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Identifying Collaboration Challenges in Crisis Management

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Abstract

Because of the urgency to respond quickly to large-scale aviation catastrophes such as the 9/11 attacks, National Airspace Security collaboration requires tightly-orchestrated activities across a number of organizations in multiple locations. Today this coordination is by voice only, using the conference call known as the Federal Aviation Agency's Domestic Events Network. Besides a lack of digital data sharing among all participants, also missing are common tools and joint training in techniques, procedures, and practices for inter-organizational decision-making, collaboration, and response coordination. We have been analyzing collaboration among National Airspace Security partners via an extensive series of interviews and observation sessions with the goal of providing recommendations for technologies, processes, and training that can improve crisis management. This paper describes the process we used to gather data, provides our interview questions as a resource for others, summarizes the problems that we have found, and presents an example of the potential solutions that we plan to investigate further. We believe that our process can be applied to investigations of large-scale collaboration in other time-sensitive, cross-organizational situations such as humanitarian response to natural disasters. Further, our results can inform others who are responsible for crisis management regarding the collaboration challenges that their operations may encounter.

KEYWORDS: crisis management collaboration, team awareness, collaboration processes.

I. Introduction

Our research is aimed at understanding and improving cross-organizational collaboration in crisis management situations, with aviation security serving as an exemplar domain and case study.

Aviation security has received much attention since 2001 and is in special need of collaboration research. The possibility of terrorism coupled with the saturation of today's air transportation system results in serious threats to aviation security. Currently the air transportation system is not expected to be able to handle the anticipated growth in air traffic demand and complexity (Bolczak and Fong, 2008). Despite the global economic downturn, numbers of aircraft are increasing along with their diversity, bringing Unmanned Aircraft Systems, Very Light Jets and similar "unscheduled" operations into an already complex system. The increasing number and types of aircraft and their unpredictable schedules bring new challenges to aviation security.

The aviation security mission has two primary objectives: prevent and (if not prevented) counter attacks on air vehicles and attempts to use aircraft as weapons. Assessing risk, detecting and communicating threats, identifying and implementing mitigation strategies, executing joint responses, and recovering from security incidents are key actions of airspace security collaboration.

Today's aviation security procedures bypass most of collaboration technologies to emphasize use of the telephone: the Federal Aviation Administration's (FAA's) audio conference call known as the Domestic Events Network (DEN). There is no sharing of graphics or video, and no common data presentation among members of the aviation security community. As air traffic grows, airspace security operations will no longer be able to rely on solely telephonic coordination: it will require more automation support and flexible collaboration to allow humans to pool resources and focus on the greatest threats.

Executing the aviation security mission requires tightly choreographed activities from a number of organizations: the FAA, airlines, one or more branches of the military; and/or local, state, and federal emergency responders. Our work focuses on developing a common coordination approach that will include common tool features for each participating organization along with requirements for training in inter-agency collaboration procedures and decision-making practices. In other words, we aim to develop a blueprint for cross-organizational, non-located collaboration.

We developed a structured interview script that enabled us to organize findings into categories relating to people, procedures, decisions, and resources; and supplemented this data-gathering method with observation notes taken during exercises and real-world operations. We believe that our process of determining collaboration problems and identifying solutions can be applied to investigations of large-scale collaboration in other time-sensitive, cross-organizational situations such as humanitarian response to natural disasters. Further, to the extent that there are similarities in environments and procedures among different domains, our results can inform others of the collaboration difficulties that their crisis management operations may encounter.

II. Related Literature

There is a very rich literature of collaboration. We particularly examined research regarding systems that are:

- synchronous (i.e., collaborators are working at the same time)
- non-located (i.e., collaborators are not all at the same location)
- cross-organizational
- time-sensitive
- pertinent to crisis management

While we could not find literature on systems that satisfied these criteria and are also in the aviation domain, we identified several recent studies that were focused on other types of crisis management or transportation safety.

