INTEROPERABILITY AMONG ENGINEERING SYSTEMS AND THEIR RELEVANCE TO THE EFFECTIVENESS OF THE ENGINEERING PROJECTS' LIFE CYCLE – REGULATION, WELL SUCCEEDED EXAMPLES AND PROPOSED ACTIONS

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Abstract. *This study reflects the need to standardize the format of files and data allowing information to be sovereign over the technology, and legacy data to be less vulnerable to technological advances and improvements, keeping up their usefulness and efficiency to the detriment of the market interests. It is presented as the open innovation has contributed to the development of the interoperability standard, and are also presented some examples of initiatives in an effort to implement the regulation ISO – 15926 – Industrial Automation Systems and Integration – life cycle data integration for process plants units including oil and gas production plants, and actions are proposed to accelerate its adoption by the national engineering community.*

Keywords*: ISO-15926, Computer-aided-design (CAD), Interoperability, Data integration, Oil and Gas.*

1. THE CURRENT SCENARY: CHALLENGES FOR IMPROVING THE EFFICIENCY THROUGHOUT THE ENGINEERING PROJECTS' LIFE CYCLE

The recent finding of the pre-salt on the Brazilian coast and the technological challenges for its exploitation, as well as to improve the production of the actual national petrochemical and refining park has a new challenging component which is the goal of nationalization on global competitive levels which was presented to the production chain for the equipment and service supply for these engineering projects.

According to the document: "Network Improvement of National Chain Management of Goods and Service Suppliers", produced jointly by Petrobras and the Industrial Engineering community to Productive Development Policy – PDP, coordinated by the Ministry of Development, Industry and Foreign Trade – MDIC, and supported by an Executive Secretariat, formed by ABDI (Industrial Development Brazilian Agency), BNDES (National Bank of Social and Economic Development) and the Ministry of Finance, assumes that the present moment of the Brazilian economy demands firm and wide support to capital formation and innovation to sustain the long-term growth of the nation.

To meet these demands, the Plant Design Automation stands as an important strategic tool to leverage the solutions of the challenges of competitiveness that the domestic industry faces new engineering projects and their nationalization index in terms of global competitiveness

The Plant Design Automation enables the resources optimization, productivity improvement and better information quality of ENGINEERING PROJECTS and assets throughout the life cycle, allowing managers a better decision making in the operational and strategic issues in managing these assets.

Globally, the theme Plant Design Automation becomes relevant with discussion forums on best practices and specially to address the issue of interoperability, key point to greater effectiveness and scale of benefits brought by the Plant Design Automation and so important to meet the challenges of the national chain suppliers in oil and gas segment.

2. INTEROPERABILITY

2.1. Definition

According to the description given by SAYÃO (2008), the Interoperability is the ability of a system (computerized or not) to communicate transparently (or close enough) with another system (similar or not). To be considered an interoperable system, it is very important that it works with open standards or ontologies. Either a portal system, or an educational system or an electronic commerce system, or e-commerce, nowadays we are more and more likely to the creation of standard systems.

There are several types of interoperability; below we highlight the most relevant ones for this article:

- Technical Interoperability – It is the continuous development of communication standards, transportation, storage and representation of information through the involvement of a number of organizations. It is up to information technology facilitate the convergence of standards, wherever is possible to have a set of standards in the system to benefit the community.

- Semantic Interoperability – Is the meaning or semantics of information from different sources, it is solved through common tools of information representation such as classification and ontologies

- Legal Interoperability – They are legal requirements and implications of making information items.

2.2. Problems caused by the lack of Interoperability

In the environment of engineering projects, with the increasing adoption of computational tools, the strategic integration with business systems and greater collaboration with stakeholders systems, it creates an environment of great challenge for convergence in interoperability.

One of the main aspects that are mentioned in the discussion of the lack of interoperability is certainly the cost dimension of engineering projects that can be impacted by lack of interoperability and therefore for redoing works, inefficiency and delays caused by the lack of interoperability among engineering systems.

