DECISION BREAKDOWN STRUCTURE: MANAGEMENT OF DECISION BASIS TO ENHANCE DECISION MAKING IN THE BUILDING INDUSTRY

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ABSTRACT

This paper provides an introductory overview of a doctoral research on the management of decision basis in the building industry. Based on industry case studies, this research has concluded that the AEC decision basis is heterogeneous and evolutionary in nature. This work bridges the gap among theories in Decision Analysis, Project Management, and Virtual Design and Construction, leading to the formalization of the Decision Breakdown Structure (DBS)—a formal vocabulary for decision stakeholders to represent and organize decision information. Complementing the DBS with a set of dynamic methods known as the Decision Method Model (DMM), a research prototype known as the Decision Dashboard was developed. Validation results from industry test cases showed that managing the decision basis with the Decision Dashboard, along with its underlying DBS and DMM, enabled project teams to improve the decision quality when compared to the use of generic decision-support means and methods found in current practice. Thus, this research formalizes the management of AEC decision basis to enhance the quality of decision making in the building industry.

KEY WORDS

Decision Breakdown Structure, Decision Dashboard, Decision Method Model, Information Management, Decision Making

INTRODUCTION

This paper provides an introductory overview of a doctoral research on the management of decision basis in the building industry. A decision is an irrevocable allocation of resources (Howard 1966). Information, preference, and choice are the three parts of the "Decision Basis" (Howard 1988). According to Decision Analysis theory, the quality of a decision is judged by the decision basis rather than the outcome of a decision. The more informed the decision stakeholders are about the information, preference, and choice, the better the decision basis, and the better the decision quality. This research centers on the unique needs,

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characteristics, limitations, consequences, and opportunities associated with the management of information that affects the decision basis in the building industry. This paper presents some of the major insights into the management of such decision basis in current practice and introduces our research outcomes—the concepts of a Decision Breakdown Structure and its associated Decision Method Model, which are implemented as a computer software application prototype known as the Decision Dashboard.

Given the number of stakeholders, teams, and individuals involved in decision making as well as the complexity and scale of an architecture-engineering-construction (AEC) project, the decision basis involves many perspectives, forms, types, levels of detail, and interrelationships. Given the long time span of a building project and the dynamics of its project context, tactical solutions, and stakeholders' preference, the decision basis changes all the time. Because existing literature lacks an in-depth documentation and assessment of the unique characteristics and challenges of the AEC decision-making process, our research documented six large-scale industry cases that cover a variety of decision foci from decision-making scenarios arisen from different building types and project phases. We concluded that the AEC decision basis is heterogeneous and evolutionary in nature. Since decision-support tools and methods employed by AEC decision facilitators (e.g., project managers, lead architects, etc.) are not tailored to manage information that is heterogeneous and evolutionary, AEC project stakeholders often need to spend valuable time during meetings to become more informed about the decision basis. In other cases, they prematurely commit to a decision without a good (i.e., informative) decision basis. The following sections present one of the six industry test cases from our work, illustrate the limitations of current practice in managing the decision basis, introduce the concepts behind the Decision Breakdown Structure (DBS) that we have developed, and explain how the DBS-based approach enhances the management of AEC decision basis found in current practice.

INDUSTRY TEST CASE

CONTEXT

Our industry test case is based on the decision basis (information) from an actual fast-track retail construction project. After unforeseen soil contaminants had halted and delayed the construction project for two critical months, the developers (decision makers) had to decide upon a project alternative that would best balance the conflicting criteria among on-time turnover, change order cost, and project risks. The developers requested the general contractor (decision facilitators) and their subcontractors (professionals) to come up with acceleration alternatives along with pertinent performance predictions such as cost estimates and acceleration schedules for consideration in an upcoming owner-architect-contractor (OAC) meeting. Based on this industry scenario and its project information, our research team applied Virtual Design and Construction concepts and technologies (Kunz and Fischer 2005) on the test case. We developed product, organization, and process models as well as functionalities to enable cross-referencing of multidisciplinary computer models in the CIFE iRoom (Kam et. al. 2003).

