# AN EXPLORATORY CASE STUDY OF OFFSHORE OUTSOURCING WITHIN DOWNSTREAM STRUCTURAL STEEL ENGINEERING SERVICES

by

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A THESIS

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## ABSTRACT

Although the offshore outsourcing trend continues to grow in the Architectural Engineering and Construction industry, research on the downstream design services has been fairly limited. In this thesis, we investigate downstream structural steel engineering services offshored from the United States to India. Employing ethnographic data collection method, we conduct face-to-face semi-structured interviews and telephonic interviews of US client and Indian vendors. Supporting evidences are gathered from multiple sources of data such as process checklists, minutes of meetings, and sample documents. Data analysis reveals 6 key constructs and 16 sub-constructs that address the issues and areas of concerns associated with offshore outsourcing of downstream design services. The key constructs include unrealistic contractual obligations, lack of constructability focus, inefficient design information exchange, technology interoperability issues, virtual team misalignment and internal team misalignment.

We further assess our constructs' validity by testing for matching patterns between observed constructs and organizational theories--Institutional theory, Transaction Cost Economics (TCE) theory and Resource Based (RB) theory. Based upon the observed matching patterns we show that these theories can be used to understand the issues and problems arising due to off shoring of downstream design services. Through this theoretical categorization we generalize our findings across a wide spectrum of downstream engineering disciplines in the AEC industry. This research characterizes the offshore outsourced downstream structural steel

engineering services and provides understanding of the critical problems and issues prevailing under the attractive surface benefits within offshore outsourced downstream design services.

## DEDICATION

This thesis is dedicated to everyone who helped me and guided me through the trials and tribulations of creating this manuscript. In particular, I would like to recognize my Mom, Dad, Avva, Sainath, Soumya and my close friends who stood by me throughout the time taken to complete this thesis.

## LIST OF ABBREVIATIONS AND SYMBOLS

*AEC* Architectural Engineering and Construction

*EPC* Engineering Procurement and Construction

*FTP* File Transfer Protocol

*TCE* Transaction Cost Economics

*RB* Resource based

*RFI* Request for information

*SES* Structural Engineering Services

*OFF* Out for fabrication- drawings sent for fabrication

*OFA* Out for Approval

*WPMS* Web Based Project Management Systems

## ACKNOWLEDGMENTS

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# CHAPTER 1

# MOTIVATION

Due to growing project complexities and expenses, Architecture Engineering and Construction (AEC) firms have been forced increasingly to divide complex tasks and distribute them among specialized trade vendors. Technological breakthroughs facilitate such work distribution to remote project participants by providing a virtual collaborative work space. As a result, more and more design services are being outsourced to specialized vendors. In fact, studies indicate that in the United States, currently, complex design services account for about 75% of all the activities outsourced by the AEC industry (Grasso et al. 2008). These outsourced design services not only comprise of primary design services, but also include downstream design services.

While primary design services deal with design of core structural components, downstream design services encompass secondary design (e.g. connection design), tertiary design (e.g., design of staircases, handrails), and ultimately production of detailed shop drawings and erection drawings. In other words, the end products of primary design services are detailed design drawings, while the end products of downstream design services are detailed shop drawings and construction (erection) drawings. Shop drawings provide information necessary for shop personnel to assemble and fabricate the structural components. Erection drawings provide information necessary for appropriate site installation of the fabricated structural members. A famous architect once said “God exists in details”. In other words details in the shop and erection drawings are extremely crucial in guiding site personnel to construct or erect a structure according to the intended design. Therefore downstream design services exercise an important role in executing capital construction projects.

Traditionally, downstream design services were outsourced to domestic vendors alone, but now Architecture Engineering and Construction (AEC) firms are increasingly hiring offshore vendors for the job—thanks to the globally expanding project networks (Bryant 2006). For instance, it is commonplace today that “a Singaporean owner offers the project to a US design build company who subcontracts fabrication to a South American fabricator who further hires the Indian vendors for downstream design services.” Even though such international collaborations are aimed at maximizing profitability, many shortcomings exist in offshore collaborations which may hinder efficiency and profitability (Nayak and Taylor 2009).

Offshoring downstream design services, not only aggravates existing project delivery complexities, but also adds newer ones (Douglas & Luth 2004; Mao et al. 2008). Increased change orders and laborious RFI exchanges are two common side effects. Additionally, cross-national and intercultural problems pose threats to team coordination. Due to coordination complexities, project participants fail to notice inconsistencies in the shop and erection drawings, which can eventually lead to faulty fabrication and serious erection conflicts. In extreme cases, even catastrophic disasters may occur. The Hyatt Regency walkway collapse and the Minnesota I-35 bridge collapse are two examples showing tragic failures due to poorly coordinated design process (Luth 2000, Liao et al. 2009). Technical errors aggravated by coordination complexities can not only nullify the intended cost savings from offshoring (Douglas and Luth 2004), but also bring additional losses. These resulting predicaments can negatively impact constructability, cost and schedule of the overall project. It is important to understand all possible problems arising in the unexplored downstream design networks. Therefore, there is an attractive opportunity to study and gain insights into offshore networks involving downstream design services.

Past researchers have focused their studies on primary design services, typically those in which US clients collaborate with offshore virtual counterparts to carry out primary design. Such studies have successfully noted that virtual team problems undermine design process efficiency. Others have studied cross-national problems arising between US expatriate engineers and international personnel in global project networks that undermine the project performance. The downstream design end--with a few exceptions, like studies of delivery systems, risk mitigation strategies, and erection safety issues--has been largely neglected by researchers. Moreover, discussions on downstream design services are mostly restricted to interactions between owners, fabricators and engineers, leaving out the offshore detailers from the loop.

Lack of research in this area has created a knowledge gap in which it is hard to identify engineering or technological issues, virtual team issues or intercultural issues arising in offshore downstream design service networks. Furthermore, we do not know how these issues can impact the overall project performance.

In order to address to this knowledge gap, I with the guidance of my advisor, perform an exploratory case study of offshore downstream design service networks. We focus our ethnographic observations on Indian vendors and US client organizations who exchange Structural steel Engineering Services (SES).SES tasks include secondary design, tertiary design and ultimately production of shop drawings and erection drawings, and are therefore an important part of downstream design services.

First we investigate the underlying issues and problems within the overall SES process. Next, we apply organizational theories as lenses through which to understand the source of these problems and how they apply broadly across downstream design services. However, we limit our research's scope to portray the current scenario among offshore downstream design networks, identify the existing problems and discuss their underlying sources, without intending to give exact solutions to the problems. Through our research findings, we intend to add to the ever-growing knowledge forum regarding cross-national team problems in international project collaborations. AEC industry practitioners can benefit from this research to understand the source of the problems in any offshore downstream design collaboration and improve the overall project performance.

The rest of this paper is organized as follows. The background section explains the offshore SES process and reviews the existing literature in the topic of study. Then, the objectives set the research goals and the methodology sets the appropriate method of investigation to reach these goals. A discussion on the data collection precedes the analysis and discussion of findings. Finally, the conclusions summarize the findings of this study.

# CHAPTER 2

# BACKGROUND

Technological advances have enabled offshore outsourcing trends in United States to evolve as an economical option (Messner 2006; Bryant 2006; Nayak & Taylor 2009) for not only trivial services but also complex design services in the construction industry (Bryant 2006; Stringfellow et al. 2008). According to NASSCOM, an Indian outsourcing organization, AEC firms have overtaken manufacturing firms in offshoring engineering services to India (Bryant 2006). A survey in 2005 concludes that 44% of US firms are already offshoring their engineering functions (Bryant 2005) and this number is ever-increasing. Another study indicates that design services are the most heavily outsourced activities in United States (Grasso et al. 2008). We can expect these numbers to increase further: Forrester research estimates that by 2015 about 3.3 million US jobs and about $136 billion wages will move out to wide open Asian markets.

Offshoring engineering services creates attractive cost benefits resulting from low cost skilled workforce that is flexible and prepared to dedicate extra time and effort (Stringfellow et al. 2008, Di Marco et al. 2010). In addition, vendor's proficiency in English language communication encourages US clients to offshore more and more engineering tasks. Despite the attractive benefits, offshoring brings many disadvantages that can jeopardize overall project success. This holds true for not only primary structural design services, but also for downstream design services. In particular, there are many unseen costs that arise between intercultural teams due to communication problems (Stringfellow et al. 2008) and coordination complexities. No matter how skilled the workforce is, bad coordination between stakeholders is detrimental to project performance. Further, coordination complexities result in overall project cost overrun, schedule delays, conflicts between teams, and impede the overall project performance (Koivu et al. 2003).

Even though few researchers have addressed offshore downstream design networks in the AEC industry, those who have tried have emphasized it as a risky endeavor. For instance, Douglas & Luth (2004) believe that offshoring complex detailing tasks, such as SES, would aggravate all problems existing in domestic outsourcing and add newer ones. Not only will there be time eating laborious RFI exchanges, but also higher likelihood of detailing errors. A single serious detailing error can be disastrous enough to negate the primarily intended cost savings. Furthermore, the reduced quality of detailing and the time lost in RFI exchanges are both replicated in time losses by others upstream project participants. Bryant (2006), mentions that downstream engineering services are one of the most difficult functions to offshore and quality is at highest risk. Dossick and Neff (2010), show that organizational trust barriers limit the collaboration effectiveness between project participants and domestic MEP vendors. Such problems are aggravated when, instead of domestic vendors, offshore vendors are involved. Further, Nayak & Taylor (2009) suggest that virtual team conflicts, cross-national and cross-cultural barriers pose additional challenges to the effectiveness of offshore collaborations.

The following paragraphs summarize past researchers' studies that address topical issues in global project networks, such as technology interoperability, virtual team- coordination trust and inter cultural nuances.

## Technology interoperability

Web-based project management systems (WPMS)--FTP servers, and virtual building information models (BIM)--provide a medium for storage and exchange of project-related information (Nitithamyong & Skibniewski 2004, Roddis & Matamoros 2004) between virtual international teams. Yet, technology interoperability is not up to the mark in offshore design networks. Offshore vendors still follow trivial methods of BIM creation (Roorda & Liu 2008; Aslani et al. 2009). The technology is not available to use because it is implemented at a very slow pace in AEC project networks, especially in offshore downstream design networks. Such poor technology implementation limits efficiency of collaboration between project participants (Dossick & Neff 2010). Thus, it is necessary to identify through empirical research methods various causes that limit technology implementation in offshore networks (Nitithamyong & Skibniewski 2004).

## Virtual teams

Most definitions of virtual teams expect teams to collaborate technologically such that they not only share data electronically but manipulate it jointly in common electronic space (Chinowsky & Rojas 2002, 2004). Most downstream design service collaborations do not meet this definition. Offshoring clients and downstream vendors mutually download data from a common electronic space and manipulate it in their personal space. Then they post it back in the common space. Even though they do not meet the formal virtual team definition offered by Chinowsky & Rojas (2002, 2004), the same authors say that such teams can still be seen as virtual teams for the following reasons. Since downstream vendors and the US clients occasionally meet through video conferences, exchange crucial design information virtually and mostly communicate in absence of physical presence, they qualify as virtual teams. Along with the advantages associated with virtual teaming, numerous drawbacks exist as well. Virtual teams face coordination problems due to lack of trust and intercultural nuances (Zolin et al. 2000; Chinowsky & Rojas 2002, 2004; Beamer & Varner 2009). Following paragraph address these issues.

## Trust and Coordination

Coordination and trust work hand in hand to increase collaborations between virtual teams. First, coordination is a key success factor especially in onetime virtual collaborations (Dossick & Neff 2010) commonly observed in the SES networks. Next, the level of coordination depends on trust development between teams (Zolin et al. 2000, Chinowsky & Rojas 2002, 2004, Nayak and Taylor 2009). Trust is also an essential factor in a vendor's work satisfaction, which is vital for better job performance (Carr et al. 2002). One-time virtual collaborators like those in SES have no previous work relationships, often miss non-verbal communications, and therefore trust development is hindered (Zolin et al. 2002). Hence, there is a need to discover more clear evidence showing the relationship between trust/satisfaction and SES workers performance. Coordination, apart from being required between clients and vendor virtual teams, is also vital between SES networks and other important stakeholder groups, including architects, contractors, mechanical, and structural engineers, (Douglas & Luth 2004).

## Intercultural diversity

Other key factors influencing virtual team work practices include communication, and, more importantly, intercultural diversity, (Chinowsky & Rojas 2002, 2004; Horii et al. 2005; Nayak & Taylor 2009; (Koivu et al. 2003). Computational model-based research by Horii et al. (2005) and Wong et al. (2010) shows that culturally-driven organizational behavior and communication nuances negatively impact project performance. However the same researchers have insisted that the cultural parameters that are inputted into the computational models have to be validated through more rigorous investigation of the virtual intercultural teams. Further, discussing international teams behaviors in intercultural contexts Beamer & Varner (2009) propose that for any intercultural virtual team to develop coordination, practitioners should first identify all their goals and choose the means to reach those goals. Next, they have to identify all possible cultural gaps hinder their goals and finally bridge the gaps. However, practitioners in downstream design networks have no such intercultural studies available to help them identify intercultural gaps and bridge them. Past research attempts mostly attempt to identify intercultural nuances between large global project networks or primary design networks, but not downstream design networks.

## Concluding remarks

Recently, researchers have advocated using innovative techniques to investigate cross-national project teams. For instance, researchers focusing on global project networks have utilized and suggested institutional theoretical frameworks to measure cross-national differences, particularly in global infrastructure projects (Mahalingam & Levitt 2007; Javernick-Will & Scott 2010). Such innovative techniques are required to trigger new discoveries and can be insightful even in international project networks involving virtual teams. However, so far no offshore outsourcing researchers have utilized such frameworks to study the virtual team behaviors and obviously not in offshore SES networks.

From the extant literature review, it is apparent that there is a potential need for more research, addressing downstream offshore outsourcing such as SES networks. Recently, many researchers have called for rigorous innovative research attempts in this area of offshore outsourcing and cross national collaborations. For instance, (Wong et al., 2010) emphasize the need to understand the hidden cultural nuances, mutual misunderstandings, technology interoperability issues and misaligned work practices and various other challenges arising between cross national and cross-cultural teams. Keeping this in mind, even though our interviews are open-ended, we keep our questions focused on these current topics.

# CHAPTER 3

# OBJECTIVES

The overreaching goal of this research is to understand and characterize the offshore outsourced Downstream Structural Steel Engineering Services from the United States to India. Therefore we set the following two objectives and sub objectives:

1. To characterize the exchange process of Structural steel Engineering Services between US clients and Indian vendors through case study research
    - To incorporate topical variables in international project collaborations such as technology interoperability, intercultural conflicts, virtual team communication, in our study.
2. To frame the process identified in the previous objective based on established organizational theories that can guarantee generalization of our findings
    - Identifying suitable theoretical frameworks that can be used as the basis for generating matching patterns or predictions that can establish external validity and generalization of our case study research.

# CHAPTER 4

# RESEARCH METHODOLOGY

To fulfill our research objectives, we adapted an exploratory case study research methodology (Glaser and Strauss1967; Eisenhardt 1989; Yin 2009) which provides interesting findings when applied to study cross-national collaborations (Javernick-Will & Scott  2010), such as offshore SES collaborations. The methodology covers 6 main phases -Motivation, Objectives, Background, Data-collection, Analysis, Construct Validity and Conclusion (see Figure 1).

