A Study of Collaborative Work Practices in a Joint Military Setting

Kevin Swanson, Dr. Jill Drury, Robert Lewis
The MITRE Corporation
202 Burlington Road
Bedford, MA 01730

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Abstract

The United States military's air operations planning process draws upon a diverse and often geographically dispersed group of experts. Effective collaboration is essential to ensure high quality and timely decision making for developing an executable plan that supports the commander's strategic intent. The Air Force has been experimenting with the use of computer-aided collaboration tools, providing a virtual environment in which the planning process can take place regardless of the group members' physical locations. By observing a small number of operators over two one-week periods, we were able to evaluate how well the tools supported the collaborative work. Based on analysis of the collected data, we generated a descriptive representation of the work, information flow, meeting formats, and interactions among group members. This descriptive representation focused on the collaborative work practices as well unique awareness needs of participants in a virtual meeting environment (as opposed to an environment where all group members are physically present). This resulted in specific recommendations for improvements to procedures and techniques as well as suggestions for modifications of the tools themselves to improve the quality of the collaborations.

Introduction

Collaboration and the Military

Computer-aided collaboration is becoming more important in managing air operations as the military moves towards distributed operations. Distributed operations can be characterized by a centralized core of operators and processes that draw upon resources and personnel that may be physically remote. This is not an uncommon model; however the dynamic nature of some work requires that effective collaboration tools be made available that go beyond the more common collaboration tools such as telephone and email. Execution of large-scale joint operations requires coordination among military services (Air Force, Army, Navy, etc) as well as the corresponding support services (logistics, legal, manning, etc.). Each of these groups has requirements and needs that frequently require prioritization and synchronization. It was this management process, and specifically the collaborative work practices of the participants in the distributed virtual environment that became the subject of this study, which took place at the Joint Expeditionary Force Experiment 2002 (JEFX02).

The Joint Expeditionary Force Experiment (JEFX)

JEFX02 was the fourth in a series of large-scale Air Force experiments that help the US Air Force prepare for the challenges of the 21st Century Expeditionary Aerospace Force operations. JEFX brings together people, processes and technologies to experiment with emerging systems, concepts, and procedures to speed the development of enhanced

capabilities to the warfighters in the field. JEFX has provided a means for exploring future capabilities in a distributed and collaborative environment.

Collaboration Tools at JEFX02
The collaboration tools available to the operators at JEFX02 ranged from telephone, email, and Voice-Over-Internet-Protocol (VOIP) telephone, to InfoWorkSpace (an enterprise collaboration toolset developed by Ezenia!), SharePoint Portal Server from Microsoft, a specially designed Air Operations portal from Lockheed Martin, and a custom-designed assessment tool to collect questionnaire data daily. The majority of the collaborations we observed were accomplished via InfoWorkSpace (IWS) tools.

IWS provides a virtual environment, based on a physical office metaphor. Within the virtual environment, there are several office-related objects that allow the operators to interact and collaborate. The environment provides file storage, bulletin boards, whiteboards and other mechanisms spread among virtual rooms separated into virtual buildings. Meetings are pre-arranged to have the participants 'meet' in a particular virtual room, at which time all those in the room are able to communicate using the above described mechanisms.

Some of the most frequently used methods for communication in these virtual rooms included the IWS audio chat, IWS text chat and IWS Shared View. Using IWS audio chat, each participant wore a headset with an integrated push-to-talk microphone and was thus provided the means to hear from or speak to the group. The IWS text chat capability allowed participants to type messages into a common window viewable by all those in the virtual room. The IWS Shared View is a one-way broadcast from one user's workstation to the other users who are in the virtual room, with the result that all participants can see the same material on their workstations.

Collaborative Work Practices
The focus of this study was the collaborative work practices of the military operators including their use of collaborative tools during JEFX02. We took a broad approach to understanding how operators work collaboratively, far beyond looking at a single collaboration tool. To address such an open-ended topic, we formulated a number of specific questions that aided in developing the study methodology. For example, what collaboration methods do operators prefer under what circumstances? Does the choice of collaboration method depend upon the priority or time-criticality of the task? What constraints does the work environment place on the operators' abilities to collaborate? What techniques and procedures are the operators currently following to aid in their use of collaborative tools? Are these techniques and procedures sufficient? How does the collaborative toolset as a whole support the operators in their collaborations?

