MODELING EMERGENCY MANAGEMENT DATA BY UML AS AN EXTENSION OF GEOGRAPHIC DATA SHARING MODEL: ASAT APPROACH

Arif Cagdas Aydinoglu

Karadeniz Technical University, Turkey[1]

Tahsin Yomralioglu

Istanbul Technical University, Turkey[2]

Wilko Quak

Delft University of Technology, The Netherlands[3]

Arta Dilo

Delft University of Technology, The Netherlands[3]

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Abstract

Applying GIS functionality provides a powerful decision support in various application areas and the basis to integrate policies directed to citizens, business, and governments. The focus is changing toward integrating these functions to find optimal solutions to complex problems. As an integral part of this approach, geographic data sharing model for Turkey were developed as a new approach that enables using the data corporately and effectively. General features of this model are object-oriented model, based on ISO/TC211 standards and INSPIRE Data Specifications, describing nationwide unique object identifiers, and defining a mechanism to manage object changes through time. The model is fully described with Unified Modeling Language (UML) class diagram. This can be a starting point for geographic data providers in Turkey to create sector models like Emergency Management that has importance because of the increasing number of natural and man-made disasters. In emergency management, this sector model can provide the most appropriate data to many "Actors" that behave as emergency response organizations such as fire and medical departments. Actors work in "Sectors" such as fire department and urban security. Each sector is responsible for "Activities" such as traffic control, fighting fire, emission, and so on. "Tasks" such as registering incident, fire response, and evacuating area are performed by actors and are part of an activity. These tasks produce information for emergency response

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[1] Karadeniz Technical University Dept. of Geodesy and Photog. Eng. GISLab 61080 Trabzon, Turkey, arifcagdas@gmail.com
[2] Istanbul Technical University, Engineering Faculty, Dept. of Geodesy and Photog. Eng., 34469 Maslak, İstanbul, Turkey, tahsin@itu.edu.tr
[3] Delft University of Technology OTB Research Institute for Housing, Urban and Mobility Studies, Jaffalaan 9 2628 BX Delft The Netherlands, C.W.Quak@tuldelft.nl, and A.Dilo@tudelft.nl

and require information based on the base data model. By this way, geographic data models of emergency response are designed and discussed with "**A**ctor-**S**ector-**A**ctivity-**T**ask" classes as an extension of the base model with some cases from Turkey.

1. Introduction

Emergency Management is to conduct preparedness, mitigation, response, and recovery activities in a cycle to save human lives, reduce material damages on natural and human-made disasters. Emergency response is the most complex phase in the entire cycle of emergency management requiring full and fast cooperation between different actors working in different sectors. Finding available information and easy access to required information is crucial. Information needed for emergency management consists of existing information such as buildings, road and dynamic information collected during disasters such as incident, casualty, and like these (Xu and Zlatanova, 2007). In this way, geographic ("geo-" prefix) information appears as active on disaster and emergency management around the world (Susan, 2003, Kevany, 2003).

The laws related to emergency management are generally related to emergency response and recovery in Turkey. When the situation is considered locally, governorships of provinces and civil authorities of counties are responsible for preparation, execution, the preservation of "Disaster Emergency Assistance Plan of Province and Counties" in the first degree. Municipalities are involved in the tasks, such as fire fighting, emergency assistance, rescue and ambulance service, besides municipality services and building geographic/urban information systems in the municipal area (Official Gaz., 2006). Provincial Public Administrations are responsible for emergency management activities in the province areas but outside of municipalities (Official Gaz., 2006). In case of an emergency, the police cope with the tasks such as evacuation of citizens from affected and threatened areas. Medical Services lead medical help for casualties.

After the two devastating earthquakes in the Marmara Region of Turkey in August and September of 1999, several emergency management agencies have been established and several activities have been carried out (Sahin et al, 2006). But, these are disconnected projects and do not have qualified information to get the desired output information for emergency management cycles. Beside this, existing data that has been produced and maintained by different public institutions does not have a standardized approach and is not able to be harmonized for geo-data related applications such as emergency management. Dynamic data is still insufficient and generally not managed together with existing data (Aydinoglu and Yomralioglu, 2006).

