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Planning and Design Considerations for Computer Supported Collaboration Spaces*

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Abstract

Architects have long been aware of the need to design for the behaviors a space is meant to support. However, neither the seminal works on architectural programming or collaborative engineering address the linkages between physical environment design and collaborative work practice. This paper posits that the design of collaboration environments should stand as a third pillar of collaboration engineering, suggests four ways in which physical environment design and collaboration engineering might mutually inform the other, and specifies several dimensions of physical environment affordance collaboration engineers might consider when developing requirements for collaboration space.

Keywords: *Collaboration Engineering, Interior Design, Space Planning, Architecture, Meeting Space, Group Support Systems*

* Robert O Briggs, Gert-jan de Vreede and Anne Massey were the accepting editors.

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Planning and Design Considerations for Computer Supported Collaboration Spaces

1. Introduction

Collaboration engineering is defined as an approach to designing collaborative work practices for high-value recurring tasks and deploying them to practitioners to execute for themselves without ongoing intervention from a professional facilitator (de Vreede and Briggs, 2005). Up to now, collaboration engineering researchers focused on designing work practices, including processes teams could follow to achieve their goals, and collaboration technologies they could use to support those processes. Collaboration engineers focus on deploying their work practice designs in ways that create self-sustaining communities of practitioners for the designs. It is also important, however, that collaboration engineers turn their attention to the physical environments in which practitioners will execute their work practices. Physical environment considerations can profoundly impact both behavioral and affective outcomes in collaborative work (BOSTI, 2001). Two examples from collaboration research aboard the USS CORONADO (Briggs, Adkins, Mittleman, Kruse, Miller, and Nunamaker, 1998-99) illuminate this point.

The first example, the Joint Air Operations Center (JAOC) of the CORONADO was designed to support a collaborative effort among approximately 80 officers who planned and coordinated military air operations in the Eastern Pacific. The space was not, however, designed with an awareness of collaboration issues. Most personnel worked at computers. The computers were secured to desks that faced the bulkheads, which meant that personnel had to choose between seeing information on their computers or seeing one another; they could not do both. The CMOC was equipped with projectors so officers could brief others on details of planning and operations. Lighting for the space, however, was tied to a single on/off switch, allowing no variations of lighting configurations. Personnel had to choose between seeing projected images when lights were off, or taking notes when the lights were on; they could not do both. Further, most of the personnel in the JAOC did not participate in most briefings, yet nobody in the JAOC had lights when the projectors were in use. Finally, like the rest of the ship, the JAOC had metal walls, floors, and ceilings. These were subjected to radiant heat from outside sources. To make the space livable, ship builders retrofitted the space with a new air conditioning system composed of a heavy fan pushing air through ventilation shafts. Ventilation shafts were serpentine (Figure 1), weaving around pre-existing structures. Every curve in the ventilation shaft slowed the flow of air while generating additional noise. By the time air reached personnel in the JAOC, almost no air flowed from the vents. Ship builders, therefore, doubled the capacity of the fan. This, however, made almost no difference in air flow, but dramatically raised noise levels, which peaked at more than 100 decibels. Personnel could not hear one another when the air conditioning was on; they had to work in a room too hot for comfort or in a room too loud for participants to hear one another.

Figure 1 An example of snaking ventilation shafts in the Joint Air Operations Center aboard the USS CORONADO

In contrast, the Civil Military Operations Center (CMOC) aboard CORONADO was designed with key principles of collaboration in mind (Figure 2). The primary users of the CMOC were planners engaged in crisis management operations. The CMOC was a 300 square foot meeting facility designed for planners to hold two to eight hour meetings before and during naval missions. The room was equipped with eight large screen workstations, a shared central work surface (for maps), two public displays, communication gear, and a ship to ship video conferencing (VTC) system. Audio, video, and data shared across ships fed through a heavily congested secure channel for off ship communication. Desks were configured so personnel could see both their computers and one another simultaneously. The air conditioning was silenced with a high-volume; low-velocity strategy involving straighter, oversized ducts lined with sound-dampening materials, and a quiet fan. Both direct and indirect lighting were controllable in several banks so a variety of lighting conditions could be created to support a variety of collaboration needs. The room also was specified to include two whiteboards.

Figure 2 The Crisis Management Operation Center (CMOC) aboard the USS Coronado. Slate gray gel board is in the back of the room.

One particular issue emerged during the design process. Among the patterns of interaction anticipated was a VTC-supported decision making activity where an officer would work through a problem on the whiteboard while being viewed on camera from other ships or land bases. The cameras used had automatic irises that set their exposure based on sensing of ambient light. With a light background, the iris closes; with a dark background, it opens. The designers discovered very quickly that a whiteboard background gave off significant ambient light, closing the iris. When this occurred, the officer's face would be darkened. VTC viewers (given the limited bandwidth) would see a very dark muddied picture – and non-verbal information from the face of the officer would be lost. This was particularly troublesome when an African-American officer was leading the meeting. The solution to this problem was to procure neon pen blackboards (similar to restaurant menu boards) for use in the CMOC. The cost of the blackboards was just slightly more than comparable whiteboards, but permitted significantly more non-verbal information to be conveyed during a VTC session, because the black background caused camera irises to open, revealing the details of facial expressions.

The experience aboard the CORONADO is not unique or random. Architects have long been aware of the need to design for the behaviors a space is meant to support. This is, indeed, the intention of a structured architectural design methodology called architectural programming (Pena, with Caudill, and Focke, 1977; Heimsath, 1977). The seminal works on architectural programming, however, account for neither collaborative work patterns nor modern information technology. Further, the grounding works in collaboration engineering (de Vreede and Briggs, 2005), which attend to collaborative processes and the collaboration technologies that support them, do not yet account for

physical space configuration as either an input to or an output of the design process for collaborative work practices. This paper posits that the design of collaboration environments should stand as a third pillar of collaboration engineering. Physical environment, work processes, and collaboration technologies each are able to inform the design or selection of the others.

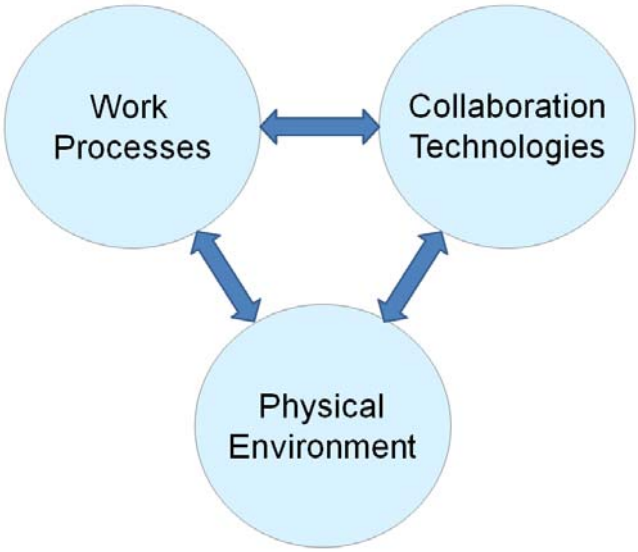

Figure 3 This paper proposes Physical Environment as a third pillar of Collaboration Engineering research and practice. To make collaborative work practice designs more fully repeatable and predictable, the collaboration engineer must take into account not only work processes and the collaboration technologies that support them, but also the configuration of the physical environments in which work practices will be executed.

Physical environment design transects collaboration engineering in four ways.

1. The collaboration engineer can use both technology information and physical environment information to inform the design of work processes;
2. The collaboration engineer can us both work process and physical environment information to inform the specification or selection of collaboration technology;
3. The collaboration engineer can work alongside an architect or interior designer to configure physical environment informed by both intended work processes and information technology affordances;
4. The collaboration engineering researcher can better interpret collaboration outcomes by understanding and controlling for physical environment affordances that are known to impact work process outcomes.

