List of abstracts for the EUROSDR/AGILE/OGC/JRC/ELF WORKSHOP 'DATA MODELLING AND MODEL DRIVEN IMPLEMENTATION OF DATA DISTRIBUTION'

Presenter	Organisation	Title	Description
Thorben Hansen	Danish Geodata Agency	111 Data modelling and data distribution seen from a NMCA perspective	Good governance depends on decisions being made on an informed basis, i.e. based on reliable information about conditions relevant for the decisions in question. Dependent on the subject, the information can be about people, enterprises, transportation infrastructure, urban planning, the environment, etc., and information required is typically in the form of data and functionality describing relevant objects and their interrelationship. Some of the basic objects and interrelationships required are the same across government, and e-government initiatives call for a shared data infrastructure to fulfil this requirement. Such data infrastructure must support e-government solutions in a heterogeneous it-environment consisting of loosely coupled systems. This requires data structures in the data infrastructure to be defined in a technology independent way and that data is made available according to standards that can be used across the heterogeneous it-environment. The data infrastructure required for e-government consists of both spatial and non-spatial data, and NMCAs are the providers of authoritative data about some of the basic geospatial objects. NMCAs have been involved for years in this development in one way or another: mapping and cadastral data is being used in e-government context, most NMCAs make maps available as standardised web-services, and many provide information according to the INSPIRE requirements, etc. This presentation will describe the development so far and the requirements we are facing at the Danish Geodata Agency from a business perspective. Emphasis will be put on describing the evolutionary approach taken by the Danish Geodata Agency, how the content provided is embedded in e-government solutions, and how the approach fits with a major e-government undertaking currently underway in Danish government encompassing a shared data infrastructure with both spatial and non-spatial data as a foundation for Danish e-government.
Michael Lutz	European Commission Joint Research Centre	112 Model-driven INSPIRE - Blessing or Curse?	The INSPIRE data specifications, which were developed concurrently by 8 experts groups for the 9 Annex I themes and 19 expert groups for the 25 Annex II+III themes, was probably the biggest ever endeavour of developing conceptual data models and data schemas in the geospatial domain. Achieving its goal within the given tight deadlines was possible only by using a model-driven approach together with a common version-controlled model repository and following a strict common development roadmap. While this highly formal approach helped to discover many inconsistencies during the development, it also required considerable training and supervision of the data model editors and led to overly complex models in a number of cases. It also showed that many experts in the geospatial domain have difficulties with understanding UML class diagrams and that only very few experts in Europe and around the world fully understand the complexities of generating xml schemas from UML class diagrams for complex, interlinked models such as those of INSPIRE. In the keynote we will discuss these success stories and challenges and point out a number of open issues, such as tool support for mapping between different models, managing dependencies between different (versions) of linked data models and how to treat code lists in the data models.
Paul Janssen	Geonovum, Netherlands	113 Starship INSPIRE meets national SDI: Collision or Merger?	Now that the INSPIRE SDI has come in to the orbit of national SDI's one has to consider how both go along. INSPIRE has 34 themes representing uniformed dataspecifications. These are mandatory for national member states to implement for publication in the INSPIRE context. But national member states also already have existing SDI's including datasets that are uniformed at the national level or other contexts, and sometimes regulated by national law. Are these different contexts in competition? Will one eat the other or are context borders artificial and not existing? Before getting too philosophical and general, let's bring it back to the specific issue of semantics and information models. Merger of SDI's is the approach that is advocated in this presentation. More specifically will be discussed how INSPIRE dataspecifications can be extended to meet national requirements. A specific use case for a national service for information on underground utilities network will be taken. Several approaches for extending INSPIRE models are explained, one is implemented.
Peter Parslow	Ordnance Survey, Great Britain	114 Does the real world fit into a general feature model?	'Automated generation of GML application schemas based on UML data model' more or less presupposes use of the OGC/ISO General Feature Model (GFM). Its critics describe the GFM as a 'closed data model', because when conventionally implemented, it starts from the assumption that we know all about the domain that we are modelling, and once implemented it is traditionally hard to change. Ten years ago, OpenStreetMap took a collaborative approach to classifying three kinds of "data primitives": nodes, ways, relations. In some ways this is based on the older GIS approach, of first splitting the world into points, lines, and polygons. But by taking an open approach to tags, the domain model emerged from the data capture. An 'informal standard' set of tags and values has emerged from the crowd, and is maintained collaboratively. Over the past few years, 'linked data' has begun to popularise a graph data model, which its proponents describe as 'open' - in the sense that the domain model grows as more data is explored. This paper will briefly describe these two approaches, identify points of commonality and points of difference, and explore a number of questions: are these a challenge to the GFM? Is the GFM consider as closed as its critics argue? Is it a myth that we ever know enough about a domain? And how can we build flexible systems?