REPRESENTATION OF THE DECISION BASIS

In current practice, the OAC meeting focused on the mitigation strategies to alleviate the impact of the unexpected delay in the construction project. Five project scenarios (alternatives) were represented by five sets of process models (i.e., one process model for each scenario), 4D (product-process) models, cost estimates, and organization-process models. The presentation, description, and explanation, and evaluation of the alternatives depended on Microsoft PowerPoint as the decision-support medium. My CIFE research team documented the assumptions, options, attributes, and rationales pertaining to each alternative with text boxes in PowerPoint. My team also presented evaluation tables by pre-determining the topics and criteria for evaluation and re-entering such topic and criterion information into PowerPoint. As we went through each baseline, impact, and acceleration scenario, a team member manually brought up each corresponding process, 4D, cost, and/or organization-process model individually. The CIFE iRoom enhanced the evaluation of the decision basis by enabling cross-highlighting features across any combination of the product, organization, and process (POP) models (Kam et. al. 2003). However, current decision-support tools did not contain knowledge about the inter-relationships or interchangeability among the POP models, their options, and their attributes. In a later section, we introduce the concept behind the Decision Breakdown Structure, which formalizes the representation of such decision topics, criteria, alternatives, options, attributes, and their inter-relationships.

METHOD TO PROCESS THE DECISION BASIS

As the decision facilitator provided a briefing on possible acceleration proposals to the decision makers in this industry test case, a decision-enabling task (i.e., a need to manage the decision basis) occurred when the decision stakeholders needed to comprehend the decision information (e.g., the assumptions and proposal details) of various competing acceleration proposals.

As explained, the briefing and review meeting took place in the CIFE iRoom, where pertinent 3D/4D models, construction schedules, cost estimates, and process-organization information was stored digitally in case-specific project files. The decision facilitator relied on the decision-support tool to help explain the scope, the assumptions, the mitigation measures, and the anticipated time saving associated with the competing acceleration proposals. This explanation had to be informative and quick. A clear comprehension of this interrelated decision information was crucial for the decision stakeholders to make an informed decision. The quicker the explanation and comprehension process, the earlier the decision stakeholders could move on to the following phase of the decision-making process and the execution of the selected alternative.

The significance of this decision-enabling task, as detailed below, is that if the decision-support tool does not offer good explanation support, the decision facilitator is then required to spend additional time in verbal explanation to fill the void of the decision-support tool. Conversely, if the decision-support tool offers the decision stakeholders a clear understanding of the decision information on hand and its basic interrelationships, the decision facilitator can complete more decision-enabling tasks given the time available during a synchronous decision meeting (e.g., in facilitating the decision stakeholders to explore the benefits and challenges of the available choices).

Under current CIFE iRoom practice, there are methods that allow decision facilitators to cross-highlight decision information among competing 4D models or across inter-related POP models (e.g., using activity names or time controller, Kam et. al. 2003). However, there were no formal methods to support a decision facilitator in explaining the acceleration proposals or in bringing up the relevant reference information during the explanation process.

The decision facilitator used MS PowerPoint as the decision-support tool to enable the explanation of the decision basis in current practice. When explaining the acceleration proposals to the decision makers, the decision facilitator needed to explain the assumptions, scope, and the distinctions among the competing proposals. The decision facilitator either had to take personal notes to mentally memorize such decision information or had to custom create introductory slides in MS PowerPoint to document such decision information for subsequent explanation. The ad-hoc nature of this PowerPoint-based documentation process required the decision facilitator to take additional time to create custom slides to recapture the decision information in the decision-support tool. Because the facilitator did not spend extra time to create those custom slides, he had to spend valuable time during the synchronous (i.e., face-to-face) meeting in offering verbal explanations to give the decision stakeholders full comprehension of the decision scenario. The limitation of the current decision-support tool required extra effort and time to ensure that the explanation process is quick and informative.

