

COLLABORATIVE DESIGN DECISIONS

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ABSTRACT

Decision making on projects is often done in isolated silos, lacking collaboration and communication between teams. This modality often leads to inefficiencies due to late changes in the design and the need for rework. Team moods decay when there is lack of a clearly defined decision-making process, provoking frustration and apathy. This paper presents a case study that demonstrates how the implementation of lean ideas and methods, specifically A3 reports and Choosing by Advantages (CBA), helped a team evolve their process beyond a traditional decision-making strategy. The researchers used a unique approach to observe the decision-making process as conversation for action to help the team overcome challenges. This paper quantifies the impacts of simultaneously implementing A3 and CBA in terms of saving money and reducing time in meetings. In addition, the research presents qualitative results in terms of improving the project design and creating a team capable of making efficient and sound decisions.

KEYWORDS

Decision-making, Target Value Design, Set-Based Design, Choosing By Advantages, A3 reports, Language Action.

INTRODUCTION

When decision making teams are detached from one another the integrity of projects is compromised by miscommunication, leading to ungrounded assessments, lack of shared understanding, and frustration in the team. Usually, miscommunication leads to poor design outcomes, late changes in the design to reduce cost, and rework. Lean Design methods and practices such as Target Value Design (TVD), Set Based Design (SBD), A3 reports, Choosing By Advantages (CBA) and The Last Planner System[®] (LPS) present an opportunity to reduce waste in the design process, reducing unproductive iterations and helping the design team define and deliver value for the client.

In particular, the decision-making process requires a transparent process in which SBD, A3 reports and CBA are well aligned (Arroyo 2014). Several studies have demonstrated case studies in which SBD, A3's and CBA were implemented mostly as independent elements (Arroyo et al. 2014b, 2015b, 2016b; Kpamma et al. 2014 and 2017;

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Parrish and Tommelein, 2009, Schöttle and Arroyo, 2016; Schöttle et al. 2017), not synergistically combined as in this case study.

In addition, the implementation of lean tools with coaches observing the decision-making process as a conversation can help teams to manage unproductive moods. The anatomy of conversations was defined by Fernando Flores (2012) and the impact of moods on the ability to learn was described by Gloria Flores (2016). These were mainly based on the observation of teams while achieving quests in role played video games.

This paper presents a retrospective reflection on a successful team that used A3 reports with CBA systematically to make design decisions in a large capital project for a major technology firm in The United States. The results of this approach with the addition of managing decisions as conversations for action was measured and documented by the design team.

RESEARCH QUESTION AND METHOD

The research questions are: 1) What is the impact of implementing A3 with CBA systematically on a project? and 2) What observations can be made when coaching the decisions of a team as conversations for action?

The nature of these questions is aligned with a case study methodology (Yin 2014). To answer these questions, a project was used as a case study for the utilization of A3 and CBA for dozens of design decisions pertaining to programing, mechanical and geotechnical systems, site safety and other design elements. The sources of evidence used were 1) direct observation, since both authors were coaching the design team to implement lean design principles and methods, 2) A3 reports, schedules, and budget documentation, and 3) Interviews with project managers and design specialists after the coaches interacted with the team. The interaction consisted of teaching, coaching, developing a system to apply lean principles and methods that worked for this project context, and specifically, coaching the decision-making process as conversations for action.

PROJECT BACKGROUND

The project described in this paper is a large and complex office building in a technology-rich area of the United States. The design team was large, multi-disciplinary, and based across multiple countries. Communication was done primarily through video conferencing and regular on-site working periods. The team had minimal or no previous exposure to lean principles. The project was complicated by aggressive schedule and budget targets, a difficult regional authority having jurisdiction, and a unique and iconic architecture.

The owner procured the design architects (two major international firms), the contractor, the construction management firm, and the executive architect. The construction manager procured the rest of the supporting engineers and sub trades, including a Lean coach and a relationship coach, sometimes in collaboration with the contractor and/or the owner. Most participants were contracted under a lump sum, fixed fee agreement and by in large worked for cost plus profit.

