Collaboration Capabilities for Crisis Management

E.K. Beaton\textsuperscript{b}, L.G. Boiney\textsuperscript{a}, J.L. Drury\textsuperscript{a}, R.A. GreenPope\textsuperscript{b}, R.D. Henriques\textsuperscript{b}, M.D. Howland\textsuperscript{b}, G.L. Klein\textsuperscript{b}

The MITRE Corp.
a. 202 Burlington Road, Bedford, MA 01730-1420 USA; \{boiney, jldrury\}@mitre.org
b. 7515 Colshire Drive, McLean, VA 22102-7539 USA; \{beaton, rgreenpope, rhenriques, mhowland, gklein\}@mitre.org

Abstract - When a crisis such as 9/11 occurs, it requires coordination and collaboration by a number of government agencies - as well as the private sector - with tightly choreographed activities from many organizations in multiple locations. Although there are accepted collaboration frameworks for operating in a “command and control” mode, where everyone understands who is in charge and what everyone’s responsibilities are, there is not yet an accepted multi-agency “coordinate and collaborate” framework specifically designed for crisis management with less clear lines of authority. This paper presents Part I of a three-part framework that explicitly addresses the multiple characteristics of crisis management collaboration: time-sensitivity, synchronicity, non-collocation, and unrelated organizations. This first part of the framework identifies and describes the collaboration capabilities needed to support such crisis management, using United States aviation security as an example domain because it has all of the characteristics described above. Based on a literature search, governance review, and 19 on-site interviews with many aviation security stakeholders, we synthesize the common challenges discovered into 13 essential collaboration capabilities. We generalize these collaboration capabilities beyond the specifics of the aviation security domain so that other crisis management environments that experience cross-organizational, time-sensitive, safety-critical collaboration, such as disaster response or joint military command and control, may leverage concepts from this framework to organize information about their collaboration challenges and solutions. Finally, using an actual aviation security incident, we illustrate the value of systematically identifying and addressing collaboration capability shortfalls.

Keywords - collaboration, crisis management, capabilities

1. INTRODUCTION

Crisis management requires rapidly choreographed and coordinated activities from diverse cross-organizational partners. During an incident, these groups must collaborate to resolve a time-sensitive crisis in the face of widely varying business models, differing organizational goals and priorities, and regulation constraints. Crisis management support must address the technical as well as the cross-organizational and cultural issues by providing a collection of procedures and practices for inter-organizational decision making, collaboration, and response coordination.

As a case in point, the United States’ airspace security mission is to prevent or counter attacks on air vehicles, including 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 the key actions of airspace security.

For example, on October 21, 2009 Northwest Airlines flight 188 had been out of radio contact well beyond the FAA’s five-minute limit. The standard procedure in the event of a “NORDO” (short for no radio contact) is for the pilot to precisely follow the planned route and for Air Traffic Control to clear the airspace around it. But NWA188 became a potentially serious security incident when it overflew its planned destination of Minneapolis airport; several different agencies had to collaborate rapidly with industry to determine what was happening on board, whether it posed a national security risk, and to coordinate a response.

Execution of the airspace security mission requires coordination and collaboration by both civil and military government agencies as well as the private sector, with coordinated activities from a number of independent organizations in multiple locations. The most prominent government stakeholders are the Department of Transportation’s FAA, multiple agencies within the Department of Homeland Security such as Customs and Border Protection and the Transportation Security Administration, and multiple branches of the Department of Defense such as North American Aerospace Defense’s Eastern and Western Air Defense Sectors. Airspace users (flight operators and crew) are the main private sector stakeholders. Local, state, and federal law enforcement and emergency responders may also be involved.

Today this stakeholder coordination takes place through voice conferencing over the Federal Aviation Administration’s (FAA) Domestic Events Network (DEN). There is no centrally-located crisis coordination center housing representatives of all parties concerned, as often exists in other crisis management domains. Although there are accepted frameworks for operating in a “command and control” mode, where everyone understands who is in charge and the individual responsibilities, there is not yet an accepted multi-agency “coordinate and collaborate” framework. This gap results in wasted time and missed opportunities to respond to crises. The Joint Planning and Development Office's Security Annex Concept of Operations for the Next Generation Air Transportation System (NextGen) recommends “a unified command, control, and communication framework for integrated risk management decision-making.”

While distinct research research efforts have explored aspects of the collaboration required for such a unified collaboration framework, none until now has combined the multiple characteristics of synchronicity, time-sensitivity, non-collocation, unrelated
organizations, and crisis management that must be brought to bear for domains such as aviation security. In this paper, we present Part I of our three-part Collaboration Framework, focusing on systematically identifying those essential collaboration capabilities required to improve the timeliness and effectiveness of multi-agency crisis management collaboration. The goal is to raise awareness and provide the community with a means to assess their collaboration readiness by systematically exploring these collaboration capabilities to identify any shortfalls.

