INTEGRATED INFORMATION PLATFORM FOR RESERVOIR AND SUBSEA PRODUCTION SYSTEM

IIP PROJECT REPORT

JOINT INDUSTRY PROJECT

INTEGRATED INFORMATION PLATFORM FOR RESERVOIR AND SUBSEA PRODUCTION SYSTEMS

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Summary:

IIP is a 26 million NOK joint industry research project with Norwegian Research Council funding. It aims at developing solutions compliant with semantic web concepts for use in the major business domains within the oil and gas business. Deliverables from the project supports The Norwegian Oil Industry Association's (OLF) intentions of establishing an "information pipeline" based on XML and opens standards for information exchange and integration.

Deliverables in the project have been:

- Development of solutions for production and drilling reporting between license operators, license partners and regulatory bodies on the Norwegian continental shelf.
- 60 out of 142 schemas in WITSML has been modeled according to ISO 15926.
- 350 terms regarding well and well zone production in Statoil's production system PROSTY has been modelled and defined in the ISO 15926 reference data library (RDL).
- Development of an ontology for main subsea production equipment. A demonstration of linkage between a 3D model of a subsea christmas tree and the developed ontology has been made.
- Terms and definitions for subsea processing equipment has been listed and documented in spreadsheets.
- Work on developing a condition based maintenance ontology has been initiated.
- Terms and definitions for subsea control modules have been included in the RDL.
- Approximately 400 classes related to environmental reporting to the regulatory bodies on the Norwegian Continental shelf have been included in the RDL
- An extensive number of publications related to the research in the project on the topics: Visualization, Ontology based search, Rule-based notification and Ontology Quality

In addition the project has contributed financially to the completion of the last version of *"ISO 15926 Part 3 - Geometry and Topology, defining, in OWL, the geometrical constructs of ISO 10303-42"*

The projects has been managed by DNV and have been supported by 14 key players in the oil and gas industry in Norway; including oil companies, service companies, engineering companies and IT Vendors. It started June 2004 and was planned to continue for three years. To support the completion of the PhD work at NTNU the official end date of the project is now 31.12.2008

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1 MANAGEMENT SUMMARY

The Integrated Information Platform for Reservoir and Subsea production systems (IIP) is a 26 million NOK joint industry research project with Norwegian Research Council funding. It aims at developing solutions compliant with semantic web concepts for use in the major business domains within the oil and gas business. Deliverables from the project supports The Norwegian Oil Industry Association's (OLF) intentions of establishing an "information pipeline" based on XML and opens standards for information exchange and integration.

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2 BACKGROUND

2.1 Integrated operations

According to OLF (www.olf.no/io/), Integrated Operations on the NCS will be implemented in two steps. Generation 1 processes will integrate offshore and onshore and facilitate real-time simulation and optimization of key work processes as the drilling process and the production process. Generation 2 processes will integrate operation centers of operators and vendors, and lead to heavy automation of processes as well as co-optimization of processes, e.g., to automatic monitoring of reservoir and production, automatic optimization of reservoir models and production plans, and automatic regulation of well completions and process trains.

