Report

Regulatory Information Requirements

Project status and findings from the perspective of RAVA3pro project

2023-09-19

Table of Content

1 EXECUTIVE SUMMARY

2 BACKGROUND

buildingSMART is an international not-for-profit organisation that has been developing information standards for the built environment for over 25 years. It works by channelling knowledge and concerns from country 'Chapters', including buildingSMART Finland. Demand for standards is discussed in separate "Domain" groups, each focussing on one aspect of the information flows. The "Regulatory Domain" has been operating for over a decade. Its mission is to make sure that the ability to represent facilities – both buildings and infrastructure – on the supply side of the industry can be represented electronically is complemented on the other hand by the ability to represent the Regulations, Requirements and Recommendations that comprise the demand side. The outcomes from the projects and studies conducted by the "Regulatory Domain" have included reports on the business case for automated compliance checking, the technical challenge of obtaining regulations in machine-operable forms and the information required through the application forms.

2.1 THE CHALLENGE: EXPOSING BIM TO AUTOMATIC COMPLIANCE CHECKING

In recent years, most organisations have taken steps to digitalise their internal processes, reducing the dependency on paper and improving the ability to progress work and projects. Some architects and engineers, builders and facility operators have extended this into using digital opportunities – such as electronic information and electronic communication – for information exchanges and collaborative working within their contractual relationship. These have increasingly used process standards, such as ISO 19650 on 'collaborative BIM', alongside information standards such as ISO 16739 concerning 'IFC schema and formats'. The degree of adoption of these standards is usually the subject of formalised contracts and agreements that define the nature of the information required, its management and its delivery.

Governments have become interested in these processes in three ways. Some Governments have chosen to create primary legislation that enables government agencies to demand open information. Some Governments, departments and agencies have used their significant role as the customers of the sector and as operators of extensive built assets to use their often-substantial share to lead and influence the industry. This may appear internally as 'mandates' and externally as the promotion of 'Best practice' guides and national, regional, and international standards.

Standards have a crucial role in the built environment sector because of the need to influence large numbers of organisations with wide ranges of size and competency. Both process and data standards can be seen as communication standards, not necessarily seeking to change the internal workings of organisations but ensuring they can orchestrate and communicate effectively.

Open standards have a particular role in this. Standards that are open – non-proprietary, freely-available, and free to use – have a particular importance as the sector understands that information has value, independent of the applications used to create or capture information and independent of the applications used to exploit the information.

Environmental, economic, and social sustainability of the sector depend on having information with a long lifespan so that decisions and actions can continue to be based on evidence and analysis throughout the life span of built facilities.

One of the most important means of securing the economic, environmental, and social value of the built environment is through the use of the regulatory processes. These apply to land-using (zooming) considerations, technical approvals prior to construction, during construction and through to handover and operations of the built facilities. The appropriate handling of end-of-purpose and end-of-life stages is a rising concern.

The regulatory process varies from jurisdiction to jurisdiction, but most regulations and supporting documents aim to secure the value of built assets, starting with fire and structural safety, environmental and energy performance and accessibility and inclusion.

2.2 STEPWISE TOWARDS AUTOMATIC COMPLIANCE CHECKING

Studies of regulatory processes have confirmed that most jurisdictions follow a similar set of steps, including submission, pre-checking, consultations, checking and implementing the implications of the checking process. Studies have also shown that the checking stage is subject to increased pressures on capacity, competence, and confidence, even whilst the pressure to be comprehensive, efficient, and accurate is rising.

At the heart of the checking process is the need for the inspecting officials to consume all the submitted documentation, create a set of mental understandings and information summaries and then assess the proposal against the regulations. It should be possible to support this process using the availability of digitalised facility representations. Such representations are conventionally called BIM but may include 3D models, application forms, maps, and written specifications.

The first stage of exploiting this digitalised representation may be to accept the delivery of a BIM model as part of the supporting material to allow inspectors to understand and inform themselves of the context and totality of the proposal. Making the BIM submittal subsidiary to the other material may reduce the concerns about the primacy of one form of information over others. Still, in practice, contradictory and incomplete documents have always been disruptive to the regulatory process.