The owner's representatives were engaged in the decision-making process as the "decision-makers", or as advisors to higher-level decision makers based on the A3 with CBA. Not all design decisions were made with the help of the A3 with CBA process and the owner did not participate in the development of an A3 until the review cycle. The lean coach assisted the construction management firm with incorporating lean tools and methods in the design phase, including Target Value Design, Pull planning, and A3 thinking with the Choosing By Advantages decision-making process. Lean principles and tools were partially adopted by the project participants. The client was particularly concerned with making sound decisions that would be acceptable to multiple, cross-functional stakeholders at all levels within the organization.

DECISION-MAKING CHALLENGES / WASTE NOT; WANT NOT!

The primary challenge that the team faced was the lack of a collaborative decision-making process. Teams were utilizing traditional decision-making techniques that inhibited innovation despite the complexities in the building design. Their initial strategy was to assess alternatives at face value, endeavoring to present a reasonable course of action that the owner and the rest of the team would agree with and adhere to. This haphazard method lacked focus and strategy, as disparate teams addressed competing design priorities without coordination or leadership. Decision-making was not synchronized with the target project schedule, resulting in the repeated need to conduct pull plans for scheduling and rescheduling the design effort. The team was frustrated by the lack of accountability, the atmosphere was chaotic, and design decisions were poorly documented. While the project appeared to have some history with formal decision-making methods such as CBA, upon examining the few documented decisions it was clear that they were unwittingly using the CBA name but actually using the Weighting Rating and Calculating (WRC) method of decision-making.

The initial communication patterns in this case resulted in 1) hasty decisions, based on ungrounded opinions without considering all relevant facts about the performance of design alternatives, 2) misalignment between team members, 3) overturned decisions causing rework, and 4) Excessive, disconcerted information overwhelming team members. In summary, the lack of structural organization, decision tracking, and methodology for conflict resolution resulted in discernable design inefficiencies.

LEAN METHODS IMPLEMENTATION

Figure 1 shows a simplification of an overall theoretical TVD strategy and the relationship between complimentary lean methods to be used in design. TVD principles should be used to identify target values and targets costs. For every opportunity identified to improve the existing baseline design, the team should use a systematic decision-making process which includes SBD principles, developing alternative design sets until the last responsible moment. These sets are collaboratively determined by the design team based on their plan. The entire process is in accordance with The Last Planner® System (LPS). In addition, Choosing By Advantages (CBA) is used as the decision-making method and included in A3s reports to manage and report the decisions, recommendations or documentation.

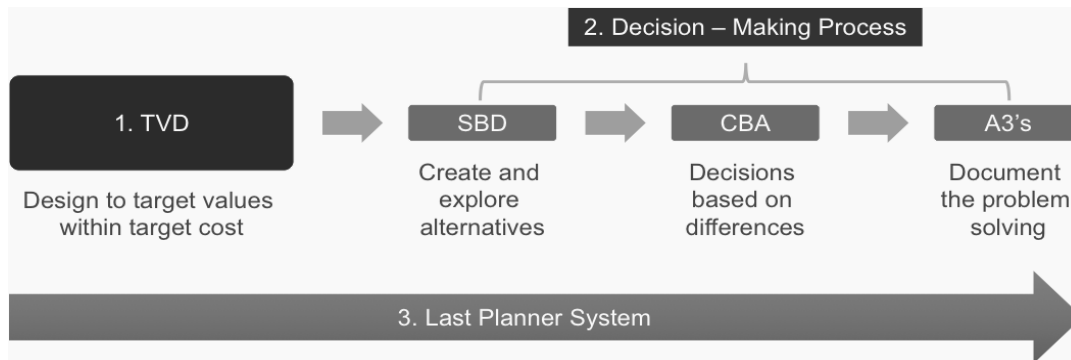


Figure 1: Lean design Methods Relationship

The following sections briefly explain a variety of lean methods introduced to the design team by the lean coaches over time. Only the project managers who were in charge of facilitating decisions had formal training in lean methodology. Lean methodology was only partially adopted by the team, however, lean coaches did attend design decision meetings through video conferences and guided decision-making processes and conversations.

