Project No. 249024

NETMAR

Open service network for marine environmental data

Instrument: *Please tick*	CA	✓ **STREP**	IP	NOE

ICT - Information and Communication Technologies Theme

D8.3 Final Scientific Report

Reference: D8.3_Final_Scientific_Report_r1_20130307

Due date of deliverable (as in Annex 1): M0 + 36
Actual submission date: 7 March 2013

Start date of project: 1 February 2010 Duration: 3 years

Nansen Environmental and Remote Sensing Center

Revision 1

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

European Commission
Information Society and Media

NETMAR

Open service network for marine environmental data
Project Reference: 249024
Contract Type: Collaborative Project
Start/End Date: 01/03/2010 - 31/01/2013
Duration: 36 months

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Acknowledgements

The work described in this report has been partially funded by the European Commission under the Seventh Framework Programme, Theme ICT 2009.6.4 ICT for environmental services and climate change adaptation.

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Document approval

- Document status: Revision 1
- WP leader approval: 2013-02-07
- Quality Manager approval: 2013-02-07
- Coordinator approval: 2013-02-07

Revision History

Issue	Date	Change records	Author(s)
Draft	2013-01-15	Topic layout for the report.	T. Hamre
Draft	2013-02-19	Inserted first description of dissemination and exploitation. Inserted report on social implications, general part. Inserted outline of main results section.	T. Hamre, S. Sandven
Draft	2013-02-27	Added description of impact, and revised dissemination and exploitation section. Updated report on social implications. Revised section on main results.	T. Hamre
Draft	2013-03-06	Added description of architecture, semantic search and semantic framework, uncertainty representation and propagation, service mark up and service chaining with semantic checking. Added description of EUMIS usage in a major crisis exercise entitled "POLMAR Baie de Seine 2012". Added summary of project context and objectives, and first version of executive summary. Elaborated dissemination section.	A. Pattersson, A. Leadbetter, R. Lowry, Y. Lassoued, M. Grant, P. Walker, V. Gouriou, Ø. Torget T. Hamre, D. Dunne, M. Treguer
Draft	2013-03-07	Completed workforce statistics and other sections. Added executive summary.	T. Hamre, M. Grant, P. Walker
1	2013-03-07	First version of the report approved by the coordinator.	T. Hamre

Executive Summary

Efficient environmental monitoring and forecasting requires timely access to a wide range of data sources, including satellites, in situ instruments, human observations, empirical and forecasting models. Data are complex, heterogeneous, distributed – and quite often sparsely documented using different terminology for the same geophysical parameter. Thus, the first problem to overcome is the discovery of relevant datasets and services that can provide such. Next, data must be accessed, interpreted, analysed and co-visualised, encapsulating their original storage form, spatio-temporal resolution and map projection, to give seamless access through a common entry point, a web portal. To advance current web GIS solutions for the marine domain, NETMAR's overall objective was to advance web GIS technologies to better meet these needs in the marine domain, demonstrating the results through a pilot European Marine Information System (EUMIS) for searching, downloading and integrating satellite, in situ and model data from ocean and coastal areas.

NETMAR has developed novel core technologies in the fields of ontologies, web processing services and semantic search, which are supporting and demonstrated by a pilot European Marine Information System (EUMIS) for searching, downloading and integrating satellite, in situ and model data from ocean and coastal areas. EUMIS uses a semantic framework coupled with ontologies for identifying and accessing distributed data, such as near-real time, forecast and historical data. The technologies, working methods and EUMIS pilot as well as the data delivery and processing services that the project has produced, are openly available and strengthen and further develop sustainable services and systems for GMES, GEO and other monitoring programmes for the marine environment.

The EUMIS portal and components are based on a portal framework that supports the Java Portlet Specification V1 and V2, and is licensed as Open Source software. NETMAR has developed three major portal components: (1) a GIS Viewer, (2) an Ontology Browser and Search Client, and (3) a Service Chaining Editor, all through use of open source software and standard libraries. NETMAR has also developed other tools and services for web-based GIS, e.g. PyWPS and NERC Vocabulary Server (NVS) V2. PyWPS is an Open Source tool that implements the OGC Web Processing Service (WPS) standard. It can be used to develop data processing services that can be combined in service chains generating new products on the fly. The NVS V2 provides online access to the NETMAR Semantic Resource that links NETMAR terminology to the vast ontologies defined during SeaDataNet and many other research projects during the last two decades.

NETMAR have been disseminated at international conferences and workshops, among others FOSS4G 2010, EGU 2011, EuroGOOS 2011, EGU 2012, AGU 2012, as well as at dedicated user community meetings (e.g. ICAN-5, EuroICAN 2012 and French national oil spill monitoring workshops). As a means to support capacity building, the project has also produced a series of cookbooks that can be used by other marine organisations to develop services of their own. The NETMAR Cookbooks cover themes such as setting up a WPS service, defining metadata and setting metadata catalogues, understanding ontologies, and more. The cookbooks are available on the NETMAR public web site.

Several NETMAR results have already been exploited in external communities. The public PyWPS wiki has received approximately 20000 hits since it went live in 2011, and is accessed by about 250 unique visitors per week. This indicates that PyWPS is being widely used to develop WPS services. The Vocabularies and Semantic Search services of the NVS, are being used by SeaDataNet-2 as well as two major U.S. programmes for oceanographic data management (BCO-DMO, R2R). The Ontology Browser/Search Client is being used in the ICAN portal, and search technologies and tools are foreseen to be re-used in the further development of the Marine Irish Digital Atlas (MIDA) coastal web atlas.

The final version of services, tools and the EUMIS portal were evaluated by users from all four user communities (sea ice, oil spills, ocean color, coastal web atlases). Besides testing, the users also assessed the potential impact of the NETMAR results in the coming 3-5 year period. The users involved in impact assessment were categorised as service providers/builders, operational service users, scientific service users and others (e.g. consultants). Based on the overall positive evaluation of NETMAR outputs and the already occurring uptake in external (to the project and its user base) communities, we are confident that many components of the NETMAR system and services will have a positive impact on the development of environmental services and systems in the coming 3-5 year period. NETMAR outputs are foreseen to be used not only in the application domains targeted by the four EUMIS pilots, but also in other environmental domains as well as across domains.

Contents

1 Project context and objectives

1.1 Project motivation

There is a growing wealth of data and data products from the oceans and seas, covering a wide range of marine disciplines, derived from in situ and remote sensing observations, in real-time, near-real-time, and delayed mode. These data are acquired as part of routine monitoring activities and research projects by more than a thousand institutes and agencies throughout Europe. To utilize these data it is vital that users can easily discover and access available data and data products in common formats with known quality.

A major challenge in European marine research and monitoring is to establish a common data management approach to be adopted by all actors to ensure marine data are available. A number of on-going initiatives and organisations are progressing in mobilising and coordinating a large part of the marine data management field in Europe. These include SeaDataNet (EC FP6), SeaDataNet-2 (EC FP7) for delayed mode data, ESONET (EC FP6) for long-term, sea floor, multi-disciplinary observatories, and national efforts coordinated within the EuroGOOS regions for operational oceanography, EUMETSAT and ESA GMES for satellite data, images and products.

An increasing number of datasets are available online, many through standard data exchanges protocols. Some providers also offer search facilities for their own data repositories, but while these are time saving, they are typically restricted to plain text search in one language or to keywords defined by an expert use. There is no common system in place allowing users to search and access data across multiple providers' data holdings, multiple languages and application domains. To implement a European system for discovery and access to marine data, recommendations have been made to develop a system of systems where interoperability between databases or data repositories will be achieved by use of common standards, protocols and OGC-compliant tools [EGOOS08] [EMOD08].

InterRisk[1] was a Specific Targeted Research or Innovation Project (STREP) under the FP6 ICT Programme. The InterRisk project developed a pilot system for interoperable GMES monitoring and forecasting services for environmental risk management in marine and coastal areas. This pilot was comprised of an open system architecture based on noted GIS and web standards, and integrated services for several European regional seas, including Norwegian, UK and Irish, French, German and Polish, and Italian waters. These services include basic services, such as delivery of satellite data products, in situ measurements, and met-ocean model forecasts as well as metadata catalogues facilitating product discovery. These services also include complex services such as detection of oil spills in satellite radar imagery, oil drift predictions for confirmed spills, and identification of ocean areas of high chlorophyll-a concentration. The complex services were realised by processing services (WPS) which were chained by operators of the pilot developers. All service and system development were based on noted web-GIS standards, in line with INSPIRE recommendations. The underlying infrastructure for the InterRisk pilot was the Service Support Environment (SSE)[2], which is a commercial system owned by ESA. The data delivery and processing services in InterRisk were developed mostly using open source software, such as GeoServer, MapServer and pyWPS. NETMAR has built on these open source tools and knowledge of OGC and other web-GIS protocols that were used for development of the service network in InterRisk. To develop an open source web portal, NETMAR has used the Liferay Community Edition portal framework.

[1] http://interrisk.nersc.no/

[2] http://services.eoportal.org/

In environmental monitoring and forecasting, there is a strong need to integrate data from all available sources to get an optimal foundation for decision-making. The NETMAR system of system concept is based on this concept, with a Service Network integrating many different types of remote sensing data from satellites, and aircrafts and other airborne platforms, in situ observations from among others vessels and buoys, as well as numerical predictions made by simulation models. Each data source go through a series of processing steps from the initial acquisition, through calibration, quality control and archival, generation of derived parameters and combined data products, and distribution of these products through a standardised web-GIS.

Figure 1-1 illustrates the underlying system-of-systems concept for EUMIS, where different types of data are collected and processed by appropriate receiving systems before being delivered and further processed into products by e.g. a service provider. At this stage, the products are typically stored in standard formats, with metadata describing its contents and how to use the data, and accessible via Internet through a standard protocols such as WMS or OPeNDAP. Some data products may be used directly in synthesis and decision-making in the EUMIS portal, where as other products are being used as input to processing services that e.g. combine multiple products or calculate statistics or indicators based on them. The EUMIS portal offers so-called “smart search” (i.e. semantic search), rich co-visualisation and layer manipulation features, and composition and execution of workflows (service chains) to generate higher-order or customised products for the end-user. EUMIS also offers a Wiki with product information, tutorials, etc. and can be extended with news services (e.g. RSS feeds) and/or forums, if desired by the targeted user communities.

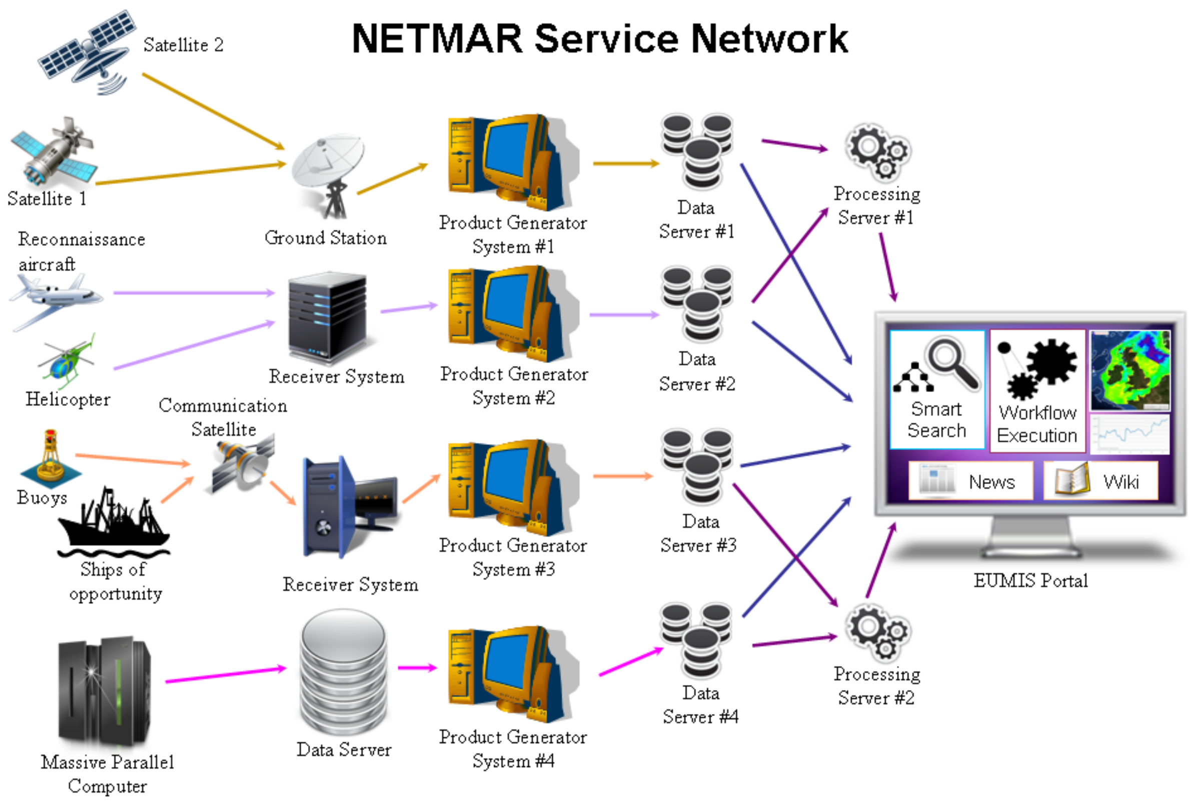

Figure 1-1 *The NETMAR Service Network*.

1.2 Project objectives

The overall objective of NETMAR was

- To ***develop a pilot European Marine Information System (EUMIS) for searching, downloading and integrating satellite, in situ and model data from ocean and coastal areas***. It will be a user-configurable system offering flexible service discovery, access and chaining facilities using OGC, OPeNDAP and W3C standards. It will use a semantic framework coupled with ontologies for identifying and accessing distributed data, such as near-real time, forecast and historical data. EUMIS will also enable further processing of such data to generate composite products and statistics suitable for decision-making in diverse marine application domains.

The implementation of EUMIS was done through a set of use cases from different marine application domains, ranging from near-real time monitoring and forecasting of marine pollution to exploration of decadal time series for assessment of climate changes.

The pilot European Marine Information System (EUMIS) web portal is publicly available at http://eumis.nersc.no/ (*Figure* 1-2). EUMIS consists of 4 pilots provided by the NETMAR service provider institutions, each demonstrating different capabilities in different marine application domains:

- Pilot 1: Arctic Sea Ice and Met-Ocean Observing System
- Pilot 2: Oil spill drift forecast and Shoreline Cleanup assessment services in France
- Pilot 3: Ocean Colour – Marine Ecosystem, Research and Monitoring.
- Pilot 4: The International Coastal Atlas Network (ICAN)

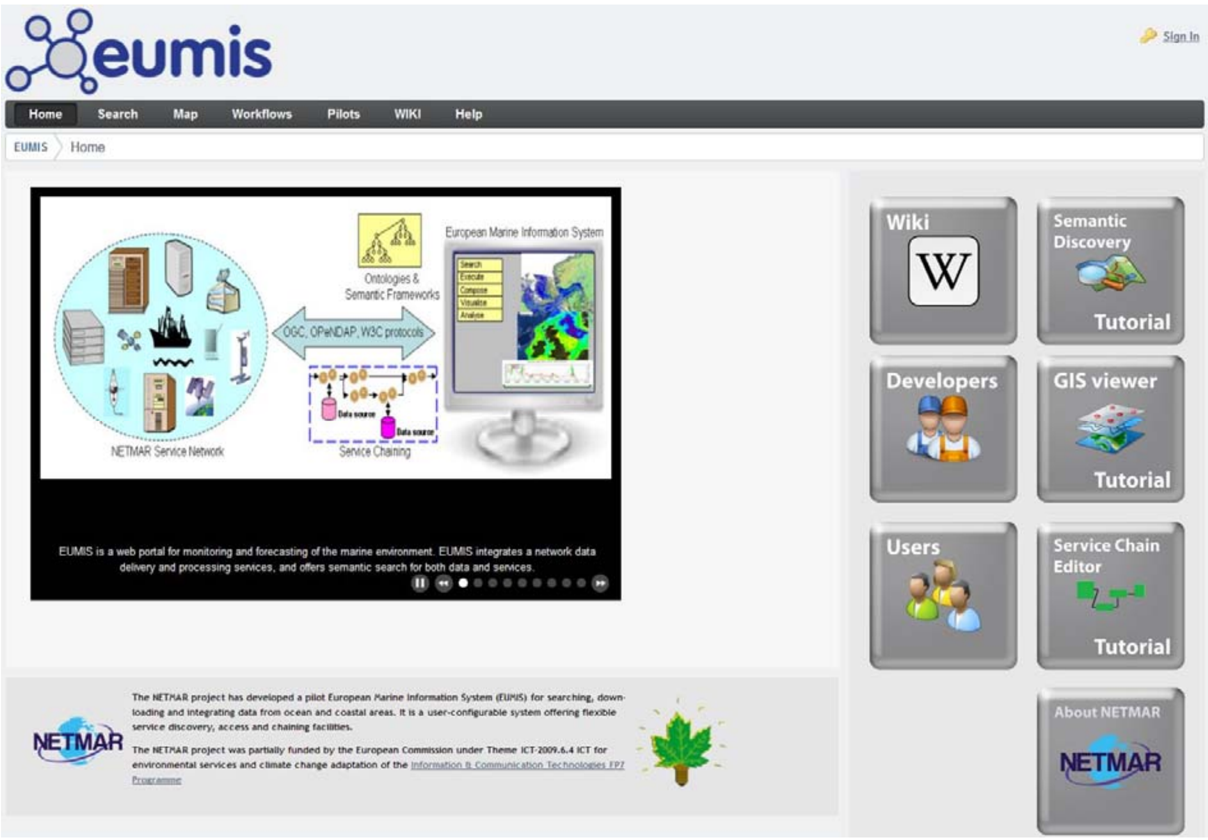

Figure 1-2 *The EUMIS web portal*.

2 Main results

2.1 Overall strategy and achievements

NETMAR's overall strategy has been to build on established protocols, technologies and tools for the development of a European Marine Information System (EUMIS) for monitoring, management and decision-support. Adopting internationally accepted standards for web services, web-GIS, ontologies and data and metadata formats, enables interoperability between the developed services and subsystems, thereby contributing to sustainability. W3C, OGC and ISO standards will persist and continue to be developed by a global user community, ensuring a wide range of implementations, both open source and commercial, from which future services and systems can be cost-effectively developed and maintained.

The approach taken in the project was thus to begin with the development of a closely linked semantic web (via BODC vocabularies in the NERC Vocabulary Server), feeding into metadata (allowing semantic discovery) and service mark-up (allowing semantic validation). Processing services were wrapped into standards (WPS and SOAP) that allow easy integration with the Taverna workflow engine and other orchestration frameworks (and entry into the DataCORE); these brought together via a graphical, semantically-enabled web-based chaining editor. The ontology browsing, discovery and visualisation clients and chaining editor brought together into a common portal framework, and used to demonstrate the potential improvements that the semantic technologies deliver in the context of 4 application areas in the marine domain. All components developed are open source to maximise reuse. The key advances in the project are therefore:

- The NETMAR Semantic Resource embedded in the vocabulary services and supporting ontologies.
- The discovery client and supporting logic that enables semantic discovery, using the vocabulary entries to identify related items that are not direct string matches (potentially even in another language)
- The web service chaining editor; the first example of an online WPS orchestration system, with semantic validation of workflows
- The GIS viewer, an open source portal component with a range of capabilities, including execution of WPS processes.
- The EUMIS portal, linking together the various components in a common framework and demonstrating the new technologies.
- The ideas, architectural concepts and standards-affecting or best-practice recommendations that will carry on or influence future work.

2.2 Overview of major results

NETMAR has developed novel core technologies in the fields of ontologies, web processing services and semantic search, which are supporting and demonstrated by a pilot European Marine Information System (EUMIS) for searching, downloading and integrating satellite, in situ and model data from ocean and coastal areas. EUMIS uses a semantic framework coupled with ontologies for identifying and accessing distributed data, such as near-real time, forecast and historical data.

The infrastructure for semantic search is underpinned by the NERC Vocabulary Server V2, the NETMAR Semantic Framework [Las12], the Semantic Web Service (SWS) and the Catalogue Services for the Web Mediator (CSWM). The semantic mark-up is defined by the NETMAR metadata profile [PHD+13], which is encoded according to the ISO 19139 standard.

The architecture of the infrastructure, service network and EUMIS web portal is illustrated in *Figure* 2-1 . The portal supports applications including GIS map viewer, smart search and discovery client, and service chaining editor. These application components rely on the underlying service-oriented architecture, where there are seven main service components.

1. **Discovery Service:** data and service discovery service using CSW standard.
2. **View Service**: data view service using WMS standard.
3. **Download Service**: data download service using WFS, WCS, SWE, and OPeNDAP standards.
4. **Processing Service:** data processing service using WPS standard.
5. **Orchestration Engine Service:** workflow engine service (invoked via direct RESTful interface wrapped in a WPS).
6. **Smart Search Service**: smart search service using bespoke CSWM (CSW Mediator), an extension of the CSW to support smart search.
7. **Semantic Service**: provides interface for retrieving knowledge from the NETMAR ontologies using bespoke SWS (Semantic Web Service). This is used by the other components which require knowledge from ontologies.

