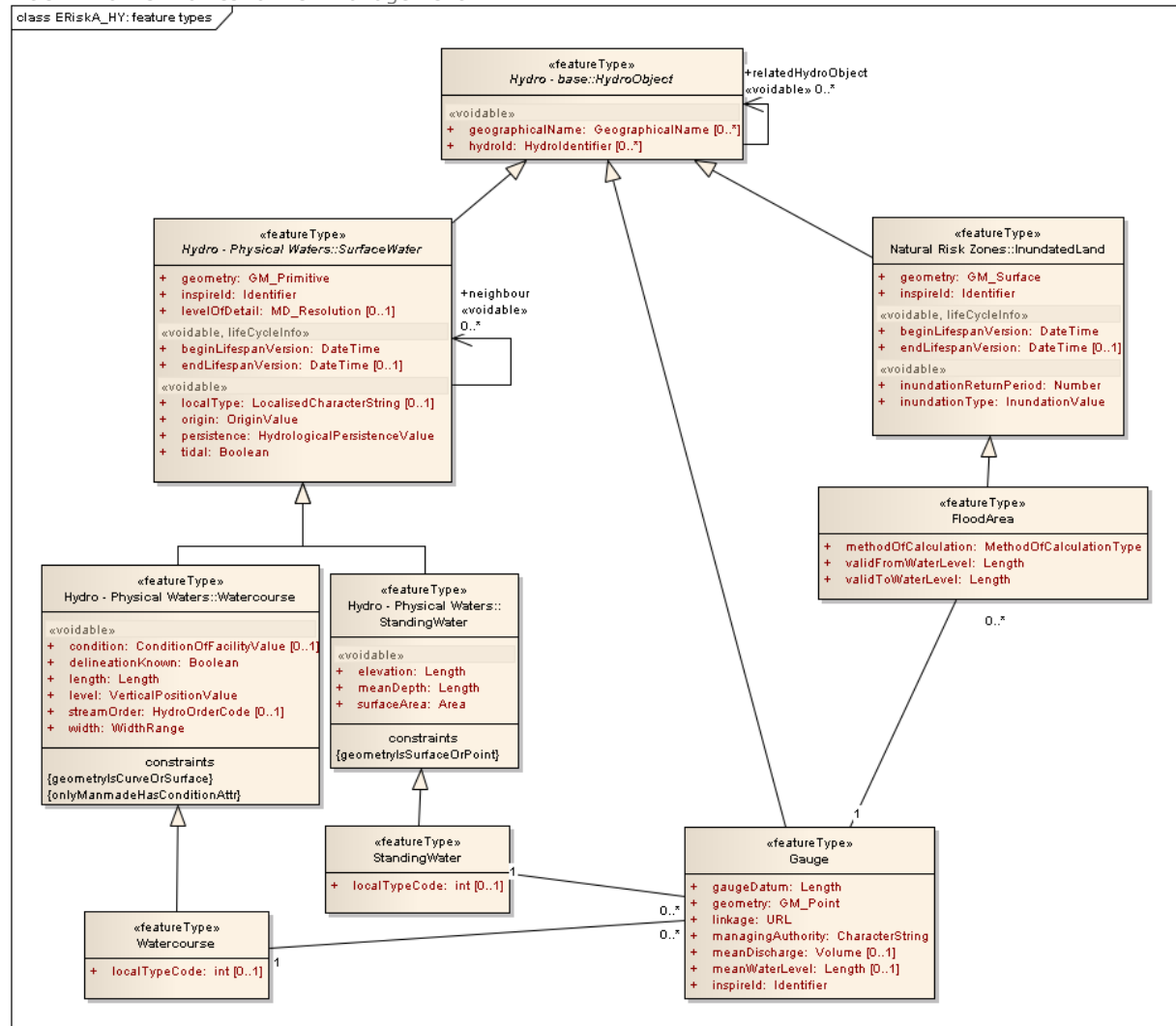


Figure 2: ERiskA data model "Hydrography" package feature types

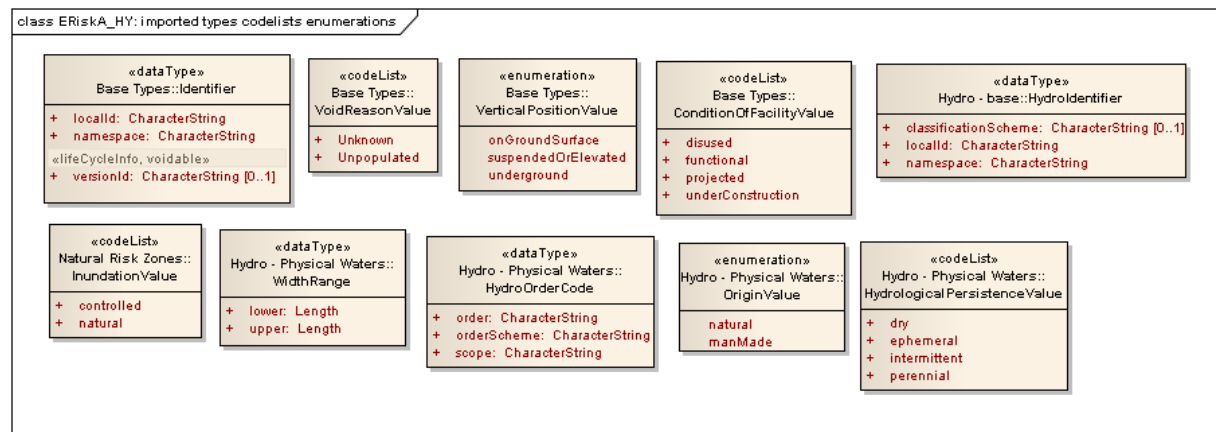


Figure 3: ERiskA data model "Hydrography" package data types, enumerations and code lists

