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Introducing a new framework for using generic Information Delivery Manuals

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ABSTRACT: Information flow management plays a significant role in ensuring the reliable exchange of Building Information Modeling (BIM) information between project participants in the Architecture, Engineering, Construction, and Facility Management (AEC/FM) industry. The buildingSMART standard approach to resolve this issue is based on the Information Delivery Manual (IDM). The IDMs in current use indicate that focus has mainly been on formalizing multifaceted and wide-ranging AEC/FM processes, and therefore often involve multiple use cases. Because IDMs typically describe such complex processes, they are difficult to manage and complicated to implement in real-life AEC/FM projects. In this study, we address these challenges by proposing a Work Breakdown Structure (WBS) methodology, breaking down the IDMs into smaller IDM Packages. We introduce a modular IDM Framework aimed at defining and organizing generic IDM Packages for all main use cases of the AEC/FM project life cycle. In this methodology, an IDM Project Plan can be created by selecting the specific IDM Packages required for the specific AEC/FM project. Ultimately, we believe that the IDM Framework will help improve information flow management and the reusability of IDM Packages amongst unique AEC/FM projects. In addition, we believe that the IDM Framework will support the potential harmonization of the development of new IDMs, as the specific context of each IDM Package, and the relationship to other IDM Packages, becomes clearer. Such harmonization is also necessary, if improved interoperability between AEC/FM software tools is the goal.

1 INTRODUCTION

1.1 *Study background*

During recent years, a great deal of effort has been devoted to improving interoperability between software tools in the Architecture, Engineering, Construction, and Facility Management (AEC/FM) industry. Despite some progress, streamlined information exchange remains a challenge (Eastman et al. 2010).

To achieve this interoperability, a common understanding of the AEC/FM processes, and the information needed by and resulting from these processes, is required (Wix et al. 2009). Software vendors need this understanding as a basis to develop software tools that support the multiple AEC/FM processes and associated information exchange structures. However, end users – that is AEC/FM project participants – also need this understanding, as the use of relevant software tools has limited impact if the AEC/FM process is confused at the outset (Koskela et al. 2002).

Generally, an increasing integration of software tools and information systems accelerates the amount of information available in AEC/FM projects. However, to ensure optimum information quality, the amount of information in information systems should be kept to a minimum (Hjelseth 2011).

Therefore, the need to define and organize AEC/FM information exchanges is of fundamental importance in trying to improve interoperability and adoption of software tools in real-life AEC/FM projects.

To address these issues, the buildingSMART alliance has introduced the Information Delivery Manual (IDM), which provides a methodology to specify AEC/FM process flows and their information content (Wix et al. 2009). However, despite the great potential of IDMs, and the fact that more than 100 IDMs are currently registered on the buildingSMART website (Karlshoej 2013), the industry-wide use of IDMs is limited (Karlshoej 2012).

1.1 *Study goals*

This study has two goals. The first is to explore the benefits and challenges associated with successful AEC/FM information flow management. The second is to introduce a common IDM Framework to define and organize AEC/FM processes and associated information exchanges.

The study goals are addressed by: (1) a review of current approaches to AEC/FM information flow management to understand the background, and (2) the development of an IDM Framework to facilitate improved AEC/FM information flow management and interoperability between AEC/FM software tools.

2 METHODOLOGY

2.1 *Review of current approaches*

A review of AEC/FM information flow management trends has been conducted. The review included articles conducted by academic institutes; industry work practice; technical reports from software vendors; guidelines generated by government institutions; and currently available IDMs.

The review was carried out to explore the benefits and challenges of AEC/FM information flow management, and specifically focused on the critical role of integrating buildingSMART standard approaches (See et al. 2012) and Work Breakdown Structure (WBS) technologies (Brotherton et al. 2008).

In a series of supplementary discussions, selected AEC/FM experts validated the components identified in the review.

2.2 *Development of IDM Framework*

A structure for the development of an IDM Framework has been planned. The IDM Framework has been developed to address challenges highlighted in the review, more specifically the challenge of ensuring successful information flow management. To address this particular challenge, generic and modular management approaches are proposed.