Anja Hopfstock Morten Borrebaek Heidi Vanparys	BKG, Germany Norwegian Mapping Authority Geodatastyrelsen, Denmark	121 Building on INSPIRE – modeling of application schemas for European Reference Data	E.L.F is a project in the CIP (competitiveness and innovation) framework programme. The purpose of this project is to deliver the European Location Framework (E.L.F.) required to provide up-to-date, authoritative, interoperable, cross-border, reference geo-information for use by the European public and private sectors. A sustainable European Location Framework (E.L.F.) for re-use of authoritative public sector reference geo-information at multiple levels of detail during the pilot phase and beyond will be created. UML and GML application schemas for the reference data must be created and maintained, based upon the INSPIRE schemas for the relevant themes. In order to do this, modelling guidelines for the E.L.F models have been established. The application schemas builds upon the INSPIRE specifications and should therefore adhere to the requirements and recommendations in the INSPIRE Generic Conceptual Model (GCM). The modelling guidelines are formed in such a way that an existing INSPIRE implementation by default is conformant to an E.L.F specifications for the themes that are in the remit of the E.L.F data specifications. The E.L.F model consists of a hierarchical structure of packages and application schemas. The <<applicationSchema>><theme> will show all imported feature types, data types, codelists and enumerations of interest for ELF. This defines the "NMCA profile for INSPIRE". The E.L.F models includes the INSPIRE consolidated UML model, with its foundation schemas (ISO/TC 211-, EarthResourceML- , GeoSciML- and OGC models), The INSPIRE Generic Conceptual model and the INSPIRE theme models). To be able to use and extend the INSPIRE schemas the relevant INSPIRE themes are imported to the ELF model by using package control in Enterprise Architect. These modelling guidelines may also be applicable for modelling of national data where INSPIRE models are the core and the national user requirements extends the INSPIRE specifications. The guidelines also documents how one GML application schemas may be used for products in different level of details. The latter may be important to reduce the cost of implementation of GML application schemas.

Knut Jetlund	Norwegian Public Roads Administration	122 ISO/TC211 Best practices for UML modelling	Data modelling in UML has become a fundamental part of standardization of geographic information, both for the ISO/TC211 core standards and for domain modelling in INSPIRE and national SDIs. The models fulfil (at least) two different needs: Documentation for human understanding, and schemas for implementation in GML, Web services etc. Many modelling rules are described in several different ISO/TC211 standards, such as 19103 (Conceptual schema language), 19109 (Rules for application schema) and 19136 (GML – Annex E). The main focus in these rules are machine readable models for implementation, while human readability is more of an issue for best practices. The ISO/TC211 has experienced through their own work on standardization that there is a need to collect and describe rules and best practices in a structured way, to make sure both the core standards and the domain models are created and maintained to fulfil demands for both human understanding and model driven implementation. An ad hoc group on Best practices for UML modelling was established through a resolution at the ISO/TC211 plenary meeting in Berlin in June 2014, and the first working group meeting was held during the ISO/TC211 meeting week in Shenzhen, China in November 2014. The group consist of 10 nominated experts from around the world, and a number of other resources on UML modelling and implementation as well. The outcome of the work is planned to be a wiki for modelling geographic information in UML, and will be freely available.
Thorsten Reitz Simon Templer	data harmonisation panel e.V., Darmstadt, Germany wetransform gmbh, Darmstadt, Germany	123 Agile Design and Testing of new Standard Information Models	Developing and implementing a standard often has great potential in reducing costs and in generating new opportunities1 by making heterogeneous products accessible, both for businesses and society as a whole. Many standards are about interoperability, such as enabling seamless usage of information across systems. An important part of such a standard is its information model. In most cases, information models and schema standards are developed in a top-down waterfall fashion, starting with an analysis phase, continuing with design (conceptual modeling), evaluation (Request for Comments), implementation (encoding in a physical/logical model) and then, hopefully, adoption throughout the community. This leads to very long standards development processes and to expensive problems in implementation, as well as mismatches to applications. As state-of-the-art standards tend to be highly complex, such risks are manifold. An example is found in the complexity of INSPIRE and OGC standards, with thousands of complex types and hundreds of associations. To reduce risks during standards development and to enable communities to reap benefits of standards faster, we have developed an integrated, fast workflow from data modeling to transformation and sharing. Our platform, wetransform.to, combines data modeling, transformation services and analytics with strong collaboration features. It is accessible and easy to use, supports collaborative work and maintenance processes, and is still powerful enough to transform any type of structured data. Teams can use it to develop standards from scratch or to maintain them and to evaluate the impact of any change made to a model in relation other models. This workflow ensures conceptual harmonization and derives data transformation rules with defined integration quality. A particular aspect of standards modelling is the usage of Explorative UML, a variant of UML we have started to develop. Explorative UML encourages interactive model exploration on any kind of client device. As in HALE, we use the spatial properties of geodata to give users fast visual feedback. With the added communication and collaboration feature set, we enable communities to develop and implement standards in an agile process. In INSPIRE adoption projects, our interactive design-validate loop enabled a speedup from initial design to implementation of 10-12 times compared to phased projects. A side effect of working with this platform is that the community develops transformations to target environments together with the standard. We also use existing reference data sets to continuously improve the transformation (e.g. for edge matching). Finally, our system links all known data sets to models, so communities such as OGC, Copernicus, SEIS or INSPIRE can use quality data as well as live usage data to determine which gaps are important.