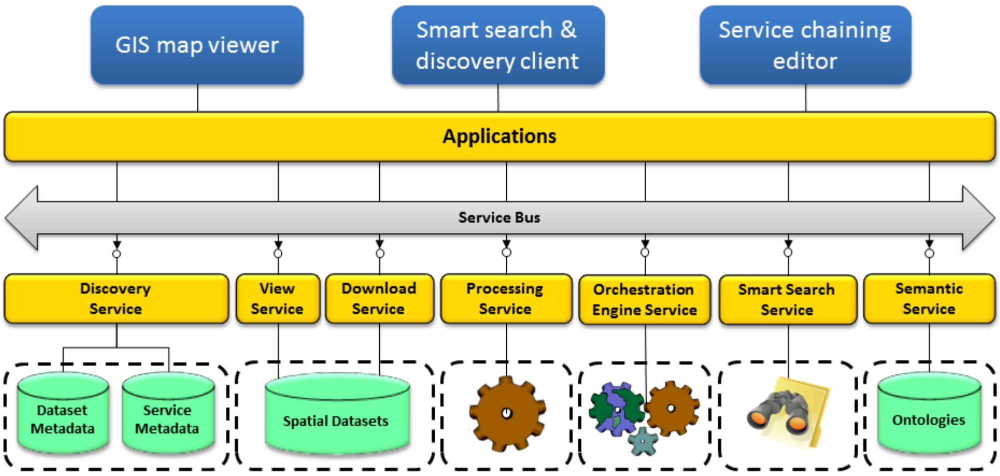

Figure 2-1 NETMAR Service Oriented Architecture.

A set of data delivery services provide satellite, in situ and model products through standard OGC protocols (WMS, WFS and SOS), with metadata encoded according to the NETMAR metadata profile using keywords from the NETMAR semantic resource to enable semantic search by the WSW and CSWM. The metadata are hosted by CSW compliant metadata catalogues by the partners and harvested into the CSWM to facilities search across all products.

A set of data processing services provide analysis capabilities and dynamic generation of new products, based on the data delivery services from the partners or external data delivery services that provide data through the OCC interfaces listed in the previous paragraphs. The data processing services have been implemented by PyWPS, an open source WPS server that has been extended in the project. Some of the processing services implement a WPS interface to the standard GRASS raster and vector processing functions, which provide a very useful “toolbox” which can be used within service chains to convert and subset data in to formats required by the more specific processing services developed explicitly for the pilot.

To provide a unified access point to the infrastructure for semantic search and the service network described above, NETMAR has developed a pilot European Marine Information System (EUMIS) web portal for searching, downloading and integrating satellite, in situ and model data from ocean and coastal areas. Within EUMIS, semantic search tools have been implemented as portal components (called portlets) and web services. In addition, portlets for co-visualisation of multi-source geographic datasets and service chaining have been developed and integrated in the EUMIS portal. The EUMIS portal also contains a Wiki, where users can find information about products and services, tutorials and links to software tools and examples.

The GIS Viewer allows users to display on a map distributed geo-spatial resources that have been shared by means of the OGC Web Map Service (WMS) standard. It provides a user-friendly way of browsing WMS servers to see what features they have available, choosing those of interest, and seeing the resulting map. The GIS viewer allows the user to obtain multiple layers overlaid on top of one another in the same geographic map projection. If the WMS server supports it, a user can click on a feature to get additional information about it, such as the values measured by an in situ sensor. Layers can be added and removed dynamically, and their display easily turned on and off. The GIS Viewer also includes common GIS functions (e.g. zoom, pan, legends), shows the latitude-longitude location of the cursor inside a map, and facilitates printing of the currently displayed layers. Furthermore, a web processing service (WPS) can be run from within the GIS Viewer and the resulting map or graph displayed in the portal.

Smart search is the ability of a discovery engine to locate target documents that do not include either an exact or fuzzy match to a user-supplied text string or user-supplied keyword. For example, if the user initiates a search on the discipline keyword ‘Physical Oceanography’, the discovery engine will find documents marked up with terms like ‘currents’, ‘waves’, ‘water temperature’, ‘salinity’ and so on, because these are semantically linked to the search criteria. The smart search and discovery client supports three features: ontology browsing, dataset smart search, and metadata visualisation. It provides search facilities based on the *semantics* of the data, including support for multi-domain and multi-lingual search in a network of metadata catalogue services connected by a mediator tool.

The service chaining editor allows users to generate new products by specifying workflows that utilise a set of data delivery and processing services. The workflow is generated using a graphical editor where individual services are chained together to form a new process. The workflows can be saved for later use, re-opened and edited, and run within an included workflow engine. Workflow output can be viewed within the GIS viewer.

All components are realised as portlets that are deployed in the open source Liferay Community Edition portal. The portlets will run in any commonly used web browser, with Flash installed to run the search and discovery client. The EUMIS portal is publicly available at http://eumis.nersc.no/, while open source EUMIS components are publicly available at https://github.com/NETMAR/netmar.

The technologies, working methods and EUMIS pilot as well as the data delivery and processing services that the project has produced, strengthen and further develop sustainable services and systems for GMES, GEO and other monitoring programmes for the marine environment. The EUMIS portal consists of 4 pilots, each demonstrating different capabilities in different marine application domains:

- Pilot 1: Arctic Sea Ice and Met-Ocean Observing System
- Pilot 2: Oil spill drift forecast and Shoreline Cleanup assessment services in France
- Pilot 3: Ocean Colour – Marine Ecosystem, Research and Monitoring.
- Pilot 4: The International Coastal Atlas Network (ICAN)

2.3 Papers for major results

The main results from the NETMAR project are presented below, with reference to white papers and journal papers where they are described.

2.3.1 *Paper 1: EUMIS portal and services – concepts, design and implementation*

EUMIS portal and services – concepts, design and implementation

Hamre[1], Torill, Adam Leadbetter[2], Yassine Lassoued[3], Mike Grant[4], Mickael Treguer[5], Øystein Torget, Vincent Gouriou[6], Stein Sandven[1], Roy Lowry[2], Declan Dunne[3], Peter Walker[4], Francois Parthiot, Morten Stette[1], Anthony Patterson[3], Oliver Clements[4] and Jorge de Jesus[4] (2013).
[1]Nansen Environmental and Remote Sensing Center, Norway
[2]British Oceanographic Data Center, United Kingdom
[3]Coastal and Marine Research Centre - University College Cork, Ireland
[4]Plymouth Marine Laboratory, United Kingdom
[5]Institut français de recherche pour l'exploitation de la mer (Ifremer), France
[6]Centre de documentation de recherche et d'expérimentations sur les pollutions accidentelles des eaux (Cedre), France
White paper (to be extended and submitted for publication)

Abstract: The pilot European Marine Information System (EUMIS) web portal combines novel semantic web technologies with established web GIS protocols and tools to support smart search, co-visualisation of multi-source data and dynamical processing of data for use in environmental monitoring and forecasting. The NETMAR project has developed innovative core technologies in the fields of ontologies, web processing services and semantic search, which are underpinning and demonstrating search, download and integration of satellite, in situ and model data from ocean and coastal areas in the pilot EUMIS web portal. EUMIS uses a semantic framework coupled with ontologies for identifying and accessing distributed data, such as near-real time, forecast and historical data. The semantic framework utilises the vast semantic resource of the NERC Vocabulary Server (version 2), which defines over 100 000 terms in the environmental application domain and incorporates both their semantics and interrelationships The semantic mark-up is done by encoding keywords from the NVS V2 ontologies using a ISO 19139 compliant metadata profile developed in the NETMAR project. Using the developed components and ontology resources, EUMIS has realised four pilots in diverse domains, including, sea ice monitoring and forecasting, oil spill drift prediction and clean-up activities, ocean colour and ecosystem modelling, and coastal web atlases. This paper presents an overview of the developed system and components, using the EUMIS pilot as a showcase to illustrate the solutions found for integrating distributed data and services by their meaning. The technologies and tools, EUMIS components as well as the data delivery and processing services that the NETMAR project has produced could be used to further develop sustainable services and systems for GMES, GEO and other monitoring programmes for the marine environment.

2.3.2 *Paper 2: Putting meaning into NETMAR - the Open Service Network for Marine Environmental Data*

Putting meaning into NETMAR
- the Open Service Network for Marine Environmental Data

Leadbetter[1], Adam and Roy Lowry[1], 2013.
[1]British Oceanographic Data Center, United Kingdom
International Journal of Digital Earth, accepted for publications.

Abstract: The Open Service Network for Marine Environmental Data (NETMAR) project uses semantic web technologies in its pilot system which aims to allow users to search, download and integrate satellite, in-situ and model data from open ocean and coastal areas. The semantic web is an extension of the fundamental ideas of the World Wide Web, building a web of data through annotation of metadata and data with hyperlinked resources. Within the framework of the NETMAR project, an interconnected semantic web resource was developed to aid in data and web service discovery and to validate Open Geospatial Consortium Web Processing Service orchestration. A second semantic resource was developed to support interoperability of Coastal Web Atlases across jurisdictional boundaries. This paper outlines the approach taken to producing the resource registry used within the NETMAR project and demonstrates the use of these semantic resources to support user interactions with systems. Such interconnected semantic resources allow the increased ability to share and disseminate data through the facilitation of interoperability between data providers. The formal representation of geospatial knowledge to advance geospatial interoperability is a growing research area. Tools and methods such as those outlined in this paper have the potential to support these efforts.

2.3.3 *Paper 3: Service mark-up and semantic validation*

Service mark-up and semantic validation

Grant[1], Mike and Peter Walker[1], 2013.
[1]Plymouth Marine Laboratory, United Kingdom
White paper. (to be combined with the uncertainty white paper and submitted for publication).

Abstract: A method has developed in the NETMAR project to add semantic metadata to OGC WxS services, that works within the existing standards, not breaking compatibility and is very lightweight/low maintenance for service providers, while giving a large amount of additional semantic functionality, including validation. The method is applicable to any WxS standard that contains a “related metadata” entry (or similar), including WMS, WFS, WCS and WPS. In the case of WPS, the required entry only exists at the function description level (GetCapabilities) rather than per-execution metadata, meaning that WPS processes must always return a specified semantic “type” and cannot dynamically adopt the “type” of the input. This limitation can be removed by a small change to the standard, but that is not the objective of this method.

The method is to simply insert into the related metadata field URLs that link directly or indirectly to vocabulary entries that describe the data or process. This field can be parsed by semantically-aware processes to identify related semantic metadata. For example, a WCS data layer can be identified as containing “chlorophyll measured by the MERIS sensor”

(parameter) measured in mg/m^3 (units) and a WPS process could be marked up as requiring an input of “sea surface temperature”.

Semantic validation is then a matter of comparing the various semantic data to ensure they are compatible. A parameter check involves translating the highly specific parameter entry to broader terms (the WCS layer mentioned above would become “chlorophyll”, while the WPS entry is already high level) and verifying that terms match. In the case of the WCS and WPS examples here, the validation would reject trying to input chlorophyll data into a sea surface temperature process. A similar check is made on units, and here it is possible to get an intermediate result – rather than just pass or fail, “needs transformation” is possible (e.g. if you have a service with data in units of centimetres but a process needs metres, this is possible with a simple numerical transform).

2.3.4 *Paper 4: Uncertainty representation and propagation*

Uncertainty representation and propagation

Grant[1], Mike and Peter Walker[1], 2013.
[1]Plymouth Marine Laboratory, United Kingdom
White paper. (to be combined with the markup white paper and submitted for publication).

Abstract: Following the model used for simple semantic markup of services, the NETMAR extended this approach to associate uncertainty with data layers. The approach works by using the metadata entries already present in standard OGC WxS services to link to reference (directly or indirectly) another data layer containing the uncertainty. This markup mechanism is flexible enough to allow the uncertainty layer to potentially be retrieved from another data source entirely, which allows an external entity to associate uncertainty layers to existing data sources by using a modified version of the server capabilities metadata – an important point when considering that the vast majority of existing data services and even the underlying data do not have associated uncertainty.

Processes or systems that are aware of this mechanism can use it to retrieve associated uncertainty while those that are not can transparently ignore it. No general declaration on the appropriate use and outputs can be made as this depends on the purpose of the processor and the input datasets, so subsequent processing and further onward propagation of uncertainty is left entirely to the process itself, which must be aware of the correct methods to use.

The development of this mechanism required extensive interaction with standard-developing projects and with a major data processing project to produce a sample test set that NETMAR has used for testing. NETMAR worked with the Framework 7 Uncertweb project, helping specify and driving the development of the NetCDF encoding for uncertainty. This encoding was then successfully pushed by PML into the European Space Agency's Climate Change Initiative project, with the aim of inclusion in all the Essential Climate Variable outputs that encode per pixel uncertainty. The NetCDF-U encoding is now being worked on for inclusion in the NetCDF Climate Forecast conventions, the primary environmental data standard for NetCDF. NETMAR partners remain involved with this process. The OGC WxS services in NETMAR primarily source their data from NetCDF and the mechanism described here complements the underlying dataset encoding, reflecting it at the higher service level.

2.3.5 *Paper 5: WPS and orchestration*

WPS and orchestration

Walker[1], Peter and Oliver Clements[1], 2013
[1]Plymouth Marine Laboratory, United Kingdom
White paper (and cookbook/best practice, [DJW11]).

Abstract: The WPS (Web Processing Service) standard defines the protocol by which service providers can expose their (geo)processing services on the web. It specifies how the service should describe itself, how processes should be called and how they return data; allowing simple web clients to make use of potentially complex services.
These services are generally used as single services accessed over the web, taking inputs from and returning results to the user. By combining these processes into more complex chains (workflows or service chains) it is possible to solve complex data analysis and/or scientific problems. However, at present, workflow design and execution systems are not widely available via a web interface, meaning one must install specific software to create workflows.
As part of its aim to produce a European Marine Information System (EUMIS) the NETMAR project has developed a web-based service chain editor, based on HTML5 and the JQuery Javascript library, which allows users to build workflows using WPS services and reduces the barrier to entry. The workflow editor uses a standard WSDL (Web Service Description Language) document describing the WPS services to display available services to the user; these services may be combined using the GUI to produce a workflow as required. The workflow can be run directly from the editor using a Taverna Server based orchestration engine with the results provided as web links or saved as XML.
This paper shows how existing standards and tools were used to provide the framework for the workflow editor and demonstrate how existing WPS services may be made available to the editor.

2.3.6 *Paper 6: The NETMAR Semantic Framework*

The NETMAR Semantic Framework

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[1]Coastal and Marine Research Centre - University College Cork, Ireland
White paper (to be extended and submitted for publication)

Abstract: Despite the momentum gained by semantic technologies in the scientific and spatial data infrastructure (SDI) communities, the use of vocabularies and ontologies in SDI and the exploitation of their full power remain very limited to the semantic annotation of data and metadata, and thesaurus browsing. The EU FP7 NETMAR project aimed to address this problem by designing and implementing a semantic framework that supports semantic interoperability of heterogeneous catalogue services, smart data and service discovery, and semantic validation of service chains.

The NETMAR Semantic Framework

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Abstract

Despite the momentum gained by semantic technologies in the scientific and spatial data infrastructure (SDI) communities, the use of vocabularies and ontologies in SDI and the exploitation of their full power remain very limited to the semantic annotation of data and metadata, and thesaurus browsing. The EU FP7 NETMAR project aimed to address this problem by designing and implementing a semantic framework that supports semantic interoperability of heterogeneous catalogue services, smart data and service discovery, and semantic validation of service chains.

Keywords

Semantic web, semantic interoperability, semantic data search

1. Introduction

Several projects and organisations are developing and maintaining large controlled vocabularies and ontologies, and web services for accessing and querying these valuable and complex resources. However, despite the advances achieved by the IT and the semantic web communities in semantic web technologies and applications, the use of the developed semantic resources in the geoscientific and spatial data infrastructure (SDI) communities is often limited to metadata or data semantic annotation and thesaurus browsing. There is an obvious lack of practical ontology use cases, applications, and semantically enabled information systems in SDIs; and ontologies often remain used as mere dictionaries or controlled vocabularies, leaving the full power of semantic technologies unexploited.

The European FP7 NETMAR[1] project (2010 - 2013) aimed to address this problem by advancing the exploitation of semantic web technologies in distributed spatial data infrastructures. This was achieved by designing and implementing a generic semantic framework (SF) that supports several practical and critical use cases, such as the semantic interoperability of distributed and heterogeneous catalogue services, smart discovery of data and services, thesaurus browsing, and semantic validation of service chains. The NETMAR SF is currently being used by the pilot European Marine Information System (EUMIS)[2], and the operational International Coastal Atlas Network (ICAN)[3], both developed as part of NETMAR.

The NETMAR SF has been designed to support the Simple Knowledge Organization System (SKOS) model. The selection of SKOS as a data model was based on the simplicity of this standard while offering enough expressiveness to respond to the needs of the most common use cases (product discovery, interoperability, service chaining, etc.). Most existing vocabulary servers developed by the geoscientific community use SKOS as a model for their vocabularies.

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[1] http://netmar.nersc.no

[2] http://eumis.nersc.no

[3] http://ican2.ucc.ie

The SF relies on a triple store to manage and deliver the semantic knowledge (SKOS thesauri). A semantic web service (SWS) allows users to query the triple store, using high-level methods, such as *get concept*, *get related concepts*, *build concept hierarchy*, etc. The SWS was designed to support the operations required by the most common use cases. The SWS is used by various semantically-enables components (services and clients) such as the semantic catalogue mediator, the semantically-enables service chaining editor, and the thesaurus browser.

This paper describes the NETMAR semantic framework and its architecture and implementation. It is organised as follows. After a brief description of related work (Section 2), Section 3 defines the ontologies and semantics use cases defined and used in the NETMAR project. Next, Section 4 describes the architecture of the NETMAR semantic framework. The components of this architecture and how they interact with each other are then detailed in Sections 5 (ontology browser), 6 (catalogue mediator), and 7 (service chain engine). Finally, Section 8 describes the implementation of the semantic framework.

2. Related Work

Several open source and commercial ontology frameworks and triple stores exist and integrate, or facilitate the implementation of, ontology web servers, usually based on SPARQL [PS08] as a protocol for querying semantic knowledge. For instance, Sesame[4] includes a REST-ful interface for querying ontologies using SPARQL. AllegroGraph[5] includes a REST-ful interface that supports SPARQL-like queries as input. The Jena ontology framework does not include a built-in server, but supports SPARQL, and therefore allows developers to implement a SPARQL-based web services for querying ontologies. For instance, the NERC Vocabulary Server (NVS)[6] has such a SPARQL-based web interface developed using the Jena framework. The Database Access and Integration Services Working Group (DAIS-WG) of the Open Grid Forum (OGF)[7] has submitted a specification for standard mechanism for accessing RDF(S) data [AAC09], also based on SPARQL.

While SPARQL provides a powerful and expressive protocol for querying general-purpose ontologies regardless of how they are structured and of the models they use, it remains difficult to use by non-computer scientist users, as it requires technical skills (similar to the use of SQL in database querying).

In practice, several projects organise their domain knowledge as SKOS thesauri rather than using ontologies in the broadest sense of the term. The choice of SKOS as an ontology model trades complexity for structure while preserving a sufficient level of expressiveness. For instance, the SeaDataNet and NVS vocabularies, the NASA Global Change Master Directory (GCMD)[8], the USGS thesaurus, and GEMET are all based on SKOS. In such a case, it is possible to provide a simple and high-level query web interface, which would facilitate semantic knowledge querying while preserving a sufficient level of expressiveness. For instance, NVS, GEMET, and SISSvoc provide high-level web interfaces for interrogating SKOS thesauri.

The NETMAR SF includes a semantic web service that builds on these efforts and proposes a more complete list of operations that meet the requirements of most common SKOS-based ontology uses cases (c.f., Section 3). In addition to the SWS, the SF includes a semantic

[4] http://www.openrdf.org/

[5] http://www.franz.com/agraph/allegrograph/

[6] http://vocab.nerc.ac.uk/

[7] http://www.gridforum.org/

[8] http://gcmd.nasa.gov/

catalogue service mediator and a semantically enabled service-chaining engine that use the SWS.

3. Thesauri and Semantics Use Cases

The NETMAR project defined a set of practical and generic use cases (applications) for ontologies and thesauri that aim to improve the pertinence of an SDI.

3.1. Use Case 1 (UC-1): Thesaurus Browsing

Thesaurus browsing is the ability to graphically navigate a thesaurus or a set of thesauri in order to understand the meaning of the concepts (ideas represented by terms) contained therein and to find out how these relate to each other (related, narrower or broader concepts, etc.). Ontology browsing is useful in web atlases as a way of providing educational information about a given domain (domain knowledge). It is also commonly used in product discovery interfaces (c.f., UC-2, section 3.2) as a way to find products by topic (e.g., multi-faceted product browsing). Existing semantic web services usually provide user-friendly ontology browsers.

Typically, an ontology browser needs to find out:

- What thesauri are delivered by a given semantic service;
- Describe a specified concept scheme;
- What terms or collections of terms are contained within a given thesaurus or term collection;
- What terms are related (same as, narrower, broader, etc.) to a given term;
- What thesauri, term collections, or terms match a given free text keyword.

Additionally, an ontology browser may request the semantic service to:

- Build a graph structure, most commonly hierarchy, of the terms of a given thesaurus or term collection.

3.2. Use Case 2 (UC-2): Product Discovery

Thesauri may be used by product (e.g., data, services, etc.) discovery services (e.g., catalogue services) as a means to improve the pertinence of their search results, by exploiting the semantic relationships between terms (narrower, related, same as, etc.), and/or trying to interpret the meaning of a user free text keyword according to a given thesaurus. For instance, if you search for datasets matching the term “seabed”, you would be able to get those tagged with the keyword “seafloor” (synonym), or if you search for “CTD” (i.e., Conductivity, Temperature, Depth), you would be able to get “Sea Surface Salinity” datasets.