3 REVIEW

3.1 *Industry Foundation Classes (IFC)*

The Industry Foundation Classes (IFC), developed by buildingSMART, is a data model standard that has been proposed to describe, exchange, and share information in a neutral file format (See et al. 2012).

Generally, IFC is the means of achieving software interoperability in AEC/FM projects. However, as stated in (Aram et al. 2010), the industry-wide use of IFC remains a challenge.

To improve the reliability of IFC, specifications and well-documented guidelines for specific information exchange scenarios are required. For this reason, buildingSMART has proposed the Information Delivery Manual (IDM) and Model View Definition (MVD) (Karlshoej 2012; Wix et al. 2009).

3.2 *Information Delivery Manual (IDM)*

The Information Delivery Manual (IDM), developed by buildingSMART, is a process standard that has been proposed to define information exchanges between any two project participants in an AEC/FM project, with a specific purpose, within a specified stage of the project's life cycle (See et al. 2012). The IDM consists of four deliverables:

- IDM use case: Defines the activities, project participants, and information exchanges, required for a specific AEC/FM process.
- IDM Process Map (PM): Formalizes the relationship between these activities, project participants, and information exchanges.
- IDM Exchange Requirements (ERs): Define the information units, required for each use case-specific information exchange.
- IDM Exchange Requirements Models (ERMs): Organize the ERs into Exchange Concepts (ECs), that is machine-interpretable information exchange packages.

The core of an IDM is the AEC/FM process that is to be standardized. However, limited guidance is provided by buildingSMART on which parts of the AEC/FM project life cycle, and which specific processes, should be included in the individual use cases that form the basis of new IDM developments. Generally, buildingSMART recommends that AEC/FM industry experts and participants of specific IDM development groups be allowed to determine the areas of need (See et al. 2012). Of particular interest is that these experts and development groups often represent specific AEC/FM disciplines or organizations. As a result, currently available IDMs describe a diverse scope of the AEC/FM project life cycle, making them difficult to reuse and implement in unique AEC/FM projects. In addition, the researchers found that using the currently available IDMs to describe greater areas of the AEC/FM project life cycle may result in both significant process overlaps and critical gaps between sub-processes that are not yet included.

3.3 *Model View Definition (MVD)*

The Model View Definition (MVD), developed by buildingSMART, is a technical standard that has

been proposed to document the required information exchanges defined in one or more IDMs (See et al. 2012). The MVD consists of four deliverables:

- MVD Description: Defines the information exchanges, as required for specific IDMs.
- MVD Concepts. Address these information exchanges, by linking with the corresponding ECs.
- MVD Diagrams: Identify and structure the IFC entities, as required for exchanging these Concepts.
- MVDXML: Generates a machine-interpretable representation of the information exchanges.

Generally, the MVD is designed to document the required IFC information exchanges, against which IFC software certification testing can be applied. Officially, there exists only a single buildingSMART MVD for such certification, that is the IFC2x3 Coordination View V. 2.0 MVD (Wix et al. 2009).

3.4 *Work Breakdown Structure (WBS)*

The Work Breakdown Structure (WBS), developed by the United States Department of Defense, is a project management methodology that defines and organizes the processes of a project (Brotherton et al. 2008) (O'Donnell 2012).

The WBS methodology uses a hierarchical tree structure, and enables the processes of a specific project to be broken down into smaller, more manageable sub-processes. Figure 1 shows an example of a WBS for building design.
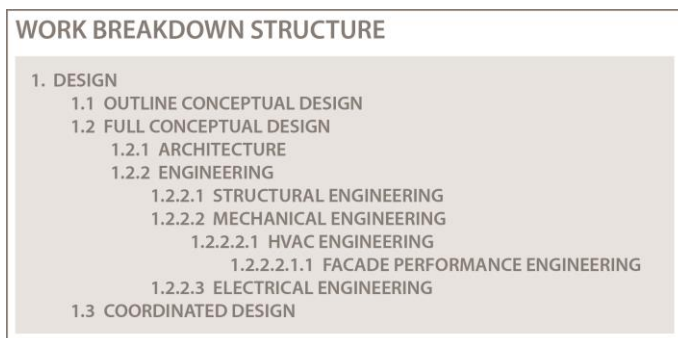

Figure 1: WBS for building design.

