A Better BIM: Ideas from other Industries

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ABSTRACT
The architecture, engineering, construction and facility management (A/E/C-FM) industries have the opportunity to interoperate with software tools which utilise the IFC standard building information model (BIM). However, within the companies and projects which are currently using this standard there have been a number of issues raised with an impact on achievable interoperability. At the time that the IFC specifiers look at approaches to address these interoperability issues it is worth looking at other industries, who also have complex models and high reliability requirements, to see how whether there are lessons which can be learnt. In this paper the healthcare and manufacturing domains are surveyed in regards to their interoperability, conformance and certification approaches and novel ideas from these industries are presented for consideration of the A/E/C-FM industries and the developers of the IFC. A number of these approaches would argue for a restructuring of responsibilities between standards setting and certification, and others propose further development of freely available resources for all in the industry.

KEYWORDS: BIM; Interoperability; Survey.

1. INTRODUCTION

A range of recent papers have documented issues with the current BIM approach utilised in the A/E/C-FM industries (Kiviniemi 2007, Amor et al. 2007, Lipman 2006, Pazlar and Turk 2006). The issues identified in these papers show that current approaches to the management of BIM data are not sufficient to guarantee the level of interoperability which is expected by the industry. This has been acknowledged by the major developer of BIM standards for A/E/C-FM, the International Alliance for Interoperability (IAI), who develop the IFC data model utilised by the majority of major CAD tools and which is being mandated for use in several countries around the world. The IAI are looking at making changes to their certification processes to address the concerns raised, though it is unclear at this point how successful that approach may be.

It is clear that interoperability is a major requirement for the A/E/C-FM industries to gain further efficiencies and to support new business processes. A BIM, that describes all the major components of a designed building, the relationships between components, important attributes of the components, and the process to deliver the building, is central to being able to support interoperability between tools with different needs for building information. The development of the IFC standard for BIM and its incorporation into the major CAD tools in the industry, as well as a swathe of related simulation and information management tools, also argues for the willingness of industry to move in this direction. There is also evidence from major surveys of the industry, most recently the NIST report on interoperability (NIST 2004) which indicated that the cost of inadequate interoperability in the capital

facilities industry was $15.8 billion per annum in the U.S. alone, that the performance of the industry can improve significantly with the acceptance of this approach.

In relation to software tools it is also clear that testing of these tools is often not at the level which is really required to ensure the overall quality of the delivered software. The NIST (2002a) report on 'The economic impacts of inadequate infrastructure for software testing' noted likely impacts to be $59.5 billion in the U.S. alone, with the potential for cost reduction of $22.2 billion from feasible infrastructure improvements. In particular they recommended:

> *"standardized testing tools, suites, scripts, reference data, reference implementations, and metrics that have undergone a rigorous certification process would have a large impact on the inadequacies listed above"* (pg ES-6, NIST 2002a)

When NIST surveyed the impact of STEP in transportation equipment industries (NIST 2002b) they identified that for the benefits of STEP to be realised, further resources have to be invested into:

- *"software developers' costs associated with the standards development and demonstration (referred to as R&D); and expenditures to integrate STEP functionality into commercial products; and*
- *end users' costs associated with the standards development, demonstration, and implementation of STEP."* (pg ES-3, NIST 2002b)

These reports argue for further consideration of the approaches to interoperability and to tackle the issues inherent in interoperability between software products within A/E/C-FM. To help address these issues Section 2 looks at approaches to supporting the development and testing of interoperability in other domains. Section 3 then puts forward a smaller set of recommendations as to changes which would be beneficial for A/E/C-FM.

2. APPROACHES IN OTHER DOMAINS
It is clear that other domains face information model issues of the same magnitude at A/E/C-FM, and in many cases their approaches to information model development share the same pathways. For example, the ISO-STEP standards (ISO 10303, which is well established for aerospace, systems engineering and design, manufacturing, ship building, and electromechanical industries) developed the specification languages (EXPRESS and EXPRESS-G) and the data transport mechanisms (STEP Physical File – ISO 10303:21, etc) which were utilised by the IAI. For these industries to interoperate they have to overcome the same data model and data transport issues as would be seen in the use of IFC as an interoperable standard. It is also clear that the models developed for these domains will be of a similar magnitude and complexity to A/E/C-FM models (e.g., ship modelling covers almost the same set of sub-professions as is found in a large building project). It is also clear that the impact of interoperability errors in these domains will have consequences at least as serious as in building projects. For example, cost of a ship or jet-liner is at least that of a major building and the impact of poor interoperability in the healthcare industries has the potential to cause injury or death to patients.

