ELEMENT 9 **INFORMATION MANAGEMENT**

Capturing Equipment Data Requirements Using ISO 15926 and Assessing Conformance (EDRC)

Element 9: **Life Cycle Data Management and Information Integrations**

Fiatech

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October 2015

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This publication was prepared with the principle writing performed by the following individuals:

Name(s)	**Organization**
Manoj Dharwadkar	Fiatech EDRC Project Lead, Bentley Systems
Jim Newman	AREVA and Bentley Systems
Mark Palmer	NIST, retired

The project was produced with the outstanding leadership of a technical team consisting of the following individuals plus the principal authors listed above:

Name (s)	Organization
Russell H. Adams	EPRI (Electric Power Research Institute)
Victor Agroskin	TechInvestLab
Rob Brawn	CH2M
Nisha Garg	Emerson
Ravindra Grampurohit	Emerson
Eric Helm	AREVA
Pouria G. Bigvand	Aucotec
Geiza Maria Hamazaki da Silva	Tecgraf
Chad Vore	Aucotec
Keith Willshaw	Bentley Systems

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Name (s)	Organization
Tore Christiansen	PCA
Hondjack Dehainsala	AREVA
Peter Denno	NIST
Georg Grossmann	University of South Australia

Alan Johnston	MIMOSA
Jim Klein	AVEVA
Avin Mathew	Assetricity
Ron Montgomery	IBM retired
Siva Nalluri	Siemens
Onno Paap	Fluor
Andrew Prosser	AVEVA
Cormac Ryan	Worley Parsons
Ursula Sadiq	Autodesk
Greg Schuler	Dow Chemical Company
Magne Valen Sendstad	PCA
Annant Srivastava	Siemens
Marcus Stumptner	University of South Australia
Hans Teijgeler	OntoConsult
Hongsong Wang	Plantsoft
Glen Worrall	Bentley Systems

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2. Automated Design
3. Integrated Automated and Procurement Supply Network
4. Intelligent and Automated Construction Job Site
5. Intelligent, Self-Maintaining, and Reporting Operational Facilities
6. Real-Time Project and Facilities Management, Certification, and Control
7. New Materials, Methods, Products, and Equipment
8. Technology and Knowledge-Enabled Workforce
9. Life Cycle Data Management and Information Integration

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Executive Summary

The Capturing Equipment Data Requirements Using ISO 15926 and Assessing Conformance (EDRC) project sought to establish a common understanding across industry projects of how to use ISO 15926, and to assess requirements for testing software conformance to specified ISO 15926 data structures and capabilities. In an effort to expand the industrial take-up of ISO 15926 for information exchange, Fiatech sponsored the EDRC project with participation by MIMOSA and PCA.

Collaboration with MIMOSA on the Oil and Gas Interoperability (OGI) Pilot was a cornerstone of this project as a source for use-case definitions and to feed the results and lessons learned into the ongoing execution of the OGI Pilot. EDRC focused on a narrow scope that was limited to equipment and system data to prove the processes for testing conformance. This scope was developed in connection with the work performed in the MIMOSA and PCA OGI pilot project, the Harmonizing Industry Standards to Exchange Equipment Data (HEED) project, and is consistent with the objectives of the ISO 15926 Information Patterns (IIP) project.

In order to meet project objectives, EDRC project results include three parts. First, to enable common understanding for the use of ISO 15926, a framework for interoperability testing is provided to explain the various parts of such testing, and includes descriptive examples and demonstrations. This is coupled with a set of observations and recommendations for next steps critical for successful understanding of the remaining steps to achieve interoperability testing. Next, conformance testing requirements and methods were assessed via the development of two succinct use cases, the results of which are documented as a proposed procedure for conformance specification and testing. That procedure will enable software vendors to offer conforming implementations and as well as the industry to achieve “plug and play” interoperability.

This report’s chapters are organized to help the reader navigate the project findings. Chapter 1, Introduction, describes in detail the context of the project and the key deliverables. Chapter 2, Business Case, explains how conformance testing is a key element in successful information exchange using interoperability. To help improve common understanding of the use of ISO 15926, a framework for interoperability is proposed to help improve the communication patterns and procedures among the ISO 15926 community. Next, the project use cases examined during the EDRC project are described, followed by key results from the demonstrations performed by the project. A final chapter presents the conclusions, lessons learned, and recommendations for further activities.

Chapter 1 Introduction

The primary objective of the EDRC project was to establish a common understanding across industry projects of how to use ISO 15926 and how to assess software conformance to specified ISO 15926 data structures and capabilities. In order to achieve this objective, the EDRC project key deliverables were:

- Procedures for specifying and assessing conformance of ISO 15926 software implementations, including recommendations for assessment methodologies to be used.
- Demonstration of successful use of these procedures for priority use cases.
- Summary of challenges and recommendations for improvements to ISO 15926 documentation development process and tools to enable effective conformance and interoperability testing.
- Input to complete core capabilities and relevant parts of ISO 15926.

It is important to note the difference between data model management and conformance and validation testing. EDRC's core purpose was to evaluate the methods for testing conformance and validation, not to validate data model management processes and procedures. Although during the project several issues and challenges arose around the data model management topic, solving those issues was not the primary focus. However, where possible, those topics are addressed in the lessons learned for future projects to explore further.

This report was primarily prepared for engineers and managers who are not trained in data modeling or software development, but who would like to understand how to exchange data using ISO 15926. This includes those interested in exchanging data related to the capital projects business lifecycle. As far as possible, there is no requirement that the reader understand ISO 15926 or have data modeling knowledge or expertise.

For clarification on the meaning of the terminology in this report, the following definitions are provided for conformance, validation, verification, and interoperability:

- Conformance — determine whether an implementation meets the requirements of the industry standard against which it is being tested.
- Validation — assess the completeness, correctness, and accuracy of a solution for its intended purpose, also known as "fit for purpose."
- Verification — determine compliance with a regulation, specification, or imposed condition.

- Interoperability — determine whether two or more devices, applications, or systems can reliably exchange and use information without need of user intervention once configured.

EDRC's companion report, "Specifying and Assessing Conformance of ISO 15926 Implementations: Procedure and Requirements" [3], addresses the first deliverable, including recommendations for conformance testing as input to the ISO 15926 Part 10 Draft under development. The following is a summary of the EDRC use cases. Full use-case documents are available on the Fiatech website.

- Use Case 1 [1]: Based on a request from an owner/operator, an EPC delivers the "as installed" data set for a replacement pump to an owner/operator. This use case was demonstrated successfully at the Fiatech 2014 Technology Showcase & Conference.

  EDRC Use Case 1 Scenario 1 (Rev 11) is available on the Fiatech Site at http://fiatech.org/images/stories/projects/Fiatech-EDRC-UseCase1-Scenario1Revn_11-Oct2015.pdf

- Use Case 2 [2]: the supplier of field instruments and an EPC exchange specifications and proposals for completing procurement. Procurement of instruments based on this use case was demonstrated successfully at the Fiatech 2014 Members Meeting.

  EDRC Use Case 2 Draft (v4.1) is available on the Fiatech Members Site at http://fiatech.org/images/stories/projects/Fiatech-EDRC-UseCase2v41-Oct2015.pdf

Conformance testing alone, however, is not sufficient for realizing full interoperability. In fact, testing of conformance cannot be done in isolation without the other elements required to achieve interoperability. Therefore, this report provides a summary of the EDRC project activities, proposes a framework of elements around which to discuss full interoperability in a larger sense, and proposes recommendations specific to conformance testing of ISO 15926.