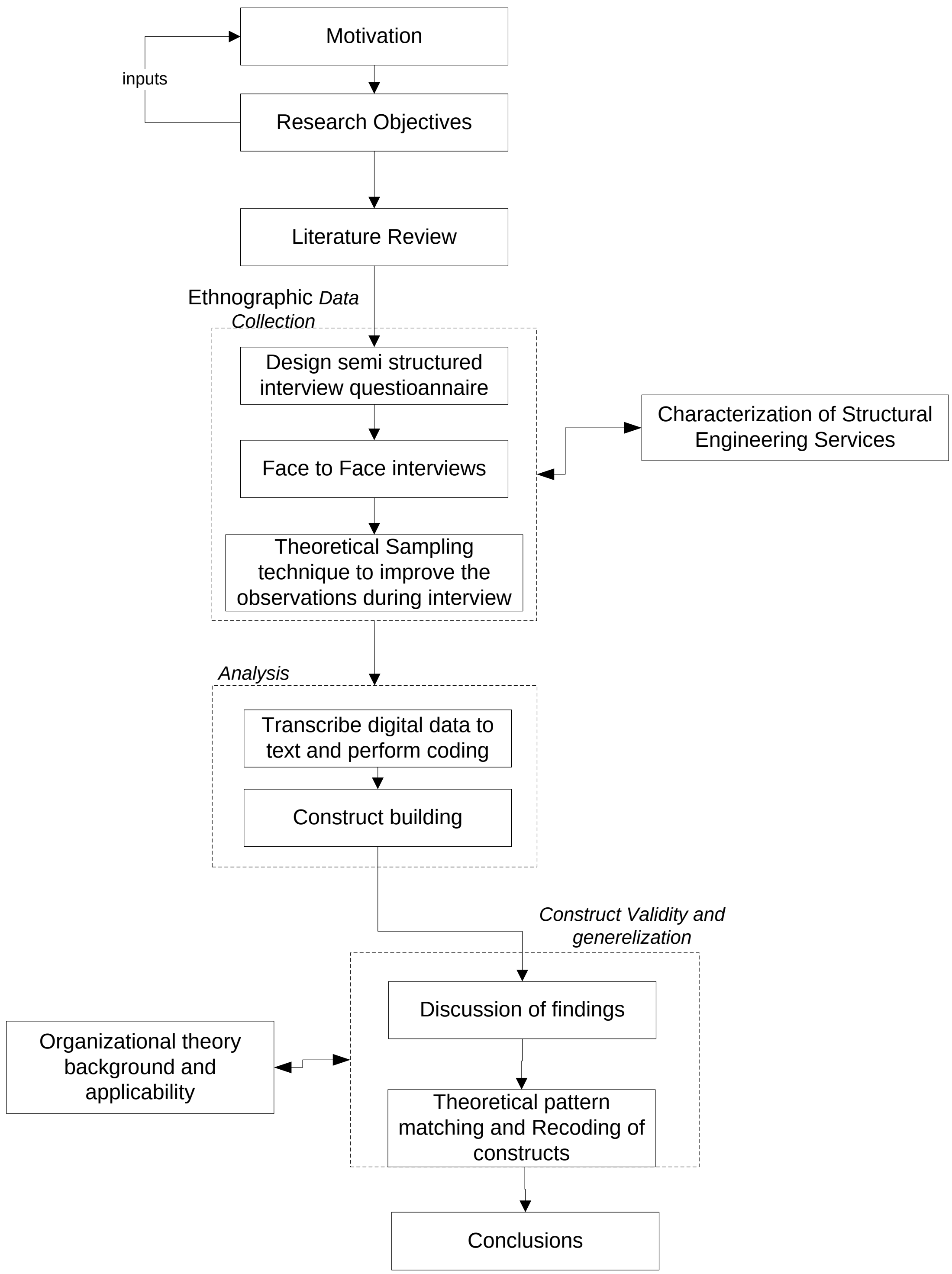



Figure 1 Methodology

The motivation section recognizes the need to study offshore downstream design networks and sets a solid base for our case study. Next we define our research objectives and then carry out the extant literature review in order to ground our research question and identify important works and topical issues revolving around our research interests.

Employing the ethnographic data collection methods, we prepared a semi structured interview questionnaire roughly focusing on the topical areas identified in literature review. These semi structured interviews, without any “a priori” theories, would help us to fetch a complete picture, particularly for exploratory type case study (Eisenhardt 1989, De vaus 2004) like ours. To conduct interviews, we selected three Indian SES vendors and one US offshoring client. The selection of the interviewees was not random, but we chose them for their relevant expertise in the area of our research interest. Further, to our advantage, one of the author’s previous work relations with the vendors and the US client increased the convenience of sample selection (Auerbach & Silverstein 2003) and also helped us to get highly realistic responses. My advisor’s inputs based on his experience of more than 10 years in the field of design, fabrication and detailing in Europe and USA, provided us an expert opinion on the client’s side of story. Further we also gathered information from vendor’s business unit heads/account managers residing in the US and maintain close affairs with US clients.

I travelled to India to conduct face-to-face interviews over a span of 3 months. We took insights from multiple project participants, including the client’s chief designer, vendor business advisors, senior project managers, team leaders, modelers, checkers and detailers/drafters. Some interviews with key personnel such as vice president, senior project manager etc., were elaborate and extended up to 4 hours. Therefore we took day breaks that helped to keep the responses fresh and spontaneous. Another advantage was that on every new interview day, we had some time to recap and reevaluate the previous session's responses. The interview discussions with key personnel were taped, and alongside we took notes, jotted down supporting flowcharts and diagrams. We captured everything that came across as a form of response making sure that nothing is lost (Eisenhardt 1989).

During the interviews, we followed an opportunistic approach (Eisenhardt 1989) and appropriately picked up new emerging cases and accordingly modified our questions in order to get deep insights into our research objective. This technique, popularly known as theoretical sampling (Glaser and Strauss 1967), helped us to obtain complete perspectives of the interviewees and also record rich anecdotal data (Eisenhardt 1989). We also collected detailed drawings samples, model snapshots, and checklists, minutes of meetings, standards, codes and training manuals that supported the interviewee's answers. Therefore the strategic selection of cases and questions combined with multiple sources of data produced replicating and complimenting evidence, thereby increasing the internal validity of our constructs (Eisenhardt 1989; De vaus 2004; Yin 2009). We stopped collecting data when theoretical saturation was reached (Auerbach & Silverstein 2003). In other words when the concerns and insights became repetitive, we stopped the data collection and began analyzing the collected data. However, we followed up with the interviewees and contacted them via email and telephone for clarifications during content analysis.

We transcribed the digitally recorded data, which generated about 70 pages of text containing 22,086 words. Then, we performed careful within-case analysis (Eisenhardt 1989) to shortlist the relevant statements, examples, experiences and anecdotes. We shortlisted more than

60 phrases, anecdotes and examples that pointed out advantages, issues and concerns associated with the offshore SES process. We identify these 60 phrases and anecdotes as “incidents” (Glaser and Strauss 1967). Next, we open-coded these incidents to identify broad constructs also referred to as “categories” or “codes” (Glaser and Strauss 1967). In other words, we examined the incidents and compared one incident with another to spot important emerging themes and then compared new incidents with the emerging themes to form key constructs. This way, we grouped all incidents pointing towards a certain theme under a large heading called “construct,” which led us to identify 6 key constructs. Some incidents did not directly point towards a theme but still supported it. Such incidents were coded under sub-constructs to the main constructs. For instance “Design information exchange” was identified as a main construct initially, but further down the road, many incidents fit more appropriately under sub constructs such as “Screened communication”, "inefficient RFI responses" and so on. Table 1 below shows all the key constructs and their sub-constructs. We stopped the coding process when theoretical saturation (Glaser and Strauss 1967) of relevant data was reached or, in other words, when no relevant and meaningful themes could be formed. Subsequently, we carried out the construct-building exercise by elaborating them based upon our direct observations, combined with interviewees’ opinions, examples, rich anecdotes and supporting documents.

In the next step, we discuss areas of improvements that became apparent from the construct-building exercise. Finally, we examine the anecdotes and opinions to identify the motives or drivers behind all the incidents that led to our constructs. This exercise showed us that the motives behind constructs actually fit appropriately into the frameworks of different organizational theories. At this point we digress temporarily to examine the extant literature on organizational theories, in order to examine and establish applicability of these theories as frameworks into our research. Finally we categorize behaviors, actions and decisions of participants that led to our constructs, under the pertinent theoretical frameworks. This resulted in recoding of constructs and sub constructs under theoretical frameworks, thus rationalizing our findings and providing external construct validity. In the next chapter, we first characterize the interview participants followed by characterization of offshore SES process.

# CHAPTER 5

# CHARACTERIZATION OF OFFSHORE OUTSOURCED STRUCTURAL STEEL ENGINEERING SERVICES

## Interview Participants

We conducted interviews in three different Indian SES vendor organizations and in one US design-build/EPC client organization. Although the US design-build organization exchanged design services with its own operational subsidiary in India, occasionally it also procured downstream design services from offshore vendors outside the organizational boundary. The three Indian SES vendors whom we interviewed were commonly specialized in providing structural engineering services (SES) for US and Canada based projects. Two of them also specialized in providing SES for projects based in Europe and the Middle East. While responding, interviewees drew on their experiences working on multiple types of US based civil engineering projects varying from heavy industrial (oil and gas, power plants) to huge commercial projects (Casinos, hospitals, shopping centers) to residential condominium projects. All vendors participating in this research shared almost similar organizational structures and employee designations. Therefore, in this report, chose to identify the anecdotes from interviewees with respect to their designations and not with their organizations. For example, instead of identifying sources of responses as vendor 1, 2 or 3, we identify them with the responder’s designation such as senior project manager or vice president etc.

**Collaboration structures**

In our investigation of the offshore SES networks, we came across two types of collaborations.

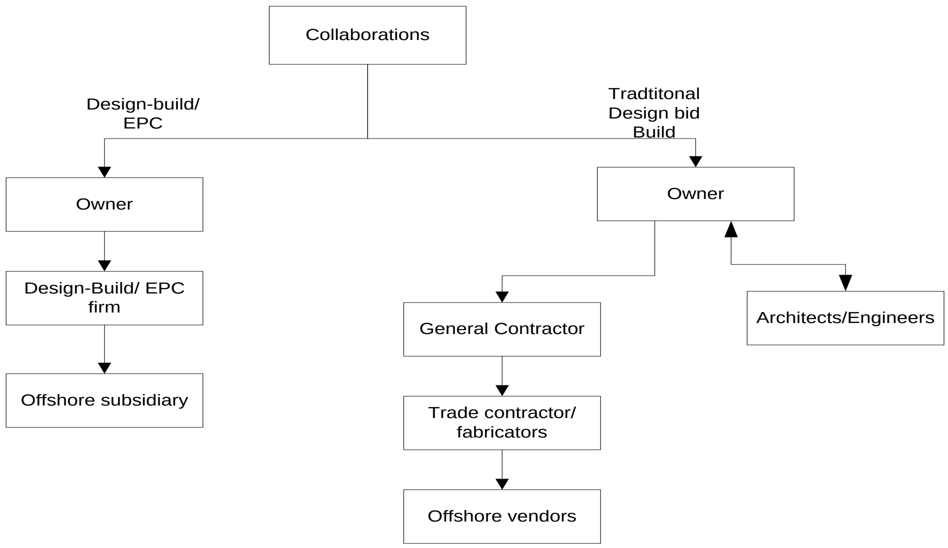



Figure 2 Types of offshore SES collaborations

Figure 2 outlines both types. One type involves large multinational EPC firms or design-build firms, working jointly with their offshore subsidiaries. In this type of collaboration structure, the client may be a design-build or Engineering procurement and Construction (EPC) firm who carry out design, material procurement and construction activities all by themselves. The second type of collaboration, and the most prevalent in offshore networks, that we observed is the traditional design-bid-build structure. In such collaborations, architects, General contractors, designers or the trade subcontractors commonly outsource downstream design services to offshore vendors. We observed that steel fabricators are the chief clients who procure complex Structural steel engineering services from offshore vendors.

### Process characterization

Figure 3 summarizes the design process flow from primary design through offshore SES to the final construction process. A detailed flowchart of the entire SES process is shown in appendix A.

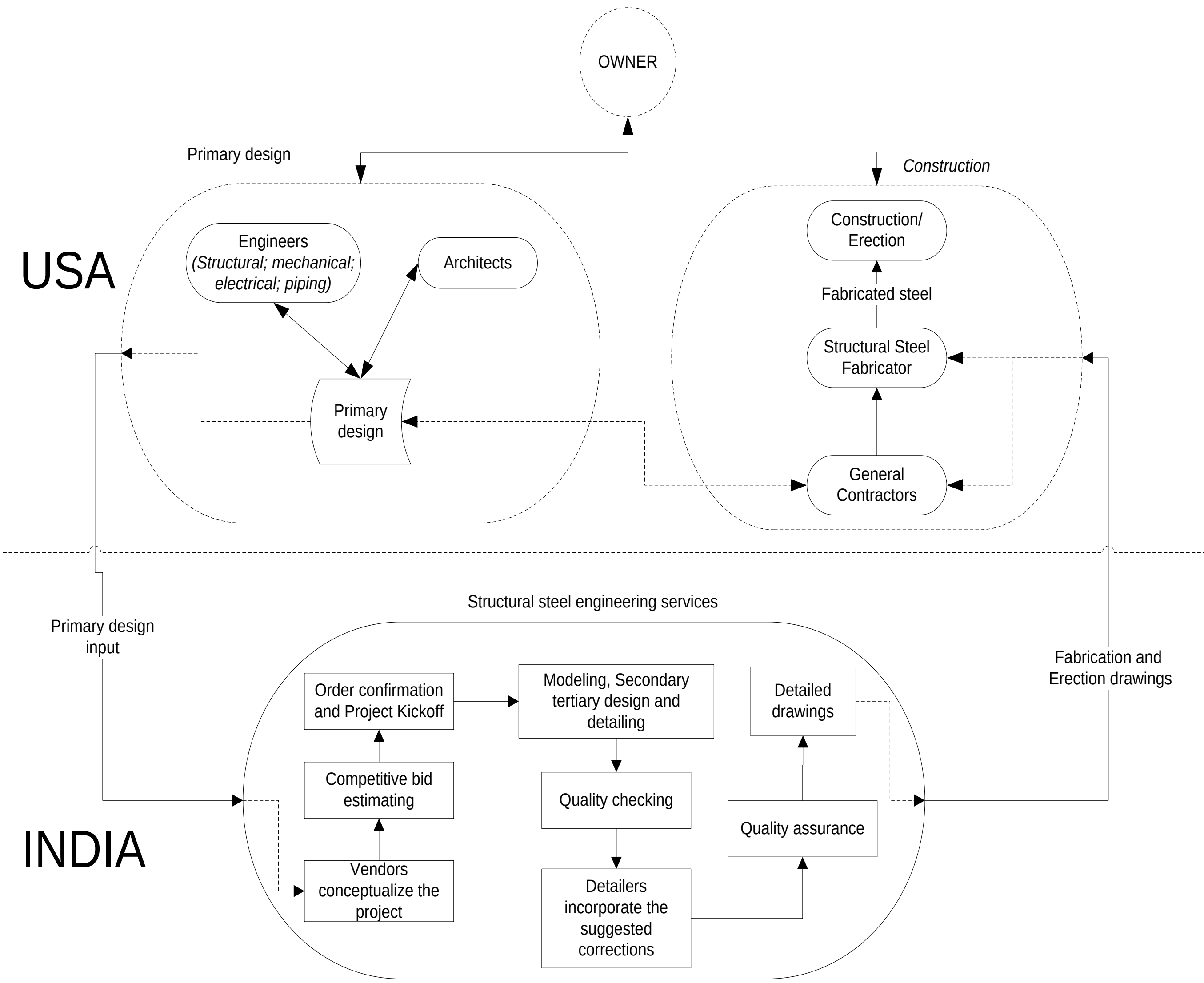



Figure 3 SES process flow outline

During the primary design process, US Architects and Engineers frequently interact with the general contractors, trade subcontractors and the owner; they work together to prepare project standards, specifications and the core design of the structure. For instance, we observed that engineers of all disciplines (structural, piping, electrical, mechanical etc.) in the design build client organization joined hands with the owner and other project participants to perform the core design.

Following primary design, the US clients commonly outsource the secondary design, tertiary design and structural detailing works to offshore SES vendors.  In other words, SES vendors are hired to design joint connections *(secondary design)*, all other miscellaneous items such as staircases, handrails, ladders *(tertiary design)* and ultimately, prepare detailed drawings showing dimensions, properties and specifications of main structural components and all other miscellaneous items. This information from SES detailers governs the subsequent fabrication and construction activities (see Figure 3 for the entire process outline).

Clients decide the right time to initiate SES works depending upon the overall project execution strategies and also the collaboration structure. For instance, the design build client expressed that whenever they hire an outside vendor, they wait until the primary design is 100% complete. In the traditional design bid build collaborations, project participants overlap offshore SES with the primary design. Therefore clients hire offshore vendors during the initial stages of the primary design itself.

Clients send a bid invitation to SES vendors' business unit heads or the commercial/marketing branch situated in the United States. Information is exchanged between both parties through web-based project management system or common web based repositories known as File Transfer Protocol (FTP). Clients upload scanned 2D images of bid set-design drawings into the FTP, based on which vendors prepare and submit the bid estimates. The customer then selects the vendor based upon factors such as bid competitiveness, reputation and past relationships etc.

Once the vendors' selection is finalized, clients provide an official project order confirmation to the vendors. Then they hand over to vendors the contract documents including detailing project scope and objectives, architectural and structural drawings (primary design information), specifications, connection design prototypes, and sample drawings. Sometimes clients share supplementary data such as archived files that can be extracted into 3D steel models. Such files are known as SDNF files, but they are not a part of the main contract documents.  Vendors are often skeptical about using these SDNF generated models, and therefore they prefer to prepare their own 3D models.

Meanwhile, after receiving the project confirmation order, the vendor's business unit head appoints a project manager (PM) at the vendor's home office and hands over all the primary design information. A single PM usually handles 3 to 4 projects simultaneously and for each project he assigns a project engineer or a project leader. The project leader uses a floating technical team comprising modelers, checkers and detailing engineers. In some vendor organizations, detailers use checklists for each and every activity that they perform. These checklists are prepared by the project managers based upon the "Memorandum." This memorandum is a document provided by the client that provides guidelines for the work to be performed. It also shows the sequence in which work has to be performed.