This article provides a theoretical grounding for exploration of these relationships, explores the physical environment design processes when informed by collaboration engineering, and suggests a number of physical environment design affordances to support collaboration.

2. Literature Informing the Collaboration Space Planner

Current research on the impact of physical environment on intellective work outcomes falls into three categories:

1. Research on individual white collar work environments;
2. Research on classroom design; and
3. Research on collaboration spaces.

The phenomena of interest greatly overlap among these three research domains, yet much of the

research has been undertaken in parallel tracks with only minimal overlap. A complete review of the literature in these three domains is far outside the scope of this article (it would take three literature review articles). However, each domain will be summarized here with attention paid to the phenomena of interest.

2.1. Work Environment Research

Work environment research is most closely associated with the fields of environmental psychology, interior design, and ergonomics. Work environment literature is well summarized by McCoy (2002), Sundstrom (1987), and Wineman J. D. (1982).

Research on white collar work environments falls into two general categories of independent variables: Spatial organization – how people are organized among the allocated space; control – the degree to which people have say over space location and ability to manipulate features (adjust thermostat, open windows, etc.) within their space; and ambient properties – the impact of environmental characteristics (such as light, noise, air quality, temperature, pollution) on work outcomes and employee attitudes (McCoy, 2002).

The phenomena of interest in work environment research are usually worker productivity and workplace satisfaction. Other measured outcomes include social or communication patterns, worker health, and worker stress. The literature on stress is particularly relevant to the collaboration engineer. Zimring (1981) conceptualized the stress results from a misfit between individual needs/goals and environmental attributes. This suggests that better fit among environment, technology, and work process should lead to less stress.

2.2. Classroom Design Research

While white collar office design research looks at the impact of many environmental factors on work productivity and worker satisfaction, the research domain focuses on the individual worker as the unit of analysis. Classroom design research is helpful to the collaboration engineer, as the presumption of learning as a group activity makes the group a unit of analysis as well as the individual.

The classroom design literature is well summarized by Lackney (1994), and McVey (1996). Classroom design research by educational psychologists and environmental psychologists looks at: seating configurations; seating positions (power seats); spatial density, crowding and stress; acoustics and noise; climate and thermal comfort. The chief phenomenon of interest is academic achievement, a reasonable analog for productivity.

2.3. Collaboration Space Research

No single focused academic sub-field yet exists for the study of collaboration spaces. However, significant work has been undertaken by environment and behavior researchers, as well as group support systems researchers.

The importance of the physical environment to the process and outcomes of technology supported meetings has been reported in the GSS literature by several authors (Nunamaker Jr., Dennis, Valacich, Vogel, and George, 1991; Olson, Olson, Killey, Mack, Cornell, and Luchetti, 1992; Mittleman, 1992).

A series of studies by the researchers at BOSTI have examined collaboration spaces in the context of white collar office space. They concluded (Brill, 1997) that success in team collaboration correlated with four factors:

1. Shared spaces that act as a team's "conceptual and technical playground";
2. Having and using multiple forms of representation and communication, such as conversation, physical models, whiteboards, computer screens, and drawings;
3. Having a wide spectrum of formal and informal environments for random encountering,

spontaneous meetings, and scheduled sessions;

4. Easy access to team' space by coworkers "casually dropping in or passing by."

Points one and two speak to spaces that afford formal, planned collaboration events. Points three and four speak to spaces that afford informal, opportunistic collaboration events. The third pillar of BOSTI's findings is that collaborators need the ability to do distractionfree, solo work as well (BOSTI, 2001).

2.4. The Focus Theory of Collaboration

The knowledge base derived from the research on environment and behavior can inform collaboration engineering through the use of the Focus Theory of Collaboration, as illustrated in Figure 4 (Briggs R. O., 1994). Focus Theory is a causal model for group productivity, defined as the degree to which people making a joint cognitive effort achieve their common goals. The theory posits that limits on human attention resources are key constraints on group productivity (See Figure 4). In order to achieve group goals, members must divide their attention among at least three processes: communication, deliberation (thinking), (DeSanctis and Gallupe, 1987), and information access. Each of these processes places demands on limited attention resources, and, therefore, beyond a certain threshold of cognitive load, each interferes with the other processes (Brainerd and Reyna, 1990). Focus Theory further posits that cognitive effort is motivated by the vested interests of individual group members. It posits, therefore, that group productivity will be a function of goal congruence, which is defined as the degree to which the public goals of the group, and means by which the group seeks to attain its goals, are compatible with the private interests of the individual group members.

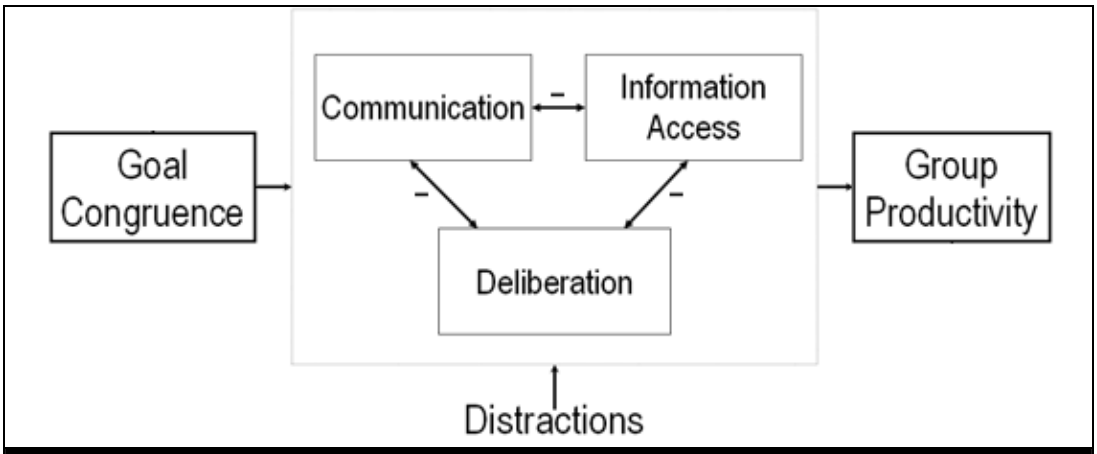

Figure 4. The Focus Theory of Group Productivity

The constructs of Focus Theory offer ready explanations for differences in the success or failure of collaborative teams in a physical setting. Indeed, a variety of physical setting anomalies can distract teams in many ways including, for example, sound disruption (Brill, Margulis, Konar, and BOSTI, 1984) (Sanoff, 1986) and poor lighting (Wineman J., 1987). In another example, maintaining acoustical privacy to support concentration may increase the productivity of deliberation (BOSTI, 2001), but raise the raising temperature above 30°C, which may constitute a distraction, decreasing the ability of group members to concentrate on the task at hand (Witterseh, Wyon, and Clausen, 2002). In a third example, space configurations that bring collaborators within social proximity may afford more effective non-verbal and verbal communication. The use of informal spaces or activity nodes may be useful for building goal congruence among team members (Bechtel, 1976;Adkins and Mittleman, 1997). Variations in the manipulation of just these four constructs – acoustics, temperature, social proximity, and informal spaces -- could result in wide variations of group productivity in a wide variety of tasks.

3. Methodology

The collaboration engineering research is driven by a design science methodology informed by social science theory. Design science (Hevner, March, Park, and Ram, 2004) posits a cyclical model of design, build, and evaluate activities producing artifacts that inform both the original design problem and are extensible to the field literature in the form of constructs, models, or methods. Design evaluation can inform the cycle by either informing design theory or raising new design research questions; or it can be explanatory (testable) in itself (Moore, 1997). Design science is grounded in both the Information Systems literature and in the architectural design literature (Gregory, 1967; Jones, 1980).

