TG90 Information Integration in Construction: Research Roadmap

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To be written

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Introduction

Purpose

The International Council for Research and Innovation in Building and Construction (CIB) started a new Task Group on Information Integration in Construction (TG90) in 2014. The task group will focus on addressing the need for:

- efficient knowledge creation, preservation and integration across the life cycle of constructed facilities
- relevant, reliable, interoperable and long-lasting data and information gathering and analysis
- monitoring and feedback from end-users into the different stages of design, construction and asset management of buildings and infrastructure.

One of the tasks of the task group is to produce this Research Roadmap. It is envisaged that this roadmap will contribute to TG90’s effort to contribute to more appropriate procurement models, including contractual frameworks, project team composition and governance, and information architecture and use.

Aim & Scope

The aim of this research roadmap is to formulate an agenda for new R&D projects and/or initiatives that focus on information and knowledge integration in construction so that construction sectors globally can respond to the significant challenges, e.g. Climate Change. Its objectives are to:

- illustrate the significance of data & knowledge integration for the construction sectors globally;
- present a framework for conceptualising information & knowledge integration at organisational and project levels across the key project phases;
- identify the current gaps in research and practice through a critical evaluation of the current state-of-the art in information & knowledge integration;
- present demonstration projects where information and knowledge has been integrated;
- present an agenda for R&D and novel initiatives to close these gaps.

There is a plethora of publications, including agendas for research, that deal with data and information integration within large, complex projects where failure to do so would have catastrophic impact on delivery. Perhaps as a result of this significant impact, the discussion on why and how information and knowledge integration can be achieved in mainstream projects is limited. This roadmap endeavours to close this gap.

Limitations

This research roadmap is based on an extensive desktop study of secondary literature, including publications from relevant CIB task groups and working commissions. It has also been informed by discussions both within the editorial team and members of TG90. As such, a Global coverage and representation have been achieved.

Secondary literature on the state-of-the-art in information and knowledge integration in mainstream projects, is limited. This limitation was addressed by contributions from members of TG90 who have access to secondary publications in their languages and insight.
to local practice. It should however be acknowledged that this contribution is confined to the representation that can be achieved within the group.

Publication Time-line
A draft of the Research Roadmap has been circulated to the TG90 members for comments at the end of March’17. The Table of Comments of this draft version is included here for information. Comments from a number of members have been received. The authors are currently formulating their responses. A revised draft will be circulated in July’17. There will also be a wider CIB consultation in early September. It is expected that the Roadmap will be launched at Curtin University (Australia) in November 2017, to coincide with the CIB Board Meeting. Prompt suggestions for case studies would therefore be gratefully received.

Draft Conceptual Framework
The draft conceptual framework is presented here in order to complement the summary provided in the call for case studies.

This framework sits against the sectoral background which defines the legal, regulatory, social, economic, environmental and political opportunities and constraints. They are translated into the framework through the strategic (organisational) level.

As integration of information in construction is multi-disciplinary, there is a need for a common base that all parties can relate to. Working with building and infrastructure engineering, the building process is a natural common ground that is present in each and every project, easy to complex. In order to give a larger perspective on research challenges, a business model that categorise research in four levels: Strategic, Tactical, Operational and Technological. With this framework, the inter-level-process challenges of research on information integration in construction can be developed and identified.

Building process - RIBA-stages
The RIBA Plan of Works is published by the Royal Institute of British Architects (RIBA). The latest version is also is endorsed by the Chartered Institute of Architectural Technologists, the Construction Industry Council, the Royal Incorporation of Architects in Scotland, the Royal Society of Architects in Wales and the Royal Society of Ulster Architects. It is also commonly used across the Globe.

Split into a number of key project stages, the RIBA Plan of Works provides a shared framework for design and construction that offers both a process map and a management tool. Whilst it has never been clear that architects actually follow the detail of the plan in their day to day activities, the work stages have been used as a means of designating stage payments and identifying team member’s responsibilities when assessing insurance liabilities and they commonly appear in contracts and appointment documents.
The latest version reflects increasing requirements for sustainability and Building Information Modelling (BIM) and it allows simple, project-specific plans to be created.

In the research road map the RIBA Plan of Work has been adopted as a framework in order to structure the research road map and define a framework for facilitating a common level of understanding. The main reason for this is the diversity of profession that work within the construction sector.

**Levels of research**

For establishing a framework for research on information integration in construction, four levels of hierarchy are identified. These levels are interdependent for a successful implementation of information integration. The organisation is based on decision making research. The decision-making organisation is based on the commonly known hierarchy levels: Strategic, Tactical and Operational.

At the Strategic level, research dealing with the benefits and organizational pre-requisites for integration of information, such as strategies for procurement, project delivery and management strategies.

On the sub-ordinate level, the Tactical level, research on team composition and team organisation, as well as research on information “reinvestments” is organised, i.e. how to incorporate expertise from all building process stages.