Work by Hanumantharao and Grabowski (2006) includes cross-organizational, distributed, synchronous, safety-critical collaboration to maintain safe separation of ships in a busy waterway. Their study examined the use of two versions of the collaborative Vessel Traffic System (VTS) on shore and aboard vessels in the St. Lawrence Seaway. The shore-based collaborators used an enhanced VTS that included visualizations of the Seaway and decision-aiding tools, whereas shipborne team members used a version that included neither visualization nor decision support. The researchers predicted that the enhanced version of the VTS would result in greater participation that was more equally distributed among roles as well as greater agreement. These expectations were not met, however, potentially because operational procedures, roles and responsibilities were not changed to be more compatible with the new technology and the way that the technology was introduced did not minimize disruption.

Another study investigated cross-organizational teams' use of networked information in regional crisis management command and control centers (van de Ven et al., 2008). They note that facts about the situation were propagated across different levels of the hierarchical organization in an ad-hoc fashion based more on personal contacts than a systematic manner. Their three case studies of crisis management field exercises resulted in several recommendations for solutions, such as to create easy access to information at all levels of the organization.

Another case study made use of a distributed collaboration emergency response system during the 2007 Tall Ships races in Denmark (Buscher et al., 2008). The primary problem being addressed was the tendency for team members to distrust information received via technology, with the consequence of delayed decision-making. As a result of their study, Buscher et al. (2008) recommended several design

guidelines, such as to provide “flexible redundancy to help build trust, because responders are more likely to trust information if they can come to the same conclusions based on two different information sources or modes.”

Altschuller et al. (2008) investigated trust of one’s colleagues in an ad-hoc, virtual crisis response team. They examined non-located, cross-organizational team members as they collaborated during an emergency using electronic means despite little or no previous experience working together. Lack of trust among team members was cited as contributing to the stress of an already challenging situation. Their results implied that crisis management systems should include features such as pictures or avatars to allow team members to identify themselves and remove anonymity.

Besides the literature specifically addressing distributed teams in crisis management situations, we also examined the more general “virtual teaming” literature, such as the papers in Nemiro et al. (2008). Further, we tapped into the literature of technology adoption (e.g., Rogers, 1995) to better understand the challenges of providing new technology for use in safety-critical, high-stress situations. For a much more complete review of the relevant literature see Drury et al. (2010).

III. Gathering Data Regarding Collaboration Problems

General design guidance can only go so far; collaboration solutions must be tailored for the specific team. In our case, the aviation security community is dispersed among installations of the FAA, Department of Defense (DoD), Department of Homeland Security (DHS), and the airlines. We visited nineteen organizations either once or twice as summarized in table 1. Examples of DoD community members visited are those responsible for maintaining air sovereignty over the continental US, and examples of FAA installations visited are en-route air traffic control centers. One of the airlines is a freight carrier and the other carries both passengers and freight.

Table 1. Organizations Visited

Type of Organization	Number visited once	Number visited twice	Totals
FAA	6	2	8
DoD	4	1	5
DHS	2	0	2
Airlines	2	0	2
Other	2	0	2

Interview sessions were conducted with between one and twelve people at each organization and visits lasted between 90 minutes and ten hours. Two to four interviewers/observers made each visit.

The approach of interviewing in the context of the interviewee’s work environment was inspired by the Contextual Inquiry technique (Holtzblatt and Jones, 1993). This technique involves the interviewer acting almost as an apprentice, asking about the work as it is being performed. A benefit of interviewing in the work environment is that the interviewee can show the interviewer how work is done while explaining it. Another benefit is that the interviewer can observe firsthand the physical and sensory characteristics of the workplace as well as the work pace. Interviewees tend to take these aspects of the work environment for granted and so do not think to explicitly describe them.

Initially, and in an attempt to be comprehensive, our set of questions was grouped into eight categories: decision making and procedures, who is collaborating, information, tools, communication, relationships, and training. After a few interviews, the group determined that trying to ask all the questions in each of the eight categories was unwieldy so the interview process was refined by grouping the questions into four categories: decisions (decision-making), people (who is collaborating, relationships), processes (procedures, communication, training) and resources (information, tools). The decision section now

focused on finding out what decisions were being made and by whom. That section also focused on finding out which rules and regulations govern the criteria for making those decisions. The people section concentrated on determining who is involved with the collaboration, plus probing their culture, goals, roles, and command structures. The processes section focused on workflow, training, collaboration and communication. Finally, the resources section tried to get at what tools were used by each organization and what information from these tools was used to make decisions and collaborate. In addition to the literature already cited, questions were informed by Klein et al.'s (2008) Collaboration Evaluation Framework and Militello and Hutton's (1998) Applied Cognitive Task Analysis.

