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AN INVESTIGATION OF CONSTRUCTION PROJECT COMMUNICATIONS UNDER IPD CONSTRAINTS

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ABSTRACT

The authors demonstrate the development of an applied framework for analyzing, influencing, and improving communications to enhance productivity through collaborative information exchange on a fast-track integrated project delivery construction megaproject. Using an interdisciplinary approach, project communications is reconsidered as an independent, value-producing system to be used to improve the relational dynamics of an enterprise. Acknowledging the critical impact of communications on project planning and execution, the framework leans heavily on prospect theory within the field of behavioral economics, which explains how people make decisions when faced with risk. The results show the efficacy of developing a model that focuses on conditions of satisfaction, rather than the traditional hierarchical systems of project information flow for decision making. As with any substantial, independent commercial organization, a dedicated communications team is instrumental to achieving previously unrealized productivity gains otherwise hampered by the pervasive nature of miscommunication in large, complex-design engineering and construction projects.

KEYWORDS

Lean construction, communications, action research, integrated project delivery, prospect theory

INTRODUCTION

In the field of risk management and mitigation, a recent study of architecture and engineering project management firms reported that communications topped the list of the costliest risk factors based on both number of occurrences and average individual financial impacts (AXA, 2021). Worldwide, studies of construction project communications suggest a leading causal nexus of attribution cascades that result in significant inefficiencies, including waste and poor productivity (Cakir et al., 2022; Drevland & Svalestuen, 2024; Flyvbjerg, 2023; Project Management Institute, 2013).

Once the purview of the humanities and business sciences, the study of project communications has only recently been considered ripe for theoretical and applied research in lean construction. Subsequently, a lack of research on communication in construction projects exists (Drevland & Svalestuen, 2024; Erazo-Rondinel et al., 2024). Foundational to all such production systems are the highly specialized financial, scheduling, quality, and life safety subsystems (the “big four”), with their associated key performance indicators (KPIs), metrics, and controls. These subsystems have been developed and refined to a high degree of technical

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specificity, with the proposed value of these critical subsystems evidenced by the large and ever-increasing investments in both human and physical capital to support them (Kaufman & Geroy, 2007). Yet despite these ongoing investments, productivity in the construction industry has remained essentially unchanged for the past 3 decades and has even decreased during the past 4 years (Mischke et al., 2024).

The construction industry has responded with novel contract agreements, including integrated project delivery (IPD), that emphasize collaborative methods. They promote an egalitarian approach to risk management, including parties putting their profit at risk in exchange for opportunities to improve their profit margins. Such incentivized agreements require participants to self-govern their performance by restraining the traditional owner, designer, and constructor (ODC) behaviors in favor of a more cooperative approach. As part of these agreements, written communications plans are contractually prescribed tools for solving problems in more effective ways.

Communications in complex production systems remains highly ubiquitous, even though it is acknowledged as a critical and costly risk factor (Project Management Institute, 2013). To date, research on construction project communications has been focused merely on processes and variables, with specific forms and discreet content, to be analyzed in terms of complexity, errors, and efficiencies (Cakir et al., 2022; Drevland & Svalestuen, 2024).

Lean construction sees the art and science of building as a complex production system in which tightly connected phases of planning, design, construction, and commissioning are orchestrated via a linear–sequential execution methodology (Ballard et al., 2009). Scant, if any, research is published in the lean construction literature that views construction communications through the lens of a holistic, systems-based model (Drevland & Svalestuen, 2024).

Although the overwhelming majority of large, multibillion-dollar organizations invest significant capital in executive-level communications management teams, systems, and strategies, no such concomitant investment has been demonstrated in similarly resourced (e.g., mega-, giga-) construction projects. This article presents a nascent initiative to address the construction industry productivity conundrum by reconceptualizing project communications as a missing critical subsystem within the greater lean construction production system paradigm.

