CIFE CENTER FOR INTEGRATED FACILITY ENGINEERING

Observations of Two MEP iRoom Coordination Meetings: An Investigation of Artifact Use in AEC Project Meetings

By

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This research is currently following the IRB (Industry Review Board) protocol “Observation of Information Use in Architecture, Engineering, and Construction Meetings on Building Projects” and Protocol Number 7404 approved September 30, 2006 by Stanford University’s IRB board.

ABSTRACT

Do teams using digital information perform better? Are they more satisfied? If so, what are the characteristics of normative use of digital artifacts? This working paper discusses research to answer these questions and to characterize the use of artifacts in architecture, engineering, and construction (AEC) project meetings based using observation-based empirical and quantitative research methods. Our observations of typical, paper-based project meetings show that teams rely predominantly on individual knowledge and expertise to address and resolve project issues often resulting in time spent clarifying, digressing, and grounding—leaving teams dissatisfied with the meeting and with the outcome. Observations of teams in digital-based meetings reveal a markedly different process with time spent focusing on and resolving project issues and satisfied with the process and their role in the process. This working paper discusses some of our empirical findings; and efforts to develop a systematic method, called the TEAM Interaction Analysis framework, to analyze the use of artifacts in meetings. This framework integrates key work in the areas of social-psychology, group research, and design research to characterize and measure team interactions in project meetings. The goal of this working paper is to introduce the framework and demonstrate its application to two observations of digital-based coordination design meetings.

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1 Summary

Architecture, engineering, and construction (AEC) teams are adopting digital models in their work practice but are slow to move digital models to the meeting workspace. This is largely due to cultural issues and the lack of established methods or tools to support group interactions and multi-disciplinary interaction with digital models and digital artifacts. This report discusses research efforts to investigate the use of digital artifacts by AEC project teams and the factors that influence - positively or negatively -meeting process as a function of those artifact interactions.

This report compares the use of digital models in two MEP coordination meetings using a research framework called TEAM interaction analysis framework. This multi-methodological empirical-based framework provides a rigorous analysis of meeting activities from four perspectives: **T**eam interactions, **E**motional interactions, **A**rtifact interactions, and **M**odel interactions. Combined, these analyses provide a relative assessment of the meeting process from a people and process-oriented view as well as an information and project-oriented view. The framework provides a consistent set of process metrics to compare different meetings and the use of different artifacts, digital or paper. The overall aim of this research is to compare use of digital or paper artifacts and identify factors of artifact use that impact process and ultimately meeting outcome. In the absence of comparative paper-based observations at Turner, this analysis focuses and compares the two observations of 3D model-based MEP coordination meetings.

The first author observed two Mechanical, Electrical, Plumbing (MEP) coordination meetings of Turner projects each employing a two-display setup and a digital, integrated MEP model and attended by a multi-disciplinary MEP team. There were two significant differences between the two observations. First, one project team had more experience using the digital MEP model and thus were further along in refining their meeting process with respect to use of the digital MEP model. Second, the same team was collocated and co-produced the digital MEP model. That is, everyone participating in the project meeting also participated in the development of the digital model. These differences are important in interpreting the findings and XXX

The observations included video and audio recording and a satisfaction survey. This report is an initial summary of those observations. The goal of this preliminary report is to provide some initial anecdotal and quantitative results of the meeting interactions and actions and the meeting outcome. These results are based on analysis of 20% of the observed data. A full report is anticipated in late summer 2007 and will include complete analysis of the remaining meeting video and additional video observations. Based on our empirical findings, the meetings were efficient, action-based, and productive. Our quantitative findings based on the satisfaction surveys show that participants were satisfied with the meeting process and outcome. The quantitative analysis of the meeting activities validate the empirical findings, showing that both meetings involved a significant amount of time directly interacting with the digital MEP model, focus on project issues and MEP coordination issues, high resolution of those issues, and an efficient workflow showing continual periods of cycling through those issues.

These empirical and quantitative findings the potential of digital models to greatly improve the coordination process through efficient issue identification and resolution, with reduced latency, increased participation, and increased interaction with project artifacts such as the digital MEP model. Based on the analysis findings we recommend that Turner invest in co-production of the model with all project participants and formal meeting management training in the context of digital model use. Lack of focus in one of the observations is attributed to participants not

involved with production of the digital model and efficiency in one of the observations can be attributed to meeting management and structure aligned with the digital coordination process.

This report summarizes the observation process, documents some excerpts from the observations as examples, and discusses the analysis process and results of the partial analysis. Preliminary findings show:

- The teams have developed an efficient process to review, identify, and resolve MEP issues with the available technologies and project structure. Although the team in Observation A had only two months of experience with the digital environment compared to six months in Observation B, both teams had developed work processes to maximize the use of the digital MEP model in their coordination activities.
- The co-located team (Observation B team) demonstrated some enhanced work processes as a result of the co-location.
- Co-location provided each participant with private access to the model while reviewing the digital model on the displays and this proved to be effective for each participant to filter their own view and follow the display camera view in 2D or 3D depending on their approach.
- When an issue forces the team to turn to paper-based artifacts, the productivity, focus, and level of engagement drops and significant time is lost both in terms of resolving the particular issue and returning to the flow of the meeting. In Observation A, these work stoppages were often attributed to participants not involved in the production of the MEP model.
- Real-time manual review (as opposed to relying solely on automatic clash detection review) is possible and quite feasible with the methods demonstrated by both teams. One team used a location-based approach and the other team used a system-path approach. Further observation is needed to determine the efficacy of one approach over the other, but both yielded successful identification and resolution of MEP conflicts and issues
- Participants not intimately involved in the modeling process are at a disadvantage in the digital review meetings.

An overview of each observation is presented with some initial empirical qualitative findings. In Section 4 we discus the quantitative process, Interaction Analysis, and introduce the TEAM Interaction Analysis framework and apply it to Observation A and B. The analysis is ongoing so the results are preliminary but demonstrate how we are using the TEAM IA to further analyze these observations and characterize the use of artifacts in those meetings.

Future steps include full analysis of both observations and future observations of paper and digital meetings at commercial project sites to compare the digital model-based meetings to paper-based meetings.

2 Observation A

Observation A was a weekly MEP coordination meeting attended by representatives for architecture, electrical, mechanical, piping, and sprinkler systems. There were a total of 13 people in the meeting. The meeting room (see Figure 1 and Figure 2) is a dedicated meeting area fit-up with two SmartBoards and four tables. It is a cramped, narrow room and not ideal for the large MEP coordination team.

Each participant had a set of drawings in front of them during the meeting as shown in Figure 1. The meeting facilitator managed the 3D model navigation and the meeting process. This particular meeting was focused on a specific floor and a specific area of the floor.

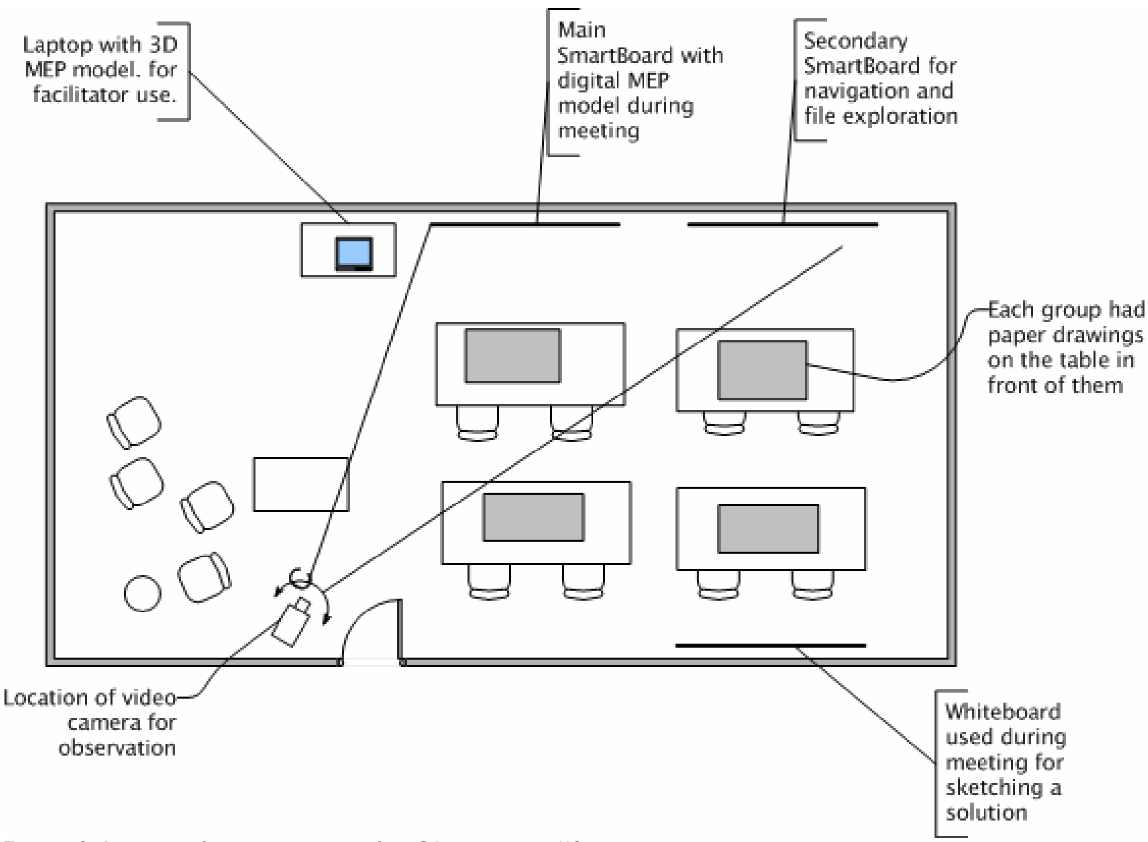


Figure 1: Layout of meeting room for Observation #1.

Consider this interaction as an example of the types of discussion the team had while interacting with the model (Figure 2):

> A025: We already know 13-3" is not going to work. I think it's going to have come down...just a couple inches <626813>
> F009: We got sprinkler main running underneath catwalk <630721>
> A026: *((zooming to view, making a note)))* <654150>
> A027: This is the tap. This tap is going to come down here about 8'. <668719>
> F010: About 8’-4”. <672103>

A028: And you are going to come straight over. <674137>
F011: Yep. And then we have offset. And we have to offset...for...to miss <680198>
A029: Which way? <682276>
F012: To miss this round. <682566>
A030: Are you going to go under? <683444>
F013: No. Umm we'll go around. What's that? That's what we are missing. <688110>
A031: Then you'll go underneath here, right? <690570>
F014: Yep. And down right here in the hole right here. <699175>

The discussion quickly focused on the physical issues and as issues were identified various participants joined the discussion with potential solutions, both with verbal comments and by going to the digital model to communicate an issue.

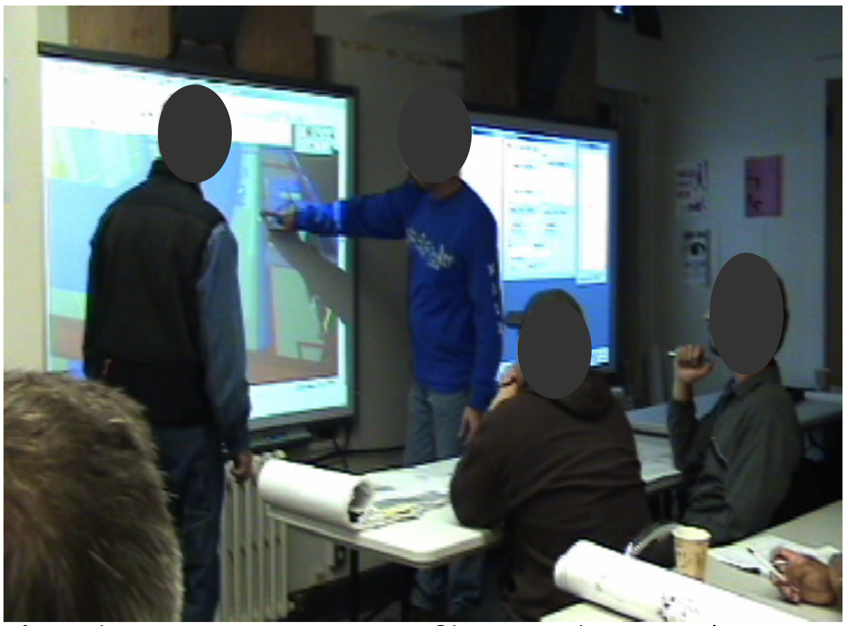


Figure 2: Video frame showing project participants in Observation A interactively reviewing an area of the project and discussing resolution of an MEP conflict.

Many questions arose with respect to confirming measurements. Often, the participants would turn to their plans to confirm measurements or confirm what they were seeing in the model, as demonstrated in this excerpt while discussing the ceiling height at a specific location[1]:

X001: *((drawing)) ((others looking for dimensions))* <763007>
A038: We'll save these PDFs and send them out to everyone. <767579>
A039: *((moving to another view))* Now let's look underneath it. <772745>
X002: *((moves to another view))* <812858>
A040: So now we're down underneath and here's the catwalk we were just looking at the door and this is the walkway over top so now the sprinkler main <819464>
F018: miss our grills...keep them straight <823341>
A041: Your sleeves are in this corner. Why are you offsetting here? <831430>
G004: Go back. Let's go back to plan view. I think there's a chase right there... <842185>
A042: Okay. Ummm. In the bistro serving area here where the kitchen actually is the ceiling is fairly low and then steps way up to 13-3 and then steps up to 15-6 at the window. So,

[1] Letters represent different participants. Italicized text between double parentheses indicates non-verbal activities and background activities.

how critical is that 13-3? Do we have some flexibility to kind of say we can back ourselves up as tight as we can and give you the height that we can get? <867619>
C005: Uhh, *((looking at drawing))*... <873018>

This team faced significant challenges with coordination between the architecture, structural, and MEP systems. The team had to turn on/off various systems, walls, etc. to effectively review and understand the area conditions. Since a right-click is not easily available to a SmartBoard user this had to be done by using a "component" browser on the adjacent SmartBoard that listed hierarchically the components in the model (Figure 3). This interaction interrupted the flow of the meeting several times. In Observation B, the team avoided these interruptions by assigning to one individual the job of controlling and navigating the model from a workstation.

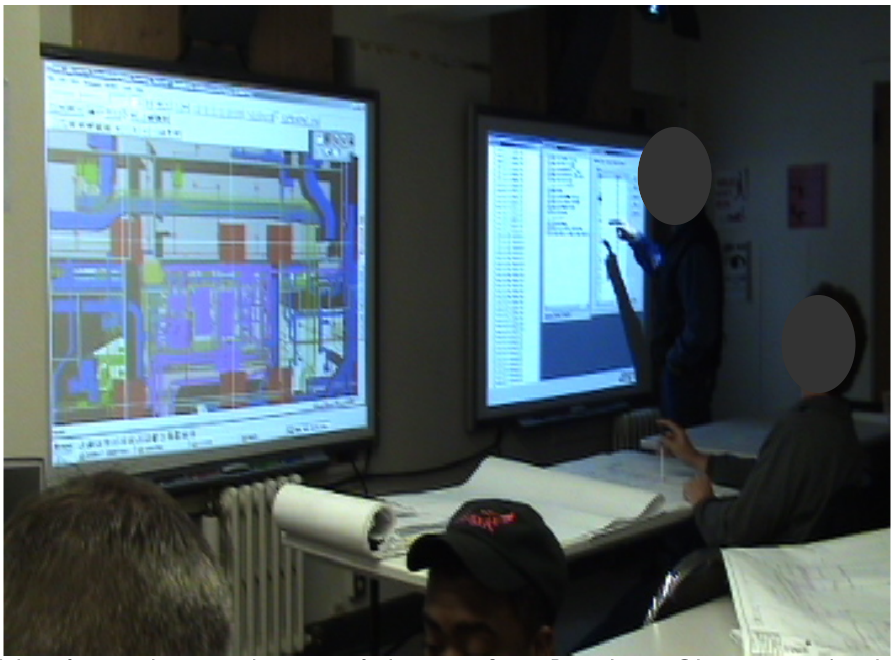


Figure 3: Video frame showing the use of the two SmartBoards in Observation A where the left SmartBoard is used for model viewing and navigation and the right SmartBoard is used for file navigation and model management.

This team also took advantage of the automatic clash detection features in the software. The team used the clash reports to identify areas where conflicts occurred and then zoomed into the specific area to qualify the conflict, review it, and resolve the conflict.

One specific issue is notable. A significant portion of the meeting time was devoted to a single, major conflict. One of the participants who had a laptop quickly modeled an alternative solution, saved the solution on a USB storage device, and the meeting facilitator updated the model with the solution for all to review. This type of real-time modeling, analysis and conflict resolution is impressive and only possible with project participants comfortable with the technology and with the domain and field expertise.

All project participations appeared comfortable with the meeting setup and proactively provided input on specific issues and suggestions for options to resolve conflicts. The only observable challenge was a participant who did not participate or contribute to the model. The participant was more comfortable with the drawings. At several points throughout the meeting, the flow of the meeting was halted to allow for this participant to orient his/herself and coordinate his/her own view of the project from the drawings with the model. This demonstrates that while the model effectively provides a basis for communication, knowledge and comfort with the model is best achieved through participation in its creation and ongoing development and maintenance.

These observations and analysis suggest the following recommendations for this team and project context:

- Dedicate a model manager for the meeting similar to that described in Observation B to more effectively navigate the model, perform snapshots, and support the meeting manager.
- Make the necessary drawings electronically accessible to prevent meeting stoppage and allow the team to review the drawings together.
- If subcontractors have laptops with software to review the model encourage them to bring the laptop to facilitate review and possible issue resolution in real-time

3 Observation B

Observation B was an MEP meeting focusing on a specific floor in preparation for final approval before proceeding with fabrication (see Figure 4). Most of the project participants were seated behind their workstations with private access to their digital model (Figure 5). One participant was the designated and dedicated model controller who performed the navigation from the workstation with the meeting facilitator/manager requesting view changes or other model actions. Additionally, one participant was designated as the dedicated "mark-up" person. Each project participant was also given a laser pointer so they could easily highlight a specific area without getting up from their workstation.

The meeting began with a review of the conflicts and issues from the previous meeting as shown in**Error! Reference source not found.** The team cycled through these previous issues one by one by selecting each issue snapshot, reviewing, and verbally confirming the resolution or status of the issue. The team quickly cycled through multiple conflicts and issues.