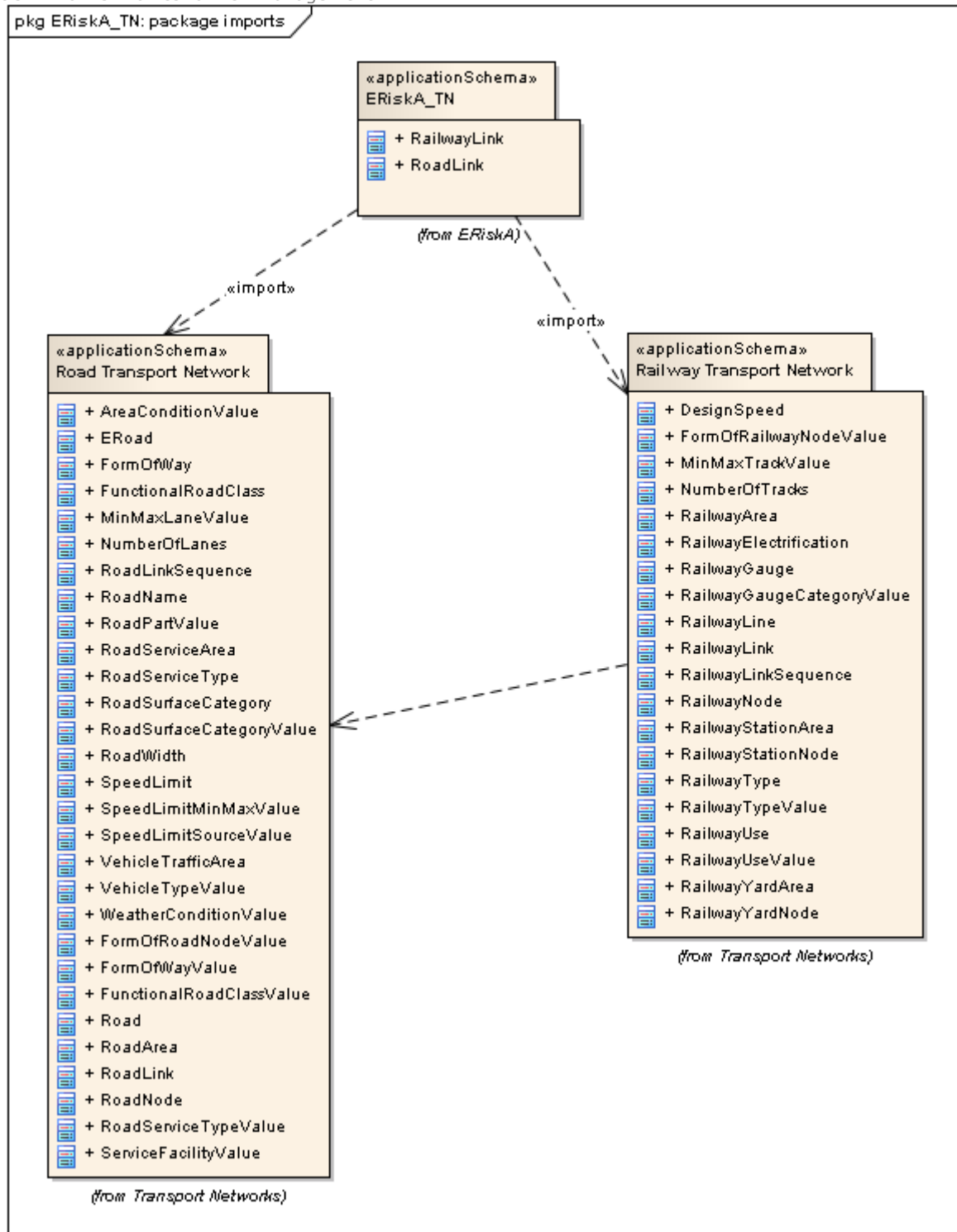


Figure 4: ERiskA data model "Hydrography" package imports

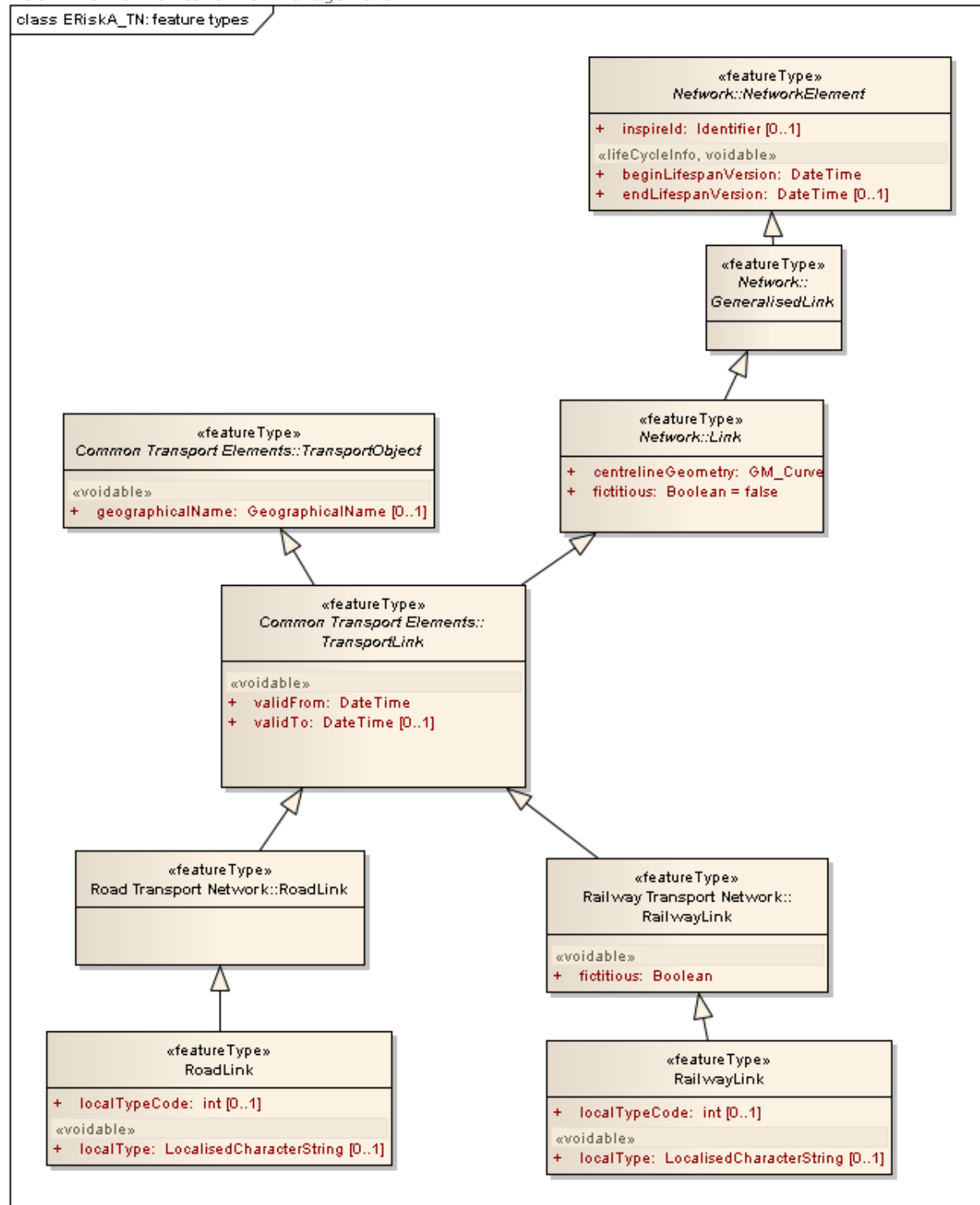


Figure 5: ERiskA data model "Hydrography" package feature types

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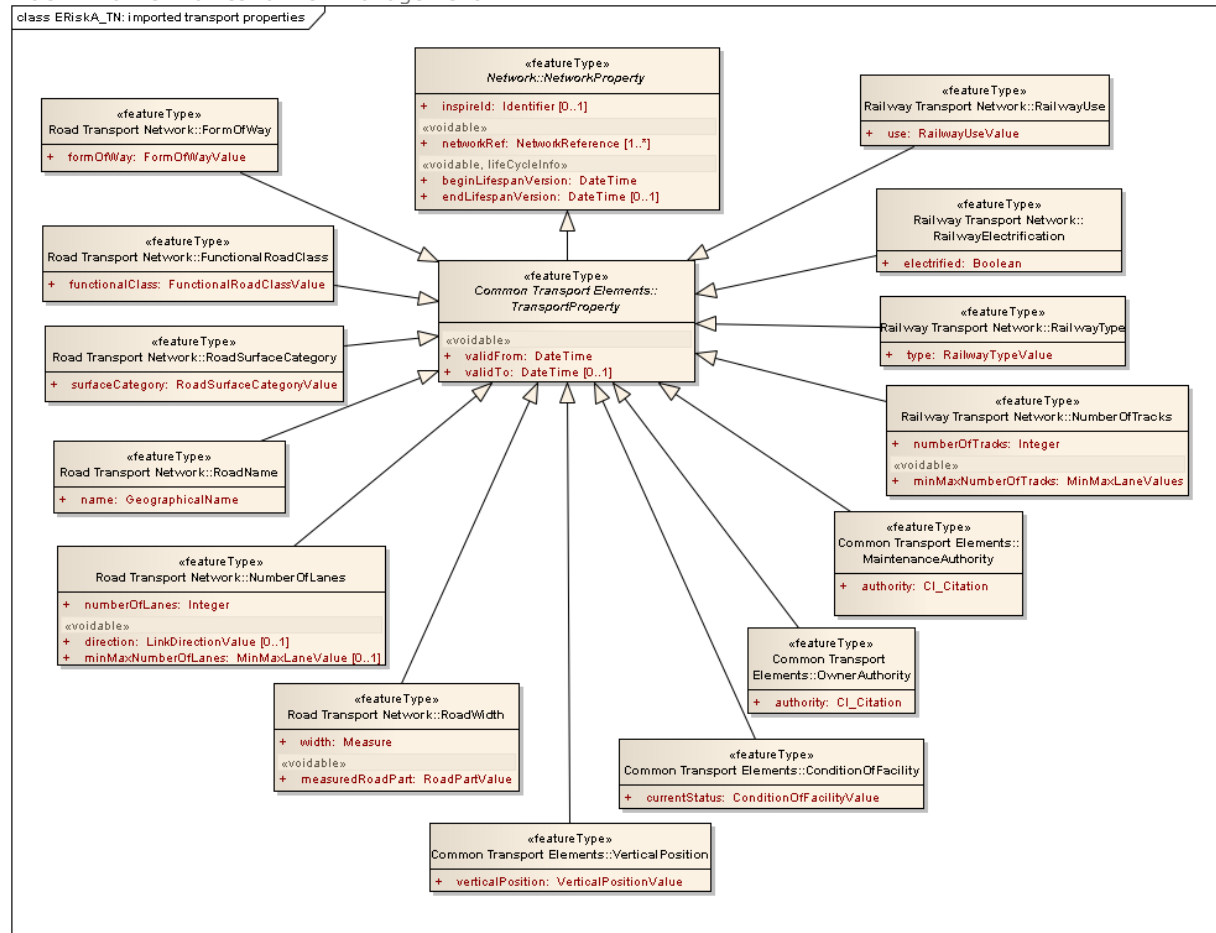


Figure 6: ERiskA data model “Hydrography” package imported transport properties

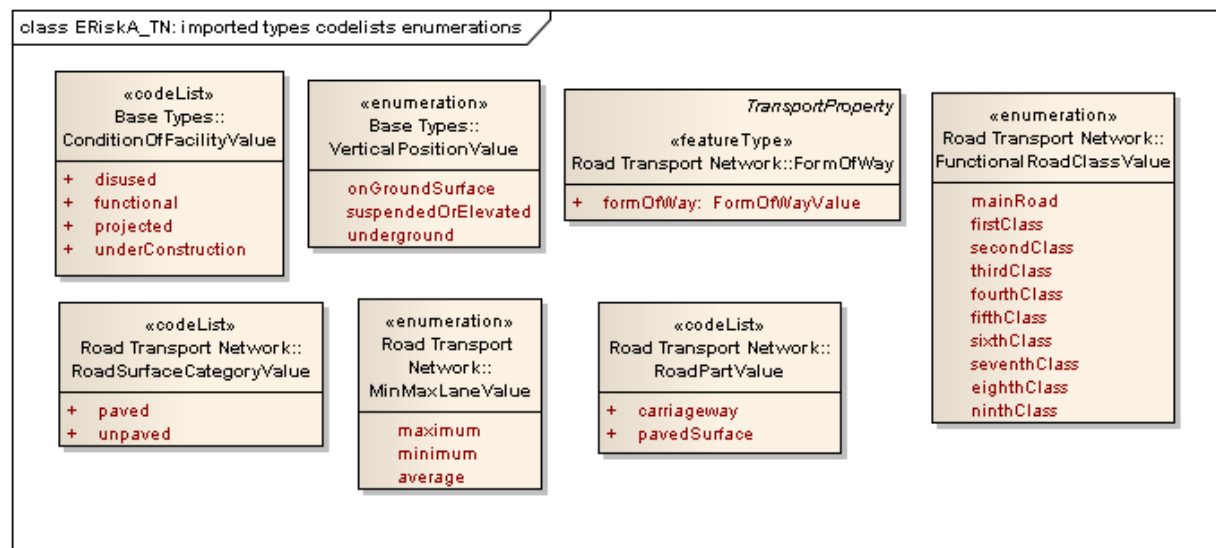


Figure 7: ERiskA data model “Hydrography” package data types, enumerations and code lists

2.2 The Wider Application Domain Risk Management

The ERiskA data model can be extended to cover the wider scope of risk management related applications.