In the following sub-sections there is a summary of the different approaches to interoperability which can be seen in these industries, and which may have a beneficial impact on interoperability in A/E/C-FM.

2.1 INDEPENDENCE
A striking aspect of the review of approaches to interoperability conformance in other industries is the separation between the standards setting body and the standards testing bodies for the domain.

For example, for ISO-STEP related standards there was the U.S. Product Data Association (USPRO 2006) which had been approved by ANSI as a body to certify processors for STEP. USPRO was a non-profit membership organisation established in 1992 and which worked through to the end of 2006 providing a range of standards-related services to U.S. government and industries. In the late 90's USPRO developed the STEP Certification Testing Programme to certify compliance of STEP-based software products. Similarly, the CAx Implementers Forum (CAx 2008), which was established in 1995, draws together a wide range of CAD vendors and third-party software developers in a less formal testing environment for ISO-STEP standards.

In the healthcare standards domain there is a similar independence between the standards development and publication (e.g., Health Level Seven (HL7 2008)), and organisations which provide conformance testing. For example, the Certification Commission for Healthcare Information Technology (CCHIT 2008) is a private non-profit initiative to act as a certification body for healthcare software system interoperability. CCHIT was formed by leading industry associations within the domain (American Health Information Management Association, Healthcare Information and Management Systems Society, and the National Alliance for Health Information Technology) and finds funding from major beneficiaries of healthcare software systems as well as the U.S. government.

These models are quite distinct from that operated by IAI, where it is both the developer and publisher of the standard, as well as the software certification body. The potential issue in the IAI structure is a perception of conflict of interest in a body which strives to develop and publish a standard which they wish to be widely used by industry and then certifies those industry software products as being conformant. It is clear from the organisations which exist in these other domains that conformance testing requires significant resources and expertise. Expertise and resources which can exist in external companies (e.g., Solibri Inc who develop a model checker for IFC-based BIM) and with business models which enable an organisation to exist purely for the purposes of certification of software tools.

2.2 CONFORMANCE CLASSES
Strikingly similar to the IAI approach to certification is that all other industries also support the notion of subsets of the total standard which form a business case that can be tested against. There is a common recognition that a total standard covers concepts not required for every data transfer, and for many tools there is a distinct subset of the model which encompasses the data required for their business and place in the market.

For example, in the healthcare industries, the labs who test conformance to HL7 (2008) provide this service against a range of subset schema. AHML (2008) allow

their clients to define a specification against which conformance can be checked, resulting in a number of publicly available specifications for large clients. IHE (2008) define a range of profiles which model a particular business process and against which data can be checked in a 'connectathon', a meeting of vendors similar in nature to the IAI open days. CIS/2 (CIMsteel 2000) define a range of conformance classes and follow the ISO-STEP methodology for conformance testing.

2.3 SUPPORT FOR CONFORMANCE TESTING

Different industries provide a range of tools and information approaches which ease the process of gaining conformance certification or checking for conformance. While there is no commonality across the different domains, a number of these approaches provide benefit to the community and are worth consideration for A/E/C-FM. Approaches include:

- Free testing of data against a particular standard. For example, AHIL (2008) have a free message testing service running beside their certification process. Any developer or user can submit a data file to this service and gain a report detailing any non-conformance to the standard which was found in the file. The report breaks message problems down into three parts: errors; warnings; and alerts. However, as they note, this service does not rectify the problems, it merely documents where they exist. In A/E/C-FM the Solibri model checker performs a similar (though more comprehensive) service, but this tool is certainly not freely available, limiting the ability to check data files to those who can afford the purchase price of the tool.