In response to limited staff and resources, the scope of the study was quite small. We studied only the collaborative work practices of the Guidance Apportionment and Tasking (GAT) Cell of the Plans Division of JEFX02.

Methodology

Contextual Inquiry

To understand operators' collaborative work practices, we knew we needed a data-gathering technique based on observing operators. Observations can be made in several ways; we chose the method called "contextual inquiry" (Holtzblatt and Jones 1993). Contextual inquiry consists of a mixture of quiet observation and brief, interactive interviews that clarify the study conductor's understanding of work activities as they take place. This technique draws on ethnography, which relies on living in a culture to understand work practice, and skills in managing the interpersonal dynamics of an interview. The success of contextual inquiry is based on the partnership of the study conductor and the person whose work practices are being studied.

Contextual inquiry was chosen over a less interactive observation method because it is possible for the study conductors to obtain a more complete understanding of work practices in a comparatively shorter time. The understanding comes about due to the explanations given by the operator whose work practices are being studied. Obtaining rapid understanding was important due to the short duration of the JEFX02 main experiment execution.

There is a danger that the operators' work practices are changed by having to provide explanations to the study conductor. In fact, it is very difficult to establish contextual inquiry partnerships when the person being observed is performing time-critical tasks. This limitation was a factor in choosing to study the GAT Cell in the Plans Division. Unlike the personnel working Combat Operations in the JEFX02 Combined Air Operations Center (CAOC), the GAT Cell personnel do not usually perform time-critical tasks.

Ground rules were established in advance so observations would not interfere with the work being done by GAT Cell members.
- Obtain buy-in from GAT Cell leadership.
  We explained the goal and proposed methodology for the study and obtained the cooperation of GAT Cell leadership prior to commencing observations.
- Request pairings.
  We asked that each study conductor be paired with a primary and a secondary person who we could shadow and who could become a contextual inquiry partner (the secondary partner was needed in case the primary partner became unavailable).
- Establish "stop" signal.
  To avoid hindering the mission, we established signals for the GAT operator to indicate that we should become quiet or withdraw.
- Set time limits.
  Because contextual inquiry can be tiring for both the study conductor and the GAT operator partner, we established limits of four hours of contextual inquiry observation per person per day.
- Collect unclassified, collaboration-related data only.

How operators collaborate is unclassified; we did not need to capture classified information such as system vulnerabilities or threat updates.

Data Collection

The data collected during JEFX02 for the purposes of the collaborative work practices study needed to be unclassified. For this reason, we were not able to collect the kind of data that would lend itself to more quantitative analysis (such as recorded conversations, chat logs, and screen captures). We were, however able to document the relevant characteristics of the collaborations that were observed. Data were collected using worksheets which provided space to capture collaborations as they occurred giving consideration to a number of dimensions, including media used, timeliness, information type, intent as well as general comments. An example of a portion of a filled-out worksheet is included in Table 1. The worksheet shown in Table 1 is the result of some minor, in-the-field refinement.

Table 1. Example Data Sheet for 27 July 2002

Date 27_/Jul/**02**   Operator Shadowed: **Location**/Rank/Name _Plans Maj M._
Position in Nellis CAOC _GAT Targeteer_____

Collabor-ator ID	Time	Media	Time-liness	Info Type	Intent	Results/ Comment
A.	0554	FTF	Took too long	target nominations	Provide target information	May have to have a private GAT for these. Marine tgt noms were 12 hrs late
G.	0557	IWS audio	Good	IWS connection check	Ensure comms working	
G.	0600	IWS audio	Good	target nom-inations	Provide target information	Late target noms; SOLE could not log on earlier
O.	0608	FTF		problem notification	Explain JF's absence	JF. can't get on server
G.	0611	FTF		problem notification	Explain that problem was noted	Lost slideshow, kept audio: 'what the hell was that'
G.	0614			problem explanation	Postulate possible source of problem	Lost slideshow momentarily: 'that might have been operator error'
JF.	0620	IWS audio		problem resolution	problem resolved	JF. on line now
JM.	0624	IWS audio	Took too long			JM sent slides in 2 mins ago, could not show during GAT