Although consolidating the categories simplified the structure of the interview, the discussion generated by the first part of the interview still did not encourage a natural progression to the questions in the latter part of the interview. The problems with the interview flow stemmed from a disconnect between our desire to drill down into each decision and the fact that the decisions touched upon all of the categories simultaneously. We decided to structure the interviews around the decisions being made. Once we determined that the interviewee made a particular type of decision, we then asked questions regarding the other three categories (people, processes and resources) that supported this decision. Thus the interview questions formed a series of nested loops to elicit information on each decision. We piloted this final version of the questionnaire with a subject matter expert who volunteered to write out the answers to the questions so all team members could examine them in detail to assess the flow of the questionnaire.

The final questionnaire consisted of six top-level questions and 54 sub-questions for drill-down, as needed. Not all interviewees were asked all sub-questions, depending on whether they had much to say about the top-level question. In addition, we sometimes asked questions not on the list to elicit details of a particularly interesting vignette being related by the interviewee. This questionnaire, used to guide most of the interviews, is included in the Appendix to this paper. Note that the questions could be easily tailored for other domains.

In addition to interviews, some of the visits also afforded opportunities to observe exercises. Responders from multiple agencies collaborated to resolve simulated crisis situations during these exercises. Exercises typically unfolded at a rapid pace and required close coordination among people who rarely had other occasion to communicate with each other. As such, these events enabled us to glimpse collaboration problems and then talk afterwards with exercise participants to understand why they happened.

IV. Analyzing Data

The research team members who participated in a particular visit pooled their notes into one consolidated written description. We started by using the four categories discussed earlier as the major structuring mechanism for the notes (decisions, people, processes, and resources). In the case where one observation or answer to a question pertained to multiple categories, we duplicated the text and placed it under each relevant category. Answers to questions about collaboration tended to fall under people or procedures, for example. Answers to questions about tools normally were placed under resources. The responses to questions about information often fell into the decisions category.

Once the notes from all of the visits were consolidated, we designed a custom (bespoke) spreadsheet to hold one observation per row. An example of an observation is: "roles and responsibilities of remote collaborators are not always clear." This observation was tagged as a problem specifically affecting the "people" category and "command structure and roles" subcategory that affected all phases of activities. Further, we tagged this observation with the data that supports it via a number identifying an "endnote." The list of endnotes contains the date, place, and person as well as the person's statement. In this example, MSGT J. at a DoD facility said on 18 February 2009 that "roles and responsibilities of [position X, removed for sensitivity] are unclear." The form allows for more than one endnote per observation, and the ability to check off more than one category and/or subcategory. The form used for filling out data is reproduced as Figure 1. The subcategories are listed for all four categories.

Frequently during data entry we read each other's entries to ensure a comparable level of detail and to eliminate redundancy.

The spreadsheet enabled us to sort the data to look at problems by categories or subcategories. The benefits of having a standard template for writing interview and observation notes and consolidating them via the custom spreadsheet were revealed when patterns emerged across descriptions of visits to different organizations. For example, evidence of distrust of collaborators in other organizations surfaced repeatedly.

We extracted from the spreadsheet the challenges that emerged during visits to multiple organizations and that appeared most serious based on frequency of occurrence, our subjective judgment and the collaboration literature. An example of a serious challenge to collaboration is something that had, in the past, delayed interviewees in taking action to address a critical situation. Other examples of serious challenges are situations that had caused misunderstandings, duplicative work, and/or a lack of response (an action had "fallen through the cracks"), according to interviewees.

We examined ten different collaboration models in the literature as part of our quest for guidance in judging the relative severity of collaboration challenges (D'Amour et al., 2008; Endsley and Jones, 2001; Hong, 2002; Klein et al., 2008; Maybury, 2006; Ozceylan and Coskun, 2008; Robertson, 2008; Salas et al., 1992; Thompson, 1967; and Warner et al., 2005). While a more detailed description is provided in Drury et al. (2010), a brief discussion of two models, Thompson's interdependencies and D'Amour's Indicators of Collaboration, can illustrate how collaboration models may provide guidance in assessing collaboration challenges.