The author's immersion into the activities of design, build, and evaluation. This research began with a theory and intervenes in a number of situations to improve both the situation and the theory (Argyris, Putman, and Smith, 1985). The principal theory guiding this research is Focus theory (Briggs R. O., 1994); the research is also informed by environment and behavior literature. This work is based on a set of 20 design interventions that I either led or participated in. These interventions include architectural programming (planning) and design for: dot.com work environments, Fortune 500 ideation spaces, military planning, decision making and training spaces, civilian government meeting spaces, high school and college classrooms, meeting rooms, and faculty officing environments. As these interventions are limited to North American projects, caution should be used when extending the findings to other national cultures. This work is also informed by observations in more than 100 other collaboration spaces -- commercial, governmental, military, and academic – that were made after implementation. Finally, the work is informed by feedback from other designers who took these concepts into the field and used them for designing new collaborative work spaces, and by feedback from the users of those spaces.

This research demonstrates that the physical environment can be manipulated to support individuals and teams engaging in cognitive effort toward a shared goal by enhancing environmental affordances that reduce the cognitive load of deliberation, and communication and ease information access. Such enhancements can increase the likelihood that group members will be able to establish and maintain goal congruence. These manipulations come through both the minimizing of environmental distracters as well as by the construction of structures to advance the four cognitive functions proposed by Focus Theory.

4. Space Planning Process

The process of design planning in architecture is called architectural programming.[1] Several programming processes are accepted and established in the field of architecture (Hershberger, 1999; Mittleman, 1995). Almost all of these different processes follow a basic model of: goal definition, needs analysis, requirements definition, and documentation. Several specify additional stages including: information gathering, generation and testing of programmatic alternatives, and program decision making.

Many knowledge acquisition methods are used to support a programming process. Among the standard architectural programming techniques for knowledge acquisition are structured interviews, structured walkthroughs, group worksessions, and surveys (Pena, Problem Seeking, 1977). It is also possible (and perhaps desirable) to use a GSS worksession to elicit information (Hershberger, 1999). All of these techniques will be appropriate at different times in a comprehensive programming process.

The programming of collaboration spaces can be integrated into the collaboration engineering approach for designing collaboration processes (Kolfschoten and de Vreede, 2007). This section of the article lays out a Collaboration Engineering Physical Environment Programming Process, an architectural programming process slightly modified for interaction with the collaboration engineering

[1] Architects use the term "programming" to refer to the planning process where space requirements are surfaced and refined. Programming precedes architectural design and results in a "design program document."

approach for designing collaboration processes (See Figure 5).

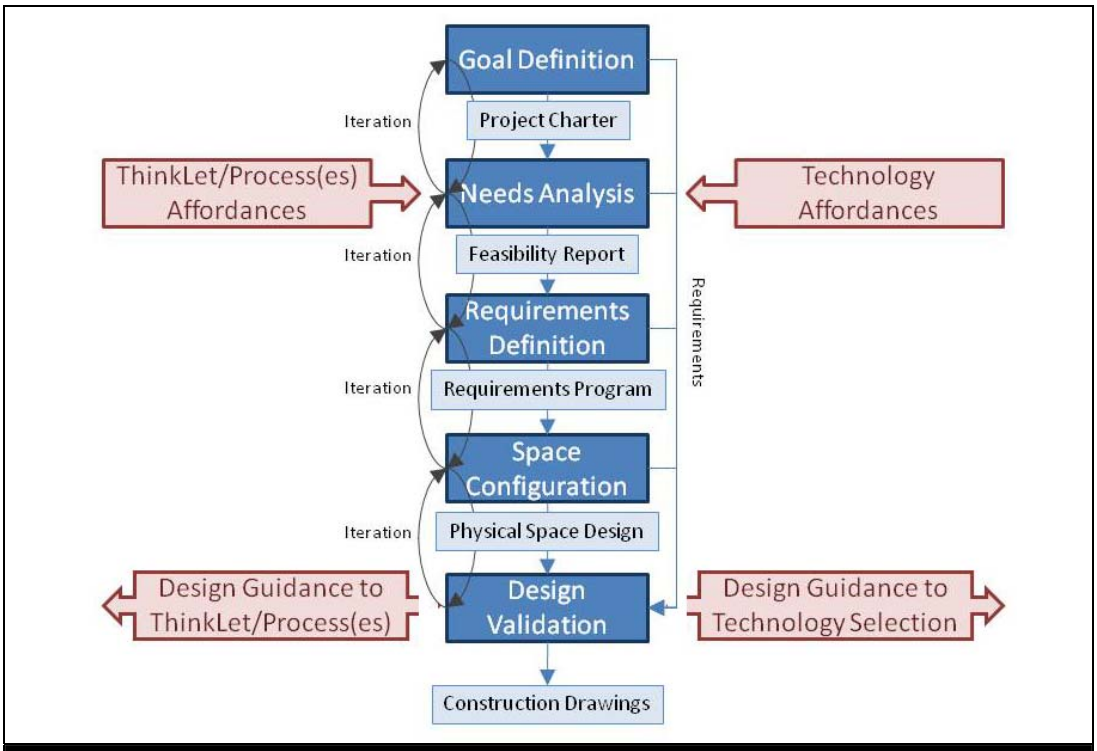

Figure 5 Collaboration Engineering Physical Environment Programming Process

The five stages of the process resemble five standard programming stages. Each stage produces documented output that can be used later in the process to validate the design. Further, there are entry points for ThinkLet or collaboration process requirements as well as information and communication technology affordances in the design. Thus, the validated physical environment design is able to generate output guidance back to the collaboration process design cycle as well as guidance for technology selection or construction.

Each of the stages is described below, along with exemplar questions that should be addressed by the client and communicated to the planner[2] at that stage. While this question inventory is specifically designed for technology-supported collaboration spaces, other question inventories exist in the literature. Question inventories for electronic classroom planning (Niemeyer, 2003; Hinchliffe, 2001; Mann, 2006) or white collar office planning (Smith and Kearny, 1994) may be useful as well.
In the following sections, I discuss the implications of many design issues for group productivity, and I codify a set of 97 questions and issues a collaboration engineer must consider when designing physical work environments for collaborating groups.

5. Goal Definition

The first step in establishing an architectural program for a collaboration environment or meeting facility is to clearly establish the goals and scope of the project.

[2] Either an architect or an interior designer may be suitable to guide the programming of a technology-supported meeting space.

Figure 6 Rich Orwig, a particularly good meeting facilitator, standing in a particularly bad meeting facility.

Early technology-supported meeting environments built to support Group Support Systems were often old mainframe computer rooms repurposed for meeting use with a set of computer-laden tables placed in the middle of the raised floor, or spare rooms organized with little regard for ergonomics or functionality (see Figure 6 as an example of the latter.) As a rule, these meeting environments were terrible. The re-purposed computer rooms tended to be noisy due to legacy 10- or 20- ton air conditioners residing in the room; be way too bright due to bright white fluorescent lighting and highly reflective walls, floors and table surfaces; be stark and cold; have bad acoustics; and have poor audio/visual support, as the lighting could not be dimmed but had to be turned completely off in order to view a public screen. The designers of these meeting spaces envisioned them as computer rooms where people happened to meet, rather than human meeting environments that happened to utilize computers as tools to support collaboration. The spare rooms often had power, data, lighting, and presentation systems built for traditional low-tech interactions, wholly unsuitable for technology-supported meetings.

While budget constraints are often a driving factor when repurposing existing space, in all likelihood, these space design errors can be traced to a lack of articulation of goals: objectives, and scope of the project. The intention of the environment was unconsciously assumed, and space was provided to fit the assumption.

In contrast, the goal definition document must set the objectives, ownership, and scoped (for planning purposes) use of the collaboration space, as well as establish a planning time horizon . This document serves to frame and to bound the programming process. The project owner and, perhaps, key stakeholders should be interviewed for preparation of the document.[3]

Questions for Consideration

Several questions that might be asked to surface project scope and objectives include:

- What is the driving objective for the creation of this space? Why is this space being built? What is the desired outcome of having this space?
- What is the scope of this design project? Is it simply the construction of a roomor development of a comprehensive meeting and/or training environment?
- How will success of this project be measured? Do quantifiable objectives exist? How will you know if this project is a success?
- What image should the space convey? Is the space meant to be a showcase? Will it be for

[3] Or, if three or more key stakeholders exist, consider facilitating a collaborative writing process enabling the key stakeholders to create the document themselves.

internal organizational use, or will clients/vendors/guests use it? Is it to be a training room or classroom? Is it to be a conference room or board room? How are similar low-technology facilities in the organization appointed?