Typically, a semantically enabled product discovery service needs to find out:

- What terms are related to a given term (same as, narrower, related, etc.);
- What terms match a given free text keyword.

3.3. Use Case 3 (UC-3): Interoperability

Database and service interoperability is another common use case of ontologies and semantic knowledge. Typically, in this area, ontologies are used as a mapping mechanism between

- Two data structures/schemas (structural interoperability);
- The values of similar properties (attributes) in different databases, using different representations (semantic interoperability).

The former occurs when two information systems, with structurally heterogeneous back ends, need to interoperate with each other or with a third party system, e.g., mediator, broker, extract transform and load (ETL) tool, etc. The latter supposes that structural interoperability has already been achieved and that actual data values need to be mapped or translated from one model, classification scheme, or terminology, to another. This is the typical case of distributed catalogue services using different vocabularies, possibly from different domains or in different natural languages, for product metadata values, e.g., descriptive keywords, units of measure, parameter names, organisation names, etc.

Structural and semantic interoperability, in the general case, may require complex ontology models and mappings, able to capture the semantic of the data model (e.g., database primary and foreign keys in a relational model, or how to convert attribute values from one unit or model into another). However, in several practical cases (e.g., catalogue service interoperability), a simple semantic model relying on basic semantic relationships, such as broader, narrower, and related, may be sufficient to perfectly interoperate two semantically or structurally heterogeneous systems. In such a case, the interoperability system (ETL, mediator, etc.) typically requires information such as:

- What terms are related (same as, narrower, broader, etc.) to a given term; this is useful to translate one attribute value from one model into another for example;
- Find all concepts from a given concept scheme or collections that semantically match (equivalent to or narrower than) a given keyword or concept scheme;
- What terms best match a keyword; this is useful for an ETL or a schema matcher to find out which table or attribute from a destination database schema matches a table or attribute from a data source schema.

3.4. Use Case 4 (UC-4): Service Chaining

A service chain is defined in ISO 19119 as “a sequence of services where, for each adjacent pair of services, occurrence of the first action is necessary for the occurrence of the second action” [ISO05]. From a user perspective, service chaining is the linking together of standardised data and processing services into a workflow to produce results that are not predefined by the service providers. The defined workflows will then be passed to a workflow engine for execution.

Typically, a processing service requires input data with given structure and semantics and outputs data also with given structure and semantics. While chaining services, one must make sure that the data output by a service and fed into another conform to the required structure and semantics of the latter.

It is possible to use semantic knowledge to ensure that the inputs and outputs of each component of a service chain are “semantically compatible.” This can be achieved by using ontologies as a way to represent the semantics of data and service input and output parameters. The service-chaining engine needs then to check whether an input dataset parameter is “semantically compatible” with a processing service input parameter (in terms of the parameter type, dimension, unit of measure, etc.). In this way, correct connections between components can be enforced (e.g., do not send chlorophyll data to a component that only knows how to process sea surface temperature).

Checking the semantic compatibility of two parameters in most practical cases is a matter of checking whether two concepts are the same, or whether a concept is narrower/broader than the other, or whether both concepts share a common broader concept. Therefore, it is commonly possible to express parameter compatibility as a combination of one or more of the following operations:

- What concepts (parameters, dimensions, units, etc.) are narrower or broader than a given concept (parameter, dimension, unit, etc.);

- Is a given concept (parameter, dimension, unit, etc.) narrower than another given concept (parameter, dimension, unit, etc.)?

4. Architecture

The typical service oriented architecture of the proposed semantic framework is illustrated in Figure 1. As shown in this diagram, the SWS uses semantic knowledge that may be stored and managed in a variety of ways, e.g., triple store, database, ontology files (RDF, OWL, etc.), external web service, etc.

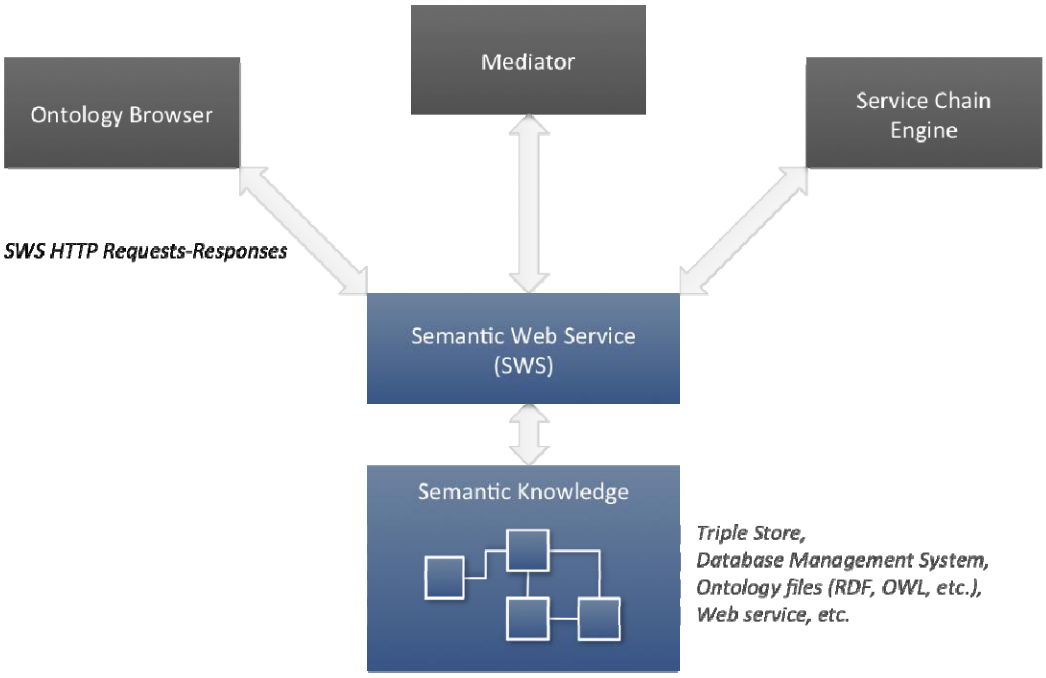

Figure 1. Typical Semantic Framework Architecture

The SWS is made accessible on the web to “semantically-enabled” applications, such as ontology browsers, semantic mediators, or service chain engines. These interact with the SWS using SWS requests and responses over HTTP.

The subsequent sections introduce the main components illustrated in Figure 1.

5. Semantic Web Service

The SWS is a high-level web interface for querying SKOS thesauri stored in a given backend. The NETMAR SWS supports various types of back ends: ontology files (RDF and OWL), Jena RDB and TDB stores, and AllegroGraph.

The SWS aims to provide a web interface for querying SKOS thesauri through a standardised set of high-level and easy-to-use operations required by most common semantically-enabled clients such as data and metadata mediators, service chaining engines, vocabulary browsers and data and service discovery interfaces. The SWS supports the operations listed in Table 1, which have been designed based on the use case requirements identified in section 3.

Table 1. SWS Operations

Operation	Definition
GetCapabilities	Retrieves service metadata, including supported operations, response formats, available concept schemes, and their supported languages.
GetConceptSchemes	Lists available concept schemes with their annotations (labels, definitions, etc.).
GetConceptScheme	Returns a concept scheme definition given its URI. The response includes the concept scheme's annotations.
SearchConceptScheme	Returns the definition(s) of one or more concept scheme(s) matching a specified free-text keyword.
GetConceptSchemeContent	Returns the content of a given concept scheme (identified by its URI), including its collections and concepts.
GetCollections	Lists available concept collections with their annotations. Collections may be filtered by one or more concept schemes.
GetCollection	Returns a collection definition identified by its URI. The response includes the collection's annotations.
SearchCollection	Returns the definition(s) of one or more collection(s) matching a specified free-text keyword.
GetCollectionContent	Returns the content of a given collection (identified by its URI), including member collections and concepts.
GetConcepts	Returns the definitions of the concepts belonging to a specified concept scheme and/or collection.
GetConcept	Returns a concept definition given its URI. The response includes the concept's annotations.
SearchConcept	A search operation that returns the concepts that textually match a given keyword.
GetRelatedConcepts	Returns the concepts related to one or many given concept(s) using one or many given SKOS relationship(s) (e.g., skos:narrower, skos:broader, skos:related, etc.), both from direct assertions and by entailment.
GetExplicitTopConcepts	Returns the concepts that have explicitly been asserted as top concepts of a specified concept scheme.
GetImplicitTopConcepts	Returns the top-level concepts of a specified concept scheme.
GetConceptHierarchy	This operation is suitable for small thesauri, and is useful for ontology browsers. It returns the hierarchy of the concepts within a given concept scheme and/or collection.
InterpretKeyword	Returns the concepts that semantically match a given keyword, within a specified concept scheme and or collection.
CheckRelation	Checks whether two specified concepts are related via a specified SKOS relationship.

A full specification of above methods including their request and response formats can be found in the NETMAR Semantic Framework Specification [Las12].

Ontology Browser

The ontology browser is a client application that allows users to navigate the thesauri delivered by the SWS and to search for concepts matching free text keywords. A screenshot of the NETMAR ontology browser is shown in Figure 2.

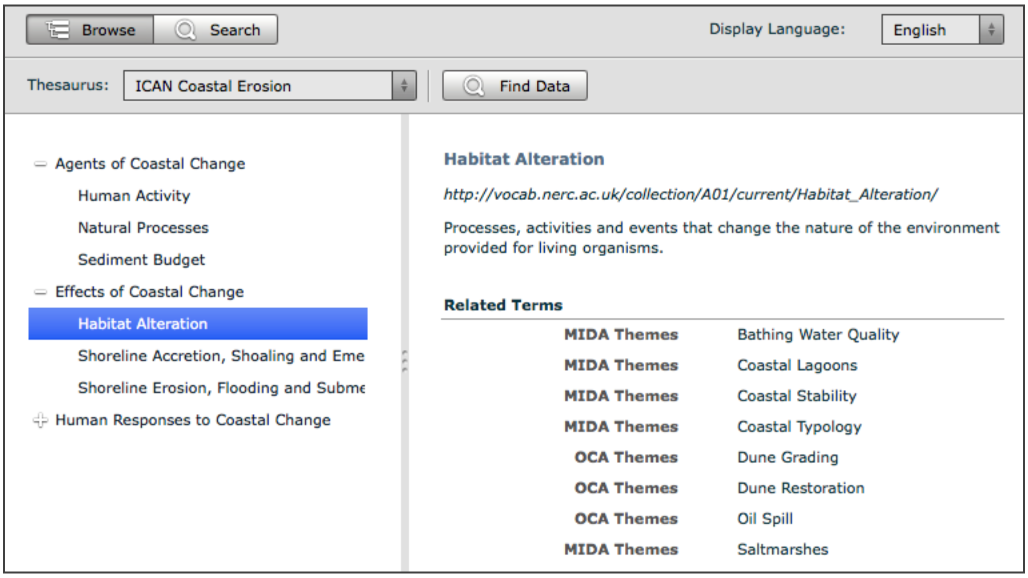

Figure 2. Screenshot of the NETMAR Ontology Browser

The ontology browser displays the defined concepts of the NETMAR thesauri in a tree structure. By clicking on a concept, its definition is shown along with related terms to the right. A "Display language" button on the top right side of the ontology browser allows users to select the language of the concept definitions and labels (this works only with multilingual ontologies). When a concept is selected, you can inspect any of the related terms by clicking on it, or move on to searching by entering a keyword in the search area.

6. Catalogue Mediator

The catalogue mediator (CSWM) is a web service that allows users to access in a seamless way a set of OGC distributed catalogue services for the web (CSW), called catalogue nodes. It translates user keywords or concepts into concepts or keywords supported by the catalogue services using ontology mappings provided as part of the ontologies. Query rewriting is performed on the fly, and responses from the different catalogue nodes are collated and returned to the user.

The protocol diagram of Figure 3 outlines the typical protocol to be followed in order to process semantic web service requests involved in the mediation of OGC catalogue services (CSW) [NW05].

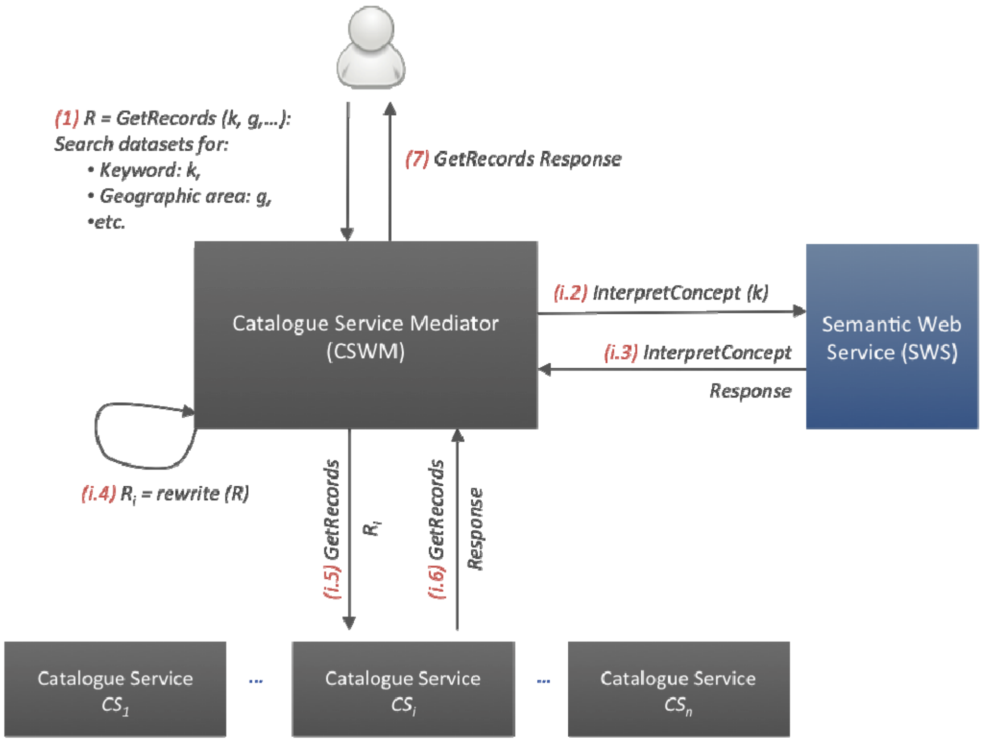

Figure 3. Protocol Diagram for an SWS Client-Service Interaction involved in Catalogue Service Mediation

This protocol diagram involves 4 actors:

- The user of the system,
- The CSWM,
- The semantic web service,
- A set of distributed catalogue services (CSW): CS_1, …, CS_n.

The typical component interactions illustrated in this figure are explained below.

- (1) The user sends a *GetRecords* request to the catalogue service mediator to search datasets for a given keyword *k* and a geographic extent *g*.
- The CSWM parses the user query *R*, and for each catalogue service CS_i to be involved in the query (by default all the catalogue nodes are involved unless otherwise specified in the user request R) it does the following (in parallel):
  - (i.2) The CSWM extracts the keyword of interest *k* and submits an InterpretKeyword request to the SWS with *k* as the keyword parameter value.
  - (i.3) The SWS responds to the CSW by sending the list of concepts semantically covered by the user keyword *k* (i.e., best matches of the keyword and their narrower concepts).
  - (i.4) The CSWM, now, has all the concepts covered by the user's keyword. It rewrites the user's request into a request supported by catalogue node CS_i and translates the original keyword using the concepts obtained in step (i.4). Let R_i denote the so-obtained query.
  - (i.5) The CSWM submits the rewritten query R_i to catalogue node CS_i.
  - (i.6) Catalogue node CS_i returns a response for the CSWM's request R_i.

- (7) The CSWM mediator collects all the catalogue node responses, wrap them in a CSWM GetRecords request and sends them back to the user.

7. Service Chain Engine

The service chain engine is the component responsible for building and executing service chains. A service chain is a sequence of services where the outputs of a service are injected as inputs into the next service in the sequence.

The NETMAR service chain engine checks the semantic validity of user-built service chains by using ontologies that describe the semantics of output and input data.

The protocol diagram of Figure 4.4 outlines the typical protocol to be followed in order to check the semantic validity of a service chain by a service chain editor or engine.

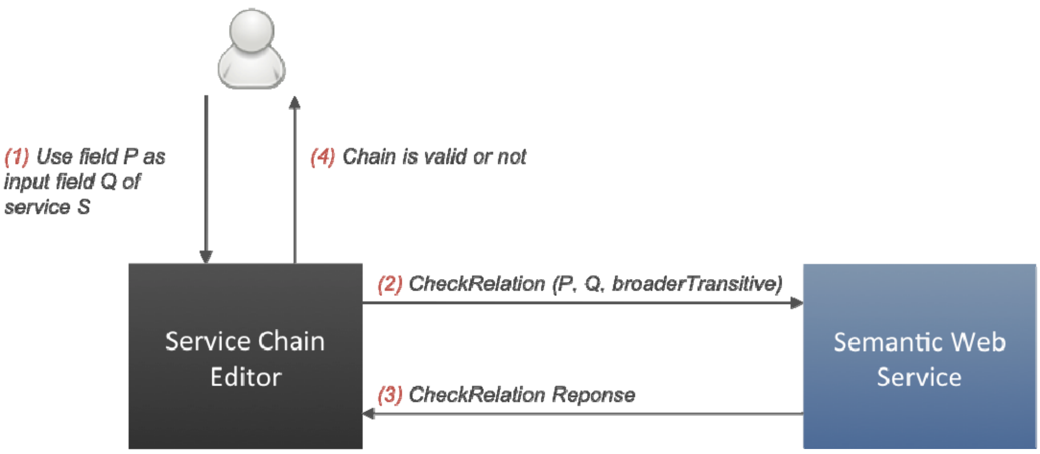

Figure 4. Protocol Diagram for an SWS Client-Service Interaction involved in Service Chaining

This service chaining protocol diagram involves 3 actors:

- The user of the system,
- The service chain editor,
- The semantic web service.

The typical component interactions illustrated in this figure are explained below.

- (1) The user sends requests that the service chain editor use a given dataset field representing a parameter *P* as input for a processing service *S*, the input representing a given parameter Q.
- (2) The service chain editor sends a CheckRelation request to the SWS to check whether parameter P (represented by the input field) is compatible with parameter Q (requested by the service), in other terms to check whether P is a narrower term than Q. For instance, “Sea Surface Temperature” is narrower than “Temperature”, therefore a dataset field tagged as “Sea Surface Temperature” can be accepted as input to a service requiring “Temperature” as an input.
- (3) The SWS sends back a positive or negative response to the service chain editor.
- (4) Depending on the SWS response the service chain editor decides whether the service chain is valid or not and warns the user accordingly.

8. Implementation

The semantic web service was implemented in Java, using the Jena ontology framework. It is deployed on the CMRC server and can be accessed at http://netmar.ucc.ie/srv/SWS. As shown in Figure 5, The SWS uses Jena TDB[9] as a backend for storing and managing the ontologies, which are automatically loaded from the NERC Vocabulary Server using and extract, transform and load (ETL) tool.

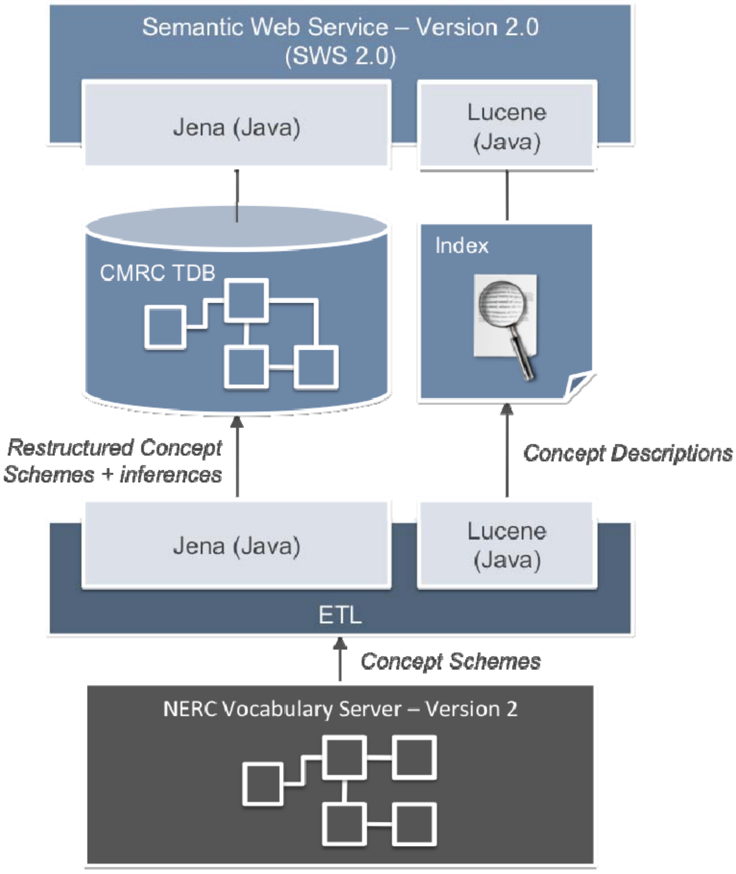

Figure 5. The NETMAR Semantic Framework Implementation Architecture

The ETL tool pulls the NEMTAR concept schemes from the NERC Vocabulary Server (NVS, version 2). Then, it computes inferences, and restructures the concept schemes according to the SWS requirements. The ETL tool also indexes the concept descriptions (labels and definitions) for fast search.