Target Value Design (TVD)

TVD is a design process which seeks to achieve a target value (desired performance outcome for the whole building) at a certain cost, in alignment with the owner's value proposition. In this framework, cost is a design parameter. This is in contrast to traditional design in which the design is completed first and the cost of the building is an outcome of that design. (Ballard,2009). Current thinking applies TVD throughout the entire project delivery process, focusing on Target Value Delivery rather than limiting TVD to the design phase only.

Set-Based Design (SBD)

SBD is a design method that encourages the exploration of alternative approaches for design solutions and concurrently carries those solutions along, gradually eliminating them until the preferred solution is determined (Ward et al., 1995). This approach prevents the premature selection of an alternative that in the end could result in re-work or subpar value to the client if it is later determined not to have been the optimal choice. Ballard (2000) expanded on SBD by defining positive and negative iteration for the design team.

A3-thinking

A3-thinking is a problem-solving method used extensively in the Toyota Production System, which puts P-D-C-A (plan-do-check-act) in action (Sobek and Smalley, 2011). This structured approach to problem-solving clearly defines the problem, the desired outcomes, the hypothesized solution, and the steps to implement the solution. Using A3 reports, the team is prompted to summarize the entire issue on an A3-sized piece of paper, which allows for feedback among stakeholders. In this case study, project team

members who used the A3 with CBA approach made sure to understand why decisions were being made, and implemented a standard method of documenting, both who was involved in decision-making as well as what actions each person had to take in order to complete the decision.

Choosing by Advantages (CBA)

CBA was developed by Suhr (1999), and it has been adopted in lean construction because it enables design by providing a sound decision-making method to be used in alignment with TVD and after exploring alternatives with SBD, both of which can be documented in an A3 format. CBA ranks decisions based on their respective advantage and identifies both the values and costs of each alternative, demonstrating a transparent rationale for each decision. Several studies have demonstrated that CBA is superior to traditional decision-making methods such as Weighting Rating and Calculating (Arroyo et al. 2014 and 2016; Correa et al 2017; Schöttle and Arroyo 2017) and Analytical Hierarchy Process (Arroyo et al 2015; Arroyo and Molinos-Senante 2018).

The Last Planner® System (LPS)

LPS is a commitment-based production control system usually used in lean construction projects. In this project it was also used to coordinate design activities and schedule design decisions according to pull planning (Ballard 2000).

DECISIONS AS CONVERSATIONS FOR ACTION

In his book *Conversations for Action and Collected Essays* (2012), Fernando Flores writes about using action language to instill a culture of commitment in working relationships. He defines six basic speech acts: declaration, request, promise, offer, assessment, and assertion (Table 1). Understanding the nuances of each speech act can explain dysfunction in communication and shed light on decision-making outcomes. The coaches guided the team members in using the speech acts during their conversations about each decision. For instance, the project manager declared the goals of a particular design decision; the architect requested more information about the space requirements of mechanical systems; the project manager promised to have a conversation with the client; the mechanical engineer offered to research the attributes of the alternatives before the next decision meeting; the mechanical engineer assessed how an alternative mechanical system would work in the future; and the mechanical engineer asserted facts on how different equipment operates. These conversations shape the decision-making conversation and help the team to ask questions and explore alternatives in a more collaborative fashion.

Design decisions are futuristic by nature and therefore design thinking, or an opinion that a design concept is appropriate for the circumstance, is characterized as assessment. The assessment (design) may be grounded or ungrounded.