FOUNDATIONAL ELEMENTS

Two fundamental elements of communication and economic prospect theory are foundational to this investigation: (a) sociopsychological communication and (b) prospect theory as it pertains to message framing and its relationship to communication error. These models form the basis for the development of an integrated framework for viewing construction project communications from a systems perspective, rather than from the limited viewpoint of processes, variables, methods, and technologies. A basic understanding of the key features of these theoretical models help ground the authors' applied approach in the sections that follow.

SOCIOPSYCHOLOGICAL COMMUNICATION

In their recent work, Drevland and Svalestuen (2024) describe communication theory as one that encompasses diverse frameworks and perspectives. Citing Craig (2019), they identify seven traditional areas of communication theory based on notions of purposeful intent and anticipated outcomes (e.g., information processing, art of discourse, production of social order). Within these seven conceptualizations, their research investigated the cybernetic tradition (i.e., communication as information processing) as a critical component for developing their Design–Construction Communication Loop (DCCL) model of the construction communications process. The authors acknowledged the narrow framing of their research, and that reliance on this foundational tradition lacks comprehensiveness because of its limitation in representing the full, complex nature of human communication.

Of particular note in this work is the notion of sociopsychological communication, where communication is conceived as a vehicle for expression, interaction, and influence (Amin, 2024; Craig & Tracey, 2021; Furman et al., 2022). This type of communication is well suited to the current investigation, which is tied closely to the decision-making process in highly collaborative construction projects. Language, its meaning and use, is identified as a primary contributory attribute of effective collaboration. However, the importance of establishing and reinforcing reference points around shared meaning among project participants is more often overlooked or simply taken for granted (Skinnarland & Bølviken, 2023).

Communication complexity, variation, and role ambiguity among stakeholders are hallmarks of large, complex endeavors. Thus, communication benchmarking becomes an exercise not just for controlling finances and schedules, but also for establishing message intent and expectations. Specific language used in communications and collaborations is critical for team alignment, however, the literature treats a number of terms interchangeably when describing communication error, such as miscommunication, misunderstanding, misconception, misalignment, and so on (Craig & Tracey, 2021; Zerjav & Ceric, 2009).

Technical aspects of problem solving are based fundamentally on physical capital systems, whereas relational aspects are grounded primarily in human capital systems (Kaufman & Geroy, 2007). For example, deciding which cooling system to specify for a building involves a number of technical and relational steps. The determination of cooling load for the building is based on mathematical calculations. The relational problem of recommending and selecting a specific vendor to install the cooling system involves interpersonal influence and negotiation among multiple project stakeholders, which necessitates robust, accurate, and subjectively framed communication of information (Craig & Tracey, 2021).

A literature review by Drevland and Svalestuen (2024) strongly suggests that communication errors, both technical and relational, lead to many of the individually small, but summative, significant productivity breakdowns in complex design and construction projects. An investigation of the relational aspects of communication error may shed additional light on how project participants can navigate effectively some of the challenges described herein.

PROSPECT THEORY AND COMMUNICATION ERROR

Flyberg and Gardner (2023, p. 8) identify their iron law of megaprojects; on average, 0.5% are on budget, on time, and on benefits. An in-depth review of their work identifies the influence of prospect theory—a body of research represented by multiple Nobel laureates in the field of behavioral economics (Kahneman, 2011; Shiller, 2017; Thayler, 2015; Thayler & Sunstein, 2021). A modern critique of rational-agent utility theory, prospect theory demonstrates the flaws in Bernoulli's (1954 [1738]) expected values of individual utility based on logarithmic probabilities, which has stood for nearly 300 years.

Prospect theory reasons that any calculation of individual utility must also consider the reference point, or recent history, of a decision maker's personal utility at the time a decision is made (Kahneman, 2011). Rational-agent utility theory adopts a uniform, stepwise value function of gains or losses along a continuum, assuming the scale is linear and discrete (e.g., from 0–10 points, with increments of 1 point). Prospect theory demonstrates that gains or losses are valued based on the individual's current or recent position on a scale.