Esa Tiainen	National Land Survey of Finland (NLS)	124 Creating Linked data infrastructure for SDI	Interoperability is recognized a strategic goal in National Land Survey of Finland (NLS) as national mapping and cadastral authority, also responsible of NSDI implementation. NLS is working to introduce a URI-based management of data infrastructure. A national recommendation for public administration is nearly completed proposing unique HTTP URI identifiers to spatial objects and the real world objects as well as the concepts that they represent. This approach suggests data model based URI implementation of geodata for Linked data, assuming a “flat” view is practical and multi-purpose. Furthermore it allows for linking of spatial and non-spatial data. The national recommendation suggests enriching the SDI with multiple URI linking that mirrors “flat” data models providing a framework of data infrastructure for data distribution. It serves service providers with complementary or replacing data sources with better quality or coverage and from local to national. Piloting has successfully combined local and national data. Current view is also to establish a URI-based production of national topographic data base in future. The URIs for spatial data are all minted in nationally centralized domain, paikkatiedot.fi (“spatial data.fi”), which provides redirections to the URI-services of data and service providers. Basically the URI design implies that real world entities are modeled as spatial objects in URI type ‘so’, and as concepts in URI type ‘def’. The real world entities are represented by URI type ‘id’ employing a placeholder with the same namespace and local identifier as the URI of the spatial object. The ‘doc’ URI type of a spatial object accommodates references to ‘id’- and ‘def’-URI types as well as representations of the spatial object (coordinate systems and formats). The ‘doc’ URI type may also include references to other spatial objects representing the same real world entity. Namespace stands for the data source. The ‘doc’-URI is implemented in RDF establishing the basis for Linked data. This enables e.g. harvesting the spatial objects representing the same concept or the same real world entity. However harmonization of the concepts in data models is implemented in the next level which is the national thesaurus and ontology service (www.finto.fi). There the concepts used in data models are annotated in concept hierarchy of General Finnish ontology (YSO) providing a wider Linked data framework for spatial and non-spatial data. In paikkatiedot.fi-domain the redirections from spatial object ‘so’-URI and real world entity ‘id’-URI are always directed to the corresponding ‘doc’-URI. The implementation strategy aims, in parallel to INSPIRE implementation, to that the data providers assign ‘def’- and ‘id’-type URIs with the same as InspireIDs for spatial objects. This is a practical and cost-effective roadmap to establish the infrastructure with INSPIRE data as a critical mass and stepping stone. Accordingly the ‘id’-URI for the real world entity is populated by the responsible INSPIRE data provider, the responsibilities assigned for each of the INSPIRE spatial data
Paul Hardy Roberto Lucchi	Esri Inc	211 GIS Data Models for INSPIRE and ELF	This presentation provides an overview of relevant data models and data services of a modern GIS, and of the processes involved in their creation and use. It concentrates on the models involved in the INSPIRE directive, and the ELF (European Location Framework) project, focussing on the approach used by Esri to generate the template data models of the ArcGIS for INSPIRE product. It studies the way that geodatabase models are generated from standard UML schemas, and the techniques and trade-offs involved in flattening complex XML schemas into tabular models. The conceptual INSPIRE UML data theme models available for download from the web page at http://inspire.ec.europa.eu/index.cfm/pageid/2/list/datamodels are used to develop a UML-based data model which relies on Esri geodatabase stereotypes (e.g. feature class, relationship class, table, and domain). During the implementation of such models, some design choices can and sometimes must be made, such as relationships between objects, how to implement comments in the original INSPIRE UML, or data attributes which would improve or allow the definition of cartographic rules. Such a model, developed in Enterprise Architect, can be used to automatically generate an Esri geodatabase implementation following the model driven pattern. Although INSPIRE specifications and compliance with the Implementing Rules can be verified against the conceptual data models, in the real world the focus is often on layers and feature types to be served from a relational database implementation via INSPIRE View and Download services, as specified in the respective technical guidance documents. In this presentation we assess the benefits and constraints of a specific, optimised implementation of the INSPIRE data models at the geodatabase level. With this geodatabase data model positioned as the main interoperability element, there are benefits which include opportunities for developing and sharing symbology rules, data quality checks, common geoprocessing tasks (e.g. edge matching, generalization) which otherwise would have to be organization specific. Furthermore, the use of such pre-prepared geodatabase templates allows COTS products such as ArcGIS for INSPIRE to deliver compliant View and Download services with minimal configuration. The long term INSPIRE implementation roadmap (http://inspire.ec.europa.eu/index.cfm/pageid/44) requires fluid development and enrichment of INSPIRE elements, as shown by recent efforts on the evolution and maintenance of the data models (http://inspire.ec.europa.eu/index.cfm/newsid/11586). Similarly, the European Location Framework project (http://www.elfproject.eu/) addresses the needs of harmonization of authoritative data across the National Mapping and Cadastral Agencies. Both these will require data model changes with consequent impact on software using the initial