- What is the planning horizon for the space? One year? Five years? Ten years? Will the space remain as built for the entire planning horizon, or must it be designed to support future growth or changes?

5.1. Needs Analysis

The second programming step is to conduct a thorough needs analysis. While this statement might seem obvious and basic, it is a step that in practice is often cut short or omitted entirely. However, shortchanging this step can lead to the design of an environment which, while pretty and effective for some situations, does not fit the needs of the organization as well as it might. It may lead to a design solution that does not address the real problems or constraints. It also may contribute to the omission of less obvious needs from the final design.

The key questions to surface during a needs analysis are:

- What are the characteristics of the group who will be using the meeting space?
- What are the tasks they will be using the space for?

Types of Technology Supported Meeting Groups

There are several key dimensions differentiating group composition that might be considered. These dimensions include:

- Will the groups only be meeting locally in the space, or will there be a virtual (distance) component to the groups?
- Are the groups all at the same hierarchy level in the organization, or is the hierarchy mixed?
- Are the groups meeting regularly on long projects, or is each meeting an independent project or task?
- Will the meeting participants likely be familiar with one another, or will they likely be strangers?
- Will the groups likely to be small or large in size?

While all of these questions will help inform the meeting space design, group size is a particularly key determinant. Small groups (three[4] to five participants) are able to communicate within a social distance (four to 12 feet). At a social distance, individuals are able to speak in a conversational voice and are able to send and receive subtle non-verbal cues. Feedback, trust, and other emotional constructs are easily communicated (Burgoon and Bacue, 2003). Mid-size (six to 12 participants) and large (13 and more participants) groups interact at a public distance (12 feet or more.) At this distance, individuals speak in a public voice projecting from the diaphragm. Conversation is more taxing, air time is limited, and subtle non-verbal cues are more difficult to pick up.

Types of Technology-Supported Meeting Tasks

One way to differentiate the use of meeting space is to consider the flow of information in the space. Some groups experience largely a one-way flow of information from an individual to the group such as when a teacher or presenter is lecturing an audience. While a feedback channel (or questions or comments) may exist, the vast majority of information is passed in a single direction from one to many. Other groups experience an N-way flow of communication where many individuals will trade off speaking (or will attempt to speak at the same time.) This is a complex many-to-many communication pattern.

[4] While some authors suggest even a pair of collaborating individuals is a group, but since this is an article on collaboration space design we will consider three as the minimum with the expectation a group of two will find a private physical or virtual space to use.

Table 1 Matrix of Meeting Types

		Communication Flow	
		N Way	**1 Way**
Group Size	**Small**	**Small Group Work Product Execution Meetings**. These are small to midsize meeting where development of a shared deliverable will take place. This is a team writing a proposal, writing a report, marking up a spreadsheet, or engaging in a similar work product development task. In all likelihood, these meetings are more common than decision making meetings. Software such as collaborative editors (e.g., Google Docs[5]) or collaborative markup tools (e.g., ConceptShare [6]) may be employed to support these processes.	**Small Group Reporting.** These include small group presentations, including staff meetings and desktop VTC meetings. This is a team checking in and providing status updates among the members. Each participant trades off being in the lead presenter role, while others serve as audience. Software such as GoToMeeting that supports PowerPoint presentations may be employed to support this process.
	Large	**Large Group Problem-Solving Meetings.** These are meetings in which the team will surface and evaluate alternatives, select from alternatives, and possibly assign execution tasks. These meetings, when large or complex, may be led by an expert facilitator. In all likelihood, only a small fraction of meetings fall into this category, but this meeting type is important due to the implications for decisions made, and the great expense in the use of time of several executives and managers. These meetings are well supported by Group Support Systems tools (e.g., GroupSystems,[7] WebIQ).[8]	**Large Group Presentations**. These include large group briefings, presentations, staff report meetings, and training sessions in which learning will take place primarily by lecture. These meetings consist of one individual giving information to a group of individuals, sometime swapping roles so that several participants take turns presenting to the group. Often the presentation is supported by physical handouts or public display images. These meetings may range from small to large group. When these meetings are virtual, presentation support software such as MS-Live Meeting,[9] or GoToMeeting [10]may be employed.

This matrix of task types becomes a useful guideline when specific space requirements are considered.

Questions for consideration

In addition to feeding in the results from the Goal Definition process, several new questions should be addressed to determine needs, including:

- Who is going to use the meeting space? How large will the groups be? Will they be ad hoc or established groups? Are they executives, managers, technicians, a mixed group, or some other grouping? Will groups be from the same hierarchy in the organization, or will there be mixed hierarchy groups?
- Do the users have any physical needs or limitations that will impact their use of the space? Might there be disabled group members? Are they experienced computer users?
- What are the inputs from the collaboration engineering design process? What kinds of work processes or ThinkLets will collaborators use the space for? Which size/communication patterns (from the matrix above) best describe the groups this space is targeted for?

[5] www.google.com/docs is one of several tools in this category
[6] www.conceptshare.com is one of many tools in this category
[7] www.groupsystems.com
[8] www.webiq.net
[9] office.microsoft.com/en-us/livemeeting/
[10] www.gotomeeting.com

- How long will meetings last? An hour? A day? A week? Will food or drink be served? Will they take breaks in or adjacent to the space?
- How will they use the space during their meetings? Will they work as a full group or break into sub-groups? Will facilitation be interactive, supported, or chauffeured (Watson, DeSanctis, and Poole, 1988)? Will break-out spaces be required? If so, for how large a sub-group?
- Will there be virtual (distant) participants? Will the meeting tasks require audio, video, or data connectivity with the virtual participants?
- Will they require information processing or communication equipment such as copy machines, faxes, or printers? Will they require privacy when using this equipment?
- What sorts of storage needs exist? Will computer equipment require storage? Office supplies? Food and beverage? Coats?
- Who will manage the space and who will maintain the equipment? Where will these people be housed and what space needs will they require?
- What is the organizational culture like? Should this facility support the existing culture or work to break down that culture?
- Are there existing physical environment, organizational structure (and politics), or financial constraints that will impact the project?
- Will the space be used for electronic technology-supported activities? If so, what needs must be met to support these other activities?

Notice that most of these questions do not require specific physical environment answers. At this stage of the process, needs are being established; and many of these needs can be met by multiple design solutions. Specifying a particular design solution too early in the process may cause other potential solutions to be overlooked.

In systems development terminology, this stage includes a feasibility study. The report generated at the end of this stage answers any and all of the questions above that are relevant to the given project. In addition, the report illuminates project constraints on the following dimensions:

- Economic: what are the limits to the construction, technology, and operations budgets?
- Technology: are there boundaries to the technology solutions that can be implemented (e.g., it must be a Microsoft shop); are there limits to availability of technical support staff?
- Schedule: is there a required completion date, or a waiting date before the physical plant becomes available?
- Operational: are there limits to operational staff that will be available to support the space?
- Political: are there organizational political issues that will bound use of the space or otherwise impact design decisions?

6. Requirements Definition

Once the needs analysis is completed, it is possible to begin looking at specific environmental design requirements to address those needs. Design options are grounded by the needs they are to address. For example, the question of whether to design a round, rectangular, or horseshoe meeting table is guided by knowledge of who will be sitting at that table and how those participants are expected to interact. Design requirement for technology-supported meeting spaces fall into several categories. Each category will be described and requirements guidance offered.

