HOW LEADERSHIP OVERCOMES ORGANIZATIONAL DIVISIONS IN BIM-ENABLED COMMERCIAL CONSTRUCTION

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ABSTRACT
Proponents of Building Information Modeling (or BIM) often claim that the adoption of these technologies will lead to greater efficiencies through increased collaboration. In this paper, we present findings from a research project that explores the use of BIM technologies for mechanical, electrical, plumbing, and fire life safety (known often collectively as MEP) systems coordination and the impact of this technology on collaboration and communication. We selected MEP coordination because it is a synecdoche, or a part that is representative of the whole, of the challenges across the entire process of collaboration in architecture, engineering, and construction. In an 11-month ethnographic study of the BIM-enabled MEP coordination process for two commercial construction projects and 65 industry interviews, we find that BIM-enabled projects are often tightly coupled technologically, but loosely coupled organizationally. In this paper, we focus on two aspects of these findings in particular. First, obligations to individual work scope or to a particular company can jeopardize project cohesion. Second, individual leadership—especially of the MEP coordinator in the teams we studied—often substitutes for stronger project organization. We argue while that cross-company project teams are often more technologically connected using BIM, there are other forces that must be considered and organizationally engineered in order for BIM to be implemented successfully.

KEYWORDS: building information model; collaborative design; virtual design and construction; integrated systems; construction industry; informational technology; MEP coordination

INTRODUCTION

As projects become more complex, project participants diversify into areas of special expertise. Diversification in turn requires communication, collaboration and coordination between specialized trades. For example, as compared to a few generations ago, when the temperature control systems of buildings amounted to fireplaces and windows, today the mechanical, electrical, plumbing, and fire life safety (known often collectively as MEP) systems of a building can be as much as 30% of the scope of a commercial construction project. With this complexity, the development, design and construction of MEP requires increasing collaboration not only among the MEP specialties, but also with the architect and structural engineers.

Building Information Modeling makes explicit the highly interdependent nature of structure, architectural layout, and the MEP systems by technologically coupling project participants together. We have observed and interviewed MEP detailers who work for MEP subcontractors (see Figure 1) and who are organizationally separated from the architects and engineers, (hereafter the term detailer will refer to a subcontractor as shown in Figure 1); but, at

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the same time, the design team has information and the decision making power that the subcontractors feel is vital to their jobs. Within this organizational infrastructure, we have identified three often competing orientations: Scope, Project and Company. In this paper, we begin to explore how conflicting obligations can undermine the goals of project collaboration and how the ways in which leadership currently serves to overcome these conflicts.

Although there are efforts in the industry to create co-located or otherwise closer connected collaboration teams, as a general rule the design teams are fairly isolated from the construction teams. For example, structural engineers are consultants to the project’s architect and their primary responsibility is to ensuring the structural integrity of the design. However, their work impacts that of MEP detailers in ways that the engineers are not aware. In the two projects we observed and in a majority of the 65 interviews we conducted, MEP detailers communicate formally with structural engineers through Requests for Information (or RFIs) and sleeving drawings that identify where MEP systems penetrate concrete slabs, shear walls and beams. Both types of documents must travel from the MEP detailer through the general contractor and the architect before finally reaching the engineer who can make a decision or provide clarification, feedback and approval. The response flows in reverse, and frustration with the delays occurs on both sides. When referring to the lack of connection between structural and mechanical engineers and MEP detailers in an interview, one structural engineer told us, “Sometimes you just want to be able to talk to the people who know what you’re talking about” (Interview E071218A).

It is in this context that proponents present BIM as a way facilitate for communication and exchange of information between designers and builders. The three-dimensional geometry of BIM, in theory, allows project participants to more easily communicate spatial and logistical issues, as well as improve access to information on material and performance specifications and requirements. What we find in practice, however, points is that while BIM is currently linking project participants more tightly together technologically, they remain organizationally loosely coupled, often lacking timely access to crucial information and decisions. Based on the ethnographic research that we have done, we find that the industry is relying heavily on the individual leadership of particular people in the MEP coordination process to substitute for closer communication connections among trades and among construction divisions—a strategy that works only when strong, effective leadership is in place.