Legend:
Media - E-mail (E), IWS Text Chat (ITC), IWS Audio Chat (IWS audio), Face to Face (FTF), Phone (P)
Intent - What AOC subtask is being worked? What info was being sought?
Results - Results of attempt to collaborate: Satisfactory Collaboration (SC), Unsatisfactory (US)

We conducted a number of observations over the course of two one-week periods. In addition to observing, documenting and confirming the intent of the collaborations, we

also took advantage of occasional opportunities to engage in more in-depth interviews to more completely understand the observations we were making.

Work Flow
The basis for making use of the observations is to have a fundamental understanding of the work tasks, motivations and goals. In a relatively short period of time we were able to gain an accurate description of the work. The work done by the GAT team serves to transform component (air, land, maritime, etc) target nominations into the Joint Integrated Prioritized Target List (JIPTL) based on the Air Operations Directive (AOD). The AOD is the product of a preceding function that transforms the Joint Task Force Commander's strategic intent into a set of high-level goals that satisfy the desired effect. The transformation of component nominations into the JIPTL can be described as a four step process. 1. First each nomination needs to be considered in the context of the AOD. 2. Once the nomination is determined to be consistent, it is checked with respect to rules of engagement. 3. Next the GAT team identifies those nominations that require more supporting information to make the decision whether or not the nomination would continue to be considered part of the JIPTL. 4. Finally the prioritization and the determination of where the "cut line" is placed serve to define the scope of operations that is forwarded through the rest of the approval and planning processes. The third and fourth steps typically require the most collaboration, and as such formed the context for the majority of the recorded collaborations. The fourth step is accomplished at a daily GAT meeting, described below.

GAT Meeting Characteristics
Preparation for the GAT meeting begins generally two hours prior with the GAT team chief and the GAT team deputy reviewing the component nominations that are submitted during the hours preceding. Convened every morning at six o'clock, the GAT meeting is the primary means of coordination among components nominating targets. This meeting has approximately 25 attendees, including Judge Advocate General (JAG), Intelligence (Intel), Weather, Special Operations Representatives, service liaison officers, among others. Approximately one-half of the attendees were physically present within the JEFX02 compound, with the other half being located at various spots around the country. All participated via the virtual environment.

The meetings began with two pre-prepared briefings that were conducted using PowerPoint and the IWS Shared View (so all participants could see when the briefer moved from one slide to the next). The first briefing concerned the weather forecast, and the second briefing consisted of an intelligence update. These briefings contained elements previously agreed upon (e.g., the current forecast, the 72-hour forecast) and so were normally completed very quickly. Follow up questions were rarely posed, however when they were, they were generally answered quickly.

The majority of the meetings were spent on discussing nominations and prioritizing targets. The meeting conductor placed a customized spreadsheet in IWS Shared View so all participants could see the list of targets being considered. The meeting conductor picked a target being considered and asked the nominator for a short description of the

importance of the target of the reason for the nomination. The rest of the participants listened if they were interested in that particular target, or "tuned out" until their target nominations were being discussed. Most of these interactions were of great interest only to the meeting conductor and the person describing their target nomination; these interactions were of mild to moderate interest for the rest of the participants. Since the meeting conductor did not discuss the target nominations in strict order, and each nomination required varying amounts of time given the topic of discussion, it was difficult for participants to gauge how long they would have until "their" targets were to be discussed.

GAT Meetings: IWS-Facilitated versus Face-to-Face
The ideal situation for studying collaboration is when multiple activities occur that are the same in all respects (e.g., same participants, same reason for collaboration, same degree of time pressure, etc.) but one, allowing study conductors to understand the effect of the single changing variable. Such a situation is difficult to design in a laboratory experiment and almost never occurs in real-world collaborations. We were fortunate enough to have this situation occur during the JEFX02 exercise.

Normally, GAT meetings occur as described above, facilitated by IWS tools. On the last day of the first one-week period, participants could not log in to IWS because of a server problem. Thus, the meeting was held in a face-to-face format with participants who normally sit in various parts of the JEFX compound sitting together in the Planning Division trailer. Some of the participants could not attend because they were located across the country, but besides this fact and the lack of IWS support, the other meeting characteristics, such as the time available and task at hand, remained the same.