Key concepts and definitions in the risk management domain are [UNISDR 2009]:

Hazard: “A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.”

Vulnerability: “The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.”

Risk: “The combination of the probability of an event and its negative consequences.”

Risk management: “The systematic approach and practice of managing uncertainty to minimize potential harm and loss.”

Disaster: “A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.”

Emergency management (often also referred to as "disaster management"): “The organization and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps.”

The disaster management cycle distinguishes different phases in a disaster management process (see Figure 8).

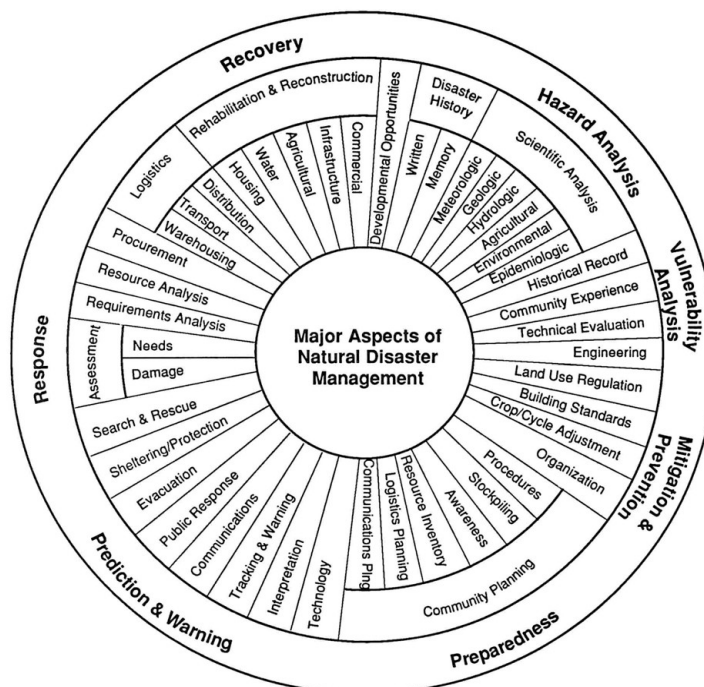
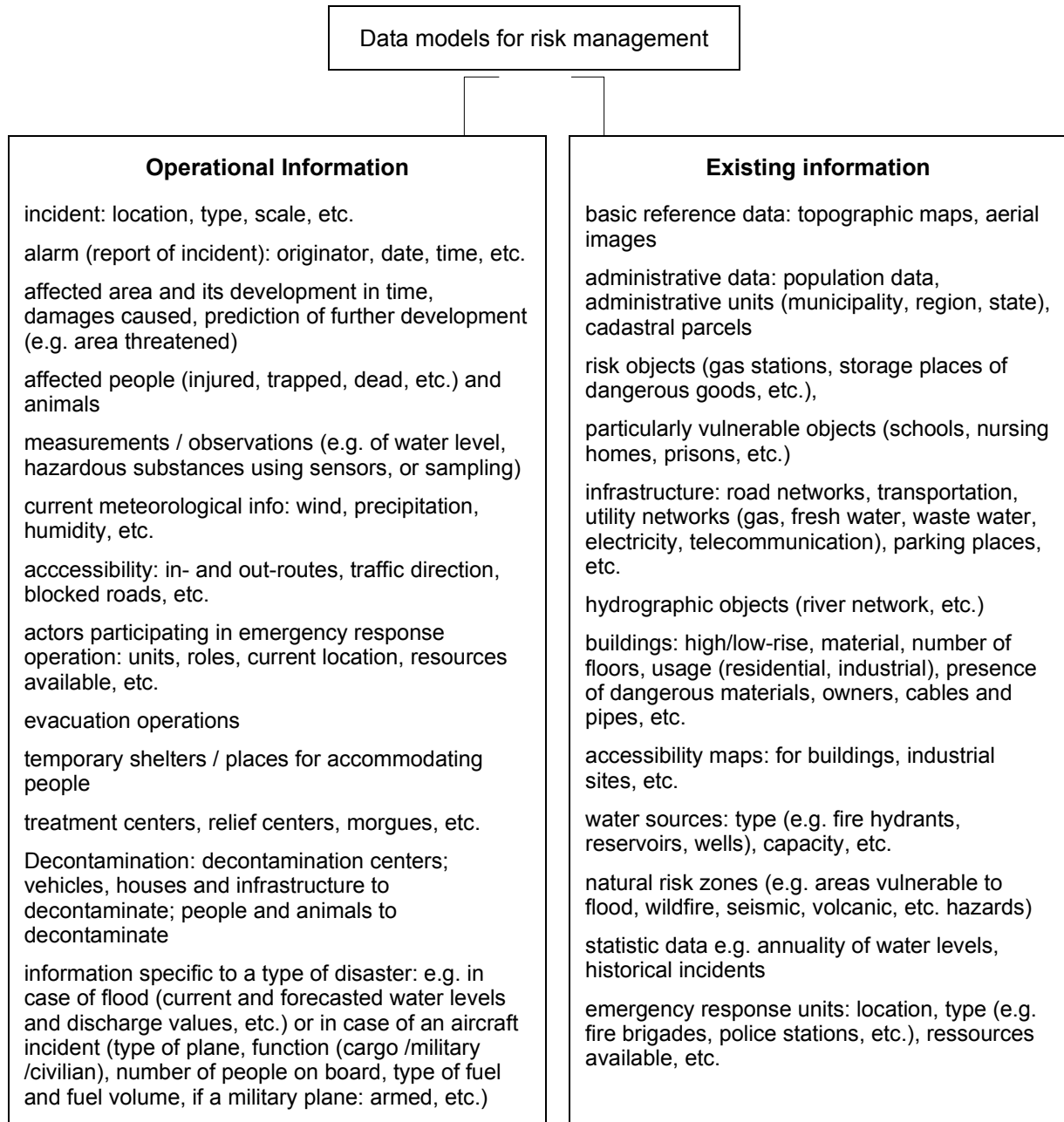


Figure 8: The Disaster Management Cycle [UW-DMC 1991]

Dilo and Zlatanova [2008] have proposed a list of information items needed for disaster management (see Figure 9). They distinguish two clusters of information:

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- a) "existing information": static information, existing prior to the disaster (e.g. information on infrastructure or river networks, etc.)
- b) "operational information": information collected during the disaster (e.g. type and location of a disaster incident, affected areas, evacuation operations, etc.) which is also in part dynamic



*Figure 9: Information items needed for disaster management
[based on Dilo and Zlatanova 2008, extended]*

Disasters can be caused by a variety of natural or man-made hazards. Burton et al. [1978] define natural hazards as "those elements of the physical environment, harmful to man and caused by forces extraneous to him." Natural hazards can be classified e.g. by physical processes (see Figure 10) or based on characteristics and impact (see Figure 11).

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Category of hazard	Types of event
Meteorological	Tropical cyclones/hurricanes Thunderstorms Tornadoes Lightning Hailstorms Windstorms Ice storms Snowstorms Blizzards Cold waves Heat waves Avalanches Fog Frost
Geological	Earthquakes Volcanoes Tsunami Landslides Subsidence Mudflows Sinkholes
Hydrological	Floods Droughts Wildfire
Extraterrestrial	Meteorites

Figure 10: Classification of natural hazards by physical process [Tobin 1997]

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Table 1.4 Ranking of hazard characteristics and impact.