Lena Hallin-Pihlatie	Finnish Environment Institute (SYKE)	212 Maintaining an environmental spatial data infrastructure (SDI) in ArcGIS	The Finnish Environment Institute SYKE is a research and expert organisation, operating under the Ministry of Environment. SYKE maintains an environmental spatial data infrastructure (SDI), which serves both the whole environmental administration and external users, such as national institutes and authorities and European bodies. SYKE has the status of a Legally Mandated Organisation (LMO) within INSPIRE, being the biggest INSPIRE data provider in Finland in numbers of different data sets and themes, and being responsible of data sets in 19 of the 34 INSPIRE themes. ArcGIS is used internally on average by 150 users per day. The present maintenance system of the data infrastructure is complex; it contains maintenance and development of the software, datasets and web-based services. A great part of the datasets to be shared has been modelled as UML-models for use in ArcGIS SDE databases, including datasets from external data provides have been remodelled at SYKE to meet the needs of the environmental sector. Some datasets are also maintained as file geodatabases, shape files or SQL databases according to a pre-defined system. Datasets that are also being shared in web-based services, which is the case for our INSPIRE compliant Atom-feeds and WMS services have its own maintenance procedures in parallel. In the future the maintenance has to be complemented with parallel hopefully semi-automatic produces taking care of the data transformation processes, which are needed to meet the requirements of the INSPIRE Directive. In autumn 2014, efforts have been made to transform national datasets to INSPIRE compliant datasets, for example within the theme Land Cover. In august 2014, a beta version of a template (file geodatabase) compliant with the INSPIRE Land Cover Core data Model was obtained from ESRI. SYKE tested the transformation of the Finnish Corine Land Cover Data (MMU 25ha) to the Land Cover Core Vector template using FME. The CorineValue code list maintained by the European Environment Agency was also used in the ETL-process. FME is a potential tool with which the data transformations can be automatically taken care of. The experiences gained and reflections that rose related to the software tested will be shared with the participants of the workshop. The transformation of the Corine Land Cover dataset is relevant to many data providers as it is produced in all member states of the European Union.
Johannes Echterhoff Clemens Portele	interactive instruments GmbH	213 ShapeChange – a tool for model-driven development involving geographic data	ShapeChange processes application schemas for geographic information modelled according to the ISO 19100 series of standards and supports generating implementation schemas and other target outputs. Originally, ShapeChange had been developed mainly to derive XML schemas, in particular GML application schemas. Over the last decade ShapeChange has been continuously extended to support a number of additional target outputs as well as other capabilities important for model-driven implementations. General target outputs supported by ShapeChange: • XML Schema (GML 3.2 encoding rule, GML 3.3 encoding rule, ISO/TS 19139 encoding rule, SWE Common Encoding Rule, several community encoding rules including INSPIRE) • Schematron schemas derived from OCL constraints • Feature catalogues in HTML, DOCX and XML, now localizable, in customizable styles, tracking changes and including UML diagrams • RDF schemas for application schemas and SKOS for code lists • JSON Schema • Enterprise Architect model, mostly of interest for transformed models, see below • SQL/DDL for PostgreSQL and Oracle (in development) • ArcGIS workspaces (in development) In addition, there exist more specific targets that have been developed in the context of a certain community or project. Some of these are part of the ShapeChange distribution, too. For example Excel tables of application schemas to support documenting mappings to/from other schemas, FME workbenches to validate data, XSLT stylesheets to convert GML to KML, a code list registry, WFS configurations for the XtraServer software, etc. In general, conceptual schemas need to be transformed into implementation schemas in order to tailor them to the capabilities of the target implementation platform. To support this requirement, ShapeChange now supports such transformations. Additional transformations can be implemented in Java, but out-of-the-box ShapeChange supports profiling and flattening. With these capabilities, ShapeChange supports implementing model-driven data distribution workflows. In our talk we will provide examples of the capabilities mentioned above. We will also demonstrate how the tool is configured and executed.
Morten Borrebaek	Norwegian Mapping Authority	214 ShapeChange plug-in for Enterprise Architect	ShapeChange is a Java tool provided by Interactive Instruments GmbH and the MITRE Corporation. The tool derives implementation specifications and other kind of documentation from the UML models. The tool directly accesses Enterprise Architect models via their Java API, it can read XMI 1.0 and directly access GSIP model databases. ShapeChange is an important tool in many SDI's, both at national, regional and global level. As part of the Norwegian Spatial Data Infrastructure the user interface including configuration has been implemented in a plug-in for Enterprise Architect. This means that you can select a UML model (for example a UML application schema) in Enterprise Architect and instantly derive different kind of output. The graphic user interface (GUI) will visualize the default configuration parameters and allow adjusting them according to the users need. This GUI will ease the use of ShapeChange for several kind of output. This representation will not focus on the functionality in ShapeChange except the UML model documentation. ISO/TC 211 established an ad hoc group for deriving documentation of ISO/TC 211 UML models directly from the models, but the tools will also be applicable for UML models that are not in the remit of ISO/TC 211. This documentation tool requires that the documentation field in Enterprise Architect is filled in, which is also a good practice to do during the modelling phase. The plug-in for ShapeChange will be publicly available.
