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Report

Virtual Collaboration for a Distributed Enterprise

Amado Cordova, Kirsten M. Keller, Lance Menthe, Carl Rhodes

RAND CORPORATION

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RAND Project AIR FORCE

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Preface

Breakthroughs in satellite and fiber-optic telecommunication networks and related technologies currently enable almost instantaneous transmission of information across the globe. Many private and public organizations have become used to depending on the global information grid to perform their daily operations. A firm with headquarters in the United States can interact with multiple affiliates and customers located on the other side of the globe in real time. With such technological advances, the need has arisen for virtual collaboration means that allow personnel at geographically diverse sites to interact and communicate effectively. Having the most effective means of virtual collaboration and ensuring they are used in the most effective way are paramount to achieving error-free, real-time communication, a goal that is particularly important for military operations.

In this report we address the virtual collaboration needs of organizations whose components have wide geographic distribution, such as U.S. military intelligence organizations or U.S. military operational units.

The research reported here was sponsored by the Deputy Chief of Staff for Intelligence, Surveillance and Reconnaissance (ISR), Headquarters United States Air Force (HQ USAF); the Assistant Deputy Chief of Staff for ISR, HQ USAF; the Director of Intelligence, Headquarters Air Combat Command (HQ ACC); the Director of ISR Capabilities, HQ USAF; and the Technical Advisor for ISR Capabilities and Integration, HQ USAF, as part of a fiscal year 2010 research effort, "Sizing the U.S. Air Force ISR Force to Meet Future Challenges." The study was conducted within the Force Modernization and Employment Program of RAND Project AIR FORCE (PAF).

The findings and recommendations in this report are relevant to organizations that conduct geographically distributed real-time military operations, including the Air Force, the Army, the Navy, the Marines, and members of the national Intelligence Community.

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Summary

The geographic diversity of many military enterprises, along with that of their partners and customers, has made virtual collaboration indispensable for conducting daily operations. To realize the potential of fully distributed teamwork, personnel at different work stations within the same site, as well as those at different sites, need to be able to work together. Virtual collaboration tools can enable intrasite and intersite collaborative analyses, can allow for sites to provide more effective surge capacity, and can allow the regional expertise developed at each site to be applied wherever necessary across the enterprise.

But communication between non-colocated (virtual) teams poses important challenges. Experts argue that face-to-face interaction—a means of communication that is unavailable to non-colocated teams—is the richest and preferred medium for conveying and correctly interpreting information in ambiguous or uncertain situations, as well as for facilitating a shared meaning or understanding of that information.[1,2] Face-to-face interactions can provide multiple nonverbal and auditory cues, such as tone of voice, hand gestures, and facial expressions, which allow the expression of feelings and provide greater personalization. Scholars argue that a lack of these cues can interfere with the team interactions necessary for effective collaboration.[3] Moreover, scholars argue that the ability to directly observe the work ethic and quality of other team members' output is important for building trust in their competency and ability to deliver quality work.[4]

Currently, secure chat is the preferred virtual collaboration medium for real-time communication between military personnel and their customers and partners due to its capacity to provide immediate feedback and its low bandwidth requirements. However, it lacks personalization, cannot provide nonverbal cues capable of conveying complex and nuanced messages, and can lead to difficulty in building trust among virtually interacting team members. Therefore, text-based communication tools, such as chat, which lack the "richness" of face-to-face communication, may not always be the optimum communication medium when two virtually interacting teams are trying to come up with a common assessment of an ambiguous or uncertain tactical situation on the ground. Moreover, the use of such computer-mediated

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[1] This report examines how the disciplines of communications, psychology, organizational behavior, and information systems have dealt with these issues using media-richness theory. We provide literature references from these disciplines throughout the report. See, for example, Richard L. Daft and Robert H. Lengel, "Organizational Information Requirements, Media Richness and Structural Design," *Management Sciences*, Vol. 32, 1986, pp. 554–571.

[2] Richard L. Daft, Robert H. Lengel, and Linda K. Trevino, "Message Equivocality, Media Selection, and Manager Performance—Implications for Information-Systems," *MIS Quarterly*, Vol. 11, 1987, pp. 355–366.

[3] James E. Driskell, Paul H. Radtke, and Eduardo Salas, "Virtual Teams: Effects of Technological Mediation on Team Performance," *Group Dynamics, Theory, Research, and Practice*, Vol. 7, 2003, pp. 297–323.

[4] Aubert A. Benoit and Barbara L. Kelsey, "Further Understanding of Trust and Performance in Virtual Teams," *Small Group Research*, Vol. 34, 2003, pp. 575–618.

communication is hypothesized to be more likely to lead to lower levels of trust among team members.[5]

In this report, we address these challenges and make several recommendations to tackle them using virtual collaboration tools.

To determine which virtual collaboration tools and features are most beneficial, we recommend that intelligence enterprises invest in experimental research involving simulated tasks and constraints that closely mimic the enterprise's operational environment. One option is to conduct this research through current U.S. military exercises such as Sentinel Focus, for example, or larger exercises such as Virtual Flag.[6]

We also recommend that intelligence enterprises standardize the lexicon and communications practices associated with chat and virtual collaboration, as well as train personnel in the proper use of computer-mediated communication tools. Establishing a standard lexicon and best practices for computer-mediated communication and training personnel in their use may help prevent misunderstandings and decrease the potential for errors. Such standardization should be joint, given the nature of recent operations.

Personal videoconferencing is the best proxy for face-to-face communication and can alleviate the shortcomings of chat to a certain extent. We therefore recommend that intelligence enterprises experiment with the use of videoconferencing (including personal or webcam-based videoconferencing) for real-time communication between personnel at different sites and between personnel and their partners and customers.[7] In particular, we recommend that Air Force intelligence enterprises consider the use of personal or webcam-based videoconferencing (1) between Air Force intelligence personnel and remotely piloted aircraft (RPA) flight crews and (2) between intelligence personnel located at different sites. To avoid the cognitive overload that may occur with additional communication requirements,[8] we suggest limiting webcam communication to noncritical times during an operation, such as when crews communicate virtually for the first time in a given work shift. Webcam sessions can also be used to enhance the personal interactions between these teams during other noncritical times of the work shift.[9] There are numerous commercial tools (Skype, FaceTime, Tanberg, etc.) that could be adapted to the military's tight security environment to facilitate personal videoconferencing.

Still, for the purpose of meeting and building trust, there is no substitute for face-to-face communication. Personal experience with people, procedures, and facilities goes a lot further than reading the tactics, techniques, and procedures of another organization. Therefore, we recommend that intelligence enterprises encourage face-to-face interactions whenever practical to familiarize supporting personnel with supported personnel and vice versa.

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[5] Driskell, Radtke, and Salas, 2003.

[6] Sentinel Focus and Virtual Flag are exercises in which Air Force intelligence personnel participate.

[7] The high bandwidth requirements of webcam communication may preclude its use inside a particular theater of operations or between the continental United States (CONUS) and such a theater.

[8] Cognitive overload is defined later in this report.

[9] The decision about when to have these additional sessions will have to rely on the discretion of the commanding officer.