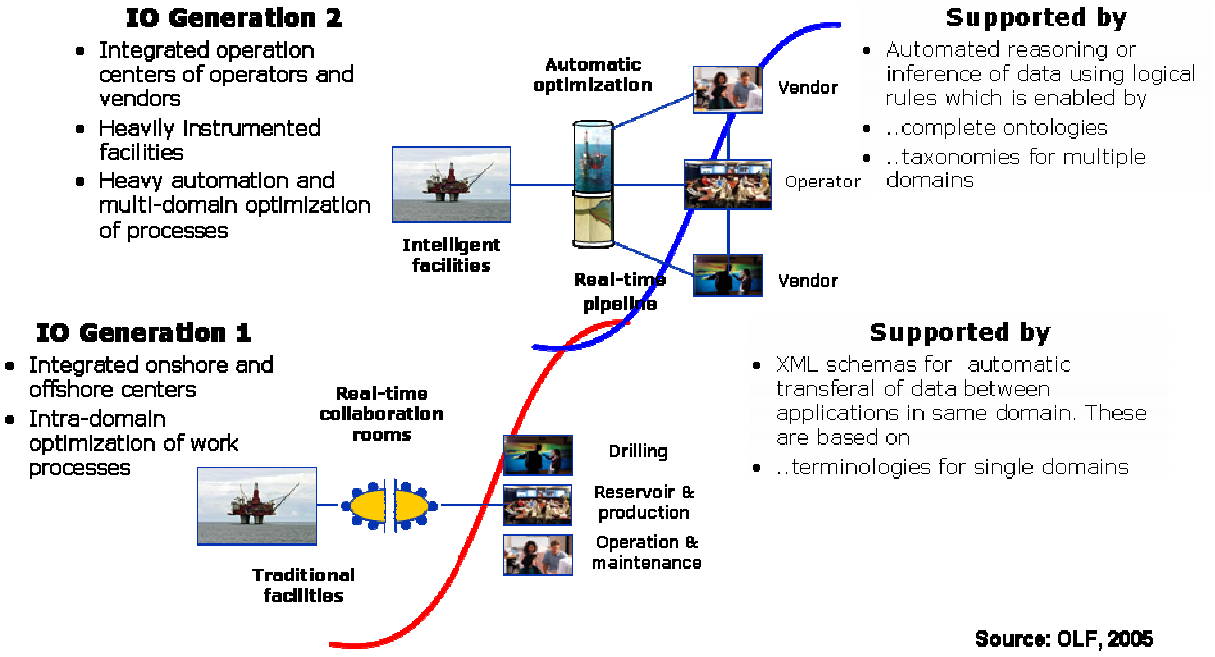

Figure 1: The relation between OLF's two generations of Integrated Operations and terminologies, taxonomies and ontologies developed in the IIP project.

2.2 Purpose and goal

Several challenges need to be resolved for Integrated Operations, as described above, to become a reality. The IIP project has made important contributions toward resolving one of the major ones; the establishment of a real-time information pipeline that supports both generations of IO. The project has done this through development of:

- Machine-interpretable terminologies or dictionaries for relevant domains. These are documented in the POSC Caesar reference data library (Accessible at: http://www.posccaesar.org/wiki/Rds), and form the basis for development of XML schemas for consistent transferal of data between applications in the same domain
- Taxonomies and ontologies for multiple domains or combination of data across domains, by appropriate placement in the upper level ontology ISO 15926-2.

The following domains have been addressed: Drilling and logging, Reservoir and production, Safety and automation systems, Subsea production equipment, Condition Based Monitoring and Health, Safety & Environment.