![Fig. 1—Typical Design-Bid-Build Organizational Structure](image)
RELATED WORK

Buildings “have a complex social and material manifestation whose organized production is reliant on shared frames of reference” (Beamish and Biggart 2006), such as standards of practice, legal arrangements, and industry norms. Building Information Models have the potential to change these frames of reference. For example, others have found that jurisdictions between occupations and organizations are often tightly tied to the technologies in use and that power struggles among these groups can emerge when new technologies are introduced (Barley 1986; Bechky 2003). Researchers found that companies resist technological change on the basis of legal risks associated with standards of practice, concerns over intellectual property, financial risks associated with capital investments in hardware and software, and the investment needed to train and maintain technologically-skilled staff (Allen et al. 2005).

Innovation in information technology in the AEC industry is driven by competitive advantage, process problems, technological opportunity, and institutional requirements (Mitropoulos and Tatum 2000). But personal responses to new technology often define the success of adoption. Moore (Moore 2002) identifies three approaches to new technologies: Innovators who celebrate change; pragmatists who are more wary of change; and skeptics who resist change on principle. Personal attitudes towards new technology adoption are shaped by the risks involved in using unproven means and methods; by the difficulty in implementing technology in particular settings; by financial risks involved; and by the perception of other workers’ attitudes towards new technologies (Paulson and Fondahl 1980; Tatum 1989).

Researchers studying web-based project management tools for collaboration and communication across organizational boundaries found a variety of factors that influence adoption: Team member’s attitudes towards the technology, corporate culture, relationships between companies, characteristics of the specific projects (Nithamyong and Skibniewski 2006), industry wide issues of legal precedents, communication density (described as “yet another channel”), organizational barriers, and individual’s resistance to change (O’Brien 2000).

Even when companies commit the resources needed for technological change, project participants do not necessarily participate equally (Cuff 1991). For instance, in design collaboration, different styles can emerge such as Mutual Collaboration (working with the other); Exclusive Collaboration (working on separate parts of the problem); and Dictator Collaboration (designating a leader) (Maher et al. 1998). Teams using digital coordination for MEP coordination were more likely to be satisfied with the meeting process and spent less time digressing from the issue at hand compared to paper-based coordination, and the digital model itself can function as a coordinating artifact to encourage conversations about the organization chart, work process and work flow, and clarification of work (Liston et al. 2007).

However, scholars of organization and communication are still divided about how technological change can support effective collaboration. People often use new tools to reassert professional status and difference, to “restructure” organizational forms, and to revisit previous distinctions (Barley 1986; Bechky 2003; Orlikowski 2000). New technologies do have the power to change organizational structure but scholars still do not fully understand what organizational forces need to be in place for effective collaboration to occur. Energy is often focused on the individuals, who are asked to participate in collaboration. For example, one architect we interviewed stated that “…a lot of what you’re going to find, and I’ve found over and over and over again with BIM jobs, it’s less about the tools and the technology, it’s more about the folks you’ve assigned and their attitude towards the process” (Interview A071114).
Within construction, organizational and cultural divisions between designers and builders and between contractors and subcontractors may stifle collaborative work and joint problem-solving, even as the expertise needed for buildings becomes increasing complex and professionally differentiated.

**SETTING AND METHODOLOGY**

This mixed method qualitative research included case study observations and industry interviews. Field data was then coded and reviewed for main themes. For studies of technology in workplaces, there is a long tradition of using these sorts of ethnographic methods and “grounded theory” (Glaser and Strauss 1967) to ascertain how people use tools in practice, the ways in which tool adoption changes power within the workplace, and how new organizational structures emerge when new tools are introduced (Barley 1986; Bechky 2003; Orlikowski 2000). Field notes and interview data were analyzed with an emergent, iterative coding schema using qualitative analysis software (Atlas.ti) and recurring themes were identified.