Once the initial issues were reviewed, the team went through each system by flying through the system, identifying conflicts during the flythrough. The team started with the fire protection and electrical system and started in a specific corner:

A044: Let me ask this real quick. We only have 12 of these, or 18? How many we got? 14? Are we confident we have taken care of all these? <827820>
F004: We've gone through all these <828972>
A045: I know we just want to make sure we haven't created any more. <832367>
Z002: That's fine <835165>
Z003: That's fine. <836827>
Z004: That's fine. <839908>
Z005: That one is okay.
G002: Okay. That's fixed. <843182>
A046: All right. Let's go through the specific fire protection and electrical <857173>
F005: Where do you want to start? <862361>
A047: Let's start in that corner there. <868613>
X011: ((*moving to view*)) ((*turn walls off*)) <891379>

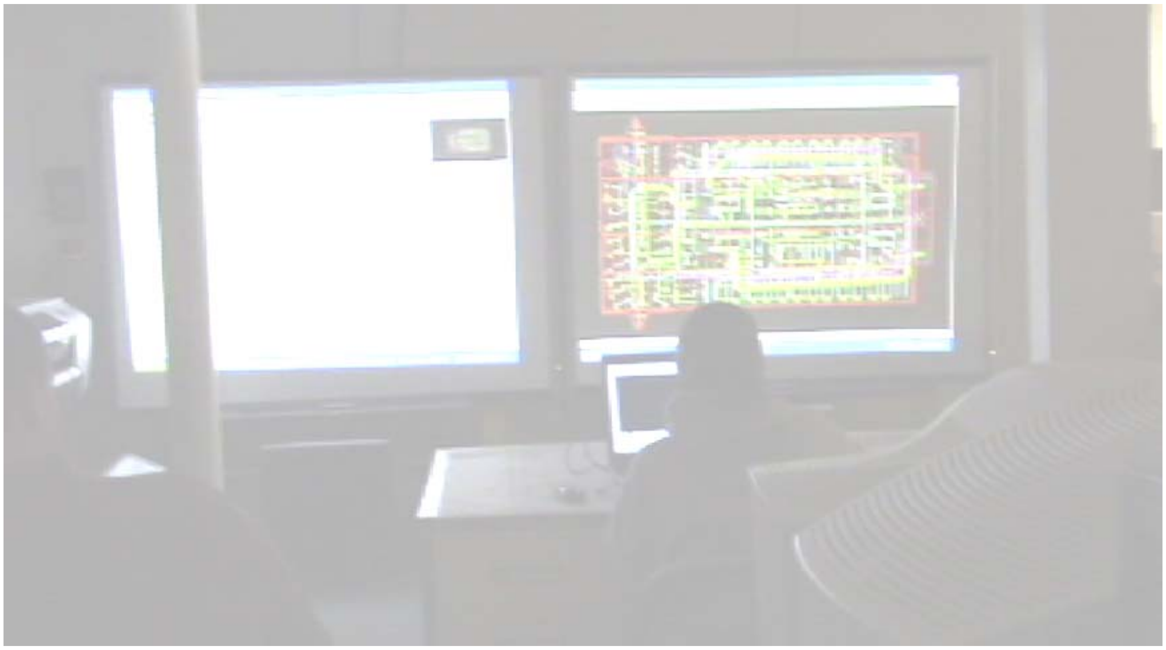


Figure 4: Video frame of initial setup for Observation B where the top-down view of the MEP model for the designated floor is shown on the right SmartBoard and the left board is used for file navigation and the overview plan.

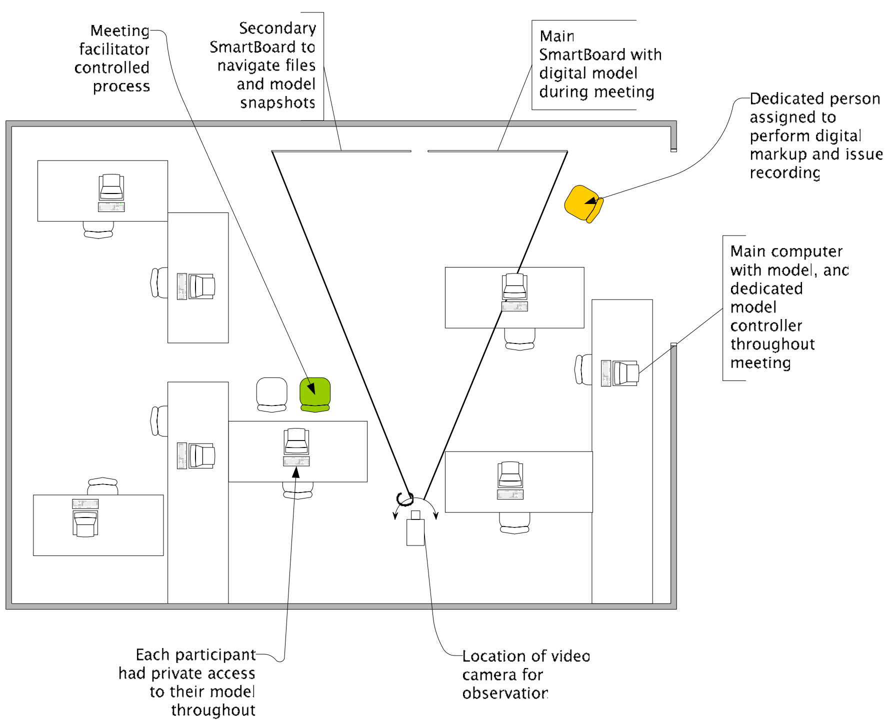


Figure 5: Physical layout of meeting area for Observation B. The meeting area is the co-location work area for the project MEP team. All subcontractors are on-site performing the MEP coordination through construction of a digital, 3D MEP model.

As a conflict was identified, the team reviewed the issue from multiple angles, considered options, and then marked-up the issue (Figure 7), took a snapshot, and continued:

A057: Another one, B. <1015641>
X015: ((*reviewing model*)) <1027075>
A058: Can't you just come across here, B? <1032487>
B004: Uhh. Look to the right? <1035537>
A059: Yeah. Why couldn't you? <1041217>
B005: What's that over here? <1043237>
A060: What's that? <1044142>
B006: Can you go a little further forward F <1046984>
B007: Go forward and look up and to the left <1055792>
A061: That's your drop right there <1061206>
B008: Yep. <1061859>
A062: Come across right here. <1064542>
B009: Yep. I'll just rise up before that <1066761>
A063: Okay. H, show a line from here and across here <1075303>
X016: ((*marking up model*)) <1098953>
X017: ((*following along cable tray*)) <1127255>

As the team reviewed the model on the SmartBoard display, participants used their own workstation model as a reference, following along in plan view or in their own 3D view on their workstation or laptop. This allowed each team member to quickly respond to issues or provide measurements when requested. When measurement questions arose, the model manager also used the measuring tools, e.g., to determine gaps between components or the length of the conflict overlap. In one case, the model manager used the “move” tool to move a duct from the current location to a proposed new location. The team then reviewed the duct to see if any additional conflicts would arise.

The MEP model contained primarily mechanical components and few architectural components. Consequently, the team could easily flythrough the MEP digital model without navigating through walls or structural components without spending time to turn on and off architectural or structural components. This flythrough MEP system by system review s proved effective for each subcontractor to stay focused for a period of time and allowed the other participants to participate as-needed.

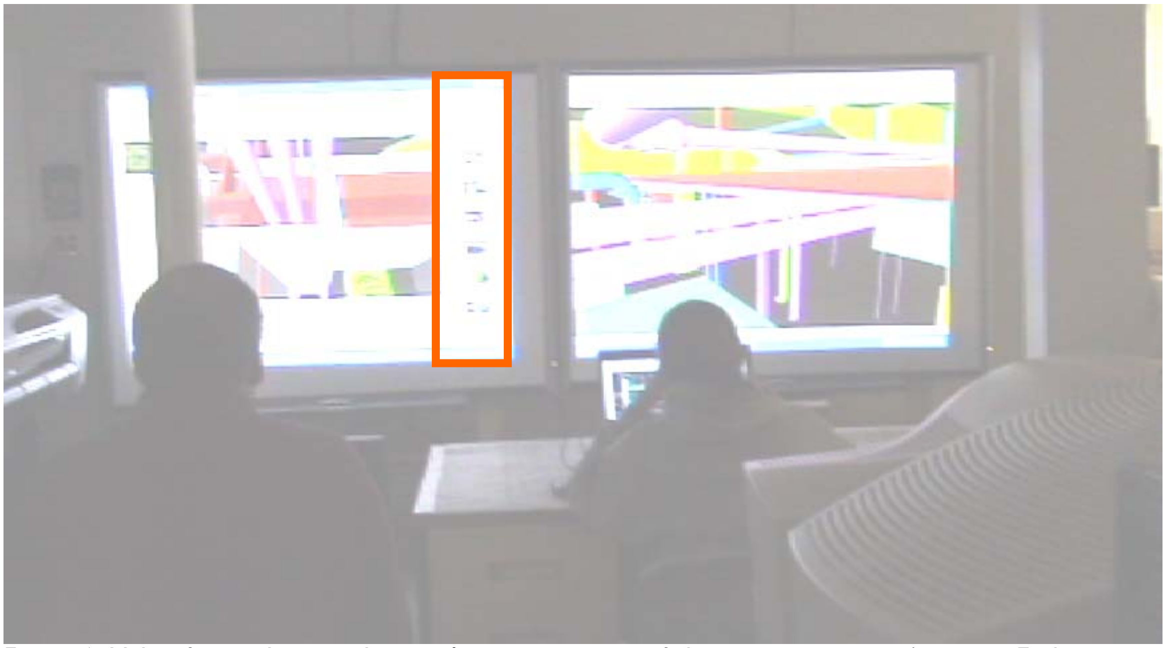


Figure 6: Video frame showing the initial review process of the previous meeting's issues. Each issue is shown as an image within the orange outlined square. The team goes through each issue snapshot and confirms the resolution and status.

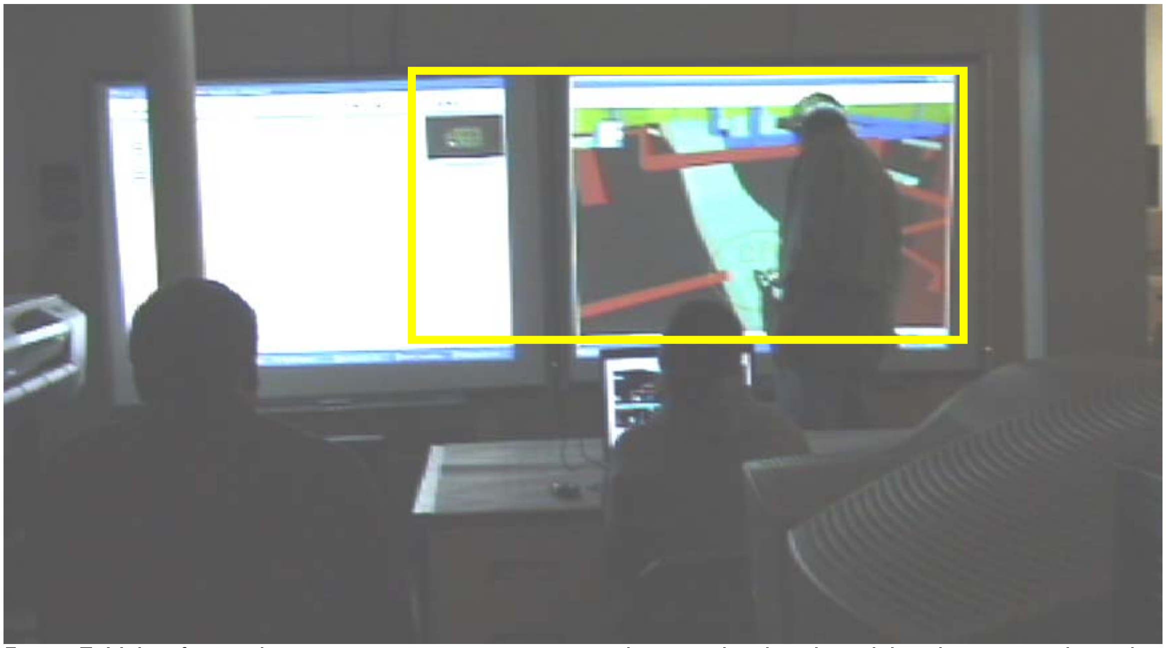


Figure 7: Video frame showing a meeting participant marking-up the digital model with notes on how the MEP conflict will be resolved. After the mark-up is complete, the dedicated model controller takes a snapshot (shown with the yellow outline) including the plan view so the team has a reference point for where the snapshot was taken.

At the conclusion of the meeting the model manager prints the snapshots and distributes them to the team. In this particular case, the meeting was the final review prior to fabrication and proceeding to the next floor.

This meeting reflects a process (Figure 8) that has been refined over several months of using the multi-display environment and working in a co-located setting and is highly optimized. There were few periods, if any, of distraction, flow stoppage, or personal conflict. The process appears to be efficient and effective and the team anecdotally reports the overall MEP coordination process has saved 3-5 months of time. A few recommendations for improvements are:

- Making the snapshots electronically accessible to the team rather than printing the set each time.
- Link snapshots to conflict locations in the model for a quick way to review the status of conflicts. As an overview the team could quickly see if any of the issues have not been resolved.
- Incorporate the automatic clash detection features of the software in the process.

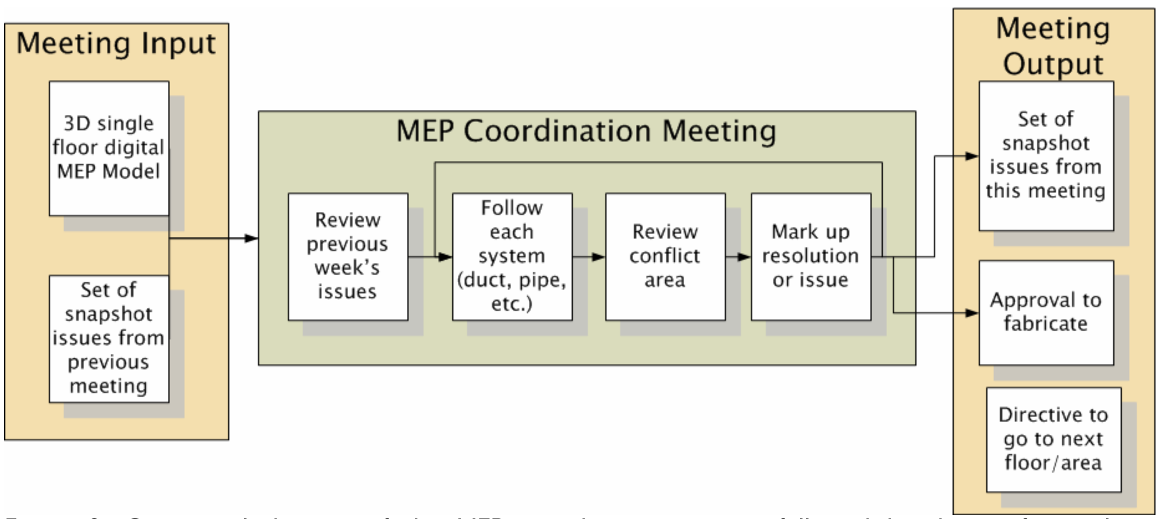


Figure 9: Conceptual diagram of the MEP coordination process followed by the professionals in Observation B.

4 Interaction Analysis

This qualitative description of how the teams used a digital model in their meeting practice is insightful but fails to characterize artifact use systematically to adequately compare multiple observations or develop a normative model of artifact use. Our intuition is that a systematic, quantitative, multi-methodological analysis of artifact use in project meetings using a set of process measures can be used to 1) consistently compare the use of digital and paper-based artifacts and 2) to develop a normative model of artifact use in project meetings (Figure 10).
To test this intuition we consider the following research questions:

1. *What multi-methodological, observation-based framework relates measurable characteristics of interactions in project meetings to performance-based and socio-emotional based outcome measures?*
   a. *What are the measurable characteristics of artifact use in project meetings?*
   b. *What measurable process characteristics situate artifact use in work practice?*
   c. *What measurable process characteristics relate the artifact use to performance or other outcome measures?*
2. *How can (1) be used to systematically compare and describe the use of digital artifacts to paper artifacts in project?*

The remainder of this working paper discusses our efforts to answer these questions by developing a multi-methodological Interaction Analysis (IA) framework consisting of artifact-oriented, information-oriented, workflow-oriented, and people-oriented views of the process. This holistic view of the process relates artifact use to both performance-based goals and socio-emotional goals. We demonstrate the use of the framework, referred to as the TEAM Interaction Analysis framework, by applying it to portions of the video recordings from Observation A and B.

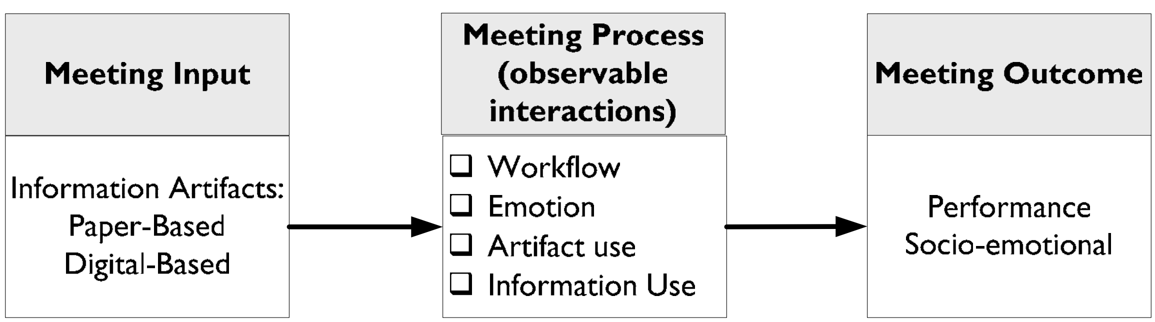


Figure 10: The research model, based on an I-P-O Model.

4.1 What is Interaction Analysis?

A primary focus of this research is to investigate the use of artifacts in natural settings or work practice. Measuring natural interactions requires the use of a quantitative, empirical-based research method. In social science and human-computer interaction—two fields that study the use of artifacts in natural settings—researchers often combine qualitative and quantitative methods to answer research questions or validate intuitions. Qualitative methods yield textual descriptions of the process and help to formulate intuitions (Figure 9-A); whereas quantitative methods yield coded or numerical descriptions and provide a basis to compare and identify relationships in the data. Charles Ragin (1994) refers to quantitative data methods in social science as 'data condensers' and qualitative data methods as 'data enhancers'. Employing both types of methods provides researchers with complementary ways to describe and explain the observations.