The screenshot shows a web-based form titled "Enter Model Row" with a blue header bar. The form is for "Aviation Security Collaboration Model Entry Form" and features the CAASI logo. It contains several sections of input fields: a "Statement" text box, an "Initials" text box, a "Model Category" section with radio buttons for "Problem", "Requirement", and "Solution", and a "Phase" section with checkboxes for "Plan", "Monitor", "Evaluate", "Act", and "Recover". Below these are four columns of checkboxes: "Decisions" (D0: Decisions, D1: Individual Decisions, D2: Collaborative Decisions, D3: Regulations), "People" (P0: People, P1: Culture, P2: Trust, P3: Motivation and Incentives, P4: Command Structure and Roles), "Processes" (PR0: Processes, PR1: Workflow, PR2: Collaboration, PR3: Communication, PR4: Training), and "Resources" (R0: Resources, R1: Tools, R2: Information). At the bottom, there are fields for "Endnote 1 #:", "Endnote 1 Text", and "Additional Details for Endnote 1". Two buttons, "Create Row Now" and "Close Form", are located at the bottom right of the form.

Figure 1. Custom Form for Entering Individual Information Elements Culled From Interviews

Thompson (1967) defined three types of interdependencies as cornerstones of collaboration. In “pooled interdependence,” collaborators independently create work products and then combine them for use by others, such as when individuals contribute information to a central database. “Sequential interdependence” implies that one person’s product or task must be completed before another person can perform his or her task. “Reciprocal interdependence” occurs when multiple people need to work closely together, such as when they iterate on each others’ work products. All three types of interdependence exist in crisis management; but normally it is more difficult to achieve effective collaboration as the type of interdependence moves from pooled to sequential to reciprocal because collaboration becomes more closely-coupled and synchronous (“real-time”). Thus, challenges that touch mostly on reciprocal collaboration may be more difficult to overcome than those that pertain solely to pooled interdependence; and thus were often judged to be more serious.

D’Amour et al. (2008) defined collaboration as occurring at three levels: level 1 is “potential or latent collaboration,” level 2 is “developing collaboration,” and level 3 is “active collaboration” (see table 2). Cross-organizational crisis management is situated in level 2. For example, a crisis operations center will likely have strong organizational interests driving its orientations and will work in venues that are related to specific issues (characteristics of level 2). The collaboration challenges that have as their roots the level 2 (or even level 1) indicators are often very difficult to resolve without changing the underlying characteristics of the participating organizations or their relationships and so were often judged to be serious.

Table 2. D’Amour et al.’s (2008) Indicators of Collaboration

Indicators	Active Collaboration: Level 3	Developing Collaboration: Level 2	Potential or Latent Collaboration: Level 1
Goals	Consensual, comprehensive goals	Some shared ad hoc goals	Conflicting goals or absence of shared goals
Client-centred orientation vs. other allegiances	Client-centred orientation	Professional or organizational interests drive orientations	Tendency to let private interests drive orientations
Mutual acquaintanceship	Frequent opportunities to meet, regular joint activities	Few opportunities to meet, few joint activities	No opportunities to meet, no joint activities
Trust	Grounded trust	Trust is conditional, is taking shape	Lack of trust
Centrality	Strong and active central body that fosters consensus	Central body with an ill-defined role, ambiguous political and strategic role	Absence of a central body, quasi-absence of a political role
Leadership	Shared, consensual leadership	Unfocused, fragmented leadership that has little impact	Non-consensual, monopolistic leadership
Support for innovation	Expertise that fosters introduction of collaboration and innovation	Sporadic, fragmented expertise	Little or no expertise available to support collaboration and innovation
Connectivity	Many venues for discussion and participation	Ad hoc discussion venues related to specific issues	Quasi-absence of discussion venues
Formalization tools	Consensual agreements, jointly defined rules	Non-consensual agreements, do not reflect practices or are in the process of being negotiated or constructed	No agreement or agreement not respected, a source of conflict
Information exchange	Common infrastructure for collecting and exchanging information	Incomplete information-exchange infrastructure, does not meet needs or is used inappropriately	Relative absence of any common infrastructure or mechanism for collecting or exchanging information

V. Identifying Challenges

Our analysis of the interviews resulted in many individual instances of challenges facing the operators of a joint crisis team. Our team was able to group these individual challenge instances into thirteen major challenge groups as highlighted in the underlined text in this section.