Arguably, if processes described in IDMs are intended to be applicable and reusable across AEC/FM disciplines and organizations, it will require that these processes can be mapped against a generic WBS, representing all processes within the AEC/FM project life cycle.

3.5 *Increasing project complexity*

As previously stated, the primary purpose of developing IDMs is to define and specify selected AEC/FM processes and information exchanges.

However, as Berard & Karlshoej (2012) indicate, AEC/FM projects are perceived as unique and ever changing. Therefore, AEC/FM processes and information exchanges are unique. This presents a considerable challenge to the concept of developing a standardized framework to define and organize AEC/FM information exchanges. Furthermore, it limits the potential industry-wide use and reusability of IDMs amongst unique AEC/FM projects.

Hjelseth (2011) recommended that BIM Guidelines (similar to IDMs) be decomposed into individual Information Modules (IMs), with each IM representing a specific use case and a set of associated information exchanges. Such IMs would provide the basis for BIM Guidelines to be implemented in a wide range of AEC/FM projects, as compared to traditional BIM Guidelines, which tend to focus on the authoring organization or project, and therefore make them less useful in other AEC/FM organizations or project types. Generally, BIM Guidelines are not sufficient to support AEC/FM information exchange. However, IDMs are. By defining IDMs in the above manner, improved approaches to standardizing information exchanges in unique AEC/FM projects can be realized.

3.6 *Review findings*

Information flow management and standardization methodologies were the most prominent points in the review. The review findings are summarized as follows:

- AEC/FM information flow management should be based on integrated approaches, common standards, and well-documented procedures.
- Unique AEC/FM projects require modular approaches and flexible methodologies if standardized information exchanges are to be reusable throughout the entire AEC/FM project life cycle.
- IDM processes should be decomposed and identified in accordance with a commonly accepted AEC/FM specified WBS, such that the IDM can be reused and applied within any given AEC/FM project.

4 IDM FRAMEWORK

4.1 *IDM Framework structure*

The proposed IDM Framework introduces a two-dimensional WBS-based methodology aimed at defining and organizing the information exchanges within AEC/FM projects.
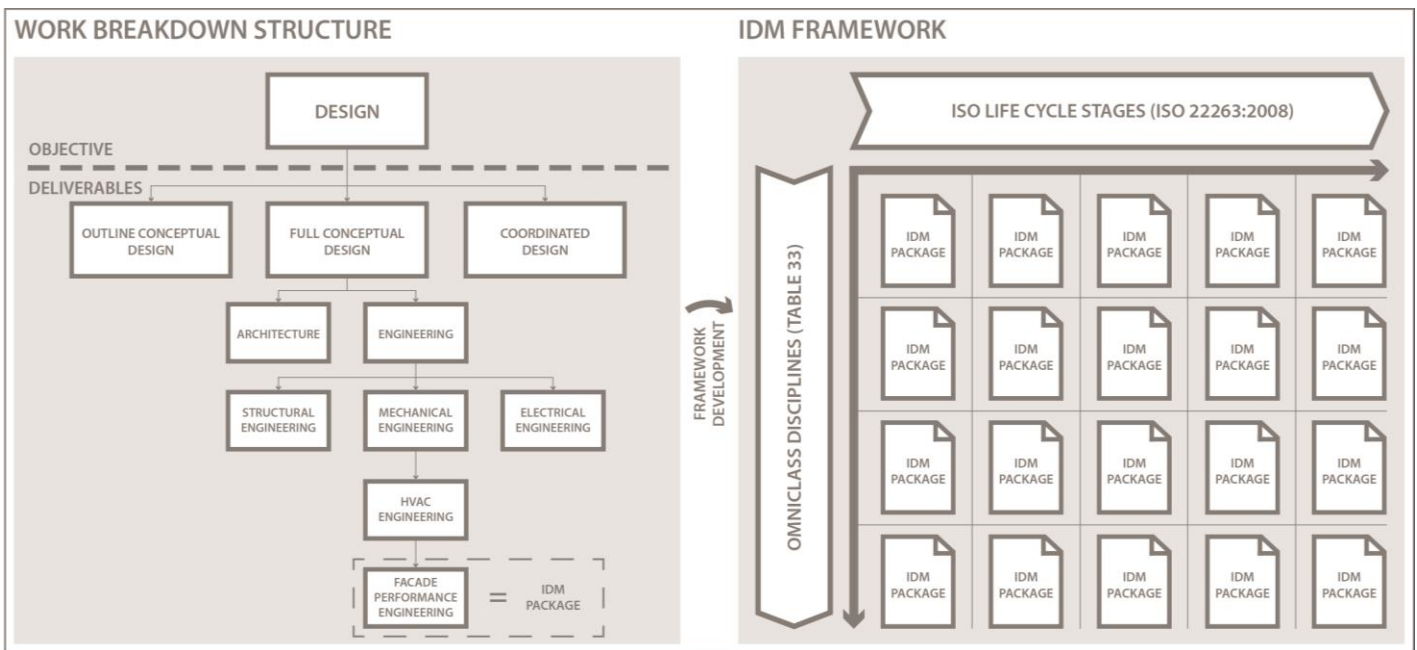
Figure 2: WBS for building design and IDM Framework structure.