- Provision of tools to identify differences between two versions of the same file. For example, the CADIQ tool (TranscenData 2008) identifies geometric differences in the data found in two versions of what should be the same model and provides graphical views to show the identified differences (see Figure 1). This tool works on data files from a range of CAD companies as well as from data in standard representations. This tool is used as part of the certification process for tools claiming compliance with ISO-STEP standards to ensure the translated geometry is maintained correctly.

- Provision of freely available comprehensive test suites for pre-certification testing. For example, CAx implementer forum (CAx 2008), CIMsteel (2000), and CCHIT (2008) provide a range of test suites for the different scenarios that tools may be tested against. CIMsteel also provide a range of worked examples showing how software vendors would proceed to gain conformance against a particular conformance class.

- Provision of recommended practices for implementers of standards and of scenarios within a standard (e.g., CAx implementer forum (CAx 2008)). These recommended practices provide for common practice which sits beyond the provisions of the standard, representing an industry consensus on how portions of the standard are, or are not, utilised.
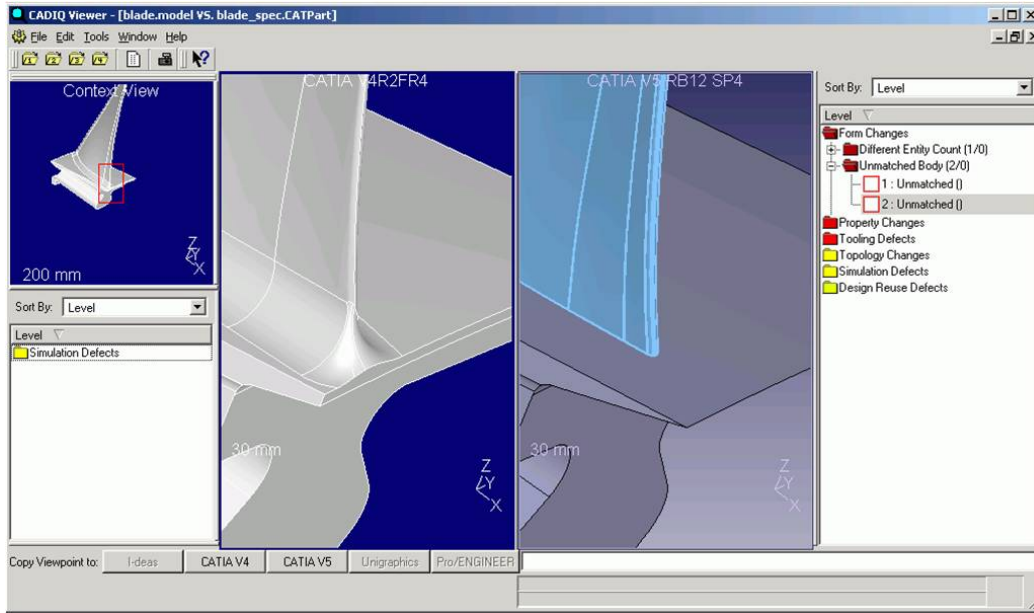
Figure 1: Comparison of geometry across representations (TranscenData 2008)