A hybrid research method commonly used to analyze empirical observations of groups is called Interaction Analysis:

"*an interdisciplinary method for the empirical investigation of the interaction of human beings with each other and with objects in their environment.*"
(Jordan et al. 1995)

A fundamental assumption of Interaction Analysis is that practice is situated in the interactions between members (Jordan et al. 1995) and can be used to understand how tools or artifacts are used in work practice. Figure 11 shows the relationship between IA research methods and other methods commonly used in system development to evaluate and test designs, artifacts, and artifacts in situated-use, i.e., work practice. The IA method is an appropriate fit for this research to understand the use of digital models and artifacts in project meetings.

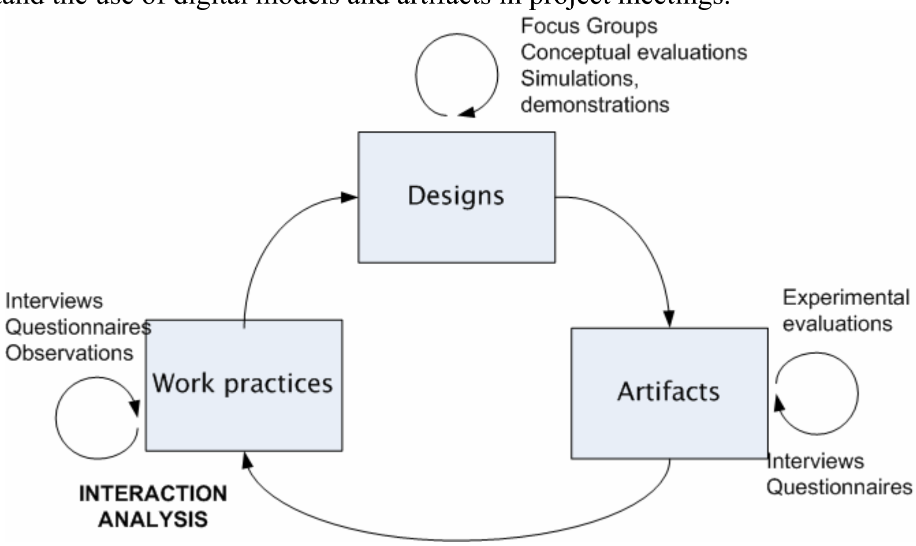


Figure 11: Types of user studies in system development (artifact development) and the role of interaction analysis as a method to study the use of artifact in work practice. Adapted from (Frohlich 1993)

Interaction Analysis (IA) involves video recording "naturally occurring talk and activity" (Frohlich 1993) and systematically coding the observed events to classify and quantify the interactions (Bakeman et al. 1986). It has its roots in structured observation methods popularized by (Mintzberg 1968; Mintzberg 1973; Martinko et al. 1985) and discourse or conversation analysis methods first developed by (Sacks et al. 1974). These methods involve the categorization or coding of interaction events such as utterances, speech acts, or non-verbal behaviors to produce numerical data and measures of the interactions. The data and measures can then be used to analyze the nature, sequence, and pattern of those interactions.

Figure 12 summarizes the overall IA process used in this research and its relationship to the empirical analysis and the use of IA to produce numerical descriptions of the use of artifacts. The numerical data is also used to systematically compare meetings and to probe the data to identify relationships between process measures, metrics, and outcome.

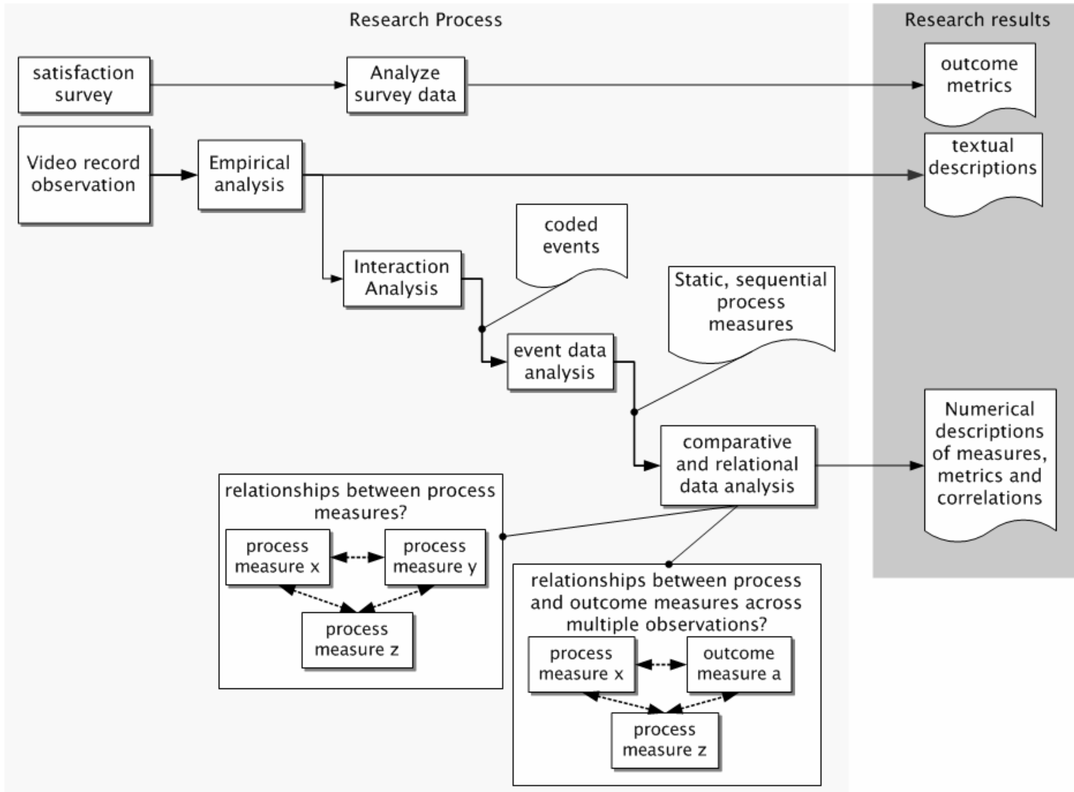


Figure 12: Overview of the Interaction Analysis process and its relationship to the empirical analysis and anticipated research results. IA builds on the intuitions formulated from the empirical analysis and systematically analyzes the video-recorded observations to produce numerical descriptions of process measures, metrics, and correlations between process interaction measures.

4.2 The Scope and Focus of the Interaction Analysis

The critical research task in IA is to develop and/or select coding scheme(s) that support the research goals and measures the appropriate characteristics of interaction necessary to answer the research questions. The design of a coding scheme and the coding scheme categories is often an iterative process, requiring formulation, testing, validation, and refinement of the scheme. A coding scheme can be as simple as differentiating whether an interaction is verbal or non-verbal or contain multiple categories differentiating characteristics of the interaction. IA researchers often use multiple coding schemes to analyze their observations.

In this research, we use coding schemes representing four perspectives of the meeting process: 1) a ***T***eam workflow perspective, 2) socio-***E***motional perspective, 3) ***A***rtifact-usage perspective, and 4) ***M***odel use perspective. We chose these four perspectives based on review of the literature, intuitions formed during the empirical analysis, and several iterations of IA. In sections 4.3 through 4.6 we describe each of the IA perspectives, the specific coding schemes, related process measures, and the IA results to date. Here we summarize each perspective and its significance to the IA:

- ***Team workflow perspective (Interactions as activity and action):*** This perspective looks at **interactions as activity** aimed towards **resolution of project issues**. *Does artifact use lead to higher resolution of issues? Does artifact use lead to more focus?* Measures of workflow include time spent on project-related activities, idle time, number of issues initiated or explored, etc.

- ***Socio-Emotional perspective:*** This perspective looks at **interaction as expression of emotion, control, or dominance**. *Does artifact use relate to more positive expressions or fewer emotional expressions? Does artifact use relate to more equal participation and fewer issues of control?* Measures of emotional expression include ratios of positive to negative expressions, participation rates, and satisfaction measures of the process.
- ***Artifact perspective:*** This perspective looks at **interaction as information artifact use**. *Do teams interact more with digital artifacts than paper? And if so, are those interactions more interactive?* Measures of artifact use include artifact utilization and interactiveness.
- ***Model perspective:*** This perspective looks at **interaction as model use and workflow**. *Do teams interact with the project model more if they interact with information artifacts? Do teams using artifacts spend less time grounding and more time working with the model?* Measures of model use and workflow include model focus and grounding vs. action.

These perspectives form the TEAM Interaction Analysis framework (conceptually shown in Figure 13). This framework defines the scope for our IA and structures the IA process. In sections, 4.4-4.7, we walkthrough each of the TEAM IA components; and discuss the point of departure for each perspective; and describe the related coding schemes, analysis, and results to date. Each part of the TEAM IA results in a set of process measures as shown in Table 1, calculated based on coding of meetings using various coding schemes. Table 1 summarizes the relationship between the eight coding schemes and various process measures. In Section 4.8 we describe how we use these process measures to identify patterns of artifact use and the process measures; and to relate those process measures to outcome measures. In Section 4.9 we discuss some preliminary findings based on the TEAM IA. First, we provide an overview of the IA process with examples from Observations A and B.

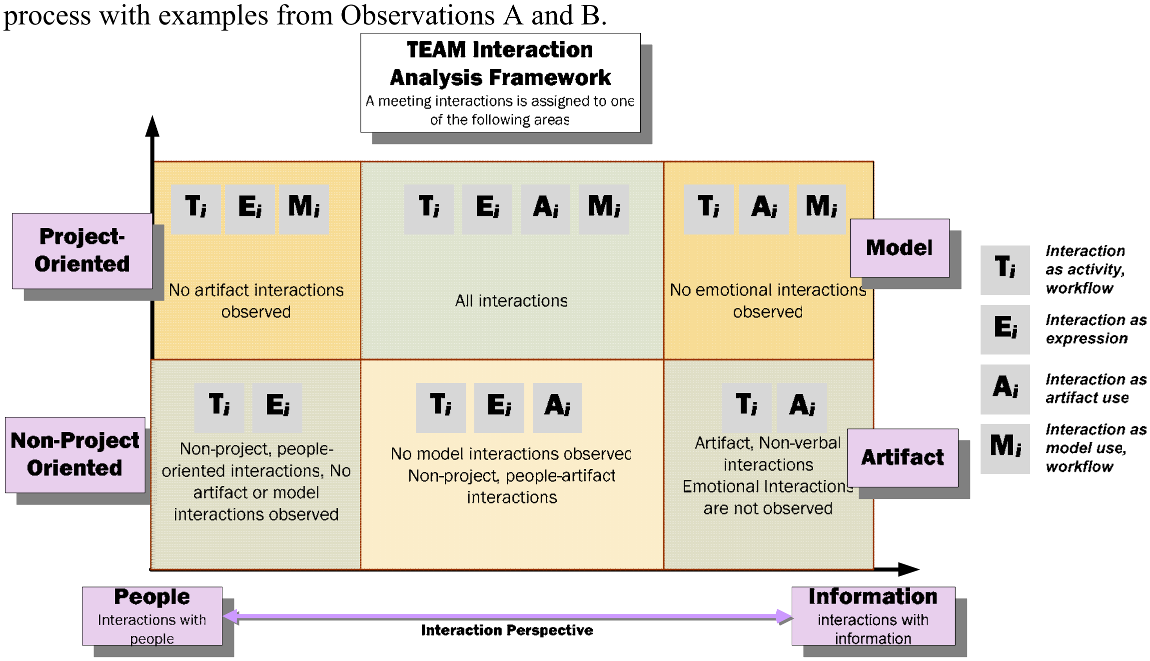


Figure 13: The TEAM interaction analysis framework showing the relationship between the TEAM perspectives. Along one, dimension, the TEAM framework differentiates between non-project and project-oriented interactions; and along another, the TEAM framework differentiates between people-oriented interactions and information-oriented interactions. Every meeting interaction meets the conditions of one of the six boxes, representing the applicable TEAM perspective.

Table 1: Coding schemes and relationship to specific TEAM interaction analysis and process measures

	Workflow measure	Description	Coding schemes based on research by others			Coding schemes developed in this research					
			Olson	Bales	Person	Resolution	Media Use	Accessibility	Interactivity	Model Use	Model Workflow
General Meeting Measures	Coded Duration	Total duration of coded meeting									
	Number of Participants	Total number of participants in meeting									
	Number of activities	Total number of activities									
	Average 'coded' activity duration	The average duration of each activity, and the standard deviation.									
Team Perspective	Project focus	Percentage of time spent focused on any activity related to the project.	●								
	Design focus	Percentage of time spent focused on 'object'-artifact related activities.	●								
	Number of issues	The total number of issues initiated and addressed in the meeting.	●								
	Time/issue	The average time spent on an issue calculated as number of issues divided by total time	●								
	Average number of activities/issue	Total number of activities/total number of issues	●								
	number of 'initiate' activities	Number of activities initiating an issue, request, clarification, etc.				●					
	number of resolved activities	Number of initiate activities that led to resolution.				●					
	number of unresolved activities	Number of 'inititiate' activities that led to no resolution.				●					
	% time 'resolving'	Amount of time spent on activities that led to resolution.				●					
Emotional Perspetive	number 'emotional' interactions	Number of segments involving a single participant speaking.		●							
	Number of positive reactions	Number of segments coded as one of the IPA categories 1-3		●							
	Number of negative reactions	Number of segments coded as one of the IPA categories 10 12		●							
	Number of questions	Number of segments coded as one of the IPA categories 7-9		●							
	Number of answers	Number of segments coded as one of the IPA categories 4-6		●							
	Ratio of positive to negative reactions	The ratio of positive reactions to negative reactions.		●							
	Ratio of questions to answers	The ratio of questions to answers.		●							
	number of participants	The total number of participants in the meeting.			●						
	Participation rate	The number of participants who spoke in the meeting.		●							
	Participation rate	The percentage of participants who spoke in the meeting.			●						
	Percent of time 'giving suggestion'-control	The percent of time engaged in control-related interactions (IPA category 4).		●							
	Gini coefficient	The calculated Gini coefficient where a value of 1 represents dominance by a single participant and value of 0 equal participation by all participants.			●						
Artifact Use Perspective	Artifact interactions	Number of interactions involving an interaction with an information artifact.					●				
	Artifact Interaction Rate	Percent of interactions involving artifacts					●				
	Media utilization	Percentage of time spent interacting with artifacts					●				
	Digital media utilization	Percentage of time spent interacting with digital media									
	Accessibility	Percentage of time spent interacting with information publicly accessible.						●			
	Interaction richness	Percentage of time spent marking-up or changing representations of information artifacts relative to other interaction types.							●		
Model use Perspective	Model Interaction activities	Number of interactions involving interaction with project model								●	
	Model Focus	Time spent interacting with the project model.								●	
	Form Focus	Percent of time using form information (product, process, organization).								●	
	Process Focus	Percent of total coded time using process information.								●	
	Requirement and Analysis Focus	Percent of total coded time spent using requirements or analysis information.								●	
	Grounding	Time spent describing and explaining.									●
	Action Focus	Time spent evaluating and predicting.									●

4.3 Overview of Interaction Analysis Process

The TEAM IA process involves video recording a meeting, transcribing the meeting, segmenting the transcription, and coding those segments using the coding schemes listed in Table 1. All research was performed using Industry Review Board (IRB) protocol to comply with ethical standards of human subject research and to ensure the anonymity of the participants. We use open source video analysis software, called Transana, to manage the transcription and coding process. Transana provides features to segment the video and associate the segments with keywords and transcription text.

A segment or a discrete event[2] represents a speaker turn, a period between speaker turns (non-verbal event), or periods of parallel conversation (where multiple participants are talking). Figures 14-20 represent a segment. Each figure includes a snapshot from the segment and the transcribed text for the segment, which starts with a four character identifier, e.g., 'Y019'. If the segment is associated with utterances spoken by a single participant, the first character is 'A-J' or 'K' (assigned to an unidentified participant). If there are no utterances, then one of three characters are assigned:

- 'X': segment involving interaction with a digital artifact
- 'Y': segment involving interaction with a physical artifact
- 'Z': segment involving multiple participants talking

The last three characters represent the segment number in the meeting. Non-verbal interactions are textually described within double parenthesis and italics, e.g., '((*moving view*))'. Appendix

Each segment is recorded with a start and stop time to calculate the segment duration. Figure 13, for example, represents a segment of 3.9 seconds. This information allows us to calculate process measures in terms of time or counts.

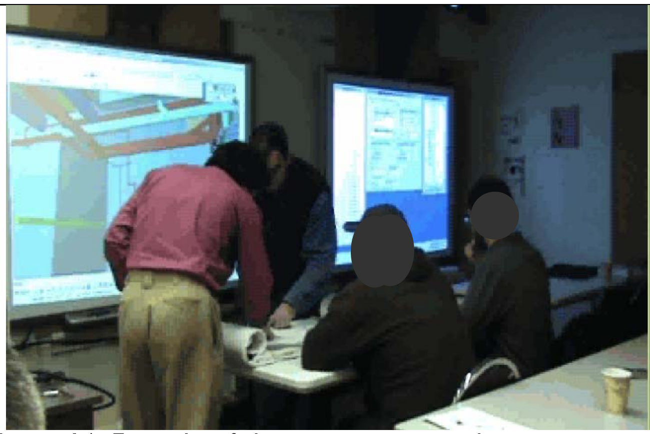
Each segment is then categorized with respect to the types of interactions observed in the segment:

- **Team Interactions**: A verbal or non-verbal action involving a meeting participant. Every segment in the meeting is a team interaction.
- **Emotional Interaction**: A verbal action between two or more meeting participants.
- **Artifact Interaction**: A verbal or non-verbal action between one or more meeting participants and an information artifact.
- **Model Interaction**: A verbal or non-verbal interaction between one or more meeting participants and the 'object' artifact.

Figure 14 shows the six different types of interactions that result by applying this TEAM interaction categorization. For example, the segment in Figure 15 represents Team, Artifact, and Model interactions; but we do not analyze the interactions from the emotional perspective because no utterances are spoken during the segment time period. In Figures 14-20, we list the assigned TEAM keywords for each segment. For example, in Figure 15, the keyword 'descriptive' was assigned based on the model workflow perspective. In the following sections we walk through each TEAM perspective and describe the coding keywords that are used to perform the TEAM IA.

[2] An event is an occurrence that is inherently countable (Mourelatos 1978) and implies no meaning or purpose.

This working paper presents results based on 10% of the data we have collected. We are in the process of validating our research methods to test for inter-rater reliability rates and completing coding of the full set of data. The results and examples are intended to describe the research methods we are using and examples of anticipated results.