The SWS performs concept search using the concept indexes, whereas it extracts semantic knowledge from the CMRC TDB.

Both the SWS and the ETL tool use the Jena 2.7.0 framework to access and manage the TDB, and the Lucene[10] 3.5.0 API for accessing and managing the concept indexes.

The CSW mediator was implemented in Java. It is deployed on the CMRC server and can be accessed at http://netmar.ucc.ie/explorer/Explorer.

[9] http://jena.apache.org/documentation/tdb/index.html

[10] http://lucene.apache.org/core/

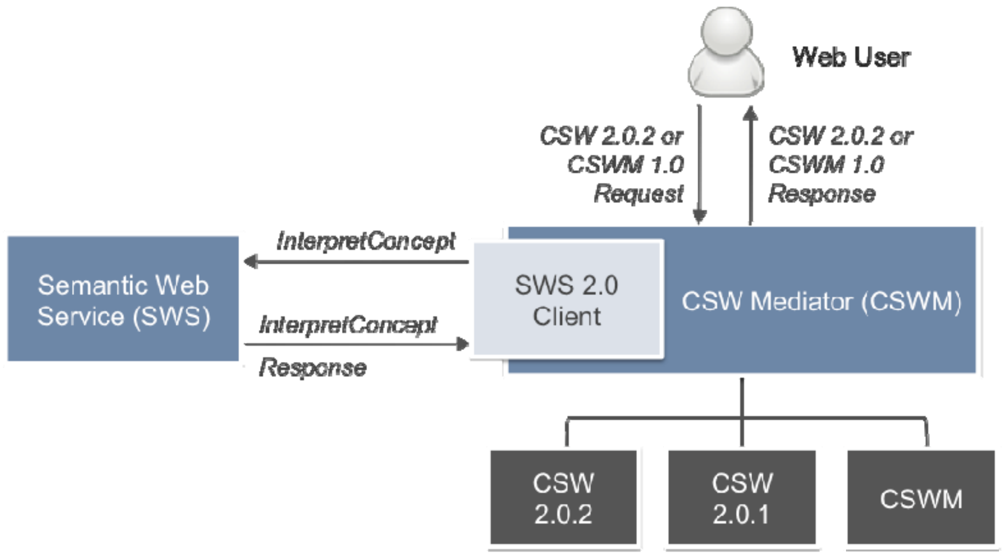

Figure 6. The NETMAR CSWM Implementation Architecture

As shown in Figure 6, the CSWM uses an SWS client to interact with the semantic web service in order to interpret the user search keywords contained in the user request. The CSWM supports three types of catalogue nodes:

1. OGC CSW 2.0.2 – This is the most common use case, as most nodes are catalogue services compliant with the CSW 2.0.2 specification, which is supported by the recent versions of GeoNetwork[11] (2.4+).
2. OGC CSW 2.0.1 – Although supported by the CSWM, we do not recommend the use of this older version of CSW as it does not allow you to specify the metadata standard in a *GetRecordById* operation (records are returned in their original standards and formats, which are not necessarily supported by the client application).

CSWM 1.0 – The CSWM may access another CSWM, which in turn has catalogue nodes. This makes it possible to cascade CSWMs (c.f., section 3.2).

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[11] http://geonetwork-opensource.org

2.3.7 *Paper 7: Architectural overview*

Architectural overview

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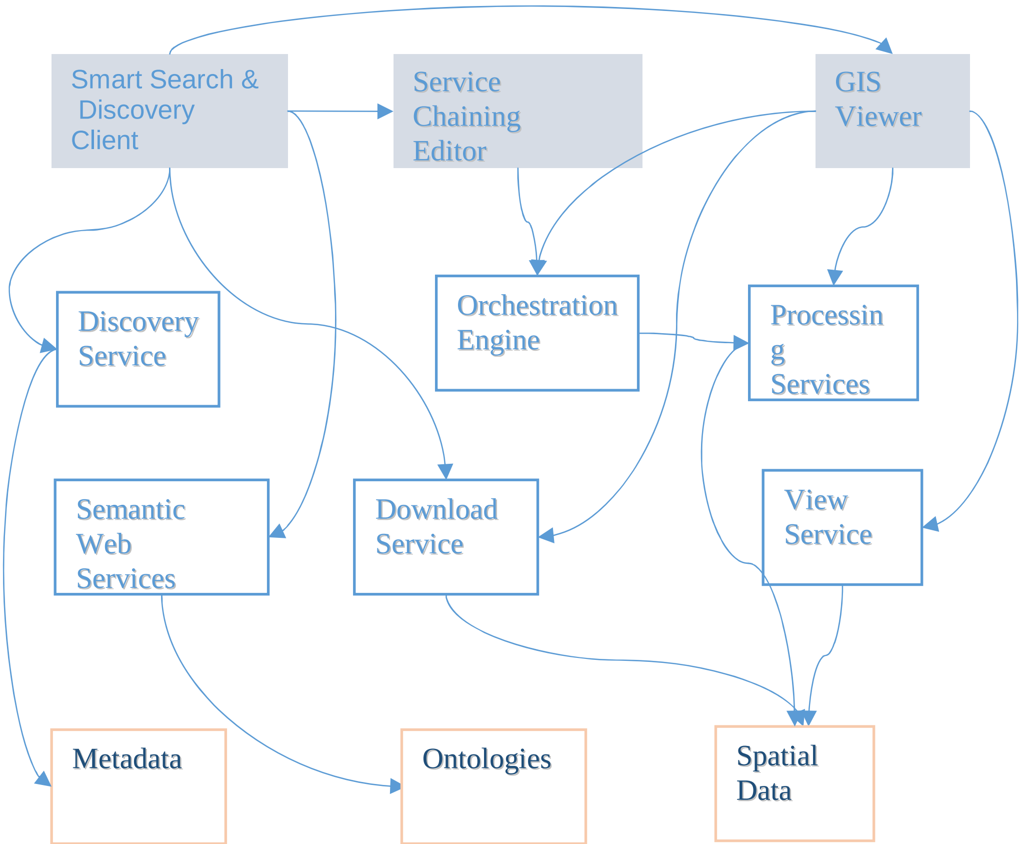
Abstract: The architecture was developed through the application of two main viewpoints; the enterprise viewpoint which examines the motivations and driving forces behind NETMAR, and the services viewpoint which describes how NETMAR's objectives can be achieved through the application of service oriented architecture patterns and principles. This short paper gives an overview of the architecture and some recommendations which may be useful to others developing similar systems

Overview



NETMAR provides services exposing spatial datasets related to a specific set of use cases concerning monitoring and understanding of the marine environment, as well as metadata concerning both the datasets themselves and the services exposing them. It provides a set of ontologies detailing the concepts used in these datasets and the relationships between them. These services provide a base of open data which can be used to develop further services for reporting and analysis on marine environmental data. At this level NETMAR provides a documented catalogue of reusable and interoperable services based on widely used standard service interfaces.

NETMAR provides reference implementations for components and services building upon this open core of data services. In some cases these follow standard service contracts defined by OGC specifications, i.e. download service, view services, processing services. Some components are provided which ease the provision via the web of services normally used on the desktop; this includes the orchestration engine as well as WPS enabled versions of many of the routines available via GRASS GIS modules. Others, i.e. the semantic web services, provide an implementation of existing web-enabled functionality tailored to specific use cases.

These value-add services enable the construction of an application layer based on a standard portal architecture. This layer allows the data and services to be validated against specific use cases by end users who are typical consumers of the end products of these data and services. The use cases are based on the needs of four pilot areas of application, i.e. arctic sea-ice monitoring, oil-spill detection and monitoring, ocean-colour and an international network of coastal atlases.

Application

An architectural process was applied to NETMAR through the application of two main viewpoints; the enterprise viewpoint which examines the motivations and driving forces behind NETMAR, and the services viewpoint which describes how NETMAR's objectives can be achieved through the application of service oriented architecture patterns and principles.

From the enterprise viewpoint two main focus areas emerged. One was the need of a pilot study to effectively address the research questions that have been asked. The Constructive Research methodology is often used in computer science projects, and relies on building a pilot application or other type of construct in order to quantify the benefits of using one approach versus another. This underlines the importance of the quality of the application being built, as it will need to stand up to being tested by a wide variety of users. Another focus area is the need to be able to provide reusable design results. This points to a use of patterns, pattern languages and techniques focused around the use of patterns, e.g. patterns-based architectural reviews.

The documentation of the architecture in terms of identifying relevant patterns and measuring their use was the focus of the services viewpoint. A number of patterns were prescribed for use within NETMAR. The Composite Front pattern was partially applied with some success. Idempotent capability was identified late in the project as having made a substantial contribution to the reliability and robustness of service composition. This is an area of the architecture which can continue to contribute useful results as new applications of the basic services and reference components illustrate the context and usage of patterns, and new patterns are published externally.

Conclusions

Based on the experience of describing and implementing the NETMAR architecture, a number of recommendations can be made which may be useful to others developing similar systems:

- Focus on patterns, principles and practices rather than formal frameworks.
- Use idempotent capability where possible to avoid complicated transaction compensation
- Apply standard software engineering practices to ensure an adequate level of quality.
- Use documented patterns in order to learn from the mistakes of others.
- Ensure a joined-up user experience by using the Composite Front End pattern.
- Choose service containers wisely, balancing functionality against added complexity.
- Do not allow technology to drive the project.

2.3.8 *Paper 8: A Web GIS Viewer in the Liferay portal framework*

A Web GIS Viewer in the Liferay portal framework

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White paper (to be extended and submitted for publication)

Abstract: Today, an every increasing number of datasets are available online, many through standard data exchanges protocols such as the Web Map Service (WMS), Web Feature Service (WFS) and Sensor Observation Service (SOS) from the Open Geospatial Consortium (OGC). From the marine modelling community, a large number of forecasts, nowcasts and hindcasts are offered through the Open-source Project for a Network Data Access Protocol (OPeNDAP) standard. Scientists, data managers and policy makers need to bring these data together and co-visualise them on the same map in a chosen projection, even if the data originally have different spatial and temporal resolutions as well as different map projections. This short paper describes a web GIS Viewer that has been developed within a project entitled Open service network for marine environmental data (NETMAR). The GIS Viewer enables users to compose a list of layers from different providers and offered through different standard protocols, co-visualise them on the same map. The GIS Viewer also has several other new and innovative features that will be described in the paper.

Purpose and features

The GIS Viewer allows users to display on a map distributed geo-spatial resources that have been shared by means of the OGC Web Map Service (WMS) standard. It provides a user-friendly way of browsing WMS servers to see what features they have available, choosing those of interest, and seeing the resulting map. The GIS viewer allows the user to obtain multiple layers overlaid on top of one another in the same geographic map projection. If the WMS server supports it, a user can click on a feature to get additional information about it, such as the values measured by an in situ sensor. Layers can be added and removed dynamically, and their display easily turned on and off. The GIS Viewer also includes common GIS functions (e.g. zoom, pan, legends), shows the latitude-longitude location of the cursor inside a map, and facilitates printing of the currently displayed layers. Furthermore, a web processing service (WPS) can be run from within the GIS Viewer and the resulting map or graph displayed in the portal.

The GIS viewer has the following features:

- Common GIS functions (e.g. zoom, pan, legends, locator map, store the context map, print the map)
- ncWMS compatibility
- Multiple projections
- WPS client
- Storage of map layout and layer list

NcWMS is a Web Map Service for geospatial data that are stored in NetCDF files, such as model output and satellite datasets. It implements some extensions to the standard, time series and transects. The GIS viewer is compatible with NcWMS, where end users can interrogate multi-dimensional services (e.g. time and elevation), change the colour map, graph time series (Figure 1) and transects.

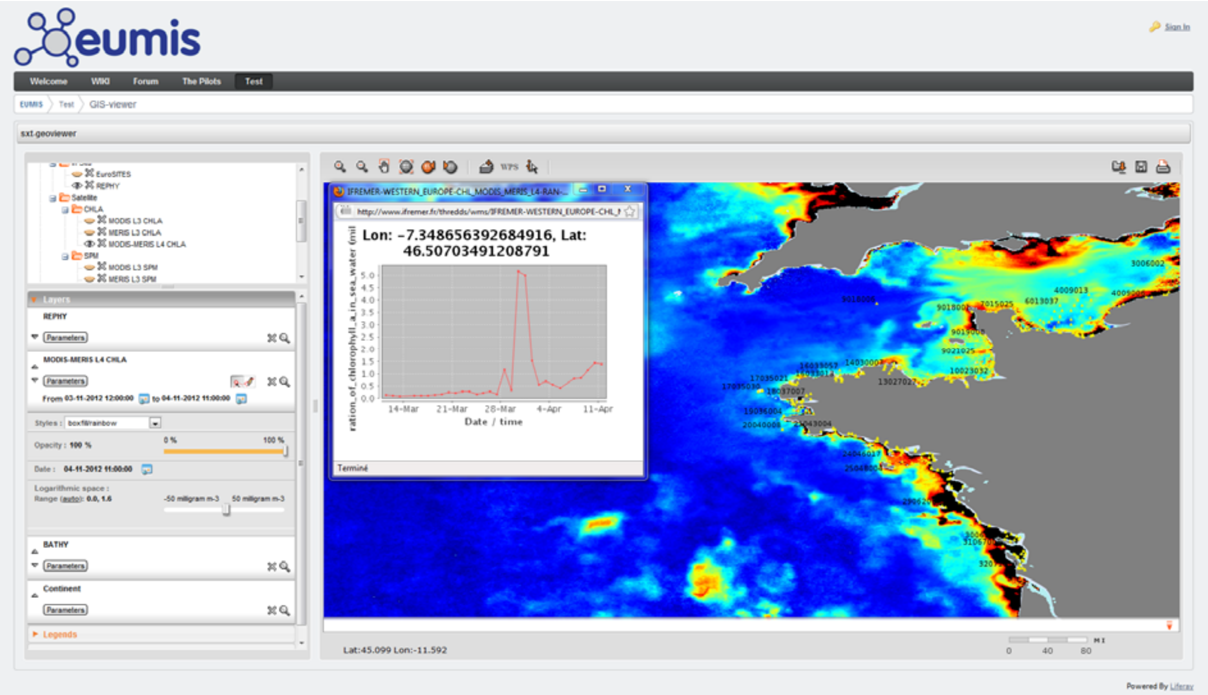

Figure 1. Example of time series from ncWMS.

The GIS viewer is able to display geospatial layers in several map projections. If the WMS server can respond using the same projection of the map, the client side of the GIS viewer directly displays this layer. Otherwise the server side of the GIS viewer performs a re-projection. Therefore, the pilots can use different projections. For example, Pilot 1 (Arctic Sea Ice and Met-ocean Observing System) uses the stereographic projection (Figure 2).

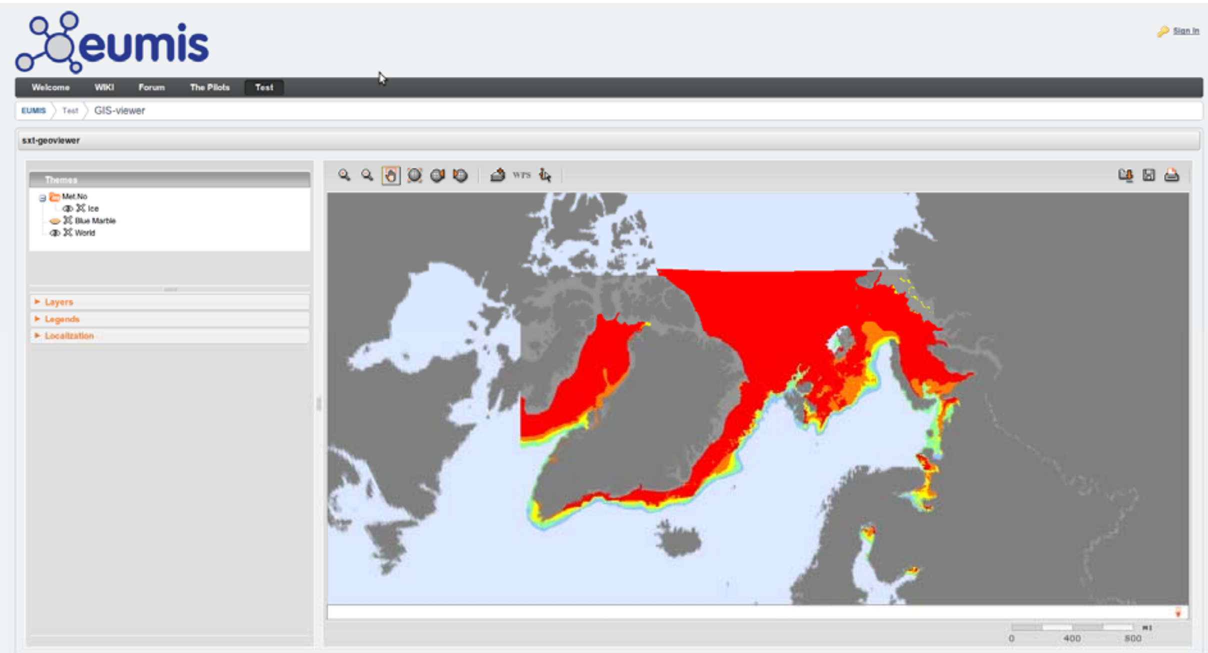

Figure 2. Example of ice chart in stereographic projection.

A WPS client is implemented in the GIS Viewer. It allows to execute remote WPS server, and when the result is a geospatial dataset (e.g. GeoTIFF, GML, KML) to display it in the map. The users can select or edit WPS URL, then choose an available Process, and set the input parameters, and finally execute the process (Figure 3).

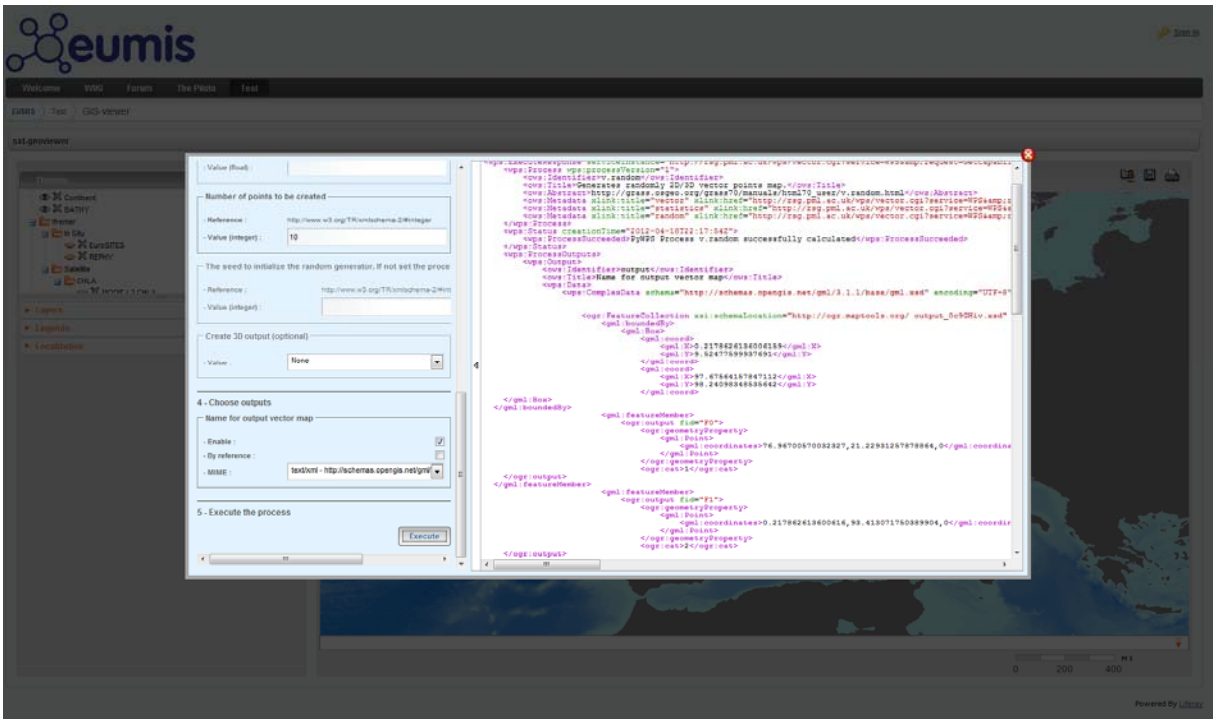

Figure 3. Example of ice chart in stereographic projection.

Initially, the GIS Viewer displays a coastline layer only. However, the user can add layers to the map by inputting URLs to Web Map Servers, and selecting from the layers offered by the identified server (Figure 4). The new layers are added to the map (Figure 4) and the current layout can be saved in a OWS-Context file [WMC05]. One example is found at:

http://eumis.nersc.no/web/guest/map2?url=http://www.ifremer.fr/isi/sextant/OWC/netmar.xml

This file contains an example of a set of layers used in NETMAR for monitoring of Phytoplankton blooms in Gulf of Biscay and English Channel. Once loaded into the GIS Viewer, the layer list will look like in Figure 5.