Due to its strategic relevance, and in order to quantify the cost of lack of interoperability, NIST – National Institute of Standards and Technology, which is the U.S. National Institute of Standards and Technology, linked to the federal department of Commerce – created a study in 2005 – the NIST GCR 04-867, to identify and estimate the loss in the Engineering Enterprises due to the lack of an appropriated interoperability in the United States.

For this study, NIST held an inadequate estimated cost of interoperability, quantifying and comparing the current state of interoperability with a hypothetical scenery against a factual in which the availability and exchange of electronic data is fluid and seamless. The difference between the current sceneries and against factual represents the total estimate economic losses associated with inadequate interoperability. The cost was calculated at the social level. In other words, this analysis quantifies the loss of efficiency by society due to inadequate interoperability.

Among the found cost, we can highlight:

- The cost avoidance - They are related to the activities of concerned parts to compromise in order to avoid or minimize the impact of problems of technical interoperability before they occur.

- The cost of acquisition, maintenance and training to redundant CAD/CAE systems; the maintenance cost of redundant paper systems to exchange information.

- Outsourcing of translation services to third parties.

- Investments in domestic programs, such as translators from point to point, and translators from a neutral file format to solve interoperability problems.

- Mitigation Costs – arising from activities in response to interoperability problems. There is often the most part of interoperability cost (Martin, 1999) (Gallaher, 2002). Most of them results from mitigation cost of electronic files or paper files which must be inserted manually into multiple systems. In this analysis, mitigation cost may also result from redundant construction activities, including scrap materials.

- The cost of redoing the work of conception and construction due to interoperability problems.

- The cost of manually re-enter data when exchange electronic data is not available or when mistakes were made during the exchange

- The cost of checking information when original sources cannot be accessed.

- The cost of delay – resulting in interoperability problems such as, delay the conclusion of a project or increase the time when a facility is not in normal conditions of operating. These costs are the most difficult ones to quantify.

- Idle resources for the delay of construction activities.

- Profit loss due to delay of revenues (discounted values of future profits).

- Losses for customers and consumers due to delay on availability of products and services.

- Lost on productivity when a resource is not in a normal operation.

This study identified U$15.8 billion in inadequate interoperability costs and were quantified for the capital installations and supply chain in the U.S. in 2002. This estimated annual cost corresponds from 0.86 to 1.24 percent of annual revenues for architects and engineers, specialist contractors and manufactures and suppliers. When compared to the annual value of construction of capital facilities' in 2002, 2.84% are the losses attributed to lack or interoperability in the projects representing U$15.8 billion and of this total, 70% are funded by owner operators. This can be considered a conservative estimate because it does not include in those cost categories, items such as opportunity cost and decommissioning costs. In addition, costs were not quantified for all components.

Collaborating with these findings, the 2007 report about interoperability from McGraw Hill ENR construction technology estimates that the cost can be twice as more than the NIST 2002 report, according to GLENDINING (2010). The author comments that, since the mid-90, repeated estimates had already suggested that the projects of individual assets spent millions of dollars to simply deliver information in the operation phase, and that inadequate operability as a whole is responsible for 1% to 2% from capital costs.

3. OVERVIEW OF ISO 15926 – STANDARD FOR INTEGRATION AND COLLABORATION IN ENGINEERING

According to Yogui (2009), in 1991, a research group in Europe called ProcessBase started a study on the development of a data model for the information cycle that would set the requirements of the process industry. At that time this group was formed by companies that formed a consortium for that study taking as a start point the STEP standard that was also an ISO regulation for the information exchange between graphic systems. From that work originated the ISO 15926 – Standard Industrial Automation and System Integration regulation in the life-cycle of process plants – including the production plants of Oil and Gas.