The IDM Framework builds on a simple matrix structure of AEC/FM disciplines and project life cycle stages (Hall 2012). This structure serves as an "umbrella", covering all main use cases of the AEC/FM project life cycle. Given that use cases are generally defined to establish a basis for IDM developments, each use case defined in the IDM Framework represents a specified IDM Package. Figure 2 shows the WBS approach and the IDM Framework structure.

As shown, the framework disciplines (vertical axis) build on the "OmniClass Construction Classification System Table 33 – Disciplines" (OmniClass 2012). OmniClass Table 33 was selected because of its deliverable-oriented hierarchical decomposition of the different AEC/FM disciplines, ranging from high-level (e.g. design disciplines) to more detailed (e.g. HVAC engineering). Accordingly, the OmniClass Table 33 structure allows for each discipline, or sub-discipline, to be mapped with a specific IDM Package within the IDM Framework.

Notably, because of the inadequate level of decomposition in some disciplines, the OmniClass Table 33 discipline definition is not ideally suited for the task. However, the OmniClass decomposition of AEC/FM disciplines appears beneficial as a basis for the layout of disciplines within the IDM Framework.

As shown, the AEC/FM project life cycle stages of the IDM Framework (horizontal axis) build on the international standard "ISO 22263:2008 Organization of Information about Construction Works – Framework for Management of Project Information" (ISO 2008). ISO 22263:2008 was selected because of its well-documented definition of the AEC/FM project life cycle stages, consisting of eleven stages in total, from inception and design to production or demolition.

In addition, the ISO AEC/FM project life cycle stages are also not ideal, as they mainly focus on pre-construction stages, such as inception and design. Accordingly, these stages appear more documented than, for example, construction stages. In other words, the ISO AEC/FM project life cycle stages do not necessarily reflect the number of use cases within specific AEC/FM project life cycle stages, as several discipline-specific stages are missing. However, the ISO decomposition of AEC/FM project life cycle stages can be used as a basis for the layout of life cycle stages within the IDM Framework.

4.2 Decomposing into IDM Packages

Ideally, the IDM Packages within the IDM Framework should be decomposed into appropriate detail to efficiently define and organize the specific use case and information exchange in question (Brotherton et al. 2008). Arguably, the IDM Packages should be decomposed into detail, where the ERs of each defined IDM Package are stable and independent of any specific AEC/FM project or organization. For this reason, the need to define optional ERs should be eliminated. If that is not possible, the specific IDM Package is either not decomposed sufficiently, or the information exchange is not absolutely necessary, and hence should not be required.