		1 – largest or most significant 5 – smallest or least significant								
Rank	Event	Degree of severity	Length of event	Total areal extent	Total loss of life	Total economic loss	Social effect	Long term impact	Suddenness	Number of associated hazards
1	Drought	1	1	1	1	1	1	1	4	3
2	Tropical cyclone	1	2	2	2	2	2	1	5	1
3	Regional flood	2	2	2	1	1	1	2	4	3
4	Earthquake	1	5	1	2	1	1	2	3	3
5	Volcano	1	4	4	2	2	2	1	3	1
6	Extra-tropical storm	1	3	2	2	2	2	2	5	3
7	Tsunami	2	4	1	2	2	2	3	4	5
8	Bushfire	3	3	3	3	3	3	3	2	5
9	Expansive soils	5	1	1	5	4	5	3	1	5
10	Sea-level rise	5	1	1	5	3	5	1	5	4
11	Icebergs	4	1	1	4	4	5	5	2	5
12	Dust storm	3	3	2	5	4	5	4	1	5
13	Landslides	4	2	2	4	4	4	5	2	5
14	Beach erosion	5	2	2	5	4	4	4	2	5
15	Debris avalanches	2	5	5	3	4	3	5	1	5
16	Creep & solifluction	5	1	2	5	4	5	4	2	5
17	Tornado	2	5	3	4	4	4	5	2	5
18	Snowstorm	4	3	3	5	4	4	5	2	4
19	Ice at shore	5	4	1	5	4	5	4	1	5
20	Flash flood	3	5	4	4	4	4	5	1	5
21	Thunderstorm	4	5	2	4	4	5	5	2	4
22	Lightning strike	4	5	2	4	4	5	5	1	5
23	Blizzard	4	3	4	4	4	5	5	1	5
24	Ocean waves	4	4	2	4	4	5	5	3	5
25	Hail storm	4	5	4	5	3	5	5	1	5
26	Freezing rain	4	4	5	5	4	4	5	1	5
27	Localized strong wind	5	4	3	5	5	5	5	1	5
28	Subsidence	4	3	5	5	4	4	5	3	5
29	Mud & debris flows	4	4	5	4	4	5	5	4	5
30	Air supported flows	4	5	5	4	5	5	5	2	5
31	Rockfalls	5	5	5	5	5	5	5	1	5

Figure 11: Classification of natural hazards based on characteristics and impact [Bryant 2006]

3 Relevant data models and specifications

3.1 INSPIRE Data Specifications

As described in chapter 2.1, feature types of the following data specifications have been re-used for the ERiskA data model:

- Hydrography [INSPIRE Thematic Working Group Geographical Names 2009]
- Transport Networks [INSPIRE Thematic Working Group Transport Networks 2009]
- Geographical Names [INSPIRE Thematic Working Group Geographical Names 2009]

In addition to that, the following INSPIRE Data Specifications could be relevant for the wider application domain risk management:

- Annex I data themes
 - Administrative units
 - Addresses
 - Cadastral parcels
 - Protected sites
- Annex II data themes
 - Elevation
 - Land cover
 - Orthoimagery
 - Geographical location of buildings.
- Annex III data themes
 - Soil (e.g. water storage capacity)
 - Land use
 - Utility and governmental services (e.g. sewage, waste management, energy and water supply, civil protection sites)
 - Population distribution — demography
 - Area management/restriction/regulation zones and reporting units

3.2 RISE Conceptual Schema

The RISE (Reference Information Specifications for Europe) project addressed data harmonisation aspects with a focus on hydrography, land-cover and elevation data themes. Based on a methodology and guidelines on use case and schema development [RISE 2007b] devised in the project, a data model was designed (see Figure 12). The data model is based on a use case dealing with the collection and harmonisation of source data for input to the "Diffuse Nutrient Leakage" model with a view of reporting to the Water Framework Directive (WFD). Concerning hydrography-related features, RISE could build on guidelines and data models developed by the GIS Working Group of the Water Framework Directive. [RISE 2007a]. The specification work for INSPIRE has taken up results of the RISE project.

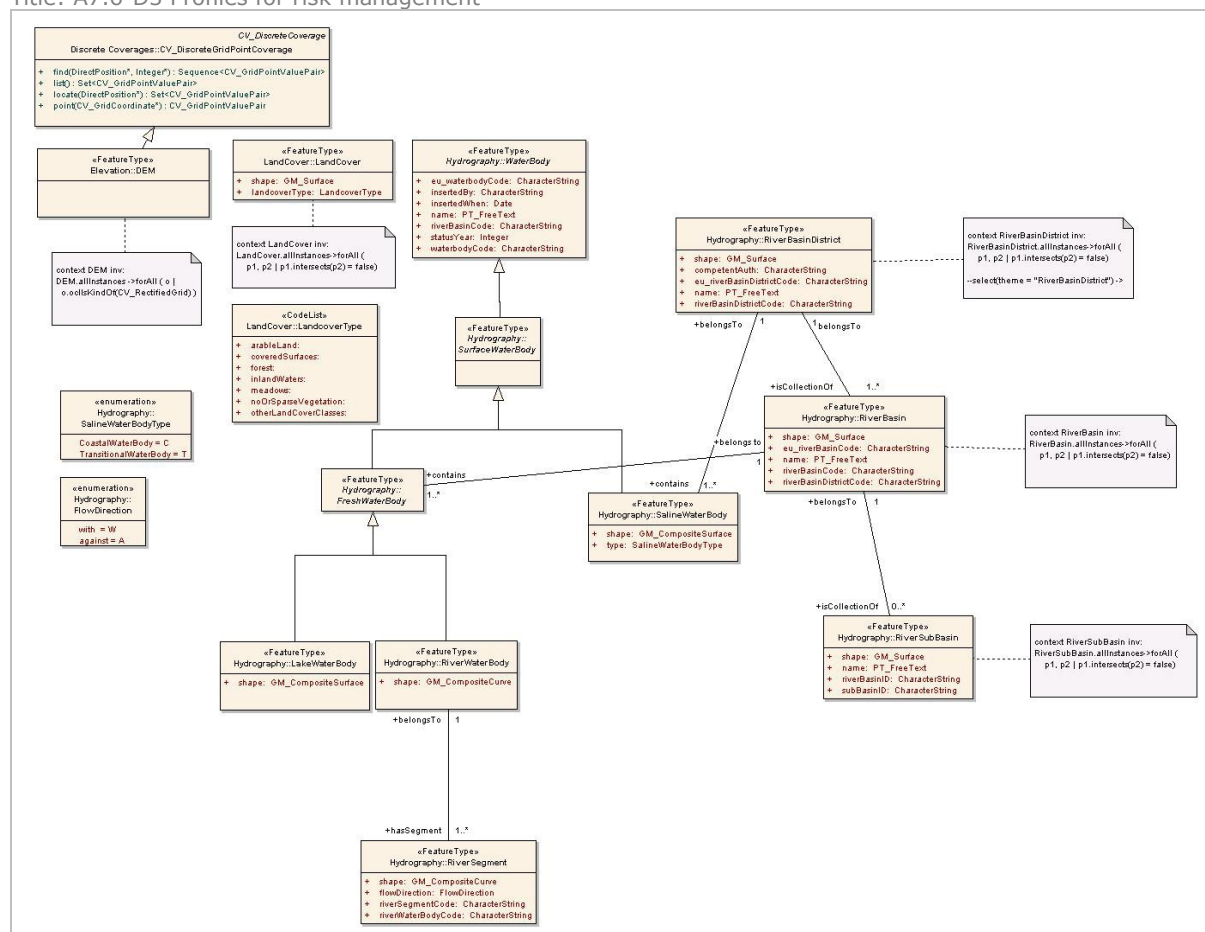


Figure 12: RISE UML model [RISE 2007a]

3.3 Water Framework Directive Specifications

In the course of the “Council Directive establishing a framework for Community action in the field of water policy”, commonly referred to as Water Framework Directive (WFD) and the Water Information System for Europe (WISE), a system and a data model have been specified for reporting purposes under the Directive. These are described in detail in the document A7.3-D3 Profiles for transboundary catchments. Parts of the WFS data model have also been incorporated into the INSPIRE Data Specification on Hydrography data model’s “Hydro Reporting” package.

3.4 WaterML

WaterML is an XML schema which defines web service messages used in the hydrological field by the CUAHSI (Consortium of Universities for the Advancement of Hydrologic Science, Inc.) community. CUAHSI web services facilitate the retrieval of information on hydrologic observations from web services using the SOAP protocol. CUAHSI WaterML defines the format of messages returned by the CUAHSI WaterOneFlow web services.

Thematically, WaterML was developed for describing and accessing water information from point observation sites. In parallel, CUAHSI was also developing a second model for hydrologic observations, called the Observations Data Model (ODM). WaterML and ODM are not equal. WaterML goes one step further than ODM and provides additional possibilities to retrieve the data and for the

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retrieval process itself. In this context, it provides on-the-fly translation of spatial and temporal characteristics, and includes SOAP messaging elements. Furthermore, ODM is defined for point-location-based observations, while WaterML covers also other spatial feature types.

The conceptual identification of hydrologic observations is described in CUAHSI [2009] by the following characteristics:

- “The location at which the observations are made (space);
- The variable that is observed, such as streamflow, water surface elevation, water quality concentration (variable);
- The date and time at which the observations are made (time).”

WaterML provides elements for these three characteristics:

- sites and datasets for spatial characteristics,
- variables to express the variable characteristic,
- lists of datetime-value pairs for representing the temporal dimension of observations.