Chapter 2 Business Case

Today, most data exchanges between equipment suppliers, EPC contractors, and owner/operators (O/O) occur as either manual or as bespoke connections between two software applications. At one end of the spectrum, for example, unintelligent data sheets are exchanged between parties, requiring the receiver to manually enter the data fields into a software repository/database. Some data exchange is occurring by specifying intelligent handover requirements by each O/O and by each project and by each EPC. Either method is highly inefficient, requiring many hours of manual data entry that could be applied to higher value-added work. For more information on the business case, see the Fiatech Conference presentation titled "Building a Cohesive Strategy for ISO 15926."[9]

Achieving interoperability via industry adoption of ISO 15926 requires that plant owner/operators contractually specifying facility and equipment data for handover at the end of a CAPEX project conform to ISO 15926 *and* that EPC contractors and O/Os demand ISO 15926 conformance (e.g., adapters) from their equipment suppliers. Both owner/operators and EPC contractors must then demand that software vendor products have the necessary adaptors to exchange the data between the products.

In order to understand this process, the EDRC team examined the process of information exchange using ISO 15926 to try to refine the steps required for performing effective information exchange. The six-step process shown in Figure 1 reflects current best practices that have evolved collaboratively in the ISO 15926 community and through usage to date. It defines various elements helpful to the information exchange process and also basic steps for defining and using reference data (RD).

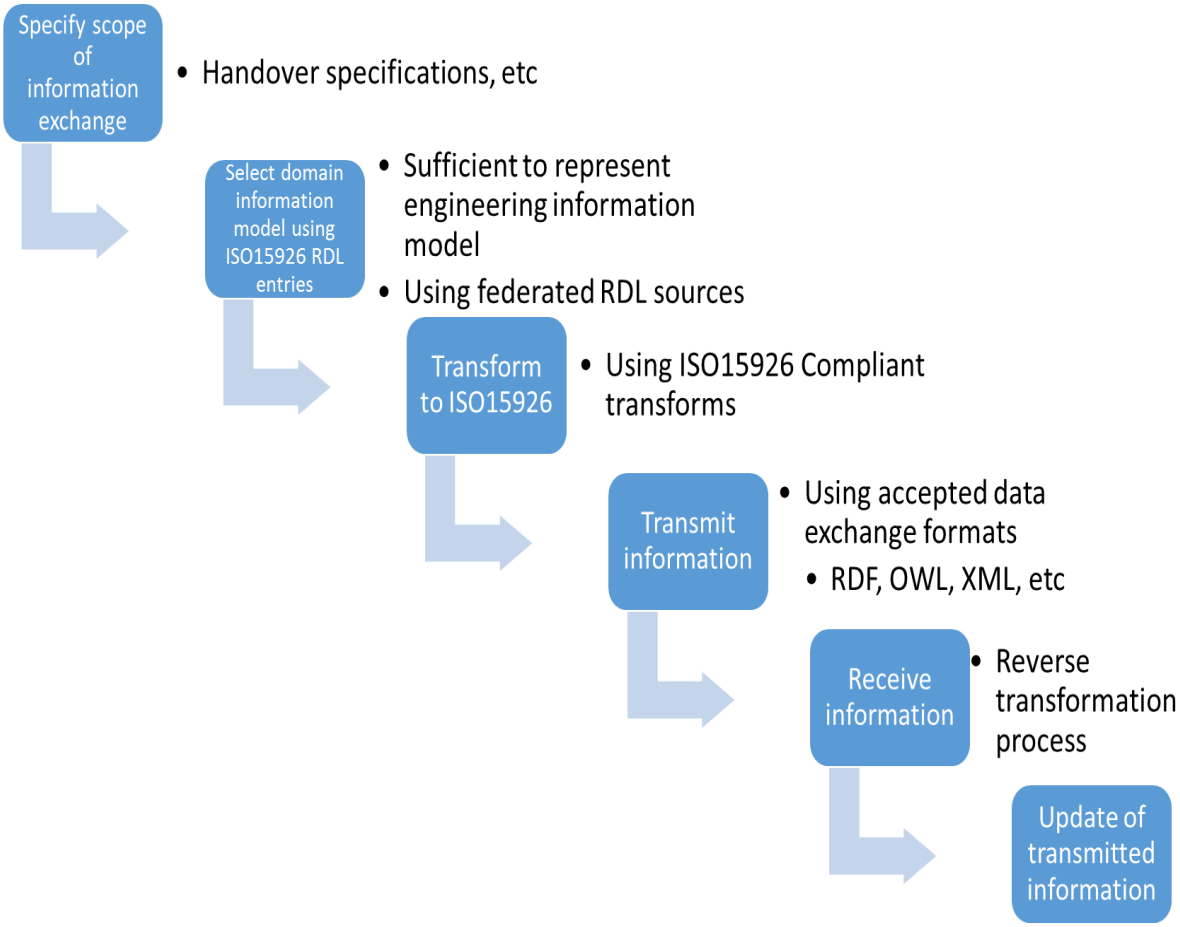

Figure 1: Recommended Information Exchange Process

Specify the Scope of Information Exchange

The first step is to define the information sets that need to be exchanged between participants. In most cases, these information sets are developed as data handover specifications based on inputs from various functional areas as needed, e.g. Process, Chemical, Mechanical, Procurement, Preventive Maintenance, Data Handover, and others. Table 1 shows a sample data handover specification that defines the base information to be exchanged.

Table 1: Example Data Handover Specification

RFQ Data Provided by EPC to Manufacturer as Engineering Data Specification
RFQ ID
Serial Number
Tag Number
Instrument Type
Operating Pressure
Operating Pressure UOM
Operating Temperature
Operating Temperature UOM
Calibration Range
Calibration Range UOM
Transmitter Product Certification
Transmitter Output
Transmitter Element Type
Transmitter Element Material
Transmitter Housing Material
Transmitter Conduit Connection Size
Process Connection Type
Proposal Data Provided by Manufacturer to EPC as a Reply to RFQ
RFQ Reply ID
Transmitter Model Number
Transmitter Price
Transmitter Price Currency

Select the Domain Information Model Using ISO 15926 RDL Entries

In order to exchange the information in the selected scope, an ISO 15926 Reference Data Library (RDL) sufficient to represent the domain information model must be available that encompasses at a minimum the mandated information. The following steps are used in establishing the existence (or completion) of the required ISO 15926 RDL and in establishing the mandated models.

A. Select object of interest (for example, transmitter).

    a. Identify object attributes.

    b. Identify object relations to other objects (repeat the process for other objects).

B. Determine appropriate reference data entries based on a descending federated approach.

    a. Examine the official ISO level RDL.

    b. Examine industry-level RDLs (PCA RDL and others).

    c. Examine publicly accepted and available RDLs.

    d. Create new data entries for missing reference data entries.

    (Data modeling techniques for this effort are outside the scope of EDRC.)

C. Develop an object declaration for each data item.

    Object declarations using federated reference data in part B can be done in several ways. These include using the W3C Resource Description Framework (RDF) properties, ISO 15926 part 7 templates, or special patterns like TIPs. The Joint Operational Reference Data (JORD) Mapping Methodology [5] document describes in more detail different approaches that can be used.

D. Determine the appropriate templates and TIPs (if used) for object relations from the reference data sources as described in part B, extending them if required.

