# BIM Design Coordination Room Infrastructure: Assessment of Communication Activities

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## ABSTRACT

This paper reports on some of the activities of a larger study whose overall objective is to propose an optimized configuration for the infrastructure of a BIM-based design coordination room. A methodology for capturing and analyzing the communication pattern among project participants inside a coordination room is presented. Understanding which participant actions ordinarily occur during design coordination meetings is necessary for providing adequate infrastructure support for them. Accordingly, twenty paper-based design coordination meetings were analyzed. Results indicated that text creation (note taking) and floor plan visualization are the most frequent actions by the most usual meeting participants (coordinator, architect and owner). By mapping user's needs to devices capabilities, it can be concluded that a large display device, such as an interactive projection screen, may support the majority of actions required from the infrastructure of a coordination meeting room.

## INTRODUCTION

Design coordination is a multidisciplinary activity that is focused on the management of technical issues and decision making, providing support to design development. This activity usually implies communication with all the project designers in coordination meetings. The spaces where these meetings occur can be physical or virtual (Liston et al. 2000) and are used to share information, for consultation and for decision-making about project issues. A growing trend among AEC project teams is collaborative project development supported by processes such as Building Information Modeling (BIM). Building information models are information-rich, geometric representations of the components of a building and typically serve for visualization and coordination of projects (GSA 2007), among other uses.

In the traditional, paper-based design coordination space, meetings are supported by printed sheets of digital files used for sharing information and design decision-making. During the coordination meeting, exchange of information can occur in various forms: by hand-writing, with annotations on printed floor plans, in the form of sketches, typing in word processing applications, viewing documents, spreadsheets, specification documents, and other forms. The adoption of BIM processes as well as the increasing complexity in projects together with the availability of new technologies are prompting users to look for alternatives to the traditional coordination process and the spaces that support it.

Many examples of innovative coordination rooms are known in universities and in the private sector, worldwide. CIFE (Center for Integrated Facility Engineering) at Stanford University (Liston et al. 2000), University of British Columbia (Fard et al. 2006) and Penn State University (Leicht 2009) are institutions that have developed research on this theme.

The final goal of this research is to define the most adequate infrastructure and layout for a BIM-based design coordination meeting room suitable for Brazilian projects. In Brazil, design coordination is usually not performed in the construction site, but in the office, and many coordination meetings may take place before the design reaches its final form. Therefore, fixed, more sophisticated facilities for this activity are conceivable so that the related BIM benefits can be attained.

## ASSESSING COMMUNICATION ACTIONS IN COORDINATION MEETINGS

To better assess the infrastructure requirements of a room to support a BIM-based coordination process, it is necessary to identify the communication activities that occur during this process and may be assisted with technology. Like previous researchers (Liston et al. 2000; Fard et al. 2006) we started observing paper-based meetings. Our assumption is that the basic communication actions required to perform design coordination are the same, regardless the technology involved, as they concern human information needs. Although a BIM-enabled meeting will probably exhibit a different communication pattern, the analysis from conventional coordination meetings can serve as the basis for an initial proposal, to be refined with results from BIM-enabled meetings.

Senescu et al. (2011) have monitored the electronic communication and file transfers among project participants to measure the interaction among them. Their study aimed to determine which professionals needed to be together in a Big Room for optimal design collaboration. However, their strategy monitored distant (virtual) interaction while we are interested in face-to-face / same room communication.

The results of one of the phases of our research are reported here: capture and analysis of the communication pattern among project participants inside the coordination room. This analysis will indicate the most important and frequent types of communication that needs to be supported by the infrastructure of a coordination meeting room.

For assessing the communication pattern of design coordination meetings, we proposed and used the following method:

a. Prepare a form for registering the communication actions, their types, agents, documents and targets;
b. Video record the meetings (with proper previous authorization of all meeting participants);
c. Watch the recorded videos to count and register the number of each action, from each type of participant, involving each class of document and target.

d. Sum up and analyze the results.

## SELECTED COMMUNICATION DIMENSIONS

Only actions that may require infrastructure support were considered. All the others were ignored. Therefore, "talking" for example, is not considered relevant for this purpose.

The following orthogonal dimensions were selected for data capture and analysis:

- **Agent Role** (Owner/Developer, Contractor, Coordinator, Coordinator Assistant, Architect, Structural Designer, MEP Designer, HVAC Designer, Waterproofing Consultant, Hoteling Consultant, Solar Heating Consultant, Landscape Designer);
- **Action** (Visualize, Mark-up, Measure, Create);
- **Target** (Oneself, a Group, All);
- **Document** (Text, Printed floorplan, 2D CAD, Image, Sketch).