A fusion of WaterML into O&M in the form of a formal profile of O&M is currently ongoing in the work towards WaterML 2.0. In the former version of WaterML, the flexibility inherent in the SWE standards was regarded as being a barrier to adoption when the target audience is not computer scientists. Also location descriptions adopted in the initial version of WaterML did not follow OGC’s GML specification [CUAHSI 2009].

3.5 OGC SensorML and Observations & Measurements

The OGC Observation and Measurements (O&M) specification [OGC 2007a, 2007b, 2007e and Geostandard Wiki] is part of the OGC’s Sensor Web Enablement (SWE) activity. It provides a generic model for representing and exchanging observation and measurements results. O&M defines an observation as “...an act of observing a property or phenomenon, with the goal of producing an estimate of the value of the property”, and a measurement as “... an observation whose result is a measure” [OGC 2007a]. The observation is modelled as a Feature within the context of the General Feature Model.

O&M aims at defining terms used for observations and measurements as well as the relationships between them, to improve the ability to discover, encode and use real-time and archived digital data produced by any measuring system.

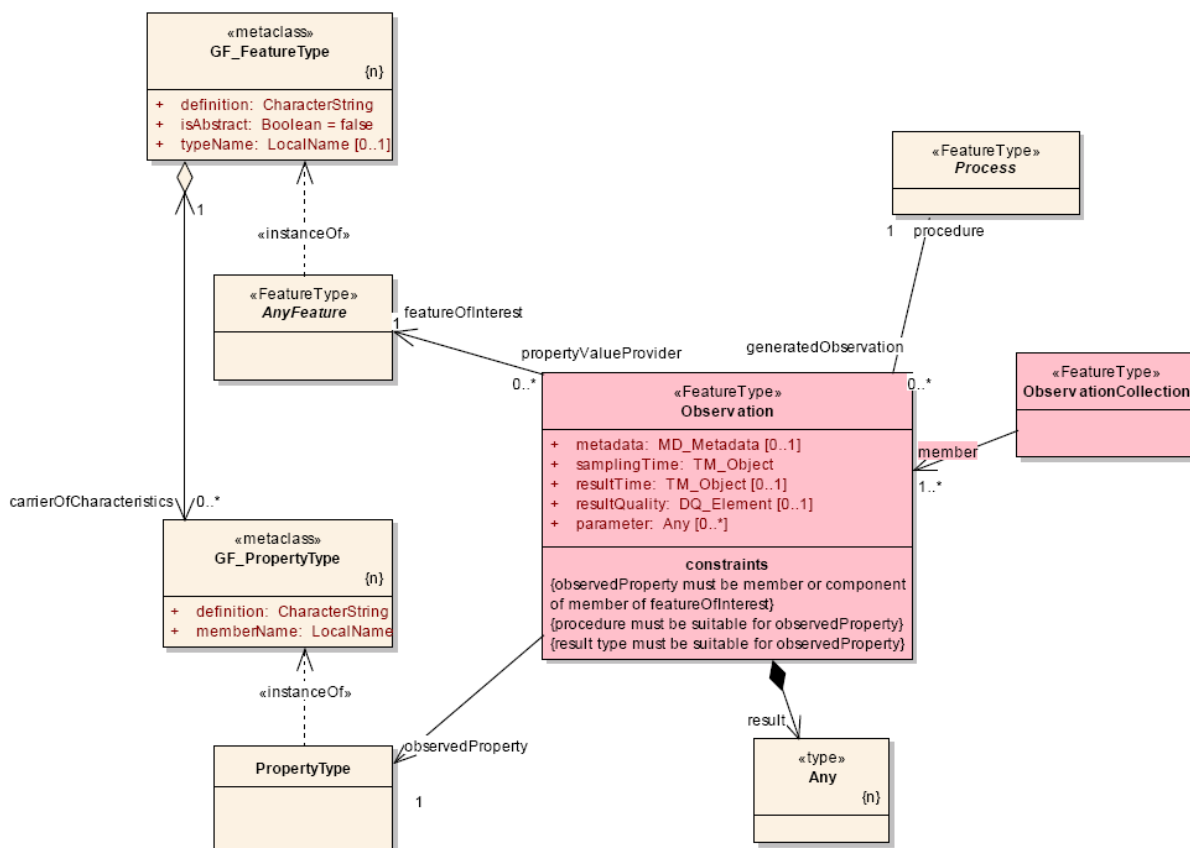


Figure 13: OGC Observations & Measurements: the basic Observation type [OGC 2007a]

The basic observation type in Figure 13 shows, that O&M is not only capable of describing the time and value (enclosed in a result) of a measurement. The observation as a feature, references a result to a feature of interest. The feature of interest specifies the identifiable object upon which the observation was made. The observed property is a property of the feature of interest. The observation uses a procedure, which is often an instrument, a sensor etc. to determine the result value. The result in O&M is an approximation of an attribute of the observed feature of interest and contains the value generated by the procedure. The type of the observation result must be consistent with the observed property. The generic Observation class does not have an associated location property. Location information should be provided by the feature of interest, or by the observation procedure. The reason why to use the pattern from Figure 13 is that the observation act is separated from the procedure, so it can be used for other observations, and from the feature-of-interest, which can have many more properties.

In contrast to O&M, which provides a user-centric view, SensorML [OGC 2007d and 2007c], as part of the OGC Sensor Web Enablement group of standards, provides a provider-centric view of information in a sensor web. SensorML provides standard models and an XML encoding for describing all kinds of sensors (dynamic/stationary platforms and in-situ/remote sensors), the sensor processes and for deriving higher-level information from observations and measurements. The processes encoded in SensorML are discoverable and executable. A process description, adapted from system theory, contains the inputs, outputs, parameters, and method, as well as relevant metadata. The sensors in SensorML are regarded as processes that convert real phenomena to data.

The OGC SensorML specification defines the purposes of SensorML as [OGC 2007d]:

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- Provide descriptions of sensors and sensor systems for inventory management
- Provide sensor and process information in support of resource and observation discovery
- Support the processing and analysis of the sensor observations
- Support the geolocation of observed values (measured data)
- Provide performance characteristics (e.g., accuracy, threshold, etc.)
- Provide an explicit description of the process by which an observation was obtained (i.e., it's lineage)
- Provide an executable process chain for deriving new data products on demand (i.e., derivable observation)
- Archive fundamental properties and assumptions regarding sensor systems

3.6 ESRI ArcHydro Data Model

Arc Hydro is a geospatial and temporal generic data model for water resources operating within ArcGIS. Hydrologic simulation can be accomplished by exchanging data between Arc Hydro and an independent hydrologic model. The basic version of Arc Hydro is called the Arc Hydro framework (see Figure 14), where classes and attributes can be added as required by object-orientated extension possibilities (e.g. for Flood Plain Mapping, see Figure 15) [cf. CRWR 2000]. Arc Hydro describes natural water systems, not man made water pipe systems such as water supply or waste water collection. It facilitates a synthesis of geospatial and temporal data. This is needed for supporting hydrologic analysis, modeling and decision making. ArcHydro links time series data on water measurements to geospatial data on the locations where measurements are made. But in general, any type of time series data can be linked to any geospatial feature in Arc Hydro, so it is possible to construct within ArcGIS time-sequenced maps of e.g. rainfall and the water conditions of the landscape. ArcHydro is linked with appropriate tools for ArcGIS working with the data structure [Maidment 2002].