Each participant in the information exchange process must map the data falling in the scope of planned data exchange to the same set of reference data entries, templates, and/or TIPs, whether using single or multiple enterprise applications as information sources/targets/stores. This commonality requirement emphasizes the need to use commonly available and accepted RDLs first and self-created or commonly created rules last.

Transformation to ISO 15926

Once the engineering information model and representative ISO15926 RDL have been established and verified, the next step is to use an ISO15926 conformant solution to convert information from the source participant's engineering information management system into the equivalent ISO15926 version. This process can be done in many different

ways, but in all cases should result in an output format containing the ISO 15926 representation of the information set to be exchanged. Specific instructions on how to perform this transformation are not mandated via the EDRC project.

Note: For the EDRC use cases described later, different transformation methods were used within the various software solutions used.

Transmit Information

With a transformed information package available, information can now be exchanged via one of several exchange formats. The current consensus within the ISO15926 community is to use an RDF format (ISO 15926 Part 8) that could also be published via a web-based RDF triple store using the standard methods; however, other methods are available, depending on the software solutions being implemented.

Note: For the EDRC use-case demonstrations, email exchanges containing the information package in RDF format were used instead of web-based triple stores.

Receive Information and Update of Transmitted Information

Receipt of the transmitted information package (via email, SPARQL query, or other) results in a reverse process for the recipient, with the ISO 15926 information package converted via their own mapping to the ISO 15926 RDL into the recipient's engineering information system following its original data model. Information is then expanded or changed as required and prepared for return transmittal using the system as a source as described in the Transformation to ISO 15926 step above.

This process can be repeated numerous times between participants as required. ISO 15926 does not explicitly require data version comparison or quality checking of transmitted information packages. However, it is expected that most software solutions will enable these capabilities to some extent.

In order to ensure that Transformation to ISO 15926 and Transmit Information steps of the above process execute as expected, the EDRC recommended procedure provides a process for testing the conformance of software solutions (determining whether an implementation meets the requirements of ISO 15926), which could then be referred to as "ISO 15926 conformant." The EDRC conformance procedure builds on concepts and documents produced by the JORD project (Phases 1 and 2) conducted jointly by POSC Caesar Association (PCA) and Fiatech. In particular, EDRC builds upon the work started in the JORD project towards specifying the requirements for conformance against ISO 15926 [6], with a dedicated purpose to provide recommendations towards a future Part 10 of ISO 15926 (conformance testing).

In addition, the EDRC project has the intent to provide a transversal view across many industry projects around ISO 15926 to advance plug and play interoperability. As a result and with feedback from several different initiatives within and external to Fiatech, EDRC team members realized the need to develop a common terminology to reduce ambiguity for both experts and interested participants.

Chapter 3 Framework for Interoperability

Many definitions of interoperability have been proposed in the industry. IEEE's definition of interoperability is widely accepted, describing interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [4]. Interoperability testing, meanwhile, is intended at its highest level to show that two devices, applications, or systems can reliably exchange and use information without the need of user intervention after initial configurations are established. The ultimate objective is that independent implementations of the same standard interoperate.

In traditional software testing scenarios, the foundations for interoperability testing can be broken down into two major streams, validation and conformance. Validation, as described in the Introduction, assesses the completeness, correctness, and accuracy of a solution for its intended purpose, also known as "fit for purpose." On the other hand, conformance testing, also as described in the Introduction, determines whether an implementation meets the requirements of the industry standard against which it is being tested. Conformance also is sometimes referred to as verification. Conformance increases the chances of successful interoperability while validation testing checks at a user level if needed functionality has been achieved.

During the course of the EDRC project, it was determined that simply having these testing definitions was insufficient to avoid confusion and ambiguity with users interested in exchanging data using ISO 15926. Therefore, the following framework is proposed to help shepherd community discussions into key topic areas that must be addressed to achieve interoperability. Some key assumptions dictate the development of this framework. In principle, no assumptions on the maturity of an individual organization that seeks to use ISO 15926 are taken. Refer to the *CEN ORCHID Roadmap Standardizing Information in the Plant Engineering Supply Chain Implementation Guide* for guidance on information maturity models [8].

Additional details such as contract terms requiring ISO 15926, maturity of a company's internal data model, and sophistication of internal IT systems are not addressed within the framework. Only those elements necessary to allow two mature organizations that have ISO 15926 enabling technologies to achieve plug and play interoperability on a technical basis are covered. These limitations (maturity of companies, contractual requirements for information exchange and handover, and so forth) are important considerations, but are beyond the scope of this document and project and should be addressed separately.

Table 2 shows the resulting eight elements of the framework to achieve interoperability discussed as part of the EDRC project activities. Within the EDRC project, Elements 1 through 4 were recognized as key elements of achieving the use-case demonstrations.

These will be discussed in the final chapter of this report. However, these elements were not “finished” or “completed” during the EDRC project, as that was outside the EDRC scope. These elements are still open items for discussion and should form the basis for future Fiatech projects. Element 8, interface conformance, is covered in the companion EDRC specification and requirements document. Elements 5-7 were not included within the scope of EDRC.

Note: The terminology in the column entitled “element” is intended for technologists. For clarity, the description and examples provide translation to common terminology.

Table 2. Framework for Achieving Interoperability

Element	Description & Example	EDRC application
1. Domain scenario contexts -Data Exchange scenario(s)	Content of business identified data sets • pump data sheet, instrument list, etc.	Use case 1, use case 2 descriptions
2. Domain semantic units unification and sharing	Agreement on the meaning of specific terms and resulting reference data entity • Not machine readable but human readable • "Maximum Pressure" is….	Use case 1, use case 2 data entities and template definitions
3. Data modeling rules	specified set of reference terms to be used for developing the ISO15926 data model ○ "class" or "individual", selection of template methodology	Use case 1, use case 2 data entities and template definitions
4. Data representation form	"Exchange format structure" to be used between parties ○ RDF, OWL, XML, etc.	Use case 1, use case 2 data entities and template definitions
5. Information configuration management practices	basic model and drawing management practices for any project and configuration management for components and systems	N/A
6. Information resource usage and dependencies	Use of federated RDLs to obtain best ISO15926 data model	N/A
7. Information communications profile (stack) capabilities	Items necessary to complete actual interconnection between systems or applications, ultimately down to the physical transport level	N/A
8. Software solution interface conformance	Confirmation of level of compliance with mandated requirements for properly exchanging ISO15926 information ○ Model Interchange Working Group (MIWG) examples ○ Future ISO15926 Part 10	EDRC Procedures document: Specifying and Assessing Conformance of ISO 15926 implementations: Procedure and Requirements

Chapter 4 Scope

To support the development of practical use cases for testing conformance processes, two EDRC use cases were identified and developed based upon the MIMOSA OGI Pilot Use Case 1: Capital Project Handovers to Operations and Maintenance (O&M). EDRC Use Case 1, "Pump Replacement Specification and Handover (O/O-EPC-O/O)" was demonstrated at the 2014 Fiatech Technology Showcase. Use Case 2, "Proposal and Implementation Cycle between EPC and MAC for Field Instruments (EPC-Automation Contractor-EPC)" was demonstrated at the 2014 Fiatech Members Meeting. These two demonstrations, available from the Fiatech website, fulfill deliverable 2 of the project charter. See Figure 2 for an overview of use cases.