Heidi Vanparys	Danish Geodata Agency	215 Code lists in the ELF project	The model driven implementation approach, in which GML application schemas are derived automatically from UML models, is in a mature stage. However, different possibilities still exist for the modelling of code lists, which are not specified nor managed as part of an application schema, and the subsequent implementation of code lists registries. The European Location Framework (ELF) is going to provide a platform of INSPIRE-compliant geo-information and it provides data specifications that extend the INSPIRE data specifications where needed. Some of these extensions involve the specification of additional code lists or extension of existing INSPIRE code lists. The ELF code lists should be provided in an online registry. During the project, choices had to be made concerning the way of modelling, which machine-readable format to use, what tool to use to create a registry and how to maintain the code lists in the future. Principles guiding those decisions were providing a minimal working solution and providing a solution that follows the general direction the geospatial community is developing in, considering e.g. concepts such as Linked Data. This presentation will explain the choices made in the ELF project and the arguments behind those choices.

Debbie Wilson	Ordnance Survey	216 Benefits and Efficiencies of Model Driven Implementation of Small Scale Content Specifications within OS GenIE system	Ordnance Survey is under increasing pressure to develop and deliver a wider range of derived contextual and analytic data products from our large scale content with improved consistency and currency. GenIE (Generalisation Information Engine) is an innovative new system that shall automatically generate derived and generalised content driven by changes our core large scale content. To ensure improved consistency of our small scale contextual and analytical content we have developed a single consolidated logical model that defines the features and properties that are applicable to all resolutions and applications. Profiling is used to specify which features and properties are applicable to a specific generalised content store. By using profiling, instead of re-defining the model for each content store it ensures that features and properties are defined consistently and we can re-use existing configurations reducing development timescales. To implement the different derived content profiles we have adopted a model driven implementation approach to automatically: • Generate schema conformance tests (Cucumber) from the logical model to support Test Driven Development (TDD) using Enterprise Architect Documentation Templates • Generate profile schema for different content stores using ShapeChange • Transform (flatten) the schema to reflect implementation constraints using ShapeChange • Generate database schema using ShapeChange, Enterprise Architect documentation templates and ETL tools • Generate data specification documentation for end users using Enterprise Architect documentation templates By adopting a model driven approach this has delivered the following benefits: 1. Significantly reduces the time taken to implement a content store for a new product (> 2 weeks) 2. Implementation schema can now be developed by a wider range of developers (software engineers, product development consultants) reducing reliance on specialist data modellers 3. Ensures consistency between the various implementation schema (GML, DDL, ArcGIS) as they are no longer manually created by different developers.
Clemens Portele Markus Seifert	interactive instruments GmbH GDI Bayern	221 The implementation of a model-driven approach for the cadastral and mapping data in Germany	The Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) has developed a common AAA application schema for all official reference data sets of all public surveying and mapping authorities in Germany. This application schema is described in UML using the software tool Enterprise Architect. Implementation products are derived from the application schema including a data exchange format (GML/XML). The presentation will focus on practical issues of the development and maintenance of this data model and model-driven workflow, such as: • Fine-tuning of the UML profile (tagged values) in order to model different level of details, manage application schema profiles, extract readable feature catalogues, derive a data exchange format (GML data exchange interface) and to support other requirements. • Derivation of the data exchange format using the tool Shape Change with an UML implementation model as an intermediate step. • Extracting code-lists and enumerations from the data model, provide them in a registry and get access to these resources. • Extensions to ShapeChange to support additional requirements of the AdV members. • Explaining of the data versioning concept that allows the handling of historical data as well as providing differential data for data updates. • Identifier management to identify, find and link the objects. • How to document changes (issue tracker, change log). • Versioning issues of the model and data exchange interface (XML schema files). The AAA application schema is fully ISO-based (19100 series of standards), describes the structure and setup of basic spatial data in a model-driven approach and establishes a modelling frame also for the integration of other thematic data. For reaching that aim, the AAA application schema is basically separated into two parts: a generic theme-independent base schema and – based on that – an application schema for cadastral, topographic and geodetic reference point features. In principle, the base schema can also be applied in other thematic domains, which is currently done by the rural development information system (LEFIS) and other domains. Thus, the AAA model is a fundamental technical and practical contribution for the German SDI (GDI-DE).