6.1. Space Configuration

Seating configurations play an important role in determining communicative social interactions in a meeting space (Hall, 1966). Meeting room and training room literature list several standard participant seating configurations. Each of these configurations optimizes for different types of group activities. Table 2 lists seven common seating configurations evaluated against three dimensions: the size of the group; the types of tasks the group is engaged in; and the form of physical or virtual presence the group is experiencing. Several historical studies have systematically tested layout in classroom and technology-supported spaces providing grounding for the priorities suggested here

(see, for example, Fulrath, 1976; Lewe and Krcmar, 1991; Maaranen, Knuuttila, and Lyytinen, 1993; Rosenfeld, Lambert, and Black, 1985).

Table 2 Space configuration performance against selected meeting characteristics

	Group Size			Task Type			Presence		
Configuration Type	Small	Medium	Large	Problem Solving	Briefing	Execution	All pco-resent	Virtual	Break Out
Classroom Rows		◆	◆		◆		◆	◆	
Tiered Case		◆	◆	◆	◆	◆	◆	◆	
Mission Control		◆	◆	◆	◆		◆	◆	
Boardroom	◆	◆		◆	◆	◆	◆	◆	◆
Horseshoe	◆	◆	◆	◆	◆	◆	◆	◆	◆
Chevron	◆	◆		◆	◆	◆		◆	
Banquet Hall			◆	◆		◆	◆		◆

◆ supports well ◆ supports minimally or with limitations

Figure 7 JAD Meeting Space at Redstone Arsenal seats 55 using a Tiered Case Room configuration with 21 inch CRTs at each station.

Collaboration space design is complicated by the fact that spaces are rarely designed for single purpose activities along all three of these dimensions; most spaces are expected to serve multiple programmatic use requirements. Nevertheless, seating configuration decisions can be supported to the extent the design goals and objectives are able to prioritize use. A correct fit between collaboration objectives and space configuration can enhance interpersonal communication opportunities and support strong goal congruence.

Take care when designing a multi-purpose facility to minimize expectations for physical reconfiguration between meeting activities. While such operational reconfiguration often looks appealing on the drawing table, real life operational constraints make it unlikely to function smoothly. This author has been involved in a half dozen collaboration or classroom space design efforts where the client requested reconfigurability. In none of those cases was regular reconfiguration used when the room was built out. If design for operational reconfiguration is contemplated, consider:

- How frequently will the room be reconfigured?
- How much time between meetings will be allocated for the reconfiguration?
- Who will do each reconfiguration?
- How will this downtime be budgeted?
- How must the design support reconfiguration with respect to resetting computer power, networks (if not wireless), and control systems (if not wireless interfaced).
- What can be done to minimize the negative effects of reconfigurability? Each

reconfiguration will be hard on the equipment and technology; anticipate shorter useful life (by about half) of all objects reconfigured, and budget replacement costs accordingly.

- Will future budgets support the expected replacement costs of reconfigurability?

Often the desire to build out reconfigurable space is an indication of incomplete goal definition and needs analysis. Revisit those stages to determine if reconfigurability is truly a core objective of the project, rather than a solution based upon being unclear of the real prioritized objectives.

Figure 8 The Executive Meeting Room, San Diego State University, is a horseshoe configuration that almost completes the circle but permits the meeting leader to enter the well.

Configuration types rank differentially by group size largely due to the proximity among participants each design affords. Some configuration types easily place participants within social distance of each other; other configuration types more readily place participants at a public distance. Configuration types rank differently by task type due to the relational configuration of the seating. Some configurations place participants opposite one another, making non-verbal cues easily readable, other configurations face participants opposite a presenter or public display, making participant-to-participant eye contact awkward. Configuration types rank differently by presence, as some configurations provide a camera with direct eye contact to participants and other configurations make such camera contact difficult to achieve. Further, some configurations easily support informal clustering for sub-group breakout work, while other configurations lock participants into inappropriate seating configurations. All configuration solutions entail a degree of tradeoff among attributes (Polley and Stone, 1993).

6.2. Workstations

In computer-supported meeting spaces, individual workstations are the core of the work environment. It is not unusual for meeting participants to homestead a particular workstation and use it continually over a multi-day meeting duration - or across several separate meetings. If a meeting environment is being built to support long meetings (lasting more than two hours) individual workstations must address the fatigue that will naturally set in among participants. In addition, workstations must support the functional task need that will occur over long meeting durations. Good workstation design supports information access by providing for effective computer display site lines and adequate space for paper reference materials. In addition, a design that keeps the monitors out of participant sight lines supports communication among team members.

In a modern technology-supported facility, a decision must be made whether to equip each workstation with a computer, or to simply provide connectivity for the participants' own laptops. If a computer is to be provided, then a decision must be made whether to provide a desktop or laptop computer. Factors influencing this decision include:

- What is the cost of computers/
- How must computers be placed?
- What is the desired size/quality of the personal display screen?
- What configurability is required of the computer?
- What kind of access will users require for data storage devices (e.g., disks, flash drives)?

In previous technology generations, desktop computers were usually the form factor of choice. Today, because of the low cost of laptops, the availability of moderately large laptop displays, and the use of thumb drives for data transfer, laptops are becoming the form factor of choice for many buildouts. Further, an external monitor and keyboard can be considered along with a laptop if such affordance fits with a particular design program. When choosing between desktop and laptop computers, the collaboration engineer must ask:

- What level of visual graphics processors is required?
- Could laptop computers be adequately secured?
- What degree of reconfigurability is required for the variety of uses proposed for the space?

Individual workstations should provide a comfortable and functional work environment, adequate visual privacy balanced with proximity and accessibility to other meeting participants, and adequate ergonomic support.

ANSI standards for workstation width are defined more by task than by specific measurements. For workstations with a computer, a minimum width would be 24 inches, but in practice 30 inches is a more reasonable minimum to consider. While some literature recommends 48 inches, even in an executive boardroom buildout, 36 inches should be adequate and provides for better proximity for human communication. Workstation depth is dependent upon monitor size and depth. About 1.5 inches of viewing distance should be provided (between the participant's eyes and the computer screen) for each diagonal inch measure of the computer screen. So, for example, if a 20-inch diagonal screen is being used, provide for about 30 inches distance between the participant's eyes and the screen display (McVey, 1996).[11] Thus screen size will drive the required depth of the workstation. A current generation buildout will use an LCD monitor (whether part of the laptop or free standing), so workstation depth no longer needs to accommodate CRT depth as previous generation buildouts had to do. Given this, below surface monitor placement (with glass surface) is no longer recommended. Appropriate workstation depth will be between 18 and 24 inches.

In the past, the depth of a CRT monitor and the size of the CPU box were significant constraints in the design of the workstation. Today, both are less of an issue. LCD monitors are affordable and, given the constraints of meeting space design, should always[12] be chosen ahead of a CRT option. Widescreen format LCDs provide additional display real estate for the vertical rise and should be strongly considered. Care should be taken to minimize the vertical rise of the LCD panel. If possible, the monitor base should be dropped below workstation height so that the bottom lip of the screen as at tabletop.

Participants must be able to see their computer screen clearly, and they must also be able to see one another clearly. Some previous generation meeting rooms had the CPUs sitting on desktop computers, and the monitors sitting on the CPUs, which resulted in a "Kilroy" effect. People strained

[11] McVey (1996) addresses research on screen distance (p 1075) and many of the other issues addressed in this section.

[12] This article rarely states a specification as absolute since so much depends upon program tradeoffs. But I can't imagine a good reason to opt for CRTs today, unless one has no budget and is forced to repurpose old computers. Even then, the least expensive LCD panels would make a world of difference in the performance of the meeting space.

to see over and around the technology. Such a configuration should absolutely be avoided. All technology not required on the desktop should be hidden. Monitors should take up a minimal amount of vertical space. Even LCD monitors should be sunk into the tabletop so that the bottom lip of the screen is at table level when this is possible to do.