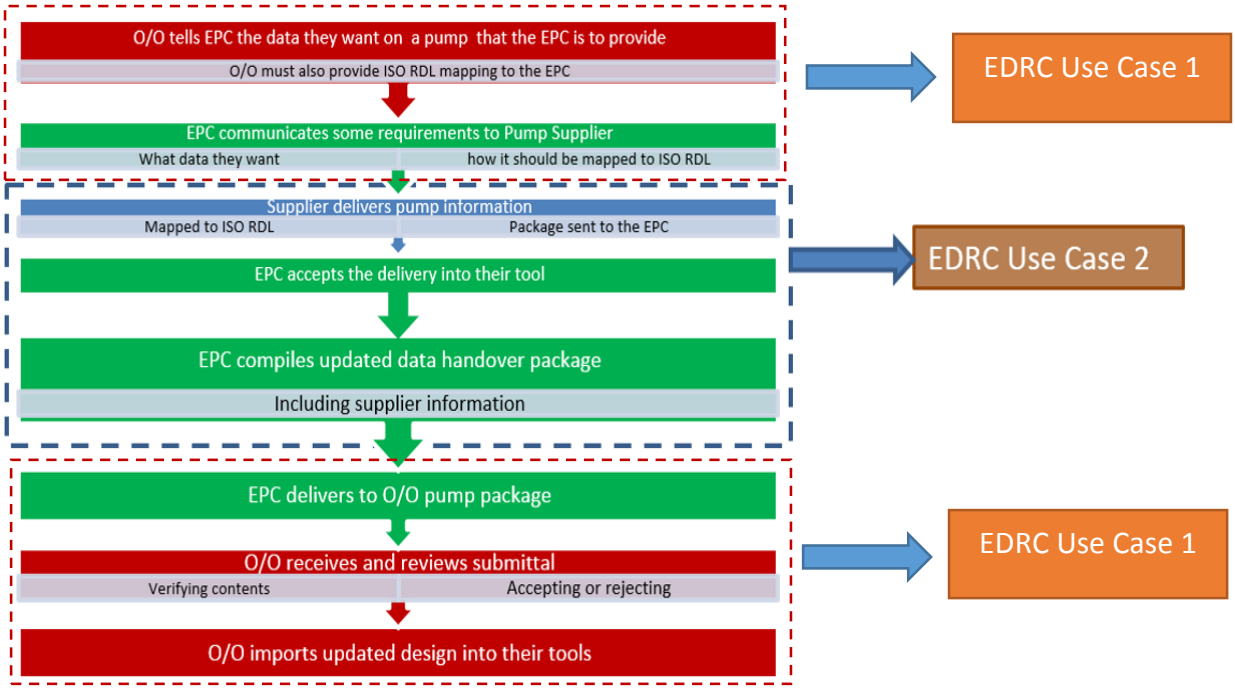

Figure 2: Overview of EDRC Use Cases 1 and 2

The use-case demonstrations have the purpose to test how data may be exchanged and how software implementations might demonstrate conformance. To build these use cases, interfaces with other industry activities, and specifically Fiatech sponsored projects such as JORD, OGI, MMT and IIP, were necessary. Input and collaboration with each of these projects were required in order to develop, test, and validate fully the use-case demonstrations. A key result of these interactions and use-case developments was the realization that a need exists to further explain the requirements for achieving interoperability. Chapter 5 will outline the assessment performed and recommended framework for future projects within Fiatech.

Figures 3 and 4 illustrate the demonstrations conducted at Fiatech events, including the steps necessary and the organizations that participated.

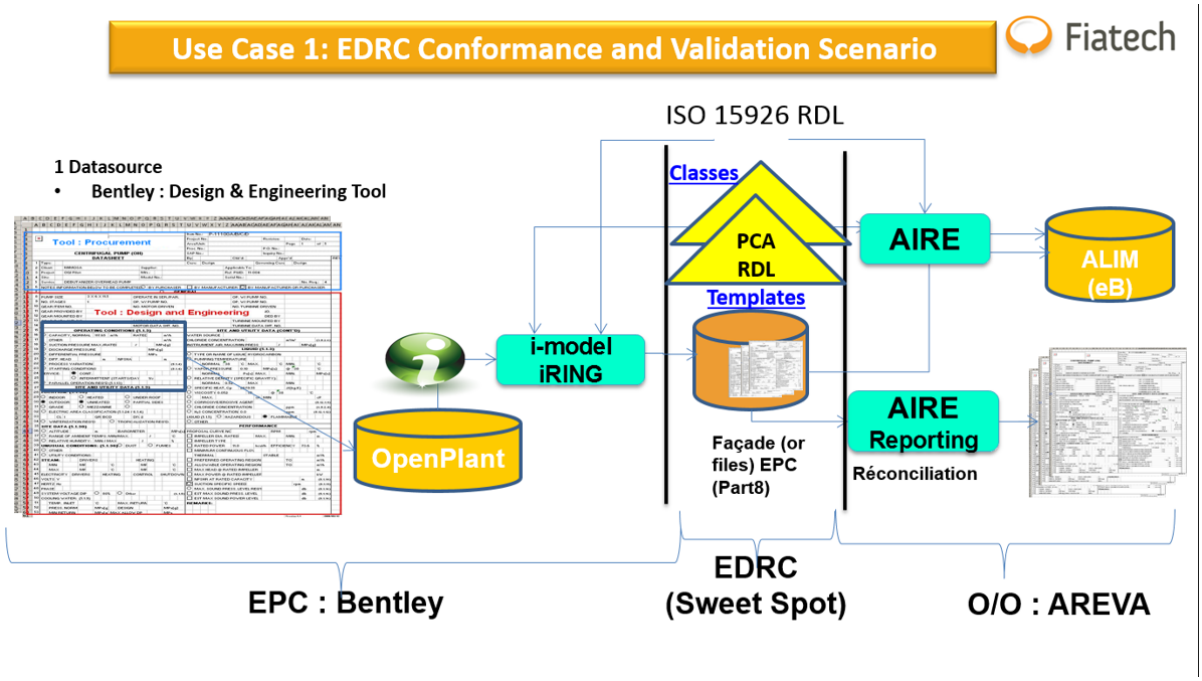

Figure 3: EDRC Use Case 1, "Pump Replacement Specification and Handover (O/O-EPC-O/O)" Demonstration at 2014 Fiatech Technology Conference