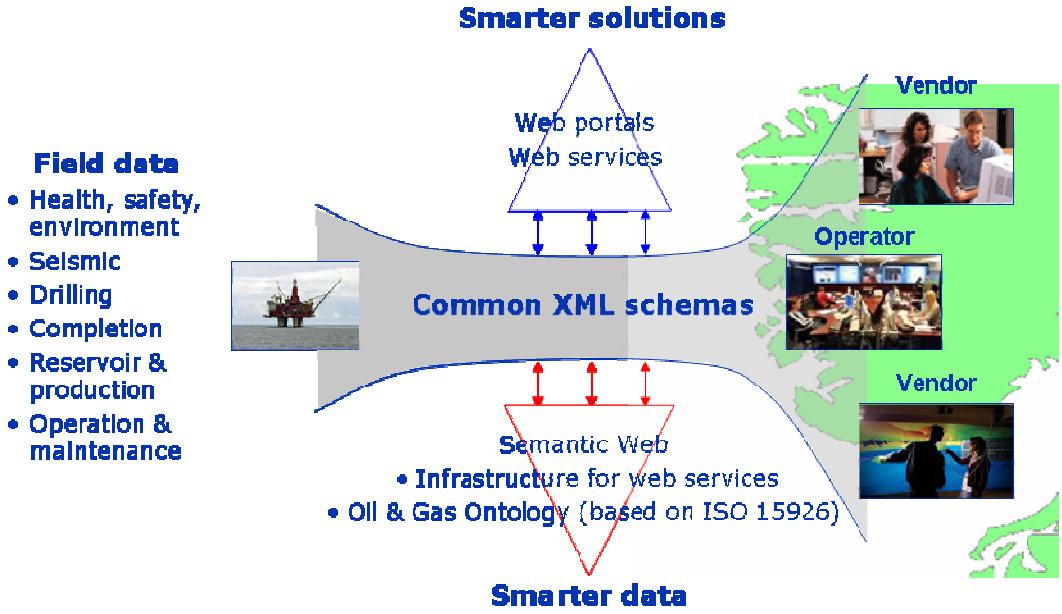

Figure 2 (Source OLF): The information pipeline. The IIP project has supported this through development of terminologies, taxonomies and ontologies for the core E&P processes

3 METHODOLOGY

The semantics developed in IIP has been based on ISO 15926: "Integration of life-cycle data for process plants including oil & gas production facilities". ISO 15926 defines a language that both applications and professionals can understand. Part 2 defines the upper ontology that is used to define the semantics, i.e., terminologies, taxonomies and ontologies. Part 4 contains the semantics or the reference data.

The concepts, relations, properties and rules that the IIP project have defined, are stored in an ISO 15926 compatible reference data library (RDL) that is available for browsing, editing and searching, by professionals as well as applications via internet (http://www.posccaesar.org/wiki/Rds). The philosophy that this concept is based on is compatible with W3C's "Semantic Web".

The project has also financed related research. This work is carried out by The Norwegian University of Science and Technology (NTNU). Some of the topics addressed by NTNU are:

- Web Ontology Language (OWL) Classification and Rule Based Notification
- OWL Classification and Rule Based Notification Prototype Decision Support Software
- Visualization Research and Prototype Visualization Decision Support Software

4 RESULTS

4.1 Integration platform

The following paragraphs describe the development done in the project regarding the integration platform within different domains for the oil and gas industry.

4.1.1 Drilling

4.1.1.1 WITSML

WITSML (www.witsml.org) - Wellsite Information Transfer Standard Markup Language - is a well established XML standard for exchange of drilling data. WITSML has a well functioning community of companies participating in the development of the standard. The IIP project identified WITSML to be a good starting point for the development of a drilling ontology in ISO 15926. A representation of WITSML in ISO 15926 will strengthen the two complimentary standards, and will ease the integration of drilling information systems based on different drilling standards, for example WITSML and IADC.

80 out of a total of 142 WITSML XSD Schemas were selected for ISO15926 modeling. Of this scope, about 75% have been modeled and included into the RDL.

4.1.1.2 Daily drilling reporting (www.olf.no/io/rapporter/?51809.pdf)

A solution for exchange of standardized daily drilling reports between drilling operators and Norwegian regulatory bodies has been developed by the IIP project, represented by Cap Gemini (www.capgemini.no), Energistics, and DNV (www.dnv.com). This solution has been successfully tested by the Petroleum Safety Authority Norway (PSA www.ptil.no) and the Norwegian Petroleum Directorate (NPD www.npd.no) together with Statoil (www.statoilhydro.com) and ConocoPhillips (www.conocophillips.com). It is now a requirement from Norwegian government that all operators shall submit their daily drilling reports on the new formats as of February 2008. A phase 2 covering requirements for exchange of daily drilling reports between operators and partners on licensees on NCS will be considered initiated at a later stage.

4.1.2 Production

4.1.2.1 Production - Prosty

A set of approximately 350 terms based on two tables, V_WR_PWEL_DAY and V_WR_PWEL_ZONE_DAY, from Statoil's production system PROSTY (Called Energy Components by TietoEnator), has been explicitly defined and added to the ISO 15926 Reference Data Library (RDL). The two tables cover production data like measured temperatures, pressures, volumes and masses from wells and well zones.