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The generosity of all these experts made this work possible.

[10] Amado Cordova, Lance Menthe, Lindsay D. Millard, Kirsten M. Keller, Carl Rhodes, and Jeffrey Sullivan, *Emerging Technologies for Intelligence Analysts: Recommendations for the Air Force DCGS Enterprise*, Santa Monica, Calif.: RAND Corporation, TR-1139-AF, 2012. Not available to the general public.

Abbreviations

AOC	Air Operations Center
AOR	area of responsibility
COCOM	Combatant Command
CONUS	continental United States
FMV	full-motion video
HQ ACC	Headquarters Air Combat Command
HQ USAF	Headquarters United States Air Force
HUMINT	human intelligence
IRC	Internet relay chat
IS	intelligence squadron
ISR	intelligence, surveillance, and reconnaissance
OLIVE	On-Line Interactive Virtual Environment
PAF	Project AIR FORCE
RPA	remotely piloted aircraft
SIGINT	signals intelligence
UAV	unmanned aerial vehicle
VoIP	voice over Internet protocol

1. The Need for Effective Virtual Collaboration

This report examines the need for effective virtual collaboration among military intelligence enterprises that comprise multiple sites distributed over a wide geographic area, such as the area of responsibility (AOR) of a Combatant Command (COCOM), a country (e.g., Afghanistan), or the entire globe. In this report, we use the word "enterprise" to refer to an organization with wide geographic distribution that performs intelligence analysis in support of military operations. In addition to interacting and communicating among themselves, personnel at these enterprises' individual sites must also engage in daily interactions with partners located elsewhere (e.g., RPA pilots and sensor operators located in the United States and the Air Force Air Operations Center [AOC] in theater); with other intelligence organizations; and with multiple customers, including commanders in theater, "boots on the ground," U.S. government agencies, coalition military partners, and humanitarian assistance and disaster relief organizations.

To illustrate the complexity of the human interactions among the various components of an intelligence enterprise, its partners, and its customers, we present the following notional narrative: Enemy insurgents prepare to ambush an allied military convoy in a theater of operations. Thousands of miles away, at an enterprise site, a signals intelligence (SIGINT) analyst recognizes the impending ambush. He presses a button attached to his headset to speak to a pilot flying half a world away and quickly conveys the details of the ambush. The pilot then switches to the communications channel monitored by the ground convoy to inform them of the danger. The SIGINT analyst speaks directly to his commander, who immediately rallies his various team heads. The commander directs the head of his analytical team to fuse the latest intelligence reporting about the convoy's geographic area from all available sources. He then directs some of his personnel to communicate via secure chat or secure phone with relevant partners to recommend that they re-direct an unmanned aerial vehicle (UAV) to provide additional overhead surveillance in the convoy's area. Additional personnel are in charge of communicating with intelligence partners located around the globe to facilitate the cross-cueing of intelligence gathered by numerous sources. Finally, the commander directs his crew to coordinate everything with their intelligence counterparts in the battalion in charge of the convoy. Moments later, intelligence analysts separated by many time zones exchange what they know about the potential ambush through secure chat, and a large amount of information about the enemy is received on the analysts' computers in theater.

This example shows two important aspects of daily human interaction in an intelligence enterprise. First, rapid and clear communication within a particular site, across sites, and with various partners and customers is needed for operations to run effectively. Second, because of the geographic distribution of sites, partners, and customers, this communication requires the use of virtual collaboration tools. Intelligence enterprises (as well as most of the military) use several legacy tools, such as secure chat and telephone, in an attempt to meet their current needs. However, with continuing improvements in technology, intelligence enterprises could benefit from exploring how to best use and adapt available virtual collaboration tools, as well as how best to modify those tools they already use. We envision tools that could make collaboration between crews more efficient, enable experts stationed in different parts of the world to more easily and effectively work together, and improve the ability to manage and organize workflow across the intelligence enterprises. Additionally, these tools could improve the ability of sites to provide additional surge capacity to one another as needed and could provide a natural impetus for standardizing procedures. In turn, standardized procedures could simplify training, among other benefits.

In assessing the effectiveness of these tools, it is important to consider not only their technological functionality but also their impact on group dynamics and productivity. As a growing body of literature has shown, virtual collaboration and the communication media used to facilitate this collaboration have significant implications for team functioning and effectiveness.[1,2]

In this report, we present a brief review of the empirical literature on available virtual collaboration tools and their potential advantages and disadvantages in situations relevant to a typical intelligence enterprise.[3] It is important to note that teams in general, including the distributed teams described in this report, face their own challenges, and their effectiveness depends on various factors beyond the virtual collaboration tools they use, including team composition, temporal framework, and organizational context. In this report, however, we focus specifically on the influence of various types of virtual collaboration tools on team dynamics and effectiveness. We start by reviewing the impact of different types of virtual collaboration on team dynamics and team effectiveness (Chapter Two). We continue by describing in more detail the three main types of virtual collaboration tools, namely computer-mediated communication (Chapter Three), audioconferencing (Chapter Four), and videoconferencing (Chapter Five). We then discuss methods of evaluating the performance of virtual collaboration tools (Chapter Six). Finally, we provide recommendations for improving the use of virtual collaboration tools (Chapter Seven).

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[1] For simplicity, we refer to all groups working collaboratively as "teams" in this paper, even though "working group" may sometimes be more appropriate.

[2] See Carolyn M. Axtell, Steven J. Fleck, and Nick Turner, "Virtual Teams: Collaborating Across Distance," in Cary L. Cooper and Ivan T. Robertson, eds., *International Review of Industrial and Organizational Psychology*, Vol. 19, 2004, pp. 205–248; James E. Driskell, Paul H. Radtke, and Eduardo Salas, "Virtual Teams: Effects of Technological Mediation on Team Performance," *Group Dynamics, Theory, Research, and Practice*, Vol. 7, 2003, pp. 297–323; Luis L. Martins, Lucy L. Gilson, and M. Travis Maynard, "Virtual Teams: What Do We Know and Where Do We Go From Here?" *Journal of Management*, Vol. 30, 2004, pp. 805–835; Lynne Wainfan and Paul Davis, *Challenges in Virtual Collaboration*, Santa Monica, Calif.: RAND Corporation, MG-273, 2004.

[3] When appropriate, we will also briefly describe relevant examples of the use of these tools.

2. The Impact of Different Types of Virtual Collaboration on Team Dynamics and Team Effectiveness

In broad terms, *virtual collaboration* can be defined as the act of working together across boundaries of space, time, and organization, aided by tools and technology.[4] What distinguishes virtual collaboration from ordinary collaboration, or teaming, is that virtual collaboration uses tools and technology to create some form of shared space (some would say shared awareness) that allows participants to interact, to some extent, as though they were physically in the same place at the same time—that is, the participants can hear each other, see each other, and/or exchange pictures and notes. Common virtual collaboration tools include computer-mediated communication, audioconferencing, and videoconferencing.

