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Causes and Effects of Rationale Clarity in AEC Design Projects

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Abstract

Managing consensus on novel building design processes is difficult because industry tradition engenders self-interested behavior by project participants and discourages designs deviating significantly from precedents. Whereas a traditional decision analysis provides a structured *conversation* leading to *clarity* of action, we have observed that the system of checks and balances in AEC conceptual design projects pre-requires a structured *collaboration* leading to *consensus* of action. The paper presents a set of propositions about the potential effects that using a clear rationale may have on the project and industry.. This paper uses theories of organization, social psychology, management, and management science to form a theoretical argument that building and maintaining consensus in AEC conceptual design using a rational, explicit, socially constructed design rationale is possible and tends to improve outcomes. The paper concludes with a discussion of findings from several ethnographic and intervention studies supports the view that, independently of hypothesized improvements to the exploration and evaluation of design spaces, improvements to consensus management justify socially constructing clear, decision-based design rationale models in AEC conceptual design.

Comment [jh1]: the big idea in this paper:
A list of theorized or observed effects, and ways to measure them, that we gathered through literature review and ethnography

The paper currently takes way too long to get to these, and the reader needs to work WAY to hard to decipher them. Looking at the subject headings, one would never guess that this is the purpose fo the paper.

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Motivation

Intuitively, in this paper providing a clear rationale means developing a broadly available and understandable reason supporting a major AEC design decision (such as choice of steel vs. concrete structure, under- vs. above-ground parking, or LEED Gold vs. Silver certification). This section explains the need for a common definition of clarity in the rationale for AEC conceptual design decisions. Intuitively, every building and infrastructure project includes a conceptual design stage, in which a team decides on one of several alternate configurations. Stakeholders, designers, regulatory gatekeepers, and management work together with some purposes in common and some at odds.

Projects vary, but this paper nevertheless finds a common language for comparing many of them: Although teams vary, this paper defines a set of roles that participants in every project play; Although buildings vary, this paper defines a set of attributes that each possess; Although decision making methods vary, this paper defines a set of elements that each contains; and although methods for documenting a decision vary, this paper defines a set of measures that identify and compare clarity.

This paper focuses on the conceptual design of AEC projects, but draws on related issues such as the organization of construction work. Conceptual design is cognitive, rather than physical, and it commits most of the project's resources, even though those resources aren't transacted until later stages. Shaping decisions early in projects therefore have a leveraged effect on total project performance [Miller and Lessard 2001].

We interpret existing theory to develop a sequence of propositions, lemmas, and corollaries <unless lemmas and corollaries only refer to theorems, and theorem is not the right word> about the relationship between formal, rational sensemaking methods. <Argue this is a collaborative data model and rational sensemaking method of assessing, and build consensus about, design decisions Using formal propositions is consistent with the paper's focus on measurement. Future studies might determine conditions where these statements tend to hold, and where they are invalid.>

Comment [jh2]: We do? Is this important? This paper says it is doing to many things in too many places.

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Existing Methods that Provide Rationale

The AEC industry contains many individual methods developed to help define organizations, propose goals, generate options, perform analyses, and make decisions. A design process must bring together the right people to define and execute the right information and processes at the right time.

Typical Practice: Precedent-Based Design

AEC Projects have difficulty generating options systematically and transparently - The project team investigated nine options, but developed only two in detail, and provided a written specification for just one. The documentation does not provide explicit relationships to the descriptions of the material properties of each option needed to assess the owner's material responsibility goal, and no explicit relationships to the other seven options is given in the final set of documents. Conclusion: Project teams lack social, formal methods to generate and manage large numbers of options.

Options: On AEC projects today, designers generate individual designs, but are unable to manage large spaces of solutions. Parametric computer-aided design is used to create and manage geometric dependencies within a model (Shah and Mäntyla, 1995). Parametric tools transform designers from creators of prototypes to creators of design spaces. Academia and industry are beginning to use parametric tools in AEC (i.e., Burry, 2003); however, parametric tools' adoption for conceptual design has been slowed by a steep learning curve and by a lack of integration with analysis processes. Figure 5 illustrates a parametric model that my PhD student Victor Gane built while working with architecture firm Skidmore Owings & Merrill (Gane & Haymaker, 2007). Barriers to parametric modeling's adoption are lowering; many architectural programs, including Stanford's, now teach parametric design in studios. Parametric design is enabling knowledgeable designers to generate infinitely many possible design options, and BIM is enabling them to represent these options to be analyzed for a number of criteria. Several industry-specific schemas, such as aecXML, gbXML, ecoXML, and Industry Foundation Classes, are emerging to enable new links between parametric tools and analysis tools. Project teams need a better way to define and communicate all of these options and to manage their relationships to the designers that generate them, the analyses performed on them, and the decisions made about them.

AEC Projects have difficulty analyzing options systematically and transparently - The project team based some of the performance numbers on systematic analysis. For example, the contractor used the steel specification and 2D plans to generate a reasonable estimate of the cost of the steel design. However, not all analyses were as systematic. For example, no explicit cost estimate was generated for concrete, and while the call for proposals by the client stated "Material Responsibility" as a high priority goal, the performance of the design in terms of this goal was not analyzed or evaluated before a decision was made. The project team did not formally represent the relationships between the +3 to -3 scores for each option and the more detailed supporting analysis. For example, it is not possible to retrieve the cost analysis on which this numeric assertion is based. The documents do not indicate the certainty of the analyses, and in many cases no supporting documentation was produced for an analysis or evaluation. Conclusion: Project teams lack social formal methods to communicate and manage large numbers of analyses.

Analyses: I have previously summarized academic work in AEC design analysis automation (Haymaker et al., 2004b). With increased computing power and the communication enabled by BIM, automated analysis of buildings for a wide number of criteria is becoming more common in practice. The General Services Administration shows how far the industry has come by calling for "a project to automate validation of new courthouse Building Information Models (BIM) for compliance with U.S. Courts Design Guide requirements" (GSA, 2007). These design guide requirements are very broad, covering issues of sustainability, security, program, and aesthetics. Project teams need a better way to manage all of these analyses and their relationships to the organizations that perform them, to the options they were performed on, and to the decisions they help enable.