The second stage is then to enable inspectors to exploit the opportunities to measure and report from the BIM model. Such reports can be tailored to the checking process and highlight where information is missing. The conventual checking process can then be conducted using checklists to record the inputs and decisions made.

Ultimately, the aim must be to perform these checks systematically, ensuring accuracy, efficiency, and completeness. The “Regulatory Domain” has continuously surveyed research, proof-of-concepts and implementations working towards this goal.

2.3 MACHINE-READABLE REGULATIONS

The growing adoption of IFC and the increasing quality of the representation of the facility suggests that this process can reach a sufficient quality to provide the information required. In particular jurisdictions, it may be possible to specify the content of such BIM models to satisfy a specific code requirement using locally crafted programs, scripts or procedures. In some cases, the content of the regulation may be directly encoded into the behaviour of particular object such as a staircase or structural member.

However, these applications are costly to create, maintain and accept. Their development may need the expertise of local regulatory experts, programming experts and model experts. With the regulatory environment subject to a significant rate of change and relatively short notice of the change, the development of such code-checking applications cannot be seen as a one-off investment. In practice, it requires a continuing program of maintenance.

Attention has shifted from such 'black box' applications towards separating out the knowledge embodied in the regulations, the knowledge embodied in dictionaries and classification and the knowledge about the proposal. This can ensure that a simple and highly consistent 'rule engine' can consume rules either to validate the proposal or to suggest or effect corrections.

Such 'rule-engines' need a machine-operable representation of the regulations. Currently, there are four methods, all of which are being trialled internationally.

a. The first alternative has been to write a manual transcription of the regulatory text, tables, and diagrams into a computer programming form. This programming can be procedural (Visual Basic or Python), or it can be declarative (e.g., Lisp). The transcription process is notoriously unreliable. In one early test, 15 of the 30 concepts found in a clause actually appeared correctly in the coding.
b. Mapping the regulations onto a library of rule templates embedded in a particular application. These rule templates assume that the nature of the checks can be listed out and are of a manageable number. Solibri offers around 60 such rule templates, Xinaps offers three more generic templates. However, the content of regulations is not simple the 'requirements': any requirement ('to be better than X') is invariably qualified by sections, clauses and provisions which focus the 'applicability' and 'selection' of scope (external doors and windows' and define any 'exceptions'. Rule templates are dependent on these scope rules being well defined and consistent. They also cannot represent the process aspects of checking, such as 'to the inspector's satisfaction'.
c. In the last decade there has been investigation of the use of Natural Language Processing (NLP), a branch of AI, to parse text and use the grammar constructs to interpret the text in to rule templates. To date NLP has not been accurate in taking the context of a single sentence into account, nor in recognizing the role of lists and tables. Regulations sometimes contain detailed knowledge that is expressed in complex sentence structures that may not fit into the fixed number of templates.
d. There is a hybrid approach which allows regulatory experts to document their understanding of the regulations by using colored mark-up to highlight the roles of key phrases and sections. This mark-up can be reviewed, corrected, and improved by consensus. Once completed, the logical structure of the entire regulation and the specific metrics that is needs to test against the proposal become available automatically. This RASE (requirements, application, selection, exception) method has been used in USA, England, and Wales and in Scotland.

Once the content of a regulation has been captured, it can be used to drive a 'rule-engine' or to drive semi-automated check lists. For example, the checking of door and corridor widths is repetitive and error prone and may best be processed mechanically. Requirements on the facility or process as a whole, such as the issuance of neighbourly notifications' may be best handled within an automated checklist.

3 PROJECT DESCRIPTION

With growing interest worldwide in improving and automating the regulatory compliance process, this project is ensuring that the regulatory information requirements common across many jurisdictions have an appropriate representation in IFC, whilst leaving jurisdictions free to add local information requirements and implement their own checklists and rules.