Similarly, there was no formal and explicit method for managing options or alternatives to form an integrated representation of the decision scenario based on the information or data coming from different AEC disciplines. To bring up a particular project file from a set of product, organization, and process models from the five scenarios for decision evaluation, the decision facilitator had to rely on his/her mental recollection or custom-create an organization scheme (e.g., by data directory and folder) and naming convention in the computer prior to the explanation process. Without this extra ad-hoc method, the decision facilitator would need to spend extra time during the explanation process to sort out and retrieve a relevant file from a set of case-specific decision information. In a later section, we introduce the Decision Method Model that is an extensible set of methods, building upon the concept of the Decision Breakdown Structure, which enable decision stakeholders to manage evolutionary decision information more effectively than in current practice.

MANAGEMENT OF AEC DECISION BASIS IN CURRENT PRACTICE

CURRENT PRACTICE AND METHODS

In summary, our industry test case illustrates that there are no explicit interrelationships among the many POP options, their corresponding intervention assumptions, and their interchangeability in current decision-support tools. These critical relationships reside in the memory of the decision facilitators, rather than an explicit decision-support tool.

Having documented and analyzed five additional industry test cases, our research conclude that current practice in the building industry lacks decision-support methods and tools to manage AEC decision basis in ways that recognize its heterogeneous and evolutionary nature. Current information management theories and methods do not respond to the heterogeneous and evolutionary nature of AEC decision information and thus, result in information homogenization and dispersal, pre-mature coupling and lock-in, and rework (Kam 2005). Consequently, decision facilitators and professionals in the industry test cases use generic (i.e., non AEC context-specific) decision-support tools and their associated methods, such as word-processing applications, MS PowerPoint, pre-determined evaluation tables, descriptive narratives, sub-headings, paper-based reports, etc. These tools and methods are generic as they are widely used in non-AEC contexts as well. However, they are not informative, flexible, resumable, or quick. Thus, they provide limited support in managing decision information that is heterogeneous and evolutionary in nature.

THE DECISION DASHBOARD APPROACH

To overcome the limitations of current practice in managing the decision basis, we developed the concept of a Decision Breakdown Structure (DBS) with an underlying AEC Decision Ontology that allows facilitators to establish an explicit, informative, and hierarchical representation of heterogeneous decision information and its interrelationships. We formalized a dynamic methodology—the Decision Method Model (DMM)—that interacts with the AEC Decision Ontology and enables facilitators to combine, evaluate, recombine formally represented information, and to complete other decision-enabling tasks flexibly and quickly. The DBS and DMM are implemented in a computer software prototype, known as the Decision Dashboard (DD, Figure 1).

