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Semantic Annotation for Web Services and their Relevance to Environmental Models

~ Enabling Environmental Models as Services on the Web: The ENVISION Approach ~

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Outline

- Environmental models on the Web
  - The need for Model as a Service (MaaS)
  - MaaS Scenarios: Landslide and Oil Spill Risk Analysis
- ENVISION: An infrastructure for MaaS
  - Baseline framework: SWING
  - Emerging trends in semantic annotations for Web services
- Conclusions and outlook

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What are environmental models and what are their limitations? What do we need to overcome them?

Environmental Models

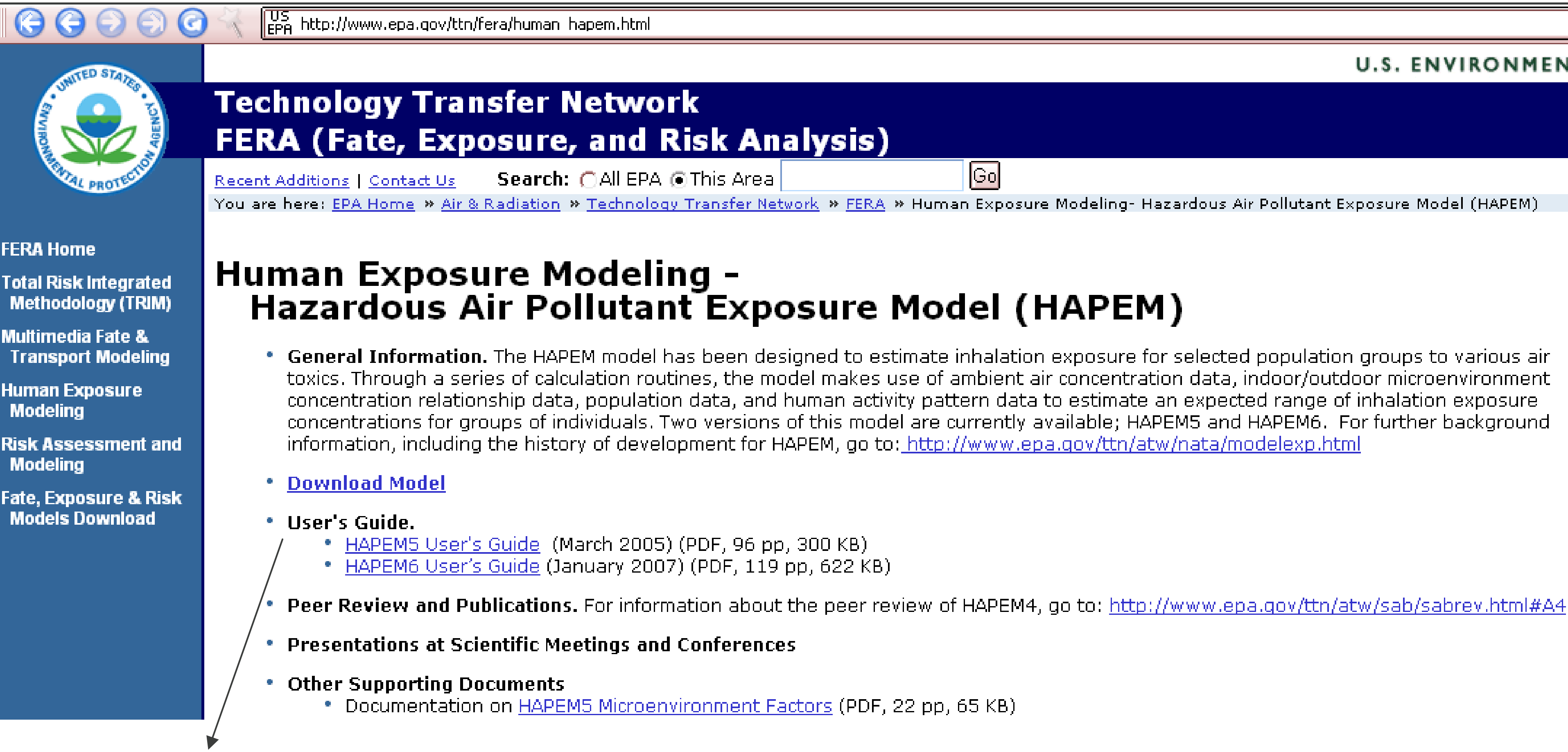
- Computer models that aim to re-create what occurs during some event in nature
- Increasingly significant in decision making
  - Diagnose and examine causes and precursor conditions of events that have taken place (i.e. what happened and why it happened)
  - Forecast outcomes and future events (i.e., what will happen).
- Models are being developed by a wide variety of scientific and engineering disciplines
  - Many types of models, e.g. economic, behavioral, physical, engineering design, health, ecological, transport
  - Good models come from an assortment of disciplines
    - ***Increased interoperability between models is needed!***

Elements of Environmental Models

- Application: the scientific problem of interest
- Algorithm: the numerical/mathematical representation of that problem, the method used to solve the problem, and its materialization in a computer program
- Architecture: the computing platform and software tools used to compute a solution set for the algorithms developed
  - What kind of computer(s) will run the program?
  - What kind of programs will use the information?
  - Will the program be downloaded and loaded onto the permanent storage space of a computer, or will it be run over the Internet?
  - …

How can the architecture enable interoperability between models?