For example, on a 10-point scale, changes of value from 8 to 7 points or from 1 to 0 point show identical loss valuation under rational-agent utility theory, but display a vastly different perception of loss valuation under prospect theory. Pragmatically, under prospect theory, if one starts with $8000 and loses $1000, the loss is perceived much differently than when one starts with $1000 and loses the same amount. In the first instance, the loss is experienced as a minority percentage of the total, whereas the second instance represents a total loss. Conversely, traditional rational-agent utility theory values both $1000 losses as identical and suggests choices that lead to one or the other result should produce the same decision outcomes. The strength of prospect theory is its ability to identify and analyze reference frames, and to predict and respond to risks and errors in decision making more effectively (Kahneman, 2011; Kahneman & Tversky 1984).

The aforementioned DCCL model by Drevland and Svalestuen (2024) asserts the need for understanding and analyzing communication error, which may be viewed as an attempt to establish reference points in mitigating communication risk. Categorizing communication error in terms of transformations and flows, the authors invoke the notion of differentiation between intrinsic process errors and those associated with extrinsic "upstream issues."

Foundational to all probabilistic models of risk is the notion of Type I and Type II errors, where the one emphasizes the risks of supporting false conclusions, and the second risks failing to support inferences that are true. It is notable that nearly all quantitative research, with its emphasis on alpha confidence intervals, is demonstrably skewed toward Type I error mitigation at the expense of Type II errors. As researchers, we guard asymmetrically against confirming false positives at the expense of accepting false negatives (Gliner et al., 2016).

Viewing communications risk as a deviation from norms, Kahneman (2011) demonstrates the asymmetric risk coefficient between acts of omission and commission, and the distinction between decision options and actions that deviate from default reference points. Critical to understanding the influence of perceived risk in rational decision making is that "broader frames and inclusive accounts generally lead to more rational decisions" (p. 372) and the demonstration of "the power of inconsequential factors as determinants of preference" (p. 374).

When applying prospect theory to large construction projects, Flyvbjerg (2021) identifies a litany of factors associated with adverse project outcomes, including stakeholder participant biases (e.g., availability, optimism, overconfidence, uniqueness), strategic misrepresentation, the planning fallacy, and more. These are inherently relational, as opposed to technical, factors that represent key sources of rational decision-making error as a result of their susceptibility to framing effects (Tversky & Kahneman, 1974). Thus, framing, associated biases, and risk factors characterize how decision choices are presented to decision makers, which is, fundamentally, an act of communication.

METHODOLOGY

Acknowledging the critical nature of project communications, the anticipated benefits of this research included the development of a robust construction project communications framework that provides net-positive contributions to overall project outcomes. The approach to this work was decidedly phenomenological (Miles & Huberman, 1994, pp. 4–5), as the researchers were provided unprecedented in-person access to all aspects of the project's activities and the entire project team during its full 30-month duration. Ethnographic methods (techniques used to study people and cultures through direct engagement) were used to describe, analyze, and interpret the theoretical and applied set of concepts.

As engaged project stakeholders, the research team performed contract due diligence, high-level project and program management, and guidance of project leadership through formal and informal facilitated group work sessions, meetings, and negotiations. Under the directive of the project owner, project communications were studied, analyzed, and developed into a comprehensive systems framework for current and future project application.

Relying on observation, discourse, and disciplined inquiry, the research team worked right to left (Ballard et al., 2009; Flyvbjerg, 2023) to establish the milestone of a vital and effective communications system. Progressing inductively, the team went to the Gemba (Liker, 2021, p. 384) to uncover and assess current project communication errors and their relationships and impacts on overall project productivity. Table 1 illustrates the initial emergent and iterative developmental research phases of the construction project communications framework.

Table 1: Research Phases for Project Communications Framework

Stakeholder Mapping	Stakeholder Onboarding	Stakeholder Engagement	Situational Comms	Alignment and Reinforcement
Identify/codify all key players working on the project, along with their roles, responsibilities, and accountabilities.	Define/disseminate what good communication is. Train/educate in communication for risk mitigation and productivity gains.	Establish frequency, audience, and relevant content to keep projects on time and on budget with an aligned and engaged workforce.	Develop troubleshooting pathways for specific issues and crisis scenarios to mitigate risks.	Help change behaviors to benefit current and future projects. Apply those tools and skills to the next job.