This paper is organized as follows. Section 2 gives an overview about geo-data needs and management issues of emergency events. Section 3 presents geo-data sharing model for Turkey that is designed to manage geo-data corporately and meets base and existing geo-data needs on emergency management. Section 4 explains designing emergency management model as an extension of geo-data sharing model with some cases. This model includes Actor, Sector, Activity, and Task components to interact with geo-data and is defined with UML diagrams. Section 5 closes the paper with conclusions and expectations.

2. Geo-Data Management Issues on Emergency Management

Decision making is a very complicated process in emergency events. When disaster occurs, it is required to react accurately, fast and effectively. Various actors from different sectors such as police and municipality are involved in emergency management. Building a good collaboration mechanism and cross-sector services have critical importance to manage emergency tasks that are rather different than their daily work routines (Scholten et al, 2008). By this way, good decision making and information management help to control damage, to save lifes and resources, and to reduce consequences of a crisis. The number of casualties is

reduced by making the emergency services work safer and more efficient, ensuring citizens to get high quality care and information (Zlatanova et al, 2006).

Geo-Information (GI) is becoming a key issue in the achievement of these targets and is widely used in the emergency management phases. Various geo-data sets are needed on emergency response and management. These geo-data can be explained with two categories, existing data and dynamic data (Dilo and Zlatanova 2006, Diehl et al, 2006).

• Existing data were produced by different organizations on heterogeneous environment. These geo-data includes topographic maps, administrative units, risk objects like gas stations, vulnerable objects like schools, government building, hospitals, and etc. Building data comprises number of floors, materials, owners, and accessibility on emergency situations. Infrastructure data includes road network, utility network, parking places, etc. These data can be base for various geo-data related emergency applications and generally managed by local governments or public institutions. And, the data can be used on emergency management activities as a base or existing data. Emergency management actors can develop emergency plans based on this existing data and use the data at the time disaster occurs, and also for pre- and post-emergency management.

• Dynamic data is collected during the disaster from the activities of emergency management. For example, incident data includes location, nature, and scale. Effects of disasters should be determined with real time data including damaged objects, buildings, and infrastructures, affected and threatened areas. Casualties as a possible result of disasters include wounded and trapped people. In addition to this, meteorological data includes wind, humidity, and precipitation. This up-to-date geo-data is obtained on actual situation and can help to analyze possible effects and to determine precautions. The location of emergency response teams are needed as a moving object for giving the route to incident location. This dynamic data is very wide depending on the nature and data needs of emergency situations. By this way, dynamic data produced on real time can support controlling emergency response activities together with the use of existing data.

Geo-Information Systems (GIS) provides a powerful decision support and helps to find optimal solutions to complex problems on emergency management. While GIS is largely designed to serve specific projects or user communities, the focus is now increasingly shifting to the challenges associated with integrating these functions. As a result of these expectations beyond GIS and a special case of Information Infrastructure (II), Geo-Information or Spatial Data Infrastructure (GII/SDI) encompasses policies, technologies, standards for the effective collection, management, and access of geo-data to stimulate better governance, and to foster environmental sustainability by reducing duplication and facilitating integration at different administrative levels (Longley, et al, 2001, Georgiadau, 2003, Masser, 2005, Yomralıoğlu, 2000, Aydınoğlu et al, 2009). The integration of geo-information through interoperable systems is the central role of GII because it provides information from different sources for effective delivery of government services (Harrison et al., 2006). By this way, GII is increasingly considered a critical aspect of decision-making in disaster management.

Most countries of developing world are in the process of building GII at different administrative levels for effective geo-data management (Crompvoets and Bregt, 2003). According to GSDI Association, the development of consistent reusable geo-data themes is recognized as a common ingredient and beginning phase in the building of GII (Nebert, 2004). Open Geospatial Consortium (OGC) and ISO/TC211 Geographic Information/Geomatics committee have developed a variety of standards in this area. Infrastructure for Spatial Information in Europe (INSPIRE) Directive (INSPIRE, 2007) was agreed to produce harmonized models of 34 different data themes, such as administrative unit, address, topography, to deliver for 27 countries of the European Union (EU). US Department of Homeland Security (DHS) Geospatial Data Model covers quite a broad number of data themes like these (Scarponcini et al, 2008)

