NCSBCS
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ATTACHMENT D TO ALLIANCE REPORT
Creating a State-of-the-Art Interoperable Building Regulatory System

February 28, 2004

Interoperability Background Study for the National Alliance on Building Regulatory Reform in the Digital Age

1.0 Introduction:

Attendees at the May 31 – June 1, 2001 National Forum on Building Smarter in the Digital Age, which was the founding meeting of the Alliance, identified the lack of software interoperability as one of the primary barriers to more effective use by state and local government of information technology. The purpose of this background study is to review a few significant interoperability efforts in an attempt to identify issues or approaches that may improve the Alliance's interoperability effort. To do this, inherent complexities of achieving hardware and software interoperability that other major efforts experienced were examined in order to define any areas of commonality with the Alliance's initiative.

Specifically, this information will be classified into several broad categories. First, the complex opportunities or needs will be reviewed which led to the initiation of each effort. Second, the issues and barriers to interoperability each effort faced as its process formed and matured will be examined. Next, the solution that was implemented will be defined. Common aspects of the different solutions will be examined and highlighted. Recommendations applicable to the Alliance's Building Regulatory Process (BRP) Interoperability effort will be noted based on the lessons learned from analysis of the interoperability efforts taking place in other industries. Ultimately, these recommendations will help shape the future direction of our project. The report ends with a listing of additional areas for possible later study.

The five interoperability efforts covered in this paper are:

- The International Alliance for Interoperability (IA)
- Web Services Interoperability (WS-I)
- Justice XML Data Dictionary (JXDD)
- LandXML
- Automating Equipment Information Exchange (AEX)

2.0 Study Methodology

Assumptions: The most critical assumption of this background study is that other interoperability efforts will have dealt with similar type of high-level issues as the Alliance's BRP Interoperability effort. This will enable the Alliance to learn from the other efforts studied and hopefully minimize common errors and pitfalls of other interoperability efforts. A second major assumption is that it is not possible to establish an integrated enterprise database that vendors of each application could base their solutions. As a result, some type of data exchange must take place between the BRP applications. All of the five projects reviewed in this paper are web-based solutions.

Methodology: Several related industry efforts were identified as offering the potential to learn the best ways that the Alliance could approach the problem of interoperability for the BRP. The approach taken for this background study was to review each identified effort with a structured set of viewpoint, including description, opportunities, issues and barriers, solutions developed and then to develop a summary of useful input for the Alliance to consider going forward.

Descriptions: A thorough description was developed for each interoperability effort as the first step to determining how useful the particular effort is to this background study. A well-defined effort includes key details about the process taken to reach interoperability as well as the quality of product and acceptance in the professional community.

Opportunities: The opportunities for interoperability all share a common need for communication. Whether it be different software applications or public safety officials, the need to share information, in real time, is becoming more and more important as systems grow more complex and disparate.

Issues and Barriers: The lack of interoperability *standards* is the primary issue most organizations face as they promote interoperability. This means that the common data elements that need be shared are not defined and agreed to. If a specification requires too many data elements then vendors could have to add useless functionality into their applications to handle the extra detail. Conversely, a dearth of data elements would require later enhancements to lower the barriers of acceptance. Each of the organizations studied has faced these challenging issues concerning interoperability standards.

Solutions: The processes, principles and techniques adopted by each organization to reach interoperability within an industry were the focus of the solutions analysis. Particular attention was given to sources that discussed in detail the process that an organization followed to provide a successful solution. In addition, how the interoperable solution or process has evolved over time was scrutinized.

Observations: Some observations were made about key practices and lessons learned to consider in future Alliance efforts in interoperability.

3.0 International Alliance for Interoperability (IAI):

3.1 Description

The International Alliance for Interoperability (IAI) has undertaken several large-scale interoperability efforts. Created in 1995, the IAI was formed to provide interoperability between the software used by all building project participants. The intent is to provide a means of passing a complete, thorough and accurate building data model from the computer application used by one participant to another; with no loss of information. The IAI is formed primarily from members of the architecture, engineering, and construction communities.

IAI's stated objectives are:

- to develop and recommend practices for the uniform transmission and sharing of information and data
- to provide a forum to promote the use of the recommended standards of information sharing
- to develop a process for certifying compliance with the recommended standards
- to implement and foster use of those standards

3.2 Opportunity

Patrick MacLeamy, the head of IAI's international Council, does a good job explaining the need for interoperability in pragmatic terms:

> "We recognized in 1995 (when IAI was initiated) that the building industry was becoming a global industry.... that I am just as inclined to use a Mitsubishi elevator as one from Otis,"
>
> - Patrick MacLeamy, chair of IAI International Council

In response to the need for interchangeability of building parts and materials, the IAI was formed to standardize the way buildings and all the data relating to the design, materials, components, development, and maintenance of buildings is shared between different software applications. With a standard data framework for any building, designers across the globe, using different software applications, can easily interpret building designs that may be supplied in the global marketplace.

3.3 Issues and Barriers

IAI describes the *lack of interoperability standards* as the primary barrier to interoperability throughout all phases of the whole building life cycle.

3.4 Solutions

IAI's primary activity has been the development of Industry Foundation Classes (IFCs), which are object models that are intended to provide a building block standard for data exchange. IFCs are object-oriented definitions of all the objects to be encountered in the building design industry, and a text based structure for storing those definitions in a data file. A plain text file is used because that is the only hardware-independent computer data format. IFC neutral text files, which were originally based on ISO 10303 (STEP) Part 21 files, have recently been migrated recently to use XML as the formatting syntax for plain text files. When IFC XML exchange files are in place, each CAD system continues to store their own data in whatever compact binary file format they wish to best suit their system. Applications provide "Save As IFC" and "Read IFC" functions, which map the IFC object definitions to the CAD system's internal representations of those objects. Thus the IFC neutral file provides a software-neutral solution for any application that can read and write an IFC formatted text file and can interpret the file information based on the IFC Schema reference within the XML document.

IAI is assisting the development of Architecture Engineering and Construction XML (aecXML). aecXML™ will be a framework, extending the basic IFCs and using eXtensible Markup Language (XML) standard for electronic communications in the architectural, engineering and construction industries. While IFC provides a means to encode and store information for the entire project in a model that can be shared among diverse project participants; aecXML will support specific business-to-business transactions over the internet thereby utilizing some of the IFC objects, as well as many common Electronic Business XML (ebXML) objects and aec specific objects. AecXML's use of ebXML (a pre-existing schema for common electronic business objects) and some IFC objects is a good example of the building block approach to interoperability in the aec industry. Figure 1 represents the relationship between IFC and aecXML.