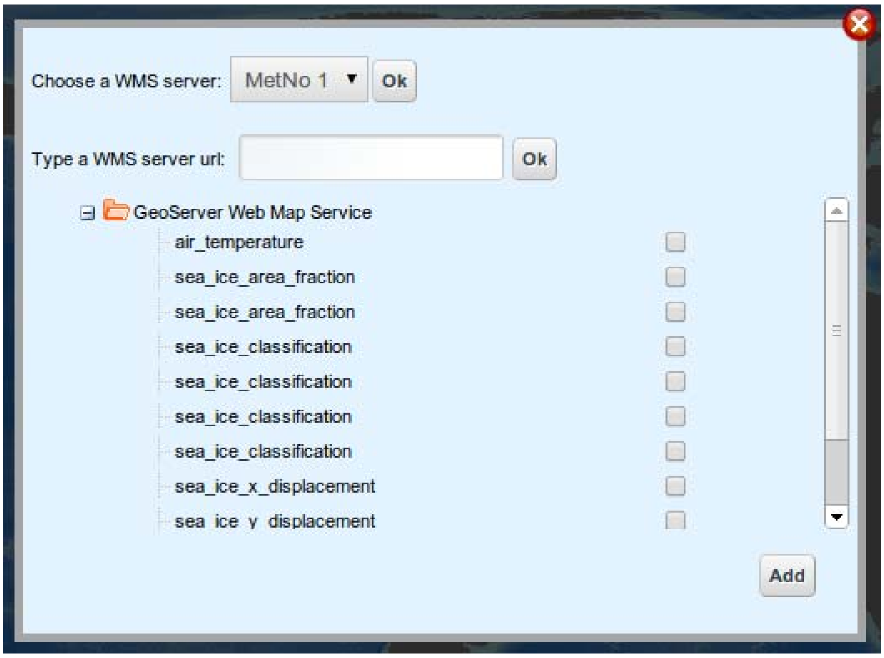

Figure 4. GIS Viewer: Adding more WMS layers.

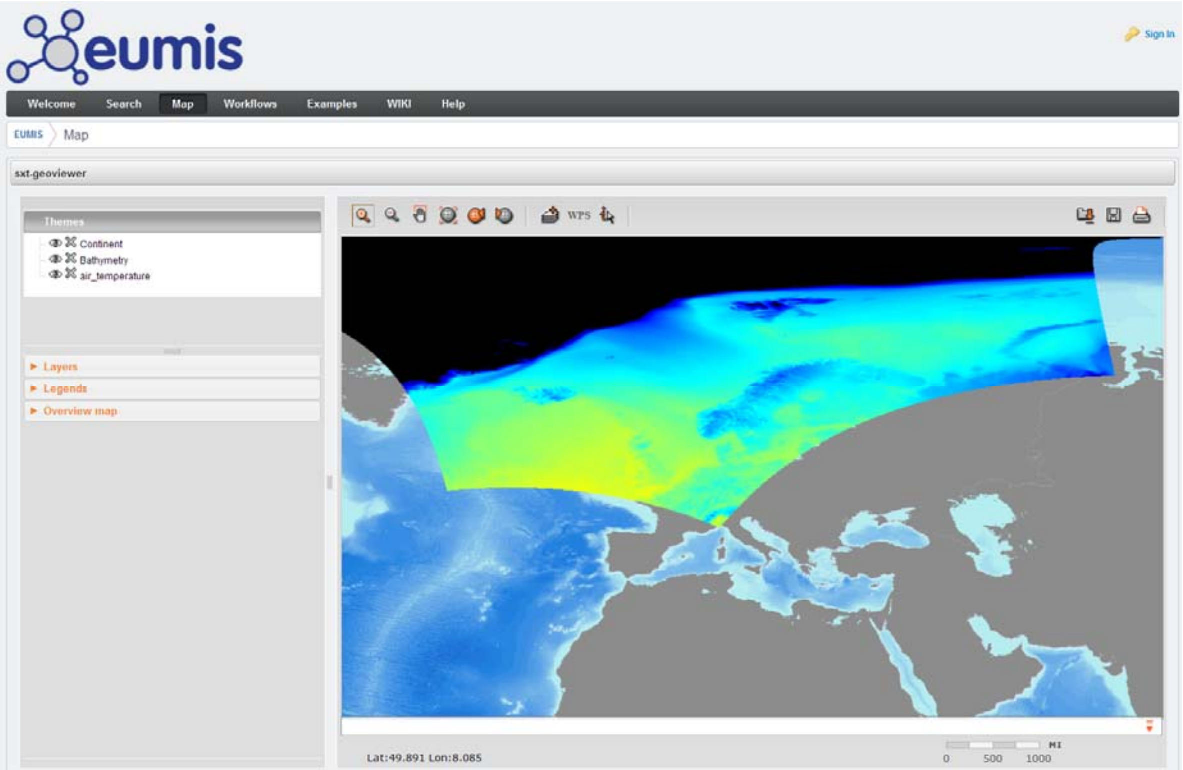

*Figure 5. G*IS Viewer: New layers added to the map*.*

Implementation

The GIS Viewer is implemented using the MapFaces library [MF]. MapFaces has a modular design consisting separate Java Server Faces (JSF) components resting on a base geo-spatial library. The components rely on several JavaScript elements for user interface elements running in the browser on the client side. MapFaces uses the jQuery JavaScript library to provide elegant and powerful components in a compact, highly structured library [JQ]. MapFaces also uses a simplified version of the OpenLayers JavaScript library for displaying map data in web browsers, providing functionality like transparent layers and simple navigation panel [OL].

The GIS viewer is a portlet running inside the Liferay Community Edition (version 6.0.5) portal [LRv6]. It uses two Java libraries:

- Java Advanced Imaging (JAI) 1.1.3 [JAI].
- Java Advanced Imaging I/O (JAI Image-I/O) libraries Image I/O 1.1 [JAIIO].

These must be installed on the portal server before the portlet itself is installed.

Figure 6 illustrates the architecture of the GIS Viewer. The client side is realised by mean of two open source libraries, OpenLayers [OL] for all GIS operations (e.g. map display, zooming and panning) and jQuery [JQ] for setting up the layer lists and panels for legends etc., in the graphical user interface (GUI). The server side is comprised of components from the MapFaces library and the GeoToolkit library [GT]. The client and server communicate via the JSF protocol.

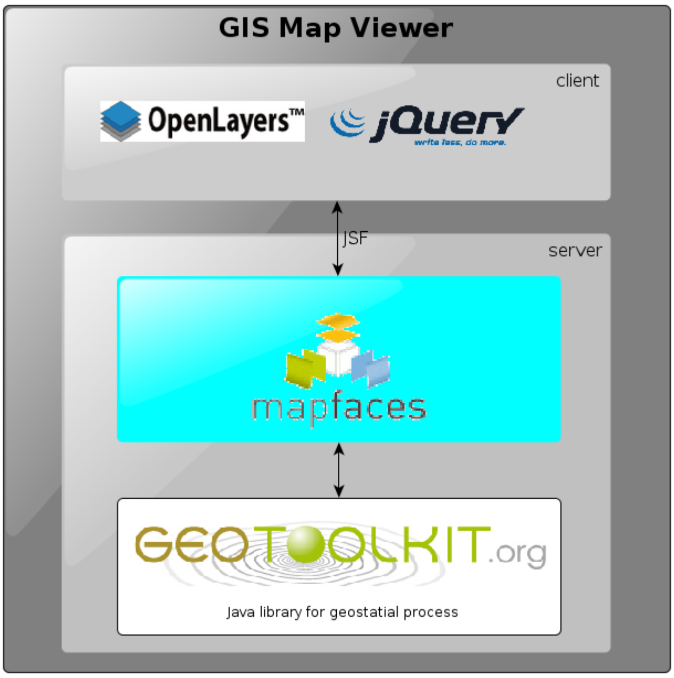

Figure 6. GIS Viewer: Architecture diagram*.*

The GIS Viewer can store the current configuration of map layers for later use. This is done in an XML (eXtensible Mark-up Language) file.

After adding the layers of interest to the GIS Viewer, each user can store a new map context file for his session. One example is found at:
http://eumis.nersc.no/web/guest/map2?url=http://www.ifremer.fr/isi/sextant/OWC/netmar.xml

This file contains an example of a set of layers used in NETMAR for monitoring of Phytoplankton blooms in Gulf of Biscay and English Channel. Once loaded into the GIS Viewer, the layer list will look like in Figure 7.

The map configuration is stored in OWS-Context files [WMC05]. The example web map context file at http://www.ifremer.fr/isi/sextant/OWC/netmar.xml is shown in Figure 8.

References

[GT] The Geotoolkit.org library, http://www.geotoolkit.org/ (accessed 12 July 2011)

[JAI] Java Advanced Imaging (JAI) 1.1.3, http://download.java.net/media/jai/builds/release/1_1_3/ (accessed 5 July 2011)

[JAIIO] Java Advanced Imaging I/O (JAI Image-I/O) libraries Image I/O 1.1: http://download.java.net/media/jai-imageio/builds/release/1.1/ (accessed 5 July 2011)

[JQ] jQuery, http://jquery.com/ (accessed 11 June 2011)

[LRv6] Liferay Community Edition, http://www.liferay.com/downloads/liferay-portal/available-releases (accessed 30 May 2011).

[MF] MapFaces, http://mapfaces.codehaus.org (accessed 31 May 2011)

[NCW] ncWMS trac, http://www.resc.rdg.ac.uk/trac/ncWMS/ (accessed 27 July 2011)

[OL] OpenLayers, http://openlayers.org (accessed 30 May 2011)

[WMC05] OpenGIS Web Map Context Implementation Specification, version 1.1.0, http://www.opengeospatial.org/standards/wmc (accessed 12 July 2011)

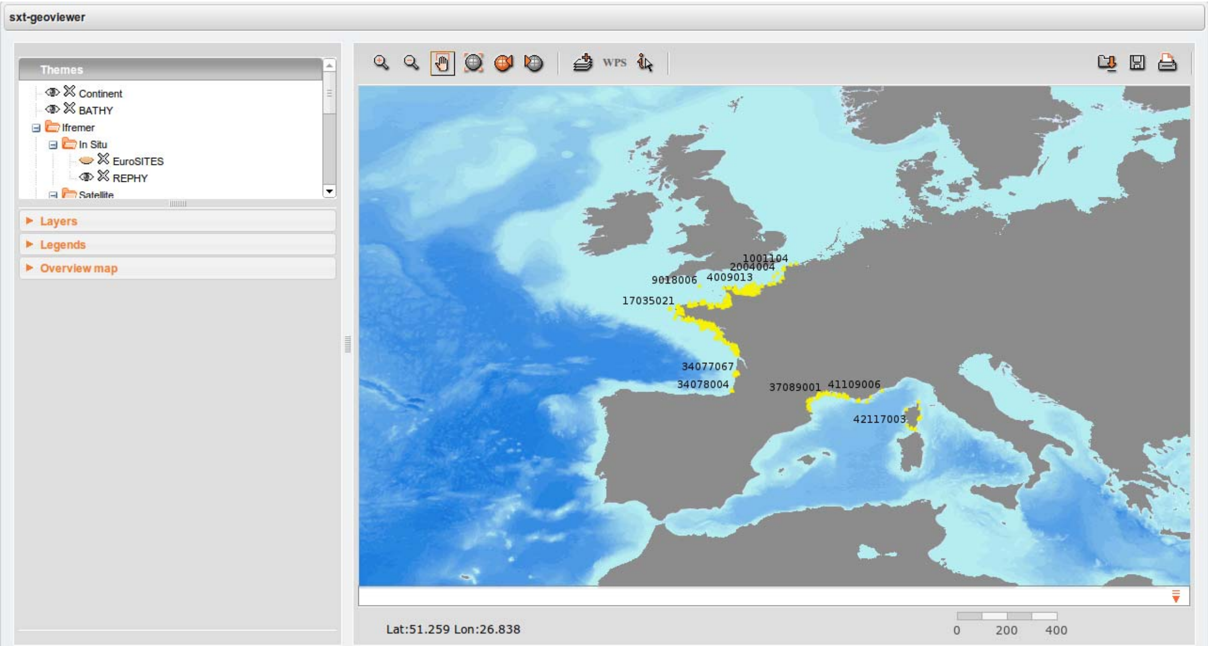

Figure 7. GIS Viewer: Loading a predefined set of map layers into the map viewer.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<ows-context:OWSContext …>
    <ows-context:General>
        <ows-context:Window height="672" width="1240"/>
        <ows:BoundingBox crs="EPSG:4326">
            <ows:LowerCorner>-90.0 -180.0</ows:LowerCorner>
            <ows:UpperCorner>90.0 180.0</ows:UpperCorner>
        </ows:BoundingBox>
        <ows:Title>BlueMarble + Google (EPSG:3857) example </ows:Title>
        <ows:Abstract/>
    </ows-context:General>
    <ows-context:ResourceList>

        <ows-context:Layer queryable="true" opacity="1" hidden="false" group="Monde"
id="8" name="basic">
            <ows:Title>Metacarta</ows:Title>
            <ows:OutputFormat>image/png</ows:OutputFormat>
            <ows-context:Server   version="1.1.1"   service="urn:ogc:serviceType:WMS"
default="true">
                <ows-context:OnlineResource
xlink:href="http://vmap0.tiles.osgeo.org/wms/vmap0"/>
            </ows-context:Server>
        </ows-context:Layer>

        <ows-context:Layer      queryable="true"      opacity="1"      hidden="true"
group="Ifremer/In Situ" id="5" name="EuroSITES">
            <ows:Title>EuroSITES</ows:Title>
            <ows:OutputFormat>image/png</ows:OutputFormat>
            <ows-context:Server   version="1.3.0"   service="urn:ogc:serviceType:WMS"
default="true">
                <ows-context:OnlineResource
xlink:href="http://www.ifremer.fr/services/wms/swe"/>
            </ows-context:Server>
        </ows-context:Layer>
…