2.4 INTEROPERABILITY LAB

Within the healthcare industry there is a concept of a data interoperability lab which appears unique to this industry. These labs tend to be national in focus, for example, in New Zealand there is the Health Data Interoperability Lab (NIHI 2007). A lab, such as in NIHI, serves two major functions. One is to allow for the testing of software conformance, performance, and usability in a vendor neutral environment. The second is to support a development environment and showcase for innovation that will appear in future tools. To achieve these goals the lab provides computer equipment, expert staff, and installed copies of software from the major vendors in the field against which new tools can be tested or demonstrated. Figure 2 shows the two main aspects (corners) of the lab, with the red corner providing 'a replicant of major healthcare systems and disidentified healthcare data suitable for stress testing of systems' (NIHI 2007) and the blue corner 'prototype systems that demonstrate the future state of health information technology' (NIHI 2007). Note that the listed organisations at the bottom of Figure 2 such as MoH, DHB, PHO, etc are users of this service and providers of data for testing.
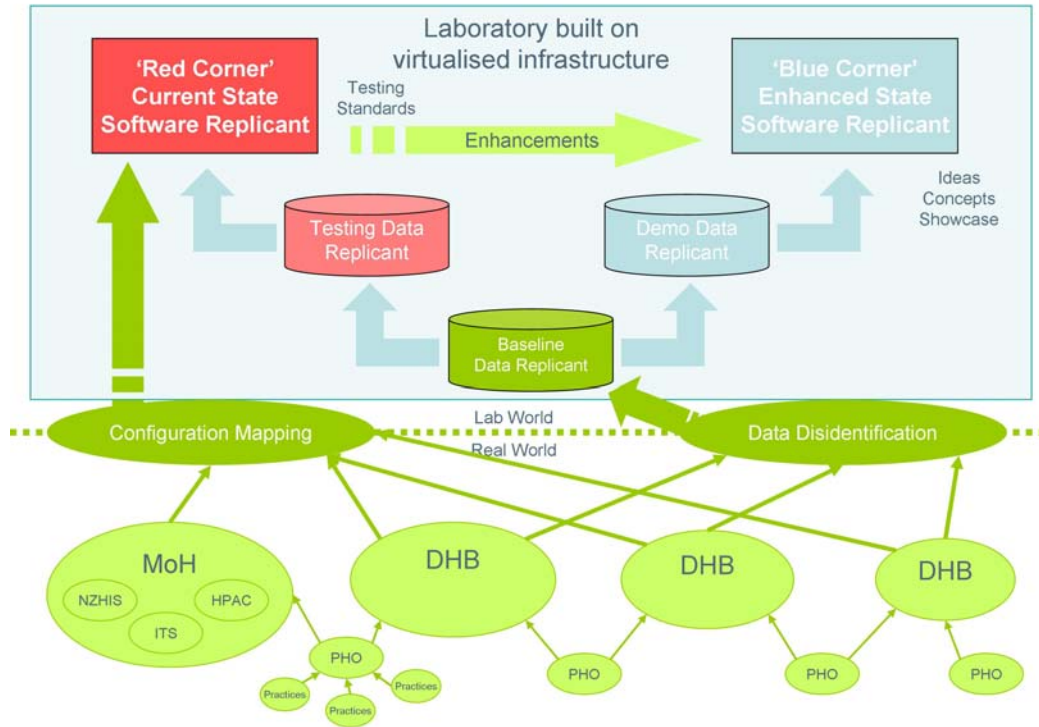
Figure 2: NIHI data interoperability lab concept (NIHI 2007).

3. RECOMMENDATIONS FOR A/E/C-FM

Reviewing the approaches taken in other domains the author would suggest the following for A/E/C-FM:

- Establish a body independent of the IAI to manage conformance testing and certification against the IFC standard. This removes the potential for a perception of conflict of interest between the standards setting and promotion body and the certification body. Evidence from other domains is that a non-profit organisation is feasible in this role and develops a very strong expertise and customer focus for certification.

- Reduce the barriers to conformance testing in the domain. A tool which freely checks a file for conformance would be of enormous benefit to all in the industry, whether they represent a software developer looking to determine the strength of their approach, or users of tools who look for reassurance of the conformance for a particular data file of their building model. Making available a larger and more representative set of standard test suites would also encourage stronger translators in software tools prior to embarking upon the formal certification process.

- Encourage companies within the ISO-STEP community to repurpose the tools developed there for model checking and comparison within A/E/C-FM. Of special interest would be tools which are able to compare geometry across the various CAD systems and their translations of standards-based data models.

- Investigate the possibility of a data interoperability lab for software vendors in the major software development regions (e.g., North America, Europe, and Asia). Such a lab provides a vendor neutral meeting point at which conformance testing can be undertaken at any time of the year (not just during

a certification meeting) and where all the major software is available along with expertise to run and test the software.

4. CONCLUSIONS

There are many industries who face similar issues as found in A/E/C-FM in the development of interoperability for their community. While the makeup of these domains is quite different from A/E/C-FM, there are lessons which can be learnt from their approaches to interoperability and ensuring conformance of software tools developed for their standards. This paper identifies a number of approaches which are applicable to A/E/C-FM and recommends that further investigation of approaches be undertaken. Some proposals would have a serious impact on the industry, such as devolving certification away from the standards setting body, but the evidence from other domains is that they are feasible and provide benefit to the industry as a whole.

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