In such disciplines as communications, psychology, organizational behavior, and information systems, media richness theory[5] is often used to examine the extent to which virtual collaboration tools may provide an effective medium for relaying information. According to media richness theory, different communication media vary in the degree to which they are able to convey cues (e.g., tone of voice, nonverbal gestures) and allow for immediate feedback, personalization, and language variety. Media that convey more of these characteristics are considered to provide richer information and are theorized to be better at reducing ambiguity and uncertainty. Richer communication media have a greater capacity to facilitate a sense of shared meaning or understanding of the information being relayed.[6] Using multiple cues, such as tone of voice and body gestures, helps to convey information so that it is correctly interpreted and also aids in the expression of feelings. The ability to provide immediate feedback allows individuals to develop a common understanding of the information being conveyed. Personalization allows for a message to be tailored to a specific individual.[7] Finally, language variety refers to the use of natural language to convey nuances in a message.

Face-to-face communication is considered the richest type of communication, because it allows for the reading of nonverbal cues, allows individuals to ask questions and verify a mutual understanding, and allows for personal interaction. On the other end of the continuum, formal written documents (particularly numerical output) are considered the least rich type of communication. Communication via formal written documents involves no human interaction at all, so nonverbal and auditory cues are unavailable; there is also no opportunity to directly clarify potential misunderstandings.

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[4] Robert P. Biuk-Aghai, *Patterns of Virtual Collaboration*, Sydney, Australia: University of Technology, 2003.

[5] Richard L. Daft and Robert H. Lengel, "Organizational Information Requirements, Media Richness and Structural Design," *Management Sciences*, Vol. 32, 1986, pp. 554–571.

[6] Richard L. Daft, Robert H. Lengel, and Linda K. Trevino, "Message Equivocality, Media Selection, and Manager Performance—Implications for Information-Systems," *MIS Quarterly*, Vol. 11, 1987, pp. 355–366.

[7] For example, the expression of feelings through tone of voice or facial expressions helps to create a more personal interaction.

To underscore the importance of face-to-face communication in military intelligence operations, let us examine an example that illustrates impact on the real-time interactions between an intelligence enterprise and its partners and customers. The enterprise's teams, collaborating virtually with partner teams and customer teams, are continuously examining tactical information coming from the theater and trying to make sense of it—they are trying to find out the "ground truth." The information they receive is often ambiguous and uncertain. Imagine two non-colocated teams are observing the same RPA video feed. On occasions, interpretation of what is happening in the video can be ambiguous: Are the people being observed enemy fighters? Are they carrying weapons? Are there civilians among them? Are there children among them? The two teams may come up with different answers to these questions. However, if they were colocated, nonverbal cues, such as eye contact[8] and appropriate posture, could convey to others a team member's confidence that he or she has assessed the situation correctly.

Of course, confidence does not imply correctness. However, conveying confidence can reassure the listener that the speaker has provided his or her best assessment of the situation. Tone of voice and body gestures can also help convey which aspects of the assessment are most critical for the team members. Moreover, colocation could allow the two teams to directly observe each other's work and thus build trust in the quality of that work. Therefore, a rich medium, such as face-to-face communication, would better enable these two teams to arrive at a common assessment of the situation on the ground. Colocation, however, is obviously not always possible. Virtual collaboration tools can provide an alternative to face-to-face communication, as we explain later in this report. In the next three chapters, we describe the most common types of virtual collaboration tools (computer-mediated communication, audioconferencing, and videoconferencing) and review prior research on how the richness or availability of different cues for each of these tools may impact team effectiveness.

[8] A widely used nonverbal cue that leaves little doubt in the listener's mind that the speaker means what he or she says is to be looked in the eye.

3. Computer-Mediated Communication

Computer-mediated communication consists of a variety of technologies and techniques that do not involve real-time audio or visual communication; data conferencing is another term sometimes used for this category. Online discussion boards, chat rooms, and email are all considered forms of computer-mediated communication.[9]

In particular, many organizations rely heavily on Internet relay chat (IRC)[10] rooms for real-time (i.e., synchronous) communication.[11] This communication medium is also generally referred to simply as chat or mIRC chat.[12] There have also been recent advances in computer-mediated communication, including the creation of virtual worlds, such as Linden Lab's Second Life and Forterra's On-Line Interactive Virtual Environment (OLIVE). In these three-dimensional virtual spaces, each participant is "present" via a personal avatar—a synthesized representation of the person. With advanced sensors such as facial markers,[13] the avatars can convey nuanced facial expressions using much less bandwidth than videoconferencing, and the virtual environment can provide avatars with collaboration props and tools, such as a virtual chalkboard. Research also continues in mixed virtual collaboration and management tools such as Google Wave, which combines features of chat, email, and graphics and document sharing.[14] Through these technologies, distant team members can now work together more closely than ever before. All of these technologies could be considered for future developments. However, the current focus of military intelligence organizations concerning computer-mediated virtual

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[9] Of course, this method may also be supplemented with either audioconferencing or videoconferencing.

[10] Chat is also referred to as *Internet Text Messaging*. One popular form is IRC, a type of real-time Internet text messaging or synchronous conferencing mainly designed for group communication in discussion forums ("chat rooms"). IRC also allows one-to-one communication via private messaging, as well data transfer, including file sharing.

[11] The difference between asynchronous and synchronous communication is in terms of the expected response time. Synchronous communication indicates an expected response time commensurate with that of ordinary face-to-face conversation, plus any (usually fixed and small) lag-time for transfer. Asynchronous refers to communication that involves any noticeably longer response time, although these terms have flexibility. For example, some chat programs transfer text as it is entered, while others wait until the user indicates the line is complete (e.g., presses the enter key) before sending the line.

[12] mIRC is the world's most popular IRC client, launched in 1995 by Khaled Mardam-Bey. The intended meaning of the lowercase "m" in the acronym has never been definitively explained.

[13] A facial marker is a device applied to a person's face to track his or her gestures. It is part of the technique of Facial Motion Capture, by which the movements of a person's face are electronically converted into a digital database using cameras or laser scanners. This technique is widely used in the film industry. There are also Facial Motion Capture techniques that do not require the use of markers.

[14] Although Google has chosen not to support this project further, the product was pulled due to a lack of consumer interest rather than any technical shortcomings. See Karim R. Lakhani, "Google Wave's Decision," *Harvard Business Review*, August 6, 2010.

collaboration tools is on the text-messaging capabilities of chat. Therefore, for the remainder of this report we refer to chat as the legacy computer-mediated communication medium.[15]

Use of Legacy Computer-Mediated Communication

In many military and nonmilitary organizations, chat is currently one of the preferred means of communication for situations in which rapid information exchanges between personnel not physically located at the same site are critical. Military organizations rely heavily on secure IRC rooms for synchronous communications. At many sites today, it is common for intelligence personnel to participate in a dozen chat rooms at once. Chat is routinely used to exchange information in real time between intelligence personnel located at different sites around the world; customers, such as an Army battalion headquarters in Afghanistan; and partners, such as RPA pilots and sensor operators (RPA flight crews) in the continental United States (CONUS) or elsewhere. For example, using chat, the customer in theater may request the RPA pilot to redirect the aircraft flying in southern Afghanistan to a nearby orbit.[16] The sensor operator would then use chat to inform the customer and the intelligence personnel where that RPA's full-motion video (FMV) sensor is pointing and adjust that sensor's aim point according to instructions also provided via chat. The customer would then also use chat to convey his or her immediate needs to the intelligence personnel in real time. These personnel would provide critical information from their real-time analysis of the video to the customer through chat. Thus, using chat, these three stakeholder groups—the customer, the RPA pilots and sensor operators, and the intelligence personnel—exchange information and ideas about the severity and danger of the situation developing on the ground and on the possible risks of collateral damage if a strike is being pursued.