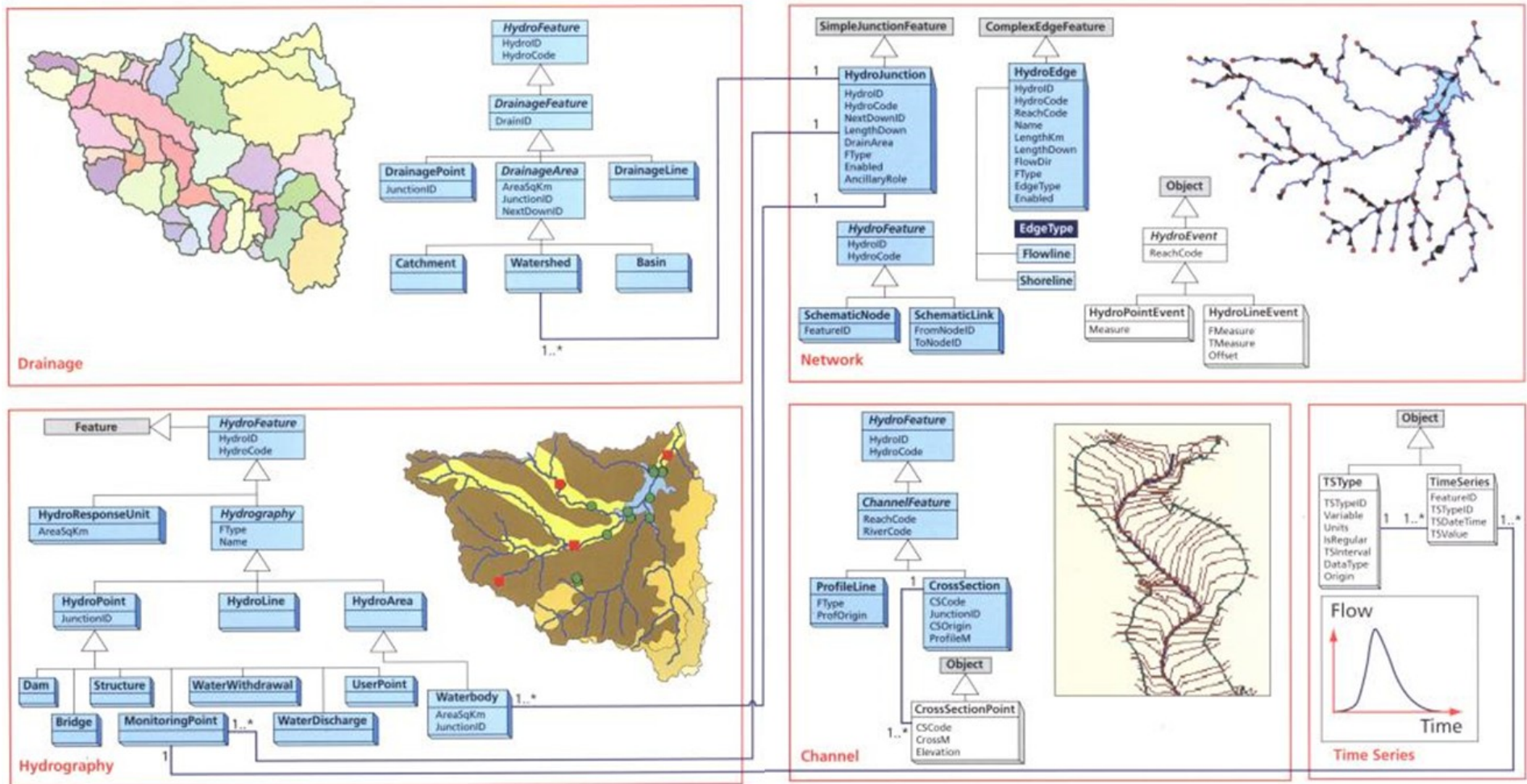


Figure 14: Arc Hydro Data Model [Maidment 2002]

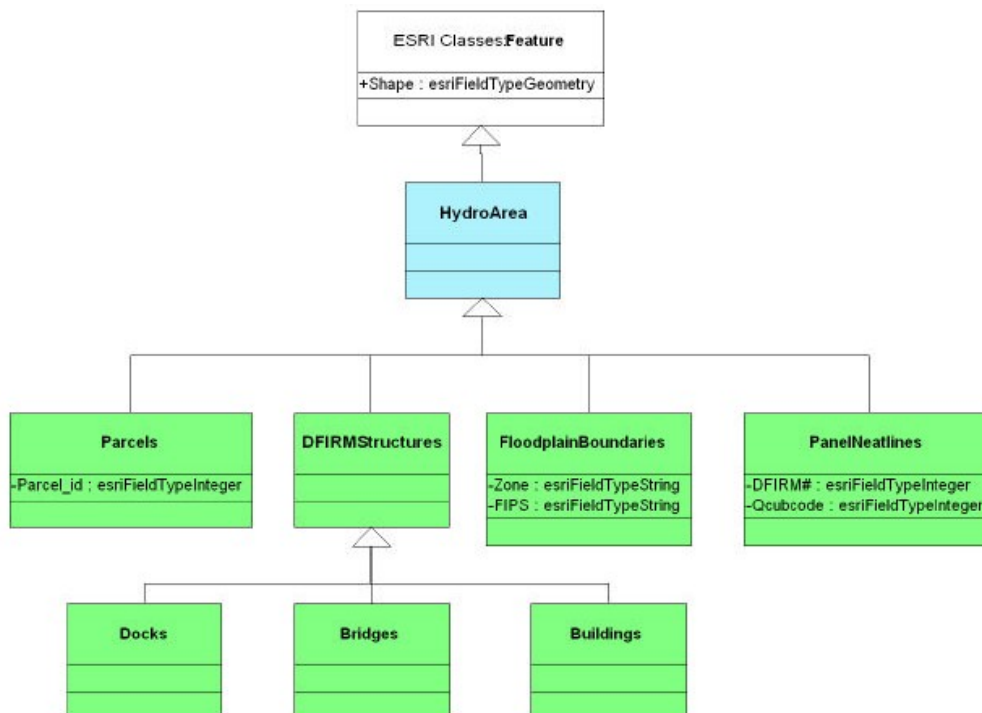


Figure 15: Detail of Arc Hydro Data Model Extension for Flood Plain Mapping [CRWR 2000]

3.7 Department of Homeland Security Geospatial Data Model

The Department of Homeland Security (DHS) Geospatial Data Model (DHM) was developed by the DHS Geospatial Management Office (GMO) to support operations at the DHS as well as interoperability and information sharing between organisations in the homeland security and disaster management community. It incorporates existing Federal and industry standards and practices like the fire/hazmat data model, the Homeland Security Infrastructure Protection (HSIP) model, FEMA Multihazard Model or the National Incident Management System (NIMS) model [FGDC 2009a].

The data model contains three main thematic packages:

- “Feature Base”: contains feature types describing e.g. cadastral parcels, administrative units, hydrography, transportation and other infrastructure
- “Security Sectors”: contains features describing e.g. the different sectors relevant to homeland security like energy, telecommunications, healthcare, water supply as well as different emergency service types
- “Security Operations”: contains emergency-management-related features describing e.g. types of disasters, hazards or incidents as well as emergency management operations.

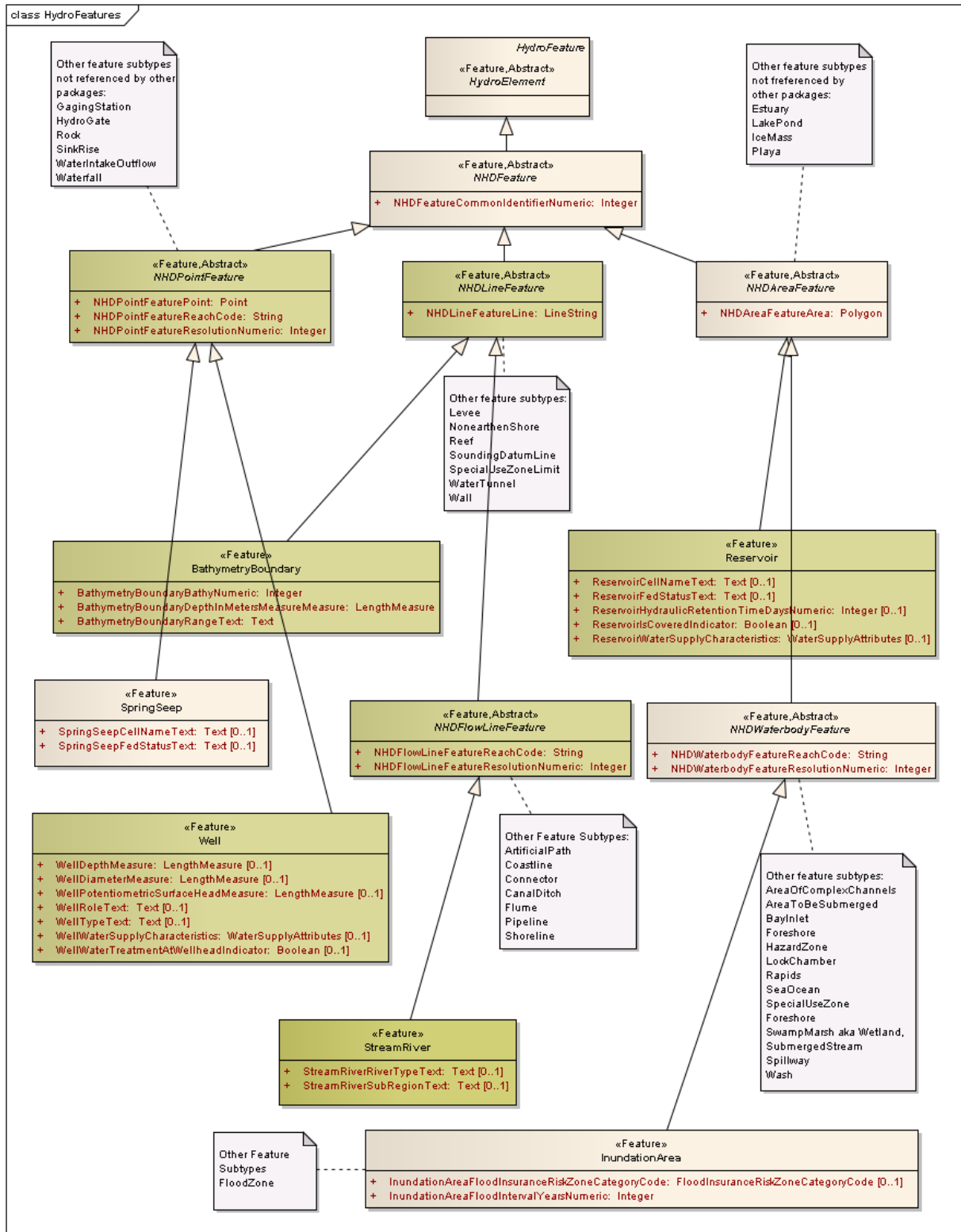


Figure 16: DHS Geospatial Data Model "Hydro Features" package [FGDC 2009b]