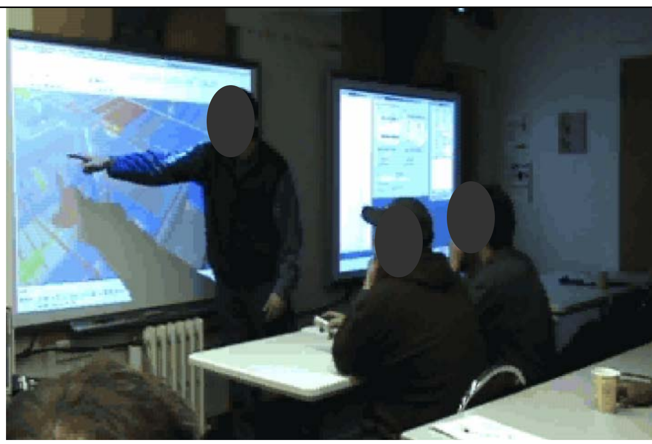
X019: ((looks at drawing, no response))

3.9 seconds

Person X

T_i	Workflow activity	walkthrough
	Resolution	continue
A_i	Media	paper
	Interactiveness	pointing
	Access	semi-public
M_i	Model Use	product
	Model workflow	describe

Figure 14: Example of descriptive activity, showing a participant pointing to paper artifact to see where a sprinkler can go. The activity is part of an issue initiated in a previous activity and resolved in the subsequent activity.



F003: Yeah. ...halfway over here Extend the duct move the tap way over here, come over here and drop it down underneath the catwalk...sprinkler main. And then this round we're going to carry that forward and then up over the staircases. So you got…

23.9 seconds

Person F

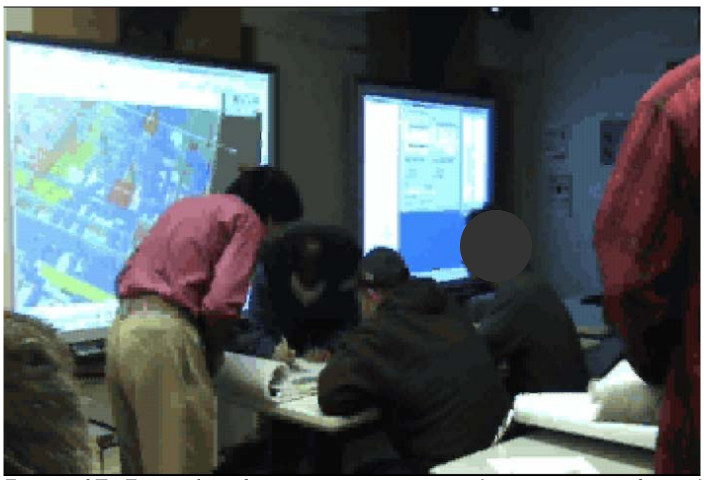
T_i	Workflow activity	alternative
	Resolution	resolved
E_i	Bales IPA	gives suggestion
A_i	Media	digital
	Interactiveness	pointing
	Access	public
M_i	Model use	product
	Model workflow	generate

Figure 15: Example of a generative activity, to resolve a coordination issue. The participant is proposing a solution for the location of a duct. The participant is pointing to the location in the digital model. The issue is not resolved.

A058: Can't you just come across here, B?
5.4 seconds
Person X

T_i	Workflow activity	alternative
	Resolution	continue
E_i	Bales IPA	gives suggestion
A_i	Media	digital
	Interactiveness	viewing
	Access	public
M_i	Model Use	product
	Model Workflow	generate

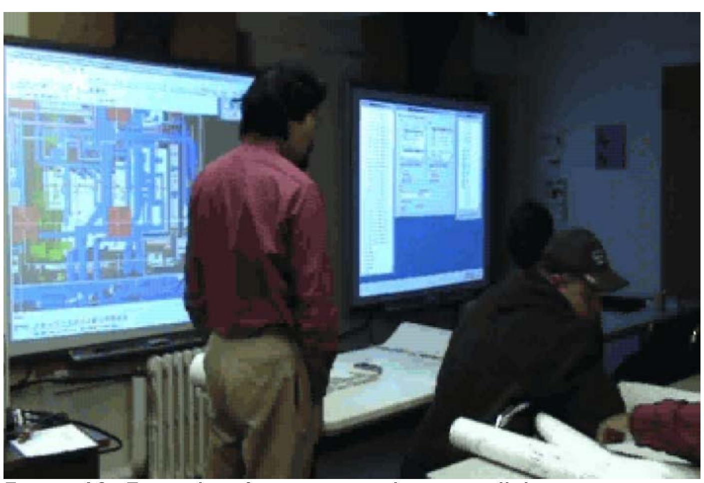
Figure 16: Example of a generative activity to resolve a coordination issue. Participant A suggests a solution to re-route the pipe around the large duct. In the subsequent activity the team agrees and the issue is resolved.



X008: ((drawing on drawing))...
5.9 seconds
Person X (non-verbal)

T_i	Workflow activity	alternative
	Resolution	continue
A_i	Media	paper
	Interactiveness	marking-up
	Access	semi-public
M_i	Model Use	product
	Model Workflow	generate

Figure 17: Example of team interacting with a paper artifact, drawing a proposed solution to a coordination issue. The participant is marking-up the drawing to show a solution to a coordination conflict. Since no one is talking and the primary interaction is with paper artifact, the person is categorized as 'X'.



Z013: ((various conversations, looking at drawings, whiteboard)) ((having conversations to work through issues))
180 seconds
Person Z

T_i	Workflow activity	digression

Figure 18: Example of activity involving parallel conversations and digression. During this activity, multiple conversations are occurring.

A044: Let me ask this real quick. We only have 12 of these, or 18? How many we got? 14? Are we confident we have taken care of all these? (next activity segment)
F004: We've gone through all these.

14 seconds
Person A

T_i	Workflow activity	project management
	Resolution	initiate
E_i	Bales IPA (emotion)	asks for orientation
A_i	Media	digital
	Interactiveness	viewing
	Access	public
M_i	Model Use	product
	Model Workflow	evaluate

Figure 19: Example of an 'evaluative' activity seeking resolution on status of issues and seeking evaluation by other meeting participants. The team is viewing a digital list of issues during this activity. The follow-up activity resolves the issue.

.

A067: I'm not real worried about this. I think we have plenty of room in that cable tray. It's a little higher than it will actually be. What's that right there? You know? Is that gravity?

21.1 seconds
Person A

T_i	Workflow activity	clarification
	Resolution	resolved; initiate
E_i	Bales IPA (emotion)	gives opinion; asks for orientation
A_i	Media	digital; pointing
	Interactiveness	viewing
	Access	public
M_i	Model Use	product
	Model Workflow	evaluate; describe

Figure 20: Example of an explanative activity segment where a participant explains the rationale for ruling out an issue and then initiates a new issue by discovering another coordination issue.

4.4 Workflow perspective: Interactions as Team Activity

A workflow represents what a team is doing as a set of activities and what the team is trying to achieve as a goal or an output. Workflow diagrams are used to describe a transformation process—physical, informational, etc.—such as a production process or a computer software process as an input-output network of related activities. By applying a workflow perspective using IA, our goal is to describe the situated use of artifacts and how artifacts relate to the process of achieving a goal.

In design studies and group research literature, outcomes or goals are categorized as performance-oriented (e.g., decisions, solutions, issues) or social-oriented (e.g., member satisfaction, cohesiveness) ((Hackman 1987). In this perspective, the focus is a performance-oriented view of the process and goals. In our empirical observations of various project meetings there was one common goal of the meeting activity—to address project issues. Meeting activities were rarely focused on making decisions. Rather, most project meetings are about identifying and addressing project issues which may or may not result in a decision. An issue is defined as:

> "a point, matter, or dispute, the decision of which is of special or public importance." (dictionary.com)

Issues are central to all types of project meetings including brainstorming and early design. In the earliest stages when team activity is focused on generating ideas and concepts, addressing project issues is part of the iterative process.

We define *meeting workflow* as:

> a sequence of team activities intended to address project issues.

We use the term activity in this definition because it "emphasizes motivation and purposefulness" (Nardi 1995). An activity represents one or more interactions. An interaction with an intended purpose is an activity.

In the following two sections we discuss two workflow perspectives of the team interactions:

1. Interaction as project activity focused on addressing project issues.
2. Interaction as question-answering, and resolving.

4.4.1 Project Activity Interaction Analysis: Interaction as Project Activity

The Project Activity IA is based on research by (Olson et al. 1992) to analyze collaborative activities of software design. Olson's research looked at the collaborative design workflow and also identified issues as a useful concept to structure collaborative design workflow. Olson categorized meeting activities into the following four categories:

- ***Coordination activities***: verbal actions to manage the meeting or the project.
- ***Design-focused activities:*** verbal or non-verbal interactions focusing on identification and resolution of project issues, clarifying the issue or a characteristic of the object

artifact[3], communicating the rationale of the current object artifact, or creating new alternative designs of the object artifact.

- ***Taking stock activities:*** verbal or non-verbal interactions summarizing project issues or walking through the current state of the object artifact as a user, i.e., contractor, client, etc.
- ***Digression or other activities:*** verbal and non-verbal interactions unrelated to the project or project issues, e.g., sidebar conversations, parallel conversation, meeting breaks, or off-topic conversation.

Olson elaborated each of these high-level categories into 11 coding categories listed in Table 2.

Olson used this coding scheme to analyze software design teams and measure the amount of time teams spent performing the various types of project activities. For example, Olson found that 40% of the time spent in meetings was focused on design-focused activities, 30% taking stock, and the remainder on project/meeting coordination or unrelated activities. Olson did not use the coding scheme to correlate patterns of activities with other process measures; or to evaluate artifact use.

The Olson coding scheme was designed to analyze issue-centered design meetings. We made minor changes to the definitions of Olson's coding scheme to broaden its application to project meetings ranging from brainstorming through planning and scheduling of a building the object artifact. For example, Olson defined the 'walkthrough' activity as walking through the design as a user. We extended the concept of walkthrough to include a broad set of users, e.g., client, contractor, or subcontractor; walking through the design or construction of an object artifact. For example, the teams in the MEP coordination meetings spent a significant amount of time walking through the design to identify potential installation problems.

Table 2: The project activity coding scheme based on (Olson et al. 1992).

Category Grouping	Category	Description of Category
Coordination	project management	activities not directly related to content of design but to project process or organization
	meeting management	activities having to do with orchestrating meeting time's activity
	goal	activities discussing purpose of group's meeting
Design-Focused	issue	major questions, problems or aspects of the design object that need to be addressed
	alternative	solutions or proposals
	criterion	reasons, arguments, opinions that evaluate an alternative solution or proposal
	clarification	questions or answers to clear up misunderstandings
Taking stock	summary	review of state of design in list format. If it is ordered by steps it is a walkthrough
	walkthrough	gathering of design so far in sequential steps
Other	digression	discussion of non project related topics
	other	time not attributed to other categories.

Table 3 lists the raw data from the project activity IA. We use this raw data to analyze and compare the observations in terms of proportional time spent on meeting activities at the high-level (Figure 22) and at a detailed-level (Figure 23); and to visually analyze the workflow patterns or activity transitions with activity profiles (Figure 24 and 25). The activity profiles

[3] Object artifact is discussed in Section 4.6. It is a term to represent the object of focus, i.e., a software product, a building, etc.

relate the raw data to time to show transitions between different meeting activity types. Future work may involve computational analysis of the workflow patterns and transitions between activity types.

Table 3: Raw data for project activity analysis

	Time (sec)	
Project Activity Type	**Observation A**	**Observation B**
Alternative	407	196
Clarification	243	451
Criteria	34	80
Digression	28	211
Goal	8	105
Issue	63	157
Meeting Management	272	254
Other	5	11
Project Management	26	2
Summary	60	0
Walkthrough	267	490
Total Analyzed Time (minutes)	**24**	**33**

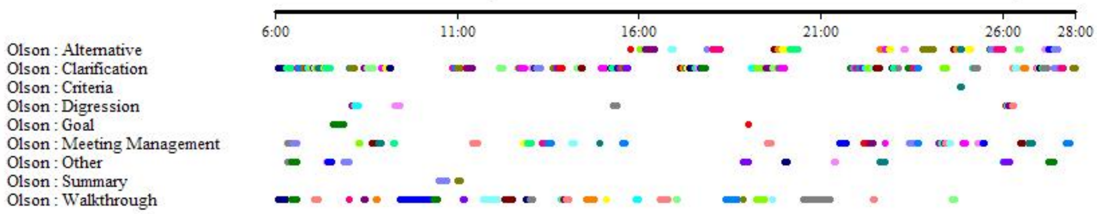


Figure 21: Keyword map for Observation B showing the coded activity types over time.

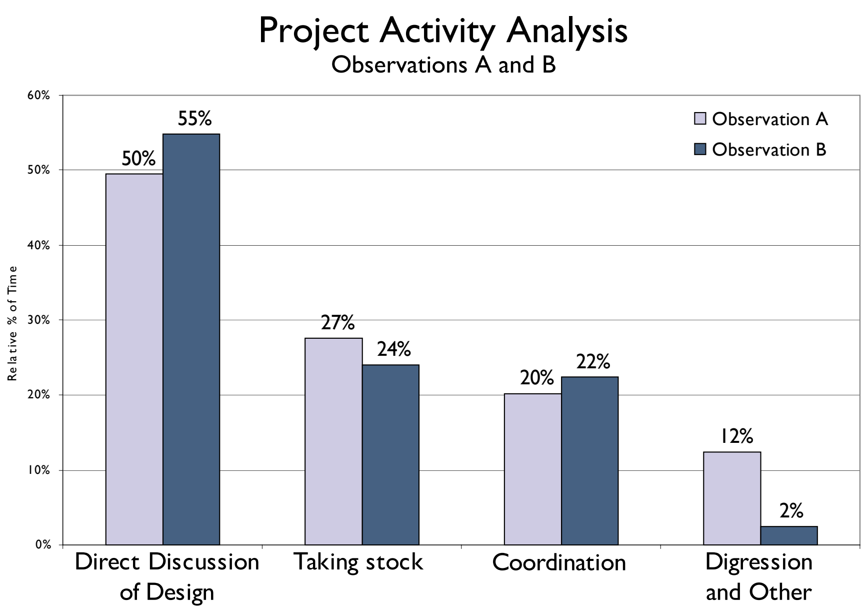


Figure 22: Project Activity analysis results for the high-level activity categories.

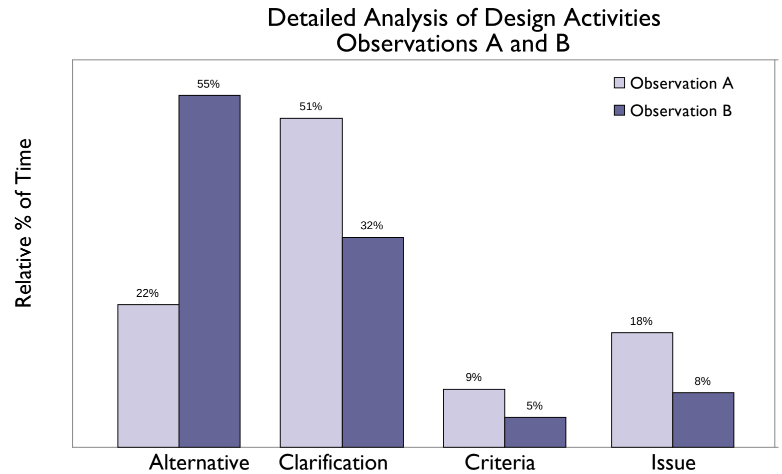


Figure 23: Analysis of time spent on 'direct discussion of design' activities. This chart shows that the Observation B team spent a larger percentage of time discussing alternatives; and the Observation A team spent more time clarifying design issues.

We also use the raw data to calculate several process measures related to meeting workflow (Table 4); and to relate these measures to other TEAM process measures (discussed in Section 4.8). Here are examples of some findings based on the project activity analysis of Observation A and B:

- A significant portion of the time, 50% and 55%, was spent focused on design - or in this case coordination. Observations A and B had very similar amounts of time spent on design-focused activities, 50% and 55%, respectively.
- The primary difference between the two meetings was the time spent on 'digression' or 'other' activities with Observation A spending 12% and Observation B, 2%.
- The Observation B team spent significantly more time focused on discussion of 'alternatives' as opposed to clarification.
- Observation B team transitioned more often between 'coordination' activities, 'direct design' activities and 'design' review activities than the Observation A team. The workflow pattern in Observation B visually appears to be more 'structured' and regular than Observation A.

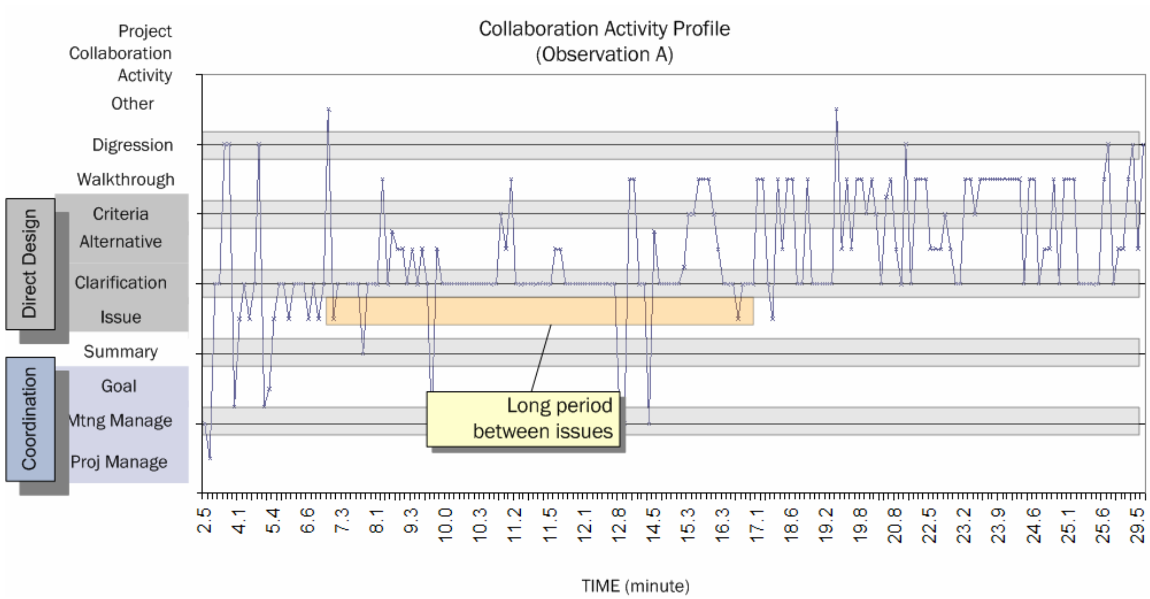


Figure 24: Activity profile for Observation A. The activity profile shows the transition over time between coordination activities (bottom three activities), to direct design activities (middle four activities, beginning with “Issue”), and non-project related activities (upper two). The highlighted block shows the time period between the initiation of an issue and the start of another issue.