The IDM Packages cannot represent all use cases within every sub-discipline of the AEC/FM industry, as local diversities and the need for customization of AEC/FM processes would require adjustments for specific purposes (Aram et al. 2010). For this reason, it could be argued that the purpose of the IDM Framework should be to identify the AEC/FM industry's best practices. Accordingly, the IDM
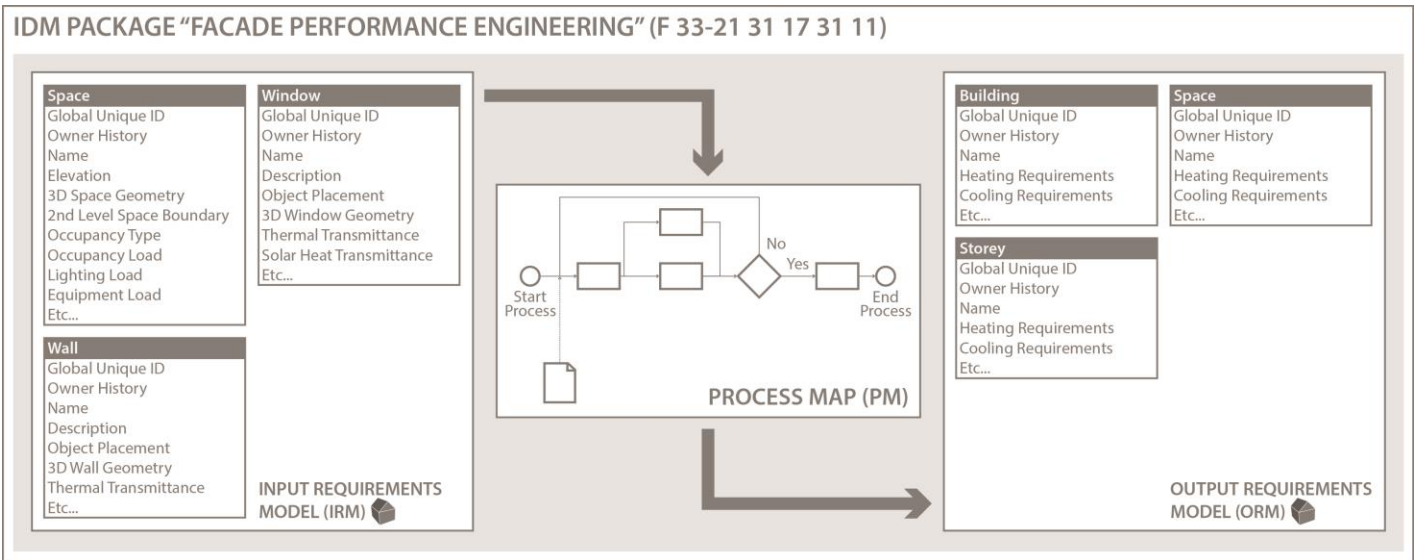
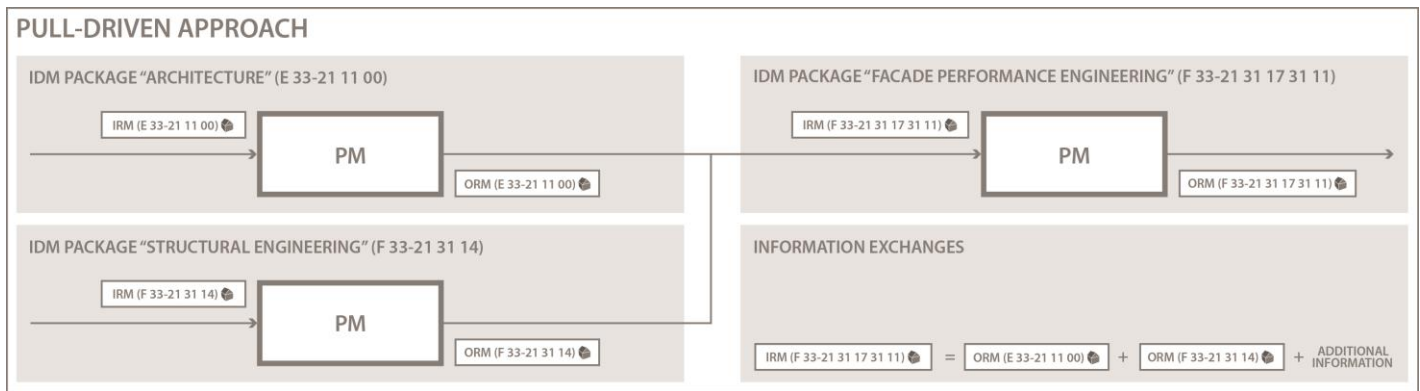Figure 3: IDM Package for façade performance engineering.

Figure 4: Pull-driven approach.