Implementations in Singapore, Finland, Estonia, Norway, Romania, Italy, Singapore, and the UK are developing Regulatory Information Requirements, and other buildingSMART Chapters have parallel programs at the research or implementation stage. This project is drawing on this and the prior work on Application Forms completed by the regulatory Domain and activity in other Domains to discover and document the best possible consensus.

The findings on national projects are similar. The properties and property sets within the IFC standard include a number of value fields related to building permits and other regulatory procedures. However, the data fields are scattered across different property groups and have major shortcomings. The outcome is, that at the national level, it has been decided to define completely separate property definitions, which are in line with the IFC scheme but poorly compatible with each other.

IFC2x2 was the first IFC release to include property sets and entities specifically to support regulatory processes. The buildingSMART Regulatory Domain has already published its roadmap and reports on electronic processes and interoperable regulations. The development of the UK BS1192 and, subsequently ISO19650 has established the role of 'Information requirements' as key elements in information management and the use of collaborative BIM, but not yet for regulatory and other third parties.

The building permit process is one of the key processes in construction. It is a mandatory step in virtually all construction projects. A building permit's information requirements also guide many other information requirements related to the construction and use phase of real estate. The introduction of IFC models as part of the building permit material will significantly impact the use of BIM in the overall construction process.

The purpose of the use of BIM in the regulatory processes is to improve the flow of data between different systems and registers, to enable various life safety and health-supporting analyses, and to automate energy efficiency reviews of buildings. For public actors, BIM data transfer must be performed using an open BIM exchange standard. In practice, this means the IFC.

As part of national digitisation projects, many countries are exploring or implementing IFC in regulatory processes. In Finland, for example, the Ministry of the Environment is preparing regulations that will, in practice, make IFC mandatory in building permit processes, and in Estonia an IFC-based building permit system has already been developed and is currently being implemented.

'Regulatory Information Requirements' extends the present set of project and in-use information requirements to include the common requirements to support third-party involvement such as government, mapping authorities, regulators, and similar bodies.

The technical roadmap for the project is divided into five main phases. The first phase has analysed the results of ongoing and already implemented national projects. In the second phase, generic IDM descriptions are being generated based on the results. In the third phase, the project will use bSDD technology to connect the identified ‘Property Sets’ and ‘Properties’ into a single Regulatory Information Requirement specification. In the fourth phase, based on the IDM descriptions and bSDD/Property specifications, one or many IDS description(s) will be developed to be used for permit system definitions and authoring tool certification. Finally, guidance is being developed on how the bSDD and IDS definitions are to be used.

The key deliverables are candidate entries in the new bSDD so that, once approved, the new and revised property sets and properties can be added to the next formal release of the buildingSMART IFC schema and define a supplementary IDS “Regulatory Information’ IDS to extend the base Coordination/reference views, using bSI IDS “Information Delivery Specification” representation.

Some specific use cases, such as ‘means of escape’ and ‘energy modelling’ are already under consideration in the Building Domain. The project will liaise with these to coordinate the regulatory parameters alongside their work on simulation parameters.

Regulatory requirements are characterised by transparency and system independence. The information specifications used for these purposes should enjoy the widest possible consensus and be widely and openly available. On the other hand, they are in many respects national or local. It is, therefore, justified to develop essential Regulatory Information Requirements into international ISO and/or CEN standards insofar as they can be generalised. At the same time, detailed property fields and their content requirements are more dynamic and for them, standardisation needs to be more agile. This development can be led by buildingSMART.

3.1 SCOPE STATEMENT

The regulatory information requirements included in scope span across the three common regulatory interventions:

1. Concept and zonal approvals
2. Technical design and construction approvals
3. Approvals for occupation and use.

The project will cover several categories of Regulatory Information Requirements and so will develop consistent approaches to the representation of:

1. Directly relevant information.
2. Information representing the results of analysis, simulation and calculations.
3. Information that may be dependent on local conventions and standards.

The project has identified three priority uses cases: project information and identification, life safety and building performance. Others such as accessibility are being considered.