Differences observed in the conduct of the two meetings (virtual vs. face-to-face) were as follows.

- *The Deputy GAT Chief inserted many comments into the flow of the face-to-face meeting to provide amplification and clarification but did not make these comments in IWS-facilitated meetings.* We attribute this fact to the serial nature of the IWS Audio Chat tool: only one person can talk at a time and care needs to be taken to avoid tying up the channel with information that may not be seen as important to moving the meeting forward. In effect, use of the audio chat tends to extend the length of the meeting. As a result, some very helpful comments were not shared over IWS that were shared in the face-to-face meeting.

- *More questions and requests for clarification were raised in the face-to-face meeting than in the average IWS-facilitated meeting.* People who want to ask questions often look around the room to see if other people are wearing puzzled expressions, and if several are observed, will go ahead with a question. There is no way to see other participants' faces in the current IWS tool suite, so participants tended not to ask questions for fear that everyone else understood the issue and thus interrupting the meeting flow would not be appreciated.

- *Participants in the face-to-face meeting persisted in unpopular stands for shorter time periods than in the average IWS-facilitated meeting.* The ability to look

around the room and see expressions in a face-to-face meeting allowed participants to understand that they were voicing an opinion that would be unlikely to garner support. In the absence of this type of awareness of other participants' attitudes, participants in IWS occasionally insisted on something (e.g., "what will it take to get my target in the top ten?") long after other participants were frustrated.

- *Participants in the face-to-face meeting remained in the room for the entire session; participants in IWS-facilitated meetings were observed taking their headsets off (cutting themselves off from the meeting) or leaving the building to get coffee.* The fact that it was more difficult to get clarifications or ask questions may have caused some disengagement due to losing the "gist" of a discussion. Also, no one knew that someone had left the IWS meeting unless he or she was called upon by the GAT Chief to answer a question. Thus, the social cost of leaving the IWS meeting was less than that of leaving the face-to-face meeting as long as the GAT Chief (as the meeting conductor) did not call upon the absent person. If the GAT Chief did call upon the absent person, his or her absence resulted in a delay (while everyone paused) and slowed the meeting if the information could not be supplied in another way.

- *Caucuses split off from, and merged back into, the main group more easily in the face-to-face meeting than in the average IWS-facilitated meeting.* Two people who needed to work together on a targeting issue sat together, slightly off to the side, in the face-to-face meeting and quietly worked out their issue. They kept "one ear" open to the main meeting in case another issue arose that pertained to them. They signaled the completion of their side-meeting in an unobtrusive manner by simply moving back into the main meeting area and returning their complete attention to the GAT Chief. The equivalent situation in the IWS-facilitated meeting was when two participants explicitly arranged to work together using the Text Chat tool, so they could listen to the main meeting via Audio Chat while typing messages to one another. It was more difficult, however, to signal the GAT Chief that they had finished their side-meeting because the GAT Chief was too busy using the Audio Chat and Shared View to monitor the Text Chat very frequently.

Effect of Awareness Problems on Collaboration Quality

The differences in collaboration behavior observed during the face-to-face versus IWS-facilitated meetings can almost all be attributed to a lack of *awareness support*. The term "awareness support" is used in accordance with the definitions below.

Awareness: Given two participants p_1 and p_2 who are collaborating via a *synchronous collaborative application*, awareness is the understanding that p_1 has of the identity and activities of p_2. [Drury and Williams 2002]

Synchronous collaborative application: A computer application used by multiple people at the same time.

Awareness support: When an application provides p_1 with information about the identity and activities of p_2 without p_1 having to request the information or p_2 having to explicitly transmit it. [Drury and Williams 2002]

Awareness information is intended to emulate the kinds of non-verbal cues that people get about each other when they work face-to-face in the same physical environment. To the extent that these cues are not replicated in the virtual environment (or are not used if they are available in the virtual environment), the quality of the collaborative activities tends to degrade. The quality of collaborations can be roughly measured by observing the number of times that participants expressed frustration, the frequency of participants expressing the opinion that "the meetings in IWS take too long" and by the number of negative comments observed (e.g., "there's too much collaboration").