As the above examples illustrate, in the military operational environment, the dynamic and rapidly changing nature of customers' intelligence requirements have made chat particularly valuable. Chat allows for real-time communication and almost-immediate feedback.[17] Moreover, because chat consists of only text, the bandwidth and other telecommunications network requirements to support this type of communication are relatively easy to satisfy.[18] Finally, a large proportion of the messages between intelligence personnel and their customers and/or partners during real-time operations are not likely to be ambiguous or pertain to ambiguous situations; thus, for conveying these messages, chat is an adequate communication medium.

[15] Some of the other media that we will be referring to, such as audioconferencing via voice over Internet Protocal (VoIP) and webcam-based sessions, are also computer-mediated.

[16] This particular exchange between the customer and the RPA flight crew can also occur via secure telephone line.

[17] The current state-of-the-art in telecommunications networks is such that the transmission delay is relatively small and thus feedback can be considered almost immediate.

[18] In other words, the insufficient bandwidth available for communication between intelligence, surveillance, and reconnaissance (ISR) assets, supported units (customers), and intelligence personnel has resulted in chat becoming the main communication medium during operations.

Impact of Legacy Computer-Mediated Communication on Team Effectiveness

According to media-richness theory,[19] a text-based communication tool, such as chat, is considered a less-rich medium of communication, given that it lacks the visual and auditory cues found in face-to-face interactions. It also lacks personalization of the messages. Therefore, chat is argued to be less effective at conveying information that is more ambiguous. In particular, chat may be a less effective communication medium when two virtually interacting (non-colocated) teams are trying to come up with a common assessment of an ambiguous and uncertain tactical situation on the ground. The previous example of two non-colocated teams observing the same RPA video illustrates this point.

Furthermore, research finds that teams using legacy computer-mediated communication report less cohesiveness[20] and more difficulty developing trust compared with face-to-face teams and teams using audio or video.[21] In the context of an intelligence enterprise, insufficient trust and a possible lack of cohesiveness have the potential to hamper the interactions between intelligence personnel and RPA flight crews, as well as their effectiveness when executing joint missions.

Scholars also argue that the lack of nonverbal and auditory cues (e.g., tone of voice, hand gestures, facial expressions), which allow for the expression of feelings and greater personalization, can interfere with the development of interpersonal relationships.[22] For example, scholars argue that the lack of social context cues in less-rich media can provide a sense of anonymity, leading to a state of deindividuation. That is, people may be less likely to focus on how they could impact others, are less inhibited and polite, and may have more difficulty forming interpersonal relationships.[23] As a result, the use of computer-mediated communication is hypothesized to be more likely to lead to lower cohesiveness and trust among team members.[24] Similarly, without being colocated, it can be difficult to observe the effort put in by other team members. Being able to directly observe the work ethic and the quality of other team members'

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[19] Daft and Lengel, 1986.

[20] Cohesiveness consists of three components: interpersonal attraction; the extent to which people like their team members; the extent to which team members are proud of being a member of the group; and the extent to which they are committed to the team goal, task, or mission. See Driskell, Radtke, and Salas, 2003.

[21] See Nathan Bos, Judy S. Olson, Darren Gergle, Gary M. Olson, and Zach Wright, "Effects of Four Computer-Mediated Communications Channels on Trust Development," Proceedings of the CHI 2002 Conference on Human Factors in Computing Systems, Minneapolis, Minn., April 20–25, 2002, pp. 135–140; Susan G. Straus, "Technology, Group Process, and Group Outcomes: Testing the Connections in Computer-Mediated and Face-to-Face Groups," *Human-Computer Interaction*, Vol. 12, No. 3, 1997, pp. 227–266; Suzanne Weisband and Leanne Atwater, "Evaluating Self and Others in Electronic and Face-to-Face Groups," *Journal of Applied Psychology*, Vol. 84, No. 4, 1999, pp. 632–639.

[22] See Driskell, Radtke, and Salas, 2003.

[23] For example, see Lee Sproull and Sara Kiesler, "Reducing Social Context Cues: Electronic Mail in Organizational Communication," *Management Sciences*, Vol. 32, 1986, pp. 1492–1512.

[24] Driskell, Radtke, and Salas, 2003.

output is argued to be important for building trust in their competence and ability to deliver quality work.[25]

Perhaps the most significant impact computer-mediated communication has on team functioning is its effect on the clarity of communication.[26] Because of the absence of verbal and auditory cues, team members are less able to detect if someone agrees or disagrees with a statement or misunderstands a statement.[27] Similarly, the lack of colocation of teammates and the absence of direct, frequent interactions between them can result in a lack of common understanding or mutual knowledge.[28] This lack of common understanding can lead to such problems as misinterpretations, unevenly distributed information across team members, and even the failure to convey important information. Therefore, the greater the extent to which a common understanding or mutual knowledge exists among team members, the less likelihood there is of such errors and mistakes. Once again, the example given of the two non-colocated teams observing the same RPA video illustrates these points.

Finally, in the case of an intelligence enterprise, there may be a risk of cognitive overload when using chat because personnel are engaged in multiple chat rooms. According to cognitive load theory,[29] individuals only have a certain amount of cognitive or mental processing capacity and can only successfully pay attention to or remember a certain number of things at once. Depending on the number of chat windows and other analytical tasks requiring their attention and concentration, personnel may experience cognitive overload, leading to potential errors and missed information. However, further examination of the degree to which this occurs, and under which circumstances, will be needed to better understand the limitations of chat within an intelligence enterprise.

It is important to add that, in the current RPA video analysis organizational construct, at least one analyst (the "eyes-on" analyst) is continuously monitoring the video feed, whereas another (the "screener" or "tactical communicator") is devoted to reading and responding to chat. These two analysts sit side by side and communicate with each other by voice. The "eyes-on" analyst does not remove his or her eyes from the video feed, whereas the screener does not remove his or her eyes from the monitor(s) capturing the different chat windows. When something important happens in the video, the first analyst relays the information via voice to the screener, who immediately transcribes it to chat. Similarly, the screener reads aloud intelligence requirements coming from the customer via chat. Our informal interviews with intelligence analysts and their

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[25] Aubert A. Benoit and Barbara L. Kelsey, "Further Understanding of Trust and Performance in Virtual Teams," *Small Group Research*, Vol. 34, 2003, pp. 575–618.

[26] See Driskell, Radtke, and Salas, 2003.

[27] Pamela J. Hinds and Suzanne P. Weisband, "Knowledge Sharing and Shared Understanding in Virtual Teams," in Cristina B. Gibson and Susan G. Cohen, eds., *Virtual Teams That Work: Creating Conditions for Virtual Team Effectiveness*, San Francisco: Jossey-Bass, 2003, pp. 21–36.