4.1.2.2 Daily production reporting (www.olf.no/io/rapporter/?51810.pdf)

A solution for exchange of standardized daily production reports between operators and partners in licenses on the Norwegian Continental Shelf (NCS) has been developed by IIP, represented by Energistics (www.energistisc.org), OLF (www.olf.no) and DNV (www.dnv.com) together with TietoEnator (www.tietoenator.no). The solution has been tested successfully on the Valhall (BP-operated) and Aasgard (Statoil-operated) fields offshore Norway and OLF's Operations Committee has recommended that all operators on the NCS implement the system in all production licensees with oil and/or gas production. The terminology and XML schemas developed have also been included in Energistics' PRODML (www.prodml.org) standard.

4.1.2.3 Monthly production reporting

A solution for exchange of standardized monthly production reports between operators and partners of licenses on NCS and Norwegian regulatory bodies are in development. This solution is based on the deliverables from daily reporting but is also including requirements from NPD. It is developed by a group of oil companies together with IIP, represented by IBM (www.ibm.no), OLF, Energistics and DNV, together with TietoEnator, but not completed within the IIP project, funds and timeline. The

testing of the first version based on requirements from NPD started in Agust 2008, and the project is expected to be completed during 2008.

4.1.3 Operation and maintenance

4.1.3.1 Subsea production equipment

An ontology covering the following types of equipment has been developed and quality assured by POSC Caesar's interest group (SIG) for subsea equipment:

- Well types
- Well assemblies and well bore completions
- Drilling and boreholes
- Christmas trees
- Structures and templates, including pipelines
- Control system
- Valves, actuators and valve operation

Scope of this work was limited by using subsea equipment types listed in the Tyrihans Functional and Design Requirements (Doc. no. C074-ZAA-U-FD-0001, Date 2001-08-27, Rev. no. 1) . Definitions for the terms identified where found in different references, for example ISO 13262 - Part 4 (Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 4: Subsea wellhead and tree equipment) , Schlumberger oilfield dictionary (http://www.glossary.oilfield.slb.com/) etc.

To demonstrate a possible use of the ontology for subsea equipment a link between the model and a 3D graphical model of a subsea christmas tree has been developed. The model included hyperlinks between parts of the model, for example "insert choke, ROV panel"etc., to the relevant terms and definitions in the ontology. The demonstrations involved use of web services implemented on top of the RDS.

4.1.3.2 Condition Based Maintenance

A subproject for development of an ontology for condition based maintenance (CBM) of equipment has been initiated. Main focus in this work has been to establish a good relationship with dominating standardization organizations in this area, - in particular MIMOSA. An attempt was made to identify and start with an appropriate and prioritized subset for ISO15926 modeling in inclusion into the RDL. The result of this effort was a list of approximately 500 relevant terms and definitions extracted from the two standards ISO1925 - *Mechanical Vibration – Balancing – Vocabulary* and ISO2041 - *Vibration and shock – Vocabulary*, both referenced from the standard ISO 13374 *Condition monitoring and diagnostics of machines*. A prioritization of these terms and definitions where done and approximately 50 prioritized terms and definitions where added as classes to the ISO 15926 RDL.

4.1.3.3 Subsea processing

Terms and definitions for subsea processing equipment (http://posccaesar.vestforsk.no/intra/Portals/0/reports/processing.pdf) have been defined, but not yet included in the RDL. See chapter on take-up process below.

4.1.4 Health, Safety and the Environment

4.1.4.1 Safety and automation system

Terms and definitions related to subsea control modules have been included in the RDL and the Subsea terminology document (http://posccaesar.vestforsk.no/intra/Portals/0/reports/subsea.pdf)

4.1.4.2 Environment

In 2005 the project increased it scope to include environmental reporting on the NCS. Based on the OLF applications EnvironmentWeb (http://www.olf.no/miljo/aktuelt/?18838), parts of the yearly environment report submitted to the Norwegian Government from the oil and gas industry in Norway was defined in the ISO 15926 reference library. This amounts to

4.1.5 Other

4.1.5.1 Geometry and topology

Finalization of the last version of *"ISO 15926 Part 3 - Geometry and Topology, defining, in OWL, the geometrical constructs of ISO 10303-42"* has been financed by the IIP project.