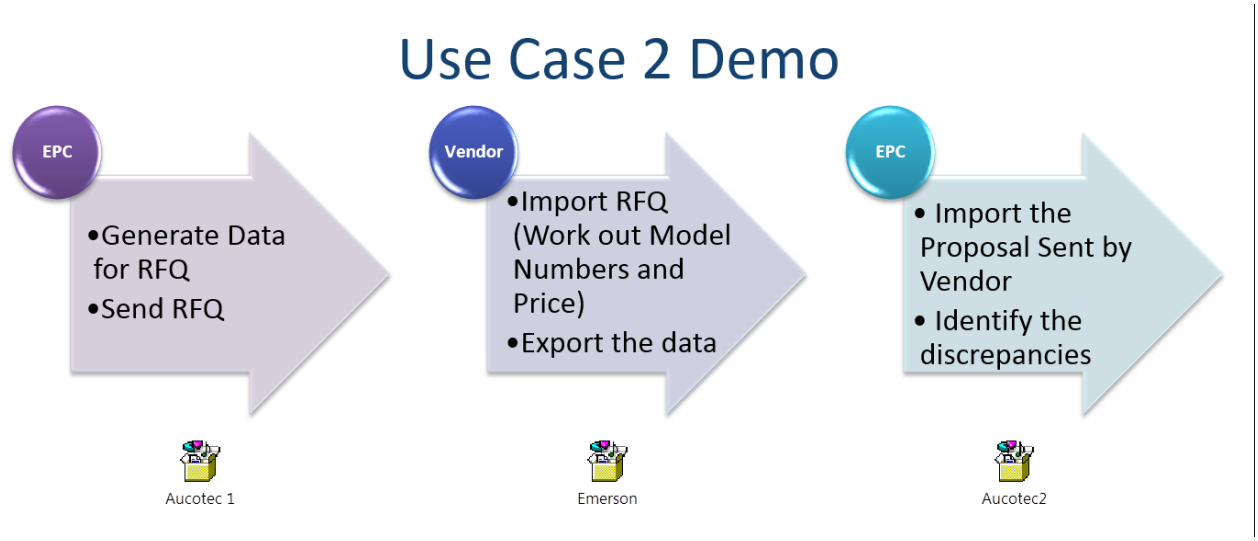

Figure 4: EDRC Use Case 2, "Proposal and Implementation Cycle between EPC and MAC for Field Instruments (EPC-Automation Contractor-EPC)" Demonstration at the 2014 Fiatech Members Meeting (Note: TechInvestLab Editor™ used)

Chapter 5 Results – Demonstration of Data Exchange

For each of the use cases, a combination of the reference data entities (parts 2 and 4) and templates/TIPS derived from the ongoing template and TIPS projects were used in accordance with the methodology outlined in Chapter 2, Business Case. Data reference entities were all taken from the PCA RDL, while templates and TIPS were either taken from the work performed by MMT, developed using the methodologies currently in practice, or taken from the IIP work on TIPS. This is a typical workflow that would be expected for the intermediate future, as templates and TIPS are created and then proposed through a work-process (MMT) to be included in the PCA RDL. Today, MMT approval is not a fast process, and therefore references to "accepted" templates are found via the MMT working group on the 15926.org forums [10].

As described in more detail in the companion document, "Specifying and Assessing Conformance of ISO 15926," selected sub-sets of information were chosen to test the information exchange and potential conformance testing requirements for each use case. For Use Case 1, presented at the 2014 Technology Showcase, the draft JORD Conformance specification [6] was used as a benchmark to determine which parts of a conformance testing methodology could be demonstrated. Figure 5 shows the process flow demonstrated for Use Case 1, with notes to reflect the parts of conformance and validation testing demonstrated from the JORD draft specification. Figure 6 shows the process map for Use Case 1, but with the parts of the process demonstrated highlighted for reference.

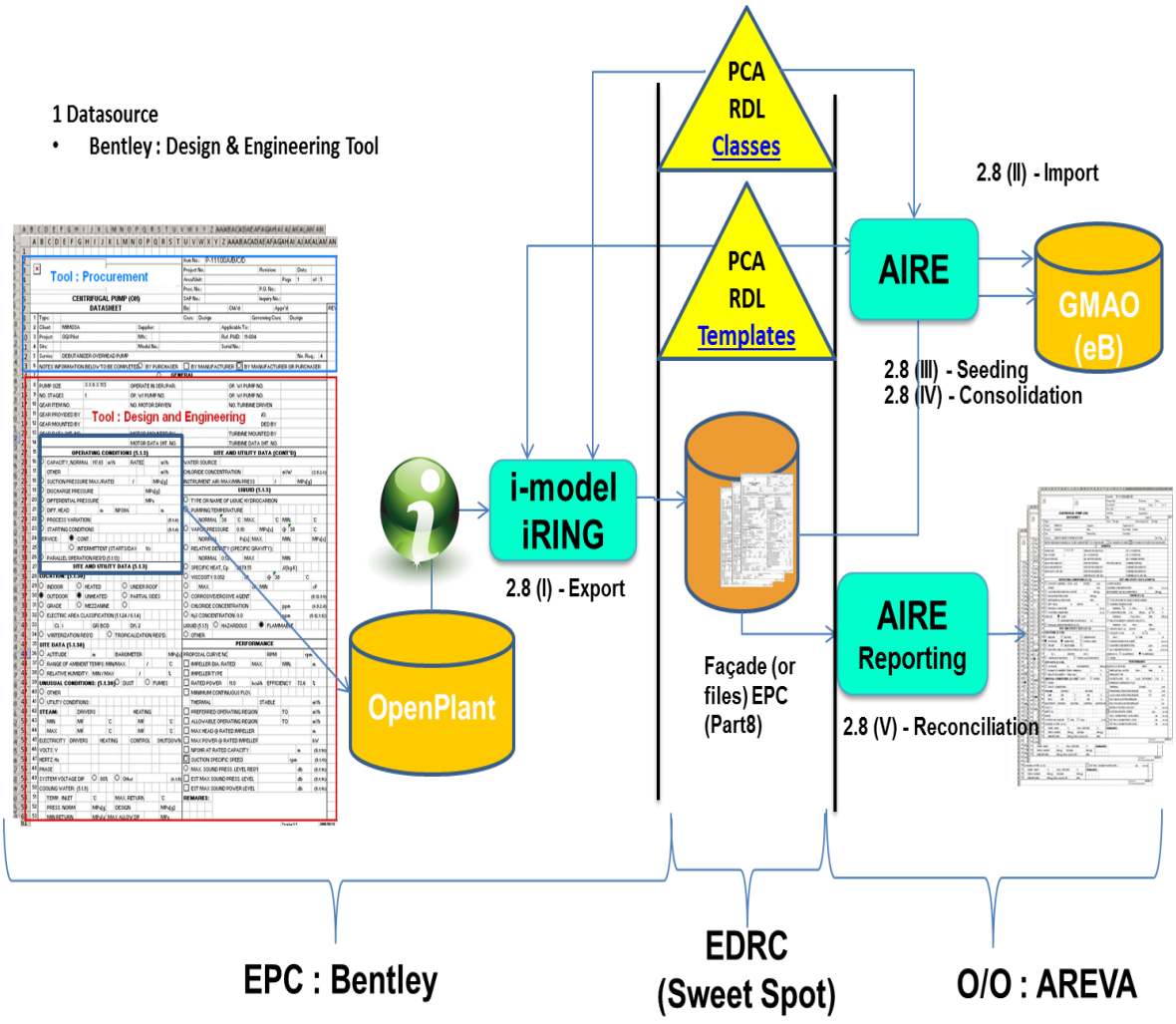

Figure 5: EDRC Use Case 1, Demonstration of Datasheet Exchange for Verifying Conformance Requirements from Draft JORD Conformance and Verification Specification

