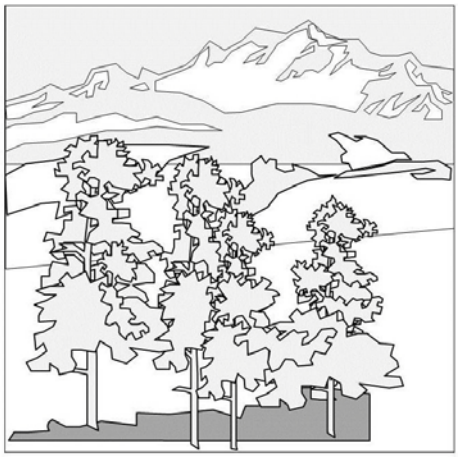


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# Constructing Teams: Adapting Practices And Routines For Collaboration Through BIM


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# CONSTRUCTING TEAMS: ADAPTING PRACTICES AND ROUTINES FOR COLLABORATION THROUGH BIM

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## ABSTRACT

The recent introduction of Building Information Modeling to design and construction has challenged teams to adjust work at all levels from project delivery strategies to day-to-day work practices. In this paper, we use ethnographic methods to study teamwork routines and practices as they adapt to new Building Information technologies. This paper leverages our understanding of conflicting obligations on construction project teams and the need for joint-problem solving messy talk to extend theories of routine adaptations and practice work-arounds, collectively called reconfiguration when team needs are misaligned with technology affordances. In this analysis, leadership that provides flexibility and distributed authority enables teams to reconfigure routines and practices and hack their tools. This reconfiguration processes itself has both direct and broad social outcomes: 1) the immediate team buy-in on new work processes as well as 2) longer term team culture building that enables messy talk engagement and orientation to project goals.

**KEYWORDS**: Collaboration, Building Information Modeling, Technology Adoption, Teams, Leadership

## INTRODUCTION: TECHNOLOGY MISALIGNMENTS WITH TEAM ROUTINES & PRACTICES

Contemporary commercial buildings are large, complex systems that require an equally complex array of teams to design and build them. Design and construction processes are rooted in layers of historical work practices that enable temporary teams of experts to come together quickly to work together (Neff, et.al. 2009). Where people working on a project have conflicting obligations—tensions between individual scope, company and project—, the conflict often impedes successful organizational collaboration. (Dossick and Neff, 2010). In this context, the introduction of Building Information Modeling (BIM) in the Architecture, Engineering and Construction (AEC) industries enhanced some existing work practices and fits with some project routines. However, BIM is misaligned with many of the routines and practices common on large-scale projects. For example, BIM enables teams to quickly detect problems during the

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coordination of mechanical systems, but may disrupt the existing practices of "messy talk," problem solving conversation, that is needed to resolve those conflicts (Dossick and Neff 2011).

In previous work, we define and describe "messy talk" as problem solving conversations, needed to syntheize knowledge distributed across teams and resolve conflicts between system requirements (Dossick and Neff 2011). In Dossick and Neff (2011) we argued that active, informal and flexible documents and visualizations support messy talk by allowing people to draw, write, sketch, talk, or otherwise modify shared knowledge together. Visual materials, such as Building Information Models, have traditionally been created by participants independently and brought into coordination meetings where they are treated as static entities (Aspin 2007; Whyte et.al. 2008) While BIM supports problem definition and explicit knowledge creation, its static (i.e. passive) and "formal" appearance makes it less powerful for joint problem solving (Dossick and Neff 2011). This may foreshorten conversation because, as currently used, these tools limit opportunities for "messier" mutual discovery and unanticipated problem solving at the expense of more efficient or "cleaner" documentation (Dossick and Neff 2011). Whyte et al. (2008) found that when visual materials were owned and negotiated by the team, as opposed to being created independently as described above, a more effective knowledge development emerged through exploration. From this we hypothesize that BIM (or any other medium) may be used for "messy" problem-solving if it is created by the team interdependently through mutual discovery and negotiation. To achieve this, the medium must necessarily be active, informal, and flexible. What happens when the medium is not?