4.1.5.2 ISO 15926 Conversion

To make the reference data library (Part 4) compliant with the International Standard version of the data model (Part 2) in ISO 15926, a conversion job has been done. This job has partly been financed by the IIP project. Classes in the former version of the library have been mapped to new classes according to the new version of the standard.

4.2 Research

4.2.1 Summary

The research carried out in the project was intended to prove the applicability of large-scale industrial ontologies in novel intelligent applications in the petroleum sector. Since ontology-driven applications depend on the quality of the ontologies, we first had to develop an understanding of what qualifies as a good ontology. A quality framework, that has later been used to justify some extensions of ontologies for use in search applications, have been defined and published. Central to our research was the development of technologies for ontology—driven semantic search, i.e. search applications that interpret users' queries semantically and retrieve documents that semantically match the queries. The solution seems to be a semantic layer built on top of a standard search platform, though the work will not be completed before our PhD student is finished with his 4 year program. The ontology can also be used to monitor real-time data from the petroleum business and notify users if certain constraints are violated. We have investigated how current rule languages recommended by the WWW consortium can be applied in such a rule-based notification system. Lastly, we have looked into how new visualization and interaction technologies can help us communicate faster and more accurately critical information in operation centers for oil companies.

4.2.2 Ontology Quality

There are several frameworks for model quality and ontological quality around, but few of them address the specific use or domain in question. Our work on search applications has shown that ontologies for search applications need to be structured according to user's usage patterns and certain application domain characteristics. They also need to be enriched with information that associates conceptual notions with linguistic expressions in the real world.

An ontology value framework for evaluating search ontology quality has been defined and published, and an evaluation of existing frameworks has been carried out.

4.2.3 Rule-based notification

Ontologies may include constraints and rules that impose requirements on real-time data that form instances of concepts (classes) and relationships in the ontology. This can for example be that a valve

of a particular type can only take a specific pressure or a specific temperature. The idea was to investigate how rules can be incorporated into the IIP ontology and used to monitor production real-time data from the Norwegian continental shelf.

Since the current ontology in the IIP project does not contain constraints or rules, it has not been possible to develop and test any large-scale applications of rule-based notification. An additional problem is that there are still several rule language proposals in the Semantic Web community, and we still lack a well-defined accepted rule language standard. However, we have demonstrated that rules may be formulated for this purpose in the IIP ontology and shown how they in combination with search functionality can support a rule-based notification system.

4.2.4 Ontology based search

Whereas traditional search technologies make use of frequencies of search terms and vector similarities, the objective of this research has been to allow the user to search on the basis of content rather than term matching. We have developed a novel approach for enriching ontological concepts with contextual linguistic characterizations of the concepts' meanings. User queries are semantically interpreted by recognizing the conceptual intentions from the user's linguistic expressions, using this ontological enrichment. Having identified the user's intentions, the system maps the conceptual query onto the linguistic expressions that are found in the documents and used in the document index. A standard search engine indexer (Lucene) is used in this process.

The formalism is finished, and a prototype developed in Java is now under development and will be completed and evaluated as part of a PhD thesis. A small prototype developed by a Master student has shown very positive results.

4.2.5 Visualization

By suggesting and implementing new types of immersive and tangible interfaces, this research has focused on discovering more efficient, effective and/or collaborative user interfaces. These interfaces should provide access and navigation to both a geometrical representation of the ontology, and the ontolgoy itself.
One prototype was developed using an immersive CAVE environment, to ensure a realistic setting and better understanding of the scenario in focus. Using different simulations, the system reported unwanted events in a 3D environment, and the user could obtain error handling procedures to recitify the given problem. These procedures were retrieved by semantic searches, defining the situation. The prototype proved to be very effective, especially in the case of training and problem understanding.
Another small-scale prototype was developed, using a multi-user direct-touch tabletop. This work discovered a great potential for efficient and effective interfaces. Also, as these tabletops are used not only for user-input and output, but also as a center for discussions and interaction, the research showed a significant improved collaborative element, compared to more traditional group-meeting visualization-methods. More work is needed to verify these results in a more complex scenario.