From a technical point of view, standard implementations are required for access and exchange of geo-information These include OGC Web Services, GML, Geo-decision support services (GeoDSS), Geo-Digital Right Management (GeoDRM) and Open Location services (OpenLS). The use of web services and XML can be considered for the communication between the systems in this architecture (OGC, 2008). On networked environment, there are a great diversity clients ranging from rich clients based on web browsers over classic workstation applications to mainframes with terminals. Geo-information should be shared and can be immediately retrieved from the sources involved in different databases (Carter and French, 2005, Grothe, 2005). The services should be a part of GII that integrates and facilitates access to existing and dynamic data on emergency management. Defining and implementing a GII within context aware services is the main focus as seen on Figure 1. The applications are directly communicating with services within these data driven GIIs.
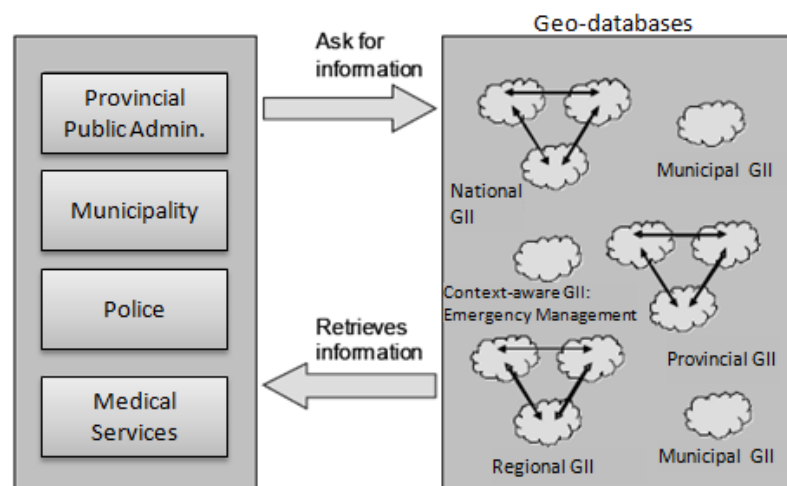

Figure 1. An overview of context-aware GDI for disaster management (adapted from Borkulo et al, 2006)

There are many approaches mentioned for reaching semantic interoperability on highly heterogeneous programming and data models. However, there are some barriers to manage geo-information corporately among different users. Definitions and concepts should be defined with common approaches. An important key for solving the problems is to capture the semantics included in different models. Based on this formal semantic approach different geo-information models can be harmonized. By this way, the data context should be defined and produced with respect to emergency types. Emergency response scenarios should be defined. And, GII services should enable users to access the existing and dynamic geo-data.

Important technology progress has been made in the discipline of knowledge engineering such as Unified Modeling Language (UML), ontology, and semantic web. For example, UML is a standardized modeling language for object modeling, is a graphical modeling tool with well defined semantics and underlying computer model in a Model Driven Approach (MDA). It is developed for the purpose of general domain modeling, application system design, database design, business modeling and so on.

3. Geo-Data Sharing Model for Turkey

A geo-data sharing model of Turkey was designed to make the data enabled for multiple uses as a preliminary work to build GII. Geo-data Exchange Model of Turkey GII, abbreviated as TURKVA:UVDM, can be accepted as a new approach on GI management in Turkey.

UVDM includes the data that needs to be shared among the users. Because all sectors share this base, data exchange between the sectors is greatly enhanced. This base and domain geo-database model is a starting point to create sector models in various thematic areas such as Land Ownership and Cadastral Information System (TAKBİS), Urban GIS applications

(KBS), and Emergency Management System (ADYS). The sectors can produce their geo-database models based on the rules of UVDM.

UVDM is an object-oriented geo-database model that enables the users to store objects and their associated attribute data in a single geo-database system. UVDM is compliant with ISO/TC 211 standards, Turkey National GIS actions, and the expectations of INSPIRE data specifications that European countries follow to utilize in their country towards building European SDI.

UVDM is a semantic model because harmonized model provides common domain of interaction and the related information. This interchangeable information in the model should explain objects with properties and relations semantically. That is, interchange of geo-information is possible. A variety of different kinds of organizations can operate in the same geo-information and exchange the data technically. For this, UVDM is designed with UML class diagrams.