The ISO 15926 consists of 7 parts. The Information related to Engineering Construction and Operation is created, used and modified by different organizations throughout the lifecycle of an Enterprise. The purpose of ISO 15926 is to facilitate the integration of data to support the activities throughout this life cycle and production processes of an Enterprise. The ISO 15926 specifies the data model and the initial reference data that share the database or a data storage system in the project development, operation and maintenance. The following are the 7 parts that make up the ISO 15926:

- Part 1 – Overview and Fundamental Principles ISO 15926-1:2003 specifies the representation of information associated with the phases of Engineering, Construction and Operation of Process Plants. This representation supports the information requirements of industrial processes at all stages of a life cycle of a plant and the integration and sharing of information between all involved parties throughout the life of the plant.

- Part 2 – Data Model ISO 15926-2:2003 is a part of ISO 15926 for the representation of information processes in the life cycle of a plant. This representation is specified by a generic data model conceptually designed to be used in conjunction with the reference data: instances of patterns that represent a common information to a number of users, process plants or both. The use and definition of reference data for process plants are topics for Parts 4, 5 and 6 of the standard. The data model can support all disciplines and stages of the project and may supporting information on functional requirements, physical solutions, types of objects and activities.

- Part 3 – Ontology (Conceptual Schema) for Geometry and Topology ISO 15926-3 is the part of ISO 15926 which deals with the topological and graphical information (geometrical) as 2D/3D CAD (Computer Aided Design) models from geographical information systems (GIS). For this feature is used Reference Data

Class. Note: The main purpose of an ontology is to make explicit the information independently of the underlying data structures that can be used to store information in data warehouse

- Part 4 – Initial Reference Data ISO / TS 15926-4:2007 defines the initial set of reference data to be used in conjunction with ISO 15926. ISO Maintenance Agency (which replaces the Part 5) ISO TC184/SC4 began the initiative to develop the ISO Maintenance Agency for Maintenance reference data in the ISO 15926.

- Part 6 – Methodology for the development and validation of Reference Data

- Part 7 – Implementation Methods for integration of distributed systems ISO 15926-7 is for the definition and tests of implementation methods. From these definitions, with the development of generic data model and a Reference Data Library (Reference Data Library - RDL), in 2006 FIATECH in conjunction with the POSC Caesar - non-profit organization that also promotes open systems specification for data interoperability - started its work for the ISO 15926 to become a standard for interoperability among systems used by its members. The benefits of its adoption are obvious and the gains are indisputable, since the integration becomes more consistent and enduring.

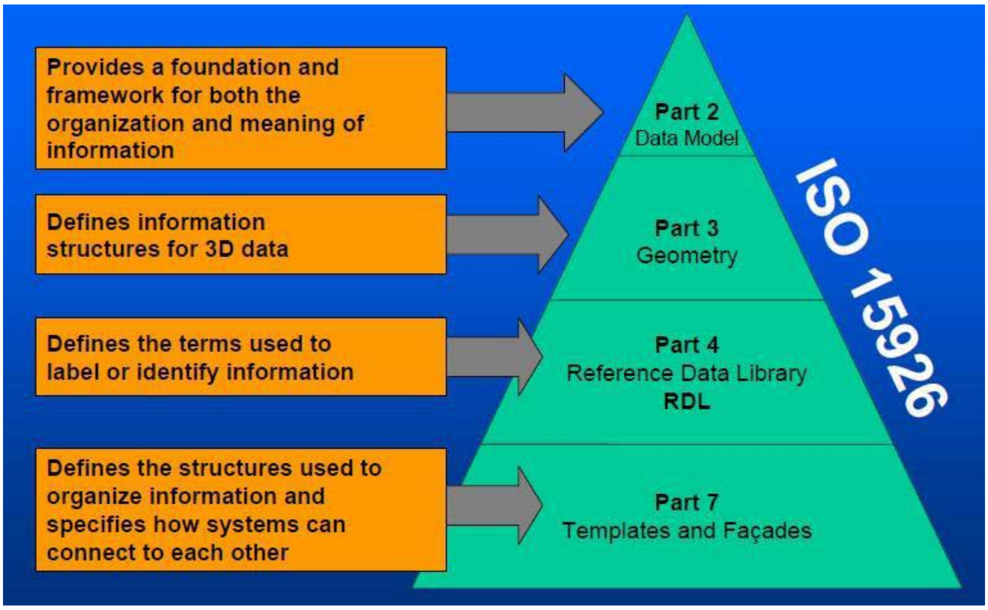

Figure 1. How information is handled through the ISO15926.