5 TAKE-UP PROCESS

5.1 Take up of deliverables

The fact that the terminologies, taxonomies and ontologies developed by the IIP project are based on ISO 15926 means that the industry will:

1. Get the basis for development of the XML schemas required to transfer real-time field data to operation centers onshore and visa-versa with the semantics intact

2. Can refer users of the XML schemas to the RDL containing the definitions
3. Are ensured that the terminologies are defined consistently across the relevant domains and that data in the future can be combined and interpreted consistently across domains

Some of the participants and other companies in the oil and gas business have started the take-up process:

1. StatoilHydro, ExxonMobil and other operators are implementing the developed solution for Daily Production Report.
2. NPD and PSA have implemented a web service solution handling validation of incoming daily drilling reports. As of February 2008 NPD and PSA require all drilling operators to submit their Daily Drilling Reports according to the new formats developed in the Daily Drilling Report project. Identification of information required for operation centers onshore to operate as planned
3. According to Statoil representatives in the project the "Subsea equipment terminology" was added as an amendment to the information to tender in the Tyrihans project, and the bidders were asked to use this where applicable.
4. The Monthly Production Report is not yet complete, but most likely this solution will be implemented both by regulatory bodies like NPD, operating companies like Statoil Hydro and Gassco.

5.2 Further development

The following are topics that the IIP project touched into, but both time and resources prevented the project to dig deep into and develop solutions for them:

1. Mapping of concepts used by in-house as well as third-party applications to the terminology in the RDL. Experiences with the need to support living mappings in a world of changing sources and destinations provide challenging requirements beyond immediate intuition.
2. Verification and quality assurance of reference data delivered by the project will be coordinated and handled by the POSC Caesar Special Interest Groups which are being established for key donains in the upstream oil and gas business (http://www.posccaesar.org/wiki/Sig)
3. WITSML: As stated above, 80 out of a total of 142 WITSML XSD Schemas were selected for ISO15926 modeling. Of this scope, about 75% have been modeled and included into the RDL. In the duration of this work, however, both WITSML and ISO15926 have changed, implying the invalidation of intermediate forms. The conversion from the past ISO15926 snapshot E (SE) version to the International Standard (IS) version was automatic, but was not complete due to the need for manual modeling for meta concepts that were split from one to many.

   The realization of the fact that both ends will continue to emerge into new versions, together with the highly manual and error prone form of modeling from a XSD WITSML form into the RDL, have given thought to the need for better tool support to manage these challenges. Mediation and annotation techniques are becoming popular for this purpose, but does not answer all needs. An analysis of needs, requirements and possibilities is recommended in light of this experience.

   Project deliverables contain the relevant downloaded XSDs together with the RDL modeling both on the form of Excel spreadsheets and loaded into the RDL.

The take up process should carefully consider the state and the requirements of a lifelong inclusion of WITSML into the RDL for the purpose of interoperation with other domain areas and standards, and consider emerging technology trends in this area.

4. Terms and definitions for subsea processing equipment are delivered on spreadsheets from the project. In coming projects it should be considered to model the content of the spreadsheets according to ISO 15926 and include this model in the RDL.
5. Automatic generation of XML schemas from ISO 15926 reference data: The XML schemas developed in the IIP project have been developed manually. In the future the RDL should be able to generate XML schemas automatically. For the purpose of availability and ease-of-use it is suggested that generation of a default schema is prioritized.

5.3 Currently planned continuation

Currently two initiatives with the potential of taking the oil and gas ontology further are on the starting line. These are described in the following paragraphs.