Modelers begin to create their own 3D models using system software such as SDS/s and Tekla Structures etc. In the meantime, if they come across any missing information in the primary design documents, they report to the PM. The PM prepares a formal question, called a Request for Information (RFI), and sends it to clients. Clients respond to the vendor's RFI with suitable clarifications which are incorporated by vendors into their work. When secondary design is in their scope, they have to design the connections and get their design calculations approved from an US Professional Engineer (PE). If secondary design is not in scope, they just copy the connection details from the connection prototypes provided by clients. Further, the 3D model is checked internally by either the checkers or project engineers. Modeling is finalized and detailing or drafting is begun. It is also referred to as editing or scrubbing.

During the detailing stage, individual components are taken out of the model and are detailed as per client requirements and kept ready for review. Checkers review these drawings for quality. They identify corrections and send them back to detailers for back drafting. At this stage, after all the structural components are detailed, vendors send their first submittals to their immediate client who forwards them for the designer's approval. These submittals are referred as "Out for Approval" (OFA) by the vendors *(see Figure 6).* The reviewed OFA with the designer's comments and suggested corrections come back to the SES vendors. Detailers incorporate all the corrections and then checkers review the drawings once again for quality assurance. Following this, project managers send the final submittals to the client, which are referred to as "Out for Fabrication" (OFF).

Clients use these final submittals to facilitate fabrication of structural steel. However before doing that, fabricators review the fabrication drawings with reference to the primary design information and any mistakes are reported back to the detailers who revert back with suitable corrections. Finally, the fabricated structural steel is shipped to the erection site along with the erection drawings submitted by SES vendors. Ironworkers utilize these erection drawings to establish each structural member’s exact installation location. Ironworkers on the site may come across questions that need to be immediately clarified. During such events, field calls are made to the SES vendor’s office and it is very important that the vendors are available at that time to provide clarifications. Eventually, clients hold the SES vendors responsible for any serious erection problems caused due to improper detailing. The final erected structure is then handed over to the owner.

# CHAPTER 6

# CONSTRUCTS

Table 1 Constructs

| CONSTRUCTS | SUB-COSTRUCTS |
|---|---|
| Unrealistic Contractual Obligations | Clients unrealistic expectations |
| | Vendor's unrealistic commitments |
| Lack of Constructability Focus | Low steel erection expertise |
| | Clash detection |
| Exchange of Design Information | Inadequate information supply |
| | Design revisions and Change orders |
| | Screened Communication |
| | Inefficient RFI operations<br>• Intricate RFI transactions<br>    • Mismatch in RFI numbers<br>• Ineffective RFI Responses<br>    • Late Responses<br>    • Incomplete RFI responses |
| Inefficient Use of Technology | Interoperability Issues<br>• Inefficient data management |
| | Detailing templates |
| | Inadequate software packages |
| Virtual Team Misalignment | Mutual Distrust |
| | Conflicting Perceptions<br>• Rules and norms<br>• Time sense<br>• End Results<br>• Authority |
| | Misaligned communication<br>• Communication styles<br>• Language<br>• Time difference |

*(Table continues)*

<table>
<tr><th>CONSTRUCTS</th><th>SUB-COSTRUCTS</th></tr>
<tr><td rowspan="2">Internal Team Misalignment</td><td>Misaligned Goals<br>• Company versus. Individual growth<br>• Profit versus Work Satisfaction</td></tr>
<tr><td>Shifting Goals</td></tr>
</table>

# CHAPTER 7

## CONSTRUCT 1. CONTRACTUAL OBLIGATIONS

Contract types in offshore SES networks are based on the types of service models offered by offshore vendors. We observed three types of service models prevalent in offshore SES networks: fixed time-cost service model, dedicated resource service model, and captive model.

The fixed time-cost model is the most prominently existing service model in offshore SES networks. This model is best suited for small projects or for large projects where the scope, schedules and requirements of the project are specifically defined. In this type, vendors and US clients sign a fixed-price contract. Depending upon the amount of work to be done, vendors quote a fixed timeline and a fixed price. Then vendors select the most suitable team and technologies required to accomplish the project as agreed. Any subsequent major changes to the scope of the project are discussed between clients and vendors and the contract is updated. For serious detailing errors, vendors can be back charged significantly. The vendor's vice president confirms,

"*Serious errors such as column misfits etc due to detailing errors might cost us the entire contract amount or about 50 to 80% of the contract. Because according to the agreement we have to pay for the time spent, equipment used for the process, material cost and the fabrication charges.*"

The contract samples that we observed showed that back charge fees vary from 10% of the contract amount to the entire contract amount.

Table 2 Contract Types in offshore SES networks

| **Fixed time-cost model** | **Dedicated resource model** | **Captive model** |
|---|---|---|
| • Adapted for projects with specifically defined schedule and scope<br>• Bidding units: fixed cost and timeline<br>• number of resources is up to the vendor's discretion<br>• Additional time and cost if there are design revisions and change orders | • Adapted for long duration projects with<br>• Bidding units: number of man hours, cost/man-hour.<br>• Only a fixed number of resources are appointed to work for a client for a contract period.<br>• Additional man hours if there are design revisions and change orders | • Adapted by large design build or EPC firms for large Turnkey projects<br>• Firms exchange work with their own branches in offshore locations and maintain resources on company payroll |

The dedicated resource model is a type of service model usually adopted in long duration projects. Offshore vendors offer a set of resources that are hired by the clients to work on theory projects for a specific contract period. Vendors bid total man hours and specify cost/man hour. A fixed team works for a particular client exclusively till the contract term expires. Further, if there is any change in scope of work due to design revisions or change orders, clients and vendors mutually negotiate additional man hours and the associated cost. The captive service model is usually practiced by large design-build and EPC firms. In this type of model, firms usually procure design services from their own subsidiary branches in offshore locations. There is no contractual binding because the work is exchanged within the organizational boundary itself.

Even though the dedicated service model and captive models are becoming popular, the fixed time cost model is still the most commonly practiced service model in offshore SES networks or any other downstream design networks. However, in this current world of fast track projects and competitive bidding, clients and vendors commit to unrealistic time and cost obligations.

Sufficient time is required to perform good quality construction work (Douglas & Luth2004). However, we observed unrealistic expectations and commitments among SES networks. Firstly, clients hire SES vendors too early and pressure them with tight expectations. Secondly, vendors make unrealistic time commitments to clients. Finally in order to fulfill unrealistic commitments, the vendor's management deliberately shrinks the schedule even more.

**a. Client's unrealistic expectations**

Firstly, in this current fast track project world, clients are obliged to apply different time saving strategies in order to stay on schedule and increase profitability. As a result, clients expect vendors to deliver the shop drawings within unrealistic deadlines. Additionally, they overlap downstream SES tasks with upstream design. Even though clients follow this approach to procure materials and fabricating steel ahead of schedule, there is also a downside to it. It results in adequate design information not being available and in delays to crucial SES tasks. For example, lack of information in the initial stages delays SES vendors' delivery of anchor bolt detailed plans, which can further cause expensive delays to foundation concreting process.

Therefore tight deadlines amid the lack of design information create frustration among vendors and reduce their work efficiency.

**b. Vendor's unrealistic commitments**

On the other hand, we observed that vendors are obligated to unrealistic time commitments. The vendor's management bids a tight schedule at an attractive price, despite the disapproval of the detailing team. Detailers complained that management disregards the fact that it is very hard to complete the required tasks efficiently in such unrealistic tight deadlines. Further, due to such agitation from detailers, management even avoids seeking sufficient input from them during the bidding process. Vendor management argues that the tight schedules are balanced by the additional time they get due to design changes and change orders: when design revisions or change orders occur, vendors hold their work until they contract price and time are renegotiated. In fact "*Vendors are happy when they get design revisions or change orders…because they can ask for more time and money...*" says the US design client.

Finally, vendors' detailers argue that the schedule is deliberately tightened internally down the organizational ladder. As a result the workers at the bottom of organizational structure are placed under the most pressure. A drafter laments

"*We are the ones who have to suffer by working late shifts under pressure. Because, the account manager gives a deadline to the project manager; he further shrinks and gives a deadline to the project engineer, who further shrinks it and gives a tighter deadline to us".*

We could easily see the increased tension among the detailers due to unrealistic deadlines. Bound to these unrealistic time commitments, detailers lose their commitment towards quality. A checker says:

*"During the upload stage, we don't have time for last minute corrections. Our only aim is to upload the detailed drawings to the client, and we tend to ignore and overlook minor mistakes."*

CHAPTER 8

# CONSTRUCT 2. LACK OF CONSTRUCTABILITY FOCUS

We observed lack of constructability focus in offshore SES networks. First of all, project participants in the downstream SES networks limit their focus to meeting their immediate goals and neglect the big picture. For instance, clients and offshore vendors are guided by unrealistic time and cost obligations; as a result, they pay no attention to the overall project execution plan. Talking about the goals, vendor's vice president said that *"both clients and vendors' mutually focus to fulfill their contract".* He further exaggerated, "*nobody would even worry if the building has to collapse later."* In pursuit of such sub-optimized goals, clients and SES vendors and their clients lose focus on constructability and the steel erection process.

We observed many factors that hinder end constructability. Firstly, constructability is at risk due to offshore vendors' lack of steel construction background. To compensate for this drawback, vendors depend heavily on visualizations that fall short due to many reasons detailed in the subsequent sections. Then, due to technological collaboration issues, SES detailers fail to check for clashes between their work and other disciplines. All these factors are elaborated in the subsequent paragraphs.

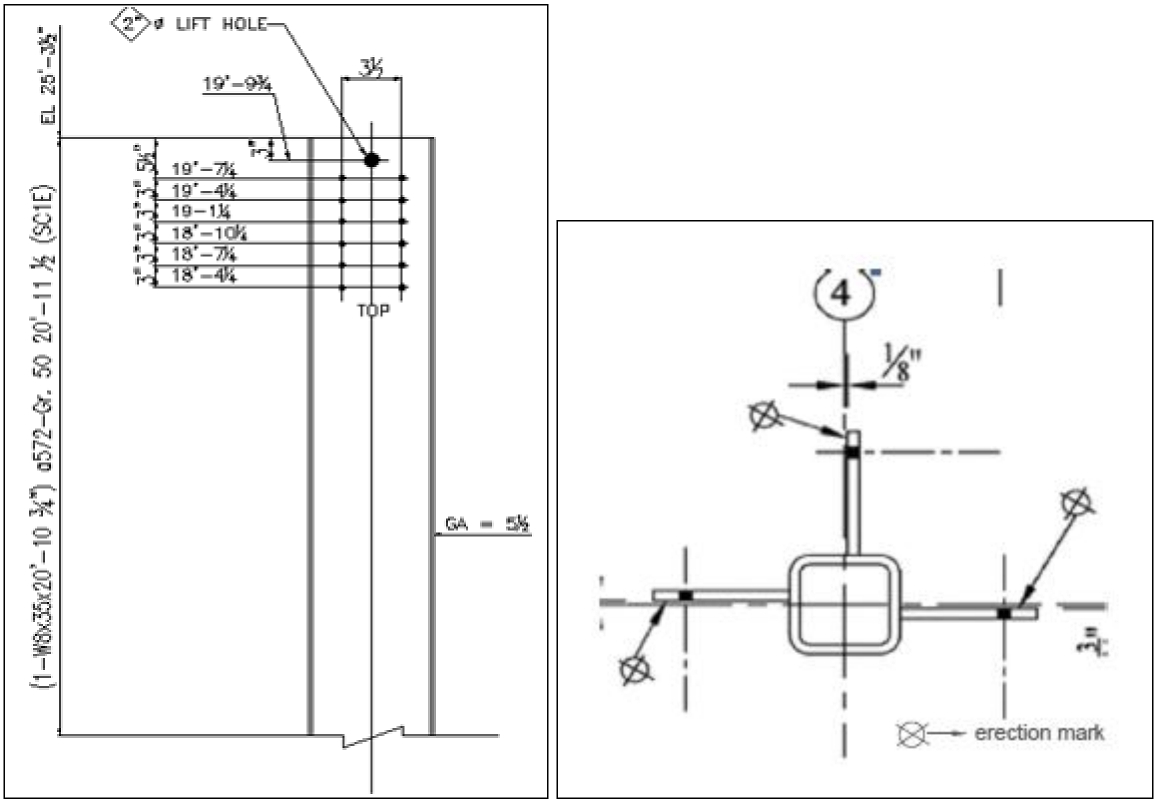
**a. Low Steel erection expertise**

Good quality work comes from a workforce with appropriate expertise (Douglas & Luth2004). However, in order to procure SES at attractive costs, the US contractors and subcontractors hire offshore vendors with comparatively lower steel erection expertise than domestic vendors. Offshore SES vendors participating in this research had no substantial steel construction background since they belong to a nation where steel construction is not yet popular. "*Experience is the only gap filler,*" says the vendor's vice president, which can compensate for their lacking steel background. However, most vendor companies are still young in this line of business, which is the reason for their inexperience. The vendor's vice president recalls that the trend of offshoring SES by foreign clients emerged in late 90s, and most vendors migrated from other services to SES in early 2000s. In addition, the experienced and skilled detailers more often quit jobs to move ahead in their career, again leaving the vendor companies with inexperienced detailers. Such lack of steel erection background in the workforce leads to low quality fabrication and erection drawings. Late conflict corrections and erection delays follow.

Coupled with inexperience, vendors' lack of specific industry knowledge further hinders the constructability. For instance, detailers need to take into account even the standard shipping size constraints while designing steel column splices. Otherwise, lengthy columns wouldn't fit into the transportation trucks, further holding up the erection. Vendors naturally do not have any idea of such hugely impactful industry requirements. They need special training to avoid such problems. Yet another similar problem we observed was that vendors are not aware of sizes of materials available in the manufacturing plant. A project manager says “We just follow the steel codes and charts and choose the best suitable design even if it has to be a W27.5 flange beam. We are certainly not aware if such a profile size is even available for fabrication.”

Further, vendors have to ensure that they do not miss even small erection details on the detailed drawings. For example, consider Figure 4 that shows simple yet crucial erection details. As shown in the exhibit (4.a), a column “must” be detailed with a lift hole, so that the crane operator can lift and maneuver it to its position on the erection site. In exhibit (4.b), the erection marks must be provided because they guide the erector to connect appropriate side of the plate to the beam.

Even though one may assume that these are small details, failing to provide such details will lead to serious fabrication and erection blunders. Offshore vendors without sufficient steel erection background need extensive training to think rigorously in terms of such meticulous requirements. Apart from training, SES detailers rely on sample 3D models, sample drawings and, most important of all, they rely on expert mental visualization skills.




(a) Column lift-hole detail (b) erection mark detail

Figure 4 Erection details

**a.1 Visualization as an alternate for lacking expertise**

“How a column or a beam is erected,” “how is the crane maneuvered,” “how do erectors reach to fasten bolts,” are only some snippets of the many things that a detailer has to visualize during modeling, detailing or checking. Such visualization helps offshore vendors to compensate their lacking steel erection expertise, at least to a certain extent. Although they make use of 3D models and sample connections, the design and detailing of complex structures demand precise mental visualization. Erection conflicts can be avoided if proper visualization is exercised during the modeling and detailing stages.

For example, *a beam which is welded with end connection angles may not fit between the columns due to minimum accessible space, making erection impossible.* Modelers have to visualize this in advance and design the connection with instructions to weld angles in the field and not prefabricate them in the shop. Modelers and detailers have to even consider the tools used at the erection site and check for space accessibility to fasten a connection. For example, a special type of tension gun is required to fasten high tension bolts. Detailers have to visualize space accessibility and consider room for the erectors while designing the connection.

Realizing the importance of visualization, vendor's management recruits their workforce based on their fine visualization abilities. The workforce is given further, formal training about steel detailing concepts and steel erection methods. Despite all these efforts, training and visualization still fall weak as compared to steel erection exposure. This is mainly because offshore SES detailers are deprived of site visits and physical experience.

Lack of site exposure troubles vendors particularly when they are designing intricate connections. We could easily make out vendors' difficulty to visualize intricate connections during discussions with the client. For instance, in one of the conference calls that we attended, when the client asked "*whether the connection can be changed from paddle plate moment connection to shear plate moment connection*" vendors did not have an immediate answer. After a while, they resumed discussion with printed connection samples for reference. Vendor's project managers stated that, "*most of the times connections are copied from previous sample models and details*." Therefore offshore vendors fall short in exercising sufficient reasoning or visualization while designing complex connections, which might in turn lead to poor constructability.