Lack of awareness support (or, in some cases, failure to use available awareness support mechanisms) in the following areas degraded the quality of collaborations:

- *Participants were not always aware of who was speaking for each agency.* Participants' identities were listed as the names of their organization, rather than their personal names. Some organizations were always represented by the same person and they became known over time, but other organizations sent different people to the meeting and the less-than-perfect audio quality of Audio Chat sometimes made it difficult to recognize a person by their voice. Knowing the source of information and understanding the level of trustworthiness of that source's information provides has considerable value when making decisions based on the information.

- *Participants were not aware if another participant was actively listening, half-listening, or absent.* When the GAT Chief asked, "does anyone have any problems with this decision" and no one said anything, he had no way of knowing if the subset of participants most affected by that statement truly agreed or were all out having coffee.

- *Participants were not aware of when other participants were expressing frustration, displeasure, agreement, or any other emotion.* Non-verbal cues that moderate behavior in face-to-face meeting were largely unsupported in the tools used for GAT meetings. This lack caused participants to persist in expressing unpopular opinions, spend more time in expressing consensus, etc.

- *Participants were not always aware of when an agreement was completed; and if they were aware, they did not always have the same understanding of the agreement.* In a face-to-face meeting, a person might suggest, "We could do such-and-such" and, if everyone nods, say, "OK" and tacit understanding of the agreement to do the action is achieved. In IWS, there was no way to see the other participants nod, so the same verbalization ("We could do such-and-such") sometimes struck participants as a nice suggestion but not something they needed to do. Even when participants were aware that an agreement had been made to do a certain tasking, their understanding of this tasking often differed more frequently than in a face-to-face situation. The differences in understanding can be attributed to less frequent use of conversational techniques to find *common*

8

ground in computer-facilitated meetings than in face-to-face meetings (a phenomenon postulated generally by Clark [Clark and Brennan 1991] and shown to be true empirically by McCarthy et al. [McCarthy et al. 1991]).

Common ground: The mutual knowledge, beliefs, and assumptions in a conversation. [McCarthy et al. 1991]

To summarize: the first bullet represents a problem with *identity awareness information*, the second bullet represents a lack of *presence awareness informatio*n, and the third and fourth bullets indicate problems with *activity awareness information*.

Identity awareness information: Information about the identities of other participants in a computer-mediated forum.

Presence awareness information: Information about the presence or absence of other participants in a computer-mediated forum.

Activity awareness information: Information about the activities of other participants in a computer-mediated forum.

Effect of Meeting Format on Collaboration Quality

The format of the 6:00 a.m. GAT meeting never varied over the course of JEFX02. We attribute this fact to our assessment that the meeting worked well for the decision-makers (i.e., the GAT Chief and Deputy GAT Chief). We are less sure, however, that the meeting worked well for the rest of the participants.

To understand the dynamics of the meeting, we examined its characteristics. We broke down the characteristics into the type of information flow versus the tempo of that flow from the point of view of the meeting attendees (not the meeting conductors). The result of our analysis of meeting characteristics is contained in Table 2, where the shaded boxes indicate the types of meeting interactions we observed.

Table 2. Group Meeting Characteristics Versus the Tempo of Relevant Information Flow

Information exchange flow structure		Tempo of relevant information flow from attendees' points of view		
Flow type/direction	**Typical example**	**Intermittent at predictable intervals**	**Intermittent at unpredictable intervals**	**Constant**
one-to-one/ bidirectional	meeting chair addresses comment or question to individual attendees in turn with others listening in	polling each attendee in order on a known topic; usually structured	directing a question to individual attendees in an unpredictable order; e.g., one that depends upon answers to preceding questions (topic not necessarily known in advance); usually fluid	not applicable
one-to-many/ unidirectional	one person presents information to the group	formal presentation of information in a pre-established order, where each attendee is interested in certain portions; usually structured	informal presentation of information, where each attendee may be interested in portions but the exact content or order is not known in advance; usually fluid	information presentation is of vital interest to attendee; usually structured
many-to-many/ multi-directional	group discussion of a topic of common interest; group may splinter to discuss several topics simultaneously	not applicable	brainstorming or free-form discussion session; usually fluid	discussion topic is of vital interest to attendee; usually fluid

Notes: Gray cells show the types of exchanges that we observed during GAT meetings. Meeting formats can be constructed using a combination of these characteristics.