    </ows-context:ResourceList>
</ows-context:OWSContext>
```

Figure 8. GIS Viewer: Excerpts of an OWS Context file.

2.3.9 *Paper 9: POLMAR Baie de Seine 2012 major crisis exercise in using the EUMIS portal*

POLMAR Baie de Seine 2012 major crisis exercise using the EUMIS portal

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Abstract: The NETMAR (Open service network for marine environmental data) project has developed a pilot European Marine Information System (EUMIS) web portal. The pilot system offered access to observations and forecasts relevant for oil spill monitoring and forecasting, and to shoreline cleanup activities, for French organizations and authorities responsible for pollution monitoring. This short paper describes how the pilot EUMIS was used during a crisis exercise in ocean and coastal waters in north-western France, and summarises the feedback from the users participating in this exercise.

Introduction
The EUMIS pilot implemented two use cases for oil spill monitoring and shoreline cleanup in cases of marine pollution. These two oil spill use cases primarily concern tasks that need to deal with huge amounts of data day after day. These data are needed to support emergency response services during long lasting oil spill crisis situations to provide accurate information about the oil pollution allowing more efficient usage of human resources and equipment.

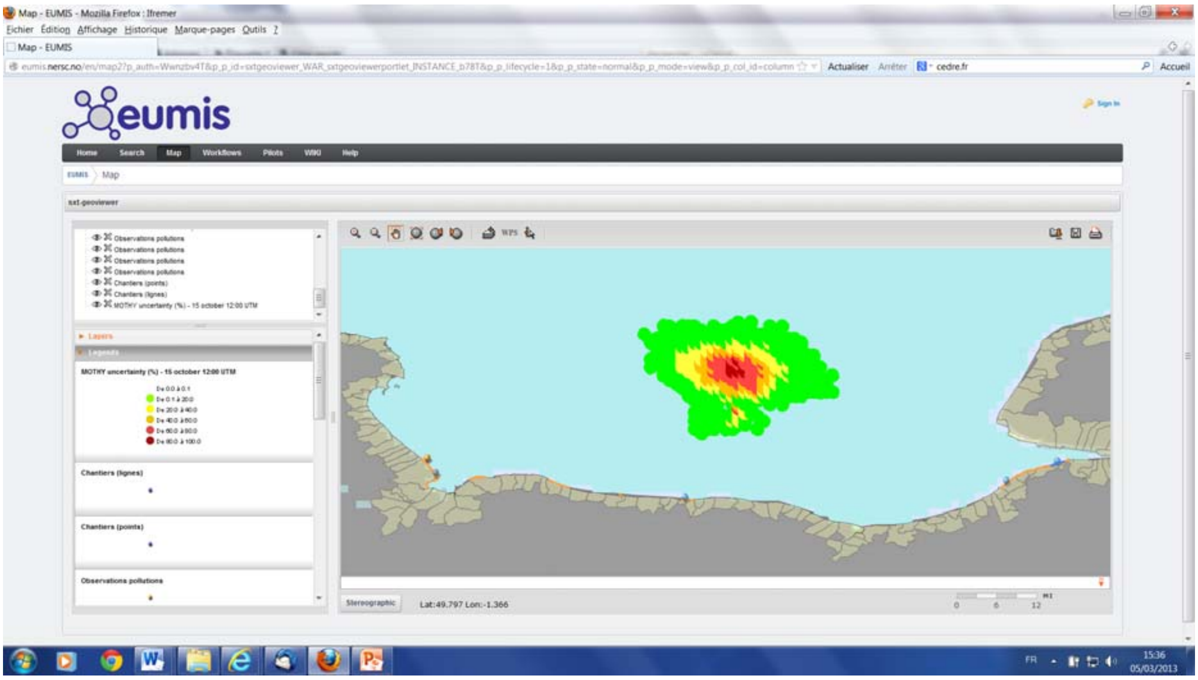
Use case 1 - Collect metocean datasets and spill trajectories forecasts – is is intended for an oil spill drift forecast service in France that will be based on new tools and enhanced functionality to support the experts in making estimates of where a slick or a group of slicks will drift.

Use case 2 - Collect observations from shoreline survey and cleanup sites - concerns the collection of all operational information about onshore pollution landings and cleanup site evolution in order to make them readily available during the crisis. The information is used to develop real-time decisions regarding shoreline treatment and cleanup operations.

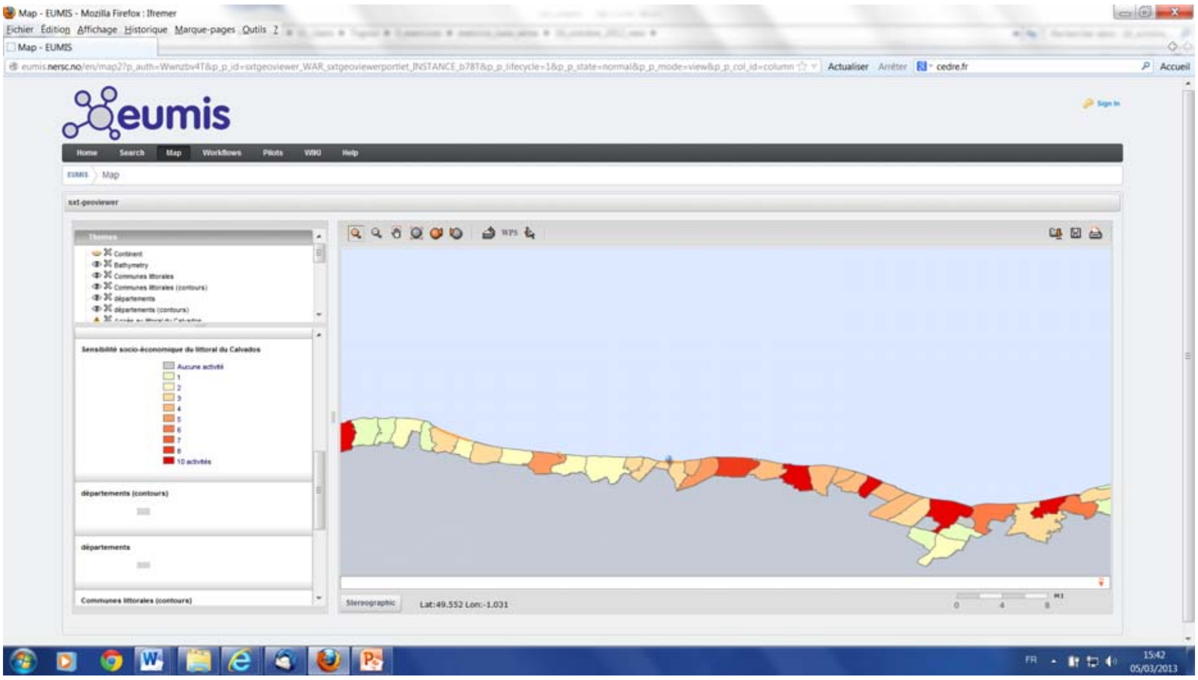
The POLMAR Baie de Seine 2012 exercise
A major crisis exercise entitled "POLMAR Baie de Seine 2012" was organised on 15-16 October 2012 as part of the revision of the specific marine pollution provisions for north-western France. It involved the Maritime Authority for the Channel and North Sea, the counties of Seine-Maritime, Calvados and Manche, as well as the civil protection authority for western France. This exercise mobilised a large number of State departments as well as 7 agents from Cedre, divided between the command centre in Rennes, the 3 counties (Rouen, Caen and Saint-Lô) and Cedre's response centre. The aims were to implement marine pollution response measures, practice applying land-sea interface procedures, assess zonal coordination and determine the capacity of department-level players in terms of shoreline surveys, site protection, clean-up site set-up and waste management, as well as to test communication on a departmental level. All parties showed a high level of involvement in the realistic, although unusual, scenario consisting of an incident in an estuary drifting seawards then towards the shore.

This exercise was a great opportunity to test the EUMIS portal with the Pilot 2.1 (Shoreline cleanup) and some parts of the Pilot 2.2 (oil spill drift forecasts). The aim of this test was to search and collect many datasets form the pollution itself (observations of pollution, oil slick drift forecasts and cleanup sites) as well as sensitivity mapping, orthophotos, currents forecast etc.

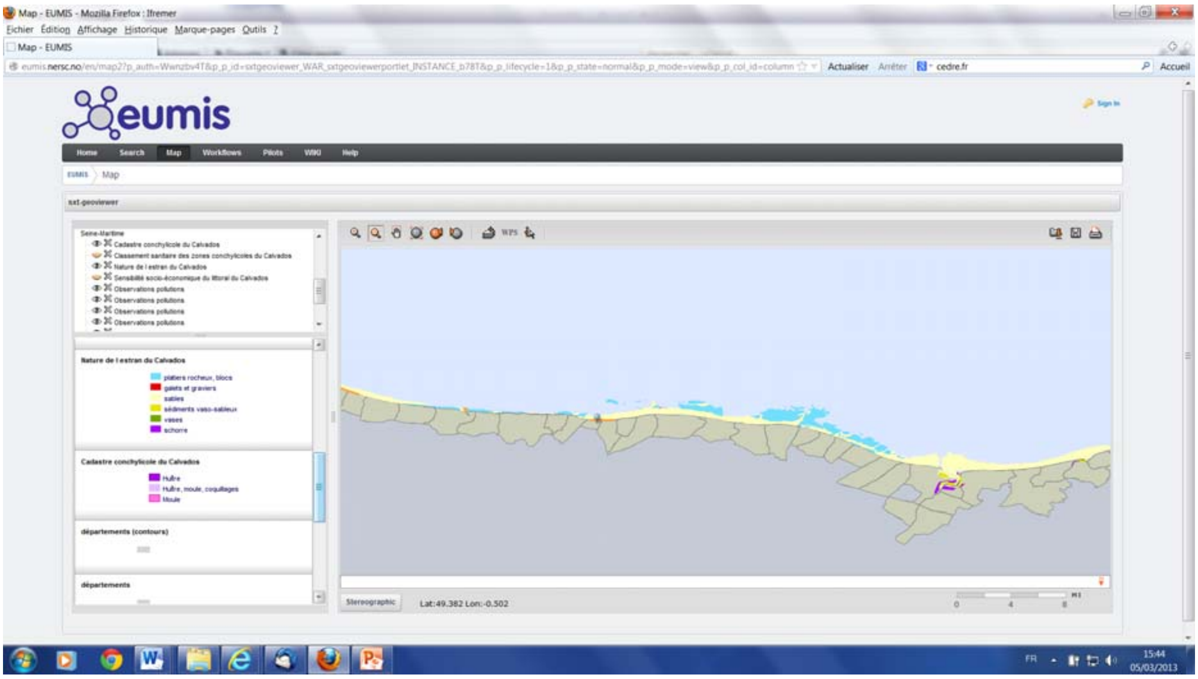
The EUMIS portal were used and consulted by the civil protection authority for western France, in the response centre room. EUMIS portal was used to define the strategy of pollution fighting and to help making decision (technical and politic decisions). Some examples of EUMIS mapping output used during this exercise are shown below.



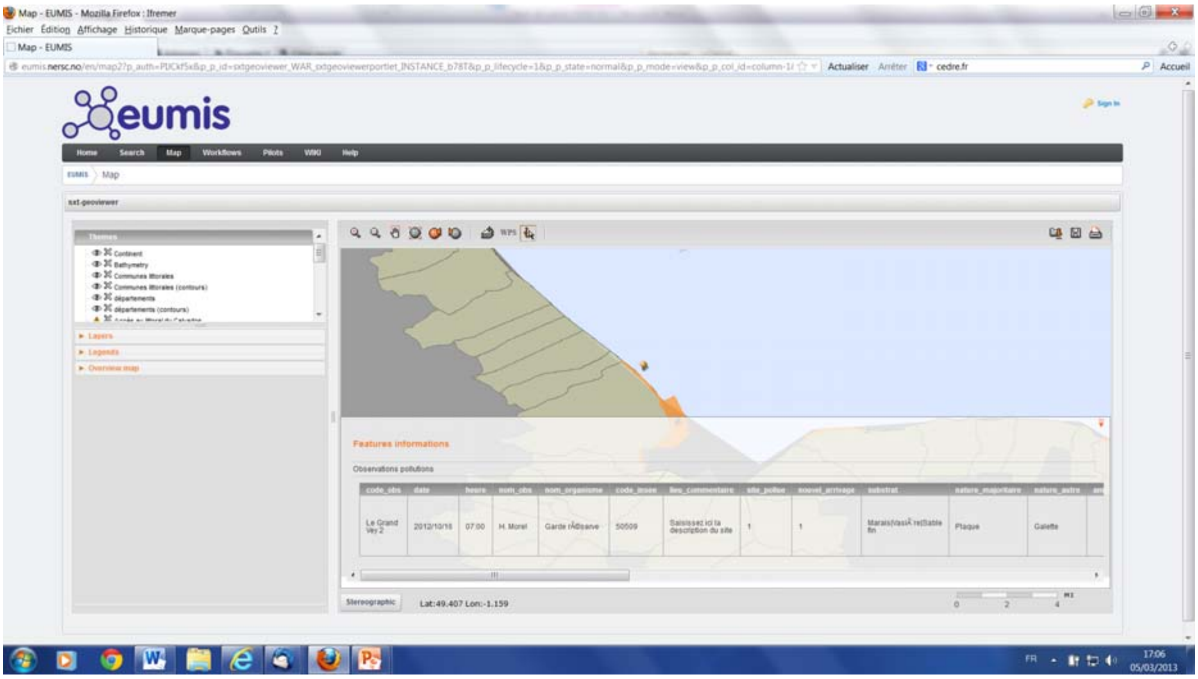
Print screen of EUMIS portal: MOTHY (Oil spill drift forecast – uncertainty of the oil slick drift presence)



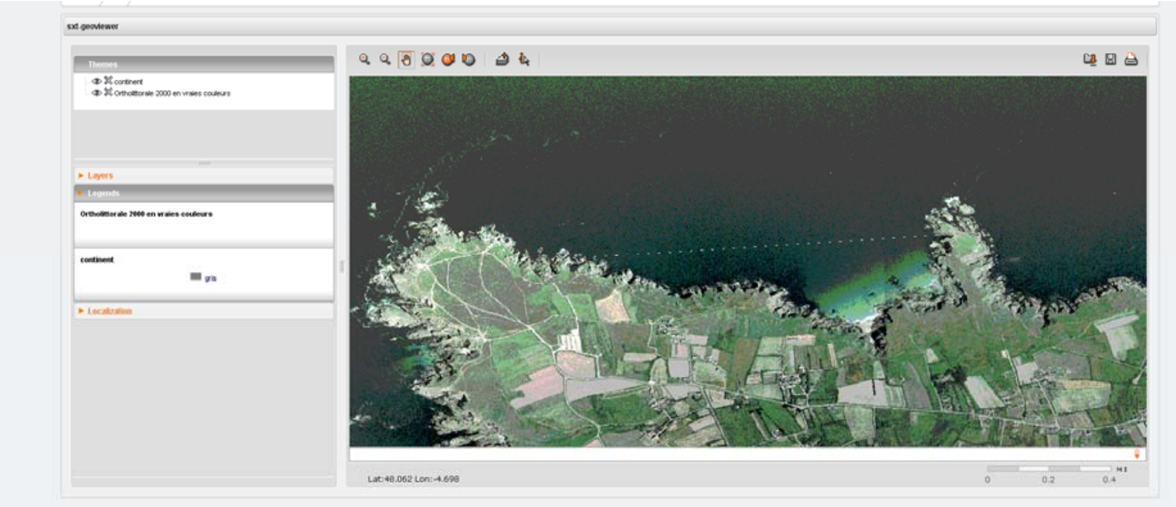
Print screen of EUMIS portal: economical sensitivity mapping (low 'yellow' to high 'red' sensitivity)



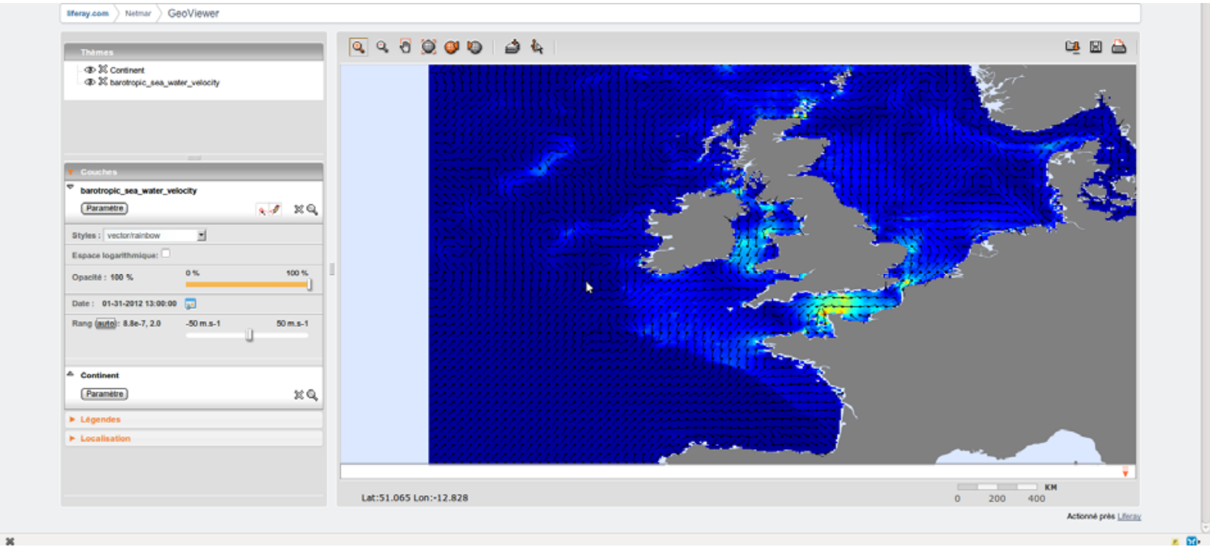
Print screen of EUMIS portal: shoreline geomorphology



Print screen of EUMIS portal: observation of pollution (with related attribute data displayed) and cleanup site (attribute data available)



Print screen of EUMIS portal: orthophoto (helping cleanup site operation and strategy)



Print screen of EUMIS portal: currents forecast and observation (source PREVIMER)

Conclusions of the exercise

The feedback from this exercise can be summarised as follows:

- The EUMIS portal was very useful for operational people as well scientists, experts and politics.
- It allowed to search and display many different datasets from different sources and format. For example, it was the first time we could display the currents forecast together with pollution observations and oil slick drift forecasts.
- It was very useful to display both marine and shoreline data on the same view in order to anticipate the oil slick landings especially on the sensitive areas.
- EUMIS portal allowed displaying all datasets on the same screen which was casted in the emergency room and consulted all the exercise long.
- The ergonomy of EUMIS portal was not really adapted to novice users so there was always someone more capable during the exercise in order to search and display datasets.

3 Impact, dissemination activities and exploitation plan

This section contains a subset of public information from the Impact Assessment Study [HPT+13] and the final Dissemination and Exploitation Plan [HSB+13] from the project.

3.1 Impact assessment

NETMAR has developed a pilot European Marine Information System (EUMIS) for searching, downloading and integrating satellite, in situ and model data from ocean and coastal areas. To facilitate semantic search, EUMIS uses a semantic framework coupled with ontologies for identifying and accessing distributed data, such as near-real time, forecast and historical data. To allow users to compose new products, EUMIS offers a service chaining editor where data delivery and processing services can be combined to generate new parameters dynamically. Both pre-made and on-the-fly generated parameters can easily be co-visualised on the same map in the EUMIS GIS Viewer. The EUMIS portal (http://eumis.nersc.no/) consists of 4 pilots, each demonstrating different capabilities in different marine application domains:

- Pilot 1: Arctic Sea Ice and Met-Ocean Observing System
- Pilot 2: Oil spill drift forecast and Shoreline Cleanup assessment services in France
- Pilot 3: Ocean Colour – Marine Ecosystem, Research and Monitoring.
- Pilot 4: The International Coastal Atlas Network (ICAN)

The impact of the developed system (EUMIS pilot) and services has been assessed by selected users from the four targeted user communities. The partners interviewed their users on their view of the impact of developed tools, components and data delivery/processing services, and captured the findings in a consistent manner using a questionnaire. Since relatively few users, only ten in total, were involved in the assessment, the analysis focussed on extracting qualitative information and describing the anticipated use of results.

The NETMAR outputs (results) are:

- EUMIS portal – A web portal offering access to the ontology browser and search client (and thereby the data and processing services), the GIS viewer and the service chaining editor, as well as a wiki describing products and services plus tutorials.
- Concepts and ideas - The concept and ideas behind EUMIS as a whole are presented in e.g. cookbooks and other project reports, papers, presentations and videos. This material can be used for capacity building.
- Publications – Publications includes all presentations, papers, reports, videos and cookbooks from the project.
- Architecture - The architecture is defined in a project report which also contains descriptions of best practices and patterns that can be used to develop new web portals.
- Semantic mark-up of datasets - The NETMAR metadata profile's definition specifies how to mark-up of datasets using the terms from the NVS as keywords, and encode it according to ISO 19139.
- Vocabularies (keyword, theme, …) – The NETMAR ontology resource is comprised of terms from the four applications domains mapped to the vast vocabularies of the NERC Vocabulary Server.
- Uncertainty representation - The NETMAR metadata profile's definition specifies how uncertainty information about a dataset can be encoded using ISO 19139, allowing to verify that the input to a service is semantically valid.
- Semantic discovery services - The semantic discovery services were built on top of the NVS vocabularies, and were comprised of the NETMAR Semantic Framework and a Semantic Web Service (SWS).

- Data and processing services – A services of data delivery and processing offering existing data or newly computed parameters for the EUMIS pilots.
- PyWPS – A public domain software tool that supports the Web Processing Service (WPS) standard for development of dynamic data processing services.
- GIS Viewer – A portlet in EUMIS that among others, providers co-visualisation of multi-source data from distributed WMS servers, manipulation of layers (colour, transparency, display level), execution of Web Processing Services, multiple map projections and storage of current map set up for later use.
- Ontology browser and search client – A portlet in EUMIS that enables smart search by exploring the NETMAR ontologies and searching for datasets and services marked up with the keywords from the vocaularies.
- Service chaining editor w/workflow orchestration and execution
- Liferay portal framework – The Liferay Community Edition framework and built-in portlets customised and populated with content from the targeted pilot domains.

The users involved in impact assessment were categorised as service providers/builders, operational service users, scientific service users and others (e.g. consultants). All service providers considered the Vocabularies as a useful result; this was closely linked to the Semantic Search services and client, which were also favourably assessed by the service providers. This group also considered the Service Chaining and Web Processing Services technologies and tools useful. The operational service user assessed the Semantic Search technology and tools positively and also found the EUMIS portal and GIS Viewer useful. The EUMIS portal and GIS Viewer also got the most positive assessments from the scientific service users. In additions, one of the scientists found the Semantic Search and Web Processing Services an exploitable result, and one scientist emphasised the Publications and especially the NETMAR Cookbooks as useful for building competence in his user community. The consultant company involved in the assessment found the EUMIS portal and GIS Viewer the most useful results from the NETMAR project.

The potential impact of each of the major results of the NETMAR project was also analysed. Eight of the interviewed users found the Vocabularies and Semantic Search services developed in the project useful, and a resource/tool that they could use to find relevant datasets, while seven of the users positively assessed of the GIS Viewer, emphasising the benefits of multi-layer co-visualisation and rich layer manipulation capabilities. Six of the users identified the EUMIS portal, the underlying Concepts and Ideas, and the Semantic Mark-up, as NETMAR outputs that they could use in the coming 3-5 year period, while five of the users considered using the Ontology Browser/Search Client after the NETMAR project ends. The other major results obtained fewer positive assessments, but can still be of use for other users. For instance, the PyWPS software is a reference implementation of the WPS specification, and is widely used by organisations developing web processing services. The public PyWPS wiki has received approximately 20000 hits since it went live in 2011, and is accessed by about 250 unique visitors per week. This indicates that PyWPS is being used by many users outside the NETMAR Consortium and Pilot User Communities.

Several results have already been exploited in external communities. The Vocabularies and Semantic Search services of the NVS, is being used by e.g. SeaDataNet-2 as well as two major U.S. programmes for oceanographic data management (BCO-DMO, R2R). The Ontology Browser/Search Client is being used in the ICAN portal, and search technologies and tools are foreseen to be re-used in the further development of the MIDA coastal web atlas.

Based on the overall positive evaluation of NETMAR outputs and the already occurring uptake in external (to the project and its user base) communities, we are confident that many components of the NETMAR system and services will have a positive impact on the development of environmental services and systems in the coming 3-5 year period. NETMAR outputs are foreseen to be used not only in the application domains targeted by the four EUMIS pilots, but also in other environmental domains as well as across domains.

3.2 Dissemination activities

NETMAR results were presented at a number of national and international conferences and workshops during the course of the project. Some of the major dissemination activities are briefly described below. A full list of dissemination activities are found in Section 4.

3.2.1 *Conferences and workshops*

Some of the presentations made at international conferences and workshops are:

- FOSS4G 2010, 6-9 September 2010, Barcelona, Spain
  - J. de Jesus, 2010, PyWPS Tutorial
- ENVIP 2010, 6-8 Octobe, 2010, Bonn/Cologne, Germany
  - A. Leadbetter, T. Hamre, R. Lowry, Y. Lassoued and D. Dunne, 2010, Ontologies and Ontology Extension for Marine Environmental Information Systems
- EuroGOOS 2011, 4-6 October, Sopot, Poland
  - T. Hamre and S. Sandven, 2011, Open service network for marine environmental data
- EGU 2012, 23 – 27 April 2012, Vienna:
  - T. Hamre et al, 2012, EUMIS - an open portal framework for interoperable marine environmental services
  - A. Patterson, 2012, Using SOA Patterns to promote understanding across disciplines
  - J. de Jesus, P. Walker, and M. Grant 2012, NETMAR services
  - A. Leadbetter, R. Lowry, and O. Clements, The NERC Vocabulary Server: Version 2.0
- GEOSS Best Practices Wiki
  - Jorge de Jesus, 2012, WPS Tutorial
- SeaDataNet-2 Plenary Meeting, 19 - 21 September 2012, Rhodes, Greece
  - Adam Leadbetter and Roy Lowry, 2012, Common Vocabularies for SeaDataNet
- AGU 2012:
  - Adam Leadbetter et al., 2012, NERSC Vocabulary Server V2

3.2.2 *User community workshops*

One of the targeted user communities is the International Coastal Atlas Network (ICAN). The overall mission/strategic aim of ICAN is to share experiences and to find common solutions to coastal web atlas development (e.g. user and developer guides, handbooks and articles on best practices, information on standards and web services, expertise and technical support directories, education, outreach, and funding opportunities, etc.), while ensuring maximum relevance and added value for the end-users.

At the European-African ICAN Workshop, London (20 September 2012), a progress update was presented concerning the NETMAR ICAN pilot. This workshop helped to gain early feedback relating to the pilot. It was attended by circa 10 coastal atlas developers.

At the ICAN 5 Workshop, Oostende, Belgium (31 August - 2 September 2011), two dedicated technical workshops were conducted directly concerning the NETMAR ICAN pilot. These workshops demonstrated the activities and tools developed to date. Live demonstrations were presented to test the pilot functionality. The first technical workshop demonstrated how an ontology can be constructed and delivered through the NERC Vocabulary Server. The second technical workshop showed how atlases can be connected to the CSW mediator in order to become part of the NETMAR ICAN pilot. It also demonstrated the NETMAR search client and ontology browser. During the two technical workshops, which were attended by circa 20 people, discussions and feedback were given on the pilot. Also, further presentations and discussions on the pilot were conducted in the plenary sessions of the ICAN 5 workshop. The structure for the ICAN semantic cookbooks to be written by NETMAR was also discussed. Overall, circa 50 people attended the ICAN 5 workshop.

At the European-African ICAN Workshop, Oostende, Belgium (26 November 2012), the semantic tools and search client, as well as the service chaining editor were demonstrated at this event. This was attended by 9 people with different backgrounds including Integrated Coastal Zone Management (Kustbeheer, Belgium), industry (CARIS, The Netherlands), arts and science (Satellietgroep, The Netherlands). The co-chair of ICAN who is driving the strategy goals of ICAN was present and chairing the overall meeting. Positive feedback was received on the demonstration. The main discussion afterwards was on exploitation. It was agreed that the underlying technologies demonstrated will be valuable for demonstrating Coastal Web Atlas interoperability. The main challenge will be to make these technologies understandable to atlas developer community in order to facilitate a wide uptake. In this regard, future opportunities in terms of training and technology leverage into new project proposals concerning coastal atlases were discussed.

3.2.3 *Capacity building material*

NETMAR also produced several cookbooks for capacity building in addition to dissemination at conferences and workshops. The cookbooks provide an introduction to some of the key technologies used and tools developed in the project, specifically:

D7.7 WPS Cookbook [DJW11]
NETMAR makes heavy use of the Open Geospatial Consortium (OGC), Web Processing Service (WPS) standard when implementing processing services. The WPS Cookbook provides a guide to implementers who wish to use WPS (specifically PyWPS) and chain processes provided by these services within their own systems.

WPS defines the protocol by which service providers can expose their geo-processing services on the web. It specifies how the service should describe itself, how processes should be called and how they return data; allowing simple web clients to make use of potentially complex services.

Service chaining further extends the power of WPS by allowing users to “chain” the output of one process into another, building a custom processing service to fit their needs. These chained processes could themselves be packaged as WPS processes to make it easy for third parties to use them.

D7.8 Semantic Data Delivery and Processing Services Cookbook [WGJ12]
Semantically enabled discovery services can be used to find services that may be useful in a particular domain; once these services have been identified data and processing services must be combined in a compatible manner to produce the desired products. Work has been carried out within the project to extend services with semantic metadata (metadata specifying the meaning of a dataset and its units) allowing this chain building to be aided by an intelligent service chaining editor and for the processes themselves to verify their inputs.

The cookbook is primarily aimed at service providers/implementers who would also like to add semantic metadata to their services, and aims to provide guidance in the form of example XML and code snippets. It requires an understanding of the OGC WxS standards and XML. For those developing processing services familiarity with Python would also be useful.