UVDM Generic Conceptual Model specifies the components to determine application schemas of geo-data themes and to harmonize geo-data. These components were defined and divided into two sections, Scope / Application Area and Technical Components.

- **Scope and Application Area Components** include; Standard Hierarchy, Scale-resolution, Generalization Approach, Building Province Level GII
- **Technical Components** include; Principles, Terminology, Reference Model, Application Schema Rules, Spatial and Temporal Aspects, General Feature Model, Identifier and Versioning Management, Registers and Registries, Portrayal, and Multiple Representation.

Geo-data should be maintained at a level where the data is managed effectively. The only way to have consistent and current national datasets is to have transactional updates performed by local datasets. Large-scaled data use level is defined as the base level for UVDM. Spatial Hierarchy Approach enables collecting the data at province (İl) level, larger than 1:5000 scale and 50 cm resolution once and then generalizes to different levels such as Region and Country.

Key classes of UVDM Application Schemas are explained on Figure 2;

- High level and base class of UVDM is *UVDM_CografiNesne* accepted as common and compulsory class.
- Geo-objects of feature classes defined on data themes are sub-class and specialization of *UVDM_CografiNesne*.
- All geo-objects in feature classes have geometry and/or topology in a position.
- All geo-objects are

Figure 2. TURKVA:UVDM Base Application Schema

referenced on a Geography Coordinate System named as *CografiReferans*.
- *NesneTanımlayıcı* defines all geo-objects with unique identification.
- *NesneVersiyonu* defines and controls changes of the objects through time with attributes,
- *KullanımHakkı* defines data access permission and sources with attributes.
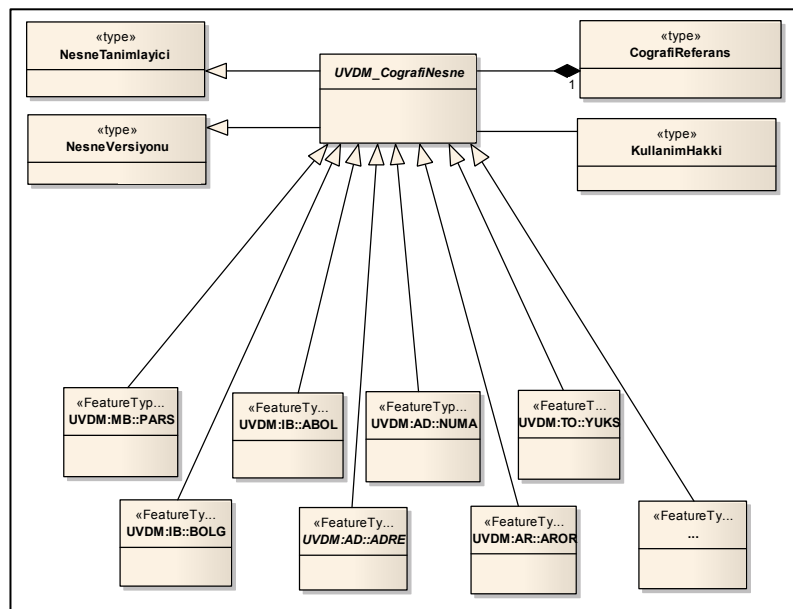- *Metaveri* defines information about all geo-objects at data set level of feature classes

A common framework is determined for the unique identification of geo-objects. These identifiers can be used to ensure interoperability among databases under national systems. This means all geo-objects shall carry a unique identifier property named as Geo-Object Identifier (CNTA). In order for a unique identifier to remain meaningful, it must persist throughout the lifecycle of the object it refers to. Feature Types defined on different data themes support data sharing for thematic applications like real world interaction. Temporal feature class is produced for each feature class to manage the data through time temporally and to control changes.

The design of UVDM follows the requirements of the application and use of information. Base principle is that if geo-database was modeled for a province, it can be a model from local to national level for all provinces of Turkey. According to the Field Work, information products and application needs relating to geo-information were determined for public/private institutions for a province. User requirements of these functions were defined with Data/Function Matrix. Data specifications of data themes were formalized from the results of user requirements and as-is analysis. The developed data specifications are then tested and revised in a pilot case study.