[28] See Catherine D. Cramton, "The Mutual Knowledge Problem and Its Consequences for Dispersed Collaboration," *Organization Science*, Vol. 12, No. 3, 2001, pp. 346–371.

[29] Fred Paas, Juhani E. Tuovinen, Huib Tabbers, and Pascal W. M. Van Gerven, "Cognitive Load Measurement as a Means to Advance Cognitive Load Theory," *Educational Psychologist*, Vol. 38, 2003, pp. 63–71; John Sweller, "Cognitive Load During Problem Solving: Effects on Learning," *Cognitive Science*, Vol. 12, 1988, pp. 257–285.

commanders suggest that this arrangement works properly (i.e., there is no substantial cognitive overload) for the analysis of RPA video in current operations.

Thus, legacy computer-mediated communication presents some shortcomings, including difficulty developing trust and cohesion, the potential for not knowing when someone has correctly understood a message because of a lack of visual cues, and difficulty developing a common understanding of situations on the ground. There is also the potential for cognitive overload if too many chat windows are used or additional features are added. However, as discussed previously, chat is widely accepted and used within the military because it does allow for immediate feedback and synchronous communication. In a later section of this report, we explore ways to enhance the widely used capabilities of chat by addressing its shortcomings.

4. Audioconferencing

Audioconferencing is the oldest of the three types of virtual collaboration tools and has evolved from simple one-on-one phone calls to complex systems that can handle hundreds of callers from many locations. Methods vary from having a few large sites where team members gather in conference rooms to each caller using his or her own line. The real-time audio of participants is the primary mode of communication, which may be supplemented by shared text or graphics. Such visual information-sharing is commonly done with predistributed documents, but other software solutions (also known as groupware) can enable shared document editing or whiteboarding on a computer.[30] Audioconferencing is the most technologically mature method of collaboration and remains the most popular in the commercial world, due in part to its reliability, affordability, and interoperability. Any telephone may be used to join an audioconference, regardless of the make or model, the telecommunications carrier, or whether the device connects via landline, cellular node, or VoIP.

Use of Audioconferencing

As the notional narrative in Chapter One suggests, audio communication via secure telephone line is routinely used between military intelligence organizations and pilots flying missions around the world. Concerning Air Force motion imagery collection, RPA flight crews (including pilots and sensor operators) and their customers also speak to each other via secure radio. However, until recently, Air Force intelligence analysts were, in general, not privy to these conversations. The fear of "clogging the airways" at critical times limited their participation in RPA-related audioconferences. Nevertheless, the Air Force has invested in two secure audioconferencing systems. The first system connects Air Force intelligence personnel with the crews that fly the RPAs. It permits them to listen in on communications between RPA flight crews and the customer(s), thus allowing these analysts to participate in the conversations in a "receive mode" to improve their situational awareness. The second system connects personnel across multiple sites by providing real-time, multichannel voice communication between analysts, regardless of geographic location.

Impact of Audioconferencing on Team Effectiveness

Although still not as rich as face-to-face interaction, audioconferencing is a richer communication medium than computer-mediated communication tools, such as chat and email.[31] Audioconferencing allows immediate feedback and the ability to personalize a message for a

[30] IBM's Lotus Notes/Domino is one example.

[31] Daft and Lengel, 1986.

specific individual.[32] It also relays some additional cues, such as tone of voice, because of the addition of sound. In comparison with legacy computer-mediated communication, the additional non-textual information conveyed by voice inflection and tone of voice in audioconferencing also provides an easier means of indicating whether a message has been understood. However, audioconferencing still lacks the visual cues provided by face-to-face communication, such as body language (e.g., posture, seating, and facial gestures) and eye contact.

Research on the effectiveness of audioconferencing as a virtual collaboration tool has found similar problems to those presented by computer-mediated communication because of the same lack of visual cues. For example, the lack of visual cues in audioconferencing may lead to problems with building trust. Again, trust is particularly relevant to an intelligence enterprise, given the importance of relying on the competence of fellow team members and partners and the accuracy of the information they provide. As discussed previously, the lack of nonverbal cues that allow the expression of feelings and provide greater personalization can lead to deindividuation and interfere with the development of interpersonal relationships.[33] Similarly, without being colocated and seeing the effort and quality of the output of fellow team members, it may be more difficult to trust that others are competent and able to deliver quality work.[34] In support of this point, research by Bos and colleagues found the development of trust in audioconferencing teams to take longer than in face-to-face teams.[35] However, they did find that it was easier to develop trust among team members using audioconferencing compared with team members using only text to communicate.

As with text and email, scholars also argue that the lack of visual cues in audioconferencing is likely to reduce the influence of social status and foster more equal participation.[36] However, in a study on audioconferencing, research by France and colleagues also found that social status can be reinforced in certain situations.[37] For example, visual cues, such as seeing someone raising his or her hand, can facilitate turn taking; France and colleagues found that the lack of these visual cues during audioconferencing results in lower-status members being "invisible" and less likely to speak up and participate with their higher-status colleagues. In situations in which team members are only listening in for situational awareness, such as when intelligence personnel listen to conversations between RPA pilots and the customer, this invisibility poses no problem. However, it may pose a problem for a situation in which audioconferencing is used for decisionmaking purposes within an intelligence enterprise.

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[32] As discussed previously, being able to personalize a conversation, for instance, by communicating feelings through tone of voice, can create a more personal exchange of information.

[33] See Driskell, Radtke, and Salas, 2003; Sproull and Kiesler, 1986.

[34] Benoit and Kelsey, 2003.

[35] Bos et al., 2002.

[36] See Driskell, Radtke, and Salas, 2003.

[37] Emma F. France, Anne H. Anderson, and Michael Gardner, "The Impact of Status and Audio Conferencing Technology on Business Meetings," *International Journal of Human-Computer Studies*, Vol. 54, 2001, pp. 857–876.

As indicated previously, audioconferencing is used by intelligence personnel to listen in on communications between RPA flight crews and the customer(s) in a “receive mode” to improve their situational awareness. This could result in potential cognitive overload for analysts, depending on the level of concentration required by their other tasks. Again, though, the degree to which this occurs, and under what circumstances, must be examined further in order to better understand the limitations of using multiple virtual collaboration tools within an intelligence enterprise.

Thus, the use of audioconferencing as a virtual collaboration tool has some similar challenges to chat, in that it can make it difficult to develop trust and can influence status perceptions. Its use may also contribute to cognitive overload, if intelligence personnel are required to listen in while also paying attention to other tasks. However, audioconferencing is a well established and easily used tool that provides additional cues beyond chat that better convey understanding and indicate reactions. Chat is expected to remain the communication medium of choice for real-time communication, such as that between RPA flight crews and intelligence personnel. Audioconferencing, though, may be preferred over chat for future brainstorming or similar sessions, in which information might be easily misunderstood or more detailed explanation or discussion may be needed. In those sessions, audioconferencing would likely provide a more efficient medium for asking questions and gaining clarification.