### b. Clash Detection

Timely checks for clashes in building information models by different stakeholders help to identify constructability issues (Taylor 2007). However, offshore SES vendors do not check for model clashes with other trade disciplines since they have no access to other models or to the designer's consolidated model. This problem exists even with other trade vendors. For example, a piping detailer does not have the steel model. One US designer laments *"Detailers only have the steel model and no piping model. Therefore they are not able to make appropriate cutouts in steel wherever there are pipe shoes or pipe trunnions."* Eventually the primary designer is crammed up with this task of detecting clashes between all multidisciplinary trades. Failing to do so, results in expensive field conflicts. The US client designer states that miscellaneous steel rework on site is a commonplace due to lack of model clash detection during the detailing process. He laments *"it is really a waste of time and money , when miscellaneous steel like, handrail, gratings, gussets, connection angles etc. are reworked on site.*" This costs a great deal, especially in heavy industry construction projects worth $4billion to $5billion. Additionally, not detecting clashes among core structural components can halt the erection process causing huge schedule delays and cost over runs and even litigations. Therefore constructability is at risk due to improper interoperability of models between multidisciplinary trades. We address this topic in much detail under the technology interoperability issues further in this report.

# CHAPTER 9

## CONSTRUCT 3. EXCHANGE OF DESIGN INFORMATION

Offshore SES collaboration exhibited serious issues with exchange of design information between vendors, clients and other trade disciplines. We observed that inadequate design supply, followed by numerous design revisions and change orders, caused a negative impact on vendor's work quality. Further, Communication flows through many unwanted screens resulting in Intricate RFI transactions and poor RFI responses.

### a. Inadequate information supply

Among the various drawbacks associated with design information exchange that we observed, the foremost is insufficient design information supply during the initial stages of SES. The vendor's PM disapprovingly commented *"The design drawings are never 100% complete till the end."* In the initial stages, SES vendors are expected to deliver the anchor bolt details and embed steel details. On-time delivery of these shop drawings is crucial because anchor rods have to be fabricated early during the construction process in order to facilitate foundation concreting. However, due to unclear design information during initial stages, vendors send requests for information (RFIs) and hold their work until they receive clarifications from the clients. This cuts their work flow and risks the overall project schedule. In addition to missing information during initial stages, at the midpoint of the project they are still missing about 20% of the information. Apparently, the quality of primary design drawings received by the SES vendors has deteriorated, in terms of information completeness, over the past few years. The vendor's vice president illustrates this through his own evaluation:

*"From a scale of 1 to 5, 1 being the most incomplete set of drawings, right now the design drawings received can be rated from 1.5 to 2.5."*

Ideally, detailers need complete information before beginning their work (Douglas & Luth 2004). However, that never happens; SES detailers are asked to begin their work using the scanned images of design drawings supplied for initial bidding purposes. Detailers expressed their contempt for these bids set drawings because they are not only very poorly detailed but poorly printed. During interviews, modelers, checkers and detailers expressed their reluctance to use such deficient information. Modelers had to prepare structural steel 3D models based on uncertain assumptions due to unavailability of sufficient information. In addition, they expressed that the scanned image files would produce a bad quality print, no matter how good the printer is. We saw checkers and detailers using magnifying lenses constantly to identify poorly detailed member sizes. They become frustrated when they have to constantly set the prints aside and refer to zoomed views on the computer to obtain information. At times, it is very hard for them to read or follow important details. For example, one of the sample design document sets that we observed was missing column locations and grid lines; other grid numbers were vaguely printed, and half of the steel member profiles were missing. This directly affects the vendor's work quality, causing them to become frustrated at spending time searching for relevant and accurate information.

SES detailers also complained about conflicts between information related to different trade groups.  For instance, in one project, vendors clarify the opening dimensions of an elevator shaft, which originally wouldn't fit within the space. Client (fabricator) couldn't get response from the Mechanical Electrical Plumbing (MEP) vendor. Finally, when the response arrived, many changes had to be done to steel 3D model.

**b. Design Revisions and Change Orders**

Revisions become inevitable due to the fact that clients hire SES vendors while design is still in the early stages and information is inadequate. As a result, many design revisions occur after the SES tasks have kicked off. Vendors expressed that on an average they receive 5 or 6 sets of revised design drawings during one project. For each revision, detailers have to track down the impact of these changes and perform rework. Design drawings are always released to vendors in stages. For example, initially they get conceptual design drawings followed by 30% complete design drawings, followed by 60% complete design drawings, then the 90% and so forth. Furthermore, there is a chain effect on revisions within the entire project network. For instance, a structural Engineer will need to change his design to accommodate the revisions done by an architect. Then the general contractors and other trade contractors give their inputs which further add to the revisions. Eventually the downstream design service providers like SES vendors have to accommodate all these revisions and perform rework. Sometimes design revisions get out of control, causing several reworks. For example, vendors suffered lots of rework when a commercial project that started with bulletin # 8 contract documents was revised to # 23 in just 6 months.

Apart from design revision, there are change orders. Changes are done to the original 100% complete design. Even though change orders mean additional money for the vendors' management, the workforce gets de-motivated to perform reworks due change orders. A PM expressed that

*"These changes are not always additions to the main structure, but these changes are various modifications done to the existing structure!-This should not happen."*

Detailers are de-motivated because they feel it is frustrating to redo the drawings which were sent to the designer for approval six months earlier.

Design revisions and change orders most often interrupt vendors' work flow. When a revision arrives, vendors stop their work to assess and determine the amount of rework needed. They proceed only after the commercial aspect is negotiated with the client. A project manager gives an example:

*"There was a change in the elevation of one floor. We had to re-model and re-detail all columns, and other members connecting on that floor. This had a great financial impact. A change request was issued and we indicated the increased man hours required and hence the additional price was updated. Until this commercial part was not over, we had to stop the work."*

Due to design revisions and change orders from the clients, the quality of 3D structural steel model is at risk. SES vendors check the revised design drawings thoroughly and update the structural steel 3D models accordingly. Every time the 3D model is changed, the change has to be reflected in the shop drawings as well. Detailers noted that after updating the model, they had to be very careful in applying the changes to the detailed drawings. Overlooking certain warning messages on the modeling/detailing software might result in irrelevant changes that are hard to locate later on.

In summary, design revisions and change orders require SES vendors to perform heavy reworks. This not only results in loss of interest in work, but also impacts the quality of 3D steel model and the final shop/erection drawings.

**c. Screened Communication**

In global SES project networks, communication flows through various organizational and geographical barriers. In other words, communication flows through various local and international stakeholders before reaching the appropriate person (see Figure 6). Figure 6 represents our observation of communication flow in AEC project networks involving SES vendors. The dashed lines in Figure 6 represent the possible communication routes which we did not observe directly, but were mentioned by our interviewees.

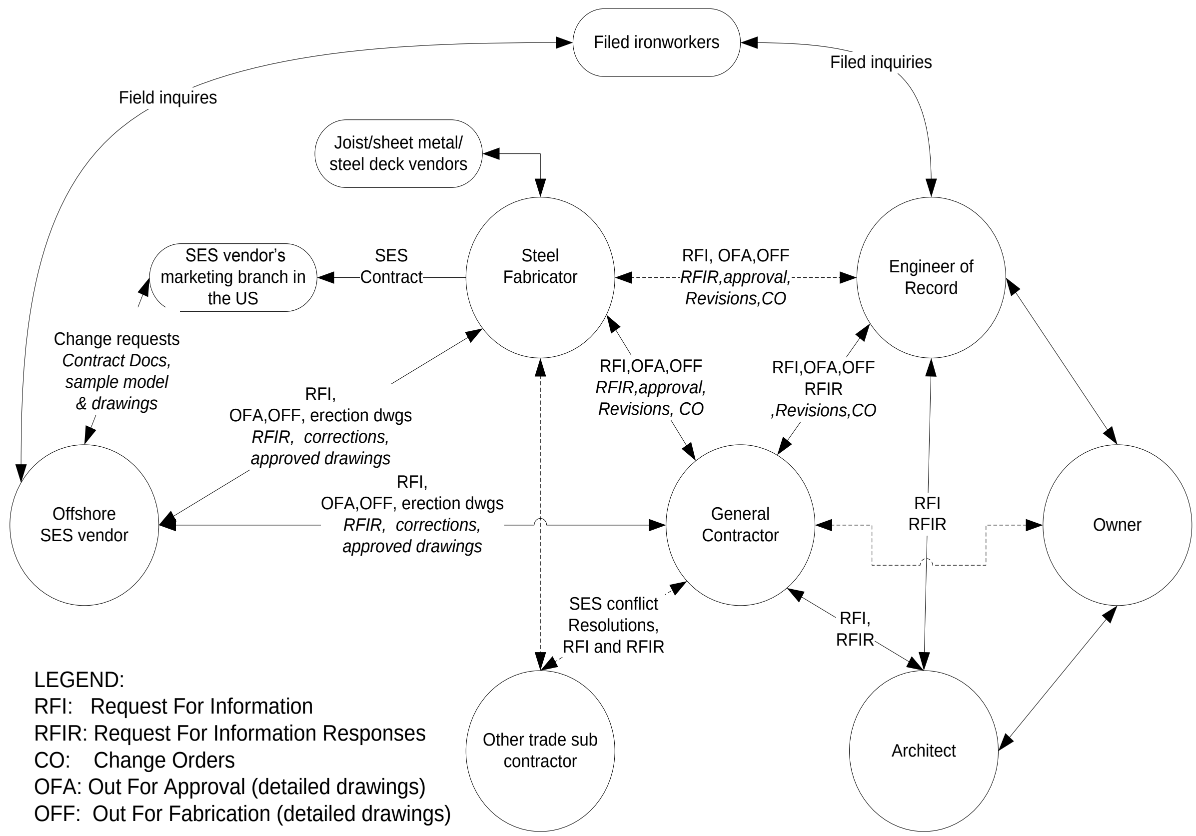



Figure 6 Information flow in SES offshore collaborations

***Note:*** *The italicized text represents information flowing between participants in a direction right to left or bottom to top. The dashed lines in the Figure represent the possible communication routes which we did not observe directly, but were mentioned by our interviewees.*

As a result of communication screening, design revisions, change orders and RFIs etc are screened through many project participants before reaching the right person. This not only delays communication, but also causes coordination complexities that produce unwanted results. For instance, consider this experience shared by the vendor's senior PM.

*"Elevation of a level had been changed and this was not communicated to us at the right time. When we received this updated information the fabrication was started and it was too late…when steel went to the site, they noticed a possible undulation in the foundation level;*

*one row of columns went down compared to the opposite row. Fabrication and detailing had to be redone. This impacted the time and cost too much*"

The screening is comparatively less when the fabricator is eliminated from the collaboration structure and a GC directly hires the SES vendors (see Figure 6). However, regardless of the collaboration structure, the main point still remains. Coordination complexities and schedule delays occur because of communication screening between the SES vendor and the responder.

**d. Inefficient RFI operations**

The entire RFI operations were inefficient in terms of RFI coordination complexity and response quality. The following paragraphs summarize our observation about the RFI process. Vendors believe the rule *"more the number of RFI, the poorer is the design quality."* In other words, inadequate information supply and inconsistent revisions forces vendors to raise RFIs and continue their work in uncertainty. Vendors start raising RFIs right after kickoff, and continue until they submit their last set of drawings. To clarify the unclear design information, vendors send requests for information (RFI) and stop their work until they receive clarifications from the clients. Since they cannot proceed with their work until these RFIs are answered, they refer to them as "work stopping RFIs." Then, during structural steel modeling and secondary design stages, vendors raise RFIs when they come across non-feasible connections or framing misfits. Finally, inconsistent information in revised bulletins of contract documents continues the RFI cycle.

Vendors raise RFIs in two ways. First, they ask the question directly ("how to do this"?) For such RFIs, vendors cannot afford to make assumptions; therefore they have to wait until the responses arrive. For example, "work stopping RFIs" explained above. The second type of RFI seeks to confirm or correct an assumption (*"we have adapted this solution, confirm if this is alright"*), such as RFIs that ask for connection details. Therefore, vendors either stop their work while waiting for the RFI responses, or continue their work based on uncertain assumptions.

Once the RFI clarifications arrive, SES detailers have to study them and incorporate all resulting changes, which can in turn lead to many reworks. Time spent in RFI processing delays a vendor's ability to deliver on time. Furthermore, clients and vendors feel that RFI processing is a mentally laborious task. In particular, checkers find it hard to go through all the RFIs and check whether the final shop drawings have incorporated changes from all the RFIs. Therefore less RFIs and quick RFI operations save time and improve project performance.

However, there is no control on RFI operations within offshore collaborations, which results in excessive RFIs. We observed that RFI numbers can go up to 200. The maximum number of RFIs observed by a vendor was 250 in a particular project. We are just referring to the RFIs relevant to SES, but there might be hundreds more RFIs coming from other trade disciplines. Such a deluge of RFI holds up work at all ends and delays the overall project schedule. In addition, an increased number of diverse project participants aggravate inefficiencies in RFI operations. Due to many project participants acting as screens, RFIs do not reach the right person at the right time. This is discussed in more detailed in the flowing section

**d.1 Intricate RFI transactions**

Communication screening, explained in the earlier sub-construct, plays a major role in complicating the RFI transactions between various project participants. RFIs and their responses flow through many screens to reach the appropriate person (see Figure 6). The vendor's senior project manager explains screening of RFI by different stakeholders using an example from one of his ongoing projects:

*"The owner is in the Middle East, the General Contractor is based in the UK but operating from Middle East. Due to local technology scarcity, the GC hired an US fabricator who further hired us, (SES vendors from India), so then... the RFIs raised by us go around the world before they reach the right person. This takes lot of time. If it was within our nation we could have directly contacted, called spoken to them and solve the problem. But in this case we have to wait for a long time".*

In the above quote, even though an RFI does not literally go around the world, individuals in separate organizational and geographical boundaries read the RFI and forward it further till it reaches the right person.

The number of interfaces between the SES vendor and the responder depends upon the organizational structures and the project delivery networks. For instance, as shown in Figure 6, an RFI raised by the offshore SES vendor may screen through the steel fabricator, general contractor before reaching the Engineer. Then, the RFI response (RFIR) flows back on the same path in reverse direction to reach the SES vendor. The number of screens may go up when the SES vendor's RFI falls under the jurisdiction of different specialty vendors like MEP vendors or a joist detailer. In such cases, the fabricator or the GC or the EOR (whoever is contractually responsible), retrieves the information from the appropriate person and forwards it to SES vendors. Due to such screening, communication does not reach the right person at the right time.

Apart from these regular delays, we observed that communication screening aggravates coordination complexities. This happens especially with a fabricator client who has limited staff with sufficient expertise to manage the deluge of information. We observed that usually a fabricator employs only one engineer to manage information exchange with all other participants. The coordinating engineer's task is complicated exponentially when the fabricator hires many engineering vendors for different sequences of the same building. Now the engineer would have to singlehandedly coordinate between multiple SES vendors and the upstream participants like the GC, designer, joist, sheet metal, steel deck detailers and so on (see fig 6). Such coordination complexities lead to mistakes such as mismatching of RFI numbers. Consider this explanation by the vendor's PM:

*"Fabricators might have divided and assigned the joist detailing to a different company, deck to a diff company, steel to a diff company. Then each detailing company will send the RFI to the fabricator with a different numbering format. For example, my RFI 10 can be same as joist detailer's RFI 15. Or, the joist detailing company might send a RFI 10 asking a question and our company might have a sent a different question with RFI no 10."*

In the above quote, common answers arrive for the same questions but with different RFI numbers. For different questions with same RFI numbers, there are different answers. In both cases, the coordinating engineer is expected to tag the vendor's original RFI number with the responses. Further, he has to segregate and send the right responses to the right vendor.

*Mismatch in RFI numbers*

However, we observed that clients fail to tag appropriate RFI numbers with their responses. When that happens, SES vendors lose considerable time in tracking the RFI responses and matching them with the original RFI numbers in their database. This problem is aggravated by the large volume of RFIs, which we observed could go up to 300 SES-related RFIs for a single project. In extreme cases, due to mismatches in RFI numbers, vendors and clients may even overlook some crucial RFIs. Further, probably as an extended negative consequence of screening, RFI clarifications became ineffective.

**d.2 Ineffective RFI Responses**

The main problem with the RFI responses (clarifications) that vendors expressed was that they were quite often delayed inestimably. Even when the responses arrived after certain delay, their quality was compromised. Most of them were incomplete or confusing, or different from the questions asked. As a result, vendors get frustrated when they aren't able to continue their work even after responses arrive.

*Late RFI responses*

Late RFI responses from clients can break a vendor's workflow, which troubled the detailers. Quoting the National Institute of Steel Detailing (NISD) manual, the vendor project manager says, "*the ideal time to answer an RFI for the client is about 24 hrs to 48 hrs".* He further adds *"but RFI responses are delayed beyond these recommended timelines..*." RFI responses are delayed are even delayed up to 3 months.  Late RFI responses can be detrimental for both types of RFI formats explained above. The first type asks for the solution and the second type seeks to confirm an assumption about the solution. In the second type of RFI, detailers have the risk of rework; if clients overrule vendor's assumptions after a considerable delay then all work based on this wrong assumption has to be redone. The overall schedule is at stake here because vendors cannot submit the final fabrication drawings ("Out for fabrication" (OFF) submittal) before the clients respond to all pending RFIs. Furthermore, the cost of services increases for any substantial changes due to client's delayed response, which can lead to change order requests and hence additional cost for clients. Here is an example from the vendor's project manager:

*"If the RFI waiting time goes for a long time… by that time we might have modeled with the information we have… Then when the answer comes for example there is a change in the elevation then the entire columns and members have to be modified etc...  We have to re-model and re-detail then this has great financial impact… This will be a change order and we indicate the increased man hours required and hence the additional cost is updated".*

Therefore, delayed responses postpone vendor's delivery, not only due to rework but also due to time lost in negotiating change order requests. In addition to the delayed responses, we observed notable problems regarding the quality of client's responses. Incomplete and too specific RFI responses are some examples of client's poor quality responses.