UVDM geo-data themes are Administrative Unit (IB), Address (AD), Land Ownership / Building (MB), Hydrography (HI), Topography (TO), Geodesy (JD), Transportation (UL), Land Cover / Use (AR). Application schemas of UVDM data themes were described with documentation, feature catalogues, and UML application schemas.

If we summarize the use of some UVDM data themes on emergency management activities;
- *Address (AD)* data theme provides a simple data structure for geocoding and address matching on controlling incident location and emergency actors.
- *Transportation (UL)* data theme is to capture basic infrastructure information for water, air, road, transit and rail networks and can be used with AD information. Transport Junction enables to mark connection points between multiple transportation modes. Also included is an Activity class to document transportation agency and other public events that will affect travel.
- *Land Cover/Use (AR)* data theme includes classes that relate to environmental monitoring and response. Most of these are oriented more towards natural disasters and recovery efforts rather than environmental monitoring for Homeland Security purposes. Land Use and Land Cover features can be used to assess damage after an event.
- *Ownership/ Building (MB)* data theme includes classes of buildings and parcels. It is related to address information. Detailed building information provides enough detail for emergency management personnel to effectively respond to local emergencies.

4. Designing Emergency Management Geo-Data Model

Emergency Management is a complex and very wide discipline that includes many actors and needs large amount of information. While disaster and emergency situation occurs, data should be used effectively to make decision and to control incident/disaster in Turkey. Local Civil authorities have responsibility to manage these events. Therefore, effective data management mechanism should be provided and building GII at provincial level is increasingly considered a critical aspect of emergency management.

Actors of emergency management sectors need base existing geo-data that was maintained by local government and public institutions. On this scope, TURKVA:UVDM can be accepted as a base model of emergency management activities because it was supposed that UVDM includes the date shared by all geo-data users at local level. UVDM can be a starting point to produce sector models for Emergency Management. By this way, Emergency Management Geo-Database Model, abbreviated as TURKVA:ADYS, can be produced as an extension and sector model of TURKVA:UVDM. As explained before, TURKVA:ADYS has existing data special for emergency management sectors and dynamic data collecting during disaster.

The conceptualization of TURKVA:ADYS is done for the purpose of developing a system that will provide the most appropriate data to each actor which is involved in emergency management. According to general conceptual approach of TURKVA:ADYS; Actor, Sector, and Task (AST) are the most important concepts between Activity and Information. Therefore they form the top-level classes. Figure 3 shows the overview of the classes and the most important relations in the model.

- Each *actor* such as fire fighter, ambulance, public security team, and etc. *work in* a *sector* such as police, municipality, and health services.
- Each *sector* is *responsible for* some *activities* such as traffic control, fighting fire, emission, and so on.
- Each *task* such as registering incident, fire response, and evacuating area *is part of activity*. In other words, Emergency activities comprise tasks respectively.
- *Actor performs task*. For Example; firefighter as an actor performs fire response.
- *Task requires and produces information* during emergency event. That is, each actor needs data to perform its task, but the actor can also deliver data to the system. Usually a task requires some *existing data* from *UVDM* geo-database and also some *existing and/or dynamic data* from *ADYS* geo-database. And, this task produces some *dynamic data* on *ADYS* geo-database during disaster.
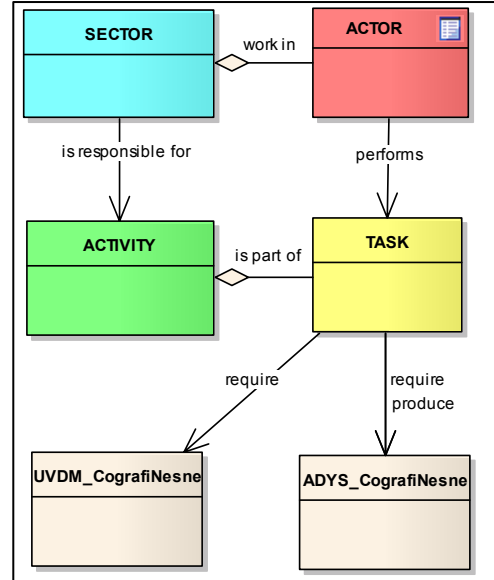

Figure 3. UVDM:ADYS Class Hierarchy (adapted from Xu et al, 2008)

- Each of the five top-level classes has its *subclass*, which is modeled as *isA* relation.