Packages defined in the IDM Framework should describe generic AEC/FM use cases and best practices, thereby allowing for later adjustment to local needs.

It is essential that, when defining the ERs of specific IDM Packages, focus should be on both input and output requirements. Therefore, ERs should be subdivided into Input Requirements (IRs) and Output Requirements (ORs), and ERMs should be subdivided into Input Requirements Models (IRMs) and Output Requirements Models (ORMs). This concept is similar to that proposed in (Anumba et al. 2010).

As this study focuses on describing the overall concepts of the IDM Framework, we will not define the content of specific IDM Packages and associated IRMs and ORMs. However, Aram et al. (2010) recommended that AEC/FM industry experts be involved in the process of defining the IRMs/ORMs.

Figure 3 shows an example of an IDM Package for façade performance engineering, and Figure 4 shows an example of the "pull-driven" exchange approach and the relationship between IDM Packages and associated IRMs and ORMs. Note that the downstream IDM Package is affected by what is produced by the upstream IDM Packages.

4.3 *Defining IDM Project Plan*

An important function of the IDM Framework is its ability to serve as a basis for defining an IDM Project Plan, in this way changing from generic use to project-specific use. Using this modular approach, the IDM Project Plan is created by selecting the specific IDM Packages required for the specific AEC/FM project. In addition, the IDM Project Plan provides an explicit description of the overall AEC/FM project scope, sequence flows, organizational interactions, and information exchanges. Furthermore, the graphical nature of the IDM Project Plan helps project managers to predict AEC/FM process flows and to communicate requests for deliverables throughout the project. Figure 5 shows an example of how selected IDM Packages can be placed in the IDM Project Plan.
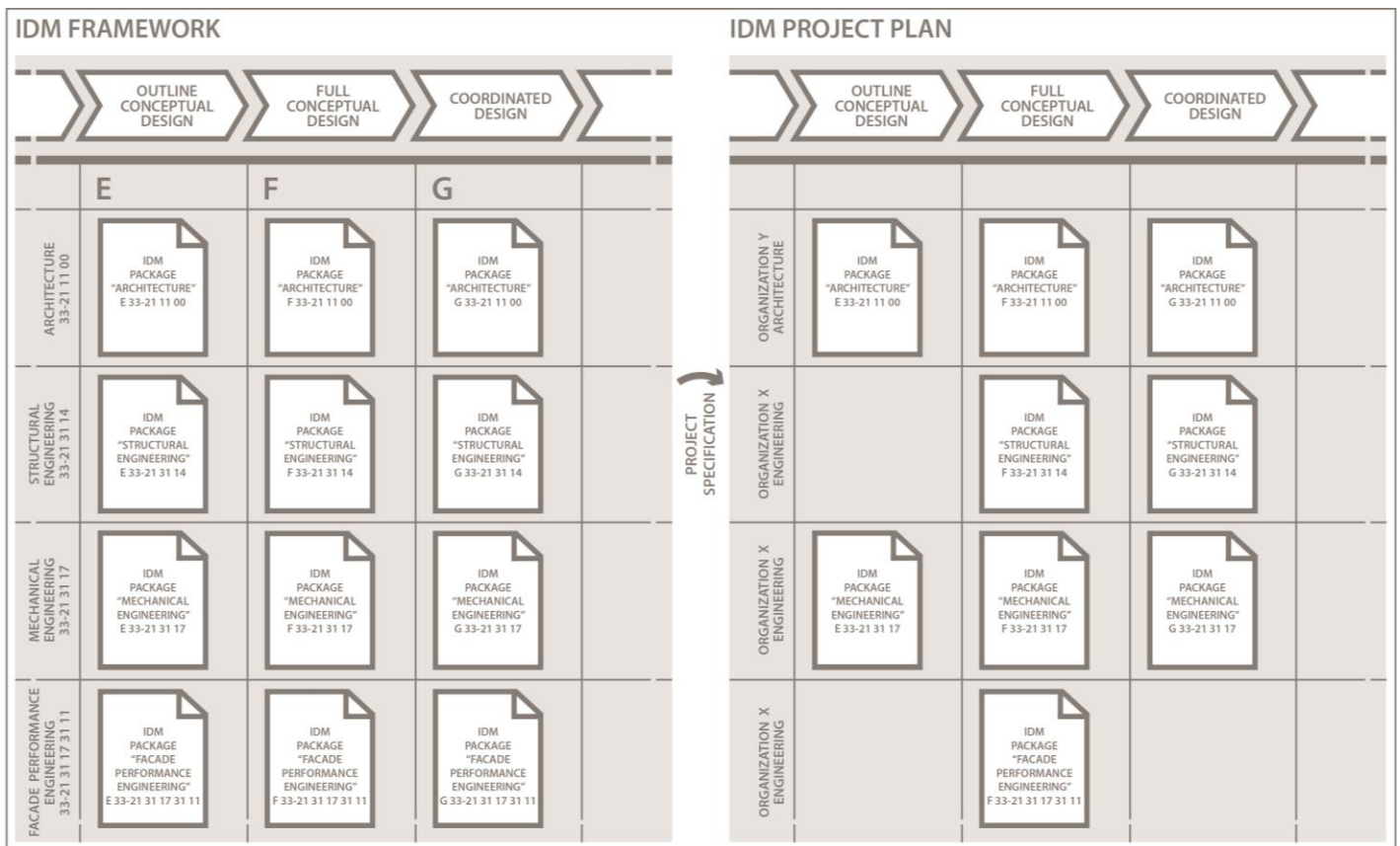
Figure 5: IDM Framework and IDM Project Plan.