Environmental Model – An Example



http://www.epa.gov/ttn/fera/human_hapem.html

U.S. ENVIRONMEN

Technology Transfer Network
FERA (Fate, Exposure, and Risk Analysis)

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Human Exposure Modeling - Hazardous Air Pollutant Exposure Model (HAPEM)

- **General Information.** The HAPEM model has been designed to estimate inhalation exposure for selected population groups to various air toxics. Through a series of calculation routines, the model makes use of ambient air concentration data, indoor/outdoor microenvironment concentration relationship data, population data, and human activity pattern data to estimate an expected range of inhalation exposure concentrations for groups of individuals. Two versions of this model are currently available; HAPEM5 and HAPEM6. For further background information, including the history of development for HAPEM, go to: http://www.epa.gov/ttn/atw/nata/modelexp.html
- **Download Model**
- **User's Guide.**
  - HAPEM5 User's Guide (March 2005) (PDF, 96 pp, 300 KB)
  - HAPEM6 User's Guide (January 2007) (PDF, 119 pp, 622 KB)
- **Peer Review and Publications.** For information about the peer review of HAPEM4, go to: http://www.epa.gov/ttn/atw/sab/sabrev.html#A4
- **Presentations at Scientific Meetings and Conferences**
- **Other Supporting Documents**
  - Documentation on HAPEM5 Microenvironment Factors (PDF, 22 pp, 65 KB)

…

The HAPEM6 programs use twelve user-supplied input data files, and two or more parameter files. All are in ASCII format. A parameter file identifies the user-supplied input files, the output files available to the user, and specifies the parameter settings for a model run.

…

Characteristics of Environmental Models

- Static, centralized, and closed systems
- Tightly coupled components
  - Integration of components requires significant work
  - Low level of reuse and sharing
- Isolated systems with limited audience (i.e. experts)
  - The growth of the system is planned
  - Limited possibilities for wider community involvement in model reuse and development

=> *There is a clear need for a dynamic, open, distributed and shared environmental modeling infrastructure that enables a high level of model reuse and is easily accessible for both experts and non-experts!*

Relevant Computing Trends for Environmental Models

- Software as a Service (SaaS)
  – Evolution of applications that are delivered at runtime over the Internet
- Semantic Web Services (SWS)
  – Automated discovery, composition, mediation of Web services, based on their semantic annotations

=> ***Model as a Service (MaaS) = Models + SaaS + SWS***

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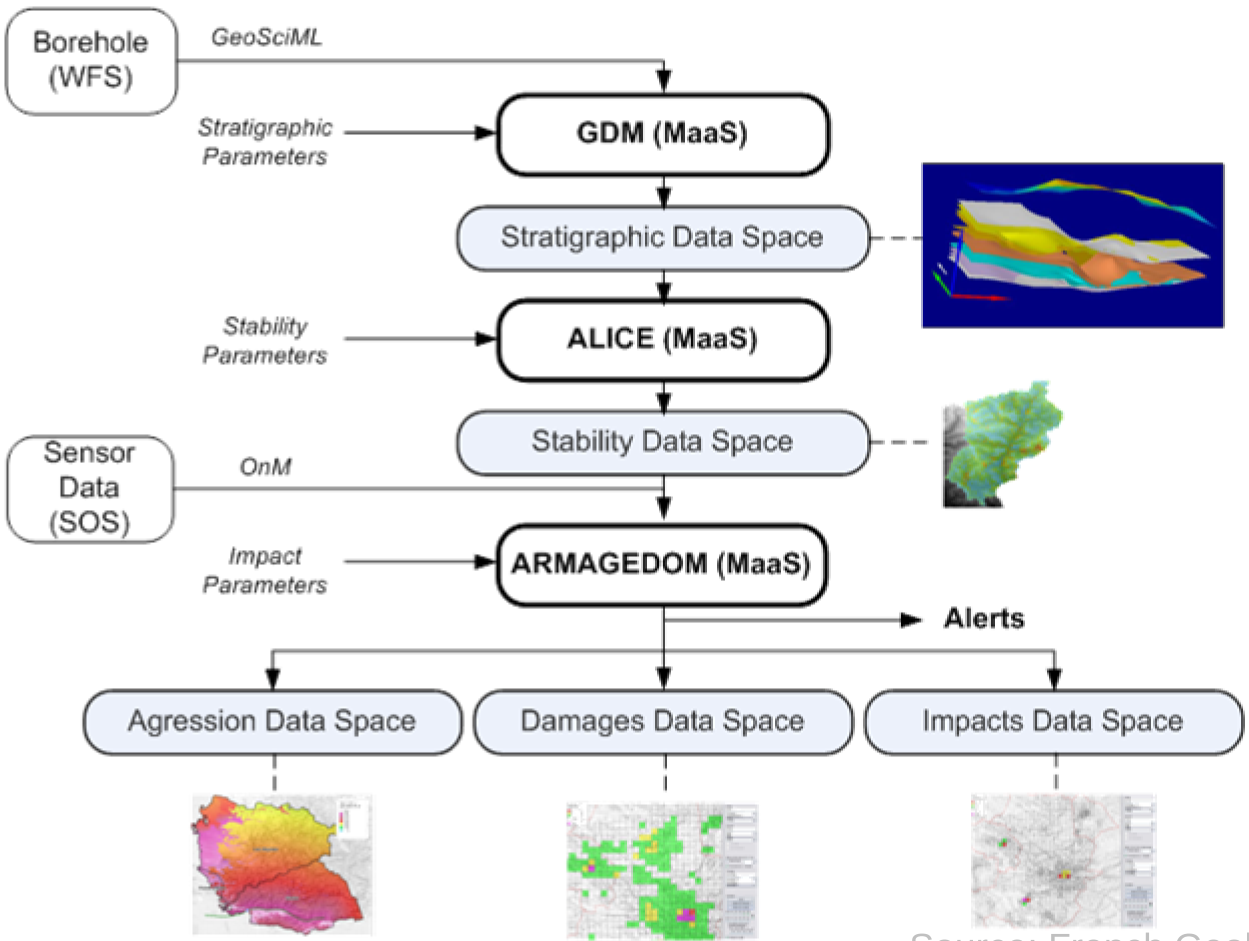
What kind of scenarios does MaaS target?