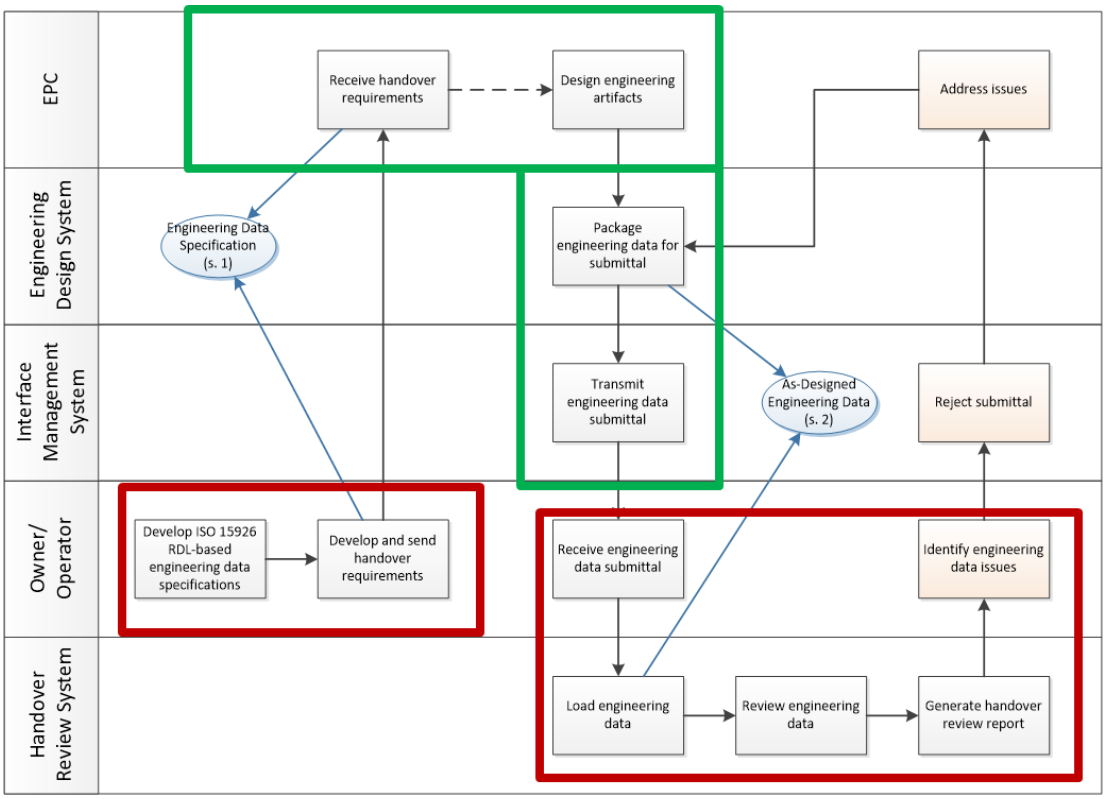

Figure 6: EDRC Use Case 1, Demonstrate Scope

For Use Case 2, the same basic workflow was followed. In order to show the application of multiple solutions towards testing conformance, however, different solutions were used for the demonstration. Figure 7 shows the workflow used for the demonstration of Use Case 2.

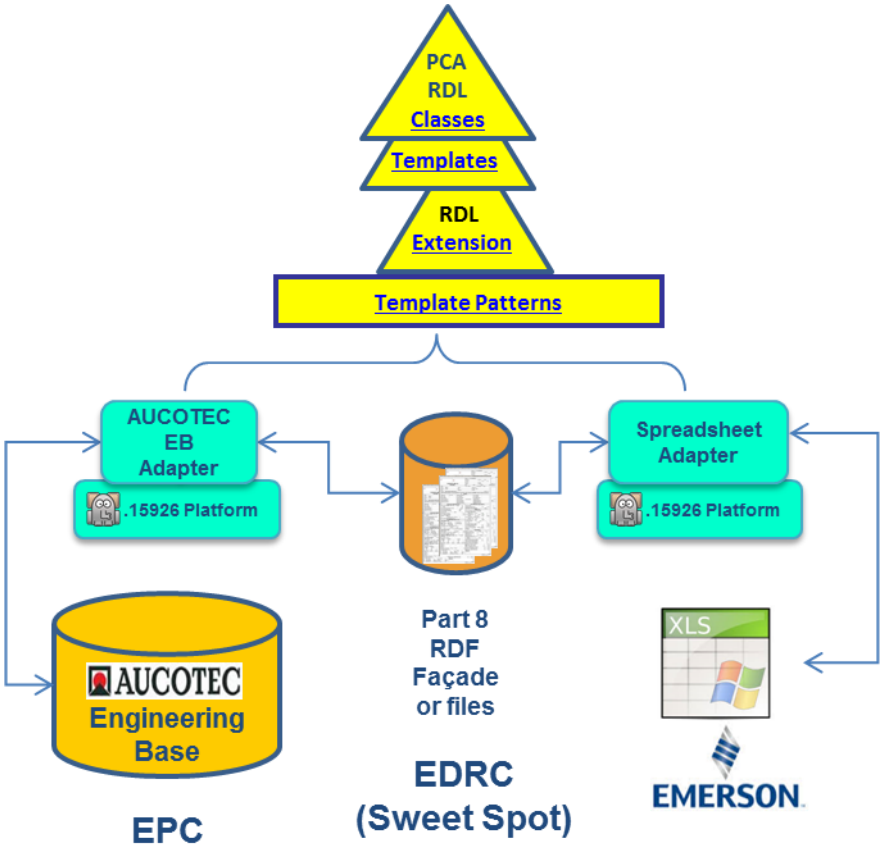

Figure 7: EDRC Use Case 2, Demonstration of Pre-Order RFQ Process

Three distinct outcomes can be described from the two use-case demonstrations performed. They demonstrated the continuing evolution of the maturity of ISO 15926-based exchange, with both use cases showing complete automated workflows using only RDL-based templates. Although some gaps in template availability and modeling methods were determined, the ability to meet these challenges in timely fashions to enable information exchange to be performed were positive results. Next, key requirements for what can be demonstrated for conformance testing of software solutions were determined and serve as input to the recommended procedures document, "Specifying and Assessing Conformance of ISO 15926." Finally, the demonstrations served as a launching pad for identifying difficulties in terminology and understanding, which led to the creation of the framework for interoperability presented in Chapter 3.

Chapter 6 Implementation and Deployment Procedures for Testing Conformance and Validation

As a result of the findings derived from the Use Case 1 and 2 test cases and demonstration projections, key recommendations for how to test conformance and validation were examined in light of developing a procedure that can be used for software implementers. The resulting procedure, "Specifying and Assessing Conformance of ISO 15926," is not repeated entirely here. However, some key findings from the project will be presented as part of the general discussion. It is expected that this proposed procedure will not be the final product used for testing conformance and validation to ISO 15926, but will serve as a launch point for the recently approved ISO project to develop ISO 15926 Part 10, Conformance Testing.

Testing of conformance and validation is neither a unique nor new concept. Several industry actions have occurred for other standards, which can serve as key input towards defining the requirements for testing as well as the methods and tools to be used. In general, the EDRC project did not try to fully define the final testing methodology or testing tools since there will be some variation in the types of tools to be used depending on the exchange format (RDF, OWL, XML) used. In parallel to the EDRC activity, NIST funded exploratory work to evaluate past industry efforts for conformance testing [7] as well as for implementation and governance methodologies. These reports were provided to the EDRC team in draft form and were used as input to the conformance and validation procedure recommendations.

Although the draft JORD specification for testing conformance and validation is a starting point, it alone is not sufficient for reaching a plug and play interoperability. The JORD specification breaks down aspects of conformance testing into several "levels" of testing. However, some of these criteria cannot be easily demonstrated, particularly those pertaining to validation. In addition, others are specifically written to support part 8 RDF exchange processes, which may not be applicable or consistent for exchanges using XML only or future OWL implementations. Therefore, although used as a baseline for the EDRC work, more work is necessary to build a more generic conformance and validation procedure that can be used for extended applications. However, the foundational recommendations on how to structure such a program as presented in the specification document should be extensible and valuable for all subsequent implementation strategies.