*Incomplete RFI responses*

A vendor's RFI sheet is sometimes formatted to contain more than one question. Each question may fall under a different stakeholder's jurisdiction, therefore the RFI solutions may arrive one at a time and not completely. The vendor's project manager gives an example as follows

"*We have raised 4 questions in one RFI sheet, one is concerned to GC, one to architect, one to EOR and so on…In such case if only two of them have answered immediately and the other two are not answered. The fabricator forwards only the two answers to us. We have to wait for the other two questions to be answered."*

Overwhelmed by data handling, the fabricator fails to follow up on these remaining questions. SES vendors then repeat the RFI with a new nomenclature, but reference the previously raised RFI. Sometimes clients say all RFIs will be completely answered in next bulletins, but that seldom happens.

Another case of incomplete response is expressed in this example provided by the vendor's project manager

*"He [the client] might have answered to our question specifically by asking to change the work point. But he might have not studied the impact of that. This change in work point might impact the detail of 20 different members."*

Such incomplete or too specific responses lead to repetitive RFIs and delay the delivery of shop drawings. This kind of problem arises when vendors or clients fail to consider all ramifications due to an RFI.

To avoid this problem, vendors thoroughly study the all the ramifications of RFI and incorporate them in the questions itself. Some vendors who realize this problem take special care to follow up on incomplete and irrelevant responses. Vendors send weekly updates to remind of the pending RFI status. One vendor organization that we observed even employed an exclusive IT employee who maintained records of RFIs and their responses on an online database management system. The project manager comments on this setup *"Until the RFIs are answered completely and relevantly, they are not closed in the online database."*

### Information exchange in design-build/EPC collaboration

Exchange of design information is more efficient in a design-build/EPC network than that of the traditional fragmented network. Figure 8 shows a typical design build set up involving offshore collaboration for SES. In such a network, design engineers and building contractors coordinate within a single organizational boundary and less participants outside the organizational boundary are involved (see Figure 8). The dashed lines in the Figure 8 show communication routes that we did not observe directly, although were mentioned by our interviewees. Another important difference we noticed from the traditional network is that design-build clients share 100% completed design drawings even with offshore SES vendors. Therefore information supply is up to date, and there are no unwarranted design revisions and uncertain assumptions from vendors. Also, we observed a considerable drop in the number of RFIs in design-build/EPC networks.

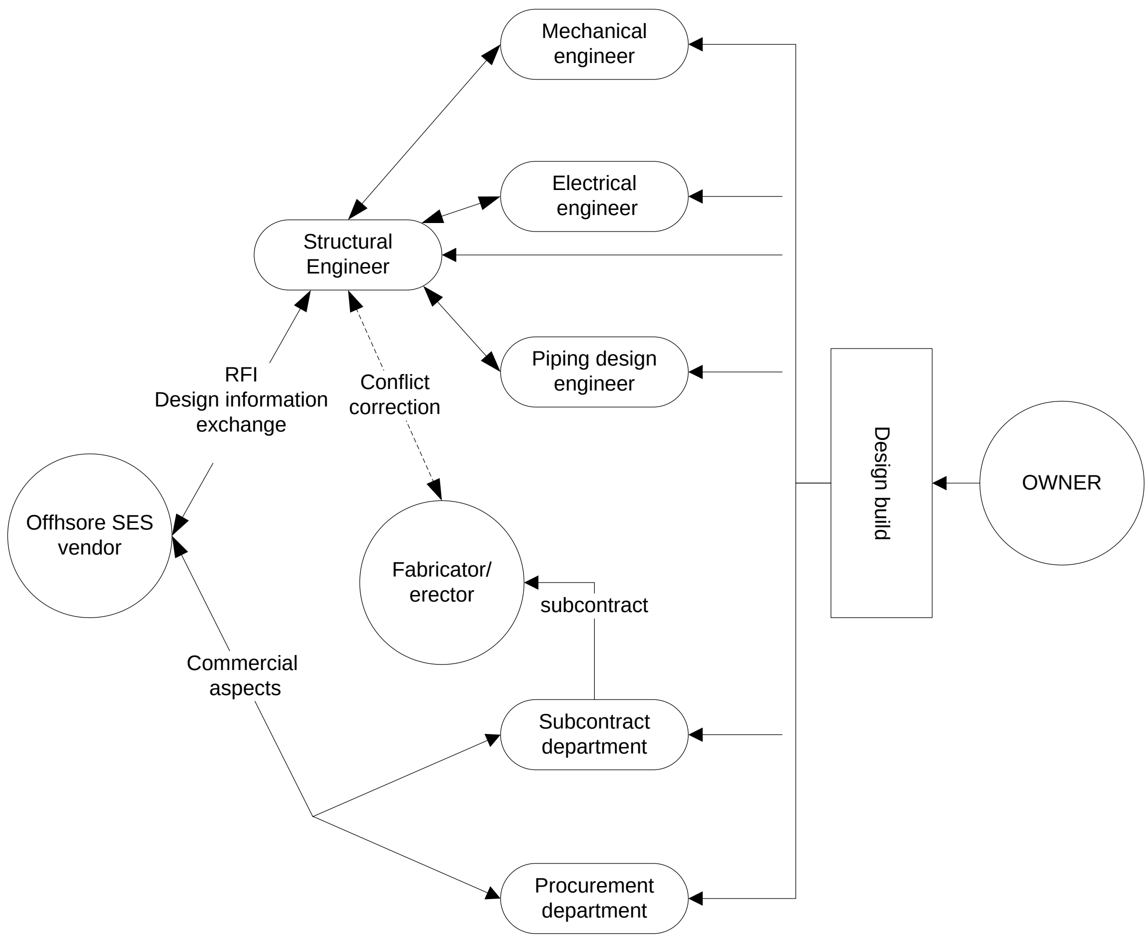



Figure 8 Information flow in design-build/EPC collaborations

Further, we observed that screening of RFI transactions is lowest when a design-build/EPC client is involved. Offshore vendors, if present, communicate directly with the designer (see Figure 8) eliminating the screening found in traditional offshore networks. For instance, If SES vendor has a RFI related to piping design then the structural engineer retrieves answers from the piping engineer and replies to vendors. The structural engineer directly interacts with the SES detailers, and conflicts are resolved quicker than the traditional offshore collaborations. The structural engineer of the design-build client in the US stated that they process a RFI in just one or two days. Offshore SES vendors had no complaints about response speed and quality from a design-build client

Clients and offshore SES vendors exchange design information thorough internet based project management systems such as FTP sites, e-rooms and so forth, also termed as Web based Project Management Systems (WPMS).

# CHAPTER 10

# CONSTRUCT 4. INEFFICIENT USE OF TECHNOLOGY

Even though technological advances have been a major contributor in enhancing collaborations between construction project participants (Dossick and Neff 2010), we observed a lag in technology use among SES offshore collaborations. Technology interoperability issues in terms of Building Information Model (BIM) sharing and data management was apparent between clients and SES vendors. Further, inadequate or outdated software packages made the downstream design process even more tedious.

## a. Interoperability Issues

Amid the high-tech BIM sharing practices between project participants, offshore downstream design networks are still stuck with 2D printed plans sharing through Web-based Project management systems.  In Figure 9, we present the limited technology interoperability that we observed in offshore downstream design networks.  To compile Figure 9, we combined our observations with that obtained from literature review.

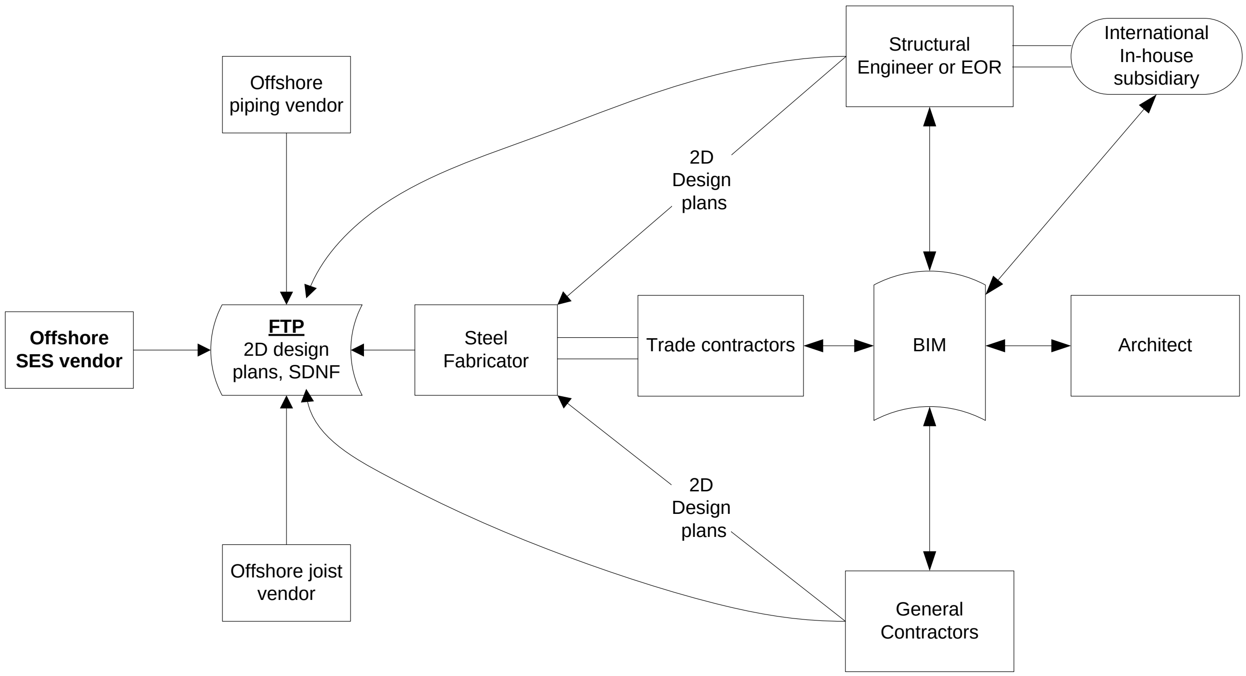


Figure 9 Technology interoperability

From figure 9, it is evident that architects, contractors, designers, and trade contractors on the upstream side join hands to create a single consolidated model (BIM). This is stored in common servers accessible to all participants. As shown in fig 7, the design-build client shares the BIM with their international in-house subsidiaries as well. However, we noted that clients (EOR/GC/Fabricators) do not share their BIM with offshore SES vendors or any other offshore engineering service provider. As a matter fact, clients limit electronic data interchange with vendors across organizational boundaries (Dossick and Neff 2010) regardless of their location (overseas or in the US). The chief designer of the US design-build/EPC company says that they avoid BIM sharing in order to preserve confidentiality of their engineering decisions, standards, styles, practices and intelligence.

Alternatively, SES vendors are provided with a structural steel 3D model that is extracted from the main BIM. In a few other cases, clients provide the Steel Detailing Neutral Files (SDNF), which can be imported into the CAD software and converted into a structural steel 3D model. According to vendors, these SDNF -generated steel models are seldom accurate and "need considerable repair work." Moreover, the clients neither vouch for the accuracy of these steel models nor do they solicit the vendors to use them. Clients do not even include this steel model as a part of their contract documents, but only share it as supplementary information. A vendor detailer says *"quality of this BIM is poor."* Therefore instead of spending time on repairing the model, vendors recreate the structural steel 3D model using the 2D plans and section details. The vendors denied using models from SDNF by saying that "*we do not want to take risks by using it."* This finding seconds that of Taylor (2007), in which he establishes that contractors recreate the CAD model due to fear of liability issues. On the downside, recreating 3D models is a time-consuming task. Moreover, vendors have poorly detailed primary design drawings to begin the modeling with. Further, they have to revise the model as many times as the design is revised, eventually risking the 3D model's quality.

**a.1 Inefficient data management**

Inefficient electronic data interchange/management is exhibited through the restricted usage of the common web repositories (FTP) between clients and vendors. We observed that the contract documents and submittals were shared through these common web repositories, but not RFIs and other informal queries. Instead, RFIs, queries and their responses are shared mostly through emails. As a result, clients may lose track of such emails amidst the high email traffic from all ends. In the worst case scenario, lost RFIs could possibly lead to overlooking of potential design mistakes leading to horrible construction errors. Furthermore, such slack in sharing disrupts the coordination between participants. For example, during a conference call, clients had no clue as to which RFI the other party was referring to. Speaking from experience, one detailer described such conference calls as *"fussy and lengthy.*" Vendors personally wished to record all mutual communications and other data in common repositories. Identifying the disadvantageous lag in technology usage, the vendor's project manager expresses the change he would want to see:

*"I would like to make everything online….All updates, communications, emails, RFI, etc. should be updated and maintained online so that each and every person associated with the project can access it online".*

**b. Detailing Templates**

Despite the fact that steel detailing template files can potentially save considerable detailing time for vendors, clients do not practice effective sharing of template files. Steel detailing templates are very handy because they are predefined with standards, styles, specifications and layout settings. We observed that clients either do not share the template files or they share poor quality ones. As a result, SES detailers spend 30% of their entire project time on detailing or editing. Furthermore, most of their editing/detailing time is wasted on fine tuning drawing representations as per specific fabricator requirements. Consider the graphical example in figure 10. Exhibit (a) shows one fabricator's requirement that the channel beam's dimension begin from the face of the cleat angle.

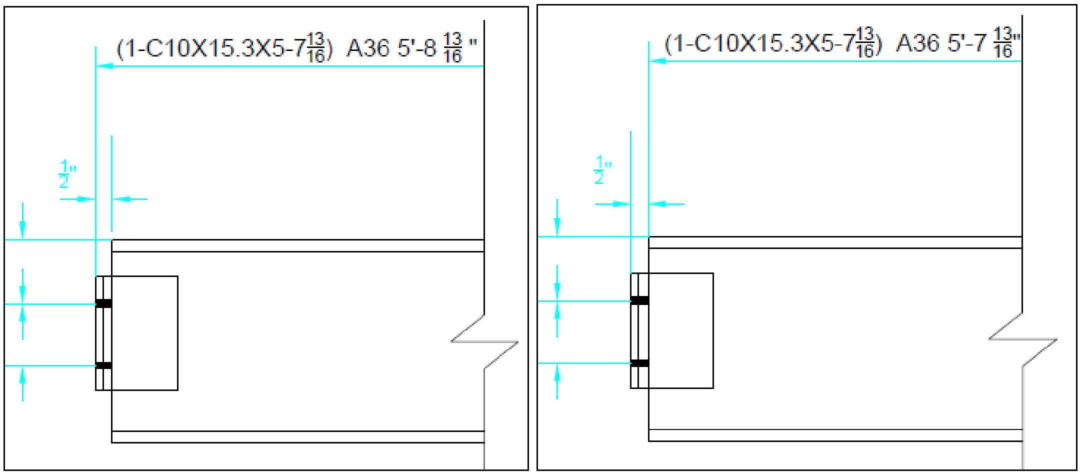



Exhibit (a) Exhibit (b)

Figure 10 Different detailing representations

A different client expects exhibit (b) for the same detail, with all dimensions starting from the channel's start point. Figure 10 gives example of a simple representation adjustment that would take considerable detailing time. There can be other complex drawing scale settings or default work point settings that take a lot of detailing/editing time and can cause work frustrations. Instead standard template files containing all predefined settings would be much easier to use and could save a lot of detailing and editing time.

Despite these advantages, clients either failed to share template files or shared poor quality versions. Since clients wouldn't even vouch for their accuracy, vendors avoided using them. Vendors partially imported the complex representation settings (e.g., drawing scale etc.) from the template files into their drawings and created their own standard templates for every client, adding to overall time consumption.

**c. Inadequate Software packages**

Offshore SES detailers work on US based software that is not available locally. Therefore they have to invest money to purchase licenses for this software and renew them every year. Due to highly disproportionate currency exchange between US clients and offshore vendors, we observed that vendors avoided purchasing expensive updated versions of software. Instead they chose to use the old outdated software that demanded greater labor. One of the interviewed vendors still uses the SDS/2 version-6 software, while the world has moved several versions ahead and currently uses version-7.2.