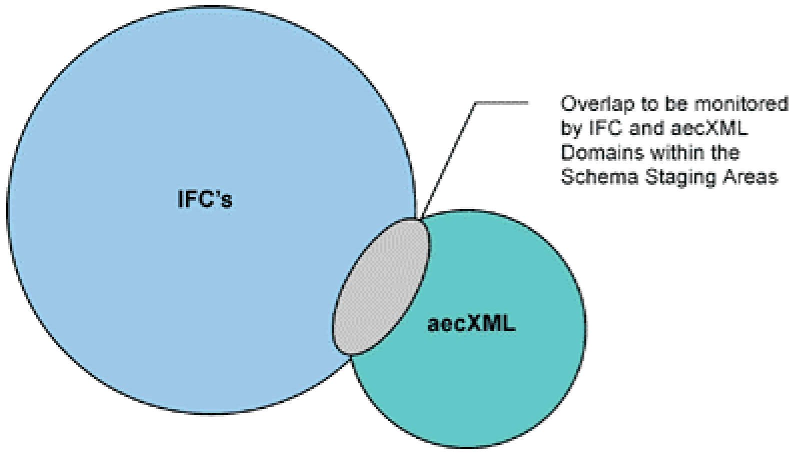


Figure 1. This figure illustrates that IFC that provide useful objects within the aecXML Schema.

3.5 Observations

The basic approach being pursued by IAI's efforts of relevance to the Alliance include:

- The concept of having a core set of components (IFCs) from which to build discipline-specific extensions (aexXML™) is a useful concept for promoting multiple groups to work together to solve interoperability problems in a common way.
- The use of XML was adopted as a preferred way to describe software-neutral information in hardware-neutral text files.

4.0 Web Services – Interoperability (WS-I)

4.1 Description

The second major interoperability effort studied was the Web Services Interoperability Organization (WS-I) formed in 2002. Web Services is an emerging technology driven by the will to securely expose business logic beyond the firewall. Through Web services companies can encapsulate existing business processes, publish them as services, search for and subscribe to other services, and exchange information throughout and beyond the enterprise. Web services will enable application-to-application e-marketplace interaction, removing the inefficiencies of human intervention. The WS-I is committed to promoting interoperability among Web services, based on common, industry-accepted definitions and related XML standards support. It is important to note that Web services is not particular to any one industry. Web services Interoperability is about providing guidance and consistency around implementing the specifications developed by standards organizations that set the specifications for technologies like SOAP, WSDL, and UDDI.

The Web Services Interoperability Organization was formed specifically for the creation, promotion, or support of Generic Protocols for Interoperable exchange of messages between services. The **open** industry organization's commitment to promoting interoperability among Web services is described by these core objectives:

- Promote consistent and reliable interoperability recommendations among Web services implementations across platforms, applications, and programming languages.

- Articulate and promote a common industry vision for Web services interoperability to:
    - Lower technical obstacles to adoption of Web services technologies
    - Grow industry adoption of Web services
    - Reduce complexity and efforts needed to integration separately developed Web services
    - Ensure the continued evolution of Web services technologies via clear and implementable processes and confirmable interoperability test suites.

WS-I is not the only organization involved with Web services interoperability. A number of other organizations are developing standards for web services and ebusiness or providing guidance for implementing specifications. The Organization for the advancement of Structured Information Standards (OASIS, www.oasis-open.org/home/index.php), Open Applications Group (OAGIS, http://www.openapplications.org/), and Electronic Business XML (ebXML, www.ebxml.org) add to the alphabet soup of organizations involved with e-marketplace interoperability.

4.2 Opportunity

The WS-I examines the opportunities for interoperability a bit deeper and explains why an organization must be created to oversee the establishment of inoperable web services. First, there is no single standards organization that "owns" Web services. The W3C is working on some of the foundational technologies such as XML, XML Schema, XML Signatures and Encryption, SOAP and WSDL. Organization for the Advancement of Structured Information Standards (OASIS) is working on some of the higher-level technologies such as WS-Security, UDDI, Remote Portals, etc. The IETF is responsible for some of the lower-level protocol technologies such as HTTP, TLS, etc. WS-I fulfills a needed function in providing a single venue for integrating the efforts of these various organizations. Secondly, with regards to SOAP1.1 and WSDL1.1, there is no standards organization that "owns" those specifications; WS-I fulfills a need by providing clarifications and constraints on those de facto standards that will enable vendors and developers to implement and use these technologies in an interoperable manner.

4.3 Issues and Barriers

As developers work to implement support of WS-I specifications the number of additional efforts focused on expanding the library of Web services related specifications to support the full Web services vision expands. Viewing each of these new specifications in isolation is an oversimplification, as many of the areas have multiple interdependencies, sometimes with conflicting requirements. Over the past few months, additional specifications in many of these areas have begun to emerge. Given the potential to have many necessarily interrelated specifications, at various versions and schedules of development and adoption, it becomes a very difficult task to determine which products support which levels of the specifications.

4.4 Solutions

The WS-I seeks to meet it's core objectives using a four pronged approach. First, WS-I is developing web services Profiles that specify collections of XML based specifications, along with clarifications of their ambiguities, so that they can be adopted in an interoperable fashion. The WS-I Basic Profile 1.0 specifications include SOAP (Simple Object Access Protocol) 1.1; WSDL (Web Services Description Language) 1.1; UDDI (Universal Description, Discovery and Integration) 2.0; XML 1.0; and XML Schema. These specifications have already gained wide-spread acceptance and are XML based. Next, WS-I is developing usage scenarios and use cases. Usage scenarios demonstrate how specific message exchange patters are constrained by a profile. Use cases capture the business requirements for an application. Together these two guidelines provide a framework for the use of WS-I compliant Web services. Next, sample applications have been developed. Sample applications demonstrate the implementation of applications that are built from WS-I compliant Web services and utilize the usage scenarios and use cases that conform to a given set of profiles. Implementations of the Sample Application will be built on multiple platforms, languages, and development tools, to demonstrate interoperability in action, and to provide readily usable resources for the Web services practitioner. Finally, testing tools must be supplied. Testing tools are used to monitor and analyze interactions with a Web service to determine whether or not the messages exchanged conform to WS-I Profile guidelines.

There is already strong consensus on the underlying protocol standards which form the base for the most basic Web services *Profile* 1.0. As new standards and specifications emerge which address aspects of Web services technologies above the level of this most basic *Profile*, it is likely, but not required, that the *Profiles* developed for these will include this basic *Profile* as a foundation. Similarly, it is expected that vertical industries will build upon the WS-I *Profiles* by adding industry-specific specifications or standards. Using the basic profile as a foundation and building subsequent profiles which include the basic profile is similar to aecXML's evolution and another example of the building block approach used to reach interoperability.