MaaS Scenario – Landslide Hazard Risk Assessment

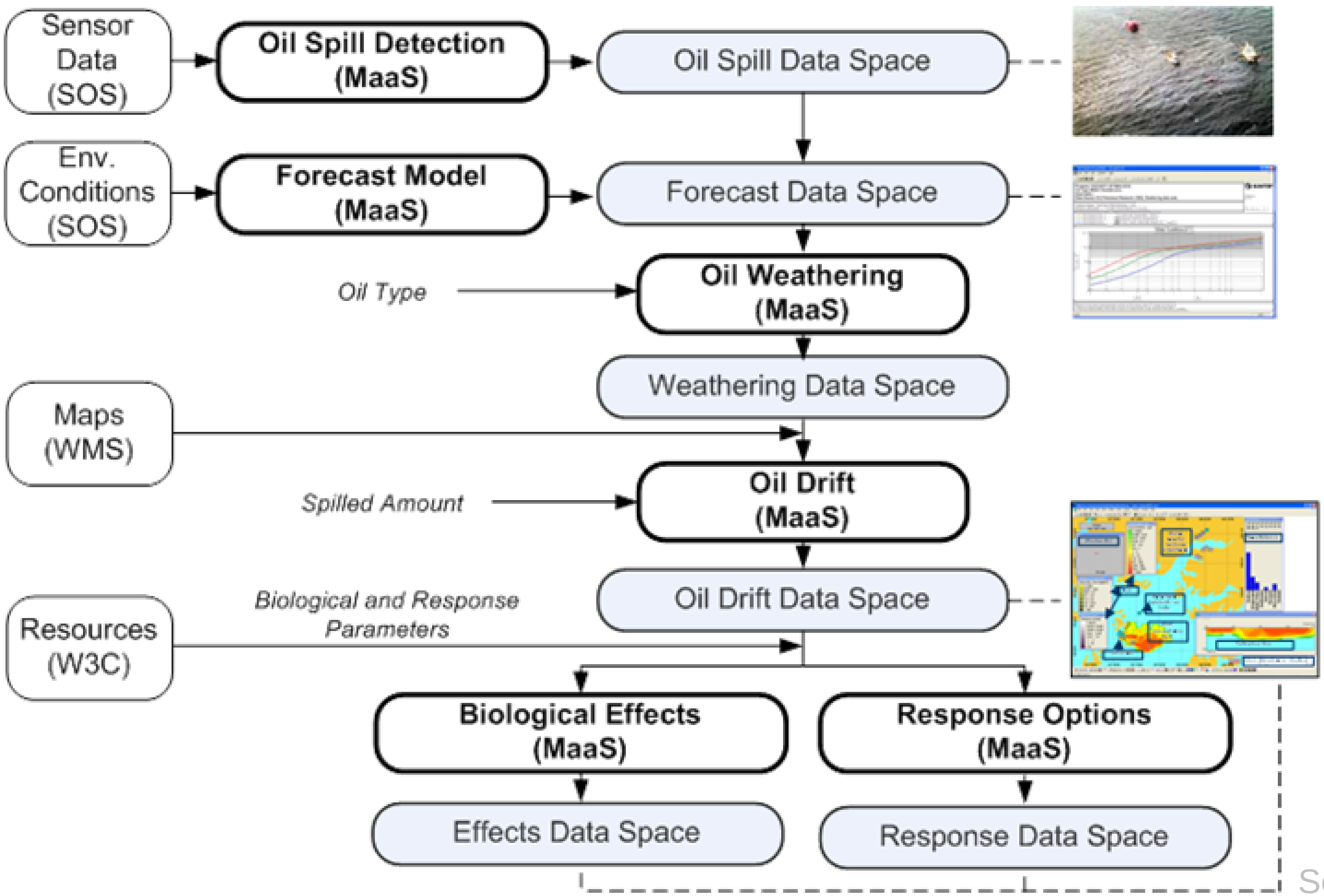
How to set up Web services that can be manipulated by non-technical operators and can simulate damage under different climatic and/or another potential trigger (e.g. earthquake) for landslides scenarios?



Source: French Geological Survey (BRGM)

MaaS Scenario – Oil Spill Risk Analysis

How to set up Web services that can be manipulated by non-technical operators and can enable a quick and adequate response in order to minimize biological consequences of oil spills at sea?



Source: SINTEF

A General Scenario for MaaS – User Operations

- **Design time**
  (provide on-the-shelf modeling solutions)
  - Discover existing resources
  - Build the modeling workflow
  - Register/Annotate the new Service

- **Set-up time**
  (connect the appropriate sources of information to feed the modeling service)
  - Discover existing Modeling Services
  - Select a region of interest
  - Discover existing data sources
  - Select the data sources
  - Set the parameters
  - Play the scenario

- **Execution time**
  (interact with the information provided by the models and monitor the system)
  - Discover existing Modeling Services
  - Select a region of interest
  - Discover existing data sources
  - Select the appropriate sensors data streams
  - Select functional parameters for the alerting system

Semantic Annotations are a key enabler for discovery of services!