Working on such outdated software is tedious and non user-friendly. For example, older SDS versions require detailers to use all three mouse buttons for model screen navigation purposes. This is quite tedious when compared to the easy mouse wheel scroll navigation in the newer versions. Even though the difference is simple in this case, the time saved is enormous. Furthermore, in the older software there was no undo command option. As a result mistakes during complex moment connections couldn't be undone. Even for small errors, the whole connection had to be redesigned from scratch. A detailer quotes yet another drawback of the older software:

"*When you make design changes to the model and refresh it, all previously detailed data might get erased….unless and until we meticulously take care to click on a check box."*

Inexperienced workers are most likely to overlook this single option and commit blunders leading to frustrating reworks. Thus, outdated software negatively impacts work productivity and the quality of detailed drawings.

# CHAPTER 11

## CONSTRUCT 5. VIRTUAL TEAM MISALIGNMENT

SES vendors and clients electronically interchange work related documents through common repositories such as File transfer Protocol (FTP) sites, e-rooms and other internet based project management systems . They mutually download data from a common FTP space and manipulate it in their personal space. Then they post it back in the common space. Such collaborations do not exactly match with the formal virtual team definition established by Chinowsky and Rojas (2002, 2004) suggest that even though such collaborations do not meet the formal definition of virtual teams, based on their virtual communication aspects they can be argued as virtual teams.

Moreover, many crucial tasks such as checking, back drafting, RFI processes require cooperative work sharing and communication between the international SES teams to resolve problems. Furthermore, we observed that the international teams often met in a common digital space enabled by "video conferencing with data sharing." These video conference sessions were reserved for client standards' training sessions, discussions for conflict corrections, and field conflict inquiries. There was also electronic sharing of important detailed drawings, RFIs, model snapshots, and scanned design drawings. Due to the digital work sharing and virtual communication between clients and SES vendors, we refer them as virtual teams. Further, we observed that these virtual teams were misaligned in terms of trust, understanding, behaviors/expectations, and communication approach.

### a. Mutual distrust

As a result of mutual distrust in terms of security concerns and confidentiality, clients withheld BIM data from vendors. Further, we witnessed various instances indicating mutual distrusts between the virtual teams. For instance, even though clients trusted vendors' capabilities in doing the job as told, they often distrusted their knowledge competencies. Clients showed lack of trust and failed to take into account detailers' concerns about the engineering design. They expected the vendors to promptly follow the contract documents and avoid questioning the rationale of design. Further, vendors complained that clients sometimes suspected the worth of their RFIs and questions. For example, when vendors assumed an engineering solution and raised an RFI to confirm it, designers wouldn't easily concede to it. A vendor PM comments in this regard that

"*the hardest part is to explain to clients and convince them that their assumption is right according to the standards".*

Sometimes egos came in the way of their decisions. Clients did not like an international vendor explaining them their own standards and design codes. On the other hand, vendors experienced occupational qualification conflicts when they had to explain their engineering solutions to the low qualified client checkers. Most vendor detailers that we observed had a bachelor's of engineering degree, while the checkers and detailers on fabricator's side had a diploma in drafting. Vendors took all actions of distrust, mentioned above, as an insult. As a result, detailers got de-motivated and lost commitment towards work.

Lack of mutual trust was especially dominant when relationships between the clients and vendors were fairly new. For example, mutual trust is better between vendors and clients working together for the 5th time, rather than those working together for the first time.

### b. Conflicting Perceptions

The virtual teams faced many conflicts due to different perceptions of rules and norms, time preferences and final result expectations. Vendors and clients had their own opinions and choices towards elements like rules, time and end results. These differences between virtual teams caused conflicts that negatively affected their work.

#### b.1 Rules and norms

We observed that the US clients strictly adhered to rules and contracts, and expected the same from the vendors. In contrast, we found vendors were happy to bend rules and manipulate standards and protocols to suit the circumstances. Consider this anecdote, for instance, from the vendor's senior PM:

*"He [the client] won't add the dimension 4" and 8" and make it 12", He expects total dimension to be present on the detailed drawing."*

Similarly, vendors would conveniently fail to provide minor dimensions, while clients would strike back asking for minute details. The vendor's senior PM confirms this with another example:

*"For a sloped member if the diagonal dimension is missing we would have used the Pythagoras theorem to calculate the missing diagonal... but they (clients) won't do that; they will strictly go on with what is there on the drawing. "*

Being firm on their rules, clients always expect 100% details from vendors. Vendors find it hard to keep up with clients' strict rules. Speaking about varying accuracy perceptions between clients and vendors, the vendors' vice president says:

**"***If the detailed drawings are even 99% accurate we are happy….but US clients are happy only if the work is 100% accurate."*

**b.2 Time preferences**

US clients viewed time as an asset and were very serious about deadlines. They expected vendors to deliver before deadline. In contrast we found vendor's detailers were comparatively lenient about time and did not mind pushing deadlines. The vendor's vice president explains the mutually varying time sense as follows:

*"USA people are very strict with their time. They come sharply and leave sharply. So they don't take things for granted and finish the work within deadline….Whereas, we are flexible in timing, and our employees don't mind working long and so they begin late accordingly. And at times we tend to push the work for next day."*

As a result of these varying time organizations, clients pressurize the vendors to meet deadlines, while detailers protest to yield to this pressure. The vendor's PM acknowledges by saying

"*Sometimes it is very hard to get the work done from our detailers within deadlines… While on the other side the client is bombarding us to deliver before deadlines.*"

Further we observed that vendors didn't mind performing multiple tasks simultaneously, as opposed to the clients more sequential, "one thing at a time" approach. For example, we observed that clients procured detailed drawings for the first sequence of the building before offering the next sequence. On the other hand, vendors engaged with 4 to 5 different clients at one time.

### b.3 End result priority

Clients prioritize their work in order to reach end results. Therefore they would check back on vendors a day before the deadline, and they wouldn't be happy if vendors start explaining reasons for their inability to finish the work. It is quite natural for them to reprimand vendors for not providing the results. On the other hand, vendors during the interview with us condemned clients for not considering the problems during the work, but only expecting end results. This quote from vendor's vice president expresses his unhappiness towards clients end oriented behavior:

*"Client is bothered only about the final delivery date. For example if something is due on 15th, client will ask us only on the 14th.....he (Client) will not ask about the progress until the deadline arrives."*

Apparently, clients place a high priority on end results, while the offshore SES vendors place higher priority on the means of reaching end results rather than the end results itself. In addition to the means, they are also concerned with their client relationships. For vendors, relationships with clients are very important, which is not necessarily the case for the clients. Vendors would attempt to preserve relationships even from a failed project. Clients on the other hand work on a one-project-relation basis. If they like the vendor's work in one project, they hire them for the next too. The vendor’s vice president said that *“if we do well in A, we get B; if we do badly in C we don’t get D.”*

**b.4 Authority**

Authority is imposed at the vendors end, hierarchically. The vendor’s detailer at the bottom of the organization structure has to follow the voice of their superiors. For instance, even though a detailer sees the client’s email asking for some changes in the drawings, he wouldn’t do it until his project manager orders him to. Furthermore, the vendor’s detailer doesn’t even reason whether the solution given to him by his project manager is right or wrong.

US client organizations, on the other hand, are more egalitarian and authority is spread horizontally. Even a low ranked employee is free to argue his decision and action.

**c. Misaligned Communication**

We observed that the communication between virtual teams would get disrupted due to varying communication styles, language problems and time difference.

**c.1 Communication styles**

Vendors and clients have varied communication styles. In that, clients have a direct and informal style of communication whereas vendors have an indirect and formal communication style.

*Indirect vs. direct style*

Clients complained that vendors' questions are too elaborate and indirect for them to comprehend. Their RFIs questions contain explanations of the whole problem scenario, and therefore become expansive. Sometimes the RFIs go up to a few paragraphs in length. Amid the bulk of text, the main question becomes elusive to the client. On the other side, vendors complain that sometimes clients' responses are over-concise and short. Clients' checkers' comments on approval drawings are very concise. Sometimes there is just one word or a phrase at most, whereas vendors seek much more detailed comments. Some vendor managers who realize these problems encourage their detailers to use graphic samples like a model snapshot or a contract doc snap shot instead of lengthy text. Obviously, *"an image is worth a 1000 words."*

*Formal vs. Informal style*

Furthermore, communication problems occurred due to clients' informal style against vendors' formal style. Although the offshore vendors we interviewed originally are very formal in their communication, they appreciated clients' polite and informal communication, which put them at ease. However, at times client informality can be detrimental to their mutual harmony. Especially when detailers miss an important deadline or there are quality issues, clients do not hesitate to express temper through informal words. Vendor's senior PM condemned this behavior and calls it *"unnatural and hurtful."* He gives an example from his experience that,

*"Once because client used harsh words detailer had quit work in between a project … and due to inadequate manpower project got delayed…So such problems are faced due to difference in communications style.*

**c.2 Language**

Language accent problems disrupted the communication between virtual teams. Vendors faced difficulty to follow clients' accents, especially when technical terms were involved. Commenting on the accent issues, the vendor's vice president says-

*" during a conference call, if someone talks with a heavy southern US accent…a Californian can't understand it then how would we understand…?" similarly, even we don't understand when some of our own team members speaks with local ethnic accent then how will the clients understand..?"*

Further, the vendor's vice president quotes one of his experiences-

*"US guys got frustrated when our guys would not follow their communication and repeated the questions, or when they did not understand our guy's speech."*

Most often, vendors wouldn’t repeat questions, to save face, even if they don’t follow the answer and try to figure it out later by themselves. To overcome language problems, vendors invest in extra training.

**c.3 Time difference**

Geographically, vendors and clients are one workday away from each other. The time difference poses some serious problems, especially during field conflicts when field engineers need on spot clarifications but steel detailers are not in office. In summary, due to different reasons such as mutual distrust, conflicting perceptions, language problems and Time differences vendors' and clients' teams were misaligned.

# CHAPTER 12

# CONSTRUCT 6. INTERNAL TEAM MISALIGNMENT

Problems due to team misalignment were not limited to the virtual interface but were also seen internally within the vendor's organization between the workforce and management. There are routine clashes between management and workforce in terms of project goals. In addition we observed that teams frequently shifted from one project to another and losing focus on the project goals.

## a. Misaligned goals

We observed that vendor management were oriented towards company's growth while the workers were motivated by individual growth

### a.1 Company versus Individual growth

Vendor management fights to fulfill their business commitments whereas the detailers fight for billability of their work. This problem occurred especially in dedicated resource models, where only limited detailers are billed under a project. In such models, when work wouldn't finish within the dedicated man-hours, the management asks for more man hours. When the client denies their request, management drafts more detailers to work on that particular project without billing them. Ironically, vendor management evaluates detailers' appraisals later on depending upon their billability. Therefore detailers dislike doing this non-billable work, because they feel their efforts are not being recognized. They get discouraged when their work is not billed, especially after putting up long work hours, day and night, sometimes up to 20 hours per day. A detailer scorns, "*forget appreciation, our work efforts (man hours) are not even billed.*

**a.2 Profit versus work satisfaction**

While management seeks profit, employees look for work satisfaction. For instance, design changes and change orders are a bonus from management perspective, but detailers dislike them, for they resent doing rework. Further, detailers dislike when the top management pushes them to maintain deadlines, as they expect more considerate behavior.

**b. Shifting goals**

Due to lack of information availability on one project, detailers intermediately shift to different projects with totally different client requirements and standards. Even though, this is in the business interest of the vendors, it undermines detailers' alignment towards project goals. We observed that vendors simultaneously work on 3 or 4 projects each with totally different demands. For example, each client had unique requirements with respect to ship mark pattern, number of sheets per drawing, connection types, types of high strength bolts, tools used, etc. It was hard for vendors to catch up with all of them at the same time.

The clash between management and the workforce is aggravated when there is a change in management due to company mergers, etc. Vendors who merge with other bigger companies struggle to divest from their prior leadership and adjust to the new management. For example, the detailers of the first vendor, who belonged to a small company prior to their merger with the current bigger company, had problems adjusting to changes in management. They couldn't accept the power imposition from the new account manager over their ex-boss who was also the current senior PM. The account manager was an US citizen who held both commercial and technical responsibilities. He coordinated between the clients and vendors for all communications. All submittals, RFIs, and queries from the vendor's technical team were reviewed by the account manager first and passed on to clients. As a result he enjoyed complete authority and had a great power distance over offshore workers. This created an agitation internally. Vendors complained that the account manager showed little interest in their cultural motives and values. The workforce disliked reporting to the" middle man" account manager. The vendor's troubled senior PM complained of the account manager: *"he would suddenly demand for submittals without prior notice and shout if we could not deliver."* Vendors wished that the middle man would be eliminated and they could communicate directly with clients.

# CHAPTER 13

# DISCUSSION OF FINDINGS

Findings of this research address factual problems/conflicts and areas of concerns prevailing in downstream offshore design networks that are usually ignored due to immediate cost/time benefits. Our constructs, either directly or indirectly, revealed constructability problems, cost overruns and overall schedule delays. From our constructs, we identify the following areas of improvements.

## Areas of improvements

### *Overcome the unrealistic contractual obligations*

Even though clients impose unrealistic deadlines and vendors' management make unrealistic commitments in order to cater to their company's interests, such decisions impart a lot of pressure on the detailing workforce. In their effort to meet tight deadlines detailers sideline quality. Vendor management relies heavily on design changes and change orders to compensate for their unrealistic contractual commitments. Even when changes occur, detailers have to perform multiple reworks which erase the "*fun and interest out of the work.*" Therefore there is a constant conflict between management's interests and worker's interests. This finding agrees with that of Dossick's (2010), in that she observes domestic MEP detailers' conflicts between obligations to scope, project and company. This confirms that the problems due to unrealistic obligations are not limited to offshore SES networks alone, but exists even in other downstream engineering networks. During an informal conversation, the vendor's PM mentioned that the effectiveness of the whole process might improve if all stakeholders in AEC project networks, from owners to detailers, compromise on time and money.

*Exercise better constructability focus*

Low priority towards end goals such as constructability is a critical risk factor observed in offshore SES engagements. Practitioners need to exercise more alertness to the lack of constructability focus among the offshore SES networks. Special industry-standard training would be required for SES detailers to think in terms of steel erection and smooth constructability. However, we observed most detailers and drafters leave the erection procedure training to engineers and project managers while they just follow their orders. As a result constructability focus is poor among offshore SES detailers resulting in a greater likelihood of late erection conflicts. Constructability conflicts due to detailing errors can be disastrous. They result in laborious reworks or halt the erection process which eventually delay the final project delivery and cause huge cost overruns.

*Improvise the exchange of design information*

Improved design information exchange is required to ensure timeliness and better quality of detailing jobs. Inadequate information supply from the clients force vendor's to make uncertain assumptions and then depend on RFI responses. This is not welcomed by detailers because; they need full design information on hands to work efficiently. Moreover, RFI processing is a time consuming and frustrating endeavor (Rutherford and Luth, 2005). Further, unwarranted screening of communication through multiple stakeholders aggravates these coordination complexities, resulting in inefficient RFI responses. Few vendor project managers understand the design exchange inefficiency, and as a remedy attempt to standardize the work process.

Project managers constantly encourage their detailers to use standard RFI formats, and employ standard checklists and drawing logs and more similar standardized components. Project managers believe that standardized components can enable better flow/transaction of information. For example, despite screening of communication, RFIs with a common format and nomenclature throughout the AEC industry are more likely to reach the intended person quickly than the current practice. According to one of the vendor's PMs who actively encourage standardization, *"standardization could solve most of the coordination problems."* He elucidates their routine attempts to standardize the process: *"First of all we set our standards –we have our own standard technical sheet for each client. It includes--- client the ship mark format of the members should be so n so, a sheet should include so many number of members ,etc.. We distribute this technical standard sheet to the team-and we work accordingly."* Once they generate the standard technical sheet for a client, they are set for every time the client returns. Using standard files and formats for regular clients speeds up the process and also results in better coordination. However, such standardization efforts are very limitedly pursued because most offshore vendors fail to establish standardization due to the current offshore network arrangements explained below.

First of all, due to the current trend of fast track projects and tight schedule requirements, vendors cannot dedicate much time to standardization. For a first time client, vendors do not have time to create new standard checklists. Therefore they follow impromptu methods to finish the project. This is a frequent problem because, out of 20 projects that vendors receive annually, every 3rd project is from a new client. This means that, annually, 30% of the time vendors are executing their work in a non standard fashion. Next, vendors usually work simultaneously for 3 or 4 different clients, each with different standards, which complicates standardization. Finally, since most vendors are busy managing engineers across many disciplines (such as MEP, automobile, software etc.), they overlook process standardization.

In addition to process standardization, efficient electronic data interchange and efficient technology interoperability can also alleviate the design exchange problems that we observed. However considering the current high end technology collaborations in the AEC industry, technology implementation has a lot of room for improvement within offshore SES networks. Organizational barriers (Dossick & Neff 2010) and trust barriers prohibit clients from exercising better interoperability. Overcoming these barriers, and sharing their BIM and crucial electronic data with the offshore vendors, would allow detailing jobs to achieve greater efficiency.