A survey of the engineers in an acclaimed international engineering company reinforces these observations (Flager & Haymaker, 2007). We found it takes engineers seven weeks to perform a first full design and analysis iteration, and five weeks for subsequent iterations: On average, they are able to generate and analyze fewer than three options rigorously during conceptual design. They also spend almost sixty percent of their time managing information and processes, and only forty percent of their time actually planning or performing value-adding design and analysis work.

Existing Methods that Clarify Rationale

This section addresses Moran and Carroll's [1996] questions, "How domain-specific are various design rationale methods?" and "Will design rationale techniques scale up to and be suitable for real development contexts?"

AEC design differs from mechanical engineering and consumer products in many ways, and comprehensively listing them is outside the scope of this paper. However there are differences worth noting because they are particularly relevant to the argument for design rationale.

In consumer and industrial products, the purchasing decision occurs after the product is built, which enables changes to marketing based on design changes. Buildings are geographically fixed, which limits the usefulness of transferring rationale elements among projects.

In AEC, the build/no-build decision occurs just once, while the building features' effects are felt over subsequent decades. This emphasizes directly involving designated representatives of

stakeholders who *will be* affected, rather than focus groups reflective of people who designers *may choose to* affect after the product is built.

Existing Methods that Clarify Rationale

This section addresses Moran and Carroll's [1996] questions, "In their natural modes of practice, do designers spontaneously capture information that we might consider design rationale? How do they do it, and why do they do it? … Can these natural points of reflection, telling, and accounting in the design process be used to generate explicit design rationale?"

AEC Projects have difficulty making multidisciplinary, multi-stakeholder decisions systematically and transparently - The design team did not use a formal process to make the decision to use steel. They did not explicitly consider the relative importance of different goals, or the certainty of analyses. For example, from these documents, it is not possible to know the amount steel prices would need to increase to make concrete a preferred choice. The design team's description fails to capture important information that is a factor in the decision, such as the importance of individual goals and the certainty of individual data or analyses. From these documents alone, it is not explicit which option should be chosen; the design team must narrate these documents. Conclusion: Project teams lack social formal methods to make and manage decisions.

On AEC projects today, organizational charts are common, but formal organizational models are not routinely built and maintained. Projects need more systematic and transparent ways to communicate and manage organizations of stakeholders and designers. Models like Virtual Design Team (VDT) (Levitt and Kunz, 2002) enable a planner to model virtual organizations of individuals; relate these individuals to design processes the individuals must execute; and simulate and evaluate the organization's performance on the processes. Should additional uses for organizational models be found, the benefits may overcome the costs of constructing and

maintaining them. AEC Project teams need a better way to collectively build and maintain models of designers and stakeholders, and relate these to project goals to represent organizational preferences, and to options, analyses, and decisions to represent organizational roles in these processes.

Decisions on AEC projects are made generally using partially structured methods. Recent methods are evolving to help make these processes more transparent and systematic. For example, the Decision Dashboard methodology (Kam, 2005) enables multiple disciplines to decide among project options and to manage and communicate these decisions. Represented in Decision Breakdown Structures (DBS), decision information includes decision topics, criteria (goals), competing sets of options, alternatives, and their relationships. The DD makes the relevant information explicit and available for stakeholders to manage and communicate their decisions. AEC projects need a way to integrate these formal decision methods into a methodology that helps them define and weigh goals, generate options, analyze these options, and to visualize the multi stakeholder multi criteria tradeoffs.

AEC projects have difficulty defining organizations systematically and transparently. While the architect, engineer, and owner each kept an organizational chart of their own teams, no detailed holistic model was constructed and maintained to communicate who the impacted stakeholders and the relevant designers were, and what their roles were in the decision-making process. The owner assigned staff to understand and represent stakeholder interests, but students' and maintenance workers' goals were not explicitly considered in the decision. Project teams thus lack social formal methods to define and manage multidisciplinary, multi-stakeholder organizations.

Difficulties in Developing Preference Clarity in Current Practice

Effects of Contract Incompleteness

This section addresses Moran and Carroll's [1996] question, "Can management rationale, as well as technical rationale, be made explicit? How does this affect the design process?"

> *Proposition 1 Projects tend to clarify design rationale related to contractually specified goals, compared to contractually unspecified goals assessed formally to have the same stakeholder preferences.*

Management and designers formally often communicate preferences and constraints through contracts designed for legal enforceability. Many governments, for example, require selecting the lowest price bid in an attempt to combat a long tradition of contract politicization [Chandler].

> *Proposition 2 Design decisions tend to weigh clear goals more heavily than opaque goals assessed formally to have the same stakeholder preferences.*

> *Proposition 3 Design decisions tend to weigh contractually specified goals more heavily than contractually unspecified goals assessed formally to have the same stakeholder preferences.*

Contractual reliance on traditionally clear goals focuses design rationality on previously identified attributes with broadly accepted measurement methods for holding firms accountable. Stipulating a building's required sustainability using the concrete LEED™ rating system also promotes the importance of building performance attributes identified before the project began.

Proposition 4 Projects that measure rationale clarity tend to develop clearer rationale.

Legal and accounting costs, procedural ambiguities, and litigation risk diminish the attractiveness of designing novel contracts that formally consider traditionally less important building attributes.

Institutionalizing the broad identification and quantification of stakeholder goals may help encourage considering those measures during the letting of contracts.

Over time, bid review processes' tendency to consider only the few goals with industry-standard metrics may hinder the industry's learning to design and construct significantly different buildings that meet new and important stakeholder preferences. In the absence of competition from entrepreneurial firms, however, companies have little incentive to invest in, therefore little experience with, therefore little ability to design, systematically underrepresented features.

Even perfectly well-intentioned project participants tend to have different information that suggests different social welfare functions. There is a need, therefore, to assess and reward for the quality of a decision, not the quality of outcome. This argues for clarity in the decision as an incentive leading to better organizational learning.