Hill and Valley are pseudonyms for two urban commercial negotiated design-bid-build construction projects in the same city that we studied in 2007–2008. Hill is a 450,000 sq. ft. mid-rise complex commercial office building. Valley is a 300-unit high-rise mixed-use residential building with retail and parking. For each project, we observed the series of MEP coordination meetings among the detailers from subcontractors for sheet metal ductwork, piping, plumbing, fire protection, and electrical systems. For the most part, the subcontractors have design-build contracts for their individual systems. For both projects the MEP coordination and clash detection process that was part of preparation of the fabrication and installation documents lasted 12 to 18 months and entailed weekly meetings of 8 to 10 people lead by the general contractor and attended by subcontractor detailers and project managers. A research team of one faculty researcher and one graduate student were primarily responsible for attending each meeting (12 months for Hill and 7 months for Valley) and writing detailed field notes as soon as possible after the meeting.

Both projects utilized Building Information Models to coordinate work in digital 3D among various subcontractors. In this use of BIM, as digital 3D drawings are created by the individual trades, they are consolidated into a single digital model of the MEP systems. This process has been termed a “loosely-coupled network of models” (Dossick and Gramer 2008), rather than a singular Building Information Model. In the meetings themselves then, the detailers reviewed the consolidated model and discussed where conflicts among the MEP systems occurred. The model coordinator managed the digital projection of the consolidated model during the meeting, and either led the meeting themselves or worked with a partner who led the meeting while model coordinator navigated the digital model.

The research team noted how technology was used within the meeting, interactions among meeting participants, and discussions about project logistics. In addition to spontaneous, informal interviews that occurred before and after meetings, meeting participants were formally interviewed individually for 15 to 40 minutes. We also collected information that circulated among meeting participants such as logs of clashes, emails about coordination schedule, and digital snapshots of the digital model showing clashes between different building systems.

Additionally, the team interviewed a snowball sample of 65 architects, engineers, and builders in five major metropolitan areas in the U.S. While the focus of this paper is not on the findings from the interview data, they are used to augment and triangulate the findings from our two case studies.
TECHNOLOGICAL TIGHT COUPLING IN MEP COORDINATION

In both of the construction projects we studied, Building Information Modeling was used by subcontractors in the MEP coordination process. Subcontractors are hired to create shop drawings, fabricate and install MEP systems. After they create shop drawings that outline the specific details of what will be manufactured, purchased and installed, these shop drawings are approved by the architect and design engineers. In order to create shop drawings, the detailers must coordinate their systems such that they all fit into the available space, and meet building code requirements. During weekly meetings, detailers from the subcontractors involved in MEP coordination would meet to examine the combined individual efforts of their digital detailing. From this “consolidated model,” conflicts between the systems, or “clashes” were automatically and manually observed for reconciliation during the meeting. The joint model functioned to highlight potential conflicts and to help the project participants solve them, well before actual field installation began. For the majority of the detailers in both settings, the project that we observed was their first time using BIM tools and work processes.

Although detailers met every week and shared information about their systems, the requirements of their scope, and potential problems or conflicts that might arise for the project as a whole, it was difficult for both projects to establish trust in the information that the model presented, trust in the competency of others in their use of the model, and trust in the technology itself (See Dossick et al. 2008). There remained much frustration over the lack of particular types of information, especially from people who were outside of the MEP coordination process.