The WS-I process begins with the definition of *Use Cases* that describe how Web services can be applied to meet real-world business needs. These *Use Cases* are then decomposed into *Usage Scenarios* supporting various aspects of the Use Cases and design patterns. The *Usage Scenarios* describe the ways in which Web services are employed in the context of the collected *Use Cases*. This work aids in the demonstration of how Web services specifications are used individually, in concert with one another, or both. Use Case analysis forms the foundation for *Profile* requirements to be defined. Each *Profile* is based on a specific set of Web services specifications, each at a particular version and revision level. Profiles provide a refined usage of these specifications and standards through *implementation and interoperability guidelines*, which, in many cases, are captured as a set of *test assertions* that can be used to verify the conformance of a given Web service implementation with the *Profile*. WS-I then defines, and implements, S*ample Applications*. The supporting implementations are developed in multiple programming languages, such as C# (C sharp) and Java™, and are deployed on multiple platforms, including Java 2 Platform, Enterprise Edition (J2EE™) and .NET. This activity demonstrates *Profile* interoperability by implementing functional applications using the *Use Cases* and *Usage Scenarios* that the *Profiles* are intended to address. Finally, to close the loop, WS-I develops *testing tools* for use by Web services practitioners, including those members of the WS-I Working Groups developing *sample applications*. These tools are used to verify that the interactions observed with the monitored Web service conform to the set of *guidelines and test assertions* that define the interoperability *Profiles*. Figure 2, below, depicts the WS-I process and interactions between the different elements.

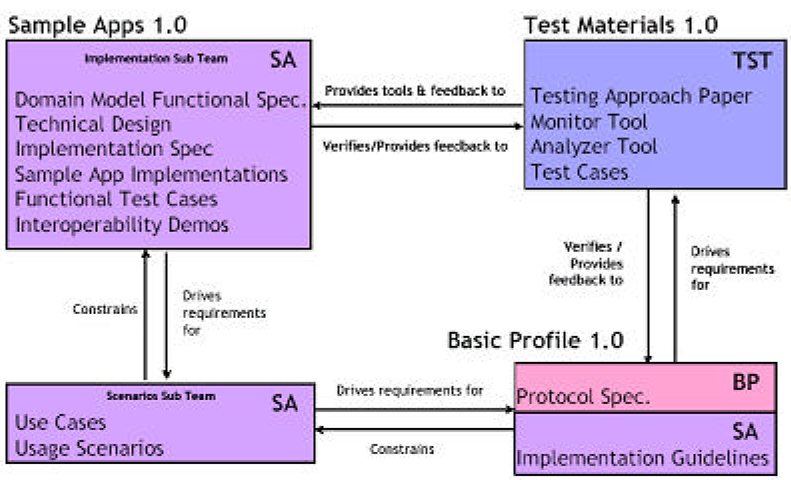


Figure 2. WS-I working group deliverables and their Relationships.

4.5 Observations

The basic approaches towards interoperability of relevance to the Alliance:

- Defining XML protocols for interoperability messaging profiles
- Defining use cases and usage scenarios is important to setting the proper context for interoperability applications
- Verification and standard test cases are needed to assess conformance
- Sample applications verify that the use cases and data exchange profiles are valid and functional

5.0 Justice XML Data Dictionary (JXDD)

5.1 Description

The next major interoperability effort studied came at the recommendation of work experience of Alliance partners, National Governors Association and National Association of State Chief Information Officers. This effort was the Justice XML Data Dictionary (JXDD). The JXDD product is a result of work performed under the guidance of the Global Justice Information Sharing Advisory Committee (GAC). The *data dictionary* is a well-defined vocabulary of data names and structures assembled in an object-oriented *data model* from which consistent *XML schemas* are generated to be used as templates for valid XML instances that carry data payload.

The Data Model is a common reference baseline that managers and developers can utilize for agreeing on meaning, structure, and form of data passed between jurisdictions (law enforcement, courts, corrections) and across local, state, and regional integrated justice information systems.

5.2 Opportunity

The Global Justice Information Sharing Advisory Committee's (GAC) effort to promote interoperability between applications functioning within the justice and public safety community seized the opportunity to consolidate three major Interoperability efforts already underway. The XML Interstate Criminal History (Rap Sheet) Transmission Specification, the Regional Information Sharing Systems (RISS) XML Data Exchange Specification, and the Court Filing XML Specification each had an independent and divergent XML specification for interaction with their systems. Justice professionals needed a way to search for information from these three data sources without having to take the time or money to create and use three different systems.

5.3 Issues and Barriers

The JXDD found that the lack of a legitimate, recognized, repository of specifications and standards for data structure and definition was the reason Rap Sheet XML, RISS XML and Court Filing XML could not support a interoperability between them. These organizations are attempting to accomplish dissimilar missions with their specifications, which makes this effort somewhat more difficult. Further, there are about 60,000 jurisdictions participating in the formation of the repository of specifications. This made the identification of common data elements a difficult issue.

5.4 Solutions

To define a core set of industry specific objects that make up the Justice XML Data Dictionary (JXDD), the Global Justice Information Network identified three emerging specifications with which to begin the reconciliation process. Reconciling the emerging specifications between the Interstate Criminal History Transmission Specification, developed by the Joint Task Force on Rap Sheet Standardization; the Regional Information Sharing Systems (RISS) XML Data Exchange Specification, developed by RISS; and the

Electronic Court Filing Proposed Standard, developed by LegalXML, provided a legitimate, recognized repository of specifications and standards for data structure and definition. In addition, the reconciliation provided the basis for interoperability because it became the core set of justice community objects.

Approximately 16,000 justice and public safety-related data elements were collected from various local and state government sources. These were analyzed and reduced to around 2,000 unique data elements that were then incorporated into about 300 data objects or reusable components. These components have inherent qualities enabling access from multiple sources and reuse in multiple applications.

The Principles and Procedures that governed the development of the Justice and Public Safety Community data objects were devised by the OJP XML Technology Working Group. The following points describe the procedures and principles used to achieve success in bringing the three aforementioned specifications closer to interoperability through reconciliation:

Procedures:

1. Identify requirements each participant is attempting to meet and the goals they are trying to accomplish. Ensure all participants have at least a moderate understanding of each other's needs.

2. Identify similar information being shared by participants, and the differences and similarities between tag names.

3. Identify and resolve non-substantive differences (e.g., tag capitalization and naming conventions).

4. Identify and resolve those substantive differences that can be resolved quickly (e.g., tag names for person name elements).