In this paper we outline one such tension of misalignment through a case analysis of one MEP coordination team's adoption of WebEx, an online meeting tool. One of the primary misalignments in this example is that online meetings with distributed team members necessitates that all of their communication is mediated through the shared BIM display. Yet, in spite of this, the team achieved messy talk and oriented to project goals. In this paper, we outline theories to define and describe 1) technologies' misalignments with routines and practices, in this case online Building Information Modeling meetings tensions with commonly held messy talk practices in the MEP coordination process and 2) reconfigurations, (adaptation of routine and work-arounds for practices) the team makes around new technology. While this MEP coordination team negotiated members' "conflicting obligations" to scope, company, and project (Dossick and Neff 2010), they also reconciled the tension between technology and the need to jointly problem solve. This allows us to take up the question of how do the existing MEP practices align with the introduction of new modeling and communication technologies and what can we learn from teams' responses when they don't. We then propose that the process of locally developing reconfigurations around the technology had broader positive social impacts that allowed the team to achieve messy talk and orientation to project.

## METHODS: STUDYING TEAM ROUTINES AND PRACTICES

Over the past five years, we have studied three different building projects that use Building Information Modeling (BIM), which is capable of integrating design and

construction databases to foster collaborative work among teams. We wrote detailed field notes as soon as feasible after each observation and meeting; the notes comprise nearly 150,000 words over the three building projects. We then compared these field notes using an iterative coding scheme based on the methods of 'grounded theory' development (Glaser and Strauss, 1967; Strauss and Corbin, 1990) using Altas.ti qualitative coding software. We diverged from grounded theory's method of strictly separating the phases of qualitative data collection and analysis. Instead, we used accepted methods of empirical field research by writing in-depth analytical memos, having regular case analysis meetings of all researchers working in the field and creating cross-case concept matrices while continuing to collect data (Miles and Huberman, 1994). We verified the conceptual categories through comparison with the general themes articulated in interview data from over 70 architects, engineers and builders across the USA on the transition to new technology influences communication and collaboration. These data allow us to confirm that the practices that we observed within our three specific cases reflect the concerns and issues of our interview respondents and that our observations resonate with the articulated challenges facing such teams more generally. In this paper, we focus on one of the teams in one of the three cases and explore this team's adaptation of and to a new technology.

## FINDINGS: LOCAL RECONFIGURATIONS LEAD TO RICH COLLABORATION

The successful adoption of practices with BIM is mixed. In the case of the coordination of a building's mechanical systems, BIM aligns well with existing coordination practices and enables teams to quickly detect where these systems might conflict with one another. However, closer and earlier collaboration between designers and builders promised by BIM proponents has yet to emerge years after BIM adoption. We argue that the story of how BIM is (and isn't) used in practice teaches us as much about teams and communication as it does about successful and failed technology adoption. In the case of BIM, a gap arose between what the tool is capable of, has affordances for, or is marketed as, and the ways in which teams and organizations work, as well as the context for and cultures around that work. We call these gaps misalignments. Industry experts and BIM proponents suggest that misalignments can be resolved if design and construction work practices and contracting structures change, in some cases significantly, to take full advantage of the virtual prototyping and information management affordances and efficiencies of BIM. Interestingly, successful teams (teams who collaborate well) have modified and adapted technologies or their work practices in support of team collaboration, in spite of contracting structures and slow industry change. These teams sometimes go against long-standing industry standards and at other times, they materially modify or reconfigure the technologies they use to meet their current practices.

This paper focuses on the ways in which teams respond to misalignments between tools and practices. To understand technology adoption and change in general and in the case of BIM use in the AEC industries specifically, we address misalignments at the scales and levels of Context, Routine and Practice (Table 1). For members of design and

construction teams, context is given: they face a context for their work over which they have little control, as contractual and organizational structures of the project as defined by project owners, company executives and industry standards. While there are some ways that individual project teams can challenge or push back against misalignments with context, for the most part, from the team's perspective the contexts are fixed. Given these fixed contexts, successful teams adopted and adapted technologies through flexibly and creatively modifying the routines and practices around the technology. In some cases they creatively adjusted technology and work practices and at other times they simply "broke the rules", exchanging informal documents first and then followed formal procedures. They adapted many material tools for communication—not just BIM models but spreadsheets, drawings, whiteboards and smart phones—to serve the project needs for conversation, documentation and information exchange. Our research shows that socio-technical misalignments are inevitable, and consequently, they need to be planned for. Teams successful at collaborating with new technologies need the leadership, management, culture and creativity that foster flexibility and distributed authority to adapt routines and develop practices to work-around those misalignments.