The top problem is the inability to cue partners' attention to relevant information because of its lack of persistence. The primary means of coordinating with others and obtaining an understanding of collaborators' activities on a moment-by-moment basis is via the DEN conference call. Because it relies on aural transmission, DEN information is transitory, yet no one is able to hear everything on the DEN all the time. Thus collaboration is inefficient and incomplete.

The limitations of coordinating over the DEN lead to a lack of knowledge of non-located team members' activities, which we term team awareness. "The right hand is not talking to the left hand" problem is a challenge that arises within and between organizations. The FAA, military, and airlines must coordinate their actions very closely in an emergency, yet they are hindered by not knowing what each other is doing in real-time. They also do not know if they are working from the same information about the event because they lack a "Common Operational Picture," and so have limited joint situation awareness.

Further, collaborators are handicapped by a lack of coordinated Concept of Operations (CONOPs) that can help them overcome differences in organizational cultures. A CONOPs is a high-level statement that describes how the different aspects of an activity will be carried out, including who is responsible for doing what. A lack of understanding of partners' roles, responsibilities, rules, laws, regulations, and internal procedures—combined with a lack of coordination guidance—leads to mistrust. Additional mistrust is generated by differing organizational motivations and agendas. Note that our analysis reflected challenges tackled in the literature, such as Altschuller et al.'s (2008) investigation into trust of collaboration partners. While the differences will likely remain, having an explicit CONOPs for joint work can set expectations regarding what each organization can and will do and when they will do it.

More specific than the challenge of not having a properly coordinated CONOPs is the lack of a clear set of standardized protocols and procedures for a practical understanding of how to carry out joint work. We found that there are inflexible rules during crisis mode, procedures that are not written in terms of what partners can actually do, and inadequate backup procedures for crisis operations.

As a result of insufficient team awareness and no coordinated CONOPs (leading to inconsistencies in protocols), information is not shared in an agile manner with the right people. Further, information is not shared widely enough due to inadequate capabilities for sharing classified and sensitive information. Even when shared, information (and the tools used to convey it) is not always trusted, at least in part because there is little accompanying data about the information's source, provenance, or pedigree, leading to mistrust of partner participants. Note that Buscher et al. (2008), discussed earlier in the section on related literature, also addressed the challenge of mistrust of automation.

Even when trusted information is available, there are no good mechanisms to fuse related information received from different organizations. Individuals must put the information together in their heads, which is too time-consuming.

Fusing information mentally is difficult, but there are inadequate joint training programs and training standards for analyzing cross-organizational information and many other aspects of joint operations. As a result, partners do not thoroughly understand each others' capabilities and capacities, or even who to call for help in different kinds of situations. There is also inadequate procedural support for joint crisis operations. This means that rules are not flexible enough to accommodate crisis mode decisions; for example, there is no universal decision-reversal procedure. Also missing are adequate secondary (alternative) procedures for crisis operations at many locations. In addition, the automation support for

_____ was found to be inadequate. Functional, usable and interoperable collaboration tools are unavailable to staff, and some partners are missing sufficient disaster recovery facilities for crisis operations. In addition to noting automation support challenges during the interviews, we also saw these difficulties mirrored in the literature, such as in the Hanumantharao and Grabowski (2006) paper discussed earlier.

Finally, apprising senior management of ongoing situations distracts staff from their core crisis management functions, slowing their response. This challenge is related to van de Ven et al.'s (2008) recommendations to create easy access to information at all levels of the organization.

VI. Conclusions and Future Work

We were successful in identifying collaboration challenges that occurred widely among the organizations studied. We have begun identifying solutions for the problems at a high level. For example, we are suggesting providing speech-to-text transcription of the DEN conference call to provide more persistence of the information. A textual version of the DEN, for example, could accommodate scrolling back to read what was said at earlier times. We are also suggesting that awareness of others on the DEN be increased by providing presence information for people monitoring the DEN.

We are also in the process of combining the major challenge categories with the candidate solutions into a framework that is helping us to understand the relationship between problems and candidate solutions. The goal is to choose the smallest (least expensive) solution set that addresses the broadest set of challenges.