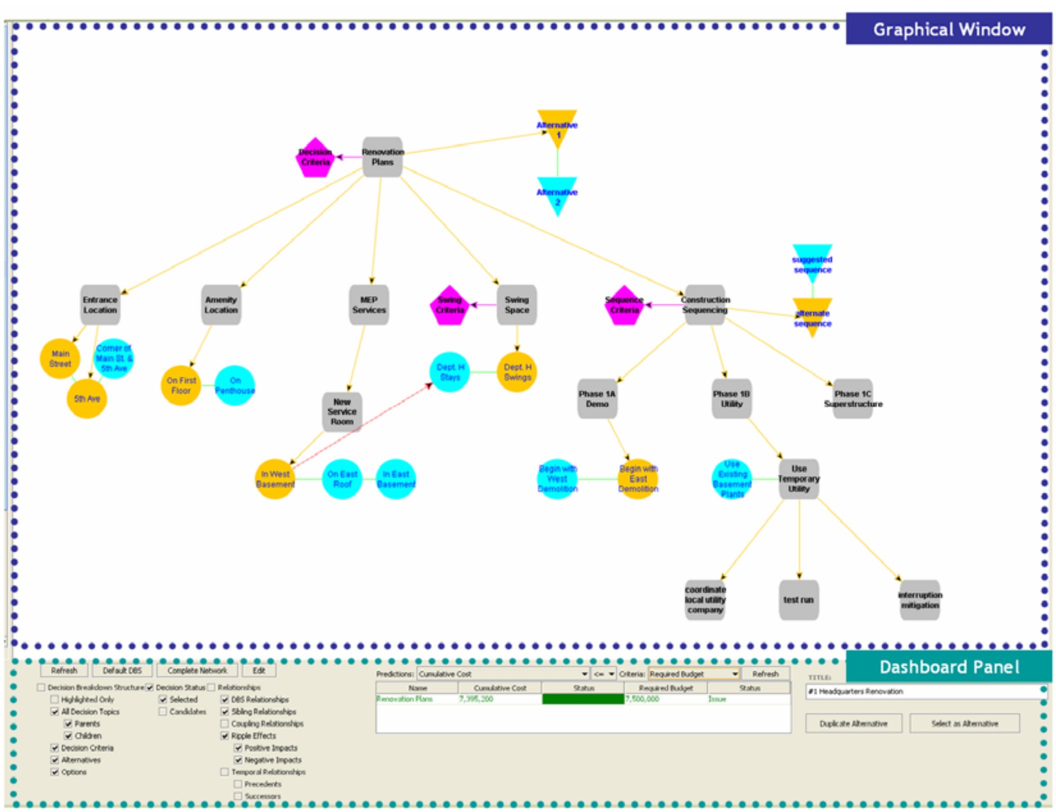

Figure 1: A computer screenshot of the Decision Dashboard (DD) prototype.

The DD is a decision-support tool for decision stakeholders to manage the heterogeneous and evolutionary decision basis, which is the characteristic of information management in the AEC decision-making process. The Graphical Window (Figure 1 Top) is an interface for facilitators to formulate and re-formulate a DBS that represents a decision solution and its choices. The symbols (squares, pentagons, circles, etc.) and arrows in the graphical window are model representations of the AEC Ontology elements and relationships that make up a DBS (Kam 2005). The Dashboard Panel (Figure 1 Bottom) provides facilitators with a dynamic methodology to manage (e.g., control, isolate, evaluate, etc.) the DBS.

The DD is analogous to dashboards that gather essential information and enable drivers and pilots to make informed decisions about the future courses of action. It supports the decision facilitators to complete decision-enabling tasks by integrating and referencing dispersed information into a central reporting and controlling interface, and thereby, empowering all stakeholders to make informed decisions quickly. Therefore, the prototype is called the Decision Dashboard.

DECISION BREAKDOWN STRUCTURE (DBS)—AN ONTOLOGY TO REPRESENT AEC DECISION BASIS

DBS CONCEPT

Today's homogenized representation of decision information results in decision making that is slow and not informative. Existing AEC theories cover the representations of design, organization, work break downs, but not related choices and associated interrelationships. Based on the information representation needs identified from the test cases, our research investigates the applicability of Decision Analysis theories and offers an AEC Decision Ontology for decision facilitators to explicitly document and categorize information according to its types, forms, states, and interrelationships (Kam 2005).

Our work provides a vocabulary for decision stakeholders and computer systems (i.e., the Decision Dashboard) to represent and structure heterogeneous decision information and its associated knowledge. While existing AEC theories primarily focus on representing certain subsets of decision information, our research categorizes these types of information subsets (as ontology elements) and relationships between them (as ontology relationships). Our hypothesis is that the ability to distinguish these information and relationship types will aid in the representation and management of AEC decision information to improve the completion of decision-enabling tasks. To support the representation of discrete items of decision information, their interrelationships and associated details, the AEC Decision Ontology offers three ontology parts—elements, relationships, and attributes (Figure 2). These three ontology parts are abstract and conceptual; they rely on symbolic representations to explicitly represent relevant decision information and its associated knowledge from the perspectives of the decision stakeholders. Following the rules and definitions associated with these ontology parts, AEC decision facilitators can build a Decision Breakdown Structure to support decision-making processes (Kam 2005).