Emergency response scenarios can be determined to manage emergency activities with UVDM:ADYS Class approach. For example, explosion of gas station as the activity "Controlling Emission" has the Actor-Activity-Sector-Task-Information classes as seen on Figure 6;

- Various sectors such as "Police, Municipality, Provincial Public Administration (PPA), and Health Services" have responsibilities on Emergency Management.
- The activity "Explosion" is one of the activities for which "PPA" is responsible out of municipality area.
- "Disaster Coordination Center (AKOM) and Civil Defense Officer" represent the responding actors working in Sector "PPA". Firefighter is a responding actor working in Sector "Municipality". "MOBESE and Public Security teams" represent the responding actors working in Sector "Police".
- The tasks such as "registering incident, determining risk zones and threatening landmarks, determining team location and routes, evacuating and controlling risk zones, fire intervention, and saving casualties" are parts of the activity "explosion".
- After getting an urgent call, AKOM performs the task 'registering the incident'. This requires road (YOLH) and numbering (NUMA) data on UVDM geo-database. This task produces the location of incident (Incident) which is dynamic data on ADYS geo-database.
- AKOM performs the tasks "determining risk zones and threatening landmarks" requiring NUMA, YOLH, and building (YAPI) data. This task produces "risk map" on UVDM geo-database. As a case study, possible explosion of LPG station were examined and the risk map including threatening building were determined (Yildirim et al., 2006) as seen on Figure 4-a.
- AKOM together with MOBESE performs the task "determining team locations and routes" requiring "incident, YOLH, Teams" data to produce "Traffic Access Map" on ADYS

geo-database. As a case study, produced map give optimum routes to fire fighters and ambulances to reach the location of incident as seen on Figure 4-b.

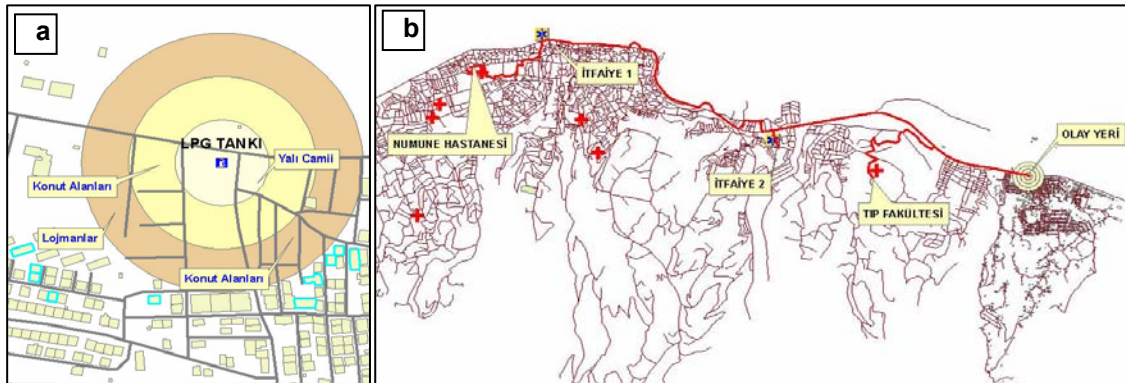• Beside these, geo-data is required and produced to execute other tasks of this emergency response.

Figure 4. Emergency Response Case from Trabzon City, a) Risk Map for the Explosion of LPG Station b) Traffic Access Map for Ambulances and Fire Fighters