The structured interviews were effective mechanisms to gather the data needed to understand collaboration challenges at a detailed and nuanced level. We learned the importance of understanding the list of interview questions as a living document that provided guidance but did not dictate the course of every interview. The structure of the list of interview questions evolved as we gained more experience with the interview flow. The final version of the question list was sufficiently structured to guide the interviewer while being simple enough to refer to easily during the course of the interview.

The questions themselves are largely domain-independent. Questions about tasks, information acquisition and usage, environment, tools, current collaboration practices and future collaboration expectations are applicable to any number of cross-organizational collaboration situations. We plan to adapt this set of questions for use in future investigations of collaboration and invite other researchers to adapt them, as well.

VII. Acknowledgements

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VIII. References

- [1] Altschuller, S., and Benbunan-Fich, R. "Potential antecedents to trust in ad hoc emergency response virtual teams." In *Proceedings of the 5th International ISCRAM Conference*, Washington, D.C., May 2008.
- [2] Bolczak, C. N. and Fong, C-C. V. "Shared situational awareness to meet future airspace security mission needs." In *Proceedings of the 2008 Integrated Communications, Navigation, and Surveillance (ICNS) Conference*, Bethesda, MD, 2008.
- [3] Buscher, M., Mogensen, P. H., and Kristensen, M. "Why and how (not) to trust IT? Supporting virtual emergency teamwork." In *Proceedings of the 5th International ISCRAM Conference*, Washington, D.C., May 2008.

- [4] D'Amour, D., Goulet, L., Labadie, J. F., San Martin-Rodriguez, L., and Pineault, R. A. Model and typology of collaboration between professionals in healthcare organizations, *BMC Health Services Research* 2008, 8(188), published 21 September 2008 at <http://www.biomedcentral.com/content/pdf/1472-6963-8-188.pdf>.
- [5] Drury, J. L., Beaton, E., Boiney, L., Duncan, M., GreenPope, R., Howland, M., Klein, G. L. A Collaboration Research for Crisis Management Teams. *Foundation and Trends in Human-Computer Interaction*, vol 3(3), March 2010.
- [6] Endsley, M. R. and Jones, W. M. A model of inter- and intra-team situation awareness: Implications for design, training and measurement. In M. McNeese, E. Salas & M. Endsley (Eds.), *New Trends in Cooperative Activities: Understanding System Dynamics in Complex Environments*, Human Factors and Ergonomics Society, Santa Monica, CA, 2001, pp. 46 – 67.
- [7] Hanumantharao, S. and Grabowski, M. “Effects of introducing collaborative technology on communications in a distributed safety-critical system,” *Int. J. of Human-Computer Studies* 64 (2006) 714 – 726.
- [8] Holtzblatt, K. and Jones, S. “Contextual inquiry: A participatory technique for system design.” In D. Schuler and A. Namioka (Eds.), *Participatory Design: Perspectives on Systems Design*, pp. 177 – 210. Lawrence Erlbaum Associates, Hillsdale, NJ, 1993.
- [9] Hong, I. B. A new framework for interorganizational systems based on the linkage of participants’ roles, *Info. and Manage.* 39 (2002) 261-270.
- [10] Klein, G. L., Adelman, L. and Kott, A. “Enabling Collaboration: Realizing the Potential of Network-Enabled Command.” In *Battle of Cognition*, A. Kott (Ed.), Praeger Security International, Westport, CN, 2008.
- [11] Maybury, M. T. Knowledge management capability maturity model (KM-CMM). In *Proceedings of the 2006 IDC IT Forum and Expo*, Boston, 2006.
- [12] Militello, L.G. and Hutton, R.J.B. “Applied Cognitive Task Analysis (ACTA): A Practitioner’s Toolkit for Understanding Cognitive Task Demands”, *Ergonomics*, Vol. 41(11), 1998, pp.1618–1641.
- [13] Nemiro, J., Beyerlein, M., Bradley, L., and Beyerlein, S., Eds. (2008). *The Handbook of High-Performance Virtual Teams*. Jossey-Bass, San Francisco, 2008.
- [14] Ozceylan, D. and Coskun, E. Defining critical success factors for national emergency management model and supporting the model with information systems. In *Proceedings of the 5th International ISCRAM Conference*, Washington., D.C., 2008.
- [15] Robertson, J. The three tiers of collaboration, <http://www.steptwo.com.au/columntwo/three-tiers-of-collaboration/>, 18 September 2008.
- [16] Rogers, E. M. *Diffusion of Innovations*, 4th Ed., The Free Press, New York, 1995.
- [17] Salas, E., Dickinson, T. L., Converse, S. A., and Tannenbaum, S. I. Toward an understanding of team performance and training. In: R.W. Swezey and E. Salas (Eds.), *Teams, Their Training and Performance*, Ablex Publishing, Norwood, NJ, 1992, pp. 3 – 29.
- [18] Thompson, J. D. *Organizations in action*, McGraw-Hill, NY, 1967.
- [19] van de Ven, J., van Rijk, R., Essens, P., Frinking, E. “Network centric operations in crisis management.” In *Proceedings of the 5th International ISCRAM Conference*, Washington, D.C., 2008.