**Agent** is the meeting participant performing the logged action. When more than one person had the same role in the meeting (e.g., two or more owner representatives), their actions were added to the same role, unless for the case of actions to oneself (like taking a note or reading a text), counted as one. Communication is analyzed considering the roles played in the meetings so that proper infrastructure support can be provided to each of them. Besides the roles mentioned above, *Group* and *All* were also listed as possible action agents.

**Action** is a communication act performed by an agent. For the sake of simplicity, actions targeted to oneself are also being called communication actions. The four actions considered relevant for this study were:

- *to visualize* a document (a written text, a printed floor plan, an image, etc.) only to oneself or showing it to other participants. This action includes pointing (may not be performed without visualizing the document);
- *to mark-up* an individual document or a shared one (a text, a blueprint, etc.);
- *to measure* (a floor plan, a 2D CAD drawing, etc.) retaining the reading for oneself or showing it to a group or all participants;
- *to create* (a text, a 2D CAD drawing, a sketch, etc.) to oneself or showing it to other participants.

**Target** is the destination of the action. It could be *oneself* (like when silently reading a text), a *group* (e.g. pointing on a blueprint to concerned consultants) or *all* the participants (like when showing an image in the projection screen).

Finally, **Document** refers to an article, object of the logged action. It can be *a text, a printed floor plan, a 2D CAD drawing, an image or a sketch*. It is important to note that, at this stage, only paper-based meetings were analyzed. Therefore, 3D models or animations, common in BIM-enabled meetings, are not among those recorded.

The communication space may have points in most of these dimensions. Notable exceptions are "measuring text" and "creating printed floorplan".

Considering all the aspects mentioned before, the final spreadsheet form created for data logging is shown in

Figure **1**.

| | AGENT: | OWNER/DEVELOPER | | | CONTRACTOR | | | COORDINATOR | | | ... | LANDSCAPING | | | GROUP | | | ALL | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TARGET: | ONESELF | GROUP | ALL | ONESELF | GROUP | ALL | ONESELF | GROUP | ALL | ... | ONESELF | GROUP | ALL | ONESELF | GROUP | ALL | ONESELF | ALL | |
| VISUALIZE | TEXT | | | | | | | | | | ... | | | | | | | | | 0 |
| | PRINTED FLOOR PLAN | | | | | | | | | | ... | | | | | | | | | 0 |
| | 2D CAD | | | | | | | | | | ... | | | | | | | | | 0 |
| | IMAGE | | | | | | | | | | ... | | | | | | | | | 0 |
| | SKETCH | | | | | | | | | | ... | | | | | | | | | 0 |
| MARK-UP | TEXT | | | | | | | | | | ... | | | | | | | | | 0 |
| | PRINTED FLOOR PLAN | | | | | | | | | | ... | | | | | | | | | 0 |
| | 2D CAD | | | | | | | | | | ... | | | | | | | | | 0 |
| | IMAGE | | | | | | | | | | ... | | | | | | | | | 0 |
| | SKETCH | | | | | | | | | | ... | | | | | | | | | 0 |
| MEASURE | PRINTED FLOOR PLAN | | | | | | | | | | ... | | | | | | | | | 0 |
| | 2D CAD | | | | | | | | | | ... | | | | | | | | | 0 |
| | IMAGE | | | | | | | | | | ... | | | | | | | | | 0 |
| | SKETCH | | | | | | | | | | ... | | | | | | | | | 0 |
| CREATE | TEXT | | | | | | | | | | ... | | | | | | | | | 0 |
| | 2D CAD | | | | | | | | | | ... | | | | | | | | | 0 |
| | IMAGE | | | | | | | | | | ... | | | | | | | | | 0 |
| | SKETCH | | | | | | | | | | ... | | | | | | | | | 0 |
| TOTAL | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Figure 1. Data collection spreadsheet.**

Although our selection of dimensions was created independently, most of conclusions/recommendations from the study of Fard et al. (2006) support it:

1. *“Make shared information persistently accessible to all members of the group”*: supports the **Visualize** action and the **All** target;
2. *“Support erasable annotation via direct input*: validates the **Mark-up** action;
3. *“Support individual activities without interfering with group activity”*: justify the **Oneself** target;
4. *“Support subgroup activities:* validate the **Group** target;
5. *“Provide very simple means for transferring information to shared displays”:* same as #1 above;
6. *“Maintain support for traditional artifacts”:* **Text** and **Printed floorplan** documents.