Proposition 5 Projects with participants related through social ties tend to develop similar degrees of clarity.

Firms tend not to recognize the importance or even existence of features that are imprecisely defined or omitted from traditional processes such as contract letting decisions <due to "blind spots">. Highly embedded teams incur added risk of all failing to identify the same information and therefore failing to adapt well to the same exogenous shocks [Uzzi 1997].

Firms that do identify underrepresented, novel building goals will tend to consider them threats to be subjugated, rather than insights to be accommodated, because they challenge the functioning of existing structures [Cite inertia]. These systematic oversights and maladaptations help define an entrepreneurial opportunity in AEC.

Preference-Setting Processes Atrophied

Learning project-specific stakeholder preferences is one of the competencies that current events have rendered inadequate. In modern times, the built environment affects stakeholders in far more complex, dynamic, and uncertain ways than just ten years ago (for example, after 9/11, security is a greater concern; after *An Inconvenient Truth*, environmental stewardship; and after Katrina, extreme weather).

Competence-destroying discontinuities are changes that decrease the productivity of existing business functions. These changes can render incumbents' existing organizations, processes, and resources obsolete. Incumbents will typically have difficulty adapting, while new organizations can exploit the best organizational and technical solutions with less inertia. The resulting failure of older organizations frees up resources available to newcomers, enabling them to survive and grow more rapidly [Tushman and Anderson 1986].

The 9/11 elevation of security, the post-"Inconvenient Truth" elevation of sustainability, and the post-Katrina elevation of extreme weather events all represent competence-destroying discontinuities. The built environment affects stakeholders in far more complex, dynamic, and uncertain ways than just ten years ago. The widespread and powerful public reactions to these

events decreased the effectiveness of firms' traditional method of assessing slowly changing preferences of a few stakeholders.

Preference-Setting Dispersed

Stinchcombe [1959] viewed tract home development as providing standardization of product parts to satisfy preferences (primarily cost) set by administrators, whereas traditional development provided standardized process tasks to satisfy preferences set by clients. Stinchcombe used this analysis to claim that "Goal-setting arrangements can be changed drastically without changing the administration of work in a bureaucratic direction." This claim suggests that projects can organize so that new sources define preferences without harming the clarity of rationale. In particular, the greatest legitimacy for defining groups' preferences comes from individual stakeholders and their representatives.

Rational administration requires "communicating at least the goals to be reached by subordinates and of seeing that these goals are accomplished" [Stinchcombe 1959].

Proposition 6 Projects stating clearer preferences tend to produce buildings satisfying those preferences more than other projects assessed formally to have the same stakeholder preference strength.

Preference Assessment

Preferences are Subtle

Preferences regarding uncertain events, such as earthquake casualties, may suffer from stakeholders' tendency to base probability assessments on events' representativeness (Kahneman and Tversky 1973). This underscores the importance of transferring uncertainty from goal statements (therefore preferences) to designer analyses, such as by defining a goal of "casualties," rather than "earthquake casualties," and delegating the assessments of earthquake probability and effects to domain experts.

People tend to underestimate the power of our psychological "immune system" to adjust expectations and stabilize emotions after conditions worsen (Gilbert et al. 1998). Stakeholders may therefore tend to weight routine detrimental effects of building features more heavily than their actual effects will be once the building is complete.

Clarifying preferences can require navigating numerous moral dilemmas, such as the risk of death, (Howard 1980) and cognitive difficulties (McNeil et al. 1982), such as decisions involving unlikely (Howard 1989) or distant future losses (Paté-Cornell 2006). In addition to the challenge of helping stakeholders navigate these dilemmas, different stakeholder groups hold beliefs regarding life hazard rates that differ greatly from one another and from actual hazard rates (Scientific American 1982 Error!).

Expert public and private agencies greatly differ on the concrete value assigned to human life, although there is hope of eventual agreement (Graham and Vaupel 1980, Paté-Cornell 1994).

Delegating the valuation of life hazards to expert, rational analysts, however, risks failing to consider authentic stakeholder preferences regarding risk attributes. For example, Slovic et al. 1983 compares preferences for risks that are natural vs. man-made, voluntary vs. involuntary, and ordinary vs. catastrophic.

Proposition 1 Preference statements tend to be clearer regarding morally trivial outcomes

Revealed Preference Models

A *revealed preference model* infers preference from observed behavior [Wassenaar et al. 2006]. Many things affect behavior that stakeholders may not wish used by proxy decision makers. For example, the stature of a product endorser affects consumer choice [], but it is hard to imagine people instructing a representative to base decisions on the perceived quality of an endorser. In these cases, revealed preferences might serve as a starting point for the model.

Research on consumer preferences, like research on design rationale, is concerned with revealing personal views of product features. For example, conjoint analysis extrapolates consumers' stated pairwise comparisons to assess preferences between pairs of alternatives that consumers have not explicitly considered. Consumers' stated pairwise comparisons are typically inconsistent, to varying degrees, and therefore contradictory to the axioms of rational choice. Inconsistent preferences are unsuitable for decision making because they enable exploitation, over time, as a "money pump." It can fall to analysts, therefore, to make rational sense of conjoint analysis results.

Whereas market research aims to forecast consumer responses and choice behavior, a design rationale's purpose is to explicitly establish the relative strength of product features for decision making. The representation of preference must be simple enough for the stakeholder group to understand and feel confident of, and yet consistent so that its implications are similarly acceptable. Analyzing pairwise comparisons statistically to produce a single preference function harms a design rationale's transparency and consensus of action. Because using the inconsistent results of pairwise comparisons thus limits a design rationale's clarity, this paper proposes an alternative method of preference assessment.

Stated Preference Models

To establish clarity and consensus, therefore, the preferences in a design rationale can derive legitimacy from having stakeholders themselves, or their clearly authorized representatives, making the difficult tradeoffs among all project goals explicitly.

Although assessing stakeholder preferences requires a similar effort to marketing [Cite], the purpose, and consequently the appropriate methods, differ. In marketing, the goal is to affect consumer decisions by matching the product perception and consumer desires. Understanding stakeholders' most abiding feelings are less important because stakeholder perspectives that abide after the transaction are generally less important.