For example, in the Hill site, MEP detailers were concerned from the beginning about the accuracy of the structural steel drawings. Although the structural steel had been drawn into the model by the general contractor using an older set of two-dimensional drawings to approximate the model’s beams, as the detailers explained “We don’t know how good it is,” and as such could not have what to the subcontractors was a degree of certainty that the model would be precise within tightly coordinated spaces. While 3D modeling is common in use among structural engineers both for their structural analysis and for steel fabrication (“shop drawings”), it is still extremely rare for these models to be shared with project participants. On the Hill site in October, Frank3, one of the detailers for the mechanical subcontractor complained in the meeting “we’ve been waiting for steel drawings for 2 months.” The target of their frustration is Sam, the general contractor’s MEP coordinator. In an interview Sam said, “I am trying to get them [the structural fabricator] to play ball, which is the hard thing to do.” When the drawings do come, they are 2D, dated six months prior, and stamped “not for construction purposes.”

The Hill site represents a case in which the detailers felt frustrated and trapped within their communication and organizational system. Their work depends on the decisions made by the architects, engineers, general contractors and other trades, but they themselves often have very little influence over those decisions. Even though they were jointly doing complex MEP coordination that relied on a great deal of precision with the consolidated model, they felt their months of work could be jeopardized by the lack of precise information from the structural engineers. The detailers in the Hill site had trouble even getting the information that they felt was important to the accuracy of their work, much less empowered to influence decisions made by the structural engineer, shop drawing detailer, fabricator or erector. This counters much of the

3 All names used are pseudonyms.
current rhetoric about the possibilities of BIM as a way to encourage closer collaboration among construction trades and disciplines. The MEP project engineer, Sam, bore the brunt of the MEP detailers’ frustration, but perhaps the real source of the problem is the fact that although the MEP detailers are closely connected solving problems together in the BIM-enabled MEP coordination process, they are organizationally disconnected from basic information that they feel they need to do their jobs.

CONFLICTING ORGANIZATIONAL OBLIGATIONS: SCOPE, PROJECT, & COMPANY

On the one hand, the MEP detailers are responsible to their scopes of work, creating details for systems that must meet building codes and regulations as well as advocating for how their particular system intersects with others on the project as a whole. On the other hand, detailers are also responsible to their own company, whose ownership and management chain places task and production expectations on the detailers and they are often scheduled on more than one project at a time, balancing the work among them. These obligations, as we will see below, can be at odds with the goals of the project itself.

The forces of scope responsibility and company obligations may often both pull away from the interests and obligation to the project. Table 1 outlines these conflicting orientations and obligations from the perspective of an MEP detailer. Each actor comes to the project with a specific mandate—a legal and ethical requirement for the building systems. At the same time, they are temporarily organized around one specific project with the goals of effective collaboration; and yet also work for independent companies with profit requirements.

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Table 1—Comparison of Conflicting Obligations

Scope

MEP detailers each work on individual scopes of the project. Their main responsibility is to create shop drawings for fabrication and field installation that translate engineering and architectural designs into detailed building plans and specifications and fabrication instructions. In the MEP coordination process, they exchange information in the form of draft drawings and models of their work in progress, working jointly to adjust their plans when conflicts arise. Within the coordination process they advocate for their particular scope of work—they are recognized by all the project participants as the subject experts with regards to building codes.
and field installation practices of their particular trade. For example, in the detailers’
coordination meeting, questions about how much space should be in front of a particular piece of
equipment is almost always addressed to the detailer in charge of that building system. Although
the engineer of record has obligations of the final approval, the detailers who work through the
coordination need to have this working knowledge as well because the engineer is not present.

Although each detailer has a specific scope of work, their systems often occupy very tight
ceiling plenum, riser and wall space, and their systems often rely upon each other, as when, for
example, electricity connects to heating and cooling systems. The level of coordination in
weekly MEP meetings ranges from a strict exchange of information, to negotiation among
different detailers over space and conflicts, to group problem-solving where detailers brainstorm
options and optimize solutions. In these meetings, detailers often identify their scopes of work
with personal pronouns, mixing the terms for self with the terms for scope. For example, one of
the Hill project detailers remarked “That’s not me, that’s a steel beam.” when discussing the
consolidated BIM model.