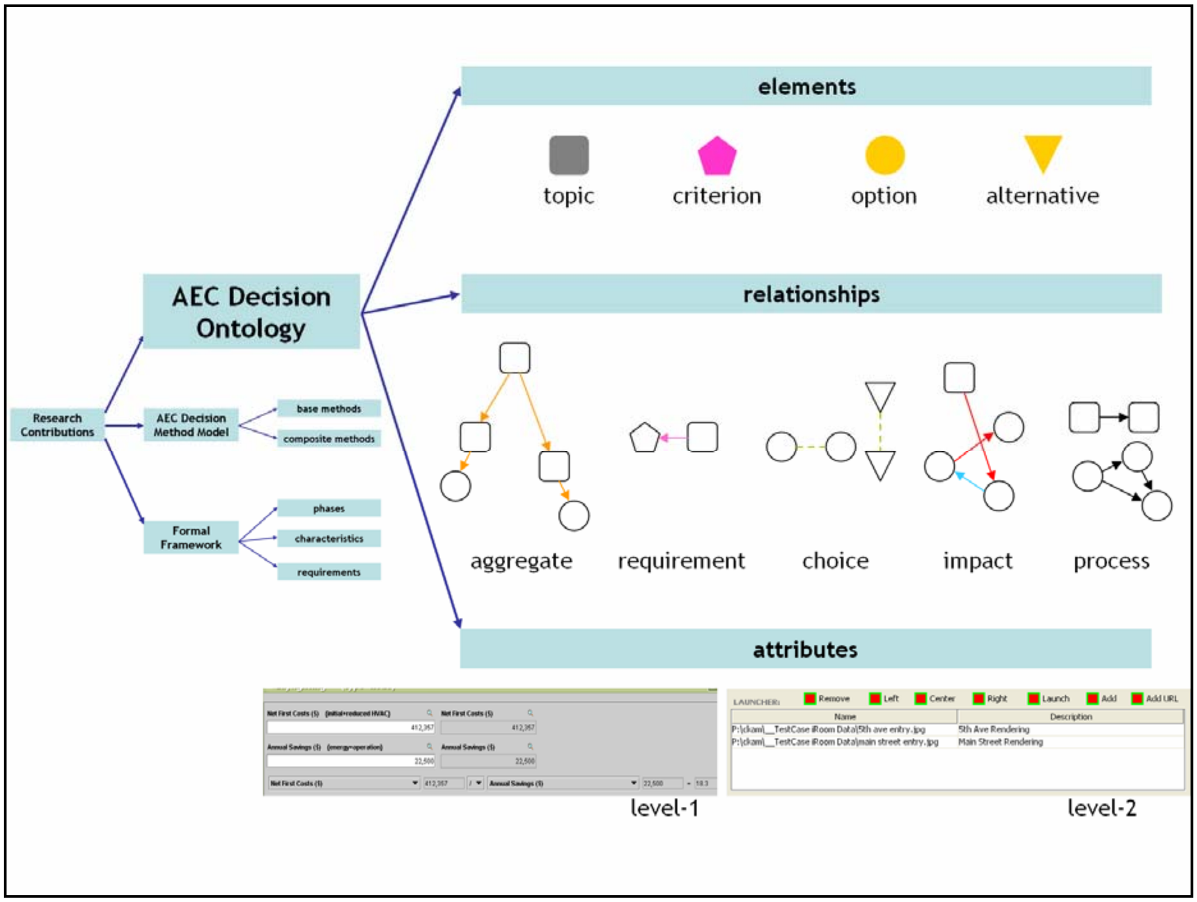

Figure 2: Elements, relationships, and attributes are the three parts of the AEC Decision Ontology, with which decision facilitators can represent decision information and its interrelationships in their formulation of a Decision Breakdown Structure.

DBS Application in Test Case

Earlier in this paper, we introduced our industry test case pertaining to a retail construction project. We reconstructed the decision basis of case with the Decision Breakdown Structure concept in the Decision Dashboard. Our effort focused on the relationships among the acceleration options, while explaining how these options combine into different alternatives. The reconstruction was made up of 9 instances of decision topic and 11 instances of decision option, which combined into 4 different instances of acceleration alternatives (Figure 3). These 24 instances of ontology elements required 38 instances of ontology relationships, including aggregate, choice, process, and impact relationships. As attributes embedded in the ontology elements, linkages to iRoom applications and specific POP models (introduced earlier in this paper) were available in the Decision Dashboard.