5. Identify those substantive differences that are difficult to resolve. Where possible, resolve them. Where resolution is not possible (usually due to differing requirements), ensure that there is no tag name overlap and document the differences.

6. Develop a plan (with tasks, goals, and objectives) to be accomplished over a defined schedule.

Principles:

1. Any XML specification developed should be guided by the principles put forth by the World Wide Web Consortium (W3C).

2. Internal system representation is not constrained by these guiding principles or the associated data element definitions. The information contained in these documents simply provides a baseline for exchange of information.

3. XML specifications shall be over-inclusive by specifying those elements that may be required by fewer than all participants and making those elements optional.

4. XML specifications shall be extensible.

5. Wherever possible, previously developed solutions should be adopted or extended.

6. International implications of XML specifications should be considered, and international standards shall be used as guides, where possible.

7. XML specifications shall be broad enough to accommodate jurisdictional differences.

8. When operational requirements dictate differences in specificity, mapping from the more specific elements to the less specific elements shall be made available.

9. It is the responsibility of each group to ensure that all system-specific features are removed prior to transmission to another group.

10. Certain complex elements are sufficiently independent and driven by group business rules such that they cannot be used by more than one organization. In such cases, the shareable simple elements contained within the complex element are defined.

11. Where necessary, it is acceptable to use a more specific tag name (e.g., arrestDate), provided it includes the data model of its more generic counterpart (e.g., date).

12. The data element <*number*> shall not be used. Rather, numbers are identified by their name; e.g., caseNumber.

5.5 Observations

This project's basic path towards interoperability of relevance to the Alliance:

- Defining XML based common data model
- Establishing an agreed-upon common data dictionary/data model is essential for achieving interoperability
- Agreeing on a set of procedures and principles is useful to guide efforts undertaken by multiple parties to develop a common data model

6.0 LandXML

6.1 Description

LandXML is a smaller interoperability effort examined because of its scale and similarity to the Alliance's Building Regulatory Project effort. Initiated by Autodesk in December 1999, LandXML was an industry-driven, open XML data exchange standard that addresses the needs of private and public land development professionals, software/hardware producers, and service vendors. The primary goal for LandXML is to specify an XML format for civil engineering design and survey data to be shared among producers and consumers.

6.2 Opportunity

The LandXML Organization presents several real world opportunities for an interoperability solution based on XML to emerge. First, a format was necessary for design data exchange for common Civil Engineering, Surveying, and Land Planning data. Second, land development professionals were looking for a way to submit project data files to approval agencies more easily, without submitting vendor- and version-specific software files. Third, long-term archival of project design data needed to be accomplished without using a proprietary database. Finally, data created during the design process was not easily leveraged beyond the engineering department. To use the data, you typically needed the initial authoring software, and the expertise to use the product to retrieve the reports and data that were desired.

6.3 Issues and Barriers

For LandXML to support the land industry worldwide, the LandXML Organization needed specifications from around the world to be standardized. Global participants required different specifications with vastly different naming conventions.

6.4 Solutions

LandXML is based on W3C's XML specification. The XML data is structured using XML Schema, which is a W3C standard for describing data structures and data types in an XML format. LandXML data describes land parcel and property data structures such as coordinate geometry, point data, road alignment geometry, parcel geometry, land survey data, and more. The first draft of the LandXML schema utilized the building block approach. The earlier ASCII-based EAS-E (Engineering and Surveying - Exchange) data interchange standard initiative was used to derive the common core objects to be used in LandXML. Once again, the building block approach is utilized to take advantage of work that was already done.

The LandXML interoperability solution indicates that a critical mass of industry acceptance exists. Recent widespread adoption of XML as the language for land data exchange has lead to explosion of software tools that use and manipulate land data. For example, a software program produces drag-and-drop HTML reports based on any XML schema and data file (or multiples of each). While this result is not critical to developing the Alliance's BRP solution, it is worthy of note since it indicates that a worthwhile solution will increase industry activity and competition, thereby benefiting the BRP.

6.5 Observations

The approach taken by LandXML towards interoperability of relevance to the Alliance was:

- ❑ Using XML schema to define common data definitions

7.0 Automating Equipment Information Exchange (AEX)

7.1 Description

The Automating Equipment Information Exchange (AEX) project is a joint industry effort organized under FIATECH (http://www.fiatech.org/projects/idim/aex.htm). The AEX project is developing data exchange specifications for automating the design, procurement, delivery, operation and maintenance of engineered equipment in capital facilities, e.g., compressors, pumps, HVAC units, heat exchangers, instrumentation, etc. The capital facilities industry XML developed by the AEX project is a comprehensive object-oriented schema framework that has been developed to support equipment item and process material data that appear on equipment datasheets. The initial focus of application for the AEX project work has been threefold:

1. basic equipment information found on various equipment lists and bill of materials documents.

2. equipment datasheets for shell and tube exchangers and centrifugal pumps

3. process materials and associated properties, calculation methods and experimental property data

A primary source of information input into the development of the XML schemas has been industry standard equipment data sheets. Another primary source includes previously developed draft STEP standards (ISO 10303, AP231). In the area of describing material properties, the AEX project has been coordinated with an effort from the Design Institute for Physical Properties (DIPPR) to develop a physical properties data XML (ppdXML)

The AEX project was initiated in mid-2002 and completed Phase 1 of its efforts by April, 2003. The AEX project is continuing its efforts in Phase 2, extending through 2004. In Phase 2 of the effort, the AEX project anticipates completing demonstration software implementations, as well as extending the initial scope to 10 additional equipment types.

7.2 Opportunity

As capital facilities are conceived, designed, constructed, operated and maintained a huge amount of information is assembled and used by many companies. Today this digital information is created and used in a number of incompatible software systems. This makes sharing and reuse of digital information over the facility life cycle difficult, time-consuming and expensive. This problem is estimated to cost the capital facilities industry at least a billion dollars a year.

The quantification of the cost or lack of interoperability in the capital facilities industry is subject of a current NIST research study. A previous NIST study for the automotive industry identified costs associated with lack of interoperability in that industry at upwards of $1 Billion annually. Other studies from CII and NIST have estimated that significant improvements in the automation and integration of software systems in the capital facilities industry could be worth up to 8% of total project capital cost, a 14% reduction in project schedule and 5-15% reduction in annual maintenance costs. Applying these percentages to the estimated $100 billion annual capital facilities investment suggests that $1 Billion per year is a reasonable, if not conservative estimate for industry-wide benefits. For any one large company engaged in capital projects, the benefits are potentially millions of dollars annually. For example, a large chemical company has estimated $375,000 savings per year just for pump procurement.