A key criterion in personal workspace design is table space or written work materials, such as a pad of paper or portfolio. Twelve inches of surface depth in front of the monitor must be provided for these materials. Care should be taken when determining keyboard location to ensure that space is available for written materials.

Chairs should provide maximal flexibility and adjustability. Chairs should have castors and provide for height adjustment, allowing participants to find a personal seating configuration. For meeting environments that will be used for more than two hours, chairs should provide lumbar support and arm rests.

6.3. Lighting

The quantity and quality of lighting significantly impact both performance and worker satisfaction in computer-supported work spaces (Sundstrom, 1987; Wineman J. D., 1987). Technology-supported collaboration spaces add additional complexity to the issue. Task lighting must be bright enough for individuals to function in their own workspace and for video conferencing cameras to pick up non-verbal cues on the faces of meeting participants, yet the bright lighting must not produce glare on computer screens and must not wash out any projected public display. The goal is to provide the right type of light for the specific type of work being undertaken. Correct lighting decisions can support individual deliberative work (reading, for example) as well as communication by providing ample lighting to see non-verbal cues. Poorly designed lighting, resulting in shadows or glare, can distract from a work process.

Program design lighting considerations include:

- To what degree will video-conferencing be used in the meeting facility?
- What form of public display will be used (will it be a projected display)?
- What sorts of tasks will individual participants engage in? Is there an expectation they will need to read?

There are several general recommendations to be made for lighting in a conference environment where computers and presentation technology will be used:

- Employ indirect lighting where possible to minimize heat and glare.
- Mix fluorescent, incandescent, halogen, and LED lighting to address flicker, spectrum, and heat issues.
- Provide low cognitive load preset controls for the meeting leader or facilitator to vary room lighting on demand.
- Provide rheostat controls for variable dimming when possible. An experienced meeting leader will make use of these controls to manage meeting tone, focus, and flow.
- Use dark matte finishes on counter and table tops to reduce glare.
- Provide for zoned lighting controls. During program development explore which zones will be important in the given meeting space. Consider zones for
- In front of the display screens;
- In front of whiteboards or other shared surfaces;
- Participant areas, possibly with inner and outer rings zoned separately;
- The room perimeter.
- If video conferencing will be employed:
- Avoid the use of wall sconces;
- Consider how the camera iris will react to the wall and whiteboard background fields. Choose wall colors to maximize facial details of meeting participants when the camera iris auto-sets to account for wall color;

- Be aware of how lighting glare and window glare will interact with the camera image.

6.4. Room Appointments and Atmosphere

Meeting room aesthetic decisions will be driven by the design program. It is possible, with some creativity, to create an attractive high-end feel at minimal expense. Occasionally, the program will demand a less than high-end aesthetic. The CMOC program on the USS CORONADO explicitly stated that the room aesthetics were to be functional only; the program went so far as to indicate that ugly was preferred to attractive. The design intention was to convey that the Navy was not wasting any money in the buildout of this space.

Some general guidelines for aesthetics and room functionality will hold true independent of the program:

- This is people space and must be conducive to human interaction. Design constraints that exist due to electronic technology must be secondary to constraints due to human interaction needs.
- Technology will tend to be highly evident in these meeting rooms. Unless the room is being designed specifically to be a technology showcase, the physical buildout should do what it can to minimize the presence of the technology. Possible solutions to consider include:
    - Neutral and muted colors on the walls, floors, and millwork. A textured wall covering will soften both the appearance of the room and the acoustical echoes.
    - Pastoral artwork on the walls. If artwork is to be displayed, the room lighting system might be supplemented by a spot light system to highlight the artwork.
    - Hiding the presence of the public display screen when not in use.
    - Hiding the presence of computer monitors and keyboards when not in use.
    - Using a flexible lighting system to shade audio/visual technology from focus when not in use.
    - Providing adequate cabinet space so that technology support materials can be hidden from view and the room can have an overall neat, clean look.
    - Use rich textures or warm wood tones to soften and humanize the room.
- A wainscoting or chair-rail might be considered, as chairs in a boardroom or horseshoe configuration will be pushed back into the walls on a regular basis.
- Adequate space must be provided for people to move about the room. It is unreasonable to assume that people will sit in their workstation chairs for an entire meeting. People will want to get up and wander and passageways must support this. This requirement is especially true for the meeting leader who may need to assist participants at any place in the room, and who may use the aisle ways for functional purpose during the meeting process (Mittleman, Wener, and Zimring, 2003)
- Care should be taken to protect space against the likely causes of damage. In most meeting facilities these will be: damage from food and drink on wood and carpeted surfaces; nicks in millwork and walls from sharp chair edges; tape marks on painted or wallpapered walls; felt pen ink marks on a variety of surfaces.
- While hiding computers within millwork adds to an executive aesthetic, designers must anticipate that movable millwork parts will fail and require regular maintenance. Custom millwork can add significantly toward an executive aesthetic as well as optimize for programmed functionality, but will add considerably to the price. Consider semi-custom millwork available from several firms.
- Adequate space may be required to support small group clustering and breakout work. Programs will vary in their demand for breakout space, but in all meeting facilities it is reasonable to assume that participants will occasionally cluster around computer stations, whiteboards or other objects of focus. Sufficient human space should be provided for this.
- Programs for meeting environments where meetings will be longer than two may require space to serve food or beverages to the group.
- Thought should be given to egress space external to the meeting environment. Meeting participants will tend to gather in whatever space is available before and after meetings (as well as on breaks). This space should support interaction as well as possible. Care should

be taken to address the acoustics, clutter, and disruption that meeting participants might cause to other dwellers of this external space.

- Participants will require way finding information to several standard resources. Those resources often include: lavatories, copier/printer, privacy for cell calls, water fountain, and building exit.
- Consider the need for a room clock in the design program. Consider whether the clock should be visible to virtual participants.

Figure 9 Millennium Boardroom, DePaul University

6.5. Public Display and Support for TelePresence

Traditional technology-supported meeting facilities included one or two public screens. These displays were either a large CRT-based television (see Figure 6, for example) or a front screen projection system (see Figure 8, for example.) Today, the public display serves not only as a shared focal point for within-room participants, but may also serve to join virtual participants. TelePresence, when appropriately matched with a work process can provide support for communication and information access (as it is possible to display and mark up external information sources on shared screens.) However, care should be taken when considering a TelePresence requirement. Many ThinkLets not only do not require TelePresence, but may suffer for it. The video image of collaborators may distract from the accomplishment of generative tasks, although there is reason to believe it can support maintenance of goal congruence and effective reduction and consensus building tasks. TelePresence may be the environmental affordance decision that most needs to be tightly integrated with work process design.

During the programming process, public display uses and requirements must be surfaced.

- Will video teleconferencing be utilized? If so, what quality level of teleconferencing is required? At the high end, TelePresence options (Figure 10) are increasingly becoming feasible, although they remain at a high price point.
- What kinds of data images will be displayed on the public display? What font sizes are anticipated?
- How important is it to the program that the public display not be impacted by human traffic in the room? This gets at the need for flat screen or rear projection display.

- How important is it for participants to directly manipulate objects on the public display? This gets at the need for a touchscreen display (note there are significant downsides to opting for a touchscreen display including: higher pricepoint, lower resolution, lower brightness and contrast, shorter expected lifespan.) A touchscreen display should only be specified if programmatic needs explicitly call for one.
- How important is reliability and 100 percent uptime to the program vs. cost of a redundant or bulletproof solution?
- How important is it to be able to show multiple images simultaneously? The images may be two data images, two virtual participant images, or one of each. Are three or more simultaneous images required by the program? Is the room seating configuration arranged so that multiple displays of the same image are required for all participants to see the image?
- If video conferencing is to be used, what camera images of the local participants will be required? Is one camera on the leader sufficient? Does there need to be one or more cameras focused on audience participants?
- Will a single room audio be sufficient, or will individual audio channels be required to indentify individual speakers? Note there are significant costs and complexities to mixing individual audio channels; this option should only be selected if programmatic needs explicitly call for it.