2. THE COLLABORATION CAPABILITIES DESCRIBED

We define collaboration capabilities as high-level concepts which, if available, would help people work together more effectively. Though the following capabilities were identified from analysis within the aviation security domain, we generalize them sufficiently to be relevant to crisis management domains beyond this example.

Methodology

To identify critical collaboration capabilities, our research team began by analyzing the relevant collaboration literature addressing time-sensitive, synchronous, cross-organizational, non-collocated collaboration among stakeholders in crisis management situations. This included theoretical constructs such as common ground theory (Clark and Brennan, 1991), collaboration models (Robertson, 2008), research in team situation awareness (Endsley, 1995), sensemaking (Leedom, 2004), and case studies of collaborative systems (Hanumantharao and Grabowski, 2006). Though it is difficult to distill our findings from this breadth and depth of collaboration literature, we can distill three important lessons related to organizational, cognitive, and systems issues, respectively:

- Organizational finding: Issues of organizational culture, work practices, interdependence, coordination, trust, and processes are entangled with each other and with how people work with the technology. We must disentangle them enough to understand how they affect each other, then recombine them so as to provide for smooth joint work.

- Cognitive finding: Level 2 situation awareness (comprehension) and sensemaking are closely related, and both are needed for recognition-primed decision-making, the type of decision-making often practiced in crisis management. Team awareness is critical for coordinating joint work and is distinct from situation awareness, focused inward at the team as opposed to outward at the external environment.

- Systems finding: Cross-organizational technology and cross-organizational training are needed to execute the mission as a whole flexibly and efficiently.

After the literature review (see Drury et al., 2009 for the full details) and a review of regulations and policy documents to understand the collaborators’ operational constraints (GreenPope et al., 2010), we began our data collection and analysis. We developed a set of 54 interview questions that covered the categories of Decisions, People, Processes, and Resources. For example, questions within the Decisions category included “Are there standards, routines or plans in place that you follow regarding this decision?” and “What are the major pieces of information needed to make this decision?” We then visited several aviation security stakeholders (19 separate visits), conducting 90-minute interviews with from 1 to 12 people at each organization. In some cases, we were also able to observe their operations as they monitored for potential crises.

We next extracted stakeholder “statements” from team members’ interview notes and entered all statements into a database, characterizing them according to the four question categories and according to whether the stakeholder statement was a problem, a requirement, or a potential solution. After correlating and analyzing this information, we synthesized our key findings into a set of 13 collaboration capability statements, explained below. (See Drury et al., 2010 for a detailed description of our approach and analysis.)

We then grouped the collaboration capabilities according to three types of tasks conducted by joint crisis operations users:

a. getting and sharing information
b. understanding information
c. coordinating operations.

Although Situation Awareness (SA) theory (Endsley, 1995) was originally defined for individuals, one can think about these three capability groups in terms of Endsley’s three levels of situation awareness (Endsley, 1988). The first, ‘getting and sharing information,’ is comparable to Endsley’s SA Level 1: perception. The second, ‘understanding information,’ can be compared to Level 2: comprehension. The third, ‘coordinating operations,’ relates to capabilities required for responding to SA Level 3: projecting the state of the situation into the future.

Capabilities for Getting and Sharing Information

Within the category of ‘getting and sharing information’, we identified four collaboration capabilities described below:

1. Enable agile information acquisition
2. Promote standardized procedures and protocols
3. Support efficient situation awareness of senior management
4. Enable sharing of classified/sensitive information

Collaboration Capability 1: Enabling agile information acquisition

Collaboration Capability 2: Promoting standardized procedures and protocols
immediate response, is intended for data mining analysis only, and so forth.

Collaboration Capability 3: Supporting efficient situation awareness of senior management refers to the capability to provide authorities not involved in direct operations with an understanding of key elements of the situation and the ability to project the state of that situation into the future, supporting their decision-making. Our stakeholder interviews revealed that apprising senior management of ongoing situations, sometimes referred to as “feeding the beast,” often detracted from core crisis management functions. We recommend that senior management have separate functionality that provides them with access to persistent information, along with summarization and extraction functions.

In the NWA188 example, this was one of the major collaboration capability shortfalls. The FAA and military senior management were not well supported. They weren’t informed in a timely manner about the extended loss of radio contact (NORDO) and therefore were not aware of a possible impending problem.

Collaboration Capability 4: Enabling sharing of classified/sensitive information refers to the capability for cross-boundary sharing of sanitized classified or sensitive information. There are inadequate facilities for cross-boundary information sharing; currently the only method for sharing information from classified systems is via voice, using classified teleconferencing. Much of the information needed is not classified but sensitive, such as personally identifiable information (PII), and may be shared with some partners but not others. For example, often military information can be shared with the FAA, but not the airlines. Security partners need systems with sensitivity-taggable data to allow or prevent partners from access, depending on their roles. For example, pilots could provide PII on a sensitive, need-to-know basis for law enforcement officers only, rather than making it available globally. Data from classified systems would be handled in a similar manner. Currently, much information to be shared is only considered classified because it resides on a classified system or network, rather than because of its true sensitivity.