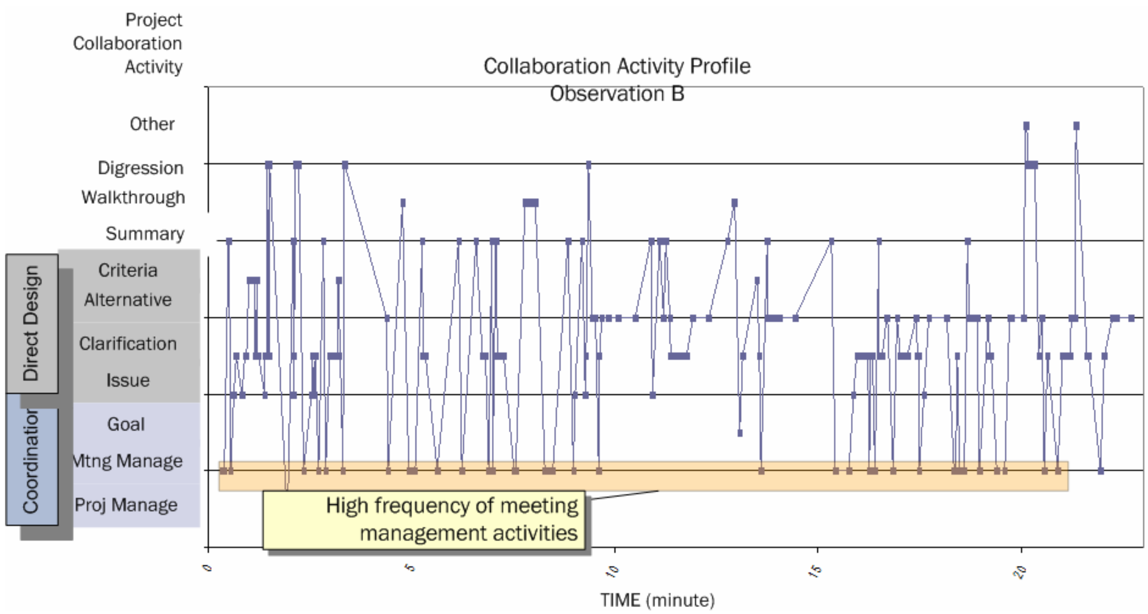


Figure 25: Activity profile for Observation B. This shows the high frequency of meeting management activities in the early part of the meeting.

4.4.2 Workflow Resolution Analysis: Interaction as Question, Answering, Resolving

The Project Activity analysis characterizes what the team is doing; but does not describe the resulting action or outcome of those activities. The teams spent significant time focused on the project and issues; and both teams addressed the same number of issues. *Did both teams perform equally?* To answer this question, we need to define an observable measure of achievement for the team activities.

In the literature, achievement is often measured as the outcome of the meeting and not at the level of granularity of the interactions or team activities. Many of the common outcome measures, such as quality of a solution, are difficult, if not impossible, to measure based purely on observations. Another common measure is number of ideas, decisions, or issues addressed. These are analyzable, but tend to occur infrequently and across many interactions. Thus, it will be difficult to characterize artifact use, which occurs at the interaction level to these outcome measures. One outcome of activity that is observable and measurable at both the micro-level (one or more interactions, typically question-answer interactions) and macro-level is resolution. Resolution is defined as:

> "determining upon an action or course of action, method, procedure, etc." and
> "a solution, accommodation, or settling of a problem, controversy, etc."
> (dictionary.com)

Based on these criteria we developed a coding scheme called 'Resolution' to analyze activity resolution consisting of the following coding keywords:

- ***initiate***: An activity that initiates an issue or requests action in the form of clarification, review, evaluation, or orientation. These activities are often in the form of a directive or 'question'.
- ***continue***: An activity that follows an 'initiate' activity; and is either followed by a 'resolve' activity or followed by an 'initiate' activity.
- ***resolve***: An activity that responds to a clarification, issue, and results in no further action or is followed by an 'initiate' activity.

Table 5 shows sample coding using this 'Resolution' coding scheme. Bold outlines show the grouping of activities to analyze resolution. If an 'initiate' activity occurs when a 'resolve' activity has not occurred this is calculated as 'unresolved'. We use this raw data to compare meetings in terms of time spent resolving or trying to resolve (activities that lead to inaction, unresolved), and activities unrelated to addressing issues. The chart shown in Figure 26 shows that the Observation B team spent more time resolving than the Observation A team.

Table 5: Sample Interaction Analysis using the workflow coding schemes.

Activity Segments in the Meeting Transcript	Olson	Resolution	Resolution Analysis	Explanation
A049: How do I get that sprinkler from there to there and this plumbing from here to over there?	issue	initiate		Requests an alternative
C011:.....main artery there...	clarification	continue	unresolved	points out one of the challenges is a main artery, not resolving the issue
C012: How big is the other one crossing?	clarification	initiate		requests clarification
G005: 6" and 4"	clarification	resolved	resolved	clarifies
A050: Right there we still have interference between plumbing and...	issue	initiate		identifies a problem
X006: ((moving model))	walkthrough	continue	unresolved	team moves the model trying to review the conflict
A051: Where did pens go?	other	non-issue	NA	statement unrelated to project
A011: C did we just move the pipe out of the way here.	clarification	initiate		requests clarification
C002: Yes I did.	clarification	concluding	resolved	clarifies
A012: On the other side?	clarification	initiate		requests additional

C003: Moved it. A013: Wow. C004: You wanted me to move it. Right. I moved it. A014: Cool. You are done with that one.	clarification digression clarification	resolved	resolved	clarification clarifies clarifies Confirms resolution
	2 issues	5 issues	2 unresolved, 3 resolved	

Table 6: Summary of workflow process measures.

Workflow measure	Description	Observation A	Observation B
Meeting duration (minutes)	Total duration of the analyzed portion of the meeting	22.7	27.2
Number of activities	Total number of activities	190	220
Activity Analysis			
Project focus	Percentage of time spent focused on any activity related to the project.	88%	98%
Design focus	Percentage of time spent focused on 'object'-artifact related activities.	50%	55%
Number of issues	The total number of issues initiated and addressed in the meeting.	12	12
Time/issue	The average time spent on an issue calculated as number of issues divided by total time	2.26 minutes	1.96 minutes
Average 'coded' activity duration	The average duration of each activity, and the standard deviation.	8.6 seconds (σ [4]=17	6.2 seconds (σ =7.8)
Average number of activities/issue		16	18
Resolution Analysis			
number of 'initiate' activities	Number of activities initiating an issue, request, clarification, etc.	80	89
number of resolved activities	Number of initiate activities that led to resolution.	59	76
number of unresolved activities	Number of 'inititiate' activities that led to no resolution.	21	13
% time 'resolving'	Amount of time spent on activities that led to resolution.	73%	86%

4.4.3 Analysis of Meeting Workflow

The workflow process measures for Observations A and B are summarized in Table 6 and characterize the meeting workflow in terms of focus on project and design, time spent addressing issues, and time spent resolving. Figure 27 compares three process measures—design focus, project focus, time spent resolving—for both observations. This visual comparison shows that in all three measures, the Observation B team had higher values. Future work will involve comparative analysis of multiple observations to identify correlations between the workflow process measures.

[4] Symbol for standard deviation.

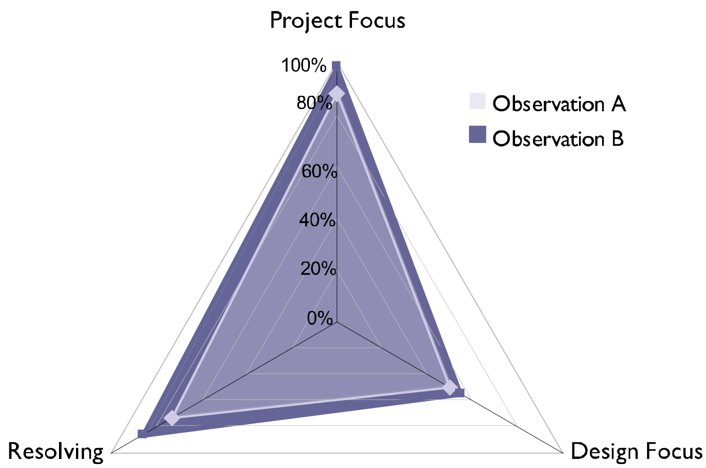


Figure 27: Radar chart showing the relationship between three workflow process measures.

4.5 Emotional Perspective: Interaction as Emotion

The role of interpersonal actions and reactions as both an indicator of meeting outcome and factor influencing group dynamics has been widely investigated. The small group research and social-psychology research literature includes a wide variety of perspectives of 'emotional' behaviors of individuals, such as interpersonal trust (Dirks 1999), self-efficacy (Bandura 1986; Staples et al. 2007), values and beliefs of members (Miliken et al. 1996; Kang et al. 2006) and how they influence or impact group process and outcome. It is beyond the scope of this research to adequately analyze the role of such variables; and research protocol is designed to analyze the 'team' and not the individual. Nonetheless, as we examine artifact use, it is important to consider its potential to reduce personal influences in group process (Walther 1996).

We chose two socio-emotional perspectives based on review of the literature and our observation-based research methods:

1) **expression of emotion**, e.g., positive or negative reactions: viewing interactions as an expression of positive or negative emotion. Does artifact use lead to more or less expressions of emotion? more positive? negative?
2) **dominance and control**: viewing interaction as attempts to control, dominate, or participate in the conversation. Does artifact use lead to more equal participation, fewer problems of control?

We limit the application of this socio-emotional perspective to verbal interactions (the workflow analysis applied to all interactions). The IA based on these two perspectives measures the ratio of positive to negative reactions; the equality of participation; and the time spent addressing 'problems of control'.

4.5.1 Interaction as Emotional Expression

The view of interaction as emotional expression is based on research by Robert Bales in the 1950s. Bales viewed the group process as "a feedback system of communication and control among a set of participants" (p. 225, (Bales 1998) moving between initial problem-solving attempts and positive or negative reactions. This view emphasizes the natural activity pattern of groups between focusing on project or work-related tasks with non-project related tasks. Meetings that are 100% focused on the project are not necessarily optimal; and digressions of a positive nature do contribute positively to meeting outcome. Likewise, meetings that are emotionally-oriented are typically not ideal.

Bales developed a coding scheme to reflect this view called Interaction Process Analysis (IPA) (Bales 1998) and it is shown in Figure 28. Through field and lab testing, Bales correlated specific interaction profile patterns to satisfaction process measures. Bales findings included a correlation between groups with more positive than negative reactions and high rates of giving suggestions (structuring activities) and higher rates of satisfaction.

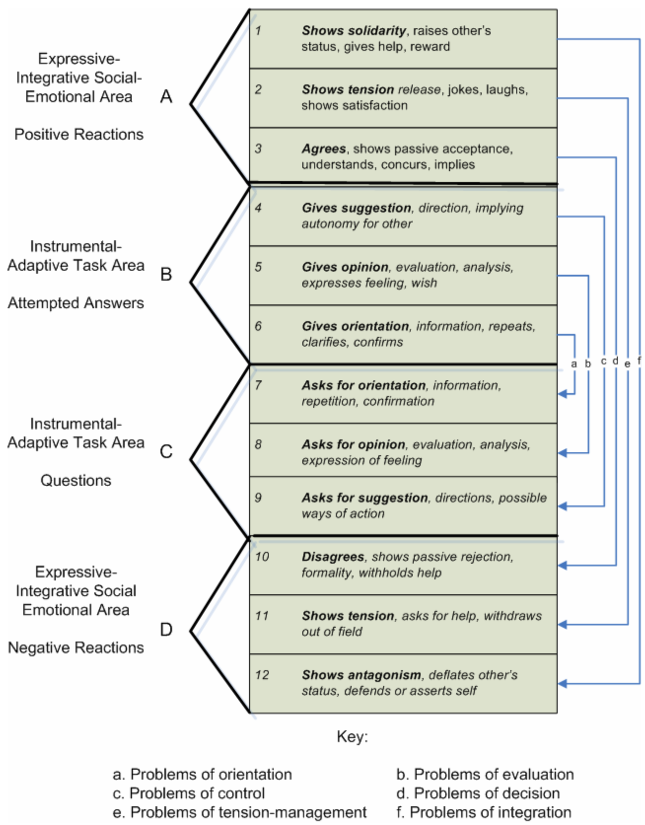


Figure 29: Social Interaction Process Analysis (IPA) coding scheme based on (Bales 1998) categories used for direct observation of the interaction process.

Figure 30 shows an interaction profile produced from the coding of Observations A and B using IPA coding scheme. An interaction profile relates the results of the different IPA categories. The interaction profile shows that a majority of the activities were not 'emotional' in nature but predominantly related to questions and answers. The primary difference between the two interaction profiles is the nature of the questions and answers. The Observation A team spent significantly more time 'giving orientation' and this may reflect the time spent by the Observation A team to respond to requests to clarify design information.

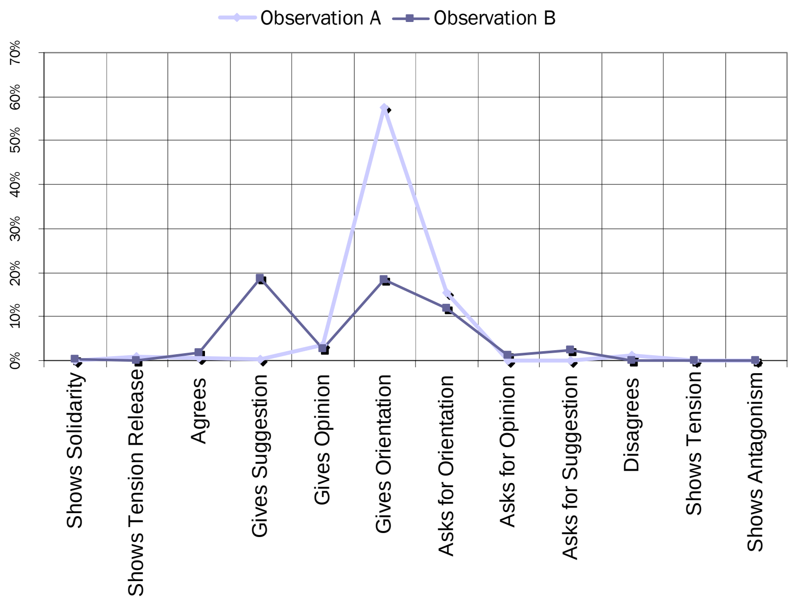


Figure 30: Bale's interaction profiles for Observations A and B showing that a majority of the activities were assigned to category 'Gives orientation' in Observation A; and Observation B had an equal amount of time spent on activities assigned to categories 'Giving suggestions' and 'Gives orientation'.[5]

Figure 31 shows a comparison of time spent questioning, answering, or reacting positively or negatively. Observation A team spent significant time attempting to answer questions compared to the Observation B team; and Observation A team spent less time reacting positively.

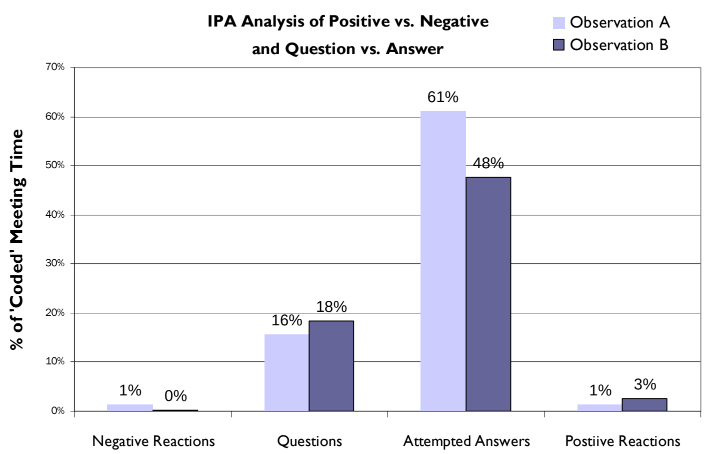


Figure 32: Chart showing relative percentage of time spent questioning, answering, and reacting positively or negatively.

[5] Bales' coding method involved counting the number of acts. The current method calculates and summarizes the time for each coded act attributed to a category. Subsequent analysis will include analysis based on counting activity segments. This is important because many of the "positive" and "negative" reactions are brief, e.g., "Great!", "Wow."

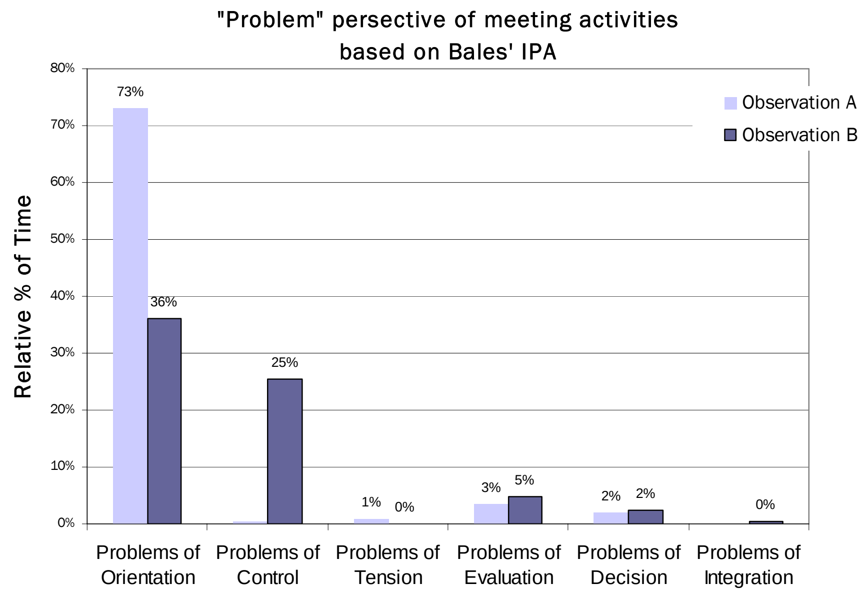


Figure 33: Bale's IPA categories organized relative to problems. A majority of the time was spent addressing problems of orientation (clarifying, confirming, etc.).