Figure 10 Cisco's TelePresence solution (see http://www.cisco.com/telepresence)

6.6. Electrical and HVAC

The use of computers and presentation hardware suggests that high technology meeting environments may require electrical and HVAC specifications over and above a standard building specification. In addition, there may be OSHA, local building code, and local fire code regulations that need be addressed.

Micro-computers and most of the audio/visual equipment in use today can be run on 110 volt outlets. They will draw minimal power and will require minimal additional buildout. Some presentation equipment, such as LCD projectors and copyboards, will draw more electrical power and give off

significant heat. Equipment vendors will be able to provide specifications for each model. A qualified engineer should be consulted to determine actual electrical draw and thermal output.

Some general rules of thumb exist:

- The design program should determine whether laptops or desktop PCs will be employed--and whether the facility will permanently install computers or participants will bring their own. If participants are bringing their own laptops, then one duplex for every second participant station is sufficient. If the facility is providing computers, then one duplex for every participant should be considered (this is because sometimes participants bring personal laptops in addition to the computers provided.) Other authors have recommended as much as four jacks per workstation (Leighton and Weber, 2000); that may be overkill, but Allen et al.'s (1996) recommendation to overbuild power capacity by 20 to 40 percent is reasonable.
- Even if wireless is being employed, the program should carefully consider the provision of a network switch (bandwidth to be specified at design time) capable of providing wired connectivity to computers for every participant and whether to pull cabling to each station (conduit for such cable pull should almost certainly be provided even if cable is not pulled at buildout.) For leader station, conduit should be provided for data connectivity and control system interface.
- Public display program decisions should include the data quality required for projectors/displays. Inclusion and location of control systems, AV mixer, data switch or POP, and other control systems (CODEC, server, etc.) determine location and diameter of conduit runs. It is prudent to slightly over spec conduit runs during initial buildout due to the minimal cost of over specing and the potentially high cost of retrofitting.
- Laptops will emit less heat than desktops. In an environment where there is no economically feasible option to upgrade HVAC, this may be a significant factor in choosing laptops over desktops.
- Isolate workstation computers on their own sets of circuit breakers. Depending upon the peripheral equipment attached to a workstation (disk drives, CD-ROM, monitors, etc.) four to 10 workstations can reside on an individual breaker. Isolate the workstation server on its own circuit breaker.
- Isolate projection and audio/visual equipment on its own circuit breaker.
- Because power spikes caused from natural occurrences (thunderstorms, tornadoes, etc.) and heavy building equipment (elevators, pumps, HVAC) can destroy electronic equipment, place all computers and audio/visual equipment behind a power conditioner. Do not rely on small residential surge protectors, as that equipment may not stand up to industrial computer-room demands.
- Think through the room locations where computers and audio/visual equipment will be placed. Construction may impact vertically adjacent space. If an LDC projector is going to be hung from the ceiling, then both power and data ports must be built into the ceiling at that location. If a table of workstations will be placed in the center of the floor, then either power and data ports must be accessible through the floor, or a conduit will need to be run over the floor to access a wall port. Such a conduit creates a safety hazard and limits accessibility for the physically challenged.
- Compute, or have the engineering consultant compute, the wattage demands from the electrical equipment to determine whether air conditioning will be required for the room in addition to standard building air conditioning. Remember to factor in the heat from the estimated number of people in the room when it is full. If the building air handling systems depend on open doors or windows to the meeting room, consider this constraint against needs for acoustical privacy.
- If the room will be on the standard building air handling system, consider the locations of the zone thermometers. As the room will likely produce more heat than adjacent environments, thermometers located outside the room may leave the room to hot; thermometers located inside the room may leave adjacent areas too cold. Consider placing the room in its own thermometer zone. Finally, consider whether the meeting leader will be provided thermostat controls, or whether that control will be held by a building engineer.

- If additional air-conditioning is to be added for the room, consider the amount of noise this unit will produce. Consider also the amount of noise an LCD projector and computer fans will produce. Consider building ventilation ductwork in such a way as to draw out noise along with the heated air to the greatest extent possible. Designers of group meeting facilities should aim for an ambient noise level of 50db or less.
- Studies summarized at the National Council for Educational Facilities suggest that meeting spaces kept at moderate temperatures and moderate humidity will contribute to the highest levels of participant performance on mental tasks (Schneider, 2002). Neimeyer and Hinchcliffe both recommend 50 percent humidty with a seaonally adusted temperature range between 68 and 74 degrees Fahrenheit (Niemeyer, 2003; Hinchliffe, 2001).
- Consider the type of lighting system used (LED, halogen, incandescent, and fluorescent all emit differing amounts of BTUs). Consider the ratio of time ceiling mounted projector(s) will be employed (if used) and the amount of BTUs emitted by the model selected. Consider whether most meetings will fill the room. If openable windows will be provided, consider acoustical privacy and sunlight glare issues that may occur.

6.7. Acoustics

There are several acoustical considerations in your design program.

First, the program should consider how much sound will bleed into your meeting space from adjacent spaces, and how much sound will bleed out of your meeting space to adjacent spaces. You will need to consider anticipated traffic and activity in adjacent spaces and design to bring sound bleed to an acceptable level. If your meeting space opens to an outdoor environment, consider what outdoor noises (from playground activity to traffic to power lawn mowers) might impact your meetings. If you will be using audio conferencing to bring virtual participants into your meeting, even minor external noises that might be ignored by participants within the physical meeting space will cause considerable obstruction. All of these are distractions that will inhibit team productivity.

Two meeting spaces I programmed (and several training room facilities) have been located adjacent to the Chicago EL. A train passing the room disrupts activity. Physically present participants recognize the interruption and pause. Virtual participants hear a roar, but do not have sufficient fidelity clues to understand (at least the first several times) the nature of the interruption. When collaboration spaces have underspecified HVAC, team members find ingenious ways to compensate. Consider the admiral with the hot meeting room; he would regularly meet for ten to twenty minutes without HVAC until the room got too hot, then offer his team a break while the loud HVAC was turned on to cool the room down. Meetings were inefficiently slow, but team building (and goal congruence) benefitted. Further, it is likely much productive work happened when the officers were given the opportunity to caucus informally. In other collaboration spaces, participants have opted to keep the door open to the hallway to encourage better airflow. But noise from the hallway can be disruptive to the meeting. This has lead to a ten minute open, ten minute closed behavior with the door.

Second, the program should consider the distribution of sound within the space. If the program suggests that meetings will be held where politically sensitive caucusing will occur among subgroups of participants, or meetings where break out teams will be employed, the acoustical characteristics of the space should provide for zoned privacy. There are several ways your architect or interior designer can solve this acoustical problem if the program suggests the importance to do so.
The meeting room used by the Justices of the Federal Constitutional Court of Germany contains a double solid oak door. One door closes to the hallway and a second door closes behind it inside the room. The intention of the double door is to prevent clerks and other court staff from being able to listen in on deliberations.

Some general suggestions to improve the acoustical performance of meeting space include:

- Use carpeting on the floor as opposed to a hard surface. Carpeting will also trap dust better than a hard surface and may contribute to longer useful life of computer equipment

(assuming the carpet is regularly vacuumed);
- Use window treatments that will buffer sound (as well as protect against glare);
- Sound absorbent wall treatments or paint may well be easily affordable;
- Variable ceiling heights (and variable use of ceiling materials) can be used to create privacy zones, managing both the distribution of sound and light.

While little research exists in meeting room acoustics, there is a significant body of literature on classroom acoustics, most of which is applicable to meeting room design. See Classroom Acoustics(2000) for an engineering overview, and Schick, Klatte, and Meis (2000, Hinchliffe (2001), Schneider(2002) for recent literature reviews.

6.8. Security

Several levels of security issues must be considered. Computer-supported meeting spaces often contain tens or hundreds of thousands of fairly portable computer equipment, making the environments primary targets for theft. In addition, many meeting environments contain computer databases that hold sensitive proprietary data. Such meeting facilities can be a weak link in organizational security if security issues are not carefully thought out during the programming phase of the project.