DBS ASSESSMENT

While current practice combined PowerPoint and individuals' mental correlations, the AEC Decision Ontology enabled the project stakeholders to understand the acceleration choices under the decision topics of product, organization, process, and resources. Project stakeholders with the Decision Dashboard were able to query specific attributes that included reference information to POP models, which pertained to particular options or topics, in the CIFE iRoom. Furthermore, they were able to adjust evaluation foci (in terms of topics and/or attributes and/or criteria) in real-time and comprehended the cross-option impacts among the many decision choices. Hence, they were informed of the opportunities and limitations associated with the reformulation process, during which professionals mixed and matched options to come up with different alternatives.

DYNAMIC METHOD MODEL (DMM)—DYNAMIC METHODS TO PROCESS AEC DECISION BASIS

DMM CONCEPT

The static management of decision information causes inflexible and slow decision making in current practice. Recognizing the limitations of current theories in offering decision-support methods that align with the unique characteristics of AEC decision information, our research formalizes a Decision Method Model (DMM) to manage information represented with the AEC Decision Ontology. The DMM is a set of methods that formalize an array of computer-based reasoning methods to process information that are formally represented by the AEC Decision Ontology (Kam 2005).

DMM APPLICATION IN TEST CASE

In the industry test case that we introduced earlier, the decision stakeholders needed to comprehend the decision information (e.g., the assumptions and proposal details) of various competing acceleration proposals. With the DMM, decision facilitators were able to explicitly break down the choice associated with each acceleration proposal, e.g., whether a specific acceleration proposal uses a double crew or a single crew. The DD as a decision-support tool enabled the decision facilitators to highlight any of the acceleration proposal scenarios and use the graphical filter to show graphically what that scenario entails. Thus, the DMM method contributed to an informative explanation of the decision basis.

To obtain specific decision assumptions, predictive values, or details, decision stakeholders were able to query for embedded level-1 decision information or launch the relevant referenced project file in the CIFE iRoom with a single click on a specific ontology element instance using the DMM. The DMM allowed DD users to launch any referenced project file with the appropriate software application on any of the CIFE iRoom computers. Hence, the DMM reduced the time it took the decision facilitator to bring up the pertinent decision information to the decision stakeholders (from minutes in current practice to seconds with automated references). Thus, the DMM contributed to a quicker decision evaluation process when compared to current practice.