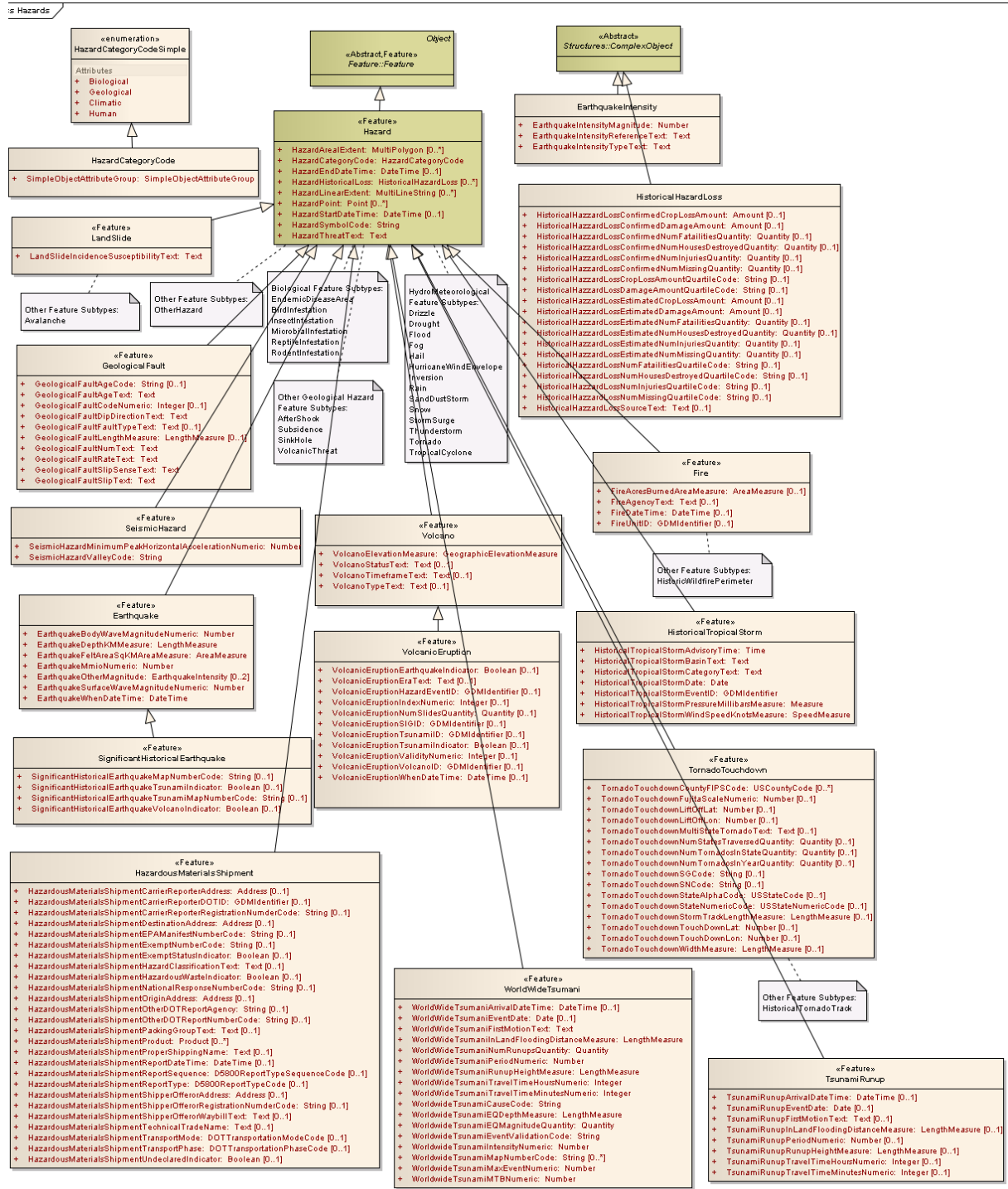


Figure 17: DHS Geospatial Data Model "Hazards" package [FGDC 2009b]

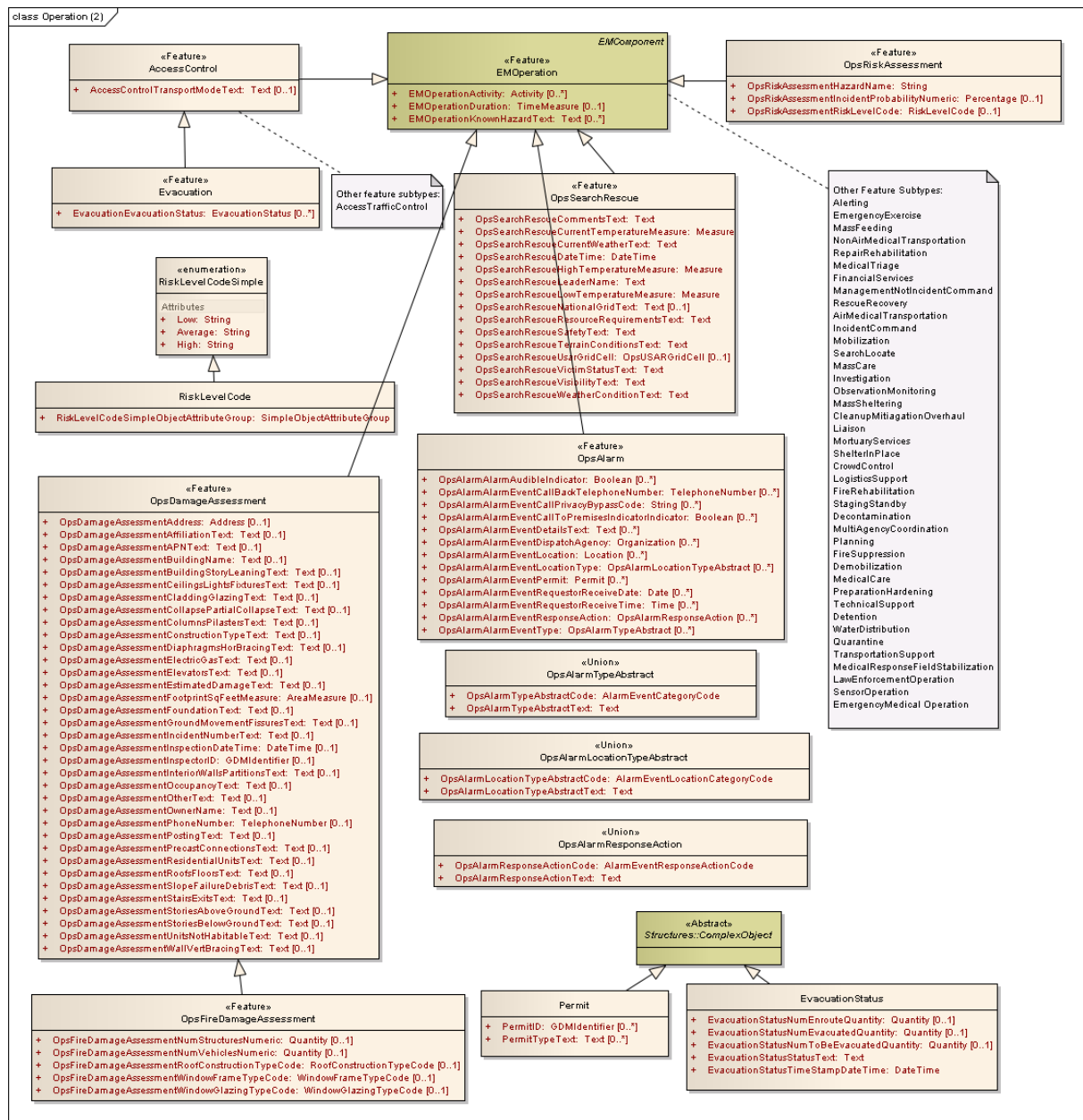


Figure 18: DHS Geospatial Data Model “Operations (2)” package [FGDC 2009b]

3.8 Data Model for Disaster Management in the Netherlands

Dilo and Zlatanova [2008] have designed a spatiotemporal data model for data collected during emergency response (“operational data”, see chapter 2.2). The data model (see Figure 19) is based on the disaster management process in the Netherlands with a focus on information requirements of fire brigades and police forces.

The use case is described as follows: “When a disaster incident happens, departments from emergency response sector get involved in order to manage the incident. Usually complaints are coming to the commando center, which report about the incident. Based on the type of the incident,

several processes are activated, each process being responsibility of one or more departments, dependent on the scale of the incident. Several people get involved in these processes having specific roles. Also, several teams are formed in order to perform specific tasks. When the incident involves release of dangerous substances, a template named sectoral is used to sketch the zone affected by gas distribution. Several measurement teams are formed and sent to specific locations to perform measurements, from which the movement of gas plume is derived. An incident usually comes with casualties in people or animals, as well as damage to infrastructure.” [Dilo and Zlatanova [2008].

To account for the dynamic nature of operational data, new spatiotemporal data types were created: dynamic counts (e.g. for number of injured persons); moving point (e.g. for the position of a vehicle); moving region (e.g. for threatened / affected area).