*SES teams need Alignment*

Alignment between teams either virtually or internally is essential for enhanced project performance. Although SES vendors and the US clients did not share a virtual building information model, most of their fundamental tasks such as checking, back drafting, RFI processing and conflict corrections needed virtual communication via video conferences, emails, teleconferences and FTP exchanges. Problems that we observed among SES networks were similar to those identified among virtual teams by Nayak and Taylor (2009), Horii et al. (2005), Chinowsky and Rojas (2002, 2004).

We observed two forms of team misalignments: first between virtual teams, and second between vendors' management and workforce. Virtual teams were misaligned due to mutual distrust, conflicting perceptions of various social aspects, and misaligned communication styles. Both parties believed their positions were right. Further investigation unraveled the influencing determinants of misalignment. Relationship span or duration between the client and vendors influenced the extent of trust. In other words, old and returning clients were somewhat more trusting of vendors than the first time clients. The understanding and reasoning of participants depended upon social institutions such as education system, rules, standards (building codes) etc. Conflicting perceptions and misaligned styles of communication were influenced by varying cultural contexts. This problem can be overcome if the gap between the intercultural team is bridged. Recently researchers have found that boundary spanners enable better coordination between intercultural teams.

*Boundary spanner's role*

Virtual team misalignment can be minimized by enforcing boundary spanners between the virtual team interfaces (Di Marco et al. 2010). Teams can coordinate better through a cultural boundary spanner. When different tasks are shared by US clients with vendors in multiple nations, clients can exercise better coordination and communication through geocentric staffing. For example, An US expatriate engineer who is knowledgeable in both US and Chinese cultures could be staffed in China to coordinate between the Chinese fabricator and US client. Similarly, an expatriate, knowledgeable in both US and Indian cultures, can efficiently coordinate between Indian detailers and US fabricators. Such geo centric staffing and cultural boundary spanning techniques will help to overcome cultural and institutional barriers and improve the overall process efficiency. In our case, the role of a vendor's account manager was the closest to that of a boundary spanner. The account manager held office in the United States and he was the vendors' representative to clients. He belongs to the top management and exerts a great power over the detailing workforce. We observed that the authoritative behavior of this account manager had a tremendous negative impact on detailers work. In one case that we observed, the account manager, who is an US citizen, showed little interest towards vendor's cultural motives and values but pressured them even more than the clients. In addition, account manager actions and behaviors also fueled internal team misalignment.

Internal team misalignment between vendor's workforce and their management (especially account manager) led to many internal conflicts. For example, detailers were more inclined towards their individual career growth and therefore they constantly opposed management's business oriented decisions and actions. In some cases, vendors' workforce could not adjust to management changes and there was misalignment between top management and the workforce.

**Better collaboration in design-build networks**

Project performance is better in design-build delivery models when compared to traditional offshoring setups (Douglas & Luth 2004). Coordination and engineering efficiency are better when the client is a design-build company. Since most of the work is entirely processed within a single organizational boundary, the design process is quite smooth as opposed to our observation of the traditional offshore networks. For example, there are no unwarranted contractual obligations between the offshore SES vendors and US design-build clients. Communication screening is less and detailers have 100% complete design drawings on hand before beginning their work. Technology interoperability is very efficient and BIM is shared with international subsidiaries engaged with downstream design support. As a result the level of alignment between teams is high. Overall, in international project networks, design-build captive model structures function better than the regular offshore outsourced service models.

However, design-build captive models are not feasible when offshoring needs are small (Overby  2006). Firms wouldn't want to spend more setting up an offshore subsidiary for short term purposes. Similarly, for special technology expertise requirements, instead of training the captive groups, it is much economical to hire offshore vendors with required expertise. A captive group is highly advantageous when a great number of offshore workers are required to do the job. Normally SES or other engineering service needs are of small magnitude compared to heavy industry design-build projects because small- and mid-cap companies are increasingly outsourcing. Therefore the areas of improvements that we propose through our constructs mostly appeal to the greater mass of offshore service vendors.

In summary, our constructs make a direct or indirect impact on constructability, quality, schedule and cost of overall project. These findings are not unique to SES networks alone, but can be generalized and related to any offshore engineering service collaboration. For instance, offshore architectural detailers, MEP detailers, HVAC detailers etc, also suffer from inefficient design information exchange, virtual team misalignment, unrealistic obligations and other areas of concerns observed in this research. Since the AEC industry's global network research spectrum has relatively ignored the offshore SES networks, our research findings will fill this gap. Moreover, with the globalized state of affairs being on the rise in AEC industry, a growing number of practitioners can learn from our findings in order to enhance the effectiveness of offshore collaborations.

# CHAPTER 14

# THEORETICAL CATEGORIZATION OF CONSTRUCTS

To achieve the second objective of our research, we address the question “why do the observed constructs occur?” In other words we focus on identifying underlying reasons for the various issues we observed. Through an extensive survey of the literature, we observed that these reasons were influenced by one or a combination of Institutional, Transaction Cost Economics (TCE) and Resource Based (RB) theories.

In order to generalize our findings and make them theoretically transferable (Auerbach & Silverstein  2003) for readers, we recode our constructs and classify the underlying behaviors/decisions with respect to the appropriate theory or combination of theories.   In the next section we digress temporarily to explain the philosophy of Institutional theory, Transaction Cost theory and RB theory in the context of our research.

## a. Background

### a. 1 Institutional Theory

The premise of institutional theory is that long standing regulations, norms and cultural context of a particular society shape the actions and behaviors of the people in that particular society (Oliver 1997, Scott W. R. 2001, Scott & Meyer 1994, Javernick-Will & Scott 2010, Madhok 2002). Therefore when people belonging to different institutional societies collaborate, e.g. in offshore SES projects, many conflicts arise. Teams make non-rational choices and decisions under social pressures (Oliver 1997; Mahalingam and Levitt 2009) that lead to unsynchronized actions between international teams.

Recently, AEC researchers have advocated the use of institutional theory as a universal framework to measure differences in global project networks (Mahalingam & Levitt 2007, Javernick-Will & Scott 2010). Institutional theory provides an efficient framework by which to map international differences specific to global infrastructure projects (Mahalingam & Levitt 2007; Javernick-Will & Scott 2010). Conflicts resulting from institutional differences can be generalized to all kinds of AEC international project networks, and such differences can be detrimental to overall project performance. Therefore we employ institutional theory to understand the subtle behavioral differences among virtual teams in offshore SES collaborations.

Advocates of institutional theory have laid down the ground concepts for different institutions that influence the actions of participating actors. Regulative, normative and cultural cognitive elements altogether form a set of predefined institutions in a society (Javernick-Will & Scott 2010, Mahalingam & Levitt 2007). Regulative institutions include laws, rules, standards etc. Normative institutions include work practices, social restrictions, self made rules, and expectations. Finally, cultural cognitive institutions include specific behavior that depends on the deeply embedded traditional and cultural values. Cultural cognitive elements are difficult to comprehend and deserve to be elaborated separately as a different theory altogether (Javernick-Will & Scott 2010). Therefore we explain the cultural cognitive elements separately under the subheading of intercultural diversity.

*a.1.1 Intercultural diversity*

Actors shape their decisions, behaviors, and actions depending on their respective cultural contexts (Beamer & Varner 2009). Elaborating cultural differences according to cultural contexts yields subtle explanations for peculiar behaviors among international teams. US clients belong to a low-context culture, while Indian vendors are a relatively high-context culture (Hall 1977, 1983; Beamer & Varner 2009). The most fundamental intercultural difference is manifested through communication style. US clients belonging to a low-context culture communicate with a direct/ informal style that is concise and direct to the point. On the other hand, SES vendors belonging to high-context cultures communicate with an indirect/formal style that is quite elaborate.

Table 3 lists differences between low-context cultured clients and high-context cultured vendors, as provided by Hall (1977, 1983), Hofstede (1980, 2001) and Beamer and Varner (2009).

Table 3 Low context Vs High Context culture

| **Client (low context)** | **Vendor (high context)** |
|---|---|
| **Monochronic time sense:**<br>*Think linearly and do one thing at a time; Times is a valuable asset; things have to be planned from the beginning* | **Polychronic:**<br>*Think holistically and do many things simultaneously. Time is not very important and things are left for the last minute.* |
| **Believe in Script/Rules:** Follow rules strictly and adhere to *the contract* | **Don't believe in Script/Rules:** *bend rules and not too particular towards contract* |
| **Result oriented:**<br>*End result matters above all.* | **Means and relationship oriented:**<br>*The situations, relations and means towards reaching the end results are more important* |
| **Direct Communication:**<br>*Explicit words, to the point and concise.* | **Indirect Communication:**<br>*Implicit words, elusive and elaborate* |
| **Egalitarian:**<br>*Horizontal flow of power and communication* | **Hierarchical:**<br>*Vertical flow of power and communication* |
| **Informal:**<br>*Casual verbal and written conversations* | **Formal:**<br>*Formal verbal and written communication* |
| **Individualistic:**<br>*Take decision on own* | **Collectivistic:**<br>*Take decisions in a group.* |

Low-context cultures are monochronic; they value time as an asset, and usually do one thing at a time. They adhere to rules and strictly respect the contract. A low-context organizational structure is usually egalitarian and the "power distance" between the managers and the subordinates is less. In other words, powers are equally distributed across the organization and communication flows horizontally among all employees (Beamer and Linda 2009).

On the other hand, high-context cultures are polychronic. Polychronic cultures believe that time should not be bound and actions should not be oriented with the clock but should be oriented according to the situations (Beamer & Varner 2009). Therefore high-context vendors did not take deadlines as seriously as the low-context clients, which led to misalignment. Further, high-context cultures easily bend rules and they are not too fanatic about following scripts and contracts. Organization structure is hierarchical and communication flows vertically downwards. In other words, power distance between managers and subordinates is huge. Or in other words, only the top managers have the power to take decisions and the subordinates just follow them.

### a.2 Transaction Cost Economics (TCE) Theory

Transaction Cost Economics theory promotes organizational behaviors and decisions that aim to minimize the transactions of supplies and services (David & Han, 2005). All choices are made in an economic context, to not only increase the revenues but also reduce the transaction costs (Madhok 2002). Firms experiment and try to adapt their governance structure based on the best alternative that reduces transaction costs (Oliver 1997; David & Han 2005; Tate et al. 2008). Therefore US clients pursue offshore outsourcing in search of a better governance structure and low transaction costs. However, TCE factors influence not only offshoring decisions, but also govern behaviors of actors in an organization (Rao 2003). For instance, a manager's business profitability oriented decisions are aimed at transaction cost minimization.

### a.3 Resource Based (RB) Theory

According to Resource Based (RB) theory, all behaviors and actions focus towards maximization of skills, knowledge and eventually the revenues. RB researchers advocate that organizations behave and decide strategically in order to attain sustainable competitive advantage (Oliver 1997; Barney et al. 2001; Halawi et al., 2005). Further, RB behaviors are strategically oriented to gain not only cost benefits but also additional non-cost benefits that will be profitable in the long run (Madhok 2002). For example, influenced by the Resource based view, firms pursue offshore outsourcing in search of unique talented resources (Tate et al. 2009). In this fashion, firms make decisions that would give them an edge over their competitors. For example they choose to accumulate a unique resource base, buy rare software proficiencies, overlap tasks to maximize time and cost benefits, etc.

**a.4 Combination of Institutional, RB and TCE theories**

Following the impressive studies of organizational theories by Oliver (1997), Madhok (2002), David & Han (2005), Rao (2003), Tate et al. (2008), and Mahalingam & Levitt (2007), we compiled Table 3. The information in Table 3 shows interrelation between the three theories in terms of rationality, nature, emphasis, threats and inter-conflicts.

Table 4 Interrelation between theories

| | **Institutional theory** | **RB theory** | **TC theory** |
|---|---|---|---|
| **Definition** | Promotes organizational behaviors that depend upon the social and cultural context | Promotes organizational behaviors that are strategically oriented in order to attain sustainable competitive advantage | Promotes organizational behaviors that aim to minimize the transactions of supplies and services |
| **Rationality** | Decisions are based on normative rationality, social judgment, historical limitations, and habitual orientations | Decisions are based on Economic rationality with focus on increasing revenues | Decisions are based on Economic rationality with focus on reducing transaction costs |
| **Nature** | Copy what competitors do. Match to the society –do not be an odd one in the group | Get an edge over competitors;<br>Seek for non cost benefits that increase the revenue in the long run | Look for cost advantage due to less costly talents |
| **Emphasis** | Emphasis on local cultures, norms, regulations relationship, trust, work satisfaction, etc. and less on cost benefits | emphasis on profitability (revenues) than work satisfaction | More emphasis on cost efficiencies than revenues |
| **Threats** | Loyalty to outdated traditions, and stagnant cultures. | Less emphasis on trust and loyalty | Less emphasis on the expertise of workforce. |
| **Inter-Conflicts** | Changes due to TC and RB based decisions are not acceptable due to institutional barriers | Firms follow traditional methods and make wrong resource decisions hindering the value maximization | transaction costs increase either due to institutional barriers or due to resource based decisions |

From the first four criteria, it is evident that there are subtle differences and relations between the three theories. From observing the critertia in the last row of Table 4, it is evident that the combined effects of institutional, TCE and RB theories can cause conflicts in actions and decisons in an organization. For instance, institutional factors compel team members to follow uniformity and not go against their traditional or political views. On the other hand, RB factors influence firms to advance towards heterogeneity (Oliver 1997) by changing the existing norms and regulations.  TC factors influence firms to make decisions that result in minimum transaction costs. Organizations quite rightly need to consider institutional factors, TC factors and RB factors in order to function efficiently.

In addition, attempts to seek economic alternatives by going against institutional factors increase the transaction costs (Mahalingam & Levitt  2007). Conversely, there are additional costs incurred when workers stick to traditional institutions and obstruct their company's economically rational interests (Oliver  1997; Madhok 2002). This will further undermine the firm's ability to gain competitive advantage (RBV).  Therefore, combining the above researcher's statements, transaction costs can be defined as the costs incurred either due to institutions opposing economical alternatives or due to costs incurred from unwanted adherence to traditional institutions against economically feasible alternatives. This shows an evident connection between institutional, transaction cost and resource based theories. Moreover, to understand the firm within the context of the institutional structure, transaction costs (TC) and the resource-based (RB) prove a good combination (Madhok 2002). Therefore we became interested to test the possibility of matching patterns between the conflicts arising offshore SES networks and those due to combined actions of the three theories.

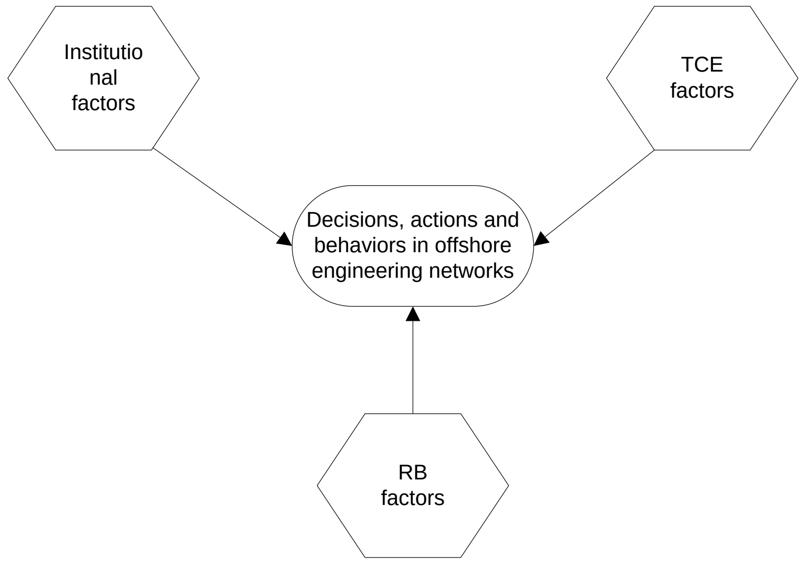



Figure 11. Influence of Institutional TCE and RB factors

All this evidence shows that combining the three theories in offshore outsourced networks will yield interesting results and insights. In fact, (Tate et al. 2008) have produced interesting insights about firms' offshore outsourcing motives by combining the three theories. Following the same philosophy, we claim that even after the kickoff of offshore engagements, the decisions, actions and behaviors of actors can be justified by using all the theoretical fronts (see Figure 11). Therefore we employ institutional, TCE, and RB theories to classify our constructs. In the next step, we recode our constructs appropriately depending on the factors that cause actors to act, decide and behave in the way they do.