ADYS geo-database model can be produced as an extension or sector model of UVDM that has generic conceptual model components and existing data needed for emergency management. In this way, ADYS has the same application schema rules as UVDM. ADYS has existing and dynamic data to use during emergency events. For example; Incident, Casualty, DisasterArea, and RiskArea are continuously changing data during emergency events as seen on Figure 5. Incident manages information about incident time, type, and like these. Casualty stores trapped, wounded, missing as a result of an incident. While DisasterArea stores the spread of disaster, RiskArea controls possible risk zones if disaster continues. EmergencyBuildings includes buildings that need to get special attention during disasters such as schools, shopping areas, governmental buildings, etc. Emergency Buildings can be related to Building (YAPI), Address (ADRE) via YAPI, and other feature types in UVDM. Incident can be related to ADRE and Road (YOLH) to get the location and route information.
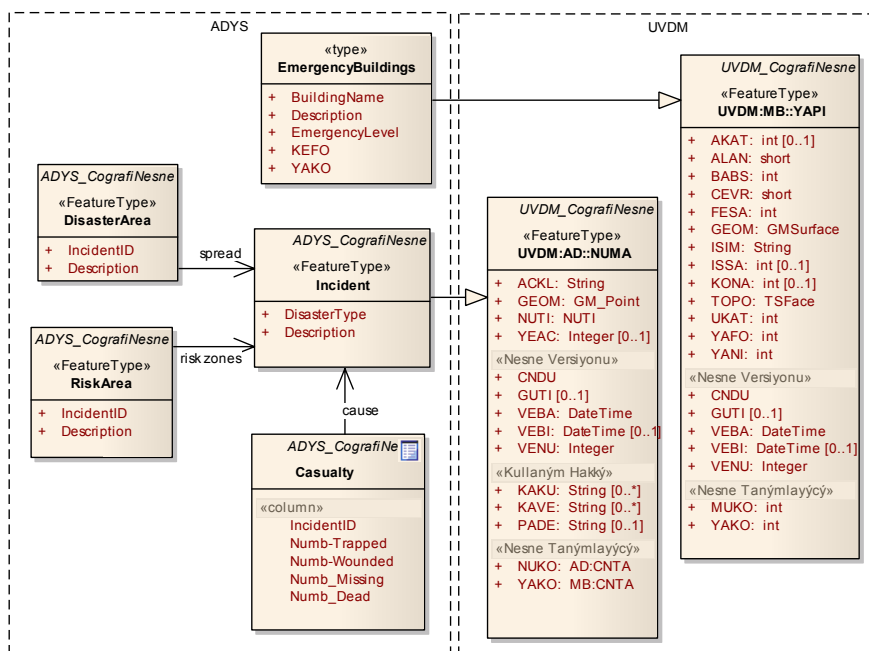

Figure 5. A Profile of UVDM and ADYS geo-database

Figure 6. UML class diagram for the process "Controlling Emission"

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5. Conclusion

Geo-information has key importance for emergency management during disaster beside pre-/post- disaster analysis. As emergency management is a multi-disciplinary activity, it should be possible to exchange information between different partners at different administrative levels. GII provides the tools giving easy access to distributed databases for emergency management actors who need geo-data for their own decision making and emergency tasks. Because time forms a critical factor in emergency management, GII should be suitable for quick data input and transfer. The most fundamental asset is the data itself that needs to be shared or to be integrated. Geo-data Sharing Model of Turkey (UVDM) that was developed to solve application-driven geo-data needs at local level with base model approach support decision making activities with common semantics. This can also solve the existing and base data needs of emergency management activities. Emergency Management Geo-database (ADYS) can be developed to be used corporately with UVDM. By this way, emergency management strategies should be developed for Turkey at local level. Activities with Tasks should be formalized sequentially while required data for each task should be defined to manage emergency events within GII mechanism.

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Author Biography

Arif Cagdas AYDINOGLU works as a research assistant at the Department of Geodesy and Photogrammetry Engineering, Karadeniz Technical University (KTU), Turkey. In 2003, he completed his MSc study and started his Phd study at KTU. He is following his researches in Technology University of Delft / The Netherlands since 2008. His research interests are GIS, SDI, Semantic Interoperability of geo-data.

Tahsin YOMRALIOĞLU is a professor at the Istanbul Technical University. He received his PhD in Newcastle Upon Tyne University. His research interests are Land Management/Valuation, Land/Urban Information System.

Wilko QUAK is a researcher at the Section GIS Technology of the OTB Research Institute for Housing, Urban and Mobility Studies at Delft University of Technology. His research interests include the development of Spatial Database Management Systems, benchmarking of Spatial DBMSs, spatial data modeling and standardization.

Arta DILO is a postdoc researcher at GIS-technology section at Delft University of Technology. She received her PhD in GeoInformatics from Wageningen University and International Institute for Geo-Information Science and Earth Observation, the Netherlands, in 2006. Her research interest includes GIS, data modelling and data processing.