Design, by contrast, seeks to assess how genuine satisfaction will result for stakeholders over the building's entire life. Assessing clear preferences consists of learning how a stakeholder clearheadedly wishes decisions made.

A *stated preference model* relies on explicit stakeholder testimony regarding preference. Due to politics, ambiguity, or other reasons stakeholders are sometimes unwilling or unable to provide precise values. Mellers and Locke [2008] review behavioral decision results and methods for reducing errors.

Our preference survey respondents have often expressed that the search for clear preferences involves hard, personal thought. Several respondents have also expressed that the survey's difficulty corresponds to its value for both decision assistance and personal growth.

Assessing Preferences is Subtle

Proposition 2 Preference statements tend to be less clear than design analyses

Assessing preferences requires considering a broad range of application-specific psychological phenomena (Kahneman and Tversky 1984, Keeney and von Winterfeldt 2007, Nau 2007). Psychologically, preferences can materialize even before conscious thought (Zajonc 1980). Preferences may be difficult to ascertain, therefore, in a survey requiring the quantitative comparison of competing motivations.

Research has shown factors seemingly unrelated to decisions at hand affect psychology so strongly that humans appear to be not rational. It may be, instead, that research simply has yet to discover how our minds formulate the basis for decisions. Regardless of the limits of human rationality, practical modelers seek "convincing" preferences that authentically reflect statements of affinity, rather than "correct" preferences that perfectly describe the merits of each outcome.

Proposition 3 Preferences procured using similar methods tends to be more consistent than otherwise

Research shows that variations in product presentation influence preference statements. Attitudes toward products stem from different attributes of presentation, depending on personal involvement. When people are highly involved, they rely on cogent arguments and product attributes, versus when people are less involved, they rely on the authority of a product endorser (Petty et al. 1983). Between argument number and quality, the number of arguments most deeply affects less involved decision makers, however the quality of arguments most deeply affects more involved decision makers (Petty and Cacioppo 1984). The following proposition claims that using consistent data collection methods helps minimize variation in data gathering.

Compared with human methods, such as interviews and focus groups, it is easier to ensure that automatic methods, such as computer or paper surveys, solicit results identically.

Using a clear rationale to present all option analyses using a consistent set of goals also minimizes these biases' potential to distort the perception of option quality.

Analysis of Sensitivity to Preferences

An alternative to stated and revealed preference models is to graph the sensitivity of decisions to different preference levels and identifying which preference values suggest which option. This process reduces the required precision for preference information from requiring an exact figure to requiring identification of preference as lying within one of several problem-dependent ranges.

Project Teams are Networks of Actors with Distinct Interests and Powers

A clear design rationale provides a medium for communicating between project participants. This paper explains how the rationale's clarity affects projects using a view of networks. Social networks consist of organizational actors, which are the individuals and teams performing various roles, and links, which are the relations through which actors communicate typically.

Project Teams have Separate Social Networks

Figure 4: Schematic of a Design Project's Social Network Each node represents a project participant, and each link represents a direct acquaintance. The project manager has access to each major group of participants – designers, gatekeepers, and stakeholders – and gains unique advantages from that position. This paper suggests that a clear design rationale best serves the project from the same position as project management, so that the same information benefits accrue broadly to the project.

Should the first proposition be something like "Projects tend to have dm, sh, gk, and ds)

Proposition 7 There tend to be many social ties within groups of designers, stakeholders, and gatekeepers.

Economic and social goals interact in forming each transaction; business relationships therefore connect broadly and deeply to social relations [Granovetter 1985]. Inasmuch as actors possess and exchange "social capital," this social structure renders competition imperfect; "Social capital is as important as competition is imperfect and investment capital is abundant" [Burt 1992 p.10].

Proposition 8 There tend to be few social ties between groups of designers, stakeholders, and gatekeepers.

In the network of social ties that connect people, "structural holes" are gaps that separate large groups [Burt 1992]. Compared to projects run within integrated firms, AEC projects' social networks are rich with structural holes; typical AEC projects' stakeholders, designers, and gatekeepers interact rarely before or after this project.

Proposition 9 There tend to be many social ties between project management and designers, stakeholders, and gatekeepers.

AEC project management, which includes consultants acting as facilitators, typically fills these structural holes.

Proposition 10 Project management derives greater power from connecting information and coordinating action between participants than others do.

Actors reap information and control benefits from facilitating communication and coordination across structural holes, and therefore provide a strategic position increasing rates of return on labor investment [Burt 1992]. AEC project participants with ties across structural holes can convey information selectively to advance their own agendas (see "Power is Partitioned," below). For example, a manager can communicate and emphasize those portions of stakeholder preference that match her own preferences, and ignore or otherwise understate those stakeholder preferences at odds with her own preferences, thereby forwarding the her own agenda while appearing to speak impartially on behalf of stakeholders.

Computers Act within Social Networks

This section addresses Moran and Carroll's [1996] questions "Who should have access to design rationale?" and "Can an explication of design rationale aid the communication between different stakeholders in the design process?"

There is a great deal of evidence that computers interact with people as social actors do [Nass], and that organizations behave as groups information processing agents do [Galbraith 1973, Levitt Management Science].

Proposition 11 Design rationale systems connecting information between all pairs of participants possess more strategic information and control power than others do.

Thinking of information technologies as social network actors suggests the systems will be the most productive when connecting to at least one member in each group of designers, stakeholders, and gatekeepers; That position fills the structural hole between the different AEC teams, which maximizes the system's information and control benefits compared with other locales.

Proposition 12 Project management derives less power from connecting information and coordinating action between participants when clearer design rationales independently connect information between all pairs of participants.

Power results from having greater influence than others [Pfeffer and Salancik]. The proposition above suggests that introducing a system that serves in the network position where project management once resided exclusively diminishes that role's power over other participants.

Disagreement, Dissent, and Legitimacy

Natural and intelligent processes select against individuals exposed for exercising illegitimate power, but select for individuals exercising illicit power without exposure.