5.3.1 Integrated Operations in the High North project

The primary objective of this project is to develop prototypes for a digital infrastructure and a semantic platform to implement Integrated Operations Generation 2 (IO G2) processes for "zero footprints" solutions. This digital infrastructure for IO G2 shall facilitate the use of limited operational personnel and the monitoring of environmental and hazardous conditions in the High North. The infrastructure will be prototyped and consists of the following elements:

- **Real time information** between sensors, activators and nodes in a high capacity network, by developing autonomous sensor-near software
- **Information transfer**, connecting professional services to network nodes, by investigating networks and developing a platform for web services and information validation
- **Information integration**, by developing an oil and gas ontology to support the interpretation of sensor data, the platform for web services and information validation services

Furthermore, the developed prototype digital infrastructure and semantic platform shall be **piloted to demonstrate the feasibility** for **unmanned drilling rigs** (Pilot for Drilling and Completion), **improved production operations** (Pilot for Reservoir & Production) and **sub-ice operations** (Pilot for Operation and Maintenance).

5.3.2 POSC Caesar Special Interest Groups (SIGs)

For assuring high quality of the RDL, PCA has established SIGs for some business domains in the upstream sector of Oil and Gas industry and for discipline areas in Process Plants. For more information see: http://www.posccaesar.org/wiki/Sighttp://www.posccaesar.org/wiki/Sig

6 PROJECT ORGANIZATION

Each of the project participants have been represented with one vote in the project steering group. The project has been chaired by Statoil and managed by DNV.

The following tables give an overview of the participants and late participants in the project

Table 6-1: Overview of the participating oranisations that joined the project June 2004.

Company	Contact persons	Company	Contact persons
STATOIL	Svein Omdal	FMC Technologies	Bjørn Haavengen
OilCamp	Tom Rune Espedal	National Oilwell Varco	Anders Holme
Capgemini	Ole Evensen	NTNU	Jon Atle Gulla Egil Tjåland
DNV	Tommy Bjørnsen Nils Sandsmark Pål Rylandsholm	olf	Thore Langeland
POSEIDON	Ståle Brattebø	POSC Caesar Association	Nils Sandsmark

Table 6-2: Overview of the organizations that joined the project after June 2004, also called "Late participants".

Company	Contact persons	Joined IIP	Company	Contact persons	Joined IIP
HYDRO	Lars Olav Grøvik	1.1.2005	energistics	Alan Doniger	1.1.2005
IBM	Øystein Haaland	1.1.2006	AMITEC	Børre Heggernes	1.1.2006

7 PROJECT DOCUMENTATION

The following paragraphs contain descriptions of and links to deliverables, reports, publications and relevant descriptions of the IIP project. Some of the links will require logon to the member's area of POSC Caesar web site.

7.1 Reference data

A description of how to access the reference data produced by the IIP project can be found here: http://posccaesar.vestforsk.no/intra/Portals/0/reports/RDL-RDS.pdf

The XML schemas produced by the IIP project can be found at http://posccaesar.vestforsk.no/intra/XSD/tabid/66/Default.aspx

7.2 Reports

The following table contains links to the reports produced by IIP sub projects.

Table 9.2-1: Reports produced by the IIP project

Domain	*Document*	*URL*	*Comment*
Production	Daily production reporting project report	www.olf.no/io/rapporter/?51810.pdf	
Drilling	Daily drilling reporting project report	www.olf.no/io/rapporter/?51809.pdf	
Production	Production terminology	http://posccaesar.vestforsk.no/intra/Portals/0/reports/production.pdf	Logon required
Operation and Maintenance	Subsea equipment terminology	http://posccaesar.vestforsk.no/intra/Portals/0/reports/subsea.pdf	Logon required
Operation and Maintenance	Subsea processing terminology	http://posccaesar.vestforsk.no/intra/Portals/0/reports/processing.pdf	Logon required
Operation and Maintenance	Condition monitoring report	http://posccaesar.vestforsk.no/intra/Portals/0/reports/monitoring.pdf	Logon required

7.3 Presentations

A general presentation of the project may be downloaded from POSC Caesar's web site (members area, logon required) http://posccaesar.vestforsk.no/intra/Portals/0/reports/IIP-presentation.pdf