The time-ordered combination of these meeting characteristics composes a meeting format. As an example, we describe the meeting format for a typical GAT meeting in Table 3.

Table 3. Meeting Format for Typical GAT Meeting

Time	Flow type/ direction	Meeting component	Media	Tempo of relevant information flow
0600 – 0610	One-to-many/ unidirectional	Weather update, intell update	IWS Shared View + audio	High (structured, formal presentations)
0610 – 0700 except for occasional one-to-many	One-to-one/ bidirectional	Target nomination and prioritization	IWS audio + Shared View	Low except for short periods at unpredictable intervals (polling of attendees in unpredictable order)
0610 – 0700 occasionally	One-to many/ unidirectional	Target nomination and prioritization	IWS audio + Shared View	Low except for short periods at unpredictable intervals (informal presentation of information on particular issue(s))
0610 – 0700 concurrent with above	Many-to-many/ multidirectional	Backchannel for various purposes	IWS text chat	Low except for short periods at unpredictable intervals (informal, multithreaded chat comments that are often humorous, editorial, or off-topic)

After the first ten minutes (when participants are most alert), the tempo of relevant information drops dramatically. The attendees were generally interested in a small subset of targets (the ones they had nominated), yet they must listen to the GAT Chief go through a list of targets, often not in the order in which they are listed, asking specific questions directed to one or a few people. Such an approach made it difficult for attendees to keep their attention on the meeting, leading to them working on their email messages, taking off their headsets to talk to the person next to them (occasionally), or going for coffee (sometimes). In general, whenever the tempo of relevant information delivery is low over extended periods, it is difficult for attendees to maintain focus.

Recommendations

One of the major questions this study posed was whether the procedures in place for collaboration are sufficient and, if they are not, to recommend additional guidance. In some cases, selected procedures existed as part of the Business Rules for JEFX02 but were not followed and we observed degraded quality of collaboration as a result. In other

cases, procedures did not exist and we recommended that they be implemented. Below are our recommendations; we note when procedures existed but were not followed. These recommendations were specifically formulated to resolve problems with the meeting format as well as insufficient identity awareness information, presence awareness information, and activity awareness information as discussed in the previous section.

Meeting Format

- The GAT Chief could announce at the beginning of the meeting the order in which blocks of targets will be discussed, so participants understand roughly when they will be needed. Note that all participants would still be welcome to attend the entire meeting. This approach, however, would allow participants to schedule any necessary breaks or sidebar conversations in such a way that they will be alert and available during the portions of the meeting that apply to them.

- Run the GAT meeting in a primary virtual meeting room but also assign participants to a secondary virtual room in addition, based on service affiliation (e.g., Navy, Marines, Army, and Air Force) or another functional allocation. The reason for this approach is so that participants can work on issues of mutual interest in the secondary virtual meeting room, if needed, during the period(s) during which their targets are not being discussed.

Information Management/Knowledge Management

- Follow document naming conventions for GAT target nomination inputs. Further, we recommend that the inputs be placed in a single location that is well-known to all participants. We observed significant confusion over whether the inputs should be transmitted via email or placed in a particular file cabinet location; there were many options for document storage and participants did not always know which option to use.

Identity Awareness Information

- Adopt a mechanism to allow participants to easily view the individual names for participants (as opposed to organizational affiliation). In general, IWS does not easily support using two identifiers for a person (organizational and personal). We suggest that a directory of names, affiliation, roles, and contact information be provided to aid in accessing identity information for fellow participants if IWS (or another system that does not support viewing of both names and organizational affiliations) is used in the future. Such a directory could even be as simple as a spreadsheet that is accessed via links found in each IWS room. Operators in another part of JEFX02 developed a workaround that represents another example of a technique that could be used by the GAT meeting participants: they placed their names and affiliations on virtual post-it notes that were then posted on a shared virtual bulletin board.