**b. Recoding of Constructs**

Table 5. Recoding of Constructs

| Constructs | Sub-constructs | Institutional motives | TCE motives | RB strategic motives |
|---|---|---|---|---|
| **Lack of constructability Focus** | Sub optimized goals | --- | reducing transaction costs | --- |
| | Vendor’s lack of steel erection background | inaccessibility to site | Vendors with no expertise are hired to reduce the transaction costs | --- |
| | | different industry standards | | --- |
| | Lack of clash detection | organizational trust barrier | --- | Client intend safeguard their trade secrets |
| **Unrealistic time and cost obligations** | *-clients’ tight schedule* | | Procure work in less time to reduce TC | competitive advantage over others |
| | *-vendor management's unrealistic commitments* | | | Cut prices to attract clients and stay in business (competitive advantage) |
| **Exchange of Design Information** | Inadequate information supply | --- | --- | client's a overlap tasks to maximize cost efficiency |
| | Design revisions and change orders | --- | --- | |
| | Screened Communication | varied viewpoints, cultural context, work context etc | hire multiple subcontractors in order reduce TC and to minimize risk | |
| | Inefficient RFI process | | | |

*(Table continues)*

| Constructs | Sub-constructs | Institutional motives | TCE motives | RB strategic motives |
|---|---|---|---|---|
| **Technology Implementation Lag** | Technology Interoperability Issues | | --- | Client want to preserve confidentiality |
| | Restricted usage of common repositories | | | Client want to preserve confidentiality |
| | Inadequate software packages | | reduce TC by purchasing lower versions | |
| **Virtual Team Misalignment** | Conflict in understanding | different local education and standards | | |
| | Conflicting perceptions | high context culture Vs low context culture | --- | --- |
| | Misaligned communication style | | --- | --- |
| **Internal Team Misalignment** | Misaligned Goals | Vendor's management behaves according to TC and RB in order to while the workforce acts according to institutional | | |
| | Shifting Goals | --- | --- | Accept more projects to stay in business |

#### c. Observations from recoded constructs

Recoding the constructs revealed that motives behind actions, decisions and behaviors are influenced by institutional, TCE and RB theories, either individually or in combination (see Table 5). Identifying the reasons behind problems that we observed through our constructs, we were able to categorize our constructs into 4 categories

1. Constructs due to mutually different norms and regulations between clients and vendors.
2. Constructs due to conflict between client's low context cultures Vs. vendor's high context culture.
3. Constructs due to TCE and RB motives.
4. Constructs due to combined actions of institutional, TC and RB motives

#### c.1 Mutually different norms and regulations between clients and vendors

SES detailers behaved and acted according to their local regulative institutions (design standards) and normative institutions (work practices, site inaccessibility). As a matter of fact, differences in normative and regulative institutions played a role in vendors' lack of constructability focus, mutual distrust, and technology interoperability issues.

Lack of constructability focus exists partially due to conflicts between design standards and work practices. Due to conflicting knowledge levels and different education patterns, there were also conflicts in understanding and mutual distrust. Calculation problems faced by offshore vendors due to different unit systems are observed due to different education systems. Mutually different education backgrounds and standards further led to mutual distrust between virtual teams.

Trust is an essential institutional (social) factor that influences virtual team interactions (Zolin, et al. 2000). Both clients and vendors put their knoweldge and education ahead of each other.  Therefore, clients would occassionally doubt a vendor's competency by disregarding their RFIs or design modification suggestions. Technology interoperability also suffered partly due to a client's lack of trust in a vendor's BIM competencies. In addition to trust lapse, the institutional differences also led to ego clashses.  It was hard on the client's ego to take design-related corrections from foreign vendors with different education and knowledge (institutional) background.

**c.2 Conflict between client's low context culture and vendor's high context culture**

Varying cultural contexts between US clients and vendors played a major role in virtual team misalignment. Even though the present world technology enables diverse project participants to come closer, varying cultural values and perceptions act as barriers to Conflicting perceptions and communication style differences exist between clients and SES vendors, occurring because of their intercultural diversity. We adapted the cultural context differences elucidated in Table 3 as the basis for our explanation in the following paragraphs.

*Polychronic Vs Monochronic Time sense*

Time is perceived differently by US clients and SES vendors. Clients coming from low-context cultures are monochronic and view time as money, an asset (Beamer & Varner 2009, Hofstede 1983). Therefore, US clients perform tasks sequentially, one thing at a time, and are very serious about schedules and deadlines. On the other hand, vendors are polychronic and believe in doing many things simultaneously. This explains why vendors stuff themselves with many projects at a time. Offshore vendors are also culturally predisposed to leave things until the last minute. Unless the management uses a strong power base to maintain deadlines, SES detailers may not approach time very strictly. Culturally varied perceptions of time not only delay the overall schedule, but also lead to clashes that negatively impact the working atmosphere. For instance, offshore detailers get the notion that US clients are not concerned about the problems involved with the project progress; instead they only seek timely submissions. This hurts mutual trust and leads to intellectual clashes hindering the project performance.

*Are rules important or not?*

Low context cultures like the US take rules and norms very seriously, while the high context cultures of vendors do not. Even the minutest contract breach would be a serious legal issue in the US. Therefore US clients are serious about the contract. For instance, US clients wouldn't derive or calculate information missing from drawings because that should be provided by the detailers as per the contract. On the other hand offshore vendors were not too worried about following rules. Therefore project managers had to constantly urge detailers to meet deadlines. Vendors bend rules easily because minor contract breaches are not reported legally in their culture.

*Perspective towards end results*

Clients from low-context cultures are result-oriented; therefore their relations with the vendors are temporary and result-based. As mentioned by the vendors *"Client gives project B if project A is done well."* They continue a relation with an offshore SES vendor only if they performed well. In contrast, vendors who come from a high-context culture are means and relationship-oriented rather than result-oriented. Therefore even if a project fails, they would consider that a contact is established and the relationship can be developed later on. Further, clients are so focused on the results that they wouldn't monitor the progress of SES processes, but only contact vendors when the deadline arrives. This was not acceptable to the relationship-oriented vendors, who sought more consistent discussions throughout the duration of project.

*Attitude towards Authority and decision making*

Vendors belong to a hierarchical culture, which explains why decisions flow vertically downwards in offshore vendors' organizational structures. According to Hofstede's (1983) cultural indices, the power distance index (PDI) at the vendors of South East Asia is high at (75) as compared to a low value of 45 for the same in USA. Communication and interactions take place hierarchically at offshore SES vendor organizations. The decisions taken by detailers at the bottom of the structure are highly influenced by the perspectives of company's superiors and less by their own reasoning and perspectives. US clients, on the other hand, are comparatively more egalitarian and discussions are horizontal within companies. US counterparts can make relatively quick decisions and don't have to wait for their superiors' consent. This difference was evident during the conference calls. Despite the client's requests, vendor detailers couldn't make changes to drawings unless their senior managers gave orders.

*Direct communication against Indirect communication Styles*

Vendors complain that responses by the client are too direct and specific. Such RFI responses again lead to repetitive questioning and rework. Further, as is characteristic of low-context cultures, a US client may at times use words that directly express temper. However, for the high-context vendor, use of direct words is awkward and offensive. At a professional level, use of intemperate words is highly unacceptable to the high-context offshore vendors. This disparity may even compel detailers to quit jobs. An anecdote from the vendor relates that

"*There were some cases when due to client's harsh language, some people had to quit the job in between and due to inadequate manpower project got delayed"*

Vendors belong to a high-context culture that practices an elaborate and indirect communication style. Therefore vendors are known for asking questions that are framed with long sentences and in paragraph formats. Also, the vendors don't mind asking many questions. This was a cause of annoyance for clients. Sometimes, US clients did not understand vendor's elaborate RFIs and returned back asking for more specific questions.

### c.3 Combination of TCE and RB motives

Clients and vendors' management focused more on their TCE and RBV motives in making certain decisions. For instance, design clients do not share their BIM with offshore vendors because they naturally intend to safeguard the confidentiality of their trade/company standards and thereby sustain their competitive advantage. Clients also focus on reducing transaction costs by hiring low cost offshore vendors with no expert steel construction knowledge. Similarly, guided by economic rationality, vendors' management make unrealistic time and cost commitments to get more business than their competitors. Also, they overburden themselves with 3 or 4 projects simultaneously in order to maximize their company's business profitability. As a result, workers are assigned to different projects intermediately, which hurts their output quality. Furthermore, vendors' management utilizes outdated software packages in order to save some transaction costs. There is lack of awareness, among clients, of such poor practices at the vendor's end.

### c.4 Combined or opposing actions of Institutional, TCE and RB motives

*Institutional + TCE + RB motives*

Even though we observed that the immediate reasons behind the worker's actions and behaviors were influenced by the social norms, regulations and cultural contexts (institutional factors), the underlying reasons were influenced by economic rationality (TCE and RB factors). For instance, lack of constructability focus caused by offshore SES vendor's lacking steel erection knowledge is mainly due to institutional factors such as inaccessibility to the site, or lack of awareness of US design and construction standards. Another probable reason is that steel construction is not popular in India. Clients' underlying decision to choose unfamiliar foreign vendors over domestic detailers was based on the reduction of transaction costs.

Design information exchange suffered from a combination of RBV, institutional and TCE motives. Inadequate information exchange and design revisions are due to clients' RBV motives. Clients adopt a concurrent engineering approach and overlap SES tasks with upstream design tasks in order to avoid schedule slippage risks and thereby maximize profitability. Even though clients act in order to avoid schedule slippage risks (RBV), we have observed that inadequate information and design revisions are manifested in the form of vendor's lack of knowledge of US design practices. Further, we saw communication screening causes many unwanted predicaments such as manipulated RFIs, mismatch in RFI numbers, and inefficient RFI responses. Again, the immediate reasons for late or irrelevant responses are institutional differences such as varying perspectives, difference in question asking styles etc.  However the underlying reason of distributing project stakes among multiple diverse stakeholders is influenced by TCE and RB based motives. These motives, at the root, aim at reducing transaction costs and dividing the overall project risk among multiple stakeholders.

*Institutional motives against RB +TC motives*

Clients and vendor management's TCE and RB based decisions and actions conflicted with detailers (workforce) **i**nstitutional interests, such as trust, relationships, work satisfactions, existing norms and regulations. Therefore there was a constant agitation between clients and the workforce or vendor's management and the workforce. For instance, clients' tight schedule requirements were influenced by their TCE-oriented intentions to buy overhead time for material procurement and fabrication by shrinking the detailing time, while the RB-oriented motive is to gain a competitive advantage over others and maximize profit by buying speedy work at low cost.

Similarly, vendors' management made unrealistic time and cost commitments in order to stay competent and grow their business (RB). However, vendors' workforce suffered due to increased pressure from the unrealistic time and cost obligations. It resulted in immense pressure on detailers, which resulted in poor work quality. Furthermore, there was misalignment between the vendors' management and the workforce because both had different motives. While management had TCE- and RB-based profit maximization motives, the workforce, who had institutional motives, sought work satisfaction, knowledge growth, and career growth. In addition, management changes at the vendors' end resulted in misalignments. Companies merge with other companies in order to accrue a talented workforce (RBV). However the workers find it hard to digress from their traditional ideals (institutional) to new ideals under the changed management.

Such conflicts between RB motives and institutional pressures not only increase transaction costs (Mahalingam & Levitt 2007), but are likely to cause additional costs, referred by Madhok (2002) as “cognitive sunk costs”. These costs occur when clients and workers’ institutional interests inhibit corporate strategies that are aimed towards profitability.

**d. Summary of theoretical categorization**

In summary we make following generalizations based on the applicability of institutional, TCE and RBV theories to our findings. Immediate motives that justify working staff behaviors are guided by society’s normative, regulative and cultural cognitive elements. Further, misalignment between virtual teams was mostly caused by culturally diverse codes of conduct and communication styles. Even though actions and behaviors on the surface can be linked with the institutional theory, underlying motives are influenced by cost minimization and revenue maximization interests that are associated with TCE and RB theory. Hence we observed that all our constructs were influenced by institutional, TCE and RB factors either individually or in combinations. We not only observed the combined influence of all three theories, but also several constructs that emerged from conflicts between institutional and TCE + RBV motives.

Based on this research outcome, we believe that institutional, TCE and RBV theories not only influence the drivers behind offshore outsourcing, but also the behaviors and incidents that occur during the offshore engagements. Past researchers have advocated an excellent framework of institutional theory to map differences in global projects. Similarly, we propose that institutional, TCE, and RBV theories will provide an efficient framework for gaining insights into downstream-offshore design networks. Practitioners and academics can make use of our approach to study other offshore design service engagements and understand the actual reason behind emerging conflicts.

CHAPTER 15

# CONSTRUCT VALIDITY

Our findings are based on replicable opinions, anecdotes and insights provided by different vendors and corroborating evidences provided by a client organization. Our ethnographic observation included open ended interviews combined with additional sources of evidence such as minutes of meetings, checklists, project conceptualization charts, codes, standards, training manuals etc. To increase the validity of the collected data, we gathered comprehensive information from the vendors' business unit heads/account managers who maintain close affairs with US clients. My advisor's inputs based on his experience of more than 10 years in the field of design, fabrication and detailing in Europe and USA, provided us an expert opinion on the client's side of story. Comprehensive interview data and corroborating sources of converging evidences provide the "data triangulation" and hence the internal construct validity (Yin 2009). Morover, our qualitative (exploratory) type of case studies enabled respondents to express even minute details and hidden risks (Javernick-Will & Scott 2010) within the offshored SES process. Eventhough we have a limited number of cases, exploratory nature of the case studies provided comprehensive and valid data. Such detailed studies which examined participants' behaviors and reactions in social and economic context further increase the internal validity (De vaus 2004).

Our findings are not rare observations, but are frequently observed in other global AEC project networks by topical researchers. For instance, part of our findings supported and replicated the findings of other researchers. The technology implementation lag associated with Web based Project Management Systems (WPMS) and Building information model implementation confirmed with the work of Dossick (2010), Aslani et al. (2009), Zolin et al. (2000) and Taylor (2007). The virtual teams' varied and shared perspectives regarding project expectations replicated with Nayak and Taylor (2009). The effects of intercultural diversity and institutionally varied virtual team behaviors replicated with Horii et al. (2005), Mahalingam & Levitt (2007) and many more.

Our constructs are not limited to offshore Structural steel engineering services' networks alone, but are also transferable and applicable to a vast area of offshore downstream design disciplines such as mechanical, electrical, plumbing, HVAC, architectural/master planning etc. Through theoretical categorization we identify matching patterns between our findings and the existing theoretical frameworks. Such pattern matching and transferability of research findings across other existing AEC disciplines provides external validity of our constructs (Yin 2009, De vaus 2004; Auerbach & Silverstein 2003).

# CHAPTER 16

# CONCLUSIONS

Through this research, we investigated downstream offshore design networks. We focused our ethnographic observations on Structural steel engineering service networks and identified 6 key constructs and 16 sub constructs. The key constructs address unrealistic contractual obligations, lack of constructability focus in downstream design services, poor design information exchanges leading to poor output quality, technology implementation issues, virtual team alignment issues and internal team misalignment. All these variables bear a tremendous negative impact on constructability of the overall project, eventually causing not only huge schedule delays and cost overruns, but also safety mishaps and litigations. Based on these findings, we further discussed critical areas of improvements.

Further, in order to identify the sources of the issues that we observed, we recoded our constructs and sub-constructs appropriately under a combination of different theories: Institutional, Transaction Cost Economics (TCE), and Resource based (RB) theories. As a result, we obtained four possible categories. First, lack of constructability focus, mutual distrust and part of technology interoperability issues occurred due to mutual differences in norms and regulations among clients and vendors. Second, virtual team misalignment and its sub-constructs, such as conflicting perceptions and communication style differences, exist because of conflicts between clients' high context culture and vendors' low context culture. Third, part of technology interoperability and use of outdated software products occurred due to a combination of TCE and RB motives. Finally, we observed that even though some behaviors and actions of the workforce were induced due to institutional theory, the underlying decisions that led to such the behaviors and actions were influenced by TCE and RBV motives. For instance, detailers exhibited lack of steel construction knowledge due to institutional factors such as foreign standards, site inaccessibility, etc., but the source of the issue was client's TCE-based decision to hire low-cost offshore detailers instead of local detailers.

Even though our constructs revolve around topical issues observed by other researchers, they provide deep insights into unexplored downstream offshore networks. Our key constructs and areas of improvements need high attention because hiring offshore vendors for design services is becoming increasingly common; at the same time, addressing problems in offshore - downstream design services is being largely ignored. Future researchers can benefit by building on our theoretical approach and adding to the ever-growing knowledge forum on cross-national and cross-cultural problems in international collaborations. Practitioners of various disciplines in the AEC industry can use our research findings to first understand issues due to offshoring in downstream design services, and then resolve them at the source identified through the proposed theoretical framework.

# CHAPTER 17

## FUTURE RESEARCH

Future research should focus more on downstream offshore engagements within specific disciplines such as steel, RCC, mechanical, electrical, HVAC etc. in order to identify trade-specific problems. We encourage future researchers to make use of our approach to study other offshore design service engagements and understand the actual reason behind emerging conflicts. Researchers should use the key issues and area of improvements in this research, and test their impact on overall project performance.

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# APPENDIX A. Offshore SES Process flow diagram