4 DELIVERABLES - PROGRESS REPORT

As of September 2023,

a. Outlines of guidance and use-cases have been prepared input have been received from several countries,
b. the content organized ready for consolidation and review.
c. Assessment, as described below, is underway.
d. The project team is working on the final deliverables.

5 FINDINGS AND ISSUES

5.1 MODEL CHECKING AND CODE CHECKING

Checking rules can be used to easily verify whether a model contains a data component and whether the component has been given the appropriate - or what appear to be the appropriate - properties. It is also quite easy to identify clashes between different components in the models and thus assess the consistency of the models.

However, when the IFC data model is to be used for automated code checking, the relationships between the data components become essential. Regulatory requirements for construction are often based on different relationships and cause-and-effect rules.

For example, the required fire class or accessibility of a door between two rooms is determined by the characteristics of the rooms. The requirements imposed on the rooms are the result of their intended use and the type of the building in which they are located. To check that these different causal relationships are reflected in the model, it is necessary to understand the relationships between these characteristics when making the specifications.

As the legislation is mainly national, defining the general relationship in an international context such as the RIR project is challenging or impossible. However, this has been recognized and an important part of the project has been to familiarize ourselves with the local requirements in Finland, Estonia, Singapore, Scotland, and England and thus try to identify common denominators. Recently, China, the Netherlands and Dubai have also announced their interest in joining the RIR project. These countries have also carried out extensive national standardization work on harmonizing the use of IFC in regulatory use cases.

As noted, the data content needs in code checking partly differ from those in conventional model checking. This should also be reflected in the standardization of data elements and property fields for regulatory use. The broad international player base provides a good foundation for common global standardization in this field.

5.2 RELIABILITY

An important aspect of regulatory procedures is the permanence and maturity of data definitions. The IFC standard data model contains several different levels of data components. These can be roughly divided into four main data component groups:

1. Entities
2. Predefined types
3. Properties which are grouped by property sets
4. Classifications and materials

Properties and classifications in IFC can be extended and linked to each other using the buildingSMART Data Dictionary. It also provides a way to create mapping between different classification systems and to link the custom classifications and properties to core IFC specifications.

Looking at the listed data component groups, it can be concluded that Entities are the most stable and mature form of data. Their implementation in the IFC standard requires a carefully regulated process both in buildingSMART, which is responsible for the development of the IFC standard, and in ISO, which is responsible for the official international publication of the standard.

The IFC standard also provides a way to link classifications and material information to entities and their breakdown structure. Classifications are often used to supplement or sometimes even replace the definition of an Entity or Predefined type in the IFC data model. From an authority perspective, this approach carries the risk of machine readability anomalies unless the control of attributes is fully under the authority's control. The authority should then also have a technical understanding of both the consequences of the solutions and the technical capabilities of the different authoring systems.

To ensure that the content of the IFC data model produced for the authorities is as reliable as possible, the specifications should be as permanent as possible. Therefore, in this scope, IFC specifications should be based on the most stable IFC components possible and on the established ISO standard.

5.3 INFORMATION REQUIREMENTS AND UNDER/OVER SPECIFICATION

In developing the RIR deliverables, two key points have emerged. Firstly, that requirements are qualified by application, selection, and exception clauses. This requires that the properties that affect the scope should be included in the project alongside the properties describing the requirements themselves. Whilst these extra properties expand the information requirements that need to be considered, they work to reduce the amount of actual information that is required in a proposal model. For example, in the UK not every door needs its closure-strength documented, only those that are entrance doors of public buildings.

Secondly, the properties needed to represent and check regulations can be classified.

a. Those reflecting specific characteristics of a local jurisdiction.
b. Those derivable (calculable) information expected to be in the proposal model
    i. information, such as totals or net clearances.
    ii. shape or extent, such as overall sizes
    iii. relationships such as adjacencies
c. Those reflecting compliance or exceptions to other specified clauses or standards

d. Those reflecting process or procedural steps, such as notifications.
e. Those that are already in IFC4.3
f. Those that are common across jurisdictions and should be included in the RIR deliverables.