INTEGRATED PROJECT DELIVERY CONSTRAINTS

Our project involved the planning, design, construction, commissioning, and operation of a large, complex commercial manufacturing facility in the United States under a ConsensusDocs 300 Standard Multi-Party Integrated Project Delivery Agreement (a proprietary document; a variety of IPD contracts can be found at https://www.consensusdocs.org/contract/300-multi-party-integrated-project-delivery-agreement/). Because of market dynamics, the project was designated as a fast-track megaproject from its inception. Table 2 includes some of the relevant descriptive data associated with the project.

Table 2: Project Descriptives

Category	Description	Metric
Investment	Budget ($US, billion)	5.0
Schedule	Duration (months)	30
Scope	Finished floor area (square feet, million)	2.2
Scope	ISO clean room (square feet, thousand)	300
Scope	Labor hours (million)	6.8
Scope	Peak daily workforce (hundred)	29

IPD is a lean construction project delivery method that is distinguished by a specific type of contract and was created to encourage collaborative behaviors among the project parties and participants. These agreements acknowledge that highly collaborative systems are more constraining than liberating. They require rigid boundaries within which innovation is allowed to flourish. Of note are the sociobehavioral constraints prescribed by the contract, including precise specifications for project team self-governance. Some of these conditions are more enigmatic, such as, “The IPD Team will promote harmony and collaboration on the Project.” Others establish stipulations without prescribing how to achieve this performance, including “each Party pledges to commit to open communication, transparent decision making, proactive and nonadversarial interaction, problem solving, and sharing of ideas.” These contractual performance constraints were among the guiding motivations for this research.

The IPD contract was executed by 13 signatories, including the owner, designer–engineer of record (“designer”), construction manager–general contractor (“constructor”), and 10 trade partner organizations (“trades”; e.g., concrete, steel, plumbing, electrical). Project participants were further constrained by a shared-risk profit pool addendum that permitted the partners to share the risks and opportunities of the project collectively. Establishing lump-sum profits for each member results in the risk of profit reduction should the project exceed the estimated maximum price (EMP). Conversely, should the project's final actual cost be less than the EMP, profit amounts are increased based on a shared savings matrix. The partners' payable costs (i.e., cost of work plus overhead) were guaranteed regardless of the final actual cost of the project, therefore incentivizing cost savings while indemnifying the risk-pool members from loss beyond their anticipated profit. All parties to the agreement either win or lose *together*, as no one party may profit at the expense of another.

The IPD contract prescribed several internal project controls that established a basis for a high degree of collaboration and an unprecedented quantity and rate of information flow. A key component of IPD project management is the formation and onboarding of the Core group ("Core"), made up of one primary and one alternate executive leader from the owner and each of the risk-pool member organizations. A requirement of each Core member was their signatory authority to bind their respective organizations to agreements. Once established, this 26-member Core became the decision-making body for the entire project.

An executive leadership team (ELT)—comprised of one senior executive of the ODC members—was empowered to adjudicate any failures to achieve unanimous decisions. Additional formal, working "cluster teams" were established to focus on specific technical aspects of project execution, including structural, site-civil, electrical, plumbing, HVAC, and so on. An ad hoc committee of Core members from the ODC was formed to evaluate and develop policy on select matters facing the Core and the project as a whole.

The research team participated in hundreds of formal and informal meetings and work sessions, including thousands of direct contact hours with project leadership and team members. From the onset, identification and classification of communication errors was assessed thematically. The facilitation and monitoring of information exchange became the responsibility of the designated communications team (COMMS). Critical to assessing the potential for communication errors and their impacts on productivity is an in-depth analysis of how information flows to and from the Core.