We have observed that separation creates a culture where obligations to individual scopes
of work often overshadow the project as a whole. Furthermore, the organizational separation
from the design disciplines creates communication challenges that reinforce the obligations of
individual scope. The work flow is such that the detailers work within the constraints dictated to
them from the design documents, and it is exceptionally difficult for the detailers to propose even
small changes to the overall design of the project in order to make their work fit within the space
allotted. It is in this way that detailers have very little influence over the building project as a
whole, and they feel constrained by project decisions that they have no voice in. While they may
have a lot of experience and ideas about how to resolve issues, within the organizational
structure they have very little leverage or ability to present these ideas and solutions. Certainly,
their job to design and build a specific building system is only one small piece of the larger
project. However, their separation from the whole disenfranchises them and creates stronger
allegiance to their individual scopes and respective companies than to the building project.

Project

The project is a temporary team collected together for a specific building project. In the
MEP process, the general contractor brings the building trades together, and the MEP project
engineer in particular focuses on creating lines of communication, solving problems, and
managing information flow. This work entails negotiations among trades, owner interests, and
design requirements. The actors on a project often experience unanticipated intersections of their
scopes where conflicts occur. Depending on the timing, these surprises can be costly, and strong,
effective leadership from the MEP project engineer or other project participant can help the
group navigate the conflict, get information from people outside the MEP coordination team, and
advocate for design changes that will benefit the project as a whole.

In the Valley project, an example of this kind of project conflict arose between Margo,
mechanical detailer responsible for the HVAC systems and Larry, an electrical detailer. During a
meeting to discuss the coordination of a mechanical room, Larry addressed Margo with a
concern about the placement an air handler unit above a transformer. Margo insisted that a
condensate protection pan under the air handler would be sufficient protection against
condensation dripping on the electrical systems. Larry then addressed the group at large about
the need for access to the transformer and the air handler and mentioned that the building
inspector will be quite strict about access to the control panel and filters. Reiterating his concern,
Larry suggested that Margo move her systems for the benefit of the project. Later in the meeting, the general contractor announced that the architect and engineers will attend a MEP coordination meeting the following week, to which Larry asked “Will the right people be there? We need to make a good decision,” ostensibly referring to the mechanical engineer and the unresolved conflict in the mechanical room. Larry then asked Margo for the submittal document that shows the details of the air handler Margo has specified for this space. Margo responses with a defensive tone that her “submittal” and an RFI regarding the issue had not been approved, saying “I am not doing anything until they tell me to,” again, referring to the mechanical engineer. When Larry continues to discuss the issue, Margo stridently tells Larry, “I don’t take direction from you.”

This exchange represents the conflicting obligations across scope, company, and project. While Larry was looking to gather the information and solve problems collectively, Margo defended her scope, her personal knowledge of building codes, and her ability to navigate the organizational structure by sending a formal question to the engineer (from whom she had not yet received an answer). Margo’s reliance on direction from the general contractor and the design team also shows the organizational constraints of project, in which collaborative problem solving among experience MEP detailers still is less valued by many participants than, in Margo’s words, waiting to let them “tell you what to do.” Larry and Margo could have worked through this problem themselves, especially if the MEP project engineer pushed for a joint solution within the coordination process instead of communicating through organizational chain and waiting for a response. Even within their own scopes of work, however, both are disenfranchised from project-level decisions, which in turn, creates conflicts and frustration, limits collaboration and reinforces the obligation to individual scope over collaborative project.

**Company**

Company obligations emphasize the financial, legal, and logistical requirements for an independent firm working on a building project. In subcontractor companies, management makes decisions about the marketplace allocates personnel to different projects. Companies optimize profits with respect to time and money spent across several projects and can make decisions that impact particular projects.

For example, during the Hill MEP coordination process, the management of the electrical subcontractor decided to pull their detailer off the project and instead hired an inexperienced superintendent to complete the detailing. This decision by the company disrupted the project cohesion that had been achieved by the MEP coordination participants and slowed down the work for other detailers on the project who were forced to work with someone new to both the process and the technology. In that case, the obligation to company needs outweighed the obligation to complete the coordination with an experienced detailer.