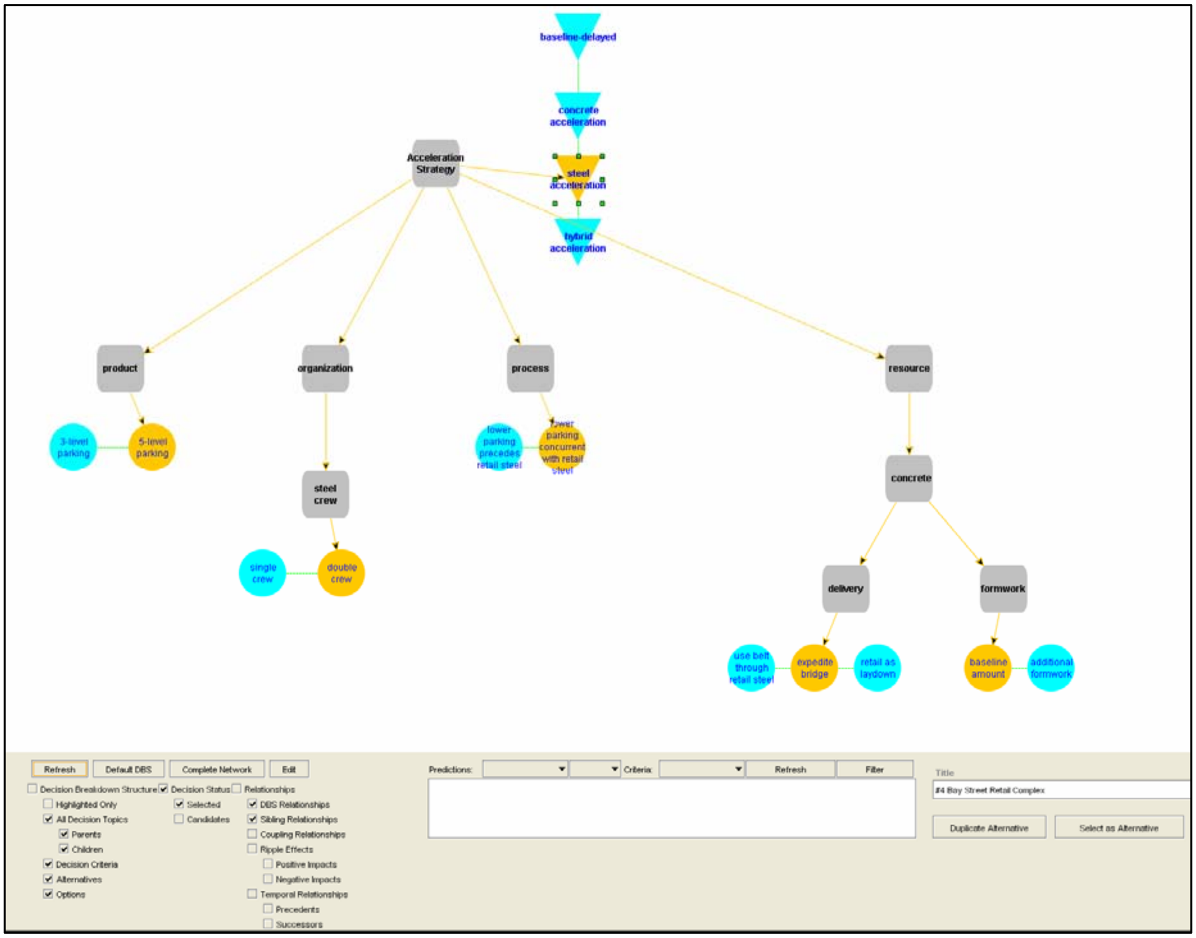

Figure 3: The DMM in TC#4 allows DD users to dynamically focus on any of the four acceleration alternatives (e.g., steel acceleration in the illustration) and learn about the specific composition (e.g., which options are selected and not) of those alternatives.

DMM ASSESSMENT

Decision facilitators have different choices of decision-support tools. They can use MS PowerPoint, the Decision Dashboard, or other decision-support tools to manage the decision information present in a decision scenario. Our industry test case showed that with the DMM, the formulation of a DBS as part of the process to manage decision information offered advantages in the evaluation phase of information management in AEC decision making. One advantage was that the decision facilitators saved time and effort in explaining the scope, assumption, and the big picture of the decision scenario. Another advantage was that the decision facilitators also saved time and effort in making connections between an array of supporting reference files and their corresponding decision information. In current practice, the decision facilitators needed to create custom introductory slides, needed to customize folder and naming conventions, and very often, these facilitators also needed to rely on their mental recollection or verbal explanation to ensure an informative explanation process. In contrast, Decision Dashbard-based management of decision information empowered the DMM to eliminate such extra time and the effort required to maintain an informative explanation process.

CONCLUSIONS

This paper provides an introductory overview of a doctoral research on the management of decision basis in the building industry. Based on industry case studies, our research has concluded that the AEC decision basis is heterogeneous and evolutionary in nature. Generic decision-support tools used in current practice do not effectively manage the interrelationships among the many decision choices, their corresponding assumptions, and their interchangeability. To overcome such limitations, we developed the concept of a Decision Breakdown Structure (DBS) that allows project stakeholders to establish an explicit, informative, and hierarchical representation of heterogeneous decision information and its interrelationships. We formalized a set of dynamic methods into the Decision Method Model (DMM) to enable project stakeholders to combine, evaluate, and recombine decision basis that is represented in form of a DBS. With our research prototype known as the Decision Dashboard (DD), we reconstructed the industry case with a DBS and reenacted the management of its decision basis with the DMM. Our validation results showed that decision facilitators were able to manage the decision basis more informatively, flexibly, and quickly with the Decision Dashboard than with generic decision support tools used in current practice. In a nutshell, our research highlighted the importance of understanding the AEC decision basis, while demonstrating the potential impact of managing the AEC decision basis with the dynamic Decision Breakdown Structure. Our work has seeded a foundation for enhancing the quality of decision making in the building industry.

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