The researchers worked alongside project leaders and team members, facilitating formal work sessions of the Core, ODC, and structured workgroups (cluster teams) focused on specific technical aspects of the project's conditions of satisfaction. Project workgroup meetings were a hybrid of in person (onsite) and virtual (through Microsoft Teams). Meeting agendas were prepared and distributed via email to group participants. Work session minutes were recorded and distributed using Procore project management software. Additional project control tools such as "critical issues" and "risk and opportunity" logs, were established using Microsoft Excel templates, which were also available for review and revision in Procore. These tools were used to manage and track day-to-day problem-solving and decision-making outcomes, and project performance. The researchers achieved a degree of objectivity by continuing to acknowledge and communicate the core value of respect for people in the lean community.

Researchers were instructed to focus on identifying communication-based issues such as failure to provide timely or accurate information during work sessions. An informal root-cause approach to these issues was established as the researchers became sensitized to statements from project team members such as, "There must have been a miscommunication," "We were unaware that a decision had been made," and so on. Researchers met privately to share findings, discuss implications, and refine their observation techniques.

As the project progressed, meeting minutes were highlighted for specific communications-related inefficiencies (e.g., "misc" = miscommunication, "misu" = misunderstanding, "misa" = misalignment). From these tools, documents, and discussions, framework boundaries were refined, and the basis of the project communications concept model was established. Prior research suggested the development and use of a dichotomous, qualitative thematic categorization scheme that includes both technical and relational communication errors (Drevland & Svalestuen, 2024; Kaufman & Geroy, 2007; Skinnarland & Bølviken, 2023).

Figure 1 illustrates both the organizational as well as the conceptual communications model for the project. Contrasted with the more traditional, hierarchical pyramid of authority and information flow, this IPD approach to communications is deterministically concentric and organized in a manner akin to a heliocentric orbital structure. Information flows between and among teams and individuals working within specified spheres of influence in the overall project. One may consider adding lines of communication flow that represent the potential to demonstrate the strength and frequency of message exchange among groups. Although the mechanics of how this occurs has been referenced in the literature to some degree, it is not included herein and is the subject of future research.

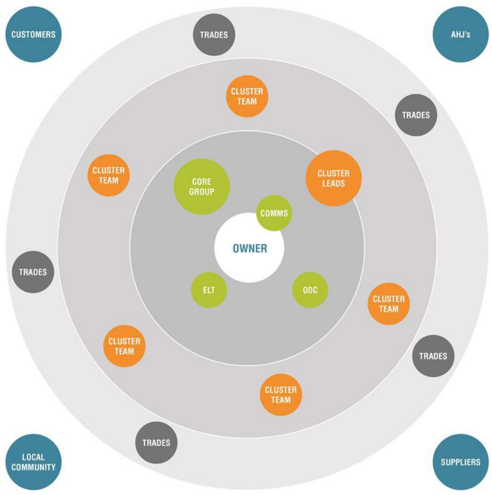

Figure 1: IPD Project Conceptual Communications Model

RESULTS AND DISCUSSION

Core and cluster team work sessions proceeded on a weekly schedule for 30 months. The research advanced by using traditional lean construction protocols while providing space for new themes and insights to emerge. Leveraging the Last Planner System (Ballard et al., 2009), percent planned complete (PPC) was monitored, which initially demonstrated high variability from week to week. The fast-track nature of the project appeared resistant to the discreet and regular response times established for efficient workflow. Metrics representing reasons for variance within a commercial pull-planning software tool proved unsatisfactory for describing the dynamic complexity of communication errors. The quantitative accounting of these errors was discontinued early on as impractical when errors exceeded multiple hundreds within the first few months of the project.

Regular weekly productivity updates (“cadenced”) proved insufficient for many of the project task sequences, requiring faster than weekly communication (“improvised”). Lookahead planning was used to counterbalance this short-circuiting of the communications loop by instituting a probability matrix of near-term requirements from the pull plans (e.g., 2–4 weeks). These future-focused productivity communications (“anticipated”) were identified as critical drivers for what would become a purposeful exploration of project communication framing. A conceptual framework of measuring project communications via cadenced, improvised, and anticipated messaging, albeit not the purview of the current research, shows promise for future investigation.