The company obligation also encourages people to avoid exposure to risk, which is one of the key obstacles to sharing information in BIM-enabled construction projects. In interview data, structural and mechanical engineers interviewed reported that their companies were hesitant to share 3D models with builders because of issues of liability. In the Hill project, the structural steel drawings being stamped “Not for Construction Purposes” intended to signal that the obligation to protect the engineering company from liability outweighed the need for MEP project participants to have current, precise information.
LEADERSHIP AS A SUBSTITUTE FOR ORGANIZATIONAL STRUCTURE

One of the prominent advantages of BIM is that the technology encourages a process of collaborative building in a virtual environment before actual construction begins. The technological requirements of BIM push project participants to work through their scopes in three dimensions. However, as we found in our two ethnographic case studies, the exchange of accurate information and group collaboration were hindered by the conflicts of both scope and company obligations with the requirements for genuinely collaborative projects.

Project participants in both of our projects targeted the leadership of the MEP project engineer as the source of their frustration. However, in interview data in which people with BIM experience reported extreme satisfaction with projects, strong leadership was credited as one of the keys for success. Although the data from our comparative projects cannot directly address the elements of good leadership in construction projects—which in both cases project participants would consider examples of ineffective leadership—our findings suggest that leaders in the MEP coordination process are saddled with the daunting tasks of navigating through a labyrinthine organizational structure for answers to crucial questions; of negotiating among conflicting obligations of scope, company, and owner interests; and of pushing for collaboration and joint problem solving among sometimes recalcitrant project participants. It is in this way that our work suggests that general contractors are relying heavily on the individual leadership of MEP project engineers as a substitute for organizational structures that would encourage closer collaboration among project participants.

CONCLUSION

To overcome the organizational disincentives inherent in scope and company, construction projects need leadership to hold the people together and “inspire collaboration.” Throughout our interviews, we have examples where leaders have inspired detailers and other project participants to step outside of their scope and work towards the common goals of the project. Without an inspirational leader who can navigate the organizational hierarchy, acquire needed information, and strongly represent the detailers at the project level, the collaboration seems to be limited to exchanges of information and project participants will focus strongly on the tasks and productivity of their own scopes.

Successful collaboration leaders leverage the forces of scope and company to bring the teams together. They advocate that group problem-solving collaboration can benefit the individual team member’s companies. In this way, they do not put the project as odds with the demands of scope and company, but philosophically align the goals of collaboration with these demands.

We hypothesize that our analysis of the particular case of MEP coordination may be applicable more broadly across the disciplinary divisions and segregated organizational structure of commercial construction. Be it personnel from the owner, architect, engineer, general constructor, or subcontractor organization, each project participant is brought into the project with a specific scope orientation, and has a tentative temporary alliance to the project while having a more permanent obligation to their company. Throughout the network of project organizational structure, effective leaders at all levels, navigate the communication infrastructure to exchange information, solve problems and “inspire collaboration” in spite of conflicting orientations of scope and company.
A comparison for four papers presented at LEAD ‘08
Dr. Carrie Sturts Dossick, P.E.

Comparison 1: Chiara Vs Dossick/Neff
Chiara: A FLEXIBILITY THEORY APPROACH
Dossick/Neff: Overcoming organizational divisions in commercial construction