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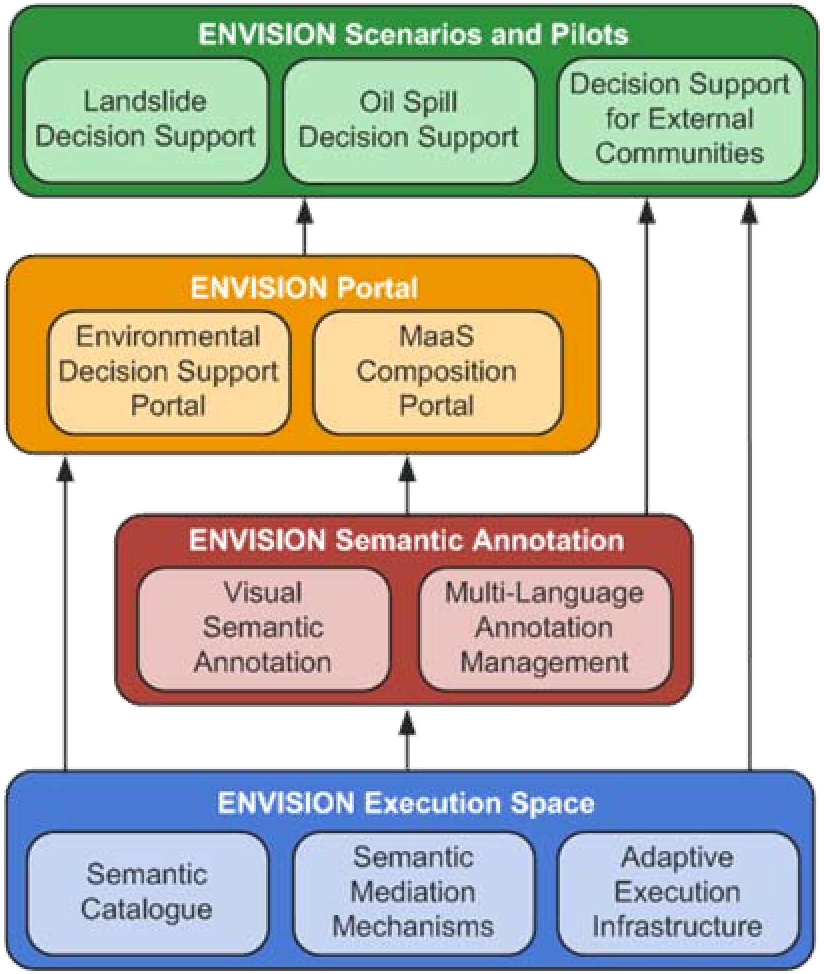
What kind of components are needed to realize MaaS?