The solution to this problem, which has been recognized for a number of years, is for the industry to agree upon and use a common electronic information exchange protocol. Extensible Markup Language (XML) is an Internet standard that offers, for the first time, a widely used, cost-effective implementation technology to solve the problem. However, the XML enabling technology does not solve the problem by itself. Rather, it is the combination of XML technology and pragmatic industry consensus that solves the problem. The Automating Equipment Information Exchange (AEX) project is aimed towards achieving this pragmatic industry consensus around the use of XML technology to solve the industry problem and achieve the noted economic benefits.

7.3 Issues and Barriers

The process industry part of the capital facilities industry has been attempting to establish interoperability standards for a number of years, including sponsoring various efforts in ISO (10303-STEP and 15926-data warehouses). One of the key issues and barriers for these efforts has been the complexity of the problem and the cost of software implementations. The AEX effort has included in its focus facilitating some test software implementations by the participants to ensure the validity of the XML schemas that are developed as well as to demonstrate 'working solutions' that will offer commercial benefits to the participants. The use of XML is seen as a way to both manage complexity and reduce the cost of software implementation. Another key success factor identified by the AEX project is to obtain active participation in the project and the example software implementations from all stakeholder participants in the work process – the owner, the engineering contractor, the equipment suppliers and the software suppliers.

7.4 Solutions

XML Schema Development Guidelines

Prior to the AEX project initiation, and refined further during the AEX project development, FIATECH and NIST developed a document, "XML Schema Development Guidelines" which is available on the FIATECH web site resources page (http://www.fiatech.org/links.htm). These guidelines summarize the background, rationale and guiding principles that the FIATECH program is using to produce XML domain schemas for automating information exchanges in the capital facilities industries and over the life cycle of equipment used in capital facilities. These principles, which are based on the work of the ebXML initiative and participants' experience with other software and standards development activities, are presented here as a working draft. This working draft will continue to be refined for use in FIATECH projects and for review and potential use by other organizations initiating work on XML specifications for the capital facilities industries and for the equipment life cycle. These guidelines have already been adopted for use by ASHRAE. The Guidelines include:

- Introduction and background on XML and related efforts
- Recommended schema development process
- Schema Development Principles
- Schema Design Principles, naming conventions, extensibility conventions
- An illustrative example of the recommended schema development process

Schema Development Principles Summary (from XML Schema Development Guidelines)

PROJECT APPROACH PRINCIPLES

First, understand the business work activities
Focus efforts on business needs of both software users and providers.
Software users and providers must both participate actively
Seek to identify reusable concepts and core components.
Share experiences and leverage experiences of others.
Establish principles, rules and guidelines to ensure consistency
Establish a mechanism for ongoing support.

SCOPING PRINCIPLES

Select documents that are heavily reused in the work process
Select data transactions that cross multiple organizations.
Focus on data content of an exchange, not the exchange mechanism.
Define sufficiently detailed data to enable software implementations
Keep the project scope relatively small.

MODELING PRINCIPLES

Develop and deliver business process models
Develop data models using common engineering terminology
Refrain from using highly abstract data modeling approaches
Define data models using a simple, explicit and contained stye
Use standard modeling notations where possible.
Use modular data architecture.
Define / develop reusable concepts underlying large amounts of data
Adopt a set of naming rules and conventions.
Define needed alternative names in application or XSLT mappings.
Group related data items together into reusable logical groupings.
Minimize complexity and depth of nesting.
Define appropriate relationships between data groups.
Separate user presentation issues from data modeling issues

XML SCHEMA DEVELOPMENT PRINCIPLES

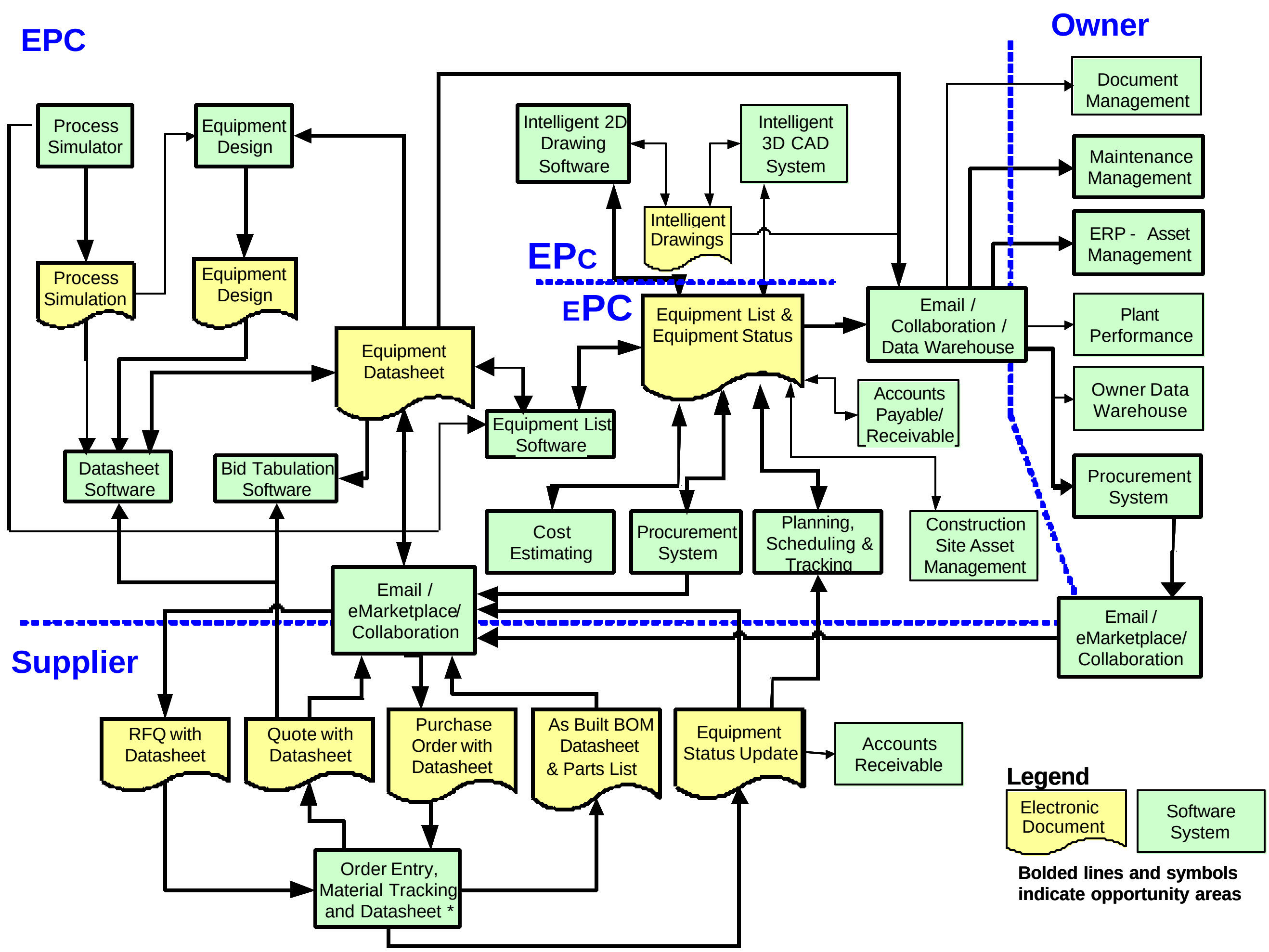
Use XML Schema instead of DTD's.
Use object-oriented data models as the basis for XML Schema.
All elements in an XML schema should be optional by default.
Define/document minimum data sets for transaction validation.
Define common user extension conventions.
Support schema versions.