A fortuitous discussion of the challenges represented by managing the project through PPC (and associated percent required complete, or PRC) led to a rejection of the empirical, process component–level communications analysis described earlier (Skinnarland & Bølviken, 2023). During the prescribed development of project KPIs, it was observed that schedule, budget, quality control, and safety each have the inherent qualities of a capital-intensive economic subsystem. One question emerged that continues to guide the researchers to this day: Where was the attendant project communications ecosystem? In essence, if communications are so critical, is the investment in human and physical capital in support of project communications sufficient?

COMMUNICATIONS AS A SYSTEM

Before the research team could conceptually align on the novel idea that communications be placed at an equivalent systems level as the big four, it had to acknowledge an inherent bias that views project communications as a unique process, an outlier, a unicorn (Flyvbjerg, 2021). Initial objections to investing project communications as foundational, with the same technical and sociopolitical power dynamics and characteristics of the big four, led to a significant breakthrough.

During regular weekly meetings of the Core, decision making through unanimous assent caused meetings to bog down. As initiatives were discussed and negotiated, it became apparent that the default reference frame for most decisions was conveyed as needing the imprimatur of the Core to proceed. With the permission of the Core, an alternative frame for decisions was tested during which prescribed initiatives were affirmed unanimously via absence of objections. This resulted in a marked reduction of open-ended, exploratory questions and an increased focus on close-ended clarifying questions.

By reframing the narrative to “this is how the Core agrees to proceed unless there is an objection to the prescribed course,” resolution flow and time-to-decisions improved substantially. Most of the decisions facing the Core were technical in nature, and participants were never at a loss to transform discussions of policy or process into an arbitration of the technical requirements of the problems to be solved. However, the previous example demonstrated the efficacy of framing effects on relational communications, resulting in critical insight into the pervasive nature of project communications among high-performing technical professionals.

Formal and informal discussions ensued during which individual participants were asked to respond to the following question: What is the ratio, in years, of the quantity of your formal education and training in your technical field relative to your formal education and training in communications and the behavioral sciences (i.e., relational field)? It was no surprise to learn that among high-technical-capacity teams of ODCs and trades, responses included 10, 20, and even 50:1. A significant general hypothesis/question emerged from these interviews: Does increased investment in communications as a system result in reduced communication errors and improved productivity?

To explore the hypothesis further, one of the members of the research team was informally designated as director of project communications, and was given the time and resources to focus on the problem of reducing communication errors. Using the existing project communications technology and channels noted previously, key project stakeholders were recruited and engaged to help shape the diffuse notions of communications tools and processes into a cohesive, systematic communications initiative. The results of the initiative included a written strategic plan for implementing project communications for current and future projects.

Our literature review strongly suggested an exceedingly high probability the project would result in demonstrably poor outcomes based on its reference class (Flyvbjerg & Gardner, 2023). Despite formidable odds, the project performed admirably on a number of its KPIs. In keeping with the intent of the IPD agreement, overall project costs showed a consistent reduction from the initial program and subsequent validation estimates. Actual project costs were below EMP, providing risk-pool members with additional profit from shared savings and improved margins.

A schedule deviation of 10% to 15% was experienced. However, it should be noted that only 30 schedule days were added to the original validation schedule in light of more than 300 documented changes. Current quality metrics, viewed as benefits delivered (Flyvbjerg & Gardner, 2023), were positive yet inconclusive, as the commissioning process is currently ongoing as of this writing. The product is being manufactured successfully on a pilot basis, with first working line certification anticipated midyear. The overall project total reportable incident rate was 0.70 across more than 6.8 million worker hours.

Table 3 shows the resulting revised framework for addressing and improving construction project communications. Onboarding and alignment was determined as the first step, which includes establishing communication goals, roles, tools, and expectations (e.g., frequency, response times, content types). Stakeholder mapping identified leaders, managers, and critical field roles, and provided a simple and maintainable project communications matrix. Identification and development of message channels for specific group information exchange was assisted through the use of templates, curated messaging, and consistent message design and cadence. Stakeholder engagement was enhanced by the creation of a playbook of messages tailored to specific project teams, managers, and leaders. Last, measurement and continuous improvement were facilitated during regular Core, leadership, and project workgroup sessions. Including project communications as a regular agenda item and encouraging discussion of communications issues during plus/delta reviews at the completion of these feedback sessions resulted in notable reductions in communication errors and misalignment.