The cookbook approach is to work within the existing OGC standards such as WMS, WFS and WCS, and services using this approach will remain compatible with clients that have no knowledge of semantics.

D7.9.2 ICAN semantic interoperability pilot cookbooks [DLL12]
NETMAR's ICAN (International Coastal Atlas Network) pilot is scoping and implementing data interoperability approaches for distributed coastal web atlases (CWAs). The ICAN community wish to make their ongoing digital atlas developments more interoperable to better support data discovery, data visualisation, and data sharing across administrative, natural and thematic borders. Data discovery is central to this pilot as it enables subsequent data visualisation and data sharing. Data discovery includes smart search functionality utilising "semantic" resources.

This cookbook is comprised of four parts, which covers key material concerning the technologies and standards utilised by the International Coastal Web Atlas (ICWA) prototype:

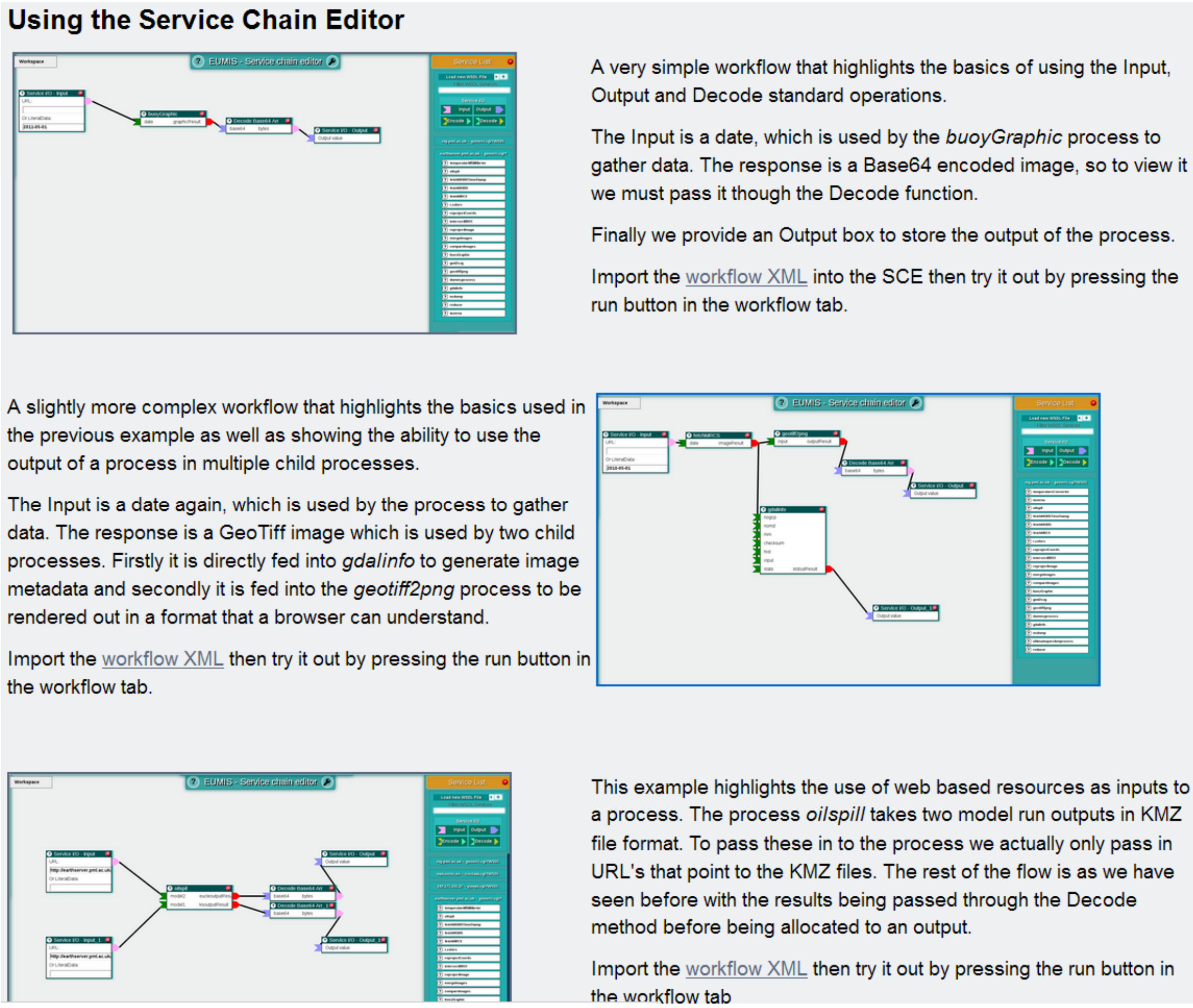
1. Understanding Semantics.
2. Understanding Metadata.
3. Establishing a CSW metadata catalogue with GeoNetwork opensource.
4. Connecting your Atlas to the ICWA prototype.

The first cookbook introduces the terms and technologies used to organise knowledge and implement semantic search in a web-based information system. The second and third cookbooks address how to mark-up metadata (i.e. data about data) with keywords that captures the semantics of the datasets, and how to set up an OGC compliant metadata catalogue that can be integrated in a semantic search service. The fourth cookbook address technical issues related to setting up a coastal web atlas.

Tutorials and videos
The PyWPS wiki contains not only links to the software and installation instructions, but also lots of documentation and examples. For instance on how to configure and use the software, how to create your own simple WPS service in Python, and background information such as a short description of the WPS standard itself and it's API. It also has links to related software tools for analysis and visualization of geographical data, standard protocols for web services, and much more. The PyWPS wiki was first presented in the FOSS4G 2010 conference in Barcelona during the tutorial "PyWPS for beginners and developers", and contains several videos showing use of PyWPS together with other GIS tools like e.g. GRASS and QGIS.

The WPS tutorial at the GEOSS Best Practices Wiki contains an introduction to the OGC WPS (Web Processing Service) standard explaining its API with examples of calls (requests) and results (responses). This tutorial also contains several examples showing how a WPS services can be implemented using tools such as PyWPS.

The EUMIS pilots contains a tutorial and a video explaining how to use the service chaining editor, with examples of workflow definitions that can be downloaded and used as basis for own workflows. Figures below show some screenshots from this tutorial and video.



Using the Service Chain Editor

A very simple workflow that highlights the basics of using the Input, Output and Decode standard operations.

The Input is a date, which is used by the *buoyGraphic* process to gather data. The response is a Base64 encoded image, so to view it we must pass it though the Decode function.

Finally we provide an Output box to store the output of the process.

Import the workflow XML into the SCE then try it out by pressing the run button in the workflow tab.

A slightly more complex workflow that highlights the basics used in the previous example as well as showing the ability to use the output of a process in multiple child processes.

The Input is a date again, which is used by the process to gather data. The response is a GeoTiff image which is used by two child processes. Firstly it is directly fed into *gdalinfo* to generate image metadata and secondly it is fed into the *geotiff2png* process to be rendered out in a format that a browser can understand.

Import the workflow XML then try it out by pressing the run button in the workflow tab.

This example highlights the use of web based resources as inputs to a process. The process *oilspill* takes two model run outputs in KMZ file format. To pass these in to the process we actually only pass in URL's that point to the KMZ files. The rest of the flow is as we have seen before with the results being passed through the Decode method before being allocated to an output.

Import the workflow XML then try it out by pressing the run button in the workflow tab

Figure 3-1 EUMIS – Tutorial for the Service Chaining Editor.

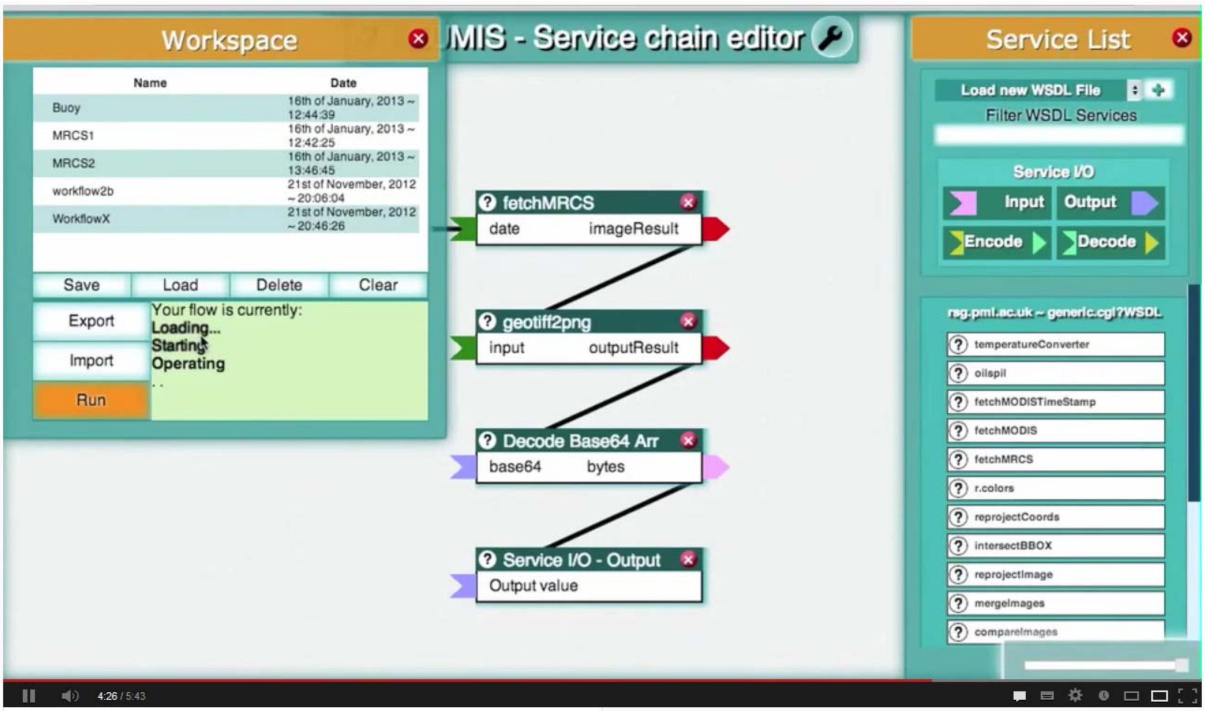


Figure 3-2 EUMIS – Video tutorial for the Service Chaining Editor.

3.3 Exploitation plan

The major results (exploitable foreground) from the NETMAR project include:

1. System architecture
2. Ontology resource
3. Semantic framework
4. WPS server (PyWPS)
5. Data delivery and processing services, including semantic mark-up
6. EUMIS portal with components (GIS viewer, search client, service chaining editor)
7. Cookbooks and other material for capacity building

The architecture of the EUMIS portal and services is described from a number of complementary viewpoints, which are based on the EC FP7 project Orchestra[3] adaptation of the RM-ODP reference architecture. The final version of the system architecture is made public on the NETMAR public web site[4], while the most relevant architectural patterns have been submitted to the GEOSS Best Practices wiki[5].

The system architecture has and will be used in the development of web portals for environmental data. For instance, lessons learned from building NETMAR's architecture have been incorporated into the Irish Environmental Protection Agency (EPA) sponsored Irish Climate Information Platform. This project started in 2011, and has already completed phase 1 in the form of a public-facing platform for providing access to climate information. Software engineering practices such as automated build and testing, continuous integration and deployment have been used to ensure that end-user feedback can be gathered continuously. Architectural patterns have been used to successfully implement a coherent and well performing user interface.

The NETMAR semantic resource was designed to support selected case studies within the application domains of the four pilots (sea ice, oil spill, ocean colour and ecosystems, ICAN), and built on the NERC Vocabulary Server[6] at BODC. The semantic resource maps terms, such as parameters, instruments, platforms and themes, from the four EUMIS pilots to the vast vocabularies of oceanographic and environmental terms established by BODC in a number of RTD and governmental projects over a period of 25 years. During NETMAR, the NERC Vocabulary Server was brought to version 2.0 (NVS2.0), with access for SOAP consumers through WSDL[7] and through a SPARQL end point[8].

The NVS content is becoming a *de facto* standard vocabulary for Linked Open Data descriptions in the marine science domain. Evidence for this was shown at AGU Fall Meeting 2012 in San Francisco where both Woods Hole Oceanographic Institution and Lamont Doherty Earth Observatory presented tools built on the interface and data descriptions using the content. To further this work, BODC has recently submitted the NVS to the datahub.io registry for consideration for the next version of the Linked Open Data diagram. Several of the other partners in the NETMAR consortium, including METNO and NERSC, will continue to use the NETMAR semantic resource together with the NVS to offer semantic search,

[3] www.eu-orchestra.org/

[4] http://netmar.nersc.no/sites/netmar.nersc.no/files/D2.4.2_System_Architecture_Authoritative_r1_20130215_0.pdf

[5] http://wiki.ieee-earth.org/Best_Practices/GEOSS_Transverse_Areas/Data_and_Architecture/Service_Portal

[6] http://vocab.nerc.ac.uk/

[7] http://vocab.nerc.ac.uk/vocab2.wsdl

[8] http://vocab.nerc.ac.uk/sparql

using the NETMAR metadata profile representation of semantic keywords in ISO 10139 encoding of metadata.

The semantic framework is defined by an authoritative specification and implemented as an open source software[9] . The authoritative specification has been made public[10], and also been submitted to the GEOSS Best Practices wiki[11]. The semantic framework specification is planned to be an authoritative specification with the intension of becoming a standard. If successful, the establishment of such a standard would be a big step towards unified access to, and querying of, semantic resources and vocabularies distributed over the web, and towards the interoperability of semantically enabled information systems.

The application scope of coastal web atlases is broad including climate change, marine spatial planning, natural hazards risks, resource availability and exploitation, population pressures, etc. It is anticipated that for new research and industry projects in these areas, CMRC will re-use relevant NETMAR technologies and knowledge. For example, it is planned to exploit NETMAR semantic framework knowledge in the FP7 MESMA project, where best practice regarding controlled vocabularies, INSPIRE themes, and how to encode INSPIRE keywords in ISO 19139 will be exploited.

PyWPS[12] is an open source implementation of the OGC WPS standard written in Python, and used worldwide. During NETMAR, PML extended the implementation allowing PyWPS to be used as a SOAP based web service. This allows PyWPS services to be used by SOAP aware orchestration systems such as Taverna[13], which is functionality generally not available in other packages. PML has also integrated the wps-grass-bridge[14] software into this framework allowing GRASS[15] GIS processes to be accessed as a web service. The orchestration component of the processing services, itself a WPS component, will also be made available (via github).

Three of the NETMAR partners, PML, NERSC and CMRC, have used PyWPS to implement web processing services during the project. PML has developed a toolkit of processes, using PyWPS and wps-grass-bridge, which allow data to be extracted from datasets (in situ, model and satellite observations). These processes include re-gridding/projecting and various statistical measures. NERSC has developed an ice classification service based on satellite SAR data, and CMRC has used PyWPS to develop a web processing service for Shaded relief map creation. All three partners plan to continue using PyWPS. In addition, METNO is also considering PyWPS as a major tool for their planned development of web processing services in the next coming years.

All partners developed data delivery and/or processing services during the NETMAR project for provision of in situ, satellite and model data to one or more of the four EUMIS pilots [WPT+12][WSH+12]. As an example, Ifremer provided access to the REPHY network of in situ observations from more than 300 stations (buoys) along the French coastline, fed this

[9] https://github.com/NETMAR/netmar

[10] http://netmar.nersc.no/sites/netmar.nersc.no/files/D4.5_Authoritative_specification_of_semantic_framework_r1_20121130_0.pdf

[11] http://wiki.ieee-earth.org/Best_Practices/GEOSS_Transverse_Areas/Data_and_Architecture/GEOSS_Architecture/Semantics_AIP_Working_Group

[12] http://pywps.wald.intevation.org/

[13] http://www.taverna.org.uk/

[14] http://code.google.com/p/wps-grass-bridge/

[15] http://grass.fbk.eu/

data into Pilot 3 Ocean colour and ecosystem modelling, for use by French authorities for algal bloom monitoring. Another example is the PML processing service for comparison of in situ chlorophyll measurements with chlorophyll concentrations derived from satellite imagery. Partners will utilise and build on these services in future projects and activities. The services that will be maintained by the respective partner for a period of one year or more have also been registered in the GEOSS CGI[16], in the GEOSS Service Registry.

The EUMIS portal is based on Liferay Community Edition portal (version 6). This is an Open Source software tool with a number of included components (portlets) for functionality such as Wiki, Forum, RSS feeds, etc. Liferay provides the underlying infrastructure for EUMIS, including user management, editing facilities, etc. Liferay Community Edition can be used as basis for other service developers that want a flexible portal framework for EIS development, where they can integrate new components according to an industry accepted standard (JSR-168 and JSR-286). A portlet can be written in several languages, including Java, Python and Flex, and can include rich user interfaces in e.g. JavaScript. In NETMAR, three web-GIS components were developed:

(1) GIS Viewer
(2) Ontology Browser and Search Client
(3) Service Chaining Editor

The GIS Viewer is a component of the EUMIS portal that allows us to view and use distributed geospatial resources that have been shared using the OGC WMS standard. It provides a user-friendly way of browsing WMS's to see what features they have available (GetCapabilities), choosing those of interest, and seeing the resulting map (GetMap). The viewer gives us the ability to request multiple maps properly geographically overlaid on top of one another. And, if the WMS and layer of interest support it, it's possible to click on a feature to get additional information about it (GetFeatureInfo).

Another output of the NETMAR project is a software component for discovering and accessing services. The EUMIS smart search and discovery client supports three features: ontology browsing, dataset smart search, and metadata visualisation. It provides search facilities based on the *semantics* of the data, including support for multi-domain and multi-lingual search in a network of metadata catalogue services connected by a mediator tool. This component has been reused and adapted by the ICAN community.

A web based service chaining editor that allows users to create workflows using only a web browser was also developed. These workflows can then be run using a web orchestration engine built by the NETMAR project using the Taverna Server component. Workflows may also be shared with other users via email or exported as Taverna T2FLOW and run within a standalone Taverna Workbench. The editor has been integrated as a portlet and is a component of the EUMIS portal. The editor can also be run in standalone mode.

The EUMIS components are publicly available at http://github.com/NETMAR/netmar.

During the project, NETMAR has produced three cookbooks to support capacity building:

- NETMAR cookbooks for data delivery and processing services (Deliverable D7.7) [DJW11]
- NETMAR cookbooks for semantic data delivery and processing services (Deliverable D7.8) [WGJ12]
- ICAN semantic interoperability pilot cookbooks (Deliverable D7.9.2) [DLL12], comprised of four parts
    - Understanding Semantics.

[16] http://geoportalng.eo.esa.int/web/guest/about_cgi

- Understanding Metadata.
- Establishing a CSW metadata catalogue with GeoNetwork opensource.
- Connecting your Atlas to the ICWA prototype.

In addition, NETMAR has also, among others, contributed to a WPS tutorial in GEOSS[17], online at, a video on how use the service chaining editor[18] and to a number of presentations introducing the concepts and technologies, and demonstrating the developed services and tools at conferences and user workshops. These and other dissemination resources can be used for capacity building after the project ends.

[17] http://wiki.ieee-earth.org/Documents/GEOSS_Tutorials/GEOSS_Provider_Tutorials/Web_Processing_Service_Tutorial_for_GEOSS_Providers

[18] http://www.youtube.com/watch?v=k3V2NYPZlso

4 Use and dissemination of foreground

This section contains a subset of public information from the Impact Assessment Study [HPT+13] and the final Dissemination and Exploitation Plan from the project [HSB+13].

4.1 Dissemination measures

LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[19] (if available)	Is/Will open access[20] provided to this publication?
1	WPS orchestration using the Taverna workbench: The eScience approach	PML	Computers and Geosciences	Volume 47, October 2012	Elsevier		2011	pp. 75–86	[1]	Yes
2	WPS tutorial	PML	GEOSS Best Practices Wiki		GEOSS	GEOSS Best Practices Wiki	2012		[2]	Yes
3	Putting meaning into NETMAR - the Open Service Network for Marine Environmental Dat	BODC	International Journal of Digital Earth	(accepted for publication)	Taylor & Francis		2013			No
4	Ontologies and Ontology Extension for Marine	BODC	ENVIP 2010 Proceedings				2010		[3]	Yes

[19] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[20] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES

NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[19] (if available)	Is/Will open access[20] provided to this publication?
	Environmental Information Systems									
5	The NETMAR Semantic Framework	CMRC	White paper							
6	EUMIS portal and services – concepts, design and implementation	NERSC	White paper							
7	Service mark-up and semantic validation / Uncertainty representation and propagation	PML	White paper							
8	WPS and orchestration	PML	White paper							
9	A Web GIS Viewer in the Liferay portal framework	Ifremer	White paper							

[1] http://www.sciencedirect.com/science/article/pii/S0098300411003906, http://dx.doi.org/10.1016/j.cageo.2011.11.011
[2] http://wiki.ieee-earth.org/Documents/GEOSS_Tutorials/GEOSS_Provider_Tutorials/Web_Processing_Service_Tutorial_for_GEOSS_Providers
[3] http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-679/paper11.pdf

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
1	Conference	BODC	ICAN Project Workshop	16-18 October 2009	Trieste, Italy	ICAN project participants	32	USA, UK, Belgium, Italy, Ireland, Brazil, Spain, Denmark, Trinidad and Tobago, Portugal, Bulgaria
2	Workshop	PML	Group on Earth Observations (GEOSS) Architecture Implementation Pilot (AIP3) kick off meeting	10-11 March 2010	Frascati, Italy	Data providers, standards bodies, developers, scientists	75	International
3	Workshop	NERSC	Information meeting for the Programme Board of the Space Programme in the Research Council of Norway	2 April 2010	Bergen, Norway	Scientific Community, RTD Program Managers, Scientists	15	Norway
4	Conference - poster	BODC	EGU 2010	2-7 May 2010	Vienna, Austria	Specialist (scientific and technical)	100	Many, including: UK, USA, Australia, France

[21] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[22] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
5	Workshop	Ifremer	User meeting	20 May 2010	Brest, France	Scientists and technical experts	10	France
6	Workshop	BODC	SeaDataNet II proposal development workshop	20 May 2010	Brussels, Belgium	Marine data managers	30	Italy, Netherlands, Greece, Russia, Germany, Spain, France, Sweden, UK, Denmark, Italy, Belgium
7	Workshop	CEDRE	User meeting	23 June 2010	Brest, France	Specialists from Ifremer, Météo-France, SHOM-French Navy, Cedre	9	France
8	Conference – invited tutorial	PML	FOSS4G 2010 Tutorial on PyWPS	6-9 September 2010	Barcelona, Spain	Geospatial software developers and users	500	International
9	Workshop	NERSC	European African ICAN community user workshop	20 September 2010	London, UK	Coastal atlas developers	10	Europe and Africa
10	Workshop	CMRC	European African ICAN community user workshop	20 September 2010	London, UK	Coastal atlas developers	10	Europe and Africa
11	Workshop	BODC	ENVIP 2010 Workshop (special session	8 October 2010	Bonn, Germany	Scientists and technical experts	30	Germany, UK, Norway, Italy, France, Austria,

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