Knowingly exercising the seemingly illegitimate forms of power described above may seem to contradict common social norms, however there is limited evidence for "generalized morality;"

[Cite Arrow]. A project's formal organization and social network structure transmits information that controls the very premises of member decisions [Perrow Error!], thereby enabling actions that seem illicit, even though they are not viewed as such by the actors themselves.

One factor sustaining the differences of view comes from social psychology's attribution theory. Attribution theory explores the phenomenon that different observers trying to make sense of the same human actions often interpret different causes and therefore respond differently. For example, people tend to attribute other's behavior to personal factors and ignore situational forces (this is known as the "fundamental attribution error" [Cite]). People also tend to attribute their own successes to personal attributes but their own failures to situational forces (this is known as the "self-serving bias" [Cite]).

In addition, the separation of AEC teams' networks also strengthens the moral hazard of knowingly violating commonly held norms: "Force and fraud are most efficiently pursued by teams, and the structure of those teams requires a level of internal trust – 'honor among thieves' – that usually follows preexisting lines of relationship … The extent of disorder resulting from force and fraud depends very much on how the network of social relations is structured" [Granovetter 1985 pp. 491-492].

Tightly collaborating teams tend to enforce conformity and incur greater risks as a result, but they can combat that tendency by encouraging dissent [Janis 1972]. To enable tight collaboration without incurring a "risky shift," an explicit map of design rationale can record and portray dissenting views. In particular, there are theory-founded methods of assessing, recording, and aggregating different experts' opinions of analyses [Clemen and Winkler 2008] and different stakeholder preferences [Cite Social Welfare].

Projects Generally Harbor Harmful Dissent

Providing a broadly understandable description of decisions and decision processes may help unify perceptions and preferences.

This section addresses Moran and Carroll's [1996] question "Will design rationale change the culture of designing?" This paper argues that a formal model of design rationale can increase consensus on the project, thereby enhancing the perceived legitimacy of decision making and the viability of formal decision making methods.

Self-Interested Behavior is Sometimes Viewed as Illegitimate

To a great degree, power in any organization rests with those tasked to absorb uncertainty. "Whatever may be the position in the organization holding the formal authority to legitimize the decision, to a considerable extent the effective discretion is exercised at the points of uncertainty absorption…uncertainty absorption is frequently used, consciously and unconsciously, as a technique for airing and exercising power" [March and Simon Error!].

It is difficult to conduct decision analysis impartially in organizations where every actor is expected to act in self-interest, rather than to collaborate impartially []. In AEC projects, participants are able, frequently willing, and sometimes expected to act illegitimately in pure self-interest using role-specific means:

1. Designers can influence design decisions by manipulating engineering analyses
2. Gatekeepers can influence design decisions by manipulating criteria for acceptability of designs
3. Stakeholders can influence design decisions by manipulating the definition of a building's purpose
4. Management can influence design decisions by manipulating the flows of information and control

Proposition 4 Participants tend to provide clearer data for information rather than for delegation

Proposition 13 Projects providing clearer design rationale tend to incur less illicit, self-interested behavior than other projects do.

Deciding to accept a clear rationale, which prevents these forms of illegitimate behavior, requires believing in a better outcome. It is possible for these teams to each believe simultaneously that it the most able to control design rationale, in spite of others' contradictory beliefs. After all, members of each team have limited information (and commonly have misinformation) regarding the others' parallel abilities and will tend toward ignorance of their own skill's limits [Kruger and Dunning 1999]. Acceptance of rationale clarity therefore relies on arguing that this isn't a zero-sum game- that all participants are likely to be better off with rationale clarity then they perceive themselves to be without rationale clarity.

To illustrate, we found it common practice for engineering firms to explain tradeoffs to the owner using a table with option rows and goal columns. The table absorbs the project organization's uncertainty about how different building systems perform by defining sets of goals and design options worth considering, and presenting analyses of how the options affect the goals. If the structural design team benefits from an owner choosing a particular structural system, changing the measurement scales and eliminating goals or options would guide the decision illegitimately to benefit the structural team rather than the other stakeholders.

Clearly, the goals contradict one another, and both statements are vague enough to provide "plausible deniability" if later information suggests they are in error. It is rational for teams to conserve their power by postponing commitments (such as these tables) to maximize the value of disclosure, even when it does not serve the rational goal of the project organization as a whole.

Proposition 14 Managing the design rationale development provides power from connecting information and coordinating action between participants.

Managing the design rationale provides numerous opportunities to influence decisions.

Proposition 15 Project participants derive more power from connecting information and coordinating action between participants who consider rationale management legitimate than between others.

We have found that each project participant can effectively claim legitimate ownership over only a subset of the design rationale.

Designer Legitimacy Comes from Professional Credentials

Analyses provided by different designers are often inconsistent, so it is necessary to assess how convincing the various sources are. Professional certification is a principal source of designer claims to legitimacy [Stinchcombe 1959].

Proposition 16 Professional designers tend to state clearer analyses than others do.

Proposition 17 Options that professional designers propose tend to satisfy more constraints than options that others propose.

Proposition 18 Options that professional designers propose tend to satisfy more preferences than options that others propose.

Proposition 19 Options that a gatekeeper proposes tend to satisfy more of that gatekeeper's constraints than options that others propose.

Proposition 20 Options that a stakeholder proposes tend to satisfy more of that stakeholder's preferences than options that others propose.

Proposition 21 Options that a stakeholder representative proposes tend to satisfy more of that stakeholder group's preferences than options that others propose.

Designer Self-Interest

From the standpoint of organizational evolution, the design team's organization and process must be sustainable. Typically, each Subteam has a specialization and competes in the market by working on projects using the design options that take advantage of that specialty. Proposing and favorably assessing technologies novel to the company jeopardize personal and financial relationships to material suppliers, brand, and strategic core competency. In addition, engineers typically prefer certain work practices and would require greater compensation if they weren't allowed the freedom to conduct the favored processes. At the same time, owner-facing design team representatives must appear dedicated to project success. This conflict of incentives for design team representatives routinely presents a range of moral hazards.