4. OPEN INNOVATION: GLOBAL MOVEMENTS AROUND THE ISO 15926 – FIATECH, PCA E OLF

Open Innovation is a paradigm that assumes that the organizations can and should use external and internal ideas as well besides internal and external ways to move forward in their innovation process (Chesbrough, 2006).

Besstant and Tidd (2009) comment that even the major companies that maintain their internal structure of Research and Development (R & D) are beginning to realize the reasons for an approach of "Open Innovation", which is also related to research sources in any other place.

According to Chesbrough (2006), the principles of Open Innovation are:

- Not all smart people work for us. We need to work with these people inside and outside of our organization.

- P&D external can create a significant value. P&D internal is necessary to claim part of this value;

- We do not necessarily need to be the origin of the research in order to make profit from it;

- It is better to have the best business model than to be the first to break into market;

- If we make a better use of the internal and external ideas, we will win;

- We can profit from the use by third-party of our innovation processes or, we can get third party innovation process at any time to make progress in our own business model.

In this line, in technology applied to industrial engineering projects, highlights the works of Fiatech, PCA e OLF.

FIATECH, in the U.S., and OLF, in Norway, are industrial consortiums focusing on promoting the integration of all industry players of large engineering projects, (Lopes 2011) and both of them adopted as data foreclose the ISO15926 which first started in 1997 to promote the interoperability standardization and the life-cycle of project information.

Since 1999, the POSC Caesar Association (PCA), in partnership with the ISO TC184 took over the development of ISO15926, through the IDS (Intelligent Data Sets). And, in 2009 the FIATECH, through your project ADI (Accelerating Deployment of ISO15926), joined the PCA in the development of ISO-15926.

In early 2009 members from PCA and FIATECH created a project called Camelot in order to implement the part 7 and support tests of parts 8 and 9 of the ISO-15926 (http://iringug.org).

In 2009 the Camelot project became an open source project and is currently developed in a massive collaborative effort, being renamed iRING - ISO 15926 Realtime Interoperability Network Grid. Recently, in early 2011, the IIP was created - iRING Tools Interfacing Project - for developing appropriate adapters to the standard to connect the range of products of SmartPlant, from Intergraph, to ISO-15926 (http://iringug.org).

5. EXAMPLES OF INTERNATIONAL INITIATIVES AROUND THE ISO-15926

Based on the initiatives undertaken by FIATECH, PCA and OLF, organizations began to develop practical applications around the ISO-15926, using the collaborative efforts greatly promoted by these institutions. Below are some examples that demonstrate these applications:

5.1. CEN ORCHID – COMITÉ EUROPÉEN DE NORMALISATION ORCHESTRATION OF INDUSTRIAL DATA

Group formed by network of European companies and consortiums, among them the PDA, dedicated to the standardization of information across the supply chain of the process industry to build competitive advantage for European companies. Part of the ICT sector - Information and Communication Technologies from CEN proposes a road map that has three important documents for orientation: Direction and Framework, Implementation Guide and Standards Landscape. The first defines a direction for better understanding of information management life cycle of the plant and introduces the concept of maturity to develop methods to measure and monitor the progress of maturity of the companies regarding the management of information. The second provides implementation guidance and presents examples of success. And the third provides an overview of the existent and relevant standards to the process industry, and also demonstrate how the standards are related to each other.

Table 1. Examples of successful adoption of standards and mapping the maturity of companies in relation to the Orchid Roadmap (CWA 16180-2:2010 (E))

Company	Standards	From Phase	To Phase
Shell, DSM	STEPlib	I1	I3
Shell EIS	STEPlib, ISO15926-4	X1	X2
Statoil Norway	POSCaesar lib	I1	I2
Siemens Energy and Oil	ISO13584,eCl@ss	I1 I2	I2 I3
Croon TBI Techniek	STEPlib, ISO15926-4,Gellish	I2 X1	I3 X2

5.1.1. Example 1 from Shell – Business Process Improvement

In mid-1990 Shell began standardizing and optimizing their business processes. There was an understanding that the information in these processes need to be standardized and therefore the definitions were standardized in SAP through the harmonization of these using the STEPLiB, standard precursor to part 4 of ISO-15926, for classifying products and attributes.