5. Videoconferencing

Videoconferencing, while it has been around for decades, has until recently been plagued by issues related to image quality and other technical problems. Now that videoconferencing technology has improved, and the technological requirements (cameras, software, and bandwidth) for the real-time, simultaneous transmission of video and audio data have decreased enough in cost, videoconferencing facilities are commonplace in many business and academic settings. Today, providers of "virtual presence" solutions, such as Polycom, sell everything from a 16-foot-wide video wall down to an ordinary office telephone with a built-in camera and video display.

The traditional videoconferencing setup occupies a dedicated space outfitted with high-quality cameras, monitors, and a control station. A dedicated technician establishes the link between multiple such locations, and each site has varying amounts of control over its cameras and monitors. Audio may be included in the same feed but is usually separated and transmitted via a dedicated phone line to avoid lag. Although most videoconferencing still occurs in these dedicated arenas, the proliferation of webcams now enables the option of holding personal videoconferences.[38]

Personal videoconferencing implies that each participant joins using his or her own computer with a web camera or via a handheld device. Commercial software applications, such as Skype and FaceTime, have begun to make such communication more common in the consumer world.[39] One of the distinguishing features of personal videoconferencing is that each participant can arrange the display of images from other participants per his or her particular preferences. The resolution of these images is generally lower than in the traditional setup, but with a camera dedicated to each participant at close range, the flow of the conversation—in particular, which person is speaking—can be easier to follow.

Use of Videoconferencing

Examples of how videoconferencing is used in military intelligence organizations include the following:

- to facilitate regular updates to the commander
- for pre-mission briefings, which bring the different sites of the enterprise up to speed on the missions of that day

[38] A webcam (from "web camera") is a video camera attached to a computer. It is typically small and inexpensive.

[39] Both commercial products allow two-way video communication. Apple's FaceTime is now standard on all fourth-generation iPhones. Skype, a well-known proprietary VoIP system by Skype Limited (partly owned by eBay), is estimated to have garnered a 13 percent share of the international call market, although it is unclear what fraction of those calls involved the video capabilities. See Steven Hodson, "Skype Commands 13 Percent of International Phone Calls," *The Inquisitr*, May 3, 2010.

- for post-mission briefings, during which the outgoing crew of analysts and support personnel hands over responsibilities to the incoming crew
- to discuss operational issues, such as daily operations
- to discuss staffing issues, including training, funding, and crews
- to plan the operational employment of assets.

We also note that the above applications tend to be performed via traditional videoconferencing—using a dedicated space, special high-quality cameras, etc.—instead of through personal or webcam-based videoconferencing.

Videoconferencing is not used for the real-time communication between intelligence personnel and RPA flight crews or during routine communication between intelligence personnel at different enterprise sites. The telecommunications infrastructure (including extensive fiber-optic networks) required to permit effective videoconferencing (even personal, webcam-based videoconferencing) between these different locations is already in place.[40] However, the same assertion cannot be made of the telecommunications infrastructure between these locations and the customers' centers in theater, for which the existing wireless networks provide only limited bandwidth. In the recommendations section of this report, we will explore the option of adding personal or webcam-based videoconferencing as a real-time communication medium, with the caveat that such an addition would need to avoid increasing the risk for cognitive overload of intelligence personnel and RPA flight crews.

Impact of Videoconferencing on Team Effectiveness

Of all virtual collaboration tools, videoconferencing is as close to face-to-face interaction as possible, making it the richest virtual collaboration tool available. Unlike chat and audioconferencing, videoconferencing can provide important visual cues that allow participants to notice acknowledgment of statements, misunderstandings, and gestures used to explain a concept.[41] However, videoconferencing is still not as rich as face-to-face communication and can still lack some key visual cues. For example, an often-overlooked issue with videoconferencing is the difficulty of making eye contact and interpreting body language or gestures.[42] In larger videoconferencing facilities, because of the distance between the video screen and the camera, a person attempting to make eye contact with a participant on-screen will appear to be looking elsewhere. (Likewise, a speaker looking into the camera so that the listener receives eye contact will not be able to watch the listener's reaction). In personal videoconferencing, a similar situation arises; typically, eye contact is not even attempted. This creates a somewhat disconcerting effect in which the illusion of visual presence is not matched by the illusion of

[40] Here we are referring to sites in CONUS or elsewhere that have access to telecommunications networks with adequate bandwidth.

[41] Ellen A. Isaacs and John C. Tang, "What Video Can and Can't Do for Collaboration: A Case Study," Multimedia *Systems*, Vol. 2, 1994, pp. 63–73.

[42] Wainfain and Davis, 2004.

visual interest: When one participant is speaking, the other participants appear to be paying attention to something slightly offscreen.[43]

Therefore, although videoconferencing is the best existing proxy for face-to-face interaction, it too may negatively impact team dynamics and effectiveness. For example, research shows that videoconferencing is often not as efficient as face-to-face communication for such tasks as negotiation,[44] and people often still have problems understanding and regulating conversations.[45] Finally, it may still be difficult to build trust among team members when communicating through videoconferencing. Although access to visual cues should reduce feelings of anonymity and help facilitate more-personal interactions, team members are still not colocated. Therefore, they are not able to consistently observe the effort and quality of the output of fellow team members on a daily basis. As a result, it may be more difficult to build trust in others' competence and ability to deliver quality work.[46] Consistent with this, research by Bos and colleagues found that, while it is difficult to build trust among team members when communicating through videoconferencing, it is easier than developing trust via less-rich media, such as chat. Bos' study did not find any advantages of videoconferencing over audioconferencing with regard to trust development though.

In sum, although there are still some challenges with videoconferencing, it is the next best means of communication when face-to-face interaction is impossible, as is the case for intelligence personnel and RPA flight crews. The use of video can make it considerably easier to know who is speaking and can permit participants to use nonverbal gestures or expressions to communicate concepts and confirm their understanding. Furthermore, because it can transmit additional visual and audio cues, videoconferencing may facilitate the development of trust more effectively than do less-rich media, such as chat.

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[43] However, most videoconferencing facilities place the camera above the receiving display screens to reduce this effect.

[44] Jill M. Purdy and Pete Nye, "The Impact of Communication Media on Negotiation Outcomes," *International Journal of Conflict Management*, Vol. 11, No. 2, 2000, pp. 162–187.

[45] Susan G. Straus, Jeffrey A. Miles, and Laurie L. Levesque, "The Effects of Videoconference, Telephone, and Face-to-Face Media on Interviewer and Applicant Judgments in Employment Interviews," *Journal of Management*, Vol. 27, No. 3, 2001, pp. 363–381.

[46] Benoit and Kelsey, 2003.