VDC methods can improve analyses perceived certainty and convincingness, however owners and stakeholders rarely understand the assumptions and approximations well enough to judge the results' legitimacy. This suggests that VDC typically reduces technical deception's range but increases its chance of success. Designers may resist the use of VDC by claiming that the assumptions do not hold or the approximations are unacceptable in their specialty.

Stakeholder Legitimacy Comes from Voluntary Delegation

Gatekeeper Legitimacy Comes from Office-Holding

Each gatekeeper's role limits the range of constraints that he or she may legitimately impose. For instance, on some projects the Chief Financial Officer may legitimately reject proposals on budgetary grounds, Chief Legal Counsel may legitimately reject proposals on liability grounds, and the Board of Directors may legitimately reject proposals on strategic grounds. In this case, a clear design rationale would include clear constraints based on budget, liability, and strategy.

Proposition 22 Gatekeepers tend to state clearer constraints than others do.

Although gatekeepers have final authority to judge options' validity, they might not clearly define the constraints they enforce. Gatekeepers have limited rationalities and therefore face similar challenges described above for designers and stakeholders seeking concreteness and completeness. To the extent that gatekeepers fear constraints may be viewed as illegitimate, gatekeepers may prefer not communicating constraints. This suggests the following proposition deserves direct investigation.

Gate decisions often involve similar power dynamics among individuals outside the project team. As large-scale construction firms rose in the mid-19th century US (first in railroads and later in cities), the letting of public contracts was a valuable form of political patronage [Chandler 1977]. The ubiquity of federal earmarks such as the "Bridge to Nowhere" [Cite] demonstrates that politicization of construction projects persists in the 21st century.

Building Consensus Using the Shared Goal of Rationale Clarity

Game Theory View of Design Projects

This section addresses Moran and Carroll's [1996] questions "Can the fast-moving tactics of a multiparty design process be captured? Does doing this affect the tempo of the design process and its concomitant tactics?"

Chanron and Lewis 2006 discuss cooperation in decision-based design. "Having several distributed design teams creates coordination issues … individual teams have a limited vision of the overall product and process …as a result, the individual design teams tend to privilege the optimality of their own subsystem, rather than the optimality of the overall product." [p. 282] <This seems to require additional reasoning to match a linear model of feature combination.>

Hermann and Schmidt [2006] provide a game theoretic analysis of how design decision coordination leads to convergence or divergence. Hermann and Schmidt 2006 provides several references [p.283] for the game theoretic formulation of distributed design decision making.

"Designers, architects, engineers, developers and builders each make decisions that serve their own interests, but create huge inefficiencies overall" [Bernstein, from Hermann and Schmidt 2006 p.282]. Establishing a common design rationale requires the three teams to "disarm" multilaterally by relinquishing illicit forms of power.

"This is the classic 'tragedy of the commons.' … Although prudent cooperation among design teams would increase overall optimality of the product, maximization of individual subsystems is standard. Cooperation increases collective success but usually at the cost of individual success." [Hermann and Schmidt 2006] Like a three-player "prisoner's dilemma" game, disarming unilaterally harms each actor (and jeopardizes its achievement of unshared goals).

To formulate a Bayesian game representing the AEC conceptual design decision (including all stakeholders, not just designers), we can consider the actions of stakeholders as their statements of preferences, the actions of designers as their statements of analysis, and the actions of gatekeepers as their statements of constraints. Each player (stakeholder, designer, or gatekeeper)

is uncertain about the other players' payoffs (preferences) and there is just one payoff (provides each player with utility based on the option the team decides upon).

Consensus on Rationale

One way of fighting attribution errors and self-serving biases is to provide a standard decision rationale. A formal rationale map's purpose is to form the basis of these requirements- to reveal information about each member's choices. A standard explanatory model, such as the rationale map, may help fight differences of opinion, such as attribution errors, by providing a shared understanding of all participants' circumstances.

Truth-telling Sometimes is the Best Policy

This section addresses Conklin and Burgess-Yakemovic's [1991] questions, "How can the sincerity of the design rationale authors be ensured? Can it be ensured? … What keeps [the design rationale] from becoming a tool of organizational politics?"

Psychological research on the "prisoner's dilemma" has found explicitly describing games as cooperative, rather than competitive, increases the likelihood of cooperation [Kay and Ross 2003].

This aim is typically difficult to achieve, in part because it requires a formal definition and method of verification. Institutional arrangements can substitute for trust [Granovetter 1985], and team members may view clear public commitments as more credible.

The Revelation Principle is an essential tool for designing games like this, in which players have private information. The principle indicates that one can design a game in which telling the truth about preferences is players' best strategy (technically, "Any Bayesian Nash equilibrium of any Bayesian game can be represented by an incentive-compatible direct mechanism" [Gibbons 1992 p.165]).

Unfortunately, the only Nash Equilibria in the Prisoner's Dilemma and Commons Tragedy have bad payoffs for all players. The challenge before project management is therefore to alter the game so that there is a better Nash Equilibrium.

This paper next explores the view that the payoff results from requiring participants to commit publicly to rationality and social welfare itself as a goal deserving loyalty. This public commitment enables holding participants accountable to truth-telling via the threat of exposing now-clear illegitimacy using modern social networks.

Consensus on Rationality and Social Welfare

Multiple interacting organizations' ideologies of rationality – what they consider rational – affect institutional change and grievance procedures [Edelman et al. 1999].

Using a design rationale map may help define such an ideology for the project, based on the rational decision making view, where previously companies previously lacked consensus.

When there is a shared model of rationality- as an explicit design rationale map provides, for example- there is a shared set of simple stories explaining rationality, and therefore there is less likely to be misunderstanding that leads to litigation.

The superordinate goal this paper advances is of adopting a specific notion of design rationality, using a fair process to arrive at consensus about the best design decision. Establishing a common model of design rationality and using a fair process to build consensus on a specific project's rationale can better incorporate goals that designers, stakeholders, and owners all share (such as global sustainability or national security) and can help unify even a previously factionalized team.