**Table 1:** *Domains, Scales & Reconfigurations in Technology Adoption*

| **Domains** | **Scales** | **Reconfigurations** |
|---|---|---|
| Context | Industries | Rules of the game |
| Routines | Projects & companies | Adaptations |
| Practices | Teams & individuals | Workarounds |

We analyze a case from a project we call Lakeside Lab to develop the framework of reconfigurations. In this case, the MEP team converts from weekly face-to-face meetings to on-line meetings, where the detailers log in to WebEx and share their screens to discuss the clash detection, which they formerly did together in weekly meetings in the jobsite trailer. This participant observation was particularly helpful, because the team was trying this for the first time; they articulated the misalignments explicitly through their discussion about using WebEx for these meetings, and then we observed how the team reconfigured routines and practices to adapt and work around these misalignments.

## Defining Misalignments in Online MEP Coordination Meetings

Misalignments are tensions between technological affordances and a team's organizational needs and functional goals. For example, in one of the face-to-face meetings we observed, the team members discussed an issue and jointly-developed a solution using the whiteboard. They drew the issue and solution actively during the discussion. When everyone agreed on the course of action, Larry, the project manager for the general contractor, broke the silence: "So how are we going to document this?" The architect laughed and said, "I thought we just did! Someone get their iPhone." While the whiteboard afforded quick, active sketching that aligned with and supported the discussion, the whiteboard was misaligned with the need to document the decision as

a formal record and the team came up with a work-around (i.e., photograph) to resolve the misalignment. In this section, we describe the misalignments and reconfigurations (routine adaptations and practice workarounds) when an MEP team adopts WebEx and conducts MEP coordination meetings online.

One significant change in project practices occurred when Lakeside Lab's Mechanical, Electrical and Plumbing (MEP) trades did MEP coordination, the joint coordination of shop drawing production, through online line meetings using Building Information Modeling. The existing practices and routines of MEP coordination privileged the project and scope over the interests of any particular subcontractor company. The introduction of BIM-model driven online meetings was at first a misalignment with the practices and routines. As we describe below, the teams response to these misalignments shows how technologies are successfully adopted in practice.

On the Lakeside Lab project, the mechanical contractor (the lead coordinator) suggested to the general contractor that they conduct weekly MEP coordination meetings online using WebEx, a tool that allows them to share computers screens over the Internet. Several of the detailers pushed for this change because it would allow them to meet while staying in their own offices and reduce the travel time to and from the jobsite. Online meetings were a significant change in routine and practice as the detailers would no longer meet face to face at the jobsite. As they made the decision to use and implement WebEx, they negotiated the trade-offs between the detailers' own efficiency (i.e., staying at their own computers) and joint problem-solving in the interest of the larger project (i.e., meeting together). Losing the opportunities for in-person meetings meant sacrificing the ability to huddle around documents for discussions and the visual and visceral connection to the daily reality of the jobsite.

The push by the detailers for online meetings was for a more efficient workflow. As detailer explained, the real time changes to BIM models could be made concurrently during coordination meetings. However, in conflicting obligation terms (Dossick and Neff 2010) such a justification places scope over project by shifting the location of the work to the detailers' desks in multiple offices scattered around the region, instead of a project-focused meeting on the jobsite. From the general contractor's perspective, online meetings were misaligned with the MEP coordination goals by reducing the accountability that comes with in-person meetings. The assistant superintendent in charge of MEP coordination was concerned that losing regular in-person meetings would reduce his ability to keep the team focused on the concerns of the project and on track with the project schedule. Repeatedly during early WebEx demonstrations and meetings, he would call for a jointly produced schedule to help hold them accountable and would remind them of the job site activities underway.