- [20] Warner, N., Letsky, M., and Cowen, M. Cognitive model of team collaboration: Macro-cognitive focus. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, Orlando, FL, 2005.

Appendix: Interview Questions

Instructions for the interviewer are italicized. Italicized words in parentheses describe the type of information that is being sought using terms defined in Klein et al. (2008).

1. What is the name and primary **function** of your group?
 - a. What is your role in the overall Crisis Management system? How do you see your job fitting into the broader mission?
 - b. What are the most important **decisions** you have to make in your role?

Decision - Focus on one at a time:

- c. Are there clearly understood common **operating procedures** for this decision?
 - Are there standards, routines or plans in place that you follow regarding this decision? Are there templates that get filled in?
 - What kinds of workarounds (if any) do people use? Why are these helpful?
 - What are some situations that trigger changes in the usual operating procedures? (e.g., time pressure, unusual scenario, need to coordinate with an unexpected group)
 - Do you notice people creating any additional charts, checklists, or diagrams to help them keep track or make sense of what is going on? Why are these needed?
- d. What are the major pieces of **information** needed to make this decision?

Information element - Focus on one at a time:

- Where does this information come from, and is it timely?
- Do you have to shop around and hunt for this information? If so, when?
- Do you have reliable and timely ways of passing this information to the next **shift**?
- Are there certain sources of this information you particularly **trust** or **doubt**?
- What do you do when you receive **inconsistent** or conflicting information on this?
- Are there factors that **discourage** people from sharing this information readily (e.g., incentives, potential for gaming the system, time constraints, etc.)
- Is there other information available that would be helpful for this decision that you currently **cannot** see or cannot share? (e.g., due to rules, restrictions or barriers)

Ask about next piece of information: loop back to 1d as needed.

2. **With whom** do you need to coordinate on this decision, and why? In other words, once you have gathered your information, do you need to wait for additional information or coordinate with anyone else - or is the decision all yours? (*interdependence*)
 - a. If you must coordinate with groups within your organization, are you waiting for them to make a sub-decision or are you negotiating with them? (*interdependence*)
 - What **kinds of collaboration** are you involved in with these internal groups (providing information, receiving information, discussion, problem solving, planning what to do, or negotiating)?
 - Where are these collaborators located and **how do you communicate** with them? (Phone, face to face, email, chat, whiteboard, videoconference, audioconference, facsimile) (*transmission*)
 - Do the communications tools available adequately meet the needs of the job?