This suggests that widespread knowledge that clear rationales incorporate the principals of rationality within the project structure will increase the project's resources and survival capabilities. Intuitively, participants in the organizational field will perceive the project as more legitimate.

Proposition 23 Project participants embrace the theory of rational decision making.

Almost without exception, the owners, designers, and stakeholders we worked with embraced the specific, decision-analytic notion of design rationality that we advanced. <provide a quote from a stakeholder, designer, owner, and project manager.>

Kleinmuntz also finds that transparency aids consensus: "Because the reasoning behind these resource allocation decisions is transparent, there is a sense that everyone is on a level playing field. This promotes consensus around the recommendations that emerge" [2008 p.414].

Kleinmuntz testifies that clients perceive value in providing a transparent process "In the best spirit of decision analysis, it is the sound and logical nature of the process that gives the participants confidence that scarce resources are being put to the best use" [2008 p.414]

Proposition 24 Project participants embrace the theory of social welfare functions.

<discussion of workaround using equal weights>

Proposition 25 Project participants embraced specific social welfare functions for information, not decision making.

Proposition 26 Clarifying project rationale data and processes within the project team aids consensus building.

In every project, participants refused to provide information for forming a social welfare function. Reasons cited include uncertainty, fear of retribution for slighting stakeholder groups, and discomfort with the lack of clarity in the model (although the weighting function's clarity, as this paper defines it, matched that of other rationale components).

Highlighting Disagreement Tends to Reduce Coherence

Drawing attention to differences among participants, such as stakeholder preferences or designer analyses, may increase the alienation between groups previously relying on ambiguity for coherence. This difference of opinion can cognitively enable behavior previously seen as illegitimate [Bandura 1990]. Attempts to develop consensus through explicit dialogue may thus backfire, polarizing a community once held together by ignorance.

Drawing attention to differences of view can lead to a destructive sequence of reasoning, from moral "justification, palliative comparison, and euphemistic labeling" to "minimizing, ignoring, or misconstruing the consequences" of actions, such as design decisions, to "dehumanization,

attribution of blame" that displaces responsibility for harmful results onto the victims themselves (Bandura 1990).

Proposition 27 (A,B,C) Providing a rationale with inconsistent constraints (preferences, analyses) tends to decrease gatekeeper (stakeholder, designer) coherence.

Highlighting Agreement on Procedural Fairness Tends to Increase Coherence

This section addresses Moran and Carroll's [1996] question "How can designers be motivated to create design rationale for the future benefit of later players in the design life cycle?"

Proposition 28 Defining rationale clarification as a collaborative effort to improve procedural fairness decreases illegitimate behavior.

Proposition 29 Participants in projects defining clear rationale tend to view the process as fairer than participants in other projects do.

One method of combating polarization is to establish the importance of a "superordinate goal." Communities once deeply divided can be united to work effectively together toward a purpose viewed as more important than the differences among individual members (Sherif 1966). In psychological studies, playing the simple Prisoner's Dilemma game results in more cooperation (and social welfare) when first framed explicitly for players as cooperative versus competitive (Kay and Ross 2003).

Proposition 30 Defining rationale clarification as a moral imperative increases the project's perceived legitimacy.

Having an institutionalized method of clearly and publicly assessing and addressing contemporary, dynamic stakeholder preferences is a powerful source of moral legitimacy.

Proposition 31 Defining rationale clarification as a moral imperative creates greater project organization's coherence than defining rationale clarification as dispensable does.

Moral legitimacy (along with power and wealth) provides internal discipline and outside consent for the firm's actions [Stinchcombe Error!]. Assessing stakeholder preferences can therefore provide a durable competitive advantage during periods of industry turbulence.

Establishing rationale clarity as critical for continuing a project will therefore tend to unite project participants who want to maintain their roles but disagree over less important matters. These theories suggest that adopting a formal design rationale benefits from presentation as necessary for project success, rather than valuable but dispensable.

Rationale Clarity Affects Project Perception

Proposition 32 Clarifying project rationale data and processes outside the project team aids consensus building.

"Organizations that incorporate societally legitimated rationalized elements in their formal structures maximize their legitimacy and increase their resources and survival capabilities" [Meyer and Rowan p. 53]. Organizations are more likely to survive if they receive legitimacy, social support, and approval from actors in the organizational field [DiMaggio and Powell 1983].

Positive engagement of future project participants and stakeholder groups relies, in part, on the engagement of third party analysts such as news media and community group leaders. Engaging third party analysts can increase the perceived legitimacy and, therefore, the market valuation of companies [Zuckerman 1999].

A clear rationale addressing projects' individual and comparative merits can clarify and legitimate third party analyst claims and thereby enhance their reputations of relevance and impartiality. This can make covering projects cheaper and more likely, which can increase the perceived legitimacy and trust of potential partners in later projects. Moreover, to the extent that analysts' accuracy promotes the continuation of audience engagement, those analysts using accurate information formal maps provide will compete more effectively for audience attention.

How Project Organizations Create Truth-Telling Nash Equilibria (Consensus)

The penalty for failing to adhere to the norms of a rational rationale can create a Nash Equilibrium based on truth-telling. In addition to considering the current project stage, participants must consider how their choices will affect later stages of the project, other projects, and lives outside work. Acting consistently with a clear, rational rationale may enhance the strength of long-lasting social ties based on shared norms of rationality and social welfare. The social capital from acting consistently with the rationale can outweigh considerations based on project-specific preferences. In addition, these actions can support a consistent, noble self-image, which is a fundamental driver of decisions and psychological well-being [cite work on consistency]. When all participants accept using a clear rationale, deviating individually from that behavior jeopardizes all the social capital invested in the project. In addition, members previously able to exercise illegitimate forms of power are at greater risk of exposure, thus jeopardizing their relationships with home organizations. For example, designers risk losing their jobs or licenses, gatekeepers may risk being terminated, and stakeholder representatives may lose their position as representatives if their constituencies feel their faith was violated.