5.1.2. Example 2 from Shell – Engineering information specification

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In order to enable epc companies and suppliers to deliver their project information by electronic way, Shell developed its Engineering Information Specification - EIS - using the STEPLiB and ISO-15926-4 to exchange information. Also in accordance with the Implementation Guide, Shell intends to migrate its dictionary classes STEPLiB for ISO-15926.

5.1.3. Example 3 from Croon Elektrotechniek B.V., TBI Techniek Example – Exchange information with partners (from X1 to X2 in maturity by criterion ORCHID)

Very often Croon faced interoperability problems with the project partners. For infrastructure and shipbuilding industry projects Croon has successfully adopted the methodology Gellish combined with the use of ISO 15926-4 reference data-library to read or exchange information about project explicitly.

5.2. INITIATIVE OF TECHNICAL INFORMATION MANAGEMENT – PCIM – PETRONAS CARIGALI INFORMATION MANAGEMENT.

Petronas developed the PCIM initiative that is meant to cover the whole chain of Oil and Gas in Malaysia. PCIM initiative was planned in achieving proof of concept of interoperability among the companies Alcimus, NRX and SAP to publish structured data in SAP using the ISO-15926. Was also implemented a Web portal of information engineering that uses data exchange standards ISO-15926, the AVEVANET.

5.3. SOUTH KOREA INITIATIVE - iCAD (Intelligent Computer Aided Design) Laboratory.

The iCAD is part of the Department of Mechanical Engineering of Korea Advanced Institute of Science and Technology - KAIST, which concentrate its studies in CAD, STEP, and Virtual Reality. The positioning of this lab in the engineering department promoted a natural environment with the industry in that country, and from this involvement were produced two articles about exchange of information through neutral formats, the first in 2008 for the Nuclear Industry (D. Mun 2008) and second in 2010 for the shipbuilding industry (HAN S. 2010).

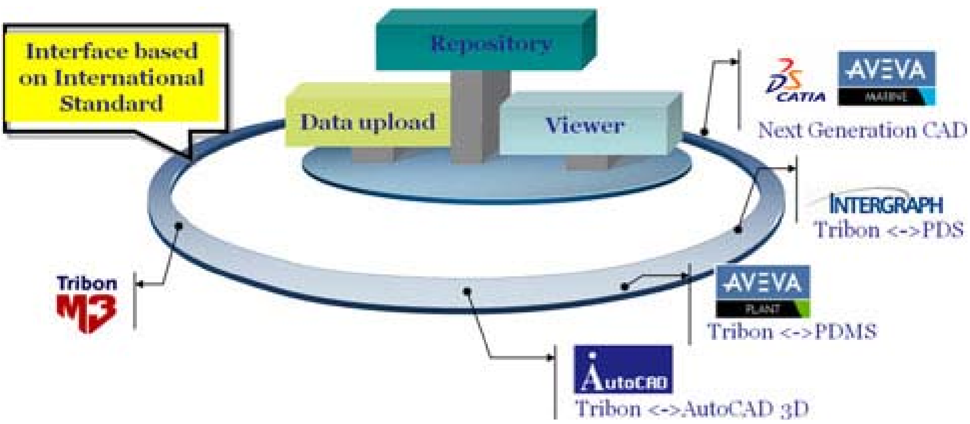

Figure 2. Data exchange requirements of a shipyard, S. HAN (2010).

6. EXAMPLES OF NATIONAL INITIATIVES AROUND THE ISO-15926.

Initiatives around the ISO-15926 in the country still has a great exploratory meaning for its comprehension and understanding on the part of the national community, as well as the consolidation of the concept of interoperability among systems.