In addition, futuristic thinking, or the “view of the future” is influenced by the mood (Flores, G. 2016), of the team. Coaches constantly observed the mood of the team, and looked for ways to cultivate productive moods.

Table 1: Speech Acts (Flores 2012)

Act	What it Does	Elements
Declare	Open a new world for action	Infers authority
Assess	Open new possibility or prepare for action	Futuristic, grounded, or ungrounded
Request	The speaker is asking a potential performer for action around a concern	Conditions of satisfaction, background of obviousness, time
Offer	Performer promises to care about something he/she perceives the listener to be concerned about	Same as request
Promise	Commit self/enterprise/team to bring a new Condition of Satisfaction	Same as request
Assert	Speaker reports facts and is prepared to offer evidence	Report of fact

RESULTS

This section presents the decisions that were made using lean principles and the results on this project. Table 2 shows a list of decisions that the team made collaboratively using SBD to explore alternatives, TVD to refer to project targets, LPS to manage the timing of the decisions, CBA to guide the decision-making process, and A3s to manage the discovery process and to validate the design team recommendations to the owner.

Table 2: List of design decisions documented.

#	Decision Title	#	Decision Title
1	Modular vs. Non-Modular IDF Closets	13	Soils Management
2	Cistern Single vs. Double Walled Construction	14	Select the Mix of Fill Material for Basement Perimeter
3	L2 Zoning Requirements for Open Office and Enclosed Studios	15	Auger Pressure Grouted vs. Precast Concrete Piles
4	Modular vs. Non-Modular Approach for Distribution Electrical Rooms	16	Access to Basement Bike Storage
5	Exhaust Locations for Basement AHU's	17	Security and Maintenance Railing at CUP Opening
6	Underground Infrastructure Support on Suspended Slab	18	PG&E Access to the Main Electrical Room
7	Cistern Sizing Evaluation	19	Location of Outdoor Fitness Area
8	Energy Pile Evaluation	20	Safety Protection at CUP Opening
9	Day 1 vs. Day 2 Lab Loads - Building System Assumptions	21	Return HVAC Zones at L1 and L2
10	Waterproof Membrane Evaluation	22	L1 Zoning Requirements for Conference Rooms
11	Vapor Intrusion Evaluation	23	First Flush vs. Pre-filtration for Canopy Drains
12	Vapor Mitigation Strategies	24	Design of Underground Utilities to Prevent Settlement Displacement

The quantitative results presented in this section are according to the client's own calculations of the initial cost of the baseline design. The design budget and value changed along with design decisions and improvements to the baseline design. In most cases the project cost decreased after a decision, but in two instances the cost of an alternative increased as the team selected the alternative that maximized value for the client. Figure 2 shows the variation of project cost with each decision made over time.

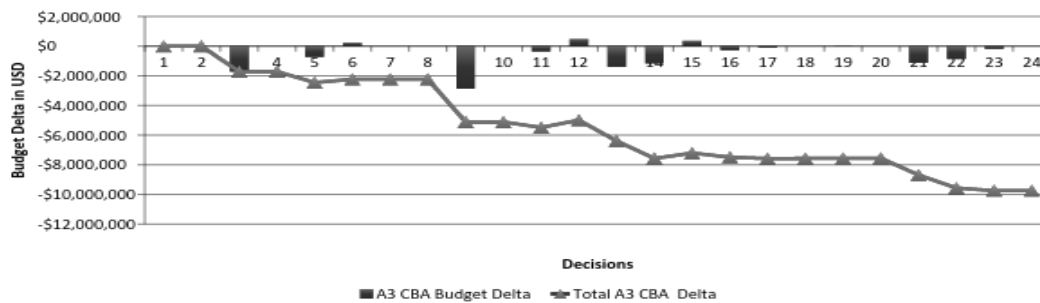


Figure 2: Project budget after each collaborative decision.