Liesbet De Wolf Hendrik Van Hemelryck Ruben Capiau Veerle Beyaert Ziggy Vanlishout Jef Vanbockryck	Flemish Geographical Information Agency (FGIA)	222 Basic registries for Flanders	The Flemish Geographical Information Agency (FGIA) has embarked on a project that will develop a set of integrated 'basic registries' for geographical information in Flanders. The set will consist of at least interoperable registries for addresses, buildings, cadastral parcels, roads and large scale topography. Today the FGIA distributes a number of 'authentic data sources' such as the Central Address Database (CRAB), the GRB (large scale topographical map) and the road registry. These products are well established, have good quality and are widely used. These data sources have been put up as independent silos. Therefore we experience problems in maintenance and distribution of the data. Information in different products is not always in sync and sometimes contradictory. The need for more interoperable data and harmonisation with INSPIRE data specifications are two of the main reasons to start the project. In addition the FGIA wants to make sure that its data can be distributed as 'open linked data'. The project has a strong model driven approach. Data is modelled according to a set of modelling rules. Data models are described as UML class diagrams using the Sparx Enterprise Architect tool with version management (provided by Team Foundation Server). Stereotypes are reused from the 'UML profile for INSPIRE data specifications'. Based on the UML models, GML application schemas and documentation (feature catalogues) are automatically generated using the ShapeChange tool. The use of standards and tools to automatically generate the implementable data models guarantees that the actual data and the data models are directly related. With the data models in place, the project will design service models that are bound to business processes. Together the business processes constitute an integrated maintenance system where centralised and decentralised data collection efforts efficiently work together according to agreed-upon business rules. Service models should include business rules and operations to manage those parts of the data that are related to the business processes. These service models are designed using the same tool and will extend the UML data models. Finally, the project will design an application and infrastructure architecture that should implement the service models to provide a controlled data management/maintenance system. The application and infrastructure architecture further extends the service models with more detailed components. As such, this model driven approach matches with a typical Enterprise Architecture design that guards the alignment between business and IT aspects.

Najar - DiDonato	Bundesamt für Landestopografie swisstopo	223 Federal Spatial Data Infrastructure in Switzerland: modelling, harmonizing and publishing geospatial data from different sources	Switzerland is a heterogeneous country with four official languages and organized as a Confederation with 26 states (cantons). This political situation has a major impact on organizational and technical aspects of the Federal Spatial Data Infrastructure (FSDI) and the way it can constitute an enabling platform on national level. Interoperability arrangements and standards are crucial for the harmonization of data from different sources. The geoinformation law, ratified 1st of July 2008, commits the federal offices and the Cantons to harmonize basic spatial data in their area of competence. In the ordinance of the geoinformation law 354 basic geodata sets are defined. They must be described by at least one conceptual model, a set of standardized metadata and published by services. Currently, 50% of the basic data models are ratified and published on the Model Repository which is accessible via Web. For 20 years the model driven approach is used to describe spatial data on the system-independent conceptual level. Spatial data models are described in INTERLIS/UML, a conceptual description language with a corresponding transfer format. Currently, INTERLIS 2.3 (textual description) is used together with UML (graphical description). The XML-based encoding rules define how to generate the transfer format. To support the entire process, from modelling to data instances, a set of tools (open source) has been developed. □ The UML Editor offers an intuitive, graphical interface for the modelling of an application domain. □ The INTERLIS Compiler enables to check the validity and consistency of the model and to derive the official and legally binding textual representation of the model itself (so called ILI Model). □ Encoding rules for data instances in XML format are available; □ The ILI Model and the encoding rules are the input of an ETL process to generate data instances: o ILI2FME in an FME plugin for reading/writing INTERLIS data; o OGR supports model-aware INTERLIS reading and writing; □ ILI models, including base models, are published in the Model Repository; □ The Checker for INTERLIS-2 enables to validate data instances against the respective ILI models; □ Metadata are generated, maintained and published in geocat.ch. □ map.geo.admin.ch is the official map viewer of the FSDI. map.geo.admin.ch is the official map viewer of the Swiss Federal Spatial Data Infrastructure. It offers about 380 information layers and has an average of 10,000 users per day. The map viewer adapts responsively to different devices and can also be used offline.
Flemming Nissen	Danish Geodata Agency	224 From data modelling to data distribution in the Danish Basic Data infrastructure *- Modelling geodata from an e-government perspective*	The race has begun towards the efficient use of public data in current public administration. The Danish e-government project concerning the development, the integration and the mutual usability of basic public data has recently emerged with a standard or mandatory specification for modelling data. The story goes few years back to the advent of the e-government project, when modelling rules came on the agenda and the version of the modelling rules now is becoming 1.1. The rules constitute both general properties for objects and rules for UML modelling behaviour. Many aspects of the modelling issues have been dealt with in other regimes. INSPIRE has left more than a footprint and the current EU-project ELF involving NMCA's geodata will benefit from the modelling methods. The modelling concept will be supported by tools and documentation that will be mutual for data content providers as well as data content consumers. The road to make modelling rules understandable, rational and implementable is not straight forwards as you imagine. Legacy data models, lack of resources and competences are aspects that make the road bumpy and dusty. The presentation will show the considerations behind the rules and the governance set-up for managing implementation and future needs. Some of the concrete rules as well as the general properties will be presented in order to demonstrate the usefulness and to give some descriptions for decision makers. Another topic of actual notice is the lack of common data resources in terms of registries, e.g. registries on public organisation and their attributes. These common needs should be facilitated by some central and responsible organisation within the public administration. What is already to be learned is that other elements of modelling will be required. The need for using the same semantics for concepts inside or outside of top domains or special domains will be obvious and it is a task that should have been addressed in advance.