6. Evaluating the Performance of Virtual Collaboration Tools

The relationship between virtual collaboration tools and team performance or effectiveness is not necessarily simple. The ultimate impact of virtual collaboration tools on team effectiveness is due primarily to the impact these tools have on basic team processes, such as the quality of communication and the development of trust, which together influence team effectiveness.[47] In addition, different types of virtual collaboration tools may be better suited for different tasks, such as providing routine updates versus deciding on an important course of action. Similarly, the impact of certain tools on team effectiveness may also depend on time constraints or the extent to which team members are comfortable using the tool. Thus, in determining what tools and features are most beneficial in the military operational environment, we recommend that intelligence enterprises invest in conducting experimental research involving simulated tasks with environmental constraints that closely mirror what takes place in the operational environment. An experimental approach would enable comparisons regarding how different types of virtual collaboration tools and features influence team effectiveness and, ultimately, reveal how to improve the use of those tools within the operational environment. In addition, given that intelligence personnel must often multitask and thus may be involved in more than one virtual collaborative session at a time, it will be important to examine the extent to which the inclusion of too many features or the use of too many different types of tools could lead to cognitive overload.

Our earlier review of the influence of virtual collaboration tools on various group dynamics and effectiveness serves as a useful starting point, but precise experimental examination can provide further guidance regarding how to best utilize and design the tools to be used within a given intelligence enterprise. There are many examples of experiments that use simulated tasks (including simulated military tasks). These experiments examine team functionality and performance and investigate the interaction between people and technology.[48,] Simulated environments can provide important means for examining such research questions.[49] Given potential constraints to conducting a true social science experiment using simulations, another approach would be to first attempt to assess the influence of different virtual collaboration tools on intelligence personnel tasks through a military exercise, such as the Air Force's Sentinel Focus or larger exercises, such as Virtual Flag.[50]

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47 See Driskell, Radtke, and Salas, 2003.

48 See Samual G. Schiflett, Linda R. Elliot, Eduardo Salas, and Michael D. Coovert, *Scaled Worlds: Developments, Validation, and Application*, Surrey, England: Ashgate, 2004.

49 Eduardo Salas, Nancy J. Cooke, and Michael A. Rosen, "On Teams, Teamwork, and Team Performance: Discoveries and Developments," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, Vol. 50, 2008, pp.540–547.

50 These exercises, however, would not provide the conditions necessary to conduct a true social science experiment.

There has also been a considerable amount of research on how to best measure and model the key performance aspects of teams.[51] Most importantly, though, objective performance metrics should be developed based on the specific performance requirements of required tasks. In addition, there are more subjective team outcomes and processes, such as satisfaction within the team, customer feedback, and perceptions of team cohesion that can be assessed.[52] These can be measured through observation or the use of participant surveys focusing on team-member and customer perceptions.

Although we focus above on assessing team effectiveness in the context of an experiment, certain technical metrics can also be valuable. The most basic is uptime—the percentage of time the virtual collaboration tool actually was able to run. There are two elements to this calculation: a measure of how often the software crashed and a measure of how much of a disruption it was to reboot and resume the collaborative session. In keeping with the convention that metrics should be positive, a metric for the former would be the mean time between software crashes, and metrics for the latter would be the percentage of time the tool was running and the percentage of data that was successfully received by all users.

The resulting metrics may depend on the number of users and the level of activity involved in a collaborative session. However, it is comparatively easy to run the same exercise several times to account for these issues.

A second technical metric of particular relevance to military operations concerns content permissions or security. Virtual collaboration tools may necessitate the editing of an intelligence product or the development of a new intelligence product. The content permissions metric is measured as a percentage of how much of the shared content is properly restricted, such that all authorized users can access the material but no unauthorized users can do so. Because users may join or leave the collaborative session frequently (depending on the type of teamwork involved), if a single unauthorized user is able to join part of the session or otherwise access material, all content so accessed should be counted as compromised in the percentage.

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[51] For examples, see Michael A. Campion, Gina J. Medsker, and A. Catherine Higgs, "Relations Between Work Group Characteristics and Effectiveness: Implications for Designing Effective Work Groups," *Personnel Psychology*, Vol. 46, 1993, pp. 823–850; Nancy J. Cooke, Preston A. Kiekel, Eduardo Salas, Renee Stout, Clint Bowers, and Janis Cannon-Bowers, "Measuring Team Knowledge: A Window to the Cognitive Underpinnings of Team Performance," *Group Dynamics, Theory, Research, and Practice*, Vol. 7, 2003, pp. 179–199; Amy Edmondson, "Psychological Safety and Learning Behavior in Work Teams," *Administrative Science Quarterly*, Vol. 44, 1999, pp. 350–383; Katherine J. Klein and Steve W. J. Kozlowski, eds., *Multilevel Theory, Research, and Methods in Organizations*, San Francisco: Jossey-Bass, 2003; Carol R. Paris, Eduardo Salas, and Janis A. Cannon-Bowers, "Teamwork in Multi-Person Systems: A Review and Analysis," *Ergonomics*, Vol. 43, 2000, pp. 1052–1075; Eduardo Salas, Clint A. Bowers, and Janis A. Cannon-Bowers, "Military Team Research: 10 Years of Progress," *Military Psychology*, Vol. 7, 1995, pp. 55–75.

[52] For a review of commonly examined team process and performance variables, see Daniel R. Ilgen, John R. Hollenbeck, Michael Johnson, and Dustin Jundt, "Teams in Organizations: From Input-Process-Output Models to IMOI Models," *Annual Review of Psychology*, Vol. 56, 2005, pp. 517–543.

7. Conclusions and Recommendations

In this report, we discussed three modes of virtual collaboration: computer-mediated communication, audioconferencing, and videoconferencing. For ease of presentation, we have discussed these options as separate choices, but the reality is more complex. Computer-mediated communication can be integrated with both audioconferencing and videoconferencing. In fact, many web conference systems now employ such integration. Moreover, intelligence personnel must often multitask and thus may be involved in more than one virtual collaborative session at a time. For example, Air Force intelligence personnel are now able to listen in to audio conversations between pilots and sensor operators on headsets while also communicating in multiple chat rooms with a different slate of participants.

Rapid and clear communication within a site, across sites, and with various partners and customers is needed for an intelligence enterprise to run effectively. Due to the geographic distribution of an intelligence enterprise's sites, partners, and customers, much of this communication requires the use of virtual collaboration tools, such as those described in this report. Therefore, having the most effective tools possible and ensuring those tools are used in the most effective way are critical to the success of the enterprise. Furthermore, truly distributed teamwork, which includes crossing time zones and organizational structures to draw on local expertise at each site as needed, will only become a functional reality when personal virtual collaboration tools—those accessible to individuals at their usual workstations—become as familiar and commonplace as email and the telephone are today. To this end, we make the following recommendations regarding virtual collaboration.

First, intelligence enterprises should experiment with and assess more-sophisticated virtual collaboration tools and technologies. To determine which virtual collaboration tools and features are most beneficial, we recommend investing in experimental research involving simulated tasks with environmental constraints that closely mirror those of the operational environment. An observational exercise, such as Sentinel Focus, or a larger exercise, such as Virtual Flag, may also be a good venue for such evaluations.[53]

Additionally, if intelligence enterprises are to realize the maximum benefit of having a distributed but unified enterprise, staff at multiple sites must be able to work together to complete shared tasks. To this end, we recommend that intelligence enterprises explore how additional virtual collaboration tools may be utilized to facilitate further collaboration. As discussed in previous chapters, the various types of tools have different advantages and disadvantages; therefore, care should be taken in determining which tools to introduce and how they could best benefit a given enterprise. For example, in a review of prior research on virtual collaboration tools, Wainfan and Davis developed a decision tree to determine which method of virtual collaboration is best suited for a given purpose based on the empirical findings in the

[53] These exercises, however, would not be able to provide the conditions needed to conduct a true social science experiment.

literature.[54,55] Their analysis suggests that computer-mediated communication and audioconferencing are best suited for sharing information or giving status updates, while videoconferencing is especially suited for resolving disputes, decisionmaking, and negotiating.