Figure 19: Data model for disaster management in the Netherlands [Dilo and Zlatanova 2008]

3.9 WIN Data Models

Results of the WIN (Wide Information Network for Risk Management) project included a number of data models (XML schemas) for risk management related thematic issues. The “CrisisEvents” data model (see Figure 20) describes the information necessary for operational management of a crisis event. Further specifications include "Actors", AreasTBMonitored", a Common Alert Protocol and a Multilingual Multi Lingual Risk Management Glossary (English, French, German, Spanish, Romanian).

```
<xs:element name="CrisisEvents" type="ce:CrisisEvents">
  <xs:annotation>
    <xs:documentation>The CrisisEvents element is a container for multiple CrisisEvent elements.</xs:documentation>
    <xs:appinfo>CrisisEvents</xs:appinfo>
  </xs:annotation>
</xs:element>
<xs:complexType name="CrisisEvents">
  <xs:sequence>
    <xs:element name="CrisisEvent" type="ce:CrisisEvent" minOccurs="0" maxOccurs="unbounded">
      <xs:annotation>
        <xs:documentation>The CrisisEvent element describes a risk or crisis event and contains information to operationally manage such
an event.</xs:documentation>
      </xs:annotation>
    </xs:element>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="CrisisEvent">
  <xs:sequence>
    <xs:element name="_registration" type="co:RegistrationData" minOccurs="0">
      <xs:annotation>
        <xs:documentation>The _registration element describes registration details about the parent element. This element is used if every
transaction on data must be registered.</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="StatusChanges" type="ce:StatusChanges" minOccurs="0">
      <xs:annotation>
        <xs:documentation>The StatusChanges element is a container for multiple StatusChange elements.</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="EventClassifications" type="ce:EventClassifications" minOccurs="0">
      <xs:annotation>
        <xs:documentation>The EventClassifications element is a container for multiple EventClassification elements.</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="CrisisEventLocation" type="ce:GeographicLocation" minOccurs="0">
      <xs:annotation>
        <xs:documentation>The CrisisEventLocation element describes the geographical location of the crisis event and is used if a CAP is
not yet created (which contains the geo location of the crisis event as well).</xs:documentation>
      </xs:annotation>
    </xs:element>
  </xs:sequence>
</xs:complexType>
```

Figure 20: WIN “CrisisEvents” data model XML schema (clip)
[WIN 2007]

3.10 Tactical Situation Object (TSO)

The Tactical Situation Object (TSO) is a proposed standard for exchanging information during disaster and emergency management based on work carried out in the OASIS project (see chapter FIXME). The TSO includes descriptions of different types of events, the resources engaged in the operation, and the tasks in progress (see Figure 21). It contains the following information about different types of events, the resources engaged in the operation, and the tasks in progress [CEN 2009]:

- Identification information:
 - identification of the individual message
 - originator
 - time of creation
 - relation to any other TSO
 - organisation level, confidentiality and urgency of the information
 - links to external information
- Description of the event:
 - limited assessment of the event
 - location of the event and associated geographical information
 - enumeration of the casualties
 - prediction of future casualties
- Description of the resources:
 - resources each agency has available for the event
 - resources in use
 - resource capabilities
 - resource position
- Description of the missions:
 - missions in progress
 - missions foreseen

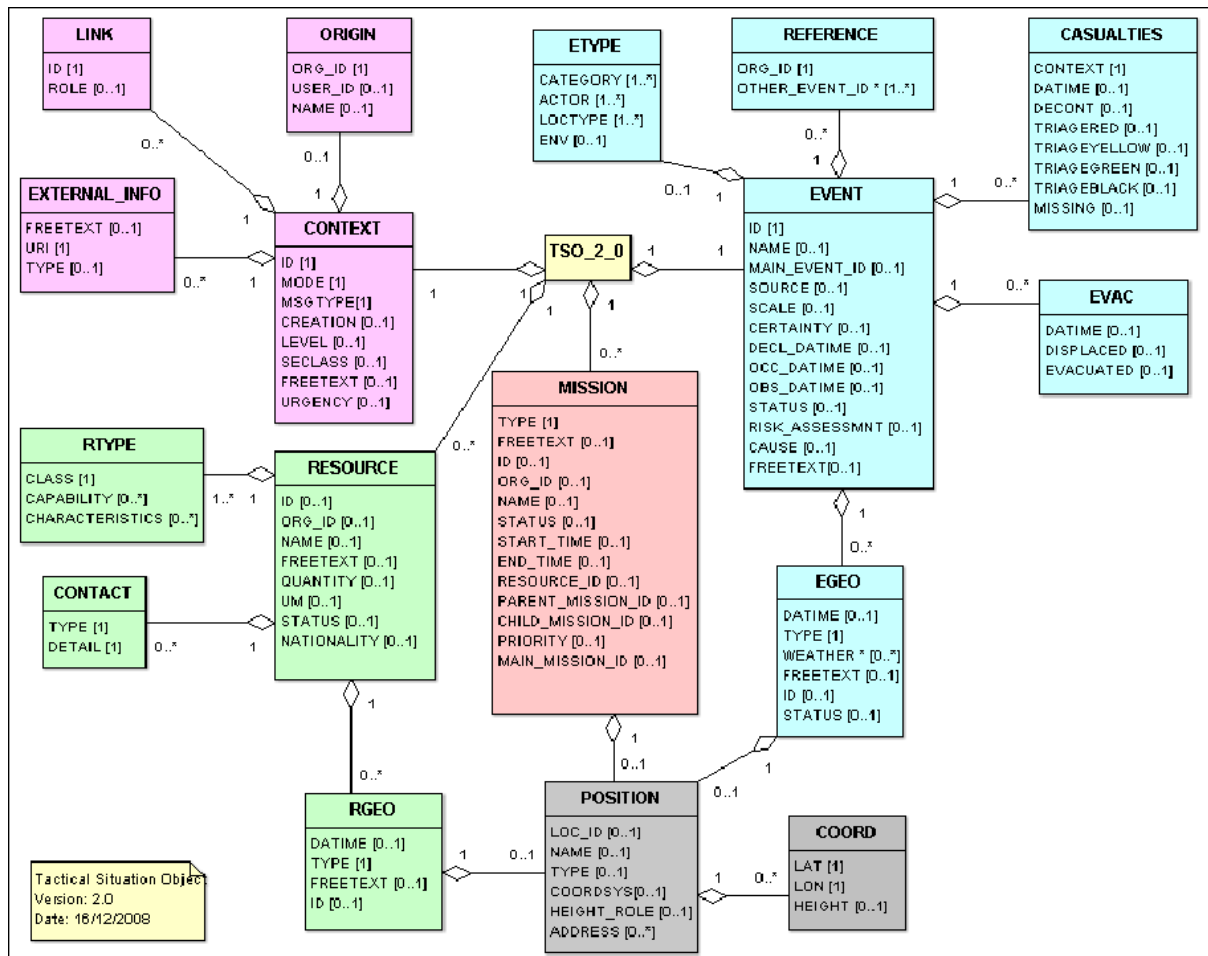


Figure 21: TSO data model
[CEN 2009]

4 Related projects and international initiatives

INSPIRE (Infrastructure for Spatial Information in the European Community)

The INSPIRE Directive defines a framework for the establishment of an Infrastructure for Spatial Information in the European Community. Technical details are specified in implementing rules e.g. on interoperability of spatial data sets. For this purpose, data specifications containing data models covering the 34 spatial data themes addressed by the Directive are being designed (see chapters 2.1 and 3.1). The INSPIRE Directive itself and its relevance for the HUMBOLDT application scenarios have been described in detail in A9.1-D1 Overall concept for scenario developments.

<http://inspire.jrc.ec.europa.eu/>

RISE (Reference Information Specifications for Europe)

The project addressed data harmonisation in the European Community by facilitating the creation of data product specifications. For this purpose, a methodologies and guidelines on use case and schema development have been devised (see chapter 3.2).

<http://www.eurogeographics.org/content/rise-0>

GMES Projects

Within the framework of the GMES (Global Monitoring for Environment and Security) initiative, a number of projects deal with disaster management. The following projects are explicitly concerned with data harmonisation and / or data modelling aspects:

WIN (Wide Information Network for Risk Management)

The WIN project aimed at integrating existing results or initiatives to contribute to the design and development of a "European Risk Management information infrastructure ". For this purpose, data models for a number of thematic issues of risk management have been specified (see chapter 3.9).

<http://www.win-eu.org/> (project website no longer available)

OASIS (Open Advanced System for crisis management)

The OASIS project's goal was to develop an information technology framework to support response operations in case of emergencies and to facilitate the cooperation between information systems used by civil protection organisations in a local, regional, national or international environment. For this purpose, the Tactical Situation Object (TSO) was drafted for exchanging information during disaster and emergency management (see chapter 3.10).

<http://www.oasis-fp6.org/>

ARMONIA (Applied multi Risk Mapping of Natural Hazards for Impact Assessment)

The ARMONIA project aimed at integrating and optimizing methodologies for risk assessment. This included harmonisation of different risk mapping processes as well as the development of a glossary of risk management language.

<http://www.armoniaproject.net> (project website no longer available)

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