Deviating unilaterally from truth-telling thus caries a threat of exposure and becomes significantly less desirable than otherwise. Where this threat seems insufficient to enforce compliance, defining an additional penalty contractually based on review of behavior may also serve, although administration of that penalty requires its own form of legitimacy. Furthermore, the likelihood of a Nash Equilibrium based on truth-telling depends upon the clarity of the design rationale.

It is important to state that these changes include hazards. For example, the act of clarifying rationale can expose how prior acts violated norms of rationality, or even norms of legitimacy. Often, human psychology adapts worldviews rather than identities [Cite truth maintenance in psychology], in this case motivating an attack on the rationale rather than acceptance of wrongdoing. An organizational analogue, in which firms reject rational adaptation in favor of the status quo, is well documented in DiMaggio and Powell [Cite year].

Consensus on Rationale and Rationality Can Help Performance

Consensus Aids Performance

Proposition 33 A clear design rationale increases the number of identified and agreed pareto improvements to the design.

Having a clear design rationale may help teams identify pareto improvements and, therefore, take better advantage of them. Broadly establishing the social goal of benefitting all team members therefore tends to make more likely pareto improvements to all participants who clarify legitimate preferences. Illegitimate preferences will tend to spawn perceived improvements that may harm, rather than help, the deceiving stakeholder representative.

Proposition 34 Clarifying design rationale increases the project organization's productivity.

Research indicates that reducing disagreement on goals, reducing intra-group competition, and reducing domination by one or more members, as clear rationales aim to do, will tend to increase the project organization's cohesiveness [Szilagyi and Wallace 1990].

Some research indicates that high coherence is risky in that it increases the productivity of well-led teams, but decreases the productivity of poorly-led teams [Schachter <Luthans>]. Clarifying project goals may help owners assess and align the project leadership, thus avoiding the risk traditionally incurred from high team coherence.

This analysis suggests that rationale clarity can help advance current organizations from positions of low coherence and unknown induction, a range of relatively safe mediocrity, toward high induction and high coherence – the highest quadrant of productivity.

This suggests that rationale clarity will tend to increase project team productivity beyond what is possible with teams conventionally organized around tension.

Organizations Require Proof to Adopt Rationale Clarity

Proposition 35 Analyzing more options tends to increase satisfaction with the completed building.

The axioms of rationality imply that having additional options cannot reduce the expected value of a decision (Howard 1983 Error!).

Proposition 36 Analyzing more options, while maintaining a fixed degree of rationale clarity, tends to increase satisfaction with the decision process.

Psychological experiments have shown people are sometimes less satisfied after evaluating greater numbers of options (Iyengar and Lepper 2000). The proposition above thus poses a distinct and important question: whether increasing the range of design options increases satisfaction with the design process. Satisfaction with the ability to choose also depends on cultural norms (Iyengar and Lepper 1999).

Proposition 37 Projects providing clearer rationale tend to satisfy more participants.

One explanation for the seeming contradiction between the rational benefit of evaluating more options and the observed psychological dissatisfaction resulting from evaluating more options is that greater satisfaction may result from greater clarity (Iyengar and Lepper 2000). An important question therefore is whether behaviors that seem to contradict the axioms of rational thought actually result from a rational assessment of decision clarity itself.

Proposition 38 Buildings designed using clearer rationale tend to satisfy more stakeholders.

The axioms of rational thought imply that the value of information is never negative [Howard]. The previous proposition reflects the intuition that clarity ought to increase the quality of design decisions.

Proposition 39 Clarifying design rationale tends to evoke debate over efficiency.

Clarifying design rationale expends resources to produce information bearing on the design decision. Decision analysis provides a method for calculating whether expenditures exceed the value of information bearing on a decision [Howard]. Management, however, tends to lack the knowledge and expertise that method requires. Management therefore typically justifies rationale clarification using unclear methods. These methods' lack of clarity renders the justification of rationale clarification vulnerable to individual power dynamics.

Proposition 40 Projects tend to develop similar clarity to successful past projects.

Exemplary precedents legitimate novel methods, such as the advanced clarification of design rationale.

Proposition 41 Projects tend to use methods successfully introduced and promoted many years earlier to clarify rationale.

The implication of rationale clarity improving building design and better building design stimulating mimicry is that the industry will tend to use methods for clarifying rationale that were justified in the past. Standard industry practice will tend to adopt the advancement of clarification methods after a delay necessary to assess and communicate broadly past projects' satisfaction of both process and product. The quality of a new building, in particular, can take many years to assess. Technology entrepreneurs term this phenomenon as "crossing the chasm" [Cite]. For a more detailed description of innovation diffusion related to rationale clarification methods, see Utterbach [] and Taylor [].

Conclusion

Discussion

Impact of Rationale Clarity

C&H 2 develops develop a collection of propositions about the impact of clarifying Rationale, We summarize these in table X. H&C applies the model of rationale clarity to a case project, and tests these propositions.

Do Organizations:

Comment [MSOffice5]: I have listed the propositions here. I suggest we place these as a list here, state that these are developed in detail in a working paper.

Comment [MSOffice6]: One thought here would be to provide the filled in MAP for MACDADI on the GSB structural decision, and then to annotate each proposition with whether the proposition was confirmed, refuted, or untestable. Just to show how it all comes together.

conduct less illicit, self-interested behavior
rely less on embedded ties
develop greater consensus
increase productivity
view the process as fair
improve communication to non participants
attain more power by managing the rationale
capture and reuse knowledge
make meaningful comparisons across projects.
improve survivability
improve learning

Do Processes:
define more goals
generate more options
perform more analyses
weigh analyses more appropriately
increase pareto improvements
generate new insights
find more creative designs
take less time to complete
focus on value adding tasks

Do Products:
perform better
satisfy more stakeholders

What are barriers to Clarifying Rationale ?
incompatible mission,
incompatible authority,
incompatible technology
incompatible marketing
legal contracts
Participants don't embrace social welfare functions.
Participants not adept at clarifying rationale.
Weights are hard to capture
Participants resist clarifying rationale for delegation
Varied reliance on explicit rationale due to carried social ties.
Cost of generating clear Rationale
It is too difficult to manage the Rationale.

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