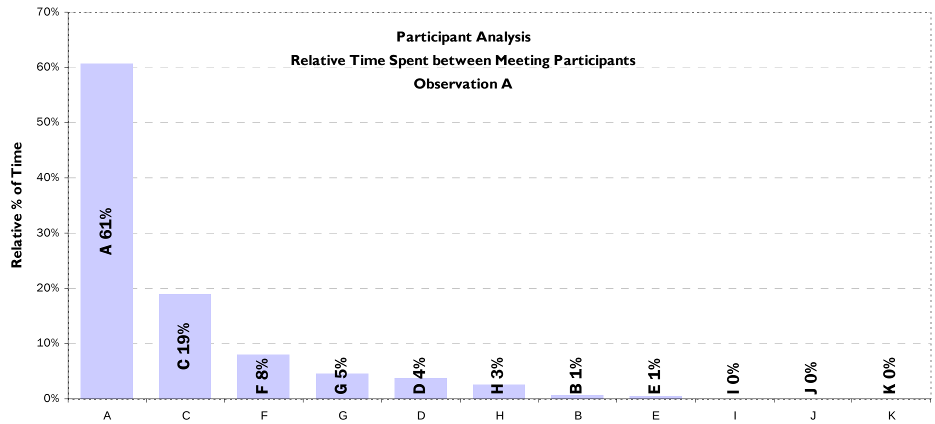
Figure 33 shows another view of the IPA analysis based on Bales' view of the process as addressing different types of problems. This is one part of considering the 'control' aspect of the process. In this view, Observation A team spent more time on 'problems of orientation' and Observation B team spent more time on 'problems of control'. Problems of control, however, are not necessarily reflective of a process with no control. In Observation B, a majority of the time related to 'problems of control' were 'giving suggestion' (Figure 34). In this respect, this represents attempts by the team to structure and control the process. Bales found that teams with high rates of 'giving suggestion' was related to higher rates of satisfaction, indicating meetings need control and direction.

4.5.2 Dominance: Interaction as Participation

Extensive research on participation in groups shows that increased participation leads to better outcomes particularly with respect to individual satisfaction with the group process and group outcome. Research in computer mediated communication with groups has shown that tools like email, conferencing, etc. improve participation (Weisband et al. 1995). Thus, improving the participation rates of individual meeting participants potentially will influence individual satisfaction and potentially the meeting outcome. Unfortunately, there is no standard recommended distribution of participation within a group. It is common though to see a principle participant with a participant rate twice that of other participants and four to ten times that of additional participants (Bales 1976).

There is one standard participation measure, called the Gini coefficient, used to look at equality of participation. The Gini coefficient (Alker 1965; Dixon et al. 1987) measures the inequality of participation as the deviation of each participant from equal participation where a value of 0 represents equality among participants and a value of 1 represents dominance by a single participant.

In Section 4.3, we described how each segment of analysis includes a reference to a speaker (A-K) if there is verbal interaction by a single participant; and to interaction with digital artifacts (X), physical artifacts (Y), or interaction between multiple participants (Z). We use this coding to analyze participation. Figure 35 compares the time spent speaking by each participant for each meeting by various participants; and shows that one participant in each meeting participated more than the other participants combined.



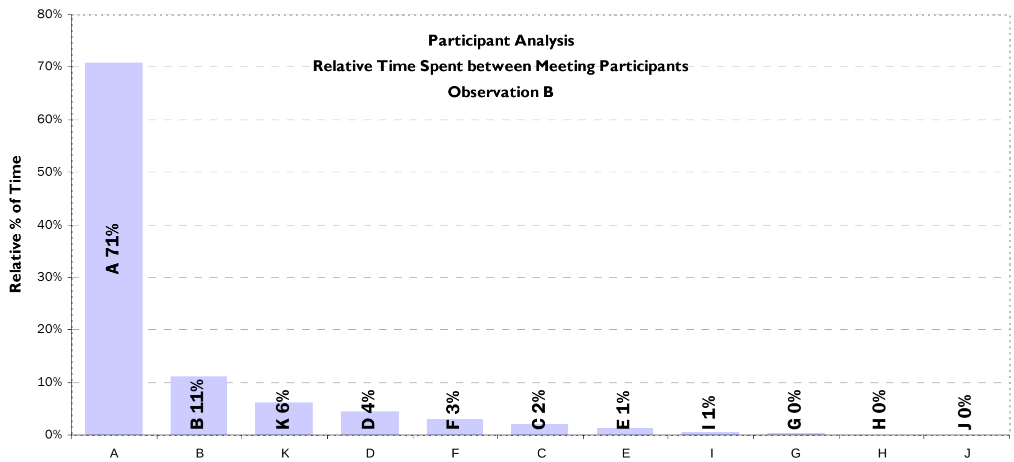


Figure 35A and B: Participation analysis of the coded portion of Observations A and B. Participant K represents verbal interaction that could not be assigned to a specific participant.

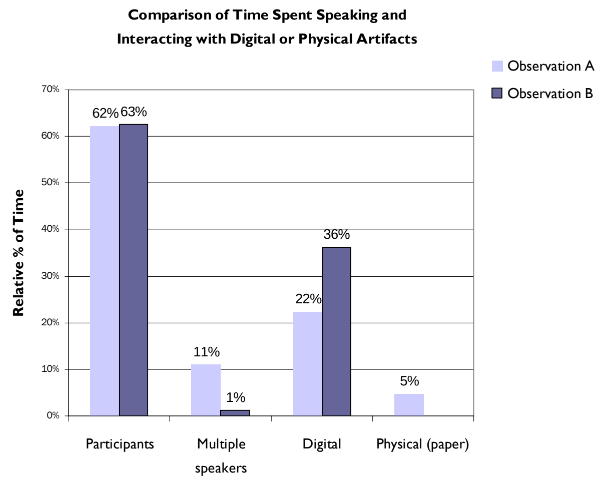


Figure 36: This chart compares the time spent in conversation by a single participant to time spent in parallel conversation and time spent interacting with artifacts when no verbal conversation takes place.

Figure 35 compares the time between verbal and non-verbal interactions. In both meetings, the teams spent the similar amount of time engaged in verbal interaction. The primary difference between the two meetings is that the Observation B team spent more time engaging in parallel conversations, less time interacting with digital artifacts, and more time interacting with physical artifacts. We discuss these observations in the following section.

Figure 33 compares the calculated Gini coefficient for Observations A and B, .81 and .75, respectively. A value of 1 represents dominance by a single person.

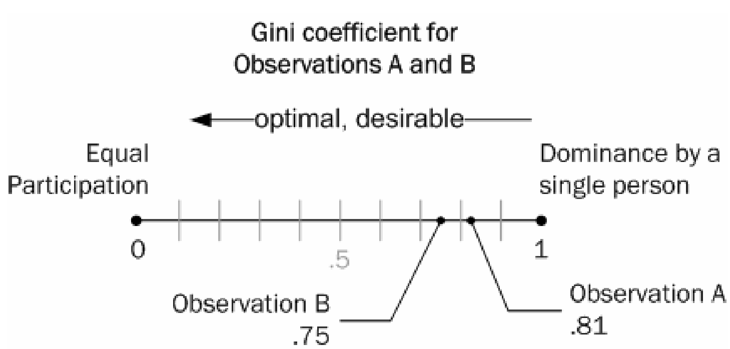


Figure 37: Comparison of Gini coefficient values for Observations A and B within the Gini coefficient scale with a value of 0 representing equal participation by all meeting participants and a value of 1 representing dominance by a single participant.

4.5.3 Analysis of Emotional Interactions

Table 8 summarizes the emotional process measures related to the expression perspective of interactions and the dominance and control perspectives of interaction. Figure 38 shows a comparison of three process measures for Observations A and B. Future research is looking at additional types of measures and metrics that can be used to describe interaction as emotion.

Table 7: Summary of emotional process measures.

Process measure	Description	Observation	Observation

		A	B
total number of coded segments	Total number of segments that were coded for Emotional IA.	190	220
number 'emotional' interactions	Number of segments involving a single participant speaking.	153	181
Expression			
Number of positive reactions	Number of segments coded as one of the IPA categories 1-3	7	25
Number of negative reactions	Number of segments coded as one of the IPA categories 10-12	4	1
Number of questions	Number of segments coded as one of the IPA categories 7-9	40	46
Number of answers	Number of segments coded as one of the IPA categories 4-6	108	122
Ratio of positive to negative reactions	The ratio of positive reactions to negative reactions.	1.8	25.0
Ratio of questions to answers	The ratio of questions to answers.	2.7	2.7
Dominance and Control			
number of participants	The total number of participants in the meeting.	12	8
Participation rate	The number of participants who spoke in the meeting.	8	8
Participation rate	The percentage of participants who spoke in the meeting.	75%	100%
Percent of time 'giving suggestion'-control	The percent of time engaged in control-related interactions (IPA category 4).	0%	22%
Gini coefficient	The calculated Gini coefficient where a value of 1 represents dominance by a single participant and value of 0 equal participation by all participants.	.81	.75

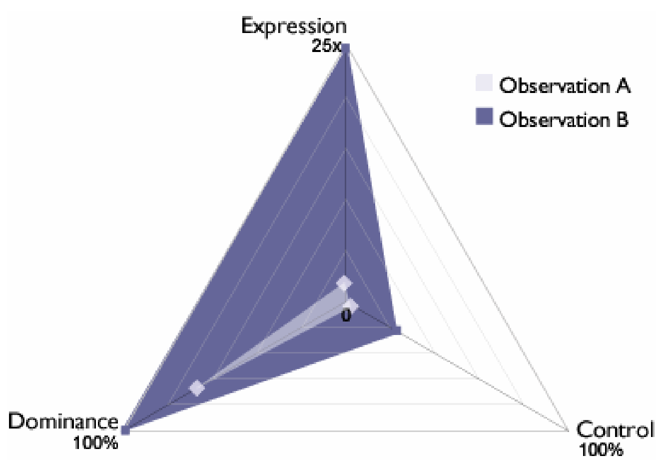


Figure 39: Relationship between three emotional process measures for each observation. In all three measures, Observation A had higher values.

4.6 Artifact Interactions: Interaction as Use

The third perspective in the TEAM interaction framework, is the artifact use perspective and looks at when, how often, and how a team interacts with artifacts. We distinguish between two types of artifacts:

1. ***object artifact***: the object of design, the 'artifact-to-be' (Bucciarelli 1988), or 'the object of activity' (Suchman 2000), e.g., a building, a space, etc.
2. ***information artifact***: Bucciarelli (1988) refers to these as "artifacts of the process" and (Suchman 2000) refers to these as 'material' artifacts. An information artifact represents the object artifact, visually, graphically, or computationally in part or whole.[6]

The object artifact is the focus of the IA discussed in Section 4.7. In the artifact use perspective we focus on interactions with information artifacts and do not consider their representational purpose or form.

We developed our perspective of artifact use to describe the different types of artifacts teams interact with in terms of their materiality; accessibility; and in terms of the nature of the interaction. In the following two sections we discuss the 'media use' perspective and the 'interaction richness' perspective.

4.6.1 Media use perspective

Information artifacts differ in materiality, e.g., digital (computational), paper, and physical. Examples of different types of information artifacts are paper drawings or schedules, whiteboard sketches, digital models, physical models, etc. Much of the research into the impact of computational artifacts on group process fails to look at such interactions in the context of interactions with other media. Bucciarelli (1988) and Suchman (2000) look at the general use of information artifacts, but do not distinguish artifacts in terms of their materiality. Instead, their ethnographic work studies the relationship between object artifacts and information artifacts in the design process.
Our interest is to compare meetings with different media use patterns-particularly meetings that are primarily paper-based to meetings that are predominantly digital-based- to describe differences or similarities in those processes. The two observations we discuss in this working paper are digital-based; but half of our observations are paper-based.

We do not distinguish media beyond the categorizations listed in Table 8. These categorizations are intended to distinguish at a high-level different media. We could further distinguish and characterize media by size, form, etc. Digital media, for example, includes information artifacts represented on electronic whiteboards, laptops, PDA's, and projected displays. These differentiations are not within the scope of this research.

The one characterization that we do intend to look at is the accessibility of the artifact or whether the media is accessible to the team, to a group within the team, or to an individual. In our empirical observations we noticed significant periods of digression related to participants working in groups around information artifacts that were not accessible to the team. Table 9 lists the accessibility type coding keywords that we have developed to describe the artifact interactions as a function of accessibility.

[6] See (Bucciarelli 1998) and (Suchman 2000) for discussion of the relationships between 'object' artifacts and material or computational artifacts and ethnographic studies of looking at how artifacts mediate interactions.

We performed IA using the media type coding schemes listed in Table 9. Figures 40 and 41 show these results. Both teams spent a significant amount of time, 87% and 93% (Figure 40); and both teams spent a large proportion of their time interacting with digital media (Figure 41). Observation B team spent significantly more time interacting with digital media than Observation A.

Table 9: Coding schemes for media use (type) and artifact accessibility.

	Media Type coding keywords	Description	Examples
		Media Type	
1	digital	An interaction with a digital representation of an information artifact.	Electronic display of information including 2D, 3D, schedule, documents, etc.
2	paper	An interaction with a paper representation of an information artifact.	2D drawings, schedules, agendas, activity logs
3	whiteboard	An interaction with an information artifact on a whiteboard or similar physical writing display.	participant uses whiteboard to draw a detail or points to information on a whiteboard
4	physical	An interaction with a physical model of the 'object' artifact.	scale model of the project, submittal sample
5	none	An interaction involving none of the media in items 1-4.	these are typically associated with Olson activities such as "digression" or "other"
		Accessibility	
1	public	Media is available to all participants	Projected display
2	semi-public	Media is available to a small group of participants	Set of drawings
3	private	Media is available only to an individual	Sketch on a paper

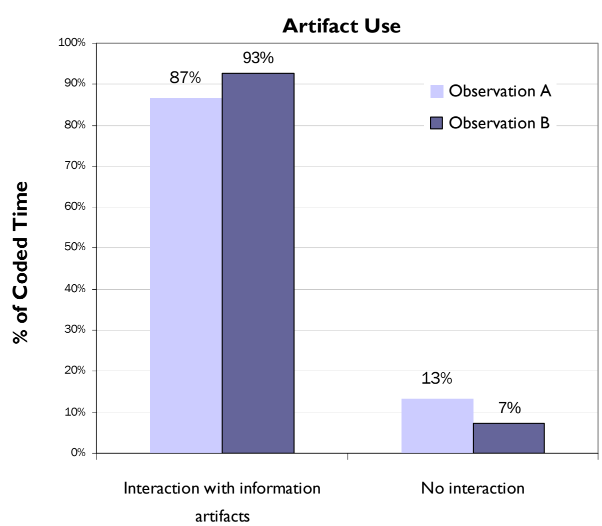


Figure 41: Comparison of time spent interacting with artifacts versus time spent interacting without artifacts. Both teams spent a significant portion of their time interaction with an information artifact.

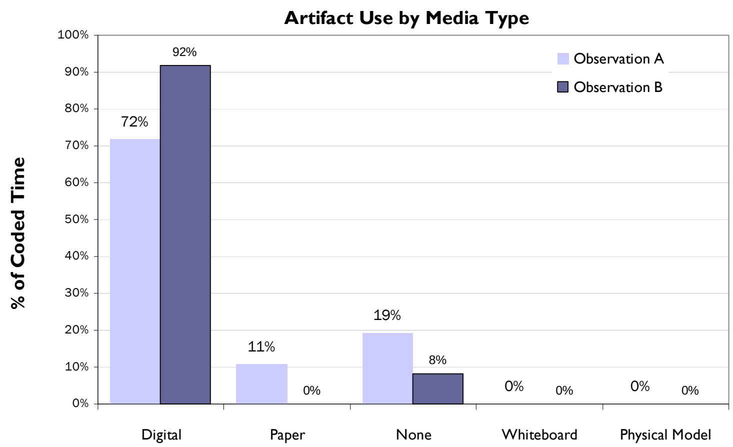


Figure 42: Artifact use by media type as a percent of coded time for Observations A and B.

4.6.2 Interaction Richness

In our empirical observations we also identified differences in 'how' teams interacted with information artifacts. In some cases, the teams only viewed digital models; and in other cases the teams stood and moved the models for review. A participant may point to an artifact but never interact with the artifact; or if the participant interacts with the drawing the interaction is one-directional since the artifact cannot react to the participants' interactions. These different degrees of 'interactiveness' are important as they characterize how participants interact with the artifacts. We developed a coding scheme, described in Table 10, to characterize interactiveness. These keywords reflect four levels of interaction from low to high where low is no interaction or single-directional, medium involving one-directional (drawing, for example), or high (two-way).

Table 11: Coding scheme for interactiveness.

Interactivity coding keywords	Description	Type	Interactiveness	Examples
viewing	An interaction that involves one or more participants directing their attention towards an information artifact, physically or verbally; and the interaction involves no direct contact with the information artifact.	unidirectional	low	viewing a static snapshot of a 2D drawing, digital or paper
pointing	An interaction involving a participant physically gesturing to an information artifact manually or with an instrument, i.e., mouse, laser pointer.	unidirectional	low-medium	physically pointing to a wall or coordination issue
Mark-up	An interaction involving annotation of an information artifact.	bidirectional	medium-high	drawing, mark up, notes
changing	An interaction involving changes to the representation of the information artifact	bidirectional	high	moving views in 3D, adjusting value in a schedule

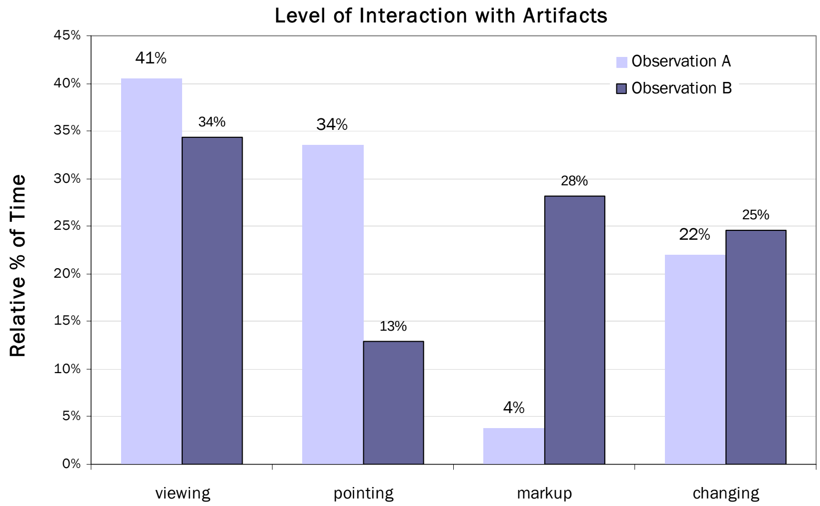


Figure 43: Comparison of the levels of interaction, interactiveness, between Observations A and B.