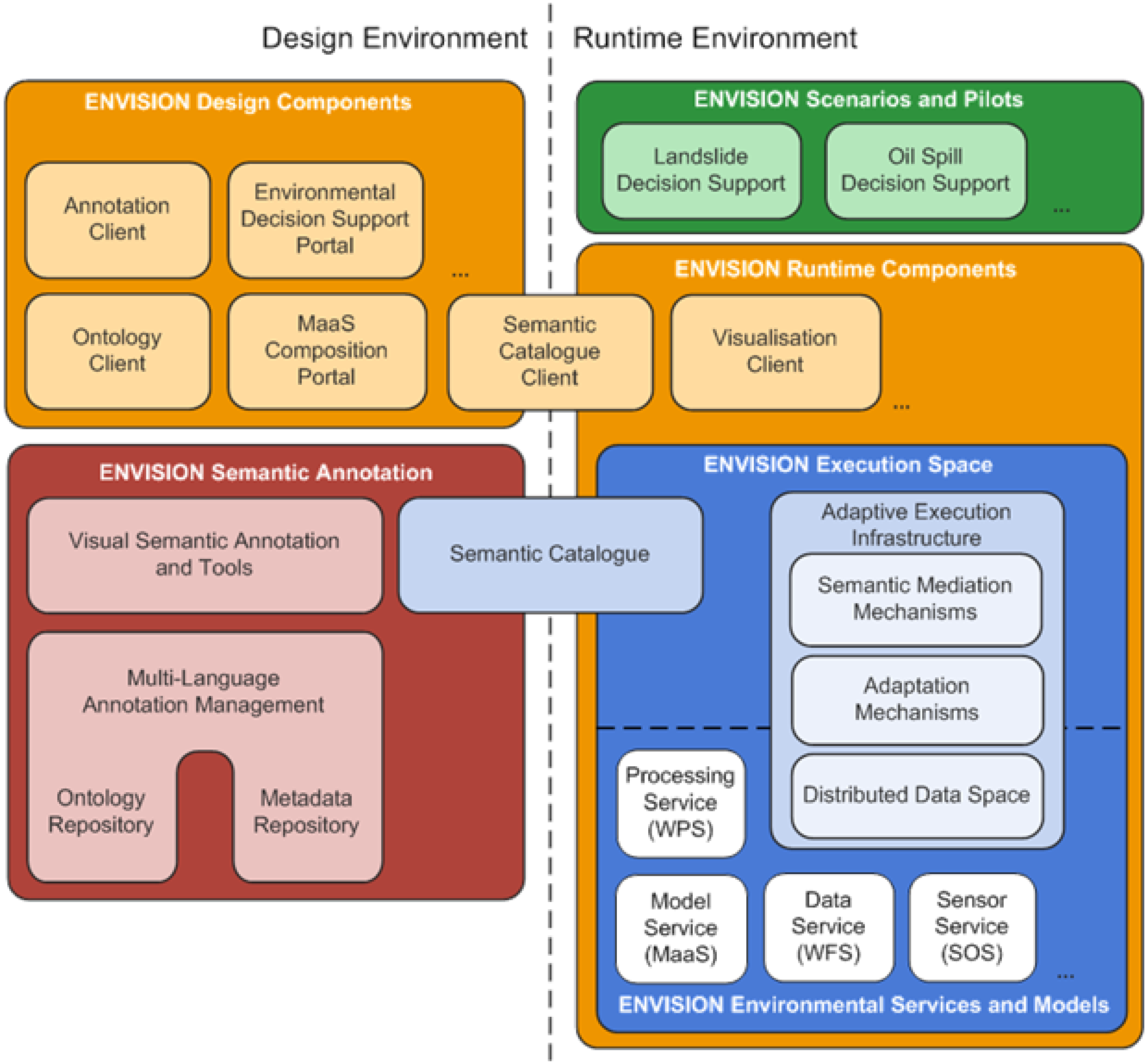
ENVISION – An Infrastructure for MaaS

- **ENVI**ronmental **S**ervices **I**nfrastructure with **ON**tologies

- Portal with a pluggable decision support framework
  - Visual service chaining
  - Migration of existing models to MaaS
- Semantic annotation infrastructure
  - Visual semantic annotation mechanism
  - Multilanguage ontology management
- Execution space
  - Semantic discovery catalogue
  - Semantic service mediator
  - Adaptive service chaining execution



ENVISION Architecture



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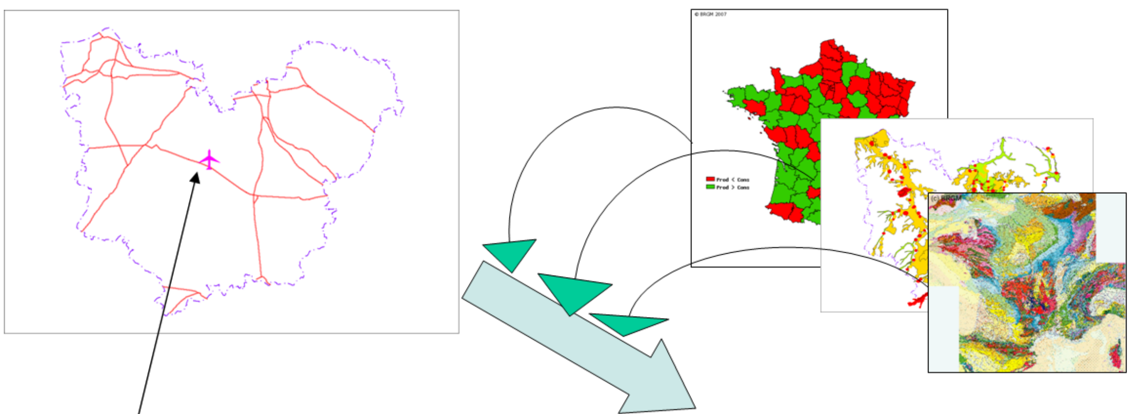
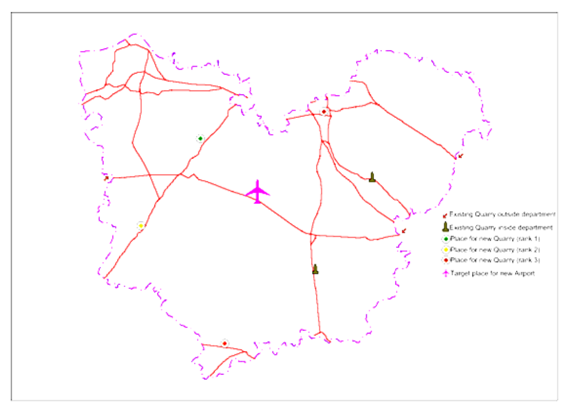
What framework can be reused for ENVISION?

SWING: A baseline framework for ENVISION

- **S**emantic **W**eb Services **In**teroperability in **G**eospatial decision making
- A framework for semantic discovery and composition of geospatial services
- Prototyped in the area of Mineral Resources Management



Substances	Quantity(*)
Sand	**110 000 tons**
Granite	**50 000 tons**
Concrete	**200 000 tons**