**Adaptations for New Routines**

At one point, the assistant superintendent suggested that the detailers have a "pre-meeting" where they work through the clash detection details, and then they could have a second meeting for larger issues. The detailers pushed back against the two meetings per week suggestion, with one saying, "The more meetings I have, the less time I have to work." The result was a new process where people could work through uploaded changes

before the weekly meetings, allowing for the most obvious clashes to be solved amongst the team before the weekly WebEx meeting and reserving that time for figuring out the most difficult problems. After a few months of this coordination process, the issue of meetings came up again. The team found themselves with "not much to discuss" today, even though there were problems that needed to be solved in the consolidated model. One detailer suggested "if we put a little more time in on this it sets us up for the above floors," which convinced others to set up an extra meeting. The team managed tensions between scope and project. The detailers wanted to balance getting their own scopes of work done on time while minimizing their obligations to attend meetings that they view take time away from their work. The assistant superintendent, Kevin, through his leadership of the team, pushed the team towards project obligations and encouraging the detailers to discuss the conflicts in their models.

**Getting to Messy Talk: Developing new routines and practices around collaboration**

In the first few meetings of the online MEP coordination, the team was both getting accustom to this new meeting practice, while getting to know each other and the project. The problem-solving dialog seemed to often be pushed outside of the meeting. For example, in one meeting, Kenneth tried to move on, but Harris said, "I have more issues!" Harris continued, "that green line cutting through my pipes, where my feet are." Kenneth replied that he "will put it in a cloud and add it to the log." In the early meetings, this was a typical way that Kenneth would stops further discussion during the online meeting: "It's on the log, so follow up with people after the meeting and solve things amongst yourselves." After they hang up from the first WebEx meeting, Kevin leans back against the wall and expresses dissatisfaction with the online meeting to the people in the room "for the meeting minutes, I need dialog. On the phone, I can't see their faces. I can't see whose talking."

A few months later into the process, the team seems to have established a rhythm. The next story exemplifies discussions the teams have in the later half of the MEP coordination process. The detailers, architect (Victor) and engineer (Evan) called in via WebEx. Kevin, the assistant superintendent and a few subcontractor field supervisors attend in person at the job site trailer. After discussing the scheduling issues, Kevin turned the meeting over to Kenneth for coordination. The 3D model appeared on the screen in the job trailer and was shared via WebEx to others who called in. All of the people in the room looked at the screen as Kenneth navigated through the model. Kenneth said "Henry put some walls and structures in." Henry replied "I want to look at the lab spaces and service levels. Right there at A line by the soffits. Does the duct move?" Kenneth moved viewpoint in the projected model and we could all clearly see a conflict in the configuration of duct, pipe and hangers. Henry asked the team, "you tell me, is this what you guys want?" Kenneth asks about the accuracy of the soffit that Henry had added. The team sought direction from Victor [the architect] and Evan [engineer] by saying "This is your deal." Henry added "It affects every level." (here Henry was referring to the fact that they are working on the first floor, and this same condition occured on levels 2, 3 and 4. Victor responded, "I guess we need to take a look at what we have there." Kenneth quickly suggested "just email me what you decide", but the engineer continued to discuss the issue in the meeting. Evan asked about moving the

duct (Kenneth's scope of work) that currently clashes with the soffit. Kenneth switches to a 2D view to see the dimension. What we saw on the screen showed the ductwork tight against the exterior wall and hangers for a horizontal service panel ran vertically through and clashed with the duct. It looked like the duct could and should move towards the interior to avoid the hangers. The team suggested this shift. Kenneth asked if they are sure. "It means multiple hours of work to move." After more discussion about the options to resolve the issue, Henry jumped in "Is that thing in brown a hard lid? Remember we have radiant floor risers – they move Harris' pipes." Someone else argued "this floor sets the tone for the rest of the floors. So let's do it right." Victor responded "we'll look at moving the duct or trapezeing around it." They end the discussion there leaving Victor to follow up with the final decision.

