InSights

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Structural Software Interoperability

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In the last two decades, the number of discrete structural software products we use has increased dramatically, along with their capabilities, complexity and power. But the ability of these products to interoperate has not always kept pace.

> *"In spite of the great progress of the last decade, many obstacles must still be overcome. … We now have to zero in on the key issue, the Achilles heel of (structural) computer programs…Compatibility!"*

Hard to believe, but this quote was made *over twenty years ago* by Charles Thornton and Emmanuel Valivaskis in the ASCE Computing Journal. This article looks at some of what has been done to address interoperability in the Structural Software (SSW) Industry, asks why we are not quite there yet, and postulates on some of the directions the industry is taking to address interoperability.

The Road Travelled

Structural software typically communicates information in one of two ways. Products either interoperate *indirectly*, passing information through an intermediate common format most often an Open Standard format; or *directly* with product-to-product communication, most often with vendor (proprietary) solutions.

Open Standards

To efficiently move information from multiple SSW products to each other, a lingua franca is needed, a common data format that each product can read from and write to. AutoCAD DXF could be considered the first such format in our industry. The richness of information contained in software today has outgrown the DXF standard, and many different organizations have been urgently trying to fill the gaps through development of more robust Open Standards. Within our industry, two standards – namely CIMSteel (CIS/2) and Industry Foundation Classes (IFC) – have achieved the widest market adoption. Both these standards are typically exposed as a file import/export option in popular structural software.

CIMsteel (CIS/2)

Computer Integrated Manufacturing of Constructional Steelwork Standard is possibly the most commercially successful of all current standards in the SSW industry. CIS/2 is a robust standard covering all things steel, from gross geometry to, literally, the nuts and bolts. The CIS standard has three different models: Analysis, Design, and Manufacturing. It is important to understand which of these your software product supports, as they are not necessarily always interoperable.

CIS/2's weakness is primarily its lack of robust support for non-steel materials, lack of an organization or process to continue its development, and its flexibility in implementation (more on this later).

Industry Foundation Classes – IFC

Industry Foundation Classes are data models that are developed under the auspices of the building SMART Organization. IFCs have the ambitious goal of providing a data model for interoperability for the entire building industry. IFCs greatest success has been in adoption by BIM physical modeling products, particularly the IFC2x3 Coordination View (for review and coordination) with over 100 certified implementers. There are multiple ongoing IFC Extension efforts by special interest groups to fill in the gaps in IFCs data models. These projects and the mechanism to initiate such a project are well defined (see buildingSMART website noted in the online version of this article). While IFCs are continuing to be developed, there is work ongoing in identifying subsets of the IFC data that is required to facilitate specific workflows between products. These subsets of the data are commonly referred to as Model View Definitions (MVDs). Several MVDs have already been defined, including the previously mentioned Coordination View and also a Structural Analysis View for interoperability mainly between analysis products.

IFCs weaknesses include some gaps in the data model that already exist in competing standards (see Robert Lipman's NIST article on the CIS/2 IFC Gap Analysis), relatively few certified MVDs, the slow pace of consensus building to evolve standards and create MVDs and, similar to CIS, the flexibility for vendor implementation that can cause interoperability issues.

Direct Interoperability

It is often the case, for strategic or technical reasons, that a direct product-to-product link provides the best or only interoperability option. These direct links often have the advantage that they can share additional data and intelligence that may not be available through an open standard.

While direct links are common in the industry and offer competitive advantage in some cases, this solution is not scalable and is difficult to maintain by software vendors as the number of products increases.

Are We There Yet?

Despite significant work in development of standards for interoperability, it remains the single largest impediment to increased productivity in our industry (McGraw Hill SmartMarket). Unlike traditional 2D CAD, when dealing with

objects, attributes and their relationships in a 3D Model, the differences between how products manage data becomes significantly more divergent and complex.

Physical vs Analytical Models

Depending on the domain problem being addressed, some structural software may require the absolute true life physical location and extents of a structure (for drawings, clash, or detailing), while others are looking for an acceptable simplification of the structure (analysis for example). The interoperation between two products with this fundamental difference in data format is a challenge. Some vendors have decided to create products where both physical and analytical models are produced together (Autodesk Revit, Tekla Structures, Nemetsheck SCIA, and Bentley AECOsim for example). The end-user is then required to be skilled in both disciplines to effectively create models with these tools, and facilitate appropriate interoperability and keep these two models in sync.

Where both physical and analytical models are not available in a single product, the burden falls on the software vendor to appropriately infer one from the other during interoperation; in many cases this requires hands-on decision making by the end-user, effectively slowing down and making the interoperability less efficient. In general, there has been greater market success interoperating between products that utilize the same fundamental data type model, be it physical or analytical.

Data Intelligence – Lowest Common Denominator

With Open Standards, we must understand that the modeling intelligence that a product may associate with its data will be lost in translation. For example, an elevator shaft object that pierces a slab creating an opening, or framing member layout relationships, are typically not part of the information shared between products. The user should consider this when deciding where they want to model their data such that it is most efficient for them.

Choose Your Flavor

Open Standards allow vendor interpretation and flexibility in how some data is specified. Some vendors choose to implement multiple versions of the Open Standard, each one targeted as a specific product and its particular implementation (flavor) of the standard. Similar issues can arise with different implementation levels in CIS/2 and IFC. You need to understand which version that each of your products can produce and consume. Saying a product is CIS or IFC compatible is sometimes only half the story.

Roundtrip Interoperability

The real power of interoperability is evident when a product can continue to synchronize updates of models over time. This technique requires vendors to manage change between subsequent updates. Some vendors like Graphisoft, Tekla, and Autodesk have provided technology to allow the user to manage change at the individual object level from within their products. Others like Bentley Systems' Integrated Structural Modeling manage the change in a standalone synchronization product. It is important to confirm if full round-tripping is possible with the product and standard in use, and not just assume it is.

Next Stop?

The need for improved interoperability is not going away, but vendors consistently have to make investment decisions that pit Open Standard development priorities against Direct API links.

On the Open Standards front, IFC is likely to garner more and more of the attention. Companies like Tekla, Nemetsheck, Solibri, and Data Design System also provide free tools like BIMsight, IFC Viewer, Model Viewer, and DDS Viewer to allow visualization and coordination between IFC models. Similar tools with capabilities of clash detection, scheduling, and more are provided by others including Autodesk's Navisworks© and Bentley Systems' Navigator products.

However, as long as there are software companies that hold dominant positions in the market or that produce multiple products in one or more market segments, the incentive to provide tight, direct links will exist and continue to be developed.

There is also precedence in other industries, such as with JT Open in the mechanical industry, for a collaborative approach amongst software vendors to create a platform for interoperability. This system pulls together the best parts of the direct approach (an API) and indirect approach (common intermediate model). Bentley's Integrated Structural Modeling Platform (ISM) provides similar advantages of visualization, change management, revision history, and interoperability through a strict API or Open Standards. ISM is addressing Bentley's own internal interoperability needs, as well as providing a platform for other vendors to integrate and realize all the aforementioned benefits.

> *"Only when the barriers of integration and compatibility are removed will we be ready to cross the final hurdle, to deliver our analysis and designs to the constructors directly from our computers to theirs."*
> *Thornton/Valivaskis*

While much has been done, there is much still to do to realize Thorton's and Valivaskis vision of interoperability. This challenge is as significant and pertinent today as it was twenty years ago.▪

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