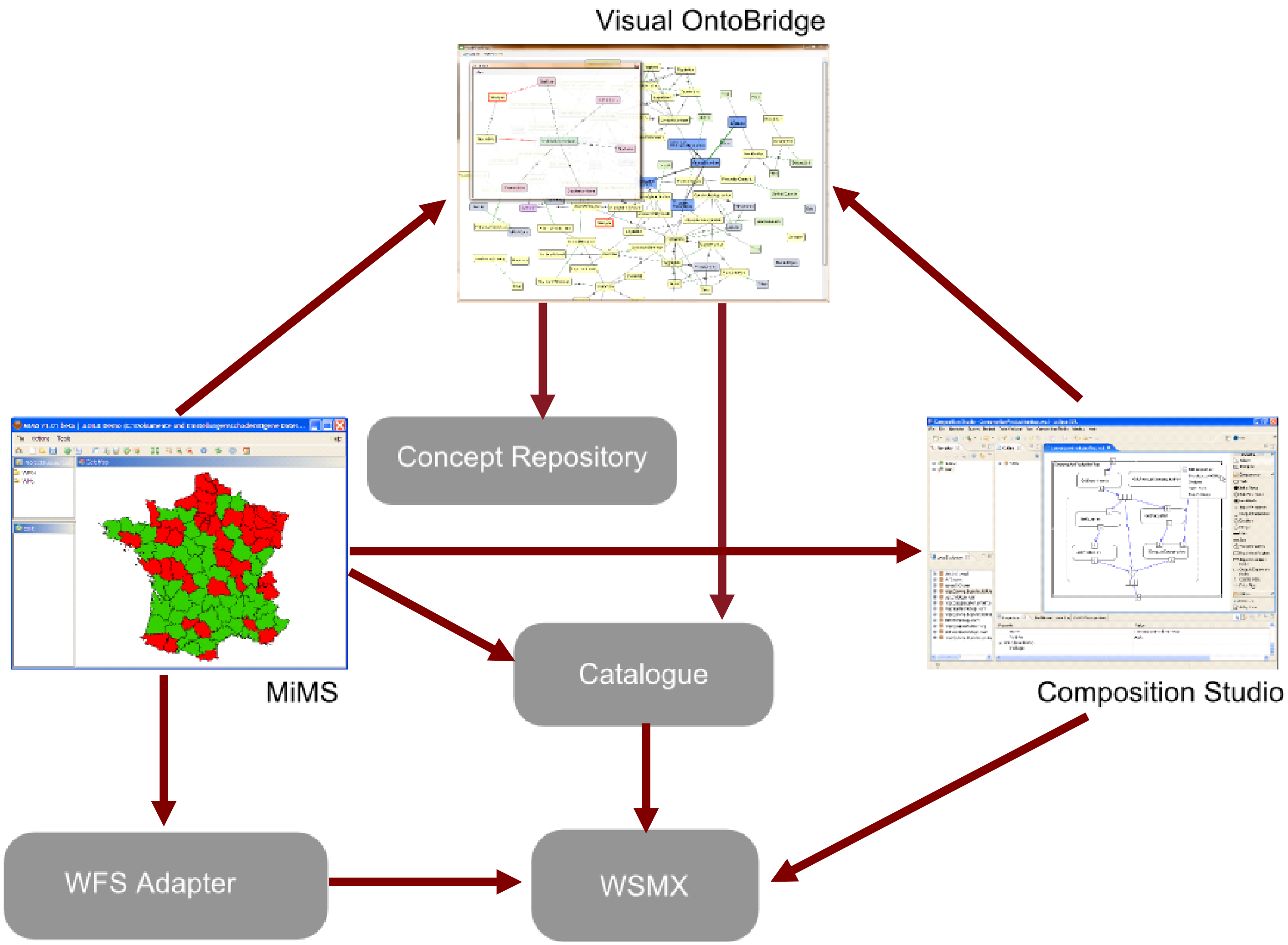
http://www.swing-project.org/

SWING components and tools

- **MiMS**: Environment for domain expert. Convenient semantic annotation & discovery; use composed services like standard OGC services
- **WSMX**: Semantic web services platform. Geospatial semantic discovery; execution of composed services
- **Concept Repository**: Ontologies for semantic annotation. Used throughout components
- **Visual OntoBridge**: Annotation tool. Semi-automatic annotation of services and queries; provides user with most plausible annotations
- **Catalogue**: OGC Catalogue. Semantic discovery in interaction with WSMX; also provides adapter OGC $\leftrightarrow$ WSMX execution
- **Composition Studio**: Environment for IT expert. Convenient semantic annotation & discovery; graphically compose services; automatic export into WSMX service execution

To be reused and enhanced in ENVISION!

SWING – High-level Architecture



See demo at http://www.swing-project.org/showcase.html

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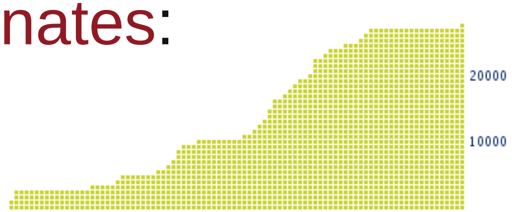
Which semantic annotation framework is appropriate for ENVISION's models as services?

Web Services – State of the Art

- Numbers of WSDL services
  - Number of unique public WSDL-based services < 30.000 [seekda.com, March 2009]
  - Large, but unknown, number of Intranet and enterprise services
- WSDL growth stagnates:

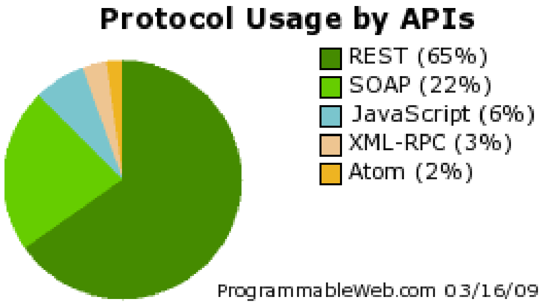


Number of Web services found during the past 26 months
[seekda.com, March 2009]

- Significant growth of Web APIs

  > 1.100 Web APIs on ProgrammableWeb.com

  > 3.700 Mashups on ProgrammableWeb.com
  (combining Web APIs from one or more sources)



Most service interfaces are proprietary Web sites, or FTP downloads of ASCII files

➔ More than 90% of the services on the Web are not described with machine-readable service interfaces!