Chapter 7 Conclusions, Lessons Learned, and Recommendations

EDRC had as core expectations several key objectives deemed critical to project success. Each of these objectives was completed either via the use-case development and demonstration, the recommended procedure for testing conformance and validation, or within this final report. In detail, these objectives were:

- Procedures for data exchange within agreed-upon use cases using ISO 15926.
    - This objective was met through the development of the process described in Chapter 2, Business Case, as well as the introduction of the framework for interoperability to help define better communication for discussion on interoperability moving forward.
- Procedures for specifying and assessing conformance of ISO 15926 software implementations, including the assessment tools used.
    - This objective was met through the development and publication of the companion document "Specifying and Assessing Conformance of ISO 15926," which describes the recommended procedures and methodologies to be used for testing conformance to ISO15926.
    - NIST Report on ISO 15926 Conformance Testing – Recommended Approaches [7] and EDRC Use Case 1 test-case repository [11] were developed in collaboration with the EDRC project.
- Demonstration of successful use of these procedures for priority use cases.
    - Use Case 1 was used as the means to develop the recommendations for procedures. It successfully demonstrated against the draft JORD specification for testing conformance and validation. The Use Case 2 demonstration did not specifically address new components of testing conformance, but provided an excellent new test case for inclusion in the recommended procedure document.
- Summary of challenges and recommendations for improvements to ISO 15926 documentation, development process, and tools to enable effective conformance and interoperability testing.

- As documented in this report, a series of recommendations have been made to further the development and deployment of ISO 15926. Among these are the recommended process for describing information exchange using federated RDLs, the framework for interoperability, the lessons learned from the use-case demonstrations, and the additional lessons learned and recommendations provided in the remainder of this chapter.

- Input to complete core capabilities and parts of ISO 15926.

  - Feedback from the work done by EDRC has and will be used to provide additional input to the capabilities of ISO 15926 and ongoing working groups. Specifically, Figure 8 shows the various working groups for ISO 15926 that were specifically linked with the activities of EDRC and that received input from the EDRC activities. Other ongoing activities may take advantage of this work as well, even if not specifically listed.

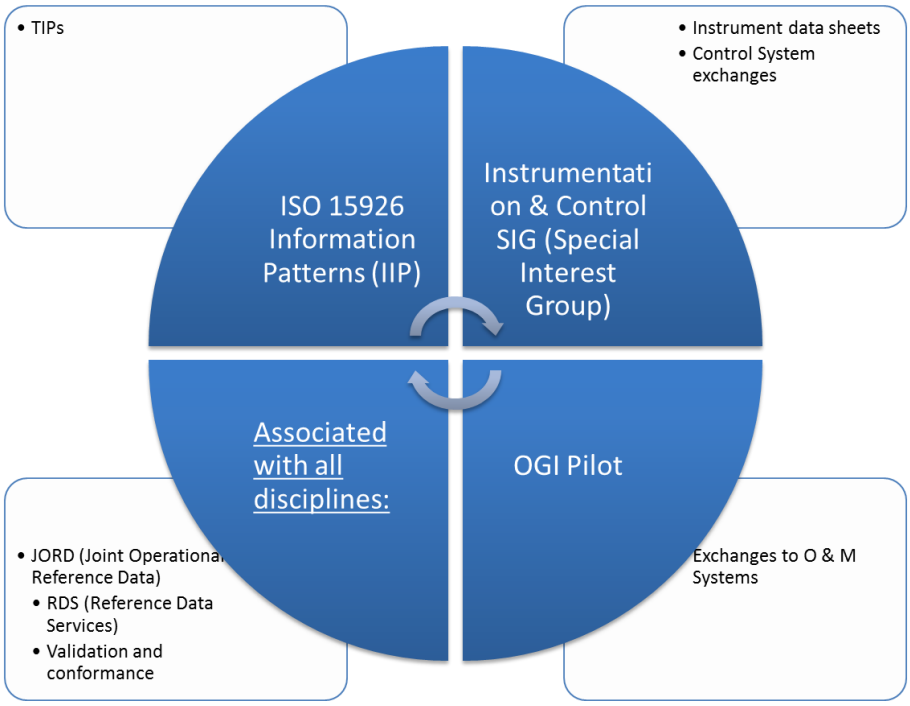

Figure 8: EDRC Contributions to Other ISO 15926 Related Working Groups

For official parts of ISO 15926, EDRC contributes directly to three distinct areas:

1. For future revisions of Part 8, EDRC has identified several areas of improvement that must be met to further the usage of RDF-based exchanges.

These improvement areas have been discussed with key authors of a future Part 8 revision in order to ensure that future exchanges will be able to take advantage of the EDRC findings.

2. EDRC's recommended procedure, "Specifying and Assessing Conformance of ISO 15926," has been targeted as initial input to an approved working group for developing the ISO 15926 Part 10 document, Conformance Testing, and will directly contribute to the first draft of Part 10. The recommended procedure will be a key document that will enable the Part 10 team to start with a known foundation that can be used to expand and develop the Part 10 standard.

3. The issues about how to establish stable, qualified, and approved "templates" as part of the baseline for conformance testing is being discussed in ongoing Part 10 web meetings and is a designated action item. Therefore, EDRC was successful in highlighting the issue and forcing examination and hopefully resolution under the ISO banner.

EDRC's results show a marked progress in the ability to describe the use and implementation of ISO 15926 for information exchange. The project deliverables reflect a great deal of effort and achievement by the project members, and contributes significantly to the future Part 10 work, as well as more effective deployment and development.

In order to capture the full extent of the lessons learned and findings of the EDRC project, project members were asked to record their insights and findings for all the project activities. In many cases, the lessons learned extend beyond the base objectives of the EDRC project for defining procedures for conformance and validation testing. However, due to the value of these lessons learned for the greater ISO 15926 community, they are captured here as part of the final takeaways. Compiling this comprehensive set of lessons learned is intended to enable clear discussion on future project needs, decisions to be taken within the ISO 15926 community, and progress to date. As such, the next portion of this chapter details the specific lessons learned, whether directly related to conformance and validation testing or to other parts of the information exchange process.

Lessons Learned — General

1. Information exchange using ISO 15926 is possible today, with some effort.

- The ISO 15926 standard family, public reference data libraries, methodologies, and available tools are mature enough for implementation in a real business context and on real data. Some challenges still exist to making this as easy as desired. The processes, however, are working and improvements are bringing real value to potential implementations.

2. Reference data is the key for making information exchange possible.

- The ultimate success of the ISO 15926 integration project depends on the availability of stable and broadly adopted reference data. As seen within the EDRC use cases, core information is usually available today, either in the PCA RDL or in an industry-accepted working groups.

- If some required reference data entities are found missing, then it is important to have a way to quickly develop and publish required items for use in the project. This process remains an open issue for full adoption of ISO 15926. There are, however, ongoing projects, such as the Fiatech project "Accelerating RDL Adoption" and "Datasheet Definitions" that are already working to establish an RDL continuous improvement framework and inject improved reference data, respectively.

3. A responsive community helps resolve issues.

- When new reference data entities are published for the project, it is important to get some feedback from the community quickly. Whether a pointer to a missed part, a small correction or tentative approval of new entities can facilitate making faster progress. Currently, this process is not responsive enough, which leads to discouragement in making progress. This is an area where the "Accelerating RDL adoption" activities likely will help to improve.