- How critical is **face to face** coordination? When and why? (*may be confirmation, justification, alternative evaluation*)
 - Are there issues that are difficult to resolve (or tasks that are difficult to accomplish) if you don't have a **relationship** with these collaborators? (*may be justification, rationalization, differentiation*)
- b. If you must coordinate with groups *outside* your organization (FAA, DoD, Airline, DHS), are you waiting for them to make a sub-decision or are you negotiating with them? (*interdependence*)
- What **kinds of collaboration** are you involved in with these external groups (providing information, receiving information, discussion, problem solving, planning what to do, or negotiating)?
 - Where are these collaborators located and **how do you communicate** with them? (Phone, face to face, email, chat, whiteboard, videoconference, audioconference, facsimile) (*transmission*)
 - Do the communications tools available adequately meet the needs of the job?
 - How critical is **face to face** coordination? When and why? (*may be confirmation, justification, alternative evaluation*)
 - Are there issues that are difficult to resolve (or tasks that are difficult to accomplish) if you don't have a **relationship** with these collaborators? (*may be justification, rationalization, differentiation*)
- c. If you must coordinate with *senior decision makers* regarding this decision, are you waiting for them to make a sub-decision or are you negotiating with them? (*interdependence*)
- What **kinds of collaboration** are you involved in with these decision makers (providing information, receiving information, discussion, problem solving, planning what to do, or negotiating)?
 - Where are these collaborators located and **how do you communicate** with them? (Phone, face to face, email, chat, whiteboard, videoconference, audioconference, facsimile) (*transmission*)
 - Do the communications tools available adequately meet the needs of the job?
 - How critical is **face to face** coordination? When and why? (*may be confirmation, justification, alternative evaluation*)
 - Are there issues that are difficult to resolve (or tasks that are difficult to accomplish) if you don't have a **relationship** with these collaborators? (*maybe justification, rationalization, differentiation*)
 - How do you prepare for the ad hoc collaboration outside of your operations center?
3. Are **roles and responsibilities** (including decision making authority) clearly understood for this decision?
- a. Where do you get your authority to act?
 - b. Do you have special responsibilities under national or local level frameworks, such as the National Response Framework? Are any of those responsibilities contradictory or difficult to execute?
 - c. Under what conditions might something fall through the cracks?
 - d. Under what conditions might different groups duplicate efforts or get in one another's way?
 - e. How do you resolve disagreements about how to proceed or which action to take? (*election*)

- f. Do coordinating agencies/organizations have sufficient **awareness** of the **status** of each other's **activities** (e.g., what they are actually doing and how it is going)? Explain.
 - Are there situations in which you need to know whether the other operator is currently present or absent?
- g. How do you locate those you need to collaborate with and determine how to contact them? (*connection*)
- h. How do you notify or alert others to an important development? (*notification*)
- i. How do you know they have received the notification? (*confirmation*)
- j. How do you preserve shared understanding throughout a mission? (*common ground preservation*)
- k. How do you synchronize and orchestrate actions with others to enable the joint response? (*synchronization*)
- l. Which parts of the collaboration process are particularly **time consuming** (e.g., identifying and connecting with others, notification of others, synchronization of activities, maintaining common ground/shared SA)?
 - Does the need to collaborate sometimes lead to unacceptable decision delays? When?

Ask about next important decision, time permitting. Loop back to 1b as needed.
4. Do you receive specific **training** in how to enhance collaboration and coordination? If so, how?
 - a. Have there been times when your tools or equipment or training pointed in one direction but your judgment told you to do something else? Or when you had to rely on experience to avoid being led astray by the tools or equipment or training?
 - b. Under what conditions do collaboration techniques tend to **fail**? (E.g., when new collaborators are encountered, or when technology performance is degraded, or when new procedures are being used, or when people haven't yet been trained)
 - Which coordination and collaboration techniques work well most of the time?
 - c. Do coordinating agencies/organizations have a clear understanding of each other's **capabilities** and **constraints** (what they can and cannot do)?
 - What do you /they still need or want to understand?
 - d. What kind of training do you wish you could have? (E.g., where you fit into the big picture, knowing the jargon/culture of collaborators, crisis management, counterterrorism, military operations, airline operations, hazard response...)
5. Overall, what are the most significant **collaboration challenges** in your job? (e.g., insufficient shared awareness, differing opinions, confusion over who is in charge or accountable, trust issues, restrictive rules or other barriers that limit your actions, resistance to information sharing...)
 - a. How would you address these if you could?
6. What is your position on the desirability and **feasibility** of a national-level civilian aviation security coordination center?
 - a. Could the NASCC be virtual instead of physical, given tools and capabilities and training to support collaboration needs?

- b. If the NASCC were virtual, which decisions or capabilities are most important to support well?
- Please step us through a challenging scenario requiring coordination with others. Please describe the **coordination flow** of a typical task (where does it originate from, who does it flow through)
 - How do you monitor your own performance? (How do you know if you are doing well?)
 - Who do people go to when they are unclear about a procedure, or not sure where to get the needed information?

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