Peter West-Nielsen Niels Kjær Heidi Vanparys	Danish Geodata Agency	224 From data modelling to data distribution in the Danish Basic Data infrastructure *- Challenges in establishing a multi-purpose data distribution environment*	Public agencies have to take into account a scene of diversity in terms of e-government initiatives concerning infrastructures for distributing spatial and non-spatial public information, such as INSPIRE, ELF and the Danish Basic Data Initiative. These initiatives comprise different but often similar rules for conceptual data modelling and setting up services. All these rules should be lived up to simultaneously, by using one source of distribution data and by using one spatial data infrastructure. The approach of the Danish Geodata Agency is to make a clear separation between the production and the distribution of geospatial data. The process of migrating data into the distribution system includes (1) consolidating the source of data, (2) establishing a Danish UML-model and (3) setting up a suite of various output formats and services, based on this common UML-model and on a mapping to models defined by other parties, such as INSPIRE. This new model driven approach builds heavily on best practices and standards, both explicit and de-facto, with a separate focus on keeping proprietary in-house development to a minimum, in order to reduce dependencies and provide a broadly applicable solution. By using standardized tools to automatically generate the needed implementation models, it is ensured that the conceptual models, their documentation and the data actually distributed are closely related. This relation makes it easier for the end users of the data to understand and to work with these data. This presentation will illustrate the principles described above by means of a specific dataset, the Danish topographic reference data, while also highlighting some of the challenges encountered in the process.
Paul Scarponcini	Bentley Systems	311 Conceptual Modeling of Linear Referenced and Geospatial Data and Operations	The use of Linear Referencing (LR) for location specification pre-dates GIS and is still relevant today. It would be quite costly to convert the significant amount of data currently using LR locations into GIS spatial coordinates. Application software would have to be rewritten. Some of these applications do not require knowing where on the face of the earth something is but are instead happy to know where something is along some linear element, like a roadway. Linearly referenced locations are simpler (one dimensional) and in some cases more accurate. As geospatial use continues to expand, an increasing number of applications require the dynamic translation between linearly referenced locations and spatial positions in order to utilize and integrate existing data as it is currently stored. In order to understand the relationship between objects and their location, both linear and spatial, it is advisable to model the concepts involved prior to coding applications. This not only offers an opportunity for consensus building before the more expensive coding step begins, but also enhances communication of the concepts and insures that different applications or merely different encodings of the same application, are compatible because they use the same underlying concepts. This has recently been demonstrated by the joint project between the geospatially oriented OGC Land and Infrastructure SWG and the engineering design oriented buildingSMART International Infrastructure Room where they were able to reach consensus on a common UML conceptual model before the individual respective InfraGML and IFC encodings began. ISO 19148 is the conceptual UML model for LR. It has been adopted as an OGC Abstract Specification and encoded in GML 3.3. It has been adopted by over a dozen other standards (e.g., ISO TC204 GDF, FGDC, COBie) and would therefore provide a sound demonstration of the use of UML modeling of linear referenced and geospatial data and operations.
Knut Jetlund	Norwegian Public Roads Administration	312 From a table based Feature Catalogue to GML Application schemas	The Norwegian Public Roads Administration has a national road database (NVDB) with the road network and features on and around the roads. This includes abstract features types like speed limits, traffic amounts etc, events like accidents, slides etc, and road equipment such as signs, man holes, railings, etc. The total number of feature types in the road database is 371 at the time being. The data is freely available through a REST API (https://www.vegvesen.no/nvdb/api/), and is also included in the national SDI for Norway. The feature catalogue for the road database is maintained in a relational database, and is not completely based on the principles in the ISO/TC211 standards. This has led to some challenges for releasing the data in GML, with application schemas. To overcome the challenges, we have created an AddIn to Enterprise Architect that converts the feature catalogue to UML conceptual models, and further on to GML Application schemas through ShapeChange. The UML models are also connected to the national SOSI Models, and will be included in a complete national model registry for geographic information.

Jørgen Flensholt Henrik Friis	Danish Road Directorate	313 Development and specification of data models and architectures: A model based approach	This presentation describes the model based approach which is used in DRD (Danish Road Directorate) for developing and specifying reference architectures and standard data models for data distribution. The presentation outlines the methods, tools, and modelling principles and patterns which are used for modelling, and describes the governance procedures for the models. The development and specification of a proposal for a national standard data model for distribution of road infrastructure data is used to showcase the model based approach. In general, the reference architectures and standard data models provide a common framework of requirements, design constraints and technologies for IT services, systems and applications which are used to support the business functions of DRD (road planning, road construction, maintenance and administration, and traffic management). The purpose of the framework is to make sure that services, systems and applications are effective, secure, interoperable and flexible. The model based approach is implemented using UML (Unified Modeling Language) as the primary modelling language and EA (Enterprise Architect) as modelling tool. Additional modelling languages include ArchiMate and RDF/OWL. The standard data model for road administrative data is developed using the class diagram notation of UML to define a logical data model. A general requirement for the distribution of data between services, systems and applications is that distribution should be based on established standard data models – in particular the two main European standards, INSPIRE (for road infrastructure data) and DATEX II (for dynamic road traffic data). Specific requirements should be met by developing extensions to the standard models, as far as possible. Both these standard data models have been developed and specified using UML as modelling language and EA as modelling tool. The data model for the distribution of road infrastructure data is defined as an extension (specialization) of the UML data model of INSPIRE following the INSPIRE guidelines for developing national and regional application schemas. This ensures strict compatibility with INSPIRE, and that the model inherits the general properties of the INSPIRE model. The specialization includes models for a proposed common national system for location referencing and for the systems for linear referencing which are used by Danish road authorities at the moment. Furthermore, the specialization includes models for various properties related to the Danish road infrastructure. The location referencing systems are modelled as specializations of the INSPIRE concept of NetworkReference and the properties of the road infrastructure are modelled as specializations of the INSPIRE concept of TransportProperty. Descriptive and explanatory text is embedded in the model and is maintained as part of the model.