Equipment security and personal artifact security

In addition to theft or intentional harm, computer-supported meeting spaces may be damaged by well meaning, but uneducated, staff. Inadvertent harm can come from, for example, placing a magnet too close to a disk drive.

An access policy for the physical environment should be considered during programming. A custodial or cleaning policy should be considered. Education for keyed staff should be considered.

Data security

Many meetings create, share, or reposit information that is confidential or strategic for the participants. The design program should consider the anticipated level of confidential or secret information that will be discussed during meetings in this space. Given the level of confidentiality required, several data security concerns may need to be addressed:

- Will it be possible for individuals in adjacent spaces to eavesdrop on meetings?
- Will data from meetings be stored within the space, or at an external location? If within the space, how will the data be stored, and who will have access to the repository? If outside, how will the data be transferred, and how secure will the transfer process be?
- How will confidential meeting materials be destroyed? Will a shredder be available? How will confidential electronic materials be destroyed?
- If virtual participants will attend meetings, will data transmission be encrypted? What techniques will be employed?
- If meeting data is to be transmitted to virtual participants, what techniques will be employed?
- If multiple groups will be using the space on the same day, how will the meeting transition processes address data security requirements?

Human security

During programming, the question should be asked whether the type of meetings anticipated for the space may result in human security risks that require pre-measures to be put in place. At most meeting facilities, this will be a fairly abstract issue, but some design programs will need to address this.

- Will a hot button be placed in the room to alert organizational security?

For example, if a meeting space is being designed to support arbitration or mediation processes where it might be anticipated that competing parties may occasionally have significantly opposing agendas, such security planning could be warranted.

6.9. Breakout and Social Space

It is important to provide a social environment along with the work environment in a technology-supported meeting space (Mittleman, 1992; Polley and Stone, 1993). There are multiple reasons for this.

First, in many organizational settings, difficult negotiation takes place outside of the formal meeting process. Interest groups informally caucus and lead parties engage in informal negotiation. Providing easily accessible and appropriately designed space can further these objectives. Facilitators sometimes schedule breaks to allow for informal conversation and for coalition building. One facility at The University of Arizona supports this sort of informal communication with an outdoor fountain placed just outside the meeting room. The running water provides a white noise which ensures acoustical privacy for small groups engaging in conversation or negotiation during breaks (Nunamaker, Briggs, Mittleman, Vogel, and Balthazard, 1997).

Second, individuals engaged in long meetings require time and space away from the meeting to regenerate personal energy and focus. Providing space where an individual can "get lost" may lead to more productive meetings. In addition, meeting participants often need to temporarily escape to address work obligations independent of the objective of the meeting at hand. For example, participants may need to make or take a cell phone call.

Social spaces will support informal communication and caucusing. Social spaces should provide for zones with acoustical privacy, comfortable clustering and seating very different from the meeting space itself. These spaces should be friendly to food and drink.

7. Space Configuration

The output of the requirements definition stage is a Requirements Program document. This document includes textual description of space and use requirements as well as models depicting a logical design of the program. This document should serve to guide and focus the designer in her work while giving her maximum flexibility to make design decisions. The program document should dictate design solutions only where absolutely necessary, allowing the architect to apply her own expertise toward finding optimal solutions. When design solutions are dictated to design professionals, their ability to contribute their skills and experience to the project is inhibited. More often than not, the final design solution will be inferior to what might have been achieved if the designer were given free reign.

Once the programmatic requirements are fully specified, the architect or interior designer can begin to develop one or several physical space design solutions. These solutions will take the form of drawings or three dimensional models.

It is not at all unusual for design to be an iterative process where the collaboration engineer (or space owner) is afforded the opportunity to critique a candidate design.

Several points here are helpful to the designer

- Use the documentation generated from previous stages of the programming process to document objections to a candidate design or suggestions for design changes;
- Do not introduce new requirements to the designer without also entering them into the program documents (and vetting them against the feasibility report and project objectives);
- Explain desired requirements changes in terms of collaboration affordances – that the change will enhance collaborative work in a particular way.

Understand that what you have done with your design program is to have fully explicated a design problem – the role of the designer is to develop for you a solution; there will be multiple correct solutions to the problem – you do not have to stop at the first solution.

8. Design Validation

As design solutions are reviewed, they should be checked against the developed set of collaboration requirements, the set of feasibility constraints, and the project objectives. A valid design is one that does not violate the constraints of the program problem.

When a design solution fails, jump back to the stage of the design process that is violated by the solution. Revisit the program decisions at that stage for correctness. When validated, then continue back through the design stages to provide the designer with updated information. The purpose of this feedback loop is to provide the architect or engineer with justification and rationale for the program decisions in case compromises or adjustments need to be made down the road. Further, it will serve to tie all of the decisions back to the project goals and objectives, ensuring a match between project intent and specific decisions made.

Once a design is validated, both the design solution and the program requirements can be shared with the collaboration engineer to inform the development of collaborative work processes. In addition, the design solution can be shared with the team charged with procuring or selecting information and communication technology to ensure fit between the design solution and selected technology.

9. Discussion

This paper argues that the design of collaboration environments should stand as a third pillar of collaboration engineering, Applying a systems development lifecycle approach to the architectural programming process for developing space requirements yields a Collaboration Engineering Physical Environment Programming Process. This process provides a framework for integrating knowledge of specific anticipated patterns of collaboration with known workspace and technology affordances to produce and validate space design requirements. Relevant environment and behavior literature is reviewed and mapped to typical collaboration spaces and collaboration technology affordances for the purpose of guiding a design programmer. A checklist of about 100 requirements elicitation questions and suggestions are surfaced to further guide the programming process.

The insights and guidelines presented in this paper were derived from several sources. I conducted qualitative field observations of people using collaborative workspaces in North America, Europe, and Asia. These observations used Focus Theory as a lens for interpreting how the organization of design elements and affordances might impact the productivity of groups. The concepts codified during those observations were taken into the field by more than a dozen designers who used them as the basis for developing designs for new collaborative workspaces in a wide variety of domains, ranging from a 55-seat collaborative decision space for the commander of a large military command to classrooms in an inner-city elementary school to a strategic planning center for a multi-national corporation. Qualitative feedback from the designers and the users of these spaces helped to refine and clarify the approach.

9.1. Future Directions

The research that engendered the design methodology reported here was qualitative and interpretive. Now that the approach has been codified, it would be useful to conduct quantitative research on the degree to which designs derived by this approach produce results that differ from results obtained in spaces designed by other methods. A multi-methodological approach may be useful for that research. Architects who routinely design organizational spaces could be recruited as subjects. Some of them could be trained in the method reported here. Others could continue with conventional methods. Quantitative evaluations could be conducted by a) asking experts to judge the effectiveness of the spaces; b) surveying users of the spaces on their perceptions of the utility of the spaces and their levels of satisfaction with the spaces; c) measuring the productivity of groups on standardized collaborative tasks in spaces of different designs.

While care has been taken to abstract the requirements constructs from specific information technologies as much as possible, this research is also limited in that it is necessarily constrained by my knowledge and familiarity with currently available technology. Extensive use and study of the models presented here will be required to further validate this marriage of collaboration engineering and design programming.

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Daniel Mittleman is an Associate Professor at DePaul University's College of Computing and Digital Media. His research focuses on collaboration engineering, virtual teamwork, and the design of both collaboration and learning spaces. His projects include investigation of collaboration aboard US Navy ships; development of team processes to support architectural planning, collaborative writing, and brainstorming; and the design of technology-supported collaboration facilities. Dr. Mittleman holds an AB and MBA from Washington University (St. Louis) and a Ph.D. from the University of Arizona, and is currently Past Chair and Webmaster of the Environmental Design Research Association. His blog on Virtual Collaboration is http://ihop.typepad.com/virtual

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