The initial response in comparing these two papers is that there are more differences than similarities. Whereas Chiara’s paper introduces a theoretical statistical model for negotiations, Dossick and Neff present data from ethnographic field observations and structured interviews that explain challenges in collaboration. However, there are a few conceptual similarities in that both papers address similar themes of bringing parties from different organizations together for a project. Chiara tackles the problem of project delivery and contractual structures – collaboration on a corporate scale, while Dossick and Neff discuss the particulars of project participant collaboration on an interpersonal scale. In addition, both papers use the structural analogy of forces, and both papers discuss organizational cooperation (Chiara calls this negotiations and Dossick/Neff call this collaboration). Both papers then describe “forces” that drive the parties apart or toward consensus. Both papers present what one might call concepts of alignment – how to bring parties together in ways that align their interests and minimize their conflicts of interest. Chiara discusses flexibilities – ways of creating room to negotiate towards an agreement for PPP projects. These flexibilities allow the parties to share risk more equitably. Dossick and Neff discuss forces in collaboration on construction projects that pull project participants apart from the common goal of Project. They suggest that the industry relies heavily upon leadership to overcome these forces and bring the parties into alignment. Consequently, as different as the two approaches are, the problems these papers address are arguably very similar.

Comparison 2: Deikmann et al. Vs. Dossick/Neff
Deikmann et. al.: SOCIAL NETWORK MODEL OF CONSTRUCTION
Dossick/Neff: Overcoming organizational divisions in commercial construction

Of the four papers, these seem to be most similar in research focus and scope. Both the Keikmann et. al. and the Dossick/Neff papers explore the challenges of social dynamics on projects where teams form temporary alliances. However, the research question is the point of departure where the two projects then use different research methods to explore questions about social forces and team dynamics. Keikman et. al. develop a social network model and map this model onto a case study. They measure the performance of this team based on their ability to be successful in a design competition, and then map back the ‘failure’ causality through interviews with the project participants. The Dossick and Neff approach is also case based, where they observe actors in the mechanical electrical and plumbing coordination phase of a project. Unlike the Keikman et. al approach however, Dossick and Neff use a grounded theory approach to discover theory and model the results from the ethnographic observations. Dossick and Neff also triangulate the case studies with interviews outside of the cases.

The themes and theories shared across the two papers are those of information exchange and trust. Dossick and Neff frame the results from the context of the actor and the forces acting upon them. Many of these forces are related to trust – trust of leadership, trust between actors,
trust that their information will be received and acted upon. Concerns about company strategies and intellectual property as well as trust between individuals are at play. Dossick and Neff also identify organizational disenfranchisement and the distance between detailer and designer. This appears in the Keikmann et. al. case study network maps as well. The architects separate themselves from the team in their network model thereby removing ability for other actors to influence the decision making. Although the research methods are somewhat polar opposites, the similarities between the findings of these two paper, reinforce and support the original research of both groups and arguably build a stronger argument for the theories of either.

**Comparison 3: Nelson et al. Vs. Dossick/Neff**

Nelson et. al. : Leadership in the Global Construction Industry
Dossick/Neff: Overcoming organizational divisions in commercial construction

These two papers are not so much comparable as they are complementary in that Nelson et. al. presents the *why* and Dossick and Neff presents the *how*. The Nelson et. al piece presents compelling evidence and arguments as to why we need to change the way we do engineering and construction in the 21st century. They present the triple bottom line as a tool for achieving better decision making to address global issues such as climate change and resource limitations. The Dossick and Neff piece picks up where the Nelson et. al. piece leaves off and discusses how engineers and builders collaborate and the challenges to these collaborations.

The implicit connection then between the papers is this. In order to address the triple bottom line as well as complex projects of the 21st century, engineering leaders we will need to consult a variety of disciplines in order to gather the data they need. A “gathering of disciplines” implies a greater need for collaboration. Therein the Dossick and Neff presents issues and solutions that will address the challenges presented by Nelson et.al.

**Summary and Conclusion**

In reviewing these four papers as a body of work, I would rearrange the order as follows. We start with Nelson et.al setting the stage with a challenge to the industry for incorporating the triple bottom line into an increasingly intuitive decision making process. Then, present the Chiara piece that explores the contractual structure of aligning project participants’ interests to set the economic and social stage for successful collaboration at a corporate level. Finishing the discussion with the Deikmann et. al and Dossick/Neff discussions on social and organizational issues surrounding the day to day interactions of project engineers and builders as they strive to meet the challenges of Nelson et. al. in the context of Chiara.

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