ENGINEERING DATA PRINCIPLES

Develop reusable schemas that underlie various engineering schemas.
Define a systematic approach for units of measurement.
For simplicity, consider adopting SI units only.
Define a systematic approach for handling valid data ranges
Support vectors, tables and multi-dimensional arrays.
Optionally support stored information about user access control.
Optionally support encrypted binary data for secured data access
Provide standard mechanisms for extending XML schema.
Provide standard approaches to object identification and references.
Support embedded binary data.
Optionally support storage of associated revision data.
Provide descriptive data about roles or use of a data element

Provide a mechanism to determine data type of “any” elements

Software and Information Flows



The AEX project first identified key use cases by analyzing the software and information flows associated with the equipment life cycle as illustrated above. As can be seen over 20 different types of software packages need to exchange equipment information over the design, procure, fabricate, install, operate and maintain life cycle. In addition to equipment datasheets, other key documents involving equipment information include equipment lists, intelligent drawings, process and equipment designs, etc.

AEX Project - XML Schema Architecture

There are four basic parts to the capital facilities industry XML architecture as illustrated in Figure 1 below.

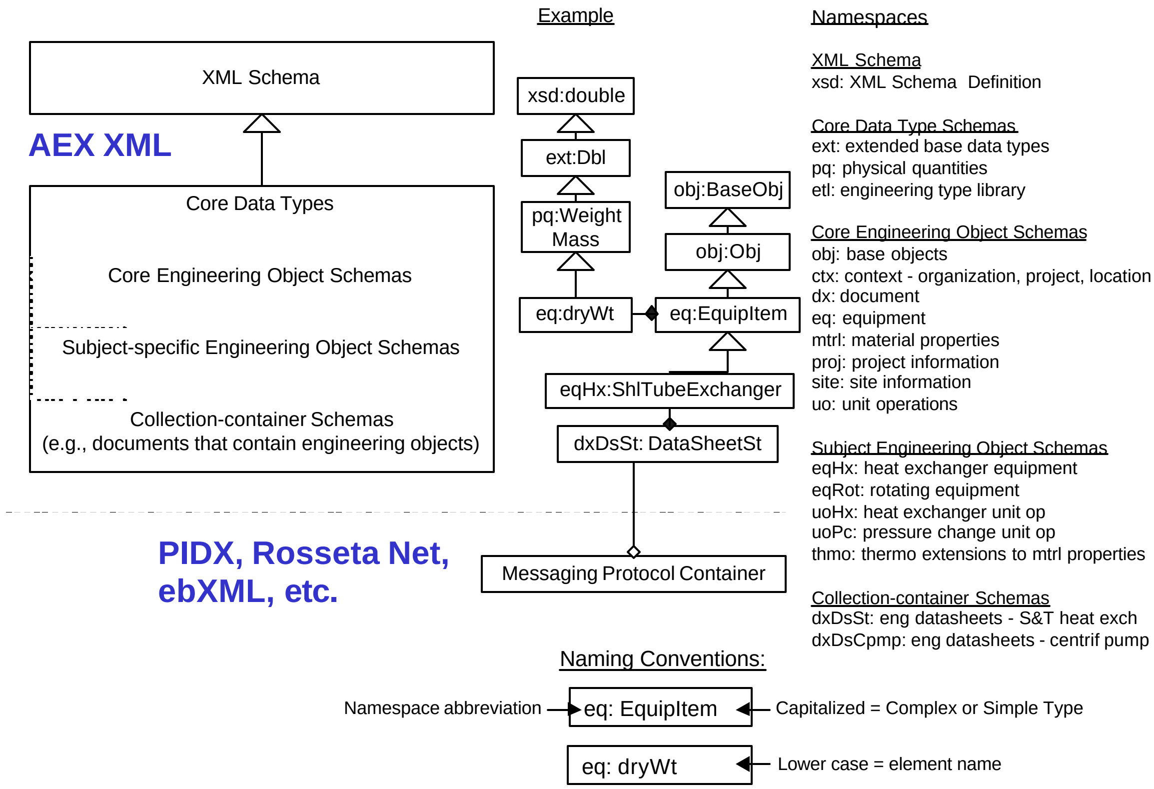


Figure 1. Overview of AEX XML Schema Architecture

1. ***core data type schemas*** for extended engineering data type requirements (these are essential extensions added to the "XSD" base data types provided in the XML Schema standard),

2. ***core object schemas*** for reusable base engineering objects that can be used by multiple engineering disciplines and subject domains