Second, intelligence enterprises should train their personnel in the proper use of computer-mediated communication tools. As part of this effort, enterprises should work to standardize the lexicon and communications practices associated with virtual collaboration and train personnel in these areas. We focus on computer-mediated communication, which presents a greater chance for misunderstanding between participants than audioconferencing or videovonferencing given its lack of visual and auditory cues.[56] Establishing a set of standards and training personnel in their use can increase the efficiency of computer-mediated communication, help prevent potential misunderstandings, and decrease the potential for errors. It is also in keeping with the long-standing military practices of disciplined communication over radio and through written memos.

There is a common misconception that those who are familiar and comfortable with computers should be able to operate collaboration software without any formal training. There is a further misconception that the ability to operate virtual collaboration software—chat, in particular—is synonymous with the ability to use it effectively for teamwork. These two misconceptions lead to the belief that computer-savvy military personnel can just sit down and use chat properly. This belief is partially justified by the likelihood that, in this era, most enlisted men and women who engage in chat rooms have done so since childhood. However, the military functions of chat may be quite different from its functions in the civilian world, with which most computer users are familiar.

In support of the usefulness of training, some research has found that training in the use of legacy computer-meditated communication helps to mitigate the potential negative effects of virtual collaboration.[57] Training personnel who will be working together in the future at the same time may also be particularly beneficial, as groups that train together have been found to have a better sense of awareness of "who knows what" within the group and thus know whom to ask when they need more information.[58] This common sense of awareness has been found to be related to better performance and the commitment of fewer errors.

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54 Wainfan and Davis, 2004.

55 It is important to note that external factors (cost, available equipment, etc.) may also dictate the method. When this is the case, steps can be taken to identify and mitigate the adverse effects introduced by the collaboration methods in use.

56 For an overview, see Driskell, Radtke, and Salas, 2003.

57 For example, see Caroline Cornelius and Margarete Boos, "Enhancing Mutual Understanding in Synchronous Computer-Mediated Communication by Training: Trade-Offs in Judgmental Tasks," *Communication Research*, Vol. 30, No. 2, 2003, pp. 147–177; Merrill Warkentin and Peggy M. Beranek, "Training to Improve Virtual Team Communication," *Information Systems Journal*, Vol. 9, 1999, pp. 271–289.

58 Richard L. Moreland and Larissa Myaskovsky, "Exploring the Performance Benefits of Group Training: Transactive Memory or Improved Communication?" *Organizational Behavior and Human Decision Processes*, Vol. 82, 2000, pp. 117–133.

The military services have long been aware of the importance of training in the area of radio communications. Air Force pilots receive special training on how to be "clear, correct, and concise" when using their radios. Collaboration over chat should be dealt with in the same way. Computer-mediated communication is no longer an auxiliary mode of collaboration, but often a primary mode. They play too important a role in military operations for training to be taken for granted.

Third, concerning the use of specific virtual collaboration tools, we recommend that intelligence enterprises experiment with the use of videoconferencing (including personal or webcam-based videoconferencing) for real-time communication between personnel at different sites and between personnel and their partners and customers. In particular, we recommend that Air Force intelligence enterprises consider the use of personal or webcam-based videoconferencing between (1) Air Force intelligence personnel and RPA flight crews and (2) intelligence personnel located at different sites. As discussed earlier in this report, there will always be challenges to effective collaboration between intelligence personnel and their partners in military operations in which they are not colocated. However, of all virtual collaboration tools, videoconferencing is the best existing proxy for face-to-face interaction. In particular, the use of videoconferencing can make it considerably easier to know who is speaking and can permit participants to use nonverbal gestures or expressions to communicate concepts and confirm their understanding. The conveyance of visual cues in videoconferencing may also help facilitate the development of trust to a greater degree than do less-rich media, such as chat. Therefore, intelligence enterprises may benefit from the addition of videoconferencing for building trust among team members, as well as for tasks that require a high degree of interaction or message complexity.

As discussed elsewhere in this report, adding another communications requirement presents the risk of cognitive overload. To avoid such overload, we suggest that communication using webcams be limited to times during which nothing critical is expected to happen in the operation. For example, when the intelligence team first communicates with the RPA flight crew during a work shift, they can spend several minutes using personal videoconferencing to exchange information about the upcoming mission. They may also need to conduct several webcam sessions during their work shift, as needed. However, intelligence enterprises will need to explore which types of tasks would most benefit from the use of videoconferencing compared with other media. There are numerous commercial tools (Skype, FaceTime, etc.) that can facilitate personal videoconferencing. These tools will have to be modified to satisfy the military's tight security requirements, but such modifications have been successfully made to other commercial tools.

Finally, to avoid the potential barriers to cohesion and trust already explained in this report, we encourage using initial face-to-face meetings to familiarize intelligence personnel with the people they will be supporting, as well as with RPA flight crews. This is one of the recommendations provided by Wainfan and Davis to help mitigate the lack of mutual knowledge, cohesion, and trust often created by the use of virtual collaboration tools, particularly computer-mediated communication.[59] A videoconference can provide some benefits, but for the purpose of meeting for the first time and building trust, there is still no substitute for face-to-face interaction. Notwithstanding the lack of practicality of such deployments in all circumstances, this underlines the importance of building such relationships. Air Force intelligence liaison officers already deploy with Army and Marine Corps units to familiarize producers and consumers of intelligence with each other, their organizations, needs, and processes. Furthermore, Air Force intelligence personnel have exchange sessions with Army and Marine Corps forces rotating to and from theater, and Army and Marine Corps intelligence personnel travel to and train in Air Force intelligence centers. The presence of the liaison officers, as well as the exchange and training sessions, implicitly discourage depersonalization by representing the other side of the virtual divide. However, there is still a need to improve the interactions and exchanges between RPA flight crews and Air Force intelligence personnel. In general, staff in career fields likely to involve collaboration with other services or agencies should be offered and encouraged to take opportunities to visit and familiarize themselves with those services or agencies, even if they do not have the opportunity to meet the individuals with whom they will be working. Personal experience with the people, procedures, and facilities of another organization goes a lot farther than reading about that organization’s tactics, techniques, and procedures.

As a final comment, while technology promises to lower the barriers to collaboration between analysts at different sites and between intelligence personnel and their partners and customers, there is, as of yet, no silver bullet solution. Computer-mediated communication, audioconferencing, and videoconferencing all have their place, and the military services should continue to invest in such tools. Technological developments in this field are continual, and, in time, virtual reality may be mature enough for widespread use, but this is not yet the case. In the meantime, the virtual collaboration tools available today can help military intelligence organizations function as truly distributed enterprises.

[59] Wainfan and Davis, 2004.

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