Presence Awareness Information

- Use a non-disruptive mechanism to alert fellow participants that they are withdrawing from the meeting either for a few minutes or for the rest of the meeting. Note that this was identified prior to the conduct of JEFX02 as a Business Rule ("Participants notify group, via chat, prior to departure from session") but it was not generally followed. We stress "non-disruptive" because we recommend that participants use a mechanism other than the main communications channel. For example, there is an IWS "in/out" feature that participants could set to provide a notice in the interface that they are away from their desks. Alternately, participants could use public Text Chat, which functioned as a "backchannel" during JEFX02 (meaning, it was a means of sharing reactions or slightly off-topic postings). We further suggest that a meeting participant, such as the Deputy GAT Chief, be charged with monitoring the in/out feature, Text Chat, or whatever other mechanism is being used for this purpose to understand who is, and is not, present at the meeting at any given time.

Activity Awareness Information

- Use techniques to establish "common ground" among participants. An example of a grounding technique when assigning a task to a participant is to ask the participant to repeat what he/she understands to be his/her action.

- Make more use of the activity awareness support provided by IWS, such as polling/voting tools and color-coded feedback to presenters (use of the latter was an existing Business Rule). For example, it is easier for attendees to vote "yes" or "no" in response to the question "does everyone agree?" than to participate in a verbal polling or (if a poll is not used) expect someone to speak up if they disagree.

- Assign a person the responsibility of monitoring the collaboration media for evidence of dissatisfaction, frustration, or confusion (e.g., by reading the public Text Chat) and alert the meeting conductor to the problems experienced by the participants. The meeting conductor would use this information to modify his/her approach (e.g., call a break or ask for several participants to continue the issue via a side meeting).

- Assign a person the responsibility for capturing changes to shared artifacts (e.g., verbal corrections to a decision brief) in real time as they are agreed to by the participants. In several cases, corrections were made verbally but not to the artifact; but then the artifact was archived (preserving the error) and caused confusion when the materials were reviewed at a later date.

Training Implications

Establishing good collaboration procedures requires specific training in collaboration work practices. It is unrealistic to expect that everyone will automatically know how to efficiently collaborate. While the following is not intended to be an exhaustive list of collaboration work practices to be trained, our observations indicate the need for emphasizing these points:

- Where to find information about fellow participants, and how to add or update information about yourself.

- How to use a mechanism that indicates whether you're actively a part of the meeting or not (and the fact that such a mechanism should be used).

- What to use the various communications channels for (e.g., Text Chat for off-topic comments; secondary virtual meeting room for working issues that are not of general interest).

- How to establish "common ground" among participants.

- How to use feedback mechanisms (e.g., voting/polling tools).

- How to name, and where to store, documents.

Conclusions and Future Work

One of the questions often asked about using collaborative applications is: what is the value of having specialized collaboration tools? The simple answer for the GAT Cell is, without some kind of collaborative tools the distributed decision-making process necessary to construct the JIPTL could not take place. Of course, the JIPTL could be coordinated using telephone conferencing and email (both considered to be collaborative tools), but this baseline does not lead to as much efficiency and accuracy as can be attained using specialized collaboration tools. The differences between having IWS (an "augmented collaborative tool") versus having only telephone and email ("baseline collaborative tools") are described below in Table 4.

Table 4. Benefits of Augmented Collaborative Tools versus Baseline Collaborative Tools*

Augmen-ted tools	Additional functionality provided	Baseline tools	Example of augmented tool use vs. baseline tool use	Benefit of augmented tools
Shared view, including shared cursor	Ability for everyone to focus on the same part of a document at the same time (one person at a time "drives" the display)	Emailing a document plus verbal explanations for where to look and what to focus on	Without a shared view, one needs to say (and have all listeners mentally process), "see the small box in the left hand corner of the briefing chart, next to the red circle, below the green square?," versus "see this?" accompanied by moving a shared cursor to the proper location.	Time savings avoiding verbal explanations; greater com-munications accuracy
Shared white-board	The ability to draw quick diagrams on the fly using a shared whiteboard tool	Drawings imported into a common-format document and emailed to participants	Without a shared whiteboard, it is very difficult to share quick sketches that illuminate discussion.	Additional clarity of communica-tions and time savings

*Augmented tools in this table are assumed to consist of IWS; Baseline tools consist of telephone with conferencing ability and email.