The first movements on the subject in Brazil date from the mid-1990s when it was established the study committee of the STEP standard - ISO-15926's predecessor - the Brazilian Association of Technical Standards. This committee developed the first understanding of the standard STEP and published some articles referred to the subject to share the knowledge acquired from the national engineering community.

Recently, in 2009 was published in V Rio Automation Congress, promoted by the Brazilian Petroleum Institute, the article by Yogui,R.: ISO 15926 - INTERNATIONAL STANDARD FOR INTEGRATION AND AUTOMATION IN PLM (Plant Lifecycle Management). In this article, (Yogui, 2009) rescued the theme and presented the basic concept of the rule as well as the major global initiatives about the subject.

In the same period, the Tecgraf laboratory, conected to the Department of Informatics of PUC-Rio was the first national institution to become a member of FIATECH and the PCA, thus engaging in major global forums for adoption and implementation of ISO-15926. Other initiatives have been established, such as the recent creation of the Laboratory of Automation Project and 3D Technology connected to the Department of Mechanical Engineering of Federal University of Rio Grande do Norte dedicated to research development and spread of this technology in the academic community, especially in the engineering environment.

The Master's thesis of UFRJ/COPPE by Domingos (2010), has the theme INTEROPERABILITY AMONG ENVIRONMENTS OF SIMULATION AND PROCESSES DESIGN OF CHEMICAL ENGINEERING addressing the relevance of the norm in engineering projects.

In November 2010 was held in Brazil the First National Forum about the ISO-15926 at PUC-Rio, with the participation of international speaker members from FIATECH, PDA and OLF as well as speakers from local organizations and companies such as Petrobras, Tecgraf, Promon, Technip Mana Engineering representing the national engineering community besides the providers of technologies such as Sisgraph / Intergraph, AVEVA, Bentley and Innotec.

As a consequence of the forum, Petrobras created an internal committee to align their initiatives with relation to ISO-15926, involving professionals in the Exploration & Production, Refining, Engineering and Research Center.

7. CONCLUSIONS AND RECOMENDATIONS

As seen, local initiatives are still undergoing compared mainly with the mobilization made mainly in the United States and Europe, involving the major operators of assets, EPC companies, the engineering community and technology providers in this segment. Thus, ensuring the competitiveness of domestic industry, take a more proactive position in generating knowledge on the interoperability theme and specifically on the ISO-15926 is required. Seen the CEN ORCHID initiative to give more competitiveness to European companies.

In this context, Brazilian companies need to seek an appropriate forum for collaboration and exchange of information regarding to the adoption of the standard. In the First National Forum about ISO 15926 in November 2010 in Rio de Janeiro it was announced the creation of AUTEC - National Network of Plant Design Automation and Collaboration - that could provide this service, although considering the European experience as the ideal forum where the discussion took place in regulatory agency CEN. While this discussion forum in Brazil is not established what can be done?

Companies can create an implementation plan of the standard with reference to the CEN-ORCHID initiative, defining in which phase it lies in the integration of its data, internally and externally, and defining actions to be taken to advance maturity phases of the company regarding the adoption of the standard.

These companies also should form partnerships with the academic community, mainly in the engineering area, as it was done with the South Korea lab ICAD, to produce knowledge applicable to the industry soon, proof of concept from parts of the pattern and tests with I-RING, locally creating a greater understanding on the subject, as well as creating conditions of criticism and suggestion in your application.

The academic community, especially engineering, should be aware of the changes brought by the adoption of ISO-15926, which affect the entire lifecycle of assets, and adjust their courses by offering knowledge and expertise in Plant Design Automation and information management, forming the workforce that will support the industry demands.

Finally, the national community must take a more proactive position on the mentioned theme putting Brazil in a prominent position in international forums, participating in working groups of the PCA and FIATECH, where the Brazilian computer graphics lab TeCGraf already participates, to influence the ways of implementing the standard and prioritizing works from national interest. We also recommend that other academic studies should be made by researchers to deepen the knowledge about the ISO-15926, opening new areas of research to collaborate effectively with corporate initiatives.

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