Table 3: Revised Project Communications Framework

Onboarding and Communications Training	**Stakeholder Mapping**	**Channels and Messaging**	**Stakeholder Engagement**	**Measuring and Improving**
Provide orientation for leadership, managers, and key contributors. Effect new-hire onboarding throughout the project.	Identify and map key leadership, manager, and field roles. Develop a communications matrix. Customize communications workflows for each group.	Identify, select, and audit channels, communications timing, and key messages. Develop communications system strategy and message design. Hold situational alignment workshops.	Provide a playbook of messages, templates, guidelines, and checklists for communicating updates. Disseminate weekly bulletins and newsbreaks. Publish leadership awards and team wins. Establish push notifications and short message system. Provide situational messaging and crisis support.	Assess channel engagement rates and regular feedback sessions. Establish baseline metrics (e.g., for engagement, email open rates, safety adherence). Monitor key performance indicators. Host quarterly reviews and stakeholder check-ins, and provide subsequent leadership feedback.

Project requirements revealed the need to de-emphasize quantitative analysis, allowing the qualitative aspects of the theory to emerge and express themselves more fully. Our results are limited by the single case narrative under which the research was performed, and cannot be applied to other works at this time. Multiple avenues for future quantitative, qualitative, and mixed-methods investigation arose, along many of the dimensions expressed in the literature, which emphasize the relational aspects of communications as a process and the technical aspects of communications as a system. The depth and breadth of the immersion left the researchers appreciative of the abundance of potential opportunities and grateful for the extraordinarily deep engagement with the project team.

CONCLUSIONS

We developed a communications execution framework and conceptual model for a large, complex, fast-track engineering and construction project under IPD constraints that led to a number of fascinating future research opportunities. Our approach integrated two foundational notions: communication and prospect theory. The integration focused on the creation of a framework that places communications on equivalent footing with other primary subsystems for which project performance is measured and controlled.

The framework and conceptual model demonstrate that communications comprises technical and relational aspects that interact in complex ways, and are prone to substantial and continuous error. The use of a collaborative agreement provides the bandwidth to explore and bring to the surface biases that represent significant threats to overall project productivity and performance. The manner in which communications are framed is equally, if not more, important than the technical aspects when considering effective and efficient planning and decision making (Kahneman, 2011).

With project communication errors, productivity impacts become an exercise in Death by 10,000 Cuts. Each communication error itself may appear minimally harmful. However, both relational and technical errors are like a stone thrown into a still pond, with errors rippling outward through the project that impact productivity negatively. They need to be identified, corrected, and rooted out from the project's conditions of satisfaction.

Our investigation highlights the need for more study of the type and nature of communication errors, including absence of communication, and their impacts on productivity. We suggest that many of the traditional wastes defined in the lean literature have their inception in the planning process, where they are most susceptible to the ambiguities and uncertainties inherent in the early stages of the design development and project execution phases. Miscommunication, misunderstanding, and misalignment are the micro-wastes of the communications ecosystem. They must be tested for, monitored, and mitigated continuously to keep the system balanced and flowing. Bad information has a long half-life.

Large, temporary enterprises such as megaprojects should consider the same level of investment and commitment of skilled practitioners controlling project communications as that applied to controlling project schedule, budget, quality, and safety. Our framework demonstrates the need to develop and empower dedicated resources such as a director of communications, chief of staff, and/or collaboration facilitators for effective communications management and control. Education and training of project stakeholders in basic and advanced communication techniques are critically important to ensure alignment across all project domains. By establishing how communications contribute to project outcomes, we may develop improved tools, skills, and systems to support more effective communication throughout the project life cycle.

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