7.4 Publications[1]

1. Gulla, J. A., H. O. Borch, and J. E. Ingvaldsen. Contexualized Clustering in Exploratory Web Search. *In do Prado and Ferneda (eds.), Emerging Technologies of Text Mining: Techniques and Applications. Chapter IX, pp. 184-207*. IGI Global, 2008.
2. Gulla, J. A. Interoperability in the Petroleum Industry. Accepted for publication at *10th International Conference on Enterprise Information Systems* (ICEIS 2008), Barcelona, June 2008.
3. Gulla, J. A., Borch, H. O., and Ingvaldsen, J. E. Ontology Learning for Search Applications. In *Proceedings of the 6th International Conference on Ontologies, DataBases, and Applications of Semantics (ODBASE 2007)*, November 2007.
4. Tomassen, S.L. Pros and cons of applying industrial ontologies in information retrieval. In *Proceedings of Workshop on Semantic Technology Adoption in Business (STAB'07)*. Vienna, Austria, 2007.
5. Dedeban, V. and Strasunskas, D. An Ontology-Centric Approach for Flexible Configuration and Pricing of Product Families. *In Proceedings of Workshop on Semantic Technology Adoption in Business (STAB'07).* Vienna, Austria, 2007.
6. Strasunskas, D. and Tomassen, S.L. Scenario-Driven Information Retrieval: Supporting Rule-Based Monitoring of Subsea Operations. *Information Technology and Control 36(1A)*, 2007, pp. 87-92.
7. Lilleng, J. and Tomassen, S.L. Cross-Lingual Information Retrieval by Feature Vectors. In *Proceedings of the 12th International Conference on Applications of Natural Language to Information Systems (NLDB 2007)*. Springer-Verlag, LNCS, Paris, France, 2007.
8. Strasunskas, D. and Tomassen, S.L. Web Search Tailored Ontology Evaluation Framework. In *Proceedings of Workshop on Emerging Trends of Web Technologies and Applications (WebETrends 2007).* Huangshan, China, 2007. LNCS 4537, Springer-Verlag.
9. Strasunskas, D. Resource Monitoring and Rule-Based Notification. Applications in Subsea Production Systems. In *Proceedings of the 2007 IRMA International Conference on Managing Worldwide Operations and Communications with Information Technology (IRMA 2007)*, Vancouver, Canada, 2007, IDEA Group Publishing.
10. Strasunskas, D. and Tomassen, S.L. Quality Aspects in Ontology-driven Information Retrieval. In *Proceedings of the 2007 IRMA International Conference on Managing Worldwide Operations and*

[1] Please also see a continually updated list of publications for NTNU IDI at http://research.idi.ntnu.no/IIP/publication.html

Communications with Information Technology (IRMA 2007), Vancouver, Canada, 2007, IDEA Group Publishing.

11. Sjovoll, H. and Tjaland, E. Immersive safety handling and training. *The SGI User Group Meeting (SGIUG 2006), Technical Conference and Tutorials*, Las Vegas, USA, Jun. 5-9 (2006).
12. Hakkarainen, S., Hella, L., Strasunskas, D., and Tuxen, S.M. A Semantic Transformation Approach for ISO 15926. *Proceedings of the ER 2006 Workshops (1st Intl. workshop on Ontologizing Industrial Standards)*, November 2006, Tucson, Arizona, US. Springer-Verlag, LNCS 4231, 2006, pp. 281-290.
13. Tomassen, S.L. Research on Ontology-Driven Information Retrieval. In R. Meersman, Z. Tari, P. Herrero et al. (Eds.), *OTM 2006 Workshops*, Montpellier, November 2006, Springer-Verlag, LNCS 4278, 2006, pp. 1460-1468.
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8 DOCUMENT CHANGE LOG

Version	Date of	Person responsible	Description
2.0	31.10.2008	Pål Rylandsholm	Removed “Project Accounts” Removed contactr details for company representatives in the project