What we see in this exchange is detailers are engaging in each other's scopes - suggesting improvements that will help the whole project. Kenneth complaint that "it means multiple hours of work" shows the tension between detailer's scope and the project optimization that others push for "it affects every level." While in earlier meetings, the team would often just mark the clash and did not discuss or resolve it during the meeting, in this later exchange we see the team engaging in messy talk problem solving – critically engaging each other in debate and discussion, exchanging their expertise and knowledge, and synthesizing around a solution that is best for the project, "let's do it right." As we will discuss in the next section, what we see here is through a leadership style of distributed authority, the team has locally adapted to this new technology with full buy-in that extends beyond the new routines and practices to engaged collaborative behaviors that orientate to innovation and optimizing the project.

## DISCUSSION: LEADERSHIP STRATEGIES FOSTER RECONFIGURATION AROUND MISALIGNMENTS

Our findings align with others who have studied technology in engineering in that we have found misalignments between technology affordances and team's needs are inevitable (Neff et. al 2013, Henderson 1999). Technology and processes cannot be designed to meet every need that arises in the complex and dynamic work of building teams. Teams that had to ability to locally reconfigure their routines and practices were more successful in their collaborations—achieved messy talk interactions that synthesized knowledge across disciplinary boundaries that resulted in innovative solutions for the project (as opposed to optimized for individual scopes). What is significant in this finding is that the reconfigurations occurred at the team level, where the team included project level decision makers.

In this ethnography, we saw distributed ownership of the adaptation (detailers exchanging the "presenter" controls between each other) as well as buy-in from the team (the team members pushed for the change to WebEx meetings and then were committed to making it work – making time for "extra meetings" when it was necessary). This leads us to propose that new standards of practice can and should develop locally, at the team level, from the workers themselves. This echoes lean manufacturing philosophy where improvements are gathered from the workers on the assembly line that enable them to make adjustments to their own work for micro-improvements or to suggest

improvements to management that supports more macro level adjustments (Suzaki, 1987).

Here we extend beyond the direct positive social benefit of local reconfiguration, the work of reconfiguration—in-depth discussions and arguments about new routines and practices—appears to have more broad positive social outcomes for team building and orientation to joint project goals. Locally, for a team who has to figure out how they are going to work together, they have to talk about the affordances of the technology, and their new routines and practices around and with it. This discussion and mutual agreement creates buy-in on the new routine and harmonizes the team's work together. What we see that in the discussions around "wanting dialog" and the team's work to resolve the misalignment between online meetings with the design for the richer social interaction of face to face meetings leads them to develop team practices that engender messy talk interactions in their WebEx meetings that were project oriented. In this case, the harmonizing team-building effects of defining reconfigurations around technological-organizational misalignments positively impacts subsequent teamwork—the team's ability to collaborate and builds a culture of joint problem-solving and decision-making.

Not only do we see a team overcoming misalignments for the sake of efficiencies, but we are seeing positive social effects when team members work together to resolve misalignments with locally and internally generated reconfigurations. This leads us to the idea that managers want to enable their teams to reconfigure around existing as well as new tools and processes to gain both direct and broader team-building cultures. To support local reconfiguration of routines and practices, we suggest that teams need three things: Flexibility, Distributed authority, and "hackable" tools.

**Flexibility**

The team had room to maneuver and modify their workflow with each other. In this case, the leadership did not dictate practice, but dictated outcome. Kevin wanted a log of the clashes and a sense of the process. He wanted to know "where they were" so that he could manage the relationship of the MEP coordination effort to the overall project. The schedule was dynamic – they changed the concrete pour schedule on several occasions, and Kevin took it upon himself to both communicate these changes to the MEP team and make sure they could meet the schedule as it shifted. He needed from them a communication of where they were in the process and how much more they needed to do before they were ready for the next pour. The team then reconfigured their routines to submit models to the mechanical coordinator earlier in the week so that he could create a log and report on the team's progress. They debated together the work process and had the flexibility to adjust to meet the needs of the team. This had the effect reinforcing the leadership as well as creating buy-in from the detailers in terms of the process.

**Distributed Authority**

In this case, we see a MEP team that includes project level decision makers, e.g. the architect and engineer, as well as effective leadership that leverages distributed authority. Flexibility and distributed authority work hand-in-hand here. Kevin, the

assistant superintendent leading the MEP coordination, did not dictate new practices. He articulated the desired outcomes that he wanted and needed from the team. This had an effect that the team had the authority to develop their new practices and adapt their routines in the ways that they saw fit. This authority reflected the same distributed authority they had for the development of their scopes of work. For example, in the project description above, the detailers debated the number and types of meetings they should have to work through and track the issues. Two meetings vs one meeting per week.