4.4 *IDM Packages and MVDs*

Traditionally, MVD developments are based on IDM-specific Exchange Requirements Models (ERMs) and associated Exchange Concepts (ECs). However, bearing in mind the concept of IRMs and ORMs, it is recommended to define MVDs based on the IRMs and ORMs of individual IDM Packages. Given that MVDs are generally defined to establish a basis for AEC/FM software integration, they can be used to describe the precise information that specific software tools should be able to import and export, as subject of specific IRMs and ORMs. This is particularly beneficial as it enables AEC/FM project participants to carefully select the most appropriate software tool for the specific use case in question.

Potentially, the IDM Framework will consist of hundreds of IDM Packages with an equal number of corresponding MVDs, which will challenge unified AEC/FM software adoption. Therefore, for software certification purposes, it is recommended to combine multiple IDM Packages into each MVD. However, if quality assurance of software-based deliverables across individual IDM Packages is the goal, each IDM Package should be linked with a single MVD.

4.5 *Potential of IDM Framework*

Generally, the IDM Framework provides a modular methodology to define and organize processes and information exchanges in unique AEC/FM projects.

Furthermore, it also has the potential to conduct many additional analyses and optimization tasks. For example, the selected IDM Packages in an IDM Project Plan could analyze potential gaps in project-specific information exchanges, and, by observing senders and receivers of specific IRMs and ORMs, could also identify non-value propositions of specific AEC/FM processes.

Another example could be to identify specific processes and IDM Packages, which are affected by, for example, building design changes, by observing changes in specific IRMs and ORMs. By extension, sensitivity analysis could be conducted to identify the full range of downstream and upstream impacts of AEC/FM stage-specific IDM Packages.

Finally, the IDM Framework could be used to describe the precise content of MVD-based software certification testing systems.

5 CONCLUSIONS

In this study, we introduced an IDM Framework aimed at defining and organizing generic IDM Packages for all main use cases of the AEC/FM project life cycle. The IDM Framework was developed from the findings obtained from a review and supplementary expert discussions.

Ultimately, we believe that integration of this IDM Framework will provide a wide range of opportunities for AEC/FM project participants, as well as project managers, to measure and improve specified information exchanges in unique AEC/FM projects.

Furthermore, we believe that the IDM Framework makes it possible to harmonize the development of new IDMs. Such harmonization is also necessary, if improved interoperability between AEC/FM software tools is the goal.

The IDM Framework represents a tool for information management improvement. However, the potential benefits do not lie in simply specifying common IDM standards. Rather, the benefits lie in the implementation and continuous development by AEC/FM industry experts and project participants.

Future areas of focus should be to investigate the detailed information exchange structures for selected IDM Packages, more specifically the structures of use case-specific Input Requirements Models (IRMs) and Output Requirements Models (ORMs).

6 ACKNOWLEDGEMENTS

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