# DESIGN MANAGEMENT: METRICS AND VISUAL TOOLS

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## 1 Background and Identification of Problem /Knowledge Gap

Design is a multidisciplinary process that aims to fulfil owner's needs and values by overcoming several obstacles and constraints (Cross 1984). Problems with design management can be attributed to the iterative nature of design, the involvement of different parties with different interests and mentalities, poor communication and inadequate information exchange, segregated delivery systems, and the absence of adequate metrics that can quantify design information flow using real time data (Ballard 2000, Tribelsky and Sacks 2011, Ford & Sterman, 2003).

Meanwhile, the industry is witnessing an increasing use of Building Information Modelling (BIM) as a platform for running the design process. BIM is a visual database that combines parametric design data into a centralized model. To manage information flow in BIM, research and industry efforts created the notion of Level of Development (LOD) as a communication language among design participants. Current LOD classification systems range from LOD 100 to LOD 500, specifying the minimum graphical and non-graphical information an element should hold at each level, and its possible authorized uses (BIMForum 2015; The American Institute of Architects 2013).

The current definition and use of the LOD concept is oriented towards the control of modelling requirement of elements in the BIM model. Nonetheless, LOD specifications are used contractually to specify the modelling duties of each design party. Although LOD reflects the modelling development of an element, it does not necessarily reflect its design maturity in the bigger design context. For instance, if a window is modelled per LOD 400 requirements, therefore having shop drawings details, and the owner disagrees on it, the window has a null design maturity. In this scenario, the designer may be required to re-design the window from scratch.

## 2 Research Aims and Methodology

The paper aims to introduce new design management metrics that can reflect the actual progress of design projects. Nonetheless, the paper uses the defined metrics to quantify and visualize the management of design projects benefiting from the object-oriented nature of BIM models.

Design Science Research (DSR) is used as a research method in this study, and the different steps are presented in Figure 1.

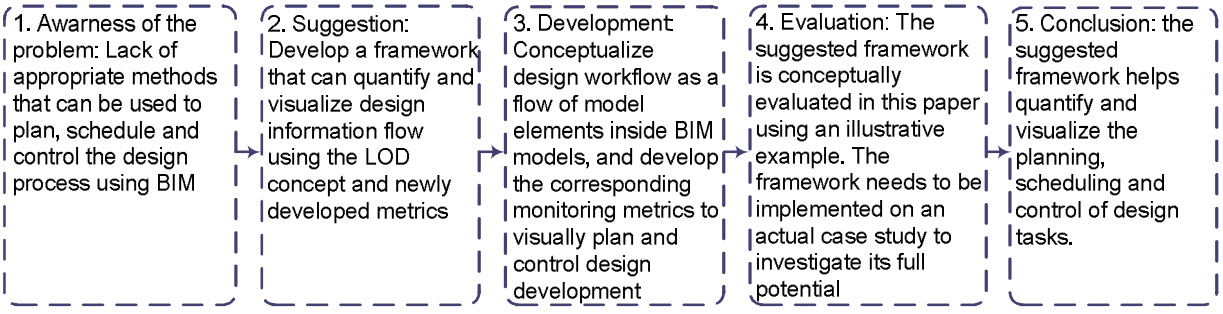


Figure 1: Research Methodology

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## 3 Framework Development and Findings

Three metrics are defined to reflect the design maturity of model elements as well as the entire BIM model. These metrics are defined as follows:

- Confidence Index (CI): this metric reflects the design reliability of a certain element based on different checks targeting the concerns of different design stakeholders. CI is based on the work of Gray and Hughes (2001). (Kindly refer to paper for more details).
- Element Design Maturity (EDM): this metric reflects the design maturity of one element based on its LOD level and CI values as highlighted in table 1.
- Design Maturity Index (DMI): this metric reflects the design maturity of the entire model or part of it. DMI is the ratio of elements that reached their desired EDMs to overall modeled elements as highlighted by equation 1.

$$DMI = \frac{\sum Elements\ that\ reached\ planned\ EDM}{Total\ number\ of\ elements\ in\ the\ defined\ set} \quad (1)$$

Table 1: Element Design Maturity Levels

| EDM Level | LOD Requirements | CI Requirements | Maturity Level |
|---|---|---|---|
| EDM-1 | LOD 100 | C1 | Conceptual |
| EDM-2 | LOD 200 | C1, C2, C4 | Schematic |
| EDM-3 | LOD 300 | C1, C2, C3, C4, C5 | Detailed |
| EDM-4 | LOD 400 | C1, C2, C3, C4, C5, C6, C7, C8 | Shop Model |
| EDM-5 | LOD 500 | C1, C2, C3, C4, C5, C6, C7, C8, C9, C10 | As-Built |

The design workflow is approached in this paper as a flow of model elements where the dynamics of design activities are reflected in elements generated in the model, progressing from one EDM level to another. Figure 2 schematically represents the new framework suggested to plan and monitor design workflows. Design Flow Lines (DFL) are introduced to reflect corresponding design tasks. Solid DFLs are the planned schedule where elements are assumed to reach a 100% DMI by the end of the tasks, while dashed DFLs reflect the actual progress of these tasks. The visual representation allows design managers to constantly detect slippage from schedule, information dependencies, and expected bottlenecks. For instance, "Architectural Walls/Floors" design task failed to stick to the plan and witnessed a delay of 1 week. The suggested framework needs to be tested on an actual design project to investigate its usefulness and practicality.

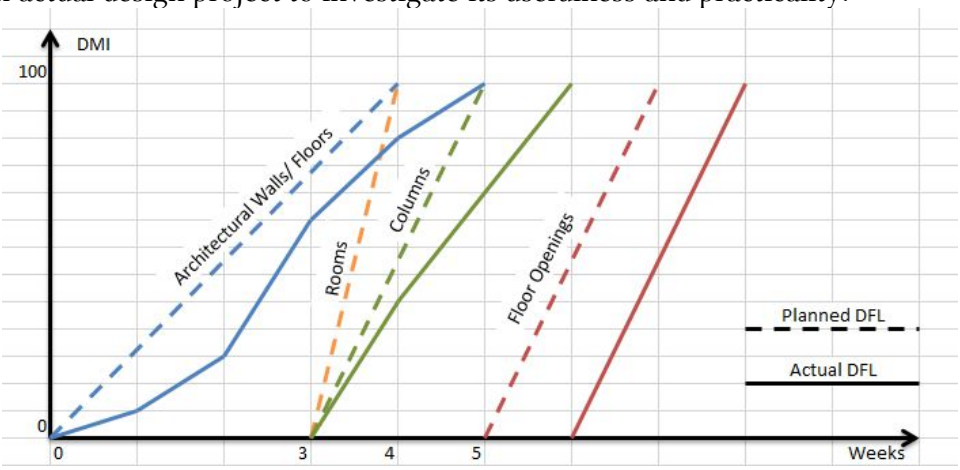


Figure 2: Design Flow Lines