Coupled with this freedom to locally adapt routines, we saw organizational integration that connected the detailers directly to the decision makers. The architect, engineer and assistant superintendent regularly attending the meetings, empowering the detailers to make suggestions and get real time feedback. This team routinely created what they called "confirming RFIs", a document that recorded a decision made in conversation that then followed the formal pathway of the RFI process. This fostered a culture of team-oriented decision-making, where ideas were presented, debated and seriously considered. This did two things socially for the team. It empowered the detailers who felt they had influence on the project outcome greater then their individual scope. And second, it reinforced confidence in the leadership. Kevin would often make the argument that he needed to know what was going on, so that he could represent the MEP coordination effort in other project discussions (concrete pour schedule, owner meetings, etc.). The architect and engineer engaged in the detailed discussions with enthusiasm, taking the detailers suggestions and issues very seriously. Because the decision makers were part of the team, they were part and party to the local adaptation of routine and work around of practices. They participated in the reconfigurations and thereby enabled the team to use BIM and online meeting tools as well as more traditional tools (RFIs) in new ways to collaborate between design and construction team members.

Table 2: Aspects of Distributed Authority in the Lakeside Lab case

| | **Lakeside MEP team** |
|---|---|
| **Organization** | Integrated |
| **Leadership** | Reinforced confidence |
| **Reconfiguration** | Shared routines and practices |
| **Result** | Joint problem solving and project focused |

As we see from the findings above, the team evolved to have routines and practices that supported messy talk. The result was that they had an emphasis towards project-orientation in spite of the potential for the technology to drive toward a focus on scope.

**"Hackable" tools**

Finally, in light of the need for active, flexible and informal tools to support messy talk (Dossick and Neff 2011). The WebEx and BIM tools were not a very hackable– unlike paper, they could not draw on it or otherwise manipulate it. However, the detailers set up their workstations so that they could have WebEx on one side

(showing the shared screen), while having their own model on another side (giving themselves their own view of the project). They also "verbally" hacked the system by saying "where my feet are" as a way to "pointing" to something on the screen. The "feet" icon appeared when they were in the walk-navigation mode. They also imported grid lines into the model to help themselves verbally explain where locations they wanted to discuss, e.g., "Right there at line A at the soffits". They also grew more adept at switching the presenter from one detailer to another, so they could take turns "driving" the shared view and leading the conversation. While they didn't literally hack the tool per say, they did adapt the practice of sharing the presenter, which had the effect of bolstering distributing authority over the conversation (different team members were in control of the view, which meant they could control the conversation). This facilitated the emergence of the new process in that they each took turns bringing issues up during the meeting, sharing unresolved issues or conflicts that they wanted to discuss. When the leadership responded positively to their ideas, this encouraged team engagement and further refinement both of routine and practice reconfiguration as well as team collaboration and innovation around project work.

## CONCLUSION

In this paper we explore the concept of misalignment between technology and team organizational work by studying a specific case in point. The conflict and tension that arises when a MEP team, which traditionally balances obligations to scope and project via face to face meetings at the jobsite, decides to adopt online meetings for these collaborations. The technology is misaligned with the team's need for messy discussions around joint problem solving and decision-making. This team is successful in overcoming this tension and achieves messy talk interactions with a focus on project optimization. What emerges in this study is a potentially powerful shift in our theoretical understanding of technology adaptation: namely that reconfigurations of routines and practices will evolve from the team members themselves. We propose that these local reconfigurations are bounded by the organization of the team. In this case, the team included project level decision makers, and together, this team developed innovative ways of using BIM, online meetings as well as RFIs to support effective collaboration, defined here as messy talk. Teams were motivated by outcome goals as well as leadership that enabled flexible distributed authority, and hackable tools. There seem to also be broader impacts to local reconfigurations in that the work of adapting new routines around technological misalignments engenders a culture of joint problem solving and collaboration.

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