Figure 43 shows the results of the 'interactiveness' coding for both observations by relative percentage of time (as a percent of time spent interacting with artifacts). The difference between the two meetings was largely the amount of time the Observation B team spent marking-up the model.

4.6.3 Analysis of Artifact Use

These characterizations of artifact use describe how teams interact with information artifacts and the type of media they interact with. Table 11 summarizes some process measures related to this perspective of the meeting interactions. Figure 44 relates each of these process measures for Observations A and B and shows that in all measures Observation B had higher process measure values.

Table 12: Summary of artifact use process measures.

Process measures	Description	Observation A	Observation B
Total Number of activities		190	220
Total number of artifact interactions	Number of interactions involving an interaction with an information artifact.	177	186
Artifact Interaction Rate	Percent of interactions involving artifacts	93%	84%
Media utilization	Percentage of time spent interacting with artifacts	87%	93%
Digital media utilization	Percentage of time spent interacting with digital media	72%	92%
Accessibility	Percentage of time spent interacting with information publicly accessible.	72%	92%
Interaction richness	Percentage of time spent marking-up or changing representations of information artifacts relative to other interaction types.	26%	53%

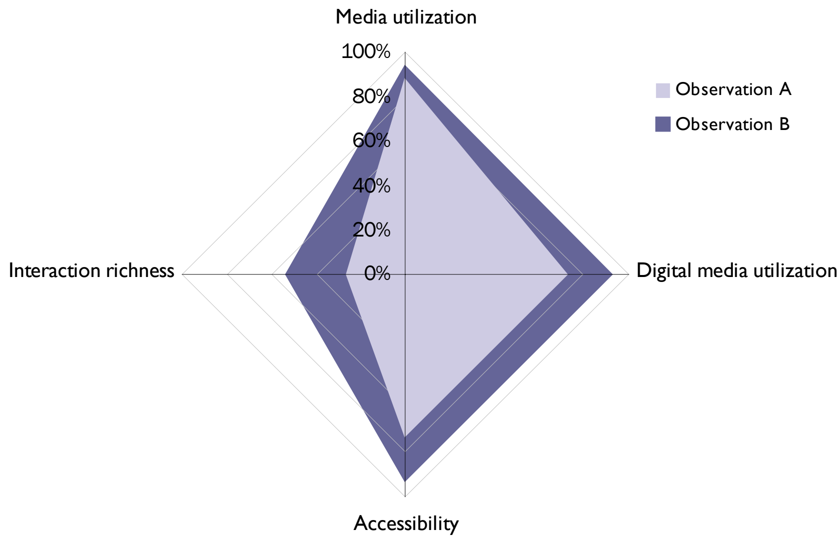


Figure 44: Radar chart comparing and relating the different artifact use process measures for Observations A and B.

4.7 Model Interactions: Interaction as Model Use and Workflow

The workflow, socio-emotional, and artifact use perspectives do not characterize the relation between interaction and the object artifact. In the workflow perspective, the interaction with the object artifact is implicit in each project activity; and in the artifact use perspective, the interaction with the object artifact is implicit in the notion that the media represent the object artifact. In this perspective interactions are viewed as activity to move towards realization of the object artifact.

In our field of focus—architecture, engineering, and construction (AEC)—practitioners are familiar with the concept of a model, in all media types, as representations of the form, function, and behavior of an object artifact (Clayton et al. 1999). Models represent the physical form of an object artifact as well as the process to build the object artifact. When teams interact with information artifacts (Section 4.6) they interact with the model (in part or whole, conceptually, digitally, or physically). The team is using some part of the model—interaction as model information use—to process that information and move closer towards realization of the project—interaction as model workflow.

4.7.1 Interaction as Model Information Use

A project model represents the function (purpose), form and behavior of an object artifact; and the processes and organizations to realize the artifact. During the course of design, engineering, or planning the project model, in various forms, is evolving and changing - it is amorphous. A project model may exist conceptually, computationally, or physically; and often exists in all these forms. Through process and organization the object artifact becomes a realized artifact. Teams interact with both conceptual model representations and media-based model representations.

In our empirical observations a predominant amount of the interactions are with information related to the form of the object artifact. Form represents the physical characteristics of the artifact as geometry and material. We use the term product to refer to this definition of form; as the organization and process can also be described in terms of their form. Drawings and 3D models are information artifacts that visually represent the form. Functions are defined as requirements or intents for the use of the artifact (Clayton et al. 1999). Examples of information artifacts representing requirements are specifications, contracts, etc. Behavior is “the performance of the artifact in the context for which it is designed” (Clayton et al. 1999). Examples of information artifacts representing behaviors are structural analysis models or day lighting analysis.

Organization refers to the “agency and agents responsible for the design and construction of the artifact” (Garcia et al. 2004). Examples of organization information are descriptions of people and their titles; and common information artifact representations are organization charts. Process refers to the activities and sequence of activities to be performed by the organization to realize the artifact.

We developed a coding scheme (Table 13) to characterize interactions as use of these different types of project model information. Figure 45 shows the results of the IA using the information use coding scheme to Observations A and B. The nature of these meetings was about coordinating the design and both teams spend a significant portion of their time interacting with product model information. The primary difference between the two meetings was the time spent interacting with process model information. This is attributed to the time that Observation B team spent discussing the meeting process and the general process of review of the design.

Table 14: Coding scheme for project model use.

Project Model Keyword	Description	Example information artifacts	Example statements, questions
product	Interactions involving the use of information representing the form of the object artifact.	2D drawing of the artifact, 3D, sketch	“Is that 13 inches or 12 inches?”
process	Interactions involving the use of information representing the processes to perform activities to realize the artifact.	Gantt chart, IDEF diagram,	“When are you installing that?”
organization	Interactions involving the use of information representing the organization.	organizational chart	“Who is doing the work?”
requirement	Interactions involving the use of information related to project requirements.	Contract, specification	“There needs to be 3’ clearance.”
analysis	Interactions involving the use of information related to analysis.	Structural loading analysis, lighting analysis	“The estimate is 20K.”

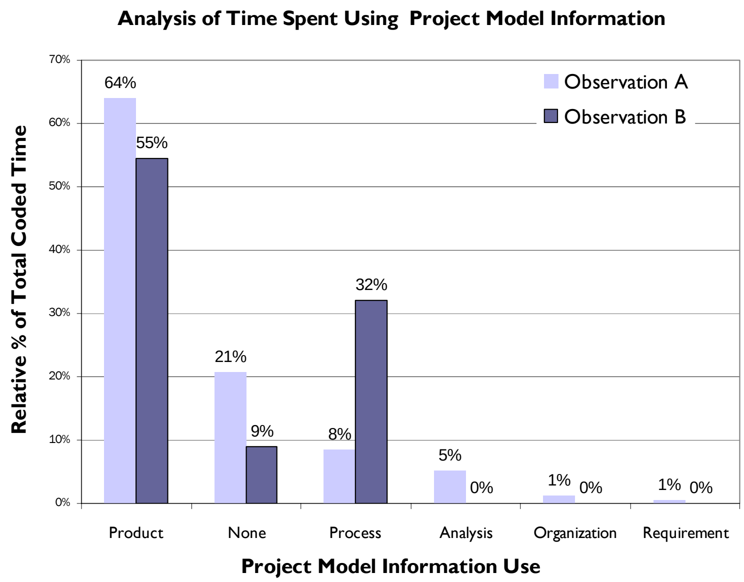


Figure 46: Relative percentage of time spent interacting with different aspects of the project model.

4.7.2 Interaction as Model Workflow

This perspective characterizes each interaction as a processing activity with an input and an output, i.e., the model workflow. This perspective is based on a coding scheme, called DEEP (Describe, Explain, Evaluate, and Predict), developed in prior research (Liston et al. 2001) to describe the use of project information. This taxonomy was further refined by (Garcia et al. 2003) to include a categorization for generation of alternatives (A), negotiate (N), and decide (A) or DEEPAND. Garcia defines each of these activities in terms of actions and goals. Neither coding scheme, however, is consistent in its characterization of activities. DEEP fails to formally distinguish the coding categories in the context of the project information model; and DEEPAND fails to consistently distinguish the coding categories in terms of goals.

In reviewing the prior research and performing additional IA using DEEP and DEEPAND we identified three distinguish characteristics of interactions from the perspective of model workflow:

- Interactions are either focused on existing or former states of the project model **or** future states of the model. In decision science, this is termed the temporal frame of the discussion. Interactions that look backward are called 'grounding' activities (Clark et al. 1991) and are intended to establish a common ground.
- Interactions can be characterized as activities directed towards changing an individuals' conceptual project model or the shared project model.
- Interactions with the model can be characterized by the informational changes to the project model: creation, modification, deletion, or no change.

We used these intuitions to define five types of model processing interactions listed in Table 15. Figure 47 shows the result of the IA using the model workflow coding scheme. Both teams spent a majority of the time describing the project model; and little to no time analyzing the product model. Figure 48 shows a grounding-action profile for each observation. The vertical axis is the grounding axis and the horizontal axis is the 'action' axis. The grounding-action profile shows whether teams spend more time grounding or more time acting.

Table 16: The model workflow coding scheme.

Model workflow keyword	Activity description	Temporal Frame	Output	
			Conceptual	Shared
Grounding Activities				
describe descriptive	Interactions involving requests to describe or the description of project model information.	Existing or prior state	None or modification to model form	None
explain explanative	Interactions involving requests to explain or the explanation (rationale) of the 'form' of the product, process, or organization.	Existing or prior state	Relationship between requirement and model form	None
Action Activities				
generate generative	Interactions generating a new forms, requirement, or analysis.	Future state	new project model form information or new requirement	
predict predictive	Interactions involving requests to analyze the model form or interactions performing an analysis	Existing and Future state	new analysis	
evaluate evaluative	Interactions involving requests to assess or choose model alternatives or involving evaluation of alternatives in the context of requirements.	Future state	deletion or no change	

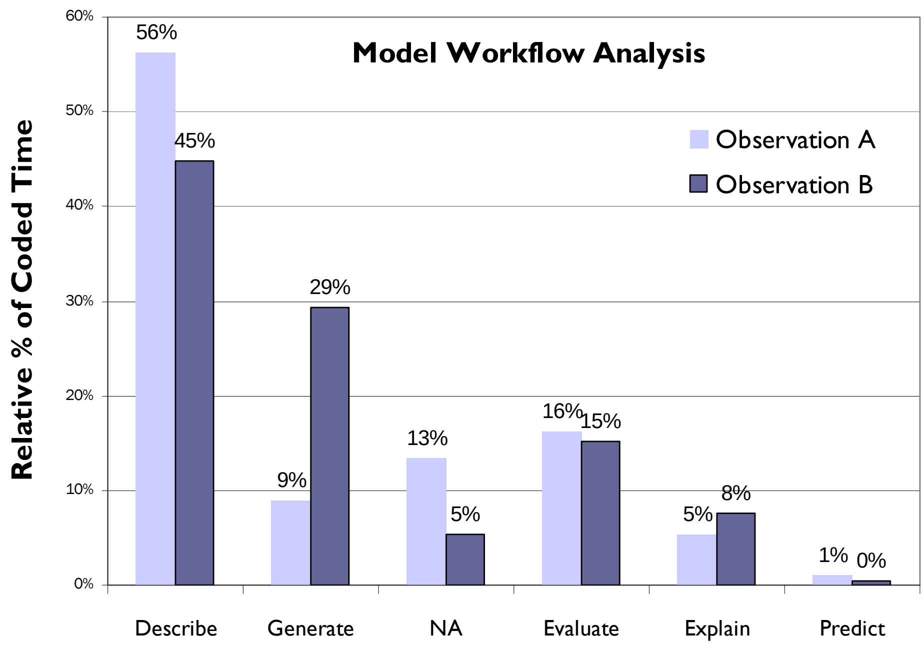


Figure 49: This chart compares how the teams interacted with the project model. Both teams spent a majority of their time involved in interactions related to describing the project model; and spent no time predicting analysis related to the project model.

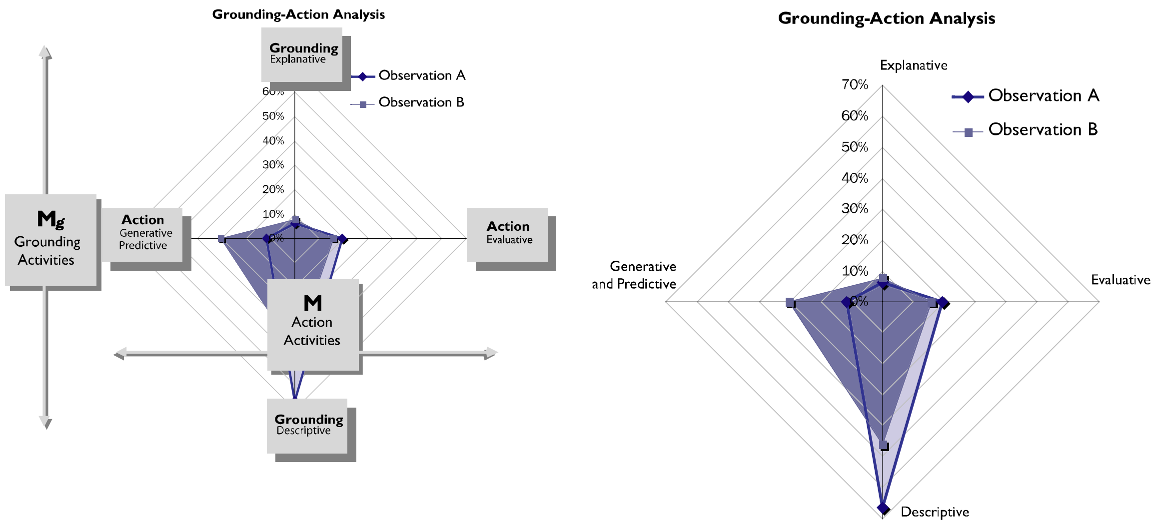


Figure 50: Grounding-Action Profile for Observations A and B showing that most of the activities are predominantly along the "grounding" axis.

4.7.3 Summary of IA Using the Model Interaction Perspective

Table 17 summarizes the model use and workflow perspective. The teams spent significant time interacting with the model form to establish common ground. The Observation B team spent more time moving towards realization of the project and more time on the process than Observation A team. Further analysis will consider how these measures relate to artifact use.

Table 17: Summary of model use and workflow process measures.

Process measure	Description	Observation A	Observation B
Total number of activities	Total number of segments coded.	190	220
Model Interaction activities	Number of interactions involving interaction with project model	190	200
Model Focus	Time spent interacting with the project model.	87%	96%
Use Measures			
Form Focus	Percent of time using form information (product, process, organization).	74%	87%
Process Focus	Percent of total coded time using process information.	8%	32%
Requirement and Analysis Focus	Percent of total coded time spent using requirements or analysis information.	2%	0%
Workflow Measures			
Grounding	Time spent describing and explaining.	73%	54%
Action Focus	Time spent evaluating and predicting.	31%	46%

4.8 Relating Parts of the TEAM

Each TEAM perspective characterizes meeting interactions as activity focused on a different goals: project-oriented goals (workflow), socio-emotional goals (dominance, control, positive), artifact-oriented (use), and information-oriented (establishing common ground and moving towards realization). In each perspective, various process measures were established and calculated for Observations A and B. Figure 52 shows a radar chart relating key process measures from each perspective. This visual tool is one method to identify relationships between process measures and across observations. In almost every process measure, the Observation B team had comparatively higher values.

The comparative analysis of process measures within and between multiple observations will potentially lead to a normative model of artifact use. A normative model of artifact use can be used by project teams to understand the role of artifact use in the process and how to improve current meeting practice. This is the focus of ongoing and future research.

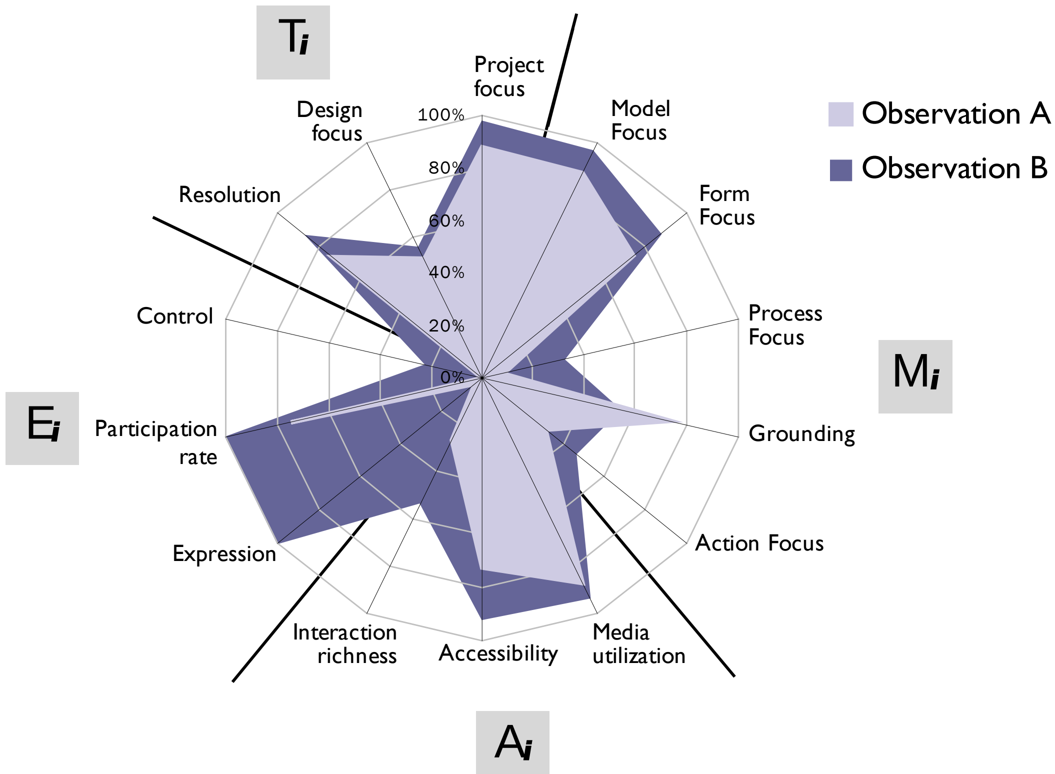


Figure 51: Comparison of process measures from each of the TEAM Interaction Analyses. This shows that in a majority of the process measures, Observation B had comparatively higher values.