The process of identifying which properties that are common across jurisdictions fall into the last category is underway.

5.4 LACK OF STANDARDS AND QUALITY AROUND MEP

At the buildingSMART Summit in Rome in the spring of 2023, the Regulatory Room sessions featured a presentation on the Finnish MEP IFC implementation. The presentation presented a study on the IFC standard carried out in the RAVA3pro project, which examined the IFC's capabilities for the data content of MEP design. The study looked at data content for the whole life cycle of building services engineering. The study concluded that IFC meets less than 10% of Finnish MEP needs.

At the same time, MEP features have been part of the IFC standard for several versions, and the standard is widely used globally for the exchange of building services data models. So, arguably, the IFC standard supports this part of the data exchange to a large extent. Why, then, does the RAVA3pro project's assessment differ from that of existing implementations?

The RAVA3pro specifications are based on the national classification of building services components and systems. The approach differs significantly from the current data structure of the IFC standard, making the transition between the two challenging or even impossible. This does not mean that the starting point for the RAVA3pro specifications is invalid, but it is not in line with the IFC standard. The situation may be similar in many other countries.

One possibility to achieve better IFC compatibility is to use the buildingSMART Data Dictionary (bSDD). It provides a mechanism for extending the IFC core data model at the national or use case level. This technology has also been utilised in the MEP specifications of the RAVA3pro project. bSDD is well suited for industry-specific property data management. However, as mentioned above, from a regulatory perspective, the reliability of bSDD is not at the same level as the reliability of standard core definitions such as entities, predefined types and standard properties. This is a dilemma in a regulatory environment.

The implementations for example in Singapore and Estonia show that the IFC can be used for all design domains in the regulatory process. However, as the RAVA3pro project demonstrates, there are shortcomings in the MEP part of the IFC that need to be addressed in the future development of the IFC standard. Identifying and communicating these shortcomings is one of the main tasks of the RIR project. Solutions to these shortcomings must be found in the relevant industry groups and the buildingSMART standardisation process.

5.5 AUTHORING TOOLS

Even a good specification will not lead to the desired result if the implementation of the specification is not possible with the authoring tools used to generate the data. If specifications are to be implemented, they must be tested on existing design systems. Better still if testing can be done in parallel with the definition work.

Software testing should include a wide range of software used by designers. In Finland and Singapore, for example, this is captured by testing the requirements with all the most used authoring tools in the local market.

5.6 CHECKING TOOLS

As noted before, model code checking differs in many respects from the usual clash checking with IFC models. However, the commercially available software solutions are mainly intended for the latter. Therefore, many research projects and national implementations have created code-checking software partly or entirely from scratch for this purpose. This approach has its strengths; given the complexity of the checking rules, a solution tailored to one market accommodates local deviations.

In the long term, however, fully tailored solutions are not sustainable. Public authorities are not software houses, and software development is not part of their core competencies. For software houses to develop solutions that can be deployed internationally, data models and data structures must be widely harmonised. The terminology used in legislation should also be such that it can be converted into a machine-readable form.

6 SUMMARY

The buildingSMART International Regulatory Domain ‘Regulatory Information Requirements’ project is on course to achieve its goals early in 2024. It has good relationships with various National programs such as RAVA3pro project in Finland, and the outcomes are mutually supportive.

More and more building control authorities are adopting an openBIM based implementation - either as a replacement for the existing proprietary based approach or as a completely new solution. One of the findings of the RIR project is that several countries have made national extensions to IFC property fields and predefined type definitions. This shows that there are shortcomings in the current IFC scheme.

The project has also identified gaps in the coverage of the IFC standard related to the needs of public authorities. Building identification information is a crucial part of the building permit content and during the project it was identified that IFC lacks a significant number of properties into which this information could be entered. At the same time, domain designs such as structural and MEP components and their data content are also partly incomplete, and this should be given special attention in the further development of the IFC standard.