Figure 2 represents the last 24 decisions where the A3-CBA system was fully implemented. Most decisions resulted in cost savings; in total all A3's documented decisions resulted in approximately \$9.7M in savings or 11% of the budgeted amount for these items. The process resulted in \$96,468 in savings per meeting or \$12,596 in savings per meeting hour. In terms of time invested for each decision, early A3's with CBA averaged 5.3 meetings per decision and reduced to 3.3 meetings per decision representing a 37% meeting efficiency increase. The design team members came to the meetings more prepared and developed a common language by which they more effectively communicated how to make decisions as well as why they were making the decision. Ultimately, as lean methods and conversations for action helped the team create a new collaborative practice and project managers were able to lead conversations and decisions, less intervention from coaches was required. The new process minimized future negative iterations and led to changes in habits. For example, teams began to cancel meetings when key participants didn't show, when there was missing information, or when people were unprepared.

DISCUSSION

Design teams reported increases in client satisfaction; better decision documentation; and more lasting, logical and reasonable decisions with increased design efficiency and velocity. The teams developed increased trust and respect and were better able to work together across contractual lines.

There were a number of barriers in implementing the A3 with CBA approach. Project participants expressed reluctance to adopt a new process with unproven results. There was initial confusion about A3 requirements and how they applied to the decision-making process. Early-stage meetings were time consuming and project participants felt they were "wasting time". Ironically, their dedication to inefficient work processes tended to

waste more time than it would take to a new methodology. Then the A3 with CBA approach started to work, the participants began to take ownership of the decision-making process. They were more prepared for meetings, and were able to define clear roles and make commitments to move forward, even if they lacked information or learned that they did not have a shared understanding of the problem. In addition, CBA helped them to have productive conversations, avoid tangential discussions, and focus on differentiating facts from opinions. They developed a shared understanding of the criteria for judgement, and how to compare the advantages of alternatives based on the project context.

The relevance and importance of coaching became evident as the decision-making process was contextualized as a time for conversation. Decisions shaped by these conversations came to be seen as commitments to a common vision of the future. This resulted in live conversation coaching in an environment where the team was learning at a fast pace despite the project managers' limited prior training in how to guide a team through this decision making process.

The relationship between moods and decision-making became evident as team-members' moods affected the direction and outcomes of conversations. Moods are contagious. And, effective group leaders can navigate turbulent moods and encourage positive moods to allow for new opportunities, improved productivity, and satisfied clients and stakeholders. It is important that the design team has flexibility in their decision-making methods and that conversations have space to develop based on new opportunities rather than being mechanical in nature. Initially, the mood of the team was one of confusion and distrust. However, the opportunity for design specialists to discuss useful distinctions between alternatives established clarity and trust among team members and fostered a mood of resolution that allowed them to move forward and feel a sense of accomplishment and ownership of the design process.

Many opportunities for improvement are evident. We observed a clear need for increased training on decision-making methods at the earliest possible time in the project. Additionally, while lean methods improved the results of this particular team adoption of lean methods across the project would have increased the benefits to the client. Improvement opportunities were missed.

CONCLUSIONS

This research is based on observations of the implementation of CBA with A3s in a large complex project. These observations were made while coaching the decision-making process as conversations for action. This case study answered two research questions. Firstly, that the impact of implementing A3 with CBA systematically on a project is quantifiable in measurements of 11% savings on budget and a 37% increase in meeting efficiency. The qualitative benefits reported by the team were increasing value for the client and improving their overall performance. Secondly, when coaching the decisions of a team as conversations for action we observed that implementing A3 and CBA evolved the mind-set and mood from one of confusion to one of resolution. Finally, qualitative data suggests that the results on costs savings and meeting efficiency would not be possible by mechanically implementing CBA with A3. The team's initial adoption of A3

and CBA tools were ineffective until the team was coached into the mindset of language action. The conversation process facilitates full and proper utilization of lean tools, although more research is needed to fully understand the impact of conversations and moods on the decision-making process.

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