At the third level, the operational level, research on the professional methodologies and use of technical support is organised. At this level, research on the creation of information is positioned, as well as the purpose of the created information. The purpose differs between professions. In the pre-construction stages information is needed for making design and planning decisions, while in the construction stage information is needed for site planning and construction management. In connection with advancements of Information Technology, machine learning and other artificial intelligence; as well as sensor technology, the creation and exploitation of information (automation, decision making, etc) is the frontier of building information research.

At the last level, research on the support and criteria for technical supportive architectures that can manage, store, filter, analyse, and make information interoperable and accessible for the team and individual in a seamless information system.

**Framework**

The framework builds on the main stages of the building process and the hierarchic levels of research. In Figure XX, these two building blocks are presented in order to show the inter-level-process relationship. In addition, the model is intended to underline the need for a broad view of research on information integration.

Research is, naturally, primarily performed within each profession (thinking of building stages) and at a certain research level. For example, research on procurement strategies or the use of building information in design, production planning or facility management. Rather many initiatives have been made to create a seamless information flow, less that cover the
technical challenge and the process at the same time. With this model it becomes clearer that an inter-professional research and understanding of the interconnections between levels are important if the building industry should benefit from information integration.

Integration framework
It is clear that an organisational framework for information integration is needed. The client, consultants, contractors and managers need to see a mutual gain in the integration and sharing of information. An imperative for this is an integration framework which includes all parties and in which each party can identify their gain and position.

Integration of professions
The information sharing at the boundaries between stages will always be a tough nut to crack. There will probably always be a “hand-over” from one organisation to another, which implies that there need to be a sharing of information that can be related to business gain, e.g. a building information model is developed in the design phase by a consultancy which is handed over to the contractor for the construction stage. In the same way, facility managers and owners of public infrastructure creates information that is beneficial and gives competitive edge for the design and construction of new buildings and structures. Trying to deal with this disincentive, the research on project delivery approaches has grown. Early Contractor Involvement and Integrated Project Delivery are delivery strategies that break down parts of this disincentive, but the complicated situation for the team and individual, referring to the deviation of aims of the “home” organisation and the project goals, has not been dealt with.

Interoperability of information
There are essential two types of approaches to interoperable information. The one that has been early adopted is consolidation of data where data from one set is shoe-horned into the
framework used for another set of data. An alternative approach is to build a federation of data where the data resides in their native data set. Interesting, federation of data does not interfere with the standards of the native data sets.

Within the architecture, engineering and construction industries, recent years have seen a shift from vision to realisation regarding the use of building information models (BIM). Using modern modelling tools, such as Revit Architecture or Tekla Structures, the content produced by architects, designers and engineers has evolved from traditional 2D-drawings, sketches and written specifications to parametric, object-oriented 3D-models embedded with information to describe a building or facility in detail. As a digital representation of the physical and functional characteristics of a building, the purpose of a building information models is to serve as a repository of information to support a multitude of applications along the design and construction processes, including cost-estimation, energy analysis and production planning. Building information models (BIM) aim to eliminate the non-value adding or lower value adding activities, to integrate the high value adding but fragmented tasks and to improve the automation of processes and the project performance in terms of project time and cost. However, in the industry, today, the concept of building information models is often degraded to sharing of 3D-CAD models for the purpose of clash detection and visualisation. The main reason is the information interoperability issue between different software and information systems. Part of this is due to the fact that information between the different stages of the design and construction processes is still transferred as independent data files. Although such an approach may utilise the IFC-file format, which is considered to be the standard for building information models, the approach puts high demands on the individual software's ability to prevent loss of information from one stage to another (import-modify-export).

Recent initiatives, such as the BIMserver project, have the potential to enhance the current situation by providing a central storage of information during the life cycle of a building or facility. Such a solution will ensure the persistence of added data and thereby limit the loss of information between the different stages of design and construction (as compared to a file-based approach). However, seen in a bigger context, the BIMServer approach may introduce limitations of its own. As based on the IFC-file format, information is inherently restricted to that of the physical and functional characteristics of a specific building or facility and does not consolidate the environmental or socio-economical factors surrounding it. For instance, if we consider the planning, design, construction and operation of a new school in the middle of a typical city it becomes clear that the processes and information surrounding such a project goes beyond that of the IFC-file format. During the planning stage, information regarding population, land use, infrastructure and public transportation becomes essential for a successful outcome. Today, these types of information are often accessible through geographic information system (GIS) and are used as input in order to form the requirements for the actual design. However, once the project enters the design phase a gap in the flow of information becomes apparent. Even with the use of a central repository for information such as the BIMServer, lack of support for consolidating geographic information system data prevents a successful transfer of information from the previous stage. As a consequence, the idea of consolidating all data (IFC/BIM + GIS + other) into a unified system has flourished and the approach has been to shoe horn BIM or 3D-VR data into the GIS system or GIS data to IFC (IFG: IFC for GIS).
For a variety of historical and operational reasons, building data are now, and will continue to be, housed in several independent data resources. Full consolidation of data holds little prospect as a solution and, for the reasons discussed above, would not be desirable. Rather, advances will be required to allow autonomous data resources to interoperate productively. The challenge will be creating collections of data resources that are perceived by users to be functionally integrated, yet with each resource maintaining its autonomy, especially in the basic creation and maintenance of its data resources.