4.9 Relating process characteristics to Outcome Measures

The next phase of this research will include analysis of the relationship between the process measures and measures of satisfaction. Satisfaction data was colleted from the teams in these observations to subjectively measure outcome. This data was collected using a survey based on Briggs and Reinig Satisfaction Attainment Theory (Ram 1991; Briggs et al. 2002) with three questions addressing individual satisfaction relative to personal goals and three questions concerning individual satisfaction with the process (see Appendix Section 6.2 for the one page survey). The survey uses a 7 point Likart scale and averages the three survey responses to satisfaction with process and individual goals. Table 18 shows the results of the survey. Observation B had slightly higher satisfaction results with both meetings showing relatively high satisfaction for individuals and the process. These outcome measures are comparatively consistent with the process measure differences between Observation B and Observation A. Observation B had comparatively higher values for most process measures and satisfaction measures.

Table 18: Satisfaction Survey Results. Values are the average of all respondents on a scale of 1 to 7.

	Observation A	Observation B
Personal satisfaction relative to personal goals	μ[7]=4.8 $\sigma = 1.3$ 68%	μ=5.3 $\sigma = 1.2$ 76%
Satisfaction with process	μ=4.8 $\sigma = 1.1$ 68%	μ=5.1 $\sigma = 1.2$ 73%

5 Conclusions

Both meetings demonstrate a highly efficient and potentially improved method of performing MEP coordination. The satisfaction surveys and the anecdotal responses from the project participants clearly indicate the method employed by both teams is enjoyed by participants and enables participants to quickly identify and resolve issues. The quantitative analysis further confirms these findings and shows high resolution rates focus on the issues at hand, and participation by multiple meeting participants.

The quantitative analysis however only provides guidance to identify the elements of the process that contribute to the positive meeting outcome both in terms of individual satisfaction and issue resolution. The comparison of the two observations and analysis of those comparisons yield insights into co-production issues and meeting management. First, the lengthy periods of clarification and lack of focus in one of the observations aligns with the periods of interaction with paper and a participant not involved in production of the model. Second, the activity profile of Observation B shows an ideal profile of combining issue activities with meeting or project management activities and overall meeting structure.

The co-located team has several advantages over the distributed team both in terms of the meeting space, review of the model with private and public models, and ability to perform these meetings as needed.

Both teams, though, have developed processes that are proving effective with one centered on manual review and the other around the automatic clash detection review. It would be valuable to compare these two methods through additional observation and analysis to determine if one proves more reliable or whether a combination of both approaches is best.

Additionally, the teams should consider ways to encourage project participants to bring digital information rather than paper information. Many of the periods of stoppage or conflict between meeting participants often involved participants resorting to private, paper drawings seeking

[7] Symbol for average value.

measurements or validation. The paper drawings did not provide resolution to the issues in any of these cases.

This is a preliminary report and the full quantitative analysis will include coding of the entire 120 minutes of observation of both meetings and comparative analysis with other meeting observations

6 Appendix A

6.1 Observation A Sample Transcript Data

<0>X000: Setting up for meeting. All right , so, XXXXX (introducing research) .... <150264>

A001: X, I don't know if you know who X is. X is the principal now at X? <151916>

B001: Yes. Has been. <153545>

A002: Has been? He is the principal engineer for X engineers. X's boss. So if you have any questions..feel free <171710>

B002: This is your chance to string him out to dry, too, if he's going to cause any trouble around here. <177582>

A003: No, man X is our budy around here. Y on the other hand is the problem. <182497>

A004: Today, too. for Z. This is an interesting meeting to come to. Today we are talking about a floor where we didn't do the MEP process the way we've beeing doing it the rest of the building. You know, I felt pretty confident speaking on the behalf of everyone that it's been a pain in the rear end because of it. The other floors were much easier when we followed our process and signed everything off and agreeing on routes before we got started. So anyway this has been a learning tool for me to say for sure what we have been doing on the rest of the building was certainly the best we could do for this process. <220663>

A005: So, umm, so one of our dilemmas so I understand right. Everyone’s drawing that has been uploaded recently is an attempt to show as-built conditions in the field. Right? An awful lot of the electrical stuff was kind of routed in the field by our superintendents and then as-builted afterward. Right? <247139>

G001: Correct. <248115>

A006: How close do you think we are to be right on the money? <251378>

G002: Real close. Almost you can look out the window and see the exact same thing. <256388>

Z001: (laughter) <258188>

A007: There are really only a couple of areas I want to make sure we talk about today. One is the mechanical mezzanine. Make sure we are square on drains. Make sure we talk about the ceiling height in the X area. It's under the catwalk if you will. Umm, we have some service that will pass underneath it that the 13'-3" ceiling doesn't really allow for a lot of services to pass through it or below the catwalk above that ceiling. Most notably the ductwork that feeds these grills and diffusers out here and the fire sprinkler main that ties this stairway to that stairway. <301388>

A008: So, those are the two main areas that I really want to talk about. What other areas do we want to focus on? <310252>

H001: Are we comfortable with the changes in this area here. X had pointed out..they had already fabbed and interest to leave original layout. <324353>

A009: This was a steel web 60 or 61 that changed the diffusers from stainless steel to not stainless steel and vice versa and in that the drawings that came back re-routed ductwork. <341334>

F001: Yeah. All of this. <342353>

D001: No that wasn’t part of stainless steel change was it, it was part of a DOH change where we had to reroute we had new fire corridors and rerouted some ductowrk and put new fire dampers in. <362640>

D002: Oh, no. <363686>

K002: Oh, yeah. This is. Okay <368895>

D003: That's all been re-routed. Correct. <371855>

A009: Sort of this area here. This looks very similar to the contract documents. It does not look like the sketch cf61 or the intent of cf 61 was a diffuser change to make sure it was clear about diffuser callouts and material types. <394860>

C001: And then we pulled out this change into another clf. So. <400073>

A010: Okay. So, is that duct routing acceptable the original way or is there some real reason for... <410239>

C002: it was because of that big transfer beam and we couldn't get ducts through the transfer beam so we have to route them around. Now.. <425809>

D004: Just like a ... <426718>

C003: Yeah now, whether or not we have to do anything east of that transfer beam. <433562>

D005: No,what I think what they have there looks like it will work too <438020>

A011: Yeah.

A012: What happened here on the clf duct change came straight closer and kind of split here <443985>

A013: All I'm saying is that they just went the original way and went around that side. <448203>

D006: Yeah if that works. That's fine. <449696>

A014: Okay, sort of a point that will be made when especially when we turn in the shop drawings for this floor you know it will be more like as-builts and so just I'm asking for our review based on the fact it's already sort of installed so it's not well we... <464269>

D007: No, uh.. <464369>

A015: Really make it more of a it really isn't going to work or fine that's how you want to do it. Where as normally we turn in shop drawings early enough where if it's hey we'd really rather do this, this, this. Okay...haven't fabbed or built anything it's really not that big of a deal. But now it kind of would be. <481566>

A016: Umm. so it's that area. <485528>

A017: this area over here is the dining area for the bistro below. So one of the hardest parts and making sure this corridor although it is a raised catwalk if you will it can't be considered a catwalk because since it's public access. So all this duct is in the process of getting moved. <505734>

E001: Demoed. <507635>

A018: Demoed. (laughter) So it's going to be tough to find a spot for it. Umm. So that we're not cruising through this doorway.

This door and that door gets blocked with it. So we have to. I don't know where <526749>

E002: ...down there. Yeah,.. <528104>

F002: we're going to come east. About 8'4". Yep. Centerline. <534414>

A019: You're going to bring.. <535466>

F003: Yeah. ...halfway over here Extend the duct move the tap way over here, come over here and drop it down underneath the catwalk...sprink main.. And then this round we're going to carry that forward and thenup over the staircases. So you got.. <559793>

H001: It's not just sprinkler you have problems with height issues over there if you are going over there you have ceiling height issue as well. <566393>

F004: Our...sit right underneath here. <570326>

H002: How big a duct? <570983>

A020: Let's.... <572374>

F005: So anyway we're proposing taking this around and taking it straight into the staircase. <578443>

G002: Do we know what the bottom of catwalk steel is? <583311>

A021: The bottom of the catwalk steel is a mere shy of 14'. It's like 14' at the bottom, but it's 13'3" to the ceiling. So there's 7" between expected ceiling height and the catwalk steel. <599133>

F006: Thought it was at 16'. <600190>

E003: No. <600641>

A022: The top is actually at that but it's fairly deep and it's got about 2" of fireproofing. <605303>

E004: ooh. <606130>

G003: The bottom should be about 14'-2" <609383>

A023: Out in the field with fireproofing it's like 14'. That's where you are at. So everything is going to be about that. <615915>

F007: 13'4"? <619706>

A024: 13'3" is the ceiling. <621480>

F008: 13'3" <621868>

A025: We already know 13-3" is not going to work. I think it's going to have come down...just a couple inches <626813>

F009: We got sprinkler main running underneath catwalk <630721>

A026: ((zooming to view, making a note))) <654150>

A027: This is the tap. This tap is going to come down here about 8'. <668719>

F010: About 8'-4". <672103>

A028: And you are going to come straight over. <674137>

F011: yep. And then we have offset. And we have to offset...for...to miss <680198>

A029: Which way? <682276>

F012: To miss this round. <682566>

A030: Are you going to go under? <683444>

F013: No. Umm we'll go around..what's that? That's what we are missing. <688110>

A031: Then you'll go underneath here, right? <690570>

F014:Yep. and down right here in the hole right here. <699175>

A032: ((marking up drawing)) <708235>

F015: And then the high pressure we'll take it east and then come over the stairs. <716769>

A033: Where do you tie into. Where does this tie into? <718140>

F016: That ...supply right there. <721525>

A034: This here? <722345>

F017: Yep. <723090>

A035:((marking up drawing) What's minimum head height on the stairs? <732146>

H003: 78" I think. <735463>

A036: What's minimum head height on these stairs when you go down. When he brings up over the stairs? <747952>

H004: 6'-8". Excuse me. 6'-8" <752561>

C004: He says its 7' <753595>

X001: ((drawing))((others looking for dimensions)) <763007>

A038: We'llsave these pdfs and send them out to everyone. <767579>

A039:((moving to another view) Now let's look underneath it. <772745>

X002:((moves to another view)) <812858>

A040: So now we're down underneath and here's the catwalk we were just looking at the door and this is the walkway over top so now the sprinkler main <819464>

F018: miss our grills...keep them straight <823341>

A041: Your sleeves are in this corner. Why are you offsetting here? <831430>

G004: Go back Let's go back to plan view. I think there's a chase right there... <842185>

A042: Okay. ummm. In the bistro serving area here where the kitchen actually is the ceiling is fiarly low and then steps way up to 13-3 and then steps up to 15-6 at the window. so, how critical is that 13-3? Do we have some flexibility to kind of say we can back ourselves up as tight as we can and give you the height that we can get? <867619>

C005: Uhh, ((looking at drawing))... <873018>

A043: I'm sure you want the soffit effect of making the dining area separate from the kitchen, but... you know <879554>

C006: uhh... <882992>

A044: and the the light cove goes up even further. <885237>

C007: ((llooking at drawing)) It's HMC's because of light cove. It's 2' right now and if you make it any deeper then they can't get up there. See that's why we wanted just 2'. <912374>

A045: This is the dilemma we have is that on the other hand on this <916647>(maintenance issue)(moving view)

H005: maintenance issue? <918269>

C008: Yeah. Just getting to the top of 15'-3", can't get in there...reach past 2' <932090>

X003: ((moving view)) <938170>

A046: Right here where the sprinkler main kind of goes down. <940860>

X004:((moves view)) <953783>

A047: Where our sprinkler main drops down we have a plumbing line that runs and they have to kind of cross each other. And so at this point it definitely has to go up to at least like 12'-9 to allow them cross under each other. <965973>

X005: ((moving view)) <972175>

C009: (goes up to view). I mean right there at this side here is 10'-5. <977968>

A048: But the 13 is right here. <981331>

C010:... <987534>

A049: How do I get that sprinkler from there to there and this plumbing from here to over there? <995512>

C011:.....main artery there... <1006082>

C012: How big is the other one crossing? <1014106>

G005: 6" and 4" <1017532>

A050: Right there we still have interference between plumbing and... <1027120>

X006: ((moving model)) <1041753>

A051: Where did pens go? <1044056>

G006: Is there any chance of that tucking up into passageway? The access on the catwalk? <1053227>

X006: ((Zooming)) <1074383>

G007: I don’t see it, unless you go from stair 4 to stair 2 and then you have mezzanine system, on up <1083554>

A052: This graded line comes down over here has to go over to drop and this is the steel for the catwalk so they are tucked up tight as they can go to the catwalk right now and this beam has to go under. This bottom of steel is 14'-2". So.. we already have 8" and 6". <1115436>

C013: We have to go around some <1118898>

D008:How deep is catwalk beam? <1125910>

A053: ....It's W12X14 <1131709>

X007: ((switching views)) <1144157>

D009: That's a 3" pipe? <1146099>

A054: What is? <1146885>

D010: That. <1148283>

A054: This? No, that's 8" <1150631>

D011: Oh, that's 8". <1150675>

X008:(...) <1160429>

C014: Can it go into vestibule below? <1164854>

X009:((moving view)) <1174298>

C015: and pop up high? <1175328>

A055: This is where we come through. This is the vestibule above. <1183451>

C016: There is a vestibule below. <1186466>

A056: Well, this main, though, has to go over and tie into into that other and also has a drain line... <1196972>

C017: ((Bring drawings over)) Thre is a vestibule below the wall righ there. <1207099>

A057: Sprinkler can’t go down over and back up. tie into trap. <1210646>

C018: where is it go down? <1217299>

A058: Sprinkler goes down here and then it goes over an down the ...so the problem is you have to cross over an area where with a really really high ceiling <1226160>

C019: ((looks at drawing, no response)) <1230073>

A059: so even if like we go that way you can go over that way and stay... <1245316>

C020: ((looks at drawing)) <1255368>

X010: ((moves model view, while someone enters room)) <1264439>

A060: so where is the...? <1266146>

C020: ((points to model)) <1270542>

Y003: ((look at drawing)) <1286983>

X011: ((back to changing model view)) <1345353>

A061: So…can we come down and you see where main is right here? <1350899>

X004: ((looking at model)) a response in background... <1359422>

A062: Yeah, down underneath. 12' long. We'll pay for the seismic bracing for that, right. The support pipe going up is 12'. <1375398>

G008: Well, I can't brace over 10'2... <1377685>

C021: Well, right next to the catwalk. Can you brace off the catwalk? <1383534>

G009: Goes right there... <1386441>

A062: the catwalk is here. That's the 13' ceiling. the catwalk is here. <1391976>

Y005: ((pointing to drawing)) <1394357>

Y006: ((looking at drawing)) <1401433>

C022: It has to go into this stair. <1402867>

C023: This is the vestibule below. <1407612>

E003: This is the vestibule above. <1409282>

X012: ((moving model in background)) <1429488>

A063: Here it is, C. <1429697>

A064: Here’s your catwalk. <1433434>

X013:((looking at model)) <1439274>

Y007: ((looking at drawing)).... <1444215>

Y008: ((drawing on drawing))... <1450135>

C024: The catwalk is right there. <1461539>

A065: C, just use this. tell me where you want it. <1467076>

A066: That is where sprinkler pipe comes down. This is where catwalk is. Right into the wall. Now i'm into the 13' ceiling. <1473142>

Y009: ((back to the paper)) <1477980>

C025:10'5... <1481004>

A067: to where? <1482682>

C026: down....10'5..and it's. <1489099>

Y010: ((back to paper)) <1495557>

A067: where's the mezzanine? <1496364>

A068: you got to go over it. <1501226>

Z011: ((moves view)) <1506570>

C027: this wall goes down... <1511366>

A069: You think the 10' wall is coincident with that wall on the mezzanine catwalk. That's what you are telling me? <1518705>

C028:...that's what the drawing says. Yes. <1519048>

A070: I don't believe that is true. Because you don't have a mezzanine drawing to show me. <1521319>

C029: I have a reflected ceiling pattern that says... <1526165>

A071: but you don’t have the catwalk above it <1528825>

C030: ((looking at drawing)) <1534080>

A072: this is perfect. <1534132>

C031: move over...((pointing at drawing)) <1541949>

A073: okay. so if that's not true, Can I make 10’5 ceiling coincident with that wall? <1549045>

C032: Sure. <1550381>

Y012: ((looking at drawings)) <1571519>

Z013: ((various conversations, looking at drawings, whiteboard)) ((having conversations to work through issues)) <1745532>

A074: I'm sure if you made an easy enough steel..

X014: ((moving views)) <1769808>

Z014: ((continued sidebar conversations, whiteboard in back of room)) <1784649>

6.2 Satisfaction survey

Please circle your answers

	1=Much Less					**7=Much** **More**	
1. I got (less/more) from the meeting than I had anticipated.	1	2	3	4	5	6	7
2. I benefited (less/more) from this meeting than I expected.	1	2	3	4	5	6	7
3. I am (less/more) likely to attain my goals because of this meeting.	1	2	3	4	5	6	7
	1=Strongly Disagree			**4=Neutral**		**7=Strongly** **Agree**	
4. I liked the way the meeting progressed today.	1	2	3	4	5	6	7
5. I feel good about today's meeting process.	1	2	3	4	5	6	7
6. I feel satisfied with the procedures used in today's meeting.	1	2	3	4	5	6	7
7. I liked the outcome of today's meeting.	1	2	3	4	5	6	7
8. I feel satisfied with the things we achieved in today’s meeting.	1	2	3	4	5	6	7
9. I am happy with the results of today's meeting.	1	2	3	4	5	6	7

Meeting Survey Part 2: Meeting Goals

	Please check all meeting types, goals that apply and indicate the primary goal of the meeting	Primary Goal	Secondary	Not a goal
1	Information Briefing/Dissemination	1	2	NA
2	Team Building	1	2	NA
3	Brainstorming, Generating New Ideas, Alternatives	1	2	NA
4	Strategic Planning	1	2	NA
5	Commitment-Building	1	2	NA
6	Program/Project Planning or Review	1	2	NA
7	Decision-Making	1	2	NA
8	Dispute Resolution	1	2	NA
9	Problem Solving/Crisis Resolution	1	2	NA
10	Coordination	1	2	NA
11	Other:________________________________	1	2	NA

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