Table 4. Benefits of Augmented Collaborative Tools versus Baseline Collaborative Tools, concluded*

Augmented tools	Additional functionality provided	Baseline tools	Example of augmented tool use vs. baseline tool use	Benefit of augmented tools
Shared feedback mechanism	The ability to give a speaker feedback without interrupting the main flow of information.	Interrupting the speaker on the telephone	A shared feedback mechanism can consist of notification that there are questions, comments or problems; and/or text describing the question, comment, or problem. By using the "stoplight" feedback mechanism in the IWS auditorium, the speaker would know when there are questions or an attendee needs technical assistance, without interrupting the presentation.	A greater percentage of relevant vs. irrelevant material presented; written questions can help speed the speaker's response.
Shared secondary channel	The ability to discuss issues in small groups without involving the entire meeting; also, a place to vent frustration or have off-topic conversations	Interrupting the speaker on the telephone	GAT meeting attendees used as a "backchannel" (an unobtrusive means of communications that avoids impacting the main meeting) a public chat room to make quick, humorous, semi-critical comments that vented frustration. There is a high social cost for interrupting the main meeting (the only option available in the workaround).	Smoother social dynamics; interruptions on the main channel are undesirable
Mechanism to notify others of an absence	A means of saying when an attendee has stepped away from the meeting temporarily	Interrupting the speaker on the telephone	In IWS, an attendee can set an "away" message. Efficiency results when meeting attendees are not waiting for someone to respond to a question, not realizing that the person being addressed is not present.	Greater efficiency of communications

*Augmented tools in this table are assumed to consist of IWS; Baseline tools consist of telephone with conferencing ability and email.

If the recommendations from the previous section are implemented, we anticipate that the magnitude of the benefits listed in table 4 would, in general, increase for the GAT Cell in the next JEFX. We suggested that the effect of implementing the recommendations be studied, however, during conduct of JEFX-04.

Approach for Follow-On Work

The basic idea behind contextual inquiry, to observe users in their work context and enlist their help in understanding their workflow and collaboration needs, is a good one. Thus, we believe contextual inquiry should be used in the follow-on study that examines the effects of implementing our recommendations. We suggest a slight modification in how data is gathered, however. We began gathering data by focusing very narrowly on the persons being shadowed: we looked at who they interacted with, how they effected the interaction, and whether the interactions (collaborations) were successful. While not a

bad approach, this sometimes led to "tunnel vision," a situation in which we focused on a small set of individuals and did not completely capture observations about the environment in which they were working. Accordingly, we suggest that data gatherers for the follow-on study broaden their viewpoint by trying to capture the following information:

- Frequent or "typical" collaborations, and tools used for those collaborations

- What roles/functions the tools perform in the collaboration context

- How well tools provide awareness of fellow collaborators

- Strategies people use to work around impoverished awareness of the presence, identities, or activities of their collaborators

- "Notable" events:

  - deviations from expected flow or activity

  - frustrations expressed

  - problems encountered

  - calls for consensus

  - attempts to focus attention

  - lengthy or complex collaborations (opportunities for performance improvement)

Summary

By studying collaborative work practices, we are able to better understand what is required of the tools that are necessary to support participants in virtual meeting environments. Examples of the information needs include awareness information, including presence awareness, identity awareness and activity awareness.

Conducting work in a virtual environment is something that is becoming more commonplace, however being an effective communicator and delivering high quality decisions in a virtual environment requires a set of skills that are different from those needed in a face-to-face environment. These skills can be learned and should be trained and exercised. Conducting virtual meetings requires that the meeting conductor take special care to manage the tempo of relevant information flow to encourage high performance and prepared participants. Well established business rules that describe the accepted procedures, and adherence to those procedures, will result in higher quality collaborations and ultimately higher levels of achievement.

For the United States military, distributed operations will likely become common practice, in which the quality of the outcomes will be based partly on the ability of the decision makers to effectively collaborate in virtual environments.

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