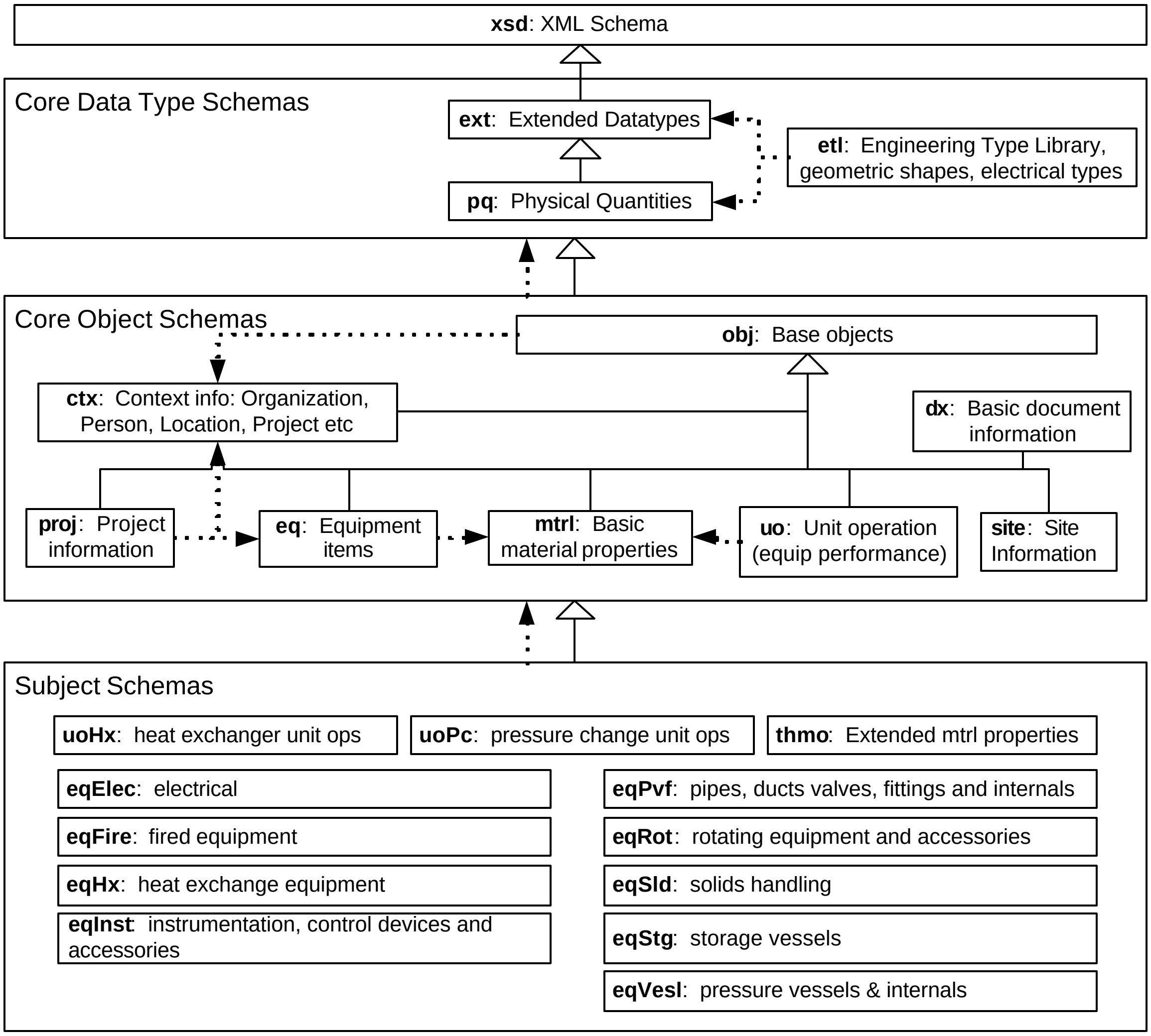
3. ***subject object schemas*** that provide schemas related to specific equipment items

4. ***collection-container schemas*** that are used to model engineering document schemas. The collection-container schemas allow core and subject-specific engineering objects to be combined in various ways to support various data transactions and usage scenarios.

Figure 1 illustrates how these parts relate to each other, to standard XML schema definitions, and to various messaging protocol containers that are currently being developed by various industry groups.

The AEX schema architecture was set up in this way to enable reuse of the information models across multiple domains, as well as providing for subject-specific schemas and arbitrary industry- and user-defined XML data exchange documents.

Further subdividing the subject domain into domain namespaces, the AEX project has defined a number of "core" and "subject-specific" schema namespaces as illustrated below.



As can be seen from the above, the AEX project has approached a very large subject domain from an overall schema organization and architectural viewpoint, while creating detailed schemas for two equipment types – centrifugal pumps and shell and tube exchangers. As part of the scope definition, there are over 300 equipment types that may eventually be covered by the AEX effort to cover the broad range of equipment encountered in capital facilities.

To date, the AEX schemas are already quite large containing over 3000 elements in the schema definition files and over 60,000 lines of XML schema definition source code.

7.5 Observations

Elements of the AEX project approach towards interoperability of relevance to the Alliance:

- Developed understanding of business work process and key data exchange scenarios
- Developed and applied a comprehensive set of XML development guidelines
- Using XML Schema to develop large object-oriented data models
- Set up a comprehensive XML architecture to facilitate reuse of information models across domains
- Including software prototype demonstrations as part of the schema validation process

8.0 Recommendations to the Alliance Drawn from Five Projects

The information learned from this background study indicates several key concepts that are common to successful interoperability efforts. These concepts aid in the development of interoperability standards and should be considered when developing the Building Regulatory Process solution.

8.1 Use XML Schema

Based upon the information that has been gathered from other interoperability initiatives, this study indicates that the use of XML as the technology to facilitate interoperability is ideal. Since it was assumed that no central database could be established, there must be some type of non-database file sharing between the different applications. A plain text file is an ideal file type for applications to share because is the only truly universal computer data format. The benefits of using an XML-based text file are:

- A published standard by W3C.org.
- Becoming the standard Meta language for data interchange across the computer industry.
- Object-oriented; supports advanced software development concepts.
- Readable.
- Extensible.

Using XML Schema to define Building Regulatory Process (BRP) data and data relationships offers self-describing and self-contained data files as well as object-oriented approaches to defining rich content data models. A self-describing, self-contained file means the data file itself has value outside the context of the application that created it. This is not true of proprietary file formats since they require written documentation and instructions to make sense of the data – that is to describe the structure and semantics for the data. This typically requires human intervention and a software engineer. Should the Alliance support BRP XML Schema requires defined semantics and basic rules and the Alliance supported BRP XML schema would describe the data structure, no other documentation is required to make sense of the data. Further, a single XML data file can contain data from any number of schemas, something that is difficult to do with non XML-based standards.

8.2 Adopt Processes and Procedures

The principles and procedures that governed the development of the Justice and Public Safety Community's JXDD are of particular note since this interoperability effort is most similar to the BRP effort involving over 40,000 units of government and the state and local levels. In addition, both efforts deal with stakeholders that are attempting to accomplish dissimilar missions. This presents a fundamentally more challenging interoperability effort than the IAI and LandXML organizations faced. The FIATECH XML Schema Development Guidelines also offer a rich source of process, procedure and principles recommendations.