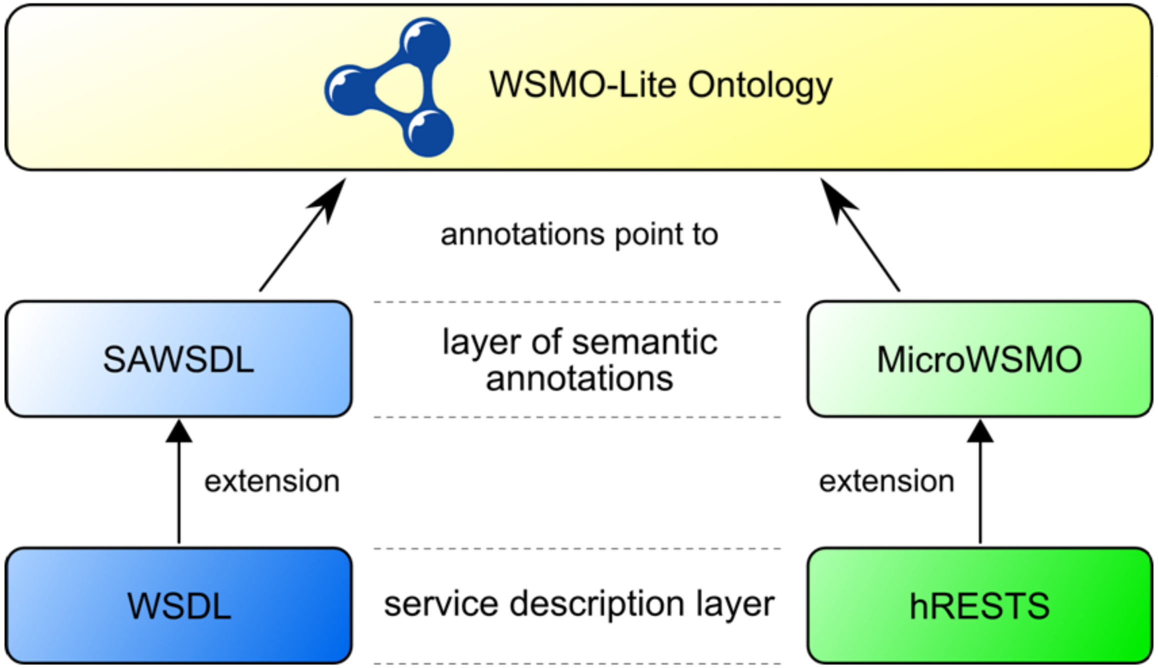
Semantic Web Services – State of the Art

- Existing approaches: OWL-S, WSMO
- They are (perceived as) complex
  - Little adoption, coming slowly
- More pragmatic solution needed
  - Scale down, modularize
  - Encompass RESTful services