			of ENVIP conference; cluster projects of NETMAR invited)					Greece, Sweden
12	Workshop	PML	UncertWeb project meeting	6-10 December 2010	Bimingham, UL	Scientists and technical experts	15	Germany, UK
13	Workshop	PML	CHPC Annual meeting: Nansen-Tutu Operational Oceanography workshop	7-9 December 2010	Cape Town, South Africa	Scientists	60-70	International
14	Workshop	PML	GeoViqua workshop	18 February 2011		Other FP7 computing project developers	20	Europe
15	Workshop	CEDRE	Management of oil spill response at sea	16 March 2011		Navy, shipping staff	20	France
16	Conference	BODC	EGU 2011	7 April 2011	Vienna, Austria	Computer and environmental scientists	100	International
17	Workshop	METNO	User workshop	29 April 2011	Oslo, Norway	Sea ice expert	1	Norway
18	Other (telemeetings)	NERSC	User workshop	May 2011		Metocean specialist	1	France
19	Workshop	PML	Collaborative meeting with UncertWeb (cluster project)	9 June 2011	UK	Technology researchers and developers	13	Germany, UK

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
20	Other (telemeetings)	BODC CMRC	ICAN technical group conference call	16 June 2011		Scientists / technical / managers	10	International
21	Workshop	NERSC	Presentation for TOTAL E&P	23 June 2011	Stavanger, Norway	Project managers, Director of Research	3	Norway, France
22	Conference	CMRC	NETMAR system architecture at ECOOP Research Project Symposium	28 July 2011	Lancaster, UK	Scientists / technical / managers	10	Europe
23	Conference	BODC CMRC	NETMAR system components and use cases at ECOOP Research Project Symposium	28 July 2011	Lancaster, UK	Scientists / technical / managers	5	UK
24	Workshop – Plenary presentation	BODC	“NETMAR Overview”, “Taking ICAN Forward Technically, Including Prototype – 3” at ICAN-5 Workshop	1 September 2011	Oostende, Belgium	Scientists / technical / managers	50	Europe and USA

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
25	Workshop – presentation / demonstration	BODC CMRC	Workshop on semantic frameworks and ontologies at ICAN-5 Workshop	1 September 2011	Oostende, Belgium	Scientists / technical / managers	20	Europe and USA
26	Conference – poster	METNO	EUMETSAT 2011	5-9 September 2011	Oslo, Norway	Scientists, data managers, technical managers, management, developers		International
27	Workshop	CEDRE	Regional Modelling workshop	13 September 2011	Galway, Ireland	Oceanographic services (Galway, Ireland), Instituto superior tecnico (Lisboa, Portugal), Instituto Tecnolóxico para o control do medio mariño de Galicia (Spain), Irish Coast Guard, CEFAS (Centre for Environment, Fisheries & Aquaculture Science)	50	Europe

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
						MeteoGroup Offshore, Ireland		
28	Conference – presentation	NERSC	EuroGOOS 2011	5 October 2011	Sopot, Poland	Oceanographers, modellers, data managers	30-40	International
29	Workshop	CEDRE	Management of oil spill response at sea	12 October 2011	Brest, France	Management of oil spill response at sea	20	France
30	Workshop	BODC	EC FP7 EuroMarine Workshop on ontologies and vocabularies	18 October 2011		Marine environmental ontology developers	10	Europe
31	Workshop	METNO	User workshop	25 October 2011	Oslo, Norway	Sea ice expert, data managers		Norway
32	Workshop	PML	User workshop	3 November 2011	Plymouth, UK	Technical lead of Western Channel Observatory	1	UK
33	Workshop	Ifremer	User workshop	7 November 2011	Brest, France	Scientist, oceanographer	2	France
34	Workshop	CMRC	User workshop	9 November 2011	Cork, Ireland	Scientists / technical / managers	2	Ireland
35	Workshop	CEDRE	User workshop	14 November 2011	Brest, France	SIDPC finistère	2	France
36	Workshop	Ifremer	User workshop	17 November 2011	Brest, France	Scientist, data manager (satellite)		France
37	Workshop	Ifremer	User workshop	18 November 2011	Brest, France	Scientist, data manager (in-situ)		France
38	Workshop	PML	User workshop	18 November 2011	Plymouth,	MEECE	1	UK

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
					UK	ecosystem modeller		
39	Workshop	BODC	EC FP7 SeaDataNet Technical Task Group meeting	30 November 2011		Marine science data managers	30	Europe
40	Other (e-mail)	NERSC	E-mal contacts	November 2011		Metocean specialist	1	France
41	Workshop	PML	EC FP7 EarthServer Project Meeting	16 January 2012		Project developers and service providers from marine land and space areas	20	Europe
42	Workshop	PML	EC FP7 OpEc Project Kick Off meeting	28 January 2012		Project developers and modelling scientists from EU institutions	20	Europe
43	Conference	PML	EuroGEOSS conference	25 January 2012	Madrid, Spain	Developers, users of geospatial software	200	International
44	Conference	BODC	Oceanology International 2012	13-15 March 2012		Marine science and technology professionals and academics	500	International
45	Conference	CEDRE	INTERSPILL 2012 (European oil spill conference and exhibition)	14 March 2012		Scientists, oceanographers, operators	20	International

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
46	Workshop	CEDRE	Etat major training Management of oil spill response at sea	4 April 2012	Brest, France	Navy, shipping staff	20	France
47	Conference – presentation	NERSC	EGU 2012	24 April 2012	Vienna, Austria	Scientists / technical / managers	60	International
48	Conference – presentation	NERSC, NERC (BODC), PML,	EGU 2012	25 April 2012	Vienna, Austria	Scientists / technical / managers	3	International
49	Conference – presentation	PML	EGU 2012	25 April 2012	Vienna, Austria	Scientists / technical / managers	60	International
50	Conference – presentation	CMRC	EGU 2012	25 April 2012	Vienna, Austria	Scientists / technical / managers	60	International
51	Conference – poster	BODC	EGU 2012	25 April 2012	Vienna, Austria	Scientists / technical / managers	100	International
52	Workshop	PML	GEO European projects workshop	7 May 2012	Rome, Italy	Computer and environmental scientists	45	Europe
53	Workshop	CEDRE Ifremer	User workshop	19 May 2012	Brest, Ifremer	Oceanographers, scientists, GIS users	50	France
54	Workshop	BODC	SeaDataNet Plenary Meeting	19-21 September 2012	Rhodes, Greece			Europe
55	Workshop	CEDRE	CLS / DAR / Expertise &	25 September 2012	Brest, France	Scientists, data managers	5	France

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
			Innovation					
56	Newsletter	CMRC, BODC, PML	NETMAR cookbooks announced in ICAN Newsletter	28 September 2012		Data managers, scientists, technical personnel in the ICAN community.		
57	Other (telemeetings)	CMRC BODC	ICAN Technical Working Group video conference call	2 October 2012		Coastal Web Atlas developers		International
58	Workshop	CEDRE	Etat major training Management of oil spill response at sea	10 October 2012	Brest, France	Navy, shipping staff	20	France
59	Workshop	CEDRE	POLMAR exercise « baie de seine » (channel sea)	15-16 October 2012	Brest, France	West Civil defense zone, French administration Cedre personnel		France
60	Workshop	CMRC	FP7 PEGASO Hands-on Workshop	23-26 October 2012		Scientists and managers		Europe
61	Workshop	CEDRE	User workshop	19 October 2012	Brest, France	Commercial consultant	1	International
62	Workshop	NERSC	Arctic ROOS Annual Meeting 2012	7 November 2012	Sopot, Poland	Scientists and managers		International
63	Conference – presentation	CMRC	EuroICAN 2012, presentation of	26 November 2012	Oostende, Belgium	Scientists and managers		International

LIST OF DISSEMINATION ACTIVITIES

NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
			ICWA prototype V3					
64	Conference – presentation	PML CMRC	EuroICAN 2012, presentation of service chaining editor	26 November 2012	Oostende, Belgium	Scientists and managers		International
65	Conference – presentation	BODC	EuroICAN 2012, presentation of semantic search / technologies	26 November 2012	Oostende, Belgium	Scientists and managers		International
66	Conference - poster	BODC	NERC Vocabulary Server V2.0 and the NETMAR Oceanography Thesaurus	3-6 December 2012	US			International
67	Workshop	CMRC	User workshop	20 December 2012	Cork, Ireland	IT researcher	1	Ireland
68	Workshop	CMRC	User workshop	20 December 2012	Cork, Ireland	Marine ecology researcher	1	Ireland
69	Workshop	CEDRE	User workshop (2 with the same user)	24 December 2012 and 21 January 2013	Brest, France	Emergency personnel	1	France
70	Workshop	PML	User workshop	8 January 2013	Plymouth, UK	Manager	1	UK
71	Workshop	PML	User workshop	9 January 2013	Plymouth, UK	Scientist	1	UK
72	Workshop	CEDRE	User workshop	15 January 2013	Brest, France	Trading and shipping company	1	International
73	Workshop	Ifremer	User workshop	21 January 2013	Brest,	Scientist	1	France

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[21]	Main leader	Title	Date/Period	Place	Type of audience[22]	Size of audience	Countries addressed
					France			
74	Workshop	NERSC	User workshop	22 January 2013	Bergen, Norway	Scientist	1	Norway
75	Workshop	NERSC	User workshop	29 January 2013	Bergen, Norway	Scientist (in commercial company)	1	International
76	Workshop	PML	User workshop	29 January 2013		Scientist/project manager, lead developer	2	International

4.2 *Exploitable foreground and plans for exploitation*

LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[23]:	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)

Not applicable – NETMAR is an open project.

[23] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Type of Exploitable Foreground[24]	**Description of exploitable foreground**	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	**Exploitable product(s) or measure(s)**	**Sector(s) of application**[25]	**Timetable, commercial or any other use**	**Patents or other IPR exploitation (licences)**	**Owner & Other Beneficiary(s) involved**
Exploitation of R&D results via standards	System architetture	No		Specification document		2014	CC BY-SA[26] for documents CC BY-SA for UML	CMRC, PML, BODC, NERSC, METNO, Ifremer, Cedre
Commercial exploitation of R&D results	Ontology resource	No		Semantic resources and their interfaces	Domains addressed by pilots	2013	CC for documents	BODC, CMRC
R&D results via standards	Semantic framework	No		Software and interfaces	Domains addressed by pilots	2014	CC for documents. GPL for specific components.	CMRC, BODC
Commercial exploitation of R&D results	Data and processing delivery services	No		Satellite, in situ and model data; derived and combined data sets	Domains addressed by pilots	2013	NETMAR data license	NERSC, METNO, CEDRE, PML, Ifremer, BODC
Commercial exploitation of R&D results	WPS server (PyWPS)	No		Software and documentation [27]	Cross domain	2011	GPL	PML, PyWPS community
Commercial exploitation of R&D results	EUMIS portal with component s (GIS viewer,	No		Software, including built-in components w/content, as well as pilot-	Cross domain	2014	Liferay Community Edition license for portal and built-in portlets.	Liferay Inc., NETMAR Consortium

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[25] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

[26] http://creativecommons.org/licenses/by-sa/2.0/

[27] PyWPS wiki http://wiki.rsg.pml.ac.uk/pywps/Main_Page

Type of Exploitable Foreground[24]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[25]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	search client, service chaining editor)			specific components.			CC for content. GPL for specific components.	
R&D results via standards	Cookbooks and other material for capacity building	No		Documentation and training material for capacity building	Cross domain	2013	CC for documents and other material.	NERSC, METNO, CEDRE, PML, Ifremer, BODC

System architecture
The architecture is defined in a report which also contains descriptions of best practices and patterns that can be used to develop new web portals [PHD+13]. The most relevant architectural patterns have been submitted to the GEOSS Best Practices wiki[28]. The architecture specification may be used by other web portal developers for environmental information systems, as an example of a working architecture based on standard interfaces between system components and data delivery/processing services and best practices from the field of software engineering.

Ontology resource
The NETMAR semantic resource was designed to support selected case studies within the application domains of the four pilots (sea ice, oil spill, ocean colour and ecosystems, ICAN), and built on the NERC Vocabulary Server[29] at BODC. The semantic resource maps terms, such as parameters, instruments, platforms and themes, from the four EUMIS pilots to the vast vocabularies of oceanographic and environmental terms established by BODC and made publicly available through the NERC Vocabulary Server version 2.0 (NVS2.0). NVS 2.0 provides open access to the concept schemes and vocabularies for SOAP consumers through WSDL[30] and through a SPARQL end point[31]. It can be used by any service provider that wants to ensure mark-up using standardised terms and/or offer semantic search clients.

[28] http://wiki.ieee-earth.org/Best_Practices/GEOSS_Transverse_Areas/Data_and_Architecture/Service_Portal

[29] http://vocab.nerc.ac.uk/

[30] http://vocab.nerc.ac.uk/vocab2.wsdl

[31] http://vocab.nerc.ac.uk/sparql

Semantic framework
One of the main outputs of the semantic framework work package is the semantic framework specification, which is planned to be an authoritative specification with the intension of becoming a standard. If successful, the establishment of such a standard would be a big step towards unified access to, and querying of, semantic resources and vocabularies distributed over the web, and towards the interoperability of semantically enabled information systems. The authoritative specification has been made public. It has also been submitted to the GEOSS Best Practices wiki[32].

Data and processing delivery services
All partners developed data delivery and/or processing services during the NETMAR project for provision of in situ, satellite and model data to one or more of the four EUMIS pilots [WPT+12][WSH+12]. These services will continue to be accessible through the semantic search client of EUMIS. The services that will be maintained by the respective partner for a period of one year or more have also been registered in the GEOSS CGI[33], in the GEOSS Service Registry. All services are open and can be freely used for non-commercial purposes. Service providers can include the data delivery services in their portals and/or implement new processing services using the data delivery services as input.

WPS Server (PyWPS)
PyWPS[34] is an open source implementation of the OGC WPS standard written in Python, and used worldwide. PML has extended the implementation allowing PyWPS to be used as a SOAP-based web service. This allows PyWPS services to be used by SOAP aware orchestration systems such as Taverna, which is functionality generally not available in other packages. PML has also integrated the wps-grass-bridge[35] software into this framework allowing GRASS[36] GIS processes to be accessed as a web service. The orchestration component of the processing services, itself a WPS component, will also be made available (via github).

EUMIS portal with components
The EUMIS portal is a web portal offering access to the ontology browser and search client (and thereby the data and processing services), the GIS viewer and the service chaining editor, as well as a wiki describing products and services plus tutorials. EUMIS is developed using the Liferay Community Edition portal framework, which has an open source license. The three components of EUMIS (GIS viewer, search client,

[32] http://wiki.ieee-earth.org/Best_Practices/GEOSS_Transverse_Areas/Data_and_Architecture/GEOSS_Architecture/Semantics_AIP_Working_Group

[33] http://geoportalng.eo.esa.int/web/guest/about_cgi

[34] http://pywps.wald.intevation.org/

[35] http://code.google.com/p/wps-grass-bridge/

[36] http://grass.fbk.eu/

service chaining editor) is also open source, and available at github. Thus, other service providers can use the portal framework and EUMIS components as building blocks in the development of new web portals for environmental data.

Cookbooks and other material for capacity building

During the project, NETMAR has produced three cookbooks to support capacity building:

- NETMAR cookbooks for data delivery and processing services (Deliverable D7.7)
- NETMAR cookbooks for semantic data delivery and processing services (Deliverable D7.8)
- ICAN semantic interoperability pilot cookbooks (Deliverable D7.9.1/D7.9.2), comprised of four parts
    - Understanding Semantics.
    - Understanding Metadata.
    - Establishing a CSW metadata catalogue with GeoNetwork opensource.
    - Connecting your Atlas to the ICWA prototype.

In addition, NETMAR has also, among others, contributed to a WPS tutorial in GEOSS Best Practices Wiki[37], a video on how use the service chaining editor[38], and to a number of presentations introducing the concepts and technologies, and demonstrating the developed services and tools at conferences and user workshops. Several papers are also in preparation (see Table 5-2). All of these resources can be used for capacity building after the project ends.

[37] http://wiki.ieee-earth.org/Documents/GEOSS_Tutorials/GEOSS_Provider_Tutorials/Web_Processing_Service_Tutorial_for_GEOSS_Providers

[38] http://www.youtube.com/watch?v=k3V2NYPZlso

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[WSH+12] Walker, Peter, Morten Stette, Torill Hamre and Declan Dunne, 2012. Data Processing Services – Semantically Enabled Processing Services. NETMAR (Open service network for marine environmental data) Deliverable D5.2.2. European Commission Information Society and Media Directorate-General Grant Agreement Number 249024.

Appendices

Appendix A. List of public project deliverables

The following public deliverables from the project can be downloaded from the project web site, under Deliverables:

- D1.3.2 Evaluation of NETMAR system applied to use cases – Final version (February 2013)
- D2.1 Review of projects, initiatives and technologies addressing system architectures for distributed EISs (October 2010)
- D2.4.2 Authoritative specification of NETMAR system architecture (February 2013)
- D3.2 Review of available ontology tooling (October 2010)
- D4.1 Review semantic frameworks (June 2010)
- D3.3 Review of available ontologies and their interfaces (October 2010)
- D3.8 Prototype interlinked ontology resource fully populated to NETMAR requirements (July 2012)
- D4.4.1 Implementation of semantic framework – First version (July 2011)
- D4.4.2 Implementation of semantic framework – Final version (August 2012)
- D4.5 Authoritative specification of semantic framework (December 2012)
- D5.1.1 Data delivery services – Basic data services (March 2011)
- D5.3.1 WPS server – Basic WPS package (April 2011)
- D5.2.1 Data processing services – Basic processing services (July 2011)
- D5.1.2 Data delivery services – Semantically enabled data services (July 2012)
- D5.2.2 Data processing services – Semantically enabled processing services (July 2012)
- D5.3.2 WPS server – Fully semantically enabled processing services (May 2012)
- D6.3 First version of NETMAR portal (July 2011)
- D6.4 Second version of EUMIS subsystems (July 2012)
- D6.5 Final version of NETMAR portal (November 2012)
- D7.2.1 Project fact sheet (August 2011)
- D7.2.2 Project highlights for Year 1 (January 2011)
- D7.5.1 Dissemination material and reports from workshops (May 2012)
- D7.5.2 Dissemination material and reports from workshops (December 2012)
- D7.6 Impact assessment study (February 2013)
- D7.7 NETMAR cookbooks for data delivery and processing services (December 2011)
- D7.8 NETMAR cookbooks for semantic data delivery and processing services (July 2012)
- D7.9.1 ICAN semantic interoperability pilot cookbooks (December 2011)
- D7.9.2 ICAN semantic interoperability pilot cookbooks (revised) (July 2012)
- D8.3 Final scientific report (March 2013)