The principles adopted by the OJP XML Technology Working Group charged with developing the JXDD should all be noted. Several principles seem quite applicable:

> "XML specifications shall be over-inclusive by specifying those elements that may be required by fewer than all participants and making those elements optional."
>
> One of FIATECH's principles says "All elements in a schema should be optional by default"

The Alliance's BRP effort will most certainly involve many data elements that are necessary to more than one but less than all nine regulatory processes. A definition of what constitutes inclusion in the BRP Interoperability must be made. In addition, the OJP XML Technology Working Group suggested:

> "Wherever possible, previously developed solutions should be adopted or extended."
> And FIATECH suggested "Share experiences and leverage experiences of others".

This statement affirms the OJP XML Technology Working Group's commitment to the building block approach and is the topic of section 8.3 in this study. The Alliance's BRP effort should determine if there have been any efforts within the BRP software industry that would be useful to the interoperability effort. Another important principle adopted by the OJP XML Technology Working Group addresses the issue of many jurisdictions. The OJP XML Technology Working Group states:

> "XML specifications shall be broad enough to accommodate jurisdictional differences."

Inevitably, there will be many jurisdictional differences with 44,000 potentially different BRPs involved. The Alliance's interoperability effort needs to create broad specifications to account for the many different BRP nuances. (The nine process models drafted by the Alliance in the fall of 2003 represent an important first step towards generating a generic and common mapping of data exchange needs.) One final principle adopted by the OJP XML Technology Working Group seems especially applicable to the Alliance's Interoperability effort. The OJP XML Technology Working Group states:

> "It is the responsibility of each group to ensure that all system-specific features are removed prior to transmission to another group."

Since the BRP involves at least 9 separate processes, it becomes extra important to make sure the software community understands exactly each data element is, and the proper relationship between the data elements in the XML document.

The procedures adopted by the OJP XML Technology Working Group are also quite interesting. To further address the issue of differing jurisdictional specifications, one of the procedures recommended by the OJP XML Technology Working Group states:

> "Identify requirements each participant is attempting to meet and the goals they are trying to accomplish. Ensure all participants have at least a moderate understanding of each other's needs."

The Alliance's Interoperability effort should make sure communication among the software community, among the BRP community, and between the software and BRP community is sufficient enough ensure the adopted solution fulfills each participants needs.

8.3. "Define XML data transactions that support the business work process"

Two of the FIATECH XML Development Guidelines principles states:

> "First, understand the business work activities"
> "Focus efforts on business needs of both software users and providers."

This principle would suggest that the Alliance pick a single functional work process area in the BRP, and/or one or more 'key documents' (e.g., permit) that is heavily used in a particular work process area and multiple software systems, or by several of the other 'downstream' work process areas and software systems.

Once a key work process area and key documents are identified, take steps to better understand how these overall software requirements identified by software users map to the 9 identified overall work processes. This is likely to involve further breaking the work processes from it's current general, high-level of detail to understand what mixture of software systems (including those that produce current paper documents) are actually used to accomplish the work.

Take steps to identify in detail the existing software systems that already performing a number of the key software functions with respect the identified key document(s). Understand how these software functions support the work process and what data is used as input to the software system or output from the software system. Understand what documents are generated and transmitted from one part of the work process to another. This understanding of how specific detailed information contained on the key documents is used in the work process is critical to understanding the information requirements that need to be exchanged between software systems.

Using the key documents and software systems identified in the previous steps, take steps to identify and document in detail the required standard data transactions in the work process, i.e., the data exchange / interoperability requirements that will enable information to move seamlessly from one software system to another to better support the detailed work process. Identify the highest value document/data exchanges and affected software systems as part of this activity. Also, identify in detail, the key data items that need to be exchanged between systems. These data transactions can be large (but relatively few needed) or small (relatively large number of transactions needed). Define the key data transactions in a 'use case' format and obtain agreement and understanding about the key use cases.

Use the detailed use case definitions to further elaborate data transaction requirements, the software systems that are needed to accomplish those transactions and the key data packages that move from one software system to another.

8.4 Use Core Objects and building blocks

In looking at five different interoperability initiatives, a study revealed a common need to define a core set of industry specific objects and their corresponding relationship hierarchy. WS-I has developed hierarchical guidelines to provide technical specifications that guarantee Web services interoperability.

- IFCs are defined objects including relationships. Electronic Business XML (ebXML) is another such building block as well as is aecXML.
- The JXDD solution reconciled pre-existing object specifications to define a core set of objects.
- LandXML utilized a data interchange standard initiative to devise their core objects.
- The FIATECH AEX XML architecture defines a core set of reusable objects

In order to help the Alliance's Building Regulatory Process Interoperability effort, the Alliance should continue to seek out any pre-existing, non-proprietary standards that may exist in the BR industry. Specifically, the Alliance should determine if the ebXML objects are technically applicable. Also, survey the software vendors for standards in use within the BRP software industry that involve the transfer of data from one application to another.

After the Alliance determines what specifications are available to help the Alliance's effort, we may want to define the core objects that are common in the building regulatory industry and develop an object model that defines their relationship to one another before attempting a full-on XML Schema development. This collection of BRP objects would be useful to chart and organize each of the core objects that are common to the 9 process applications. Then, the functional use cases of the BRP objects and subsequent basic XML schema could be created from the data objects that are shared by every process.

Additionally, the 9 separate process descriptions could be created to represent all data components of each of the processes. These separate profiles would lead to 9 separate XML Schema; any of which could be referenced along with the basic schema for a particular export. For example, an export from a licensing application to an inspection application would then only require the basic schema and the licensing schema.

9.0 Possibilities for Future Study

The purpose of this study was to investigate and describe a few significant interoperability efforts in an attempt to guide the Alliance's interoperability effort. This study is not intended to serve as a complete study nor as a benchmarking analysis of all interoperability efforts. Such a study would require further analysis and funding support. A number of notable efforts have been uncovered by the Expanded Core Work Group over the past months that could be included in a follow-on benchmark study. They are:

- GIS Interoperability – http://www.opengis.org/
- Automotive - http://www.aiag.org
- HIPAA - http://www.hipaadvisory.com/
- A review of the Commonwealth of Massachusetts' recently announced policies on Enterprise Open Standards and Enterprise Information Technology Acquisition Policy (copy attached).

Further review and analysis also needs to be done for ebXML (http://www.ebxml.org). Additionally, review of the "Best Practices for the Development and Use of XML Data Interchange Standards" by William Behrman of Stanford University was suggested.

10.0 Closing Comment – Request for Your Input

Please provide the Alliance your input on this report in the following areas:

1. Does this report offer any recommended actions that your firm can support? If yes, which ones and why?

2. Are there other interoperability projects the Alliance should study besides those covered in this document? If yes, which ones?