## RESULTS

A camcorder and other simple devices were used to video record a total of 20 meetings. Together, these recordings amount to about 100 hours of video, captured between March and August, 2013. Using a tripod, the camera was positioned so that all the participants and the documents over the meeting table could be seen. All the roles shown in the previous section were present in some meetings, but not in all of them. A total of 3,222 actions were manually logged from the analysis of the recorded videos.

The recorded meetings were classified according to its stage on the design phase (Schematic Design / Design Development) and type of project (Residential / Commercial / Mixed use). See Figure 2.

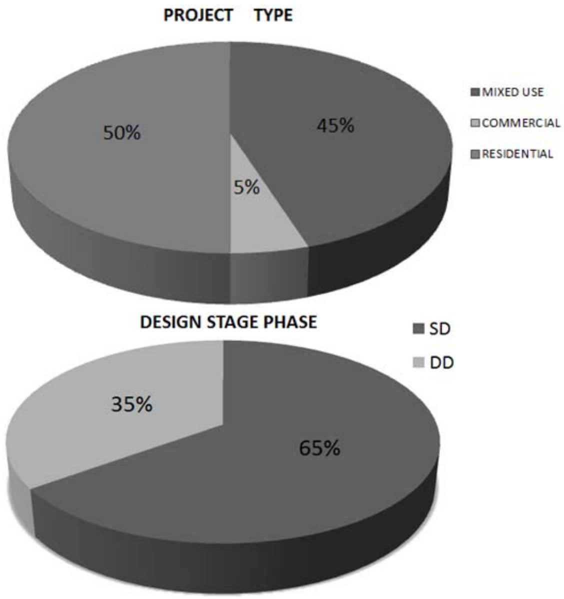


**Figure 2. Specifications of the recorded coordination meetings.**

The meeting attendance was computed according to participant role (see Figure 3) to support prioritization of the spending on the room infrastructure.

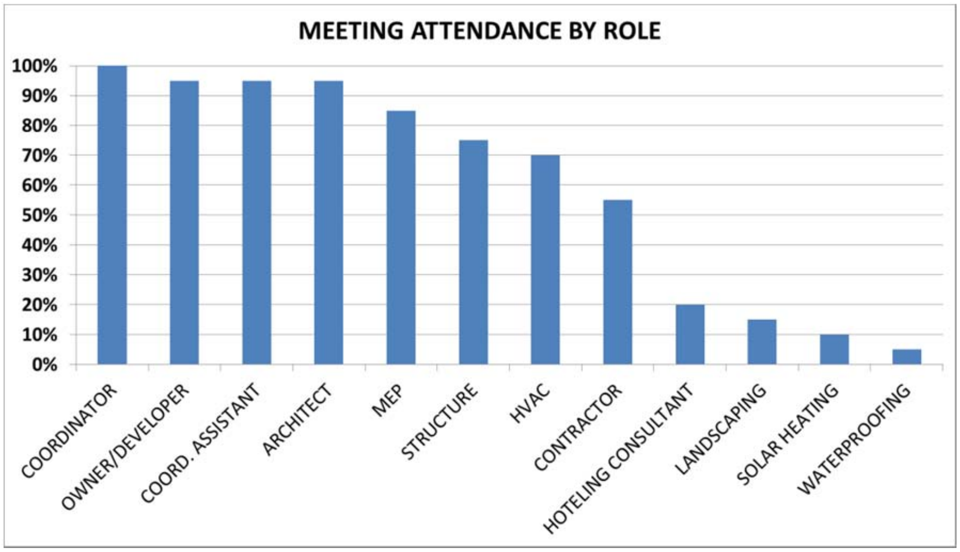


**Figure 3. Coordination meeting attendance by role.**

Table 1 shows the total number of actions by type of action and document. The results show that actions can be clustered in four groups:

- **high frequency actions** (33% - 50%): visualization of floor plan and creation of text;
- **low frequency actions** (3 to 5%): visualize text, mark-up floor plan, and creation of sketch;
- **very low frequency actions** (1 to 2.5%): visualize 2D CAD drawing, visualize image, mark-up text and measure floor plan;
- **irrelevant frequencies** (< 1% of all actions)**:** all the rest of action types.