4. Business context and scenario are important

- In many ambiguous cases where certain simplification decisions are required, such decisions should be guided only by a particular business scenario and specific usage of the data. If understanding of the business environment is good, then it is easy to see whether some

compromise is possible. Otherwise, strict compliance should be achieved at any cost. Sufficient guidance should be provided to the data exchange users and engineers responsible for mapping the data to RDL on data content and data definitions.

5. Modeling methodologies and data representations may differ.

- Use Case 1 and Use Case 2 demonstrated good results can be achieved with very different approaches and technologies. However, whether allowing such diversity in methodology is a good thing in the long-term is a topic for discussion outside the scope of EDRC. This topic is of extreme importance in achieving the goal of plug and play interoperability and hence should become a focus point for future projects.

- In the short term, data representation rules may differ and unification in this area can take time. This situation requires further study. A future governance policy should be developed that regulates the degree of possible variance. The long-term goal should be to minimize the variance.

6. Conformance testing should be independent of enterprise or product-modeling methodology and tools. Verification of data and conformance checks must be as independent of modeling methodologies and tools used as possible. This requirement seems simple. It is critical, however, for insuring software solutions are not limited to current thinking only, but advance as technology and understanding of web semantics solutions continue to develop.

7. Part 7 Templates methodology

- The JORD methodology that serves as a basis for current template creation is a useful baseline document. However, as evidenced and discussed during the EDRC project, areas of needed requirements need revision or are incomplete. The ongoing MMT project is expected to help resolve some of this, but during the EDRC project, the MMT activities were limited, resulting in some difficulties in getting feedback and resolution to open questions.

8. Existing PCA RDL errors need to be fixed.

- Although the two EDRC use cases employed the PCA RDL as a base source, there were times when errors in the PCA RDL caused difficulty in finding the right data entry. These concerns involve

problems such as incorrect typing, and an inability to add new classes or to clean up obsolete data.

- It is expected that the "Accelerating RDL Adoption" and "Datasheet Definitions" projects will be instrumental in resolving this issue.

9. Part 7 template set review process

- As noted previously, the current mechanism for reviewing and approving new and revised templates via the MMT project has been currently delayed. Proposed new templates, even if reviewed by other working groups, are not yet able to pass to the PCA RDL for use by a wider audience as "accepted" templates.

10. Base specification development

- Being business level, functional use-case driven is the only way to develop good base specifications. Also, an approach that works well is to set the scope of implementation and allow that to drive standards making.

- The best way to publish the base specifications in the paradigm of ISO 15926 will be to make all specifications available as reference data as a first step. All levels of data model being used should be published as triples by an authoritative RDL owner (or federation) from a 15926 Part 2 system through template meta models and template definitions and up to the template signature patterns, which are currently the uppermost level of modelling used (this is referred to as base specifications in the context of conformance testing).

- The IIP group is a good example of preparing public specifications in the form of TIPs. With support from other communities, this group can be expanded and the process standardized. Unfortunately, it is hardly recognized by the broader community and little effort goes into discussion and verification of the IIP group's work.

11. Part 8 implementation roadblocks

- During the use-case demonstration projects, some incompatibility between Part 7 templates and current Part 8 spec were found that caused some confusion. Discussions with the Part 8 team from PCA and ISO determined that the current Part 7 templates are considered to be the proper direction,

however, the official Part 8 revision to support them has not been proposed. Comments about current Parts 7 and 8 have been raised, but need to be processed through the ISO process with high priority towards creating the newer version of Parts 7 and 8.

- Until this issue is resolved, questions about what is a conformant Part 8 implementation will arise and should be treated on a case-by-case basis.

- Templates used for Use Cases 1 and 2 are taken from 15926.org set. Use Case 1 was executed much earlier, and some time has passed since the execution of Use Case 2. Therefore, some templates have been changed since that time, some significantly. Nevertheless, Use Case 1 and 2 templates were represented in a fully Part 8 compliant format, and this was used by the EDRC project for test cases.

Today, a lack of formal guidelines or examples leads to a great deal of subjectivity for how to use Part 8 correctly. As noted, a revision of Part 8 is expected to be created. However, procedures and best practice guides for implementers would typically not be included in the revision document. Therefore, dedicated projects within Fiatech or other organizations should be formed to develop these guides for next-step implementation acceptance. Currently, the SVRDL team is working on improving the RDL related to properties/indirect properties and on formalizing the TIPs. The latter is essential for reducing the mentioned subjectivity. The current source for PCA MMT approved templates and implementation best practice is 15926.org.

Lessons Learned — Conformance and Validation

1. Conformance and validation testing are not well understood terms, and therefore they must be well defined for understanding.

    - This finding led to the development of the framework for interoperability to help better guide future discussions.

2. Use of the draft JORD specification for conformance and validation testing is a baseline start for Part 8 RDF implementations, but is not complete nor sufficient for all potential exchange mechanisms. As identified via the NIST parallel efforts, there are many elements of conformance testing that must be addressed, and they must be developed more fully as part of the ISO 15926 Part 10 process.

3. Conformance testing seems relatively straightforward, while validation testing remains more ambiguous. Defining test cases and tests suites for testing of conformance is a known process that can be leveraged for ISO 15926. Validation testing of the "quality" of information exchanges is much more subjective and difficult to prove. Future works for Part 10 must account for this ambiguity within the testing methods proposed for implementation by industry.

Recommendations

Several key recommendations arise from the work of EDRC that reflect both the results of the project and the team's lessons learned. These include:

1. The framework for interoperability should be expanded and used by future Fiatech projects to identify where in the interoperability story they are focused. As noted by EDRC, some projects will cover several parts of the framework, but each project should have one particular part of the framework as a central target in order to move forward.
2. Formal cooperation between Fiatech projects must continue to strengthen. Done currently via common members between projects, coordination meetings should be scheduled quarterly between project leads to address open issues affecting multiple projects.
3. The MMT process for approving templates must be repaired.
4. Broad public agreement is needed for the data exchange base specifications so that more than the two parties involved agree (i.e., make the base specification an easily available standard somewhere). NIST recommendations white paper [7] concluded this and stated it is the biggest barrier to ISO 15926 adoption. The reason is because so much of what is happening now is hidden from public view, thus making stability a major concern.
5. Convince software vendors to implement and test adaptors that implement those standard base specifications, and provide a forum where vendors and users can raise issues and find resolutions, which then can be driven back into the base specifications and adaptors.
6. The "Accelerating RDL Adoption" and "Datasheet Definitions" projects must become highly visible and supported projects within Fiatech and the larger ISO 15926 community. Ensuring a robust and flexible methodology for validating the contents of the RDL, approving and making required changes available quickly, and documenting and validating changes to the RDL are critical for future advancement.

7. ISO 15926 Part 10 must have the support from and acceptance by many levels of industry. EDRC examined one part of future Part 10 work. In order to ensure that software suppliers are able to truly test the conformance and validation of their respective solutions, however, this part must be developed and accepted as a quality process. International support from the various working committee members from ISO and from interested implementers (within Fiatech and external to it) are critical to moving this effort forward.

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Fiatech
The University of Texas at Austin
3925 W. Braker Lane (R4500)
Austin, TX 78759-5316
Tel: 512/232-9600
Fax: 512/232-9677
www.fiatech.org

3925 West Braker Lane (R4500)
Austin, TX 78759-5316

t: (512) 232-9600

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