  => SWS-Lite

SWS-Lite – Service Annotations for ENVISION

WSMO-based annotation mechanism for WSDL and RESTful services



simple service semantics

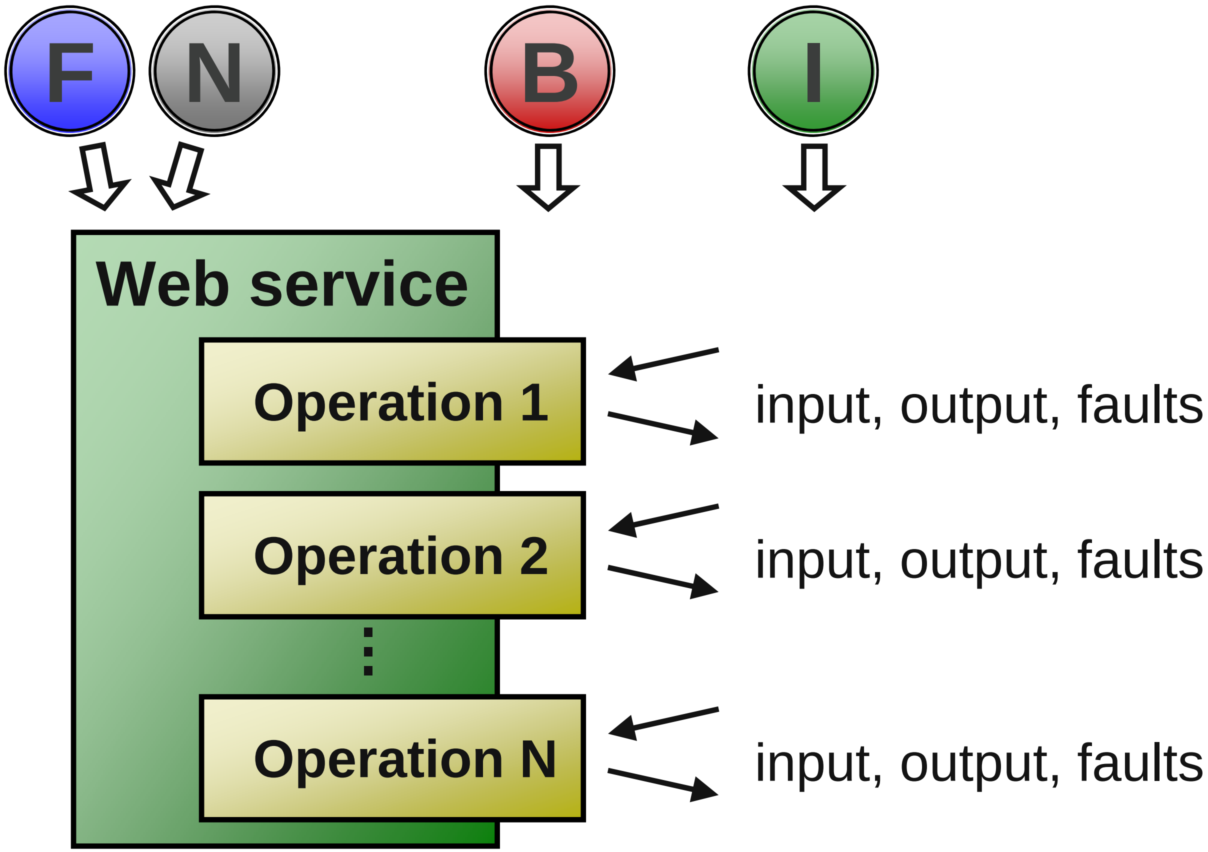
SAWSDL for hRESTS

WSDL in HTML

Types of Service Semantics

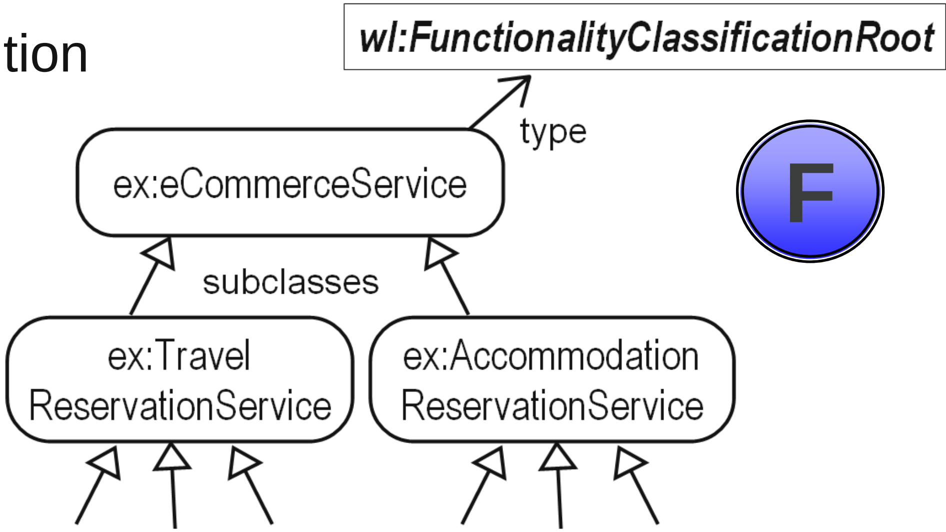
- **Functional**
  - What the service does
- **Behavioral**
  - How the client talks to the service
- **Information model**
  - For handling data
  - Incl. lifting/lowering
- **Nonfunctional**
  - Policies, QoS, price, location etc.

Semantic Annotations



Functional and Nonfunctional Semantics

- Functional Semantics
  - For service discovery, composition
  - *Category*
    - Functionality categorization
    - E.g. eCl@ss
  - *Capability*
    - *wl:Precondition, wl:Effect*
    - Using WSML rule languages



- Nonfunctional Semantics
  - For ranking and selection
  - Not constrained, any ontologies
  - Example: ex:PriceSpecification
    rdfs:subClassOf *wl:NonFunctionalParameter* .
    ex:ReservationFee
    rdf:type ex:PriceSpecification ;
    rdf:value "15"^^ex:euroAmount .

Behavioral and Information Semantics

- Behavioral Semantics
  - For invocation, composition, process mediation
  - Functionalities on operations
    - Capabilities, categories
  - Client selects operation to invoke next
    - Instead of being strictly guided by an explicit process

- Information Semantics
  - For invocation, composition, data mediation
  - Not constrained, any ontologies
  - Marked as *wl:Ontology*

WSMO-Lite – Service Semantics

- WSMO-Lite elements
  - *wl:Ontology*
  - *wl:FunctionalityClassificationRoot*
  - *wl:Precondition*
  - *wl:Effect*
  - *wl:NonFunctionalParameter*
- WSMO-Lite
  - Identifies the types and a simple vocabulary for semantic descriptions of services (a service ontology) as well as languages used to define these descriptions
  - Defines an annotation mechanism for WSDL and RESTful services using a simple service ontology
  - Provides the bridge between WSDL, SAWSDL RESTful services, and (existing) domain-specific ontologies such as classification schemas, domain ontology models

Conclusions and Outlook

- Environmental models are important for decision making
  - Models' current limitations hinder their reuse and interoperability
  - A platform of interoperating models is needed
- MaaS aims to combine SaaS and SWS to overcome the existing limitations of environmental models
- ENVISION: An emerging infrastructure for realizing MaaS
  - SWING provides a set of components and tools to be reused and enhanced
  - A pragmatic approach to service annotations is needed: WSMO-based SWS-Lite

Thank you!

Acknowledgements

- Initial ideas behind the MaaS concept, ENVISION infrastructure and its current use cases emerged as a result of discussions and collaboration with Arne J. Berre (SINTEF ICT, Norway), Sven Schade and Patrick Maué (University of Muenster, Germany), Nils Rune Bodsberg (SINTEF Environmental, Norway), and Joël Langlois (BRGM, France)
- The WSMO-Lite semantic annotation approach to SWS is being developed in the the Conceptual Model for Services Working Group, Jacek Kopecky (STI Innsbruck, Austria) has been a core person behind WSMO-Lite