**Table 1. Total number of actions by type, document and target.**

| ACTION | DOCUMENT | ONESELF | GROUP | ALL | # ACTIONS | %ACTIONS |
|---|---|---|---|---|---|---|
| VISUALIZE | TEXT | 129 | 6 | 19 | 154 | 4.8% |
| | PRINTED FLOOR PLAN | 403 | 153 | 995 | 1551 | 48.1% |
| | 2D CAD | 18 | 2 | 36 | 56 | 1.7% |
| | IMAGE | 39 | 13 | 22 | 74 | 2.3% |
| | SKETCH | 5 | 2 | 4 | 11 | 0.3% |
| | **SUBTOTAL** | **594** | **176** | **1076** | **1846** | **57.3%** |
| MARK-UP | TEXT | 27 | 0 | 4 | 31 | 1.0% |
| | PRINTED FLOOR PLAN | 70 | 2 | 30 | 102 | 3.2% |
| | 2D CAD | 0 | 0 | 0 | 0 | 0.0% |
| | IMAGE | 0 | 0 | 0 | 0 | 0.0% |
| | SKETCH | 0 | 0 | 0 | 0 | 0.0% |
| | **SUBTOTAL** | **97** | **2** | **34** | **133** | **4.1%** |
| MEASURE | PRINTED FLOOR PLAN | 3 | 1 | 33 | 37 | 1.1% |
| | 2D CAD | 0 | 0 | 1 | 1 | 0.0% |
| | IMAGE | 0 | 0 | 0 | 0 | 0.0% |
| | SKETCH | 0 | 0 | 0 | 0 | 0.0% |
| | **SUBTOTAL** | **3** | **1** | **34** | **38** | **1.2%** |
| CREATE | TEXT | 1068 | 0 | 1 | 1069 | 33.2% |
| | 2D CAD | 0 | 0 | 0 | 0 | 0.0% |
| | IMAGE | 0 | 0 | 0 | 0 | 0.0% |
| | SKETCH | 64 | 7 | 63 | 134 | 4.2% |
| | **SUBTOTAL** | **1132** | **7** | **64** | **1203** | **37.4%** |
| **TOTAL** | | **1826** | **186** | **1208** | **3220** | **100.0%** |

Individual data by each role will not be shown here because of space constraints.

## DISCUSSION

Regarding the high frequency actions, the data shows (Table1) that, for paper-based coordination meetings, the most frequent actions are “printed floor plan visualization” and “text creation”. By further examining the data, it can be seen that 74% of the “visualize floor plan” actions are directed to some or all participants, implying that a large graphical display device (e.g., a projection screen) can fulfill the requirements of this action.

A similar analysis shows that the “create text” action is performed 99.9% of times to oneself, i.e., a person taking personal notes or the coordination assistant preparing meeting minutes (coordination assistants are responsible for 59% of such actions). Individual note taking does not need room support, as it is done on personal devices (notepads, tablets, etc.) brought to the meeting room. Meeting minutes probably can be replaced by model annotation/mark-up which registers the detected clashes and the decisions about how and who is responsible for fixing each of them in BIM-enable projects.

Concerning meeting attendance, coordinator and his/her assistant are, obviously, the most frequent meeting participants, followed by owner and architect (Figure 3). Therefore, it is important to support the most frequent actions by these four roles. The “visualize floor plan” directed to all is the most frequent action by the coordinator and coordination assistant (about 46% of their combined actions, if text annotation is excluded). This same action is owner’s most frequent action (36%) as well as architect’s (37%). Again, a large graphical display device can fulfill these needs.

Analysis of the collected data could not show any significant difference in percentage of action types when the stage of design is considered, although in the SD stage the percentage of the “text creation” action (33%) is higher than in DD (28%) and “floor plan visualization” is higher in DD (52%) than in SD (45%).

No relevant differences in performed actions were found when focusing the type of project (Residential, Commercial or Mixed Use), although only one commercial project was studied. The only observation was that the visualization of 2D CAD files was twice as big in the mixed use projects compared to residential ones. We believe this happed due to the bigger size of mixed used projects, making it more difficult to work with printed documentation, inducing the use of electronic floor plans.

## CONCLUSIONS

In this paper, we have shown a methodology for collecting coordination meeting room communication related data along with an instrument (form) to support it.

Analysis of collected data has shown that "visualize floor plan" and writing down text" are the most frequent actions performed in a coordination room for conventional (non-BIM) projects.

Stage of the design phase and type of project were not relevant factors affecting the considered type of actions performed by participants in coordination meeting rooms.

At this stage, considering paper-based projects, the results indicate that a large graphical display device can fulfill the needs of the most frequent actions in the coordination room.

Nevertheless, we expect to find a slightly different communication pattern on BIM-enabled coordination meetings compared to that of conventional projects as participant behavior tends to change when this kind of technology is introduced, as was evidenced by some of our very preliminary results (not shown in this paper).

On the continuation of this research, we will derive from the analysis presented here the required technological infrastructure for a BIM coordination room, assemble such a room and perform a similar data capture and analysis on it to confirm if there is really a communication pattern change and how is this change. This will allow us to fine tune the infrastructure requirements for BIM coordination meeting rooms.

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