Tatjana Kutzner Thomas H. Kolbe	Technische Universität München (TUM)	314 Data Modeling Concepts introduced by CityGML and their Transferability to other Geospatial Application Models	The international OGC standard CityGML is a common Geospatial Information Model for semantic 3D city and landscape models. CityGML has been defined as a conceptual, platform-independent data model using the modelling language UML. Currently, the next major version of CityGML, version 3.0, is being developed which will enrich CityGML with new concepts relevant to the modelling of virtual 3D city and landscape models. Although the concepts aim at enhancing the functionality of CityGML, some of these concepts are by no means specific to CityGML only; they are rather of advantage to any application in the field of geospatial data modelling, such as national or European SDI initiatives, or any other community-specific data modelling tasks. We consider in particular the following CityGML concepts to be universally applicable in any geospatial data modelling task: • A well-known and meanwhile commonly accepted concept introduced by CityGML is the Application Domain Extension (ADE) mechanism. This mechanism allows for enriching existing CityGML feature types with additional application-specific properties by modelling the new properties as subclasses of existing classes as part of a separate ADE model and injecting the properties into the respective superclass during the encoding, thus, applying a so-called super class strategy. In addition, the ADE mechanism also allows for extending CityGML with new feature types. • One of the new concepts in CityGML 3.0 will be a versioning schema which provides the ability to identify and organize multiple states of a city model, to represent the evolution of the city (model) in the form of different versions, and to represent the features as alternatives. This versioning mechanism supports the representation of version transitions as well as of snapshots, i.e. of the state of the entire city model at a specific point in time. • Furthermore, CityGML 3.0 will include a dynamic data schema which aims at tighter coupling of semantic 3D city models and simulations and will allow for representing dynamic variations within a city model through specific types of features which act as modifiers to the static values of the CityGML model. These dynamic variations are time-variant or time depending values of individual spatial and thematic feature properties as well as associations over time and can e.g. be used to represent the variation of sea surface level based on tidal hub or the electrical energy demand of a building along the course of the day, week, or year. • 3D city and landscape models often require the evaluation of alternative scenarios in order to support automated decision-making. The Chair of Geoinformatics at TUM is developing a data model to facilitate this process which relies on key performance indicators (KPI). This indicator model defines the indicators as complex attributes to represent e.g.
Jan Kolar	Grifinor Project	316 Methods and tools to design a computable geospatial model	This contribution will present methods and tools developed in order to design a computable geospatial model. Findings and technology of this effort address many topics of the workshop characterised by the demand for uniform data models, faster implementation cycles, or more streamlined data distribution from data modelling. The resulting design method and technological implementation of geospatial managed objects (GMO) have focus on standardising how the geospatial content can work. This contrasts with attempts focused on standardising data structures and formats for geospatial content. GMOs are based on exhaustive definition of how the content can function, while the common properties of geospatial content are kept to the most abstract minimum. The motivation for standardising the ways in which the provided content can compute is to make change and evolution of data models and their applications the inherent property of the design. Hence GMOs use mostly inverse strategy relatively to the one of traditional standard exchange data formats and protocols, where great flexibility is left to the actual software implementation, but the geospatial representations and data formats are fixed by standard definitions. Having a fixed computation platform and flexible representations on one hand, and flexibility in computation platform with fixed representations on the other hand, provides simplified yet characteristic context of this contribution. The root of the differences between the two alternatives is deep. It provides entire pool of R&D subjects relevant for many technical challenges in designing of geospatial information infrastructure. Today, the state-of-the-art analysis shows that fixed representations of real world features or even their ontology are very difficult to standardise for broad spectrum of domains and applications and that such attempt is bound to be incomplete and prone to frequent changes causing difficulties with adoption. Providing a fixed, compact and standardised computational platform, on the other hand, is a subject with much higher level of progress. Reliable, broadly adopted, industry-proven implementation can be provided. Both alternatives are essentially complementary strategies towards ideal situation when both aspects would be fixed and provide sustainable solution. Causality of the alternatives towards the solution is also important. The cause for the fixed data representations is to mimic the success of standards in many industries with parallels in efforts to standardise office file types or web technologies. Leaving the flexibility of the software implementation out is caused by demand for flexible adoption. The causality in the alternative with the fixed computational platform is to support flexibility and evolution of data representation, which itself is the second aspect of the solution, Thus the effect of the GMO alternative seems to be better aimed towards the solution. Many interesting properties unfold such as that the data format for GMO models is far less significant in practice, that