Capabilities for Understanding Information

The second class of collaboration capabilities, ‘understanding information,’ can be compared to Endsley’s Level 2 situation awareness: comprehension. The next four of our identified collaboration capabilities fall into this category:

5. Cue for appropriate attention to relevant information
6. Facilitate trust among partners, their information, and tools
7. Enable successful information fusion
8. Promote joint situation awareness

Collaboration Capability 5: Cueing for appropriate attention to relevant information means the capability to alert participants to those items which require their consideration. Transitory, intermittent attention to collaboration teleconferencing was considered a top problem based on interviews and observations. Since current collaboration is primarily via a non-persistent voice conference, partners who are away from their desks or attending to other tasks when information is spoken do not hear it, and do not know they missed it. Yet partners in operations centers often have to leave their desk to coordinate with others, and their intermittent attention to the DEN teleconference results in repetitions of the same information as people request updates. Information should be provided with real time alerts to tell people when their participation may be required, and alerts should be delivered via whatever tool the partners require, be it a cell phone, special pager, email, or other device. Cues should be restricted to the information essential to each partner in order for the alerts to be perceived as helpful, rather than annoying or disruptive.

This was a second major collaboration capability shortfall seen during the NWA188 example. The right people were not alerted until very late in the incident; cueing was not facilitated by the systems in place at the time. Because the NORDO started while the flight was within the Denver Center area of responsibility, Minneapolis Center assumed Denver had already notified the DEN teleconference. Because the DEN has no persistent recording, there was no way for them to check if their assumptions were correct, other than to ask, and they were too busy going through all their procedures to try to re-establish contact with the airplane.

Collaboration Capability 6: Facilitating trust among partners, their information, and tools means the capability to help participants to rely on one another’s actions, judgment, and the facts, figures and data provided. Often information is not trusted because partners don’t trust the tools providing the information. Partners should be able to trust that the tools, and the information in them, are reliable and current. Provenance information, such as the source, date, and time of the initial acquisition of the information, will help people evaluate the data’s trustworthiness. Similarly, when decision support tools make a recommendation, they should provide transparency into the analysis process used. Joint training can also support trust when it is provided in the context of scenarios.

Collaboration Capability 7: Enabling successful information fusion means the capability to help participants and their tools combine different types of information from disparate sources into a cohesive whole. This enables collaborators to reach conclusions that may not have been possible from a single source. Determining what information is useful in a fusion system is critical, as are the rules describing how information will be analyzed by the system. Interoperable tools to share information, particularly cross-boundary information-sharing tools, are needed to provide the information to the fusion automation supporting analysts. Partners must be educated about what information is relevant to each others’ missions so each can be assured they will get the information needed in time to make the required decisions.

Collaboration Capability 8: Facilitating joint situation awareness refers to the capability to help participants understand key elements of the situation, know their collaborating partners are seeing it in the same way, and to be able to share a projection of the future state of that situation. Facilitating joint situation awareness, or a common operating picture, is a critical capability for partners during crisis management. It is a difficult task because partners have different points of view, different primary missions, and different tools to provide a picture of the unfolding incident. For example, each aviation security partner has its own airspace situation display, sometimes with slightly different aircraft locations, with slightly different information provided for each one. Consequently, arriving at a common understanding about the location of an aircraft of interest is often inefficient and time-consuming. We recommend that a Needs Analysis include a determination of the set of information required by them for situation awareness, such as the status of inter-dependent tasking, process awareness, or aircraft locations. A set of interoperable tools is needed to share this information, such as a portal with links to needed information.
Capabilities for Coordinating Operations

The third category of collaboration capabilities, coordinating operations, relates to capabilities required for responding to Endsley’s SA Level 3: projecting the state of the situation into the future. Five of our identified collaboration capabilities fall into the category of coordinating operations:

9. Promote an actionable, coordinated, concept of operations
10. Facilitate team awareness
11. Provide appropriate automation support
12. Provide appropriate procedural support
13. Provide joint training support

Collaboration Capability 9: Promoting an actionable, coordinated concept of operations refers to the capability to help participants develop and adopt a joint vision, intent, or assumptions regarding joint operations. A top collaboration problem for many crisis management partnerships is the lack of a coordinated Concept of Operations (Con Ops) that is not just a plan on paper, but is actionable; that is, its realization is practical and believable. A coordinated Con Ops is necessary to overcome conflicting cultures. Our interviews and observations revealed unclear coordination participation requirements. Mistrust arose due to inadequate understanding on many fronts including: a) other partners’ roles and responsibilities, b) partners’ rules, laws, and regulations; c) their internal procedures, d) their motivations and agendas; and e) their operational capabilities (e.g., situation monitoring). We recommend the partners jointly develop an integrated, over-arching Concept of Operations. This might begin as a set of pair-wise MOUs between partners that would end up collectively describing an integrated Con Ops to use during joint training.

Collaboration Capability 10: Facilitating team awareness refers to the capability to help participants know who else is participating, what they are doing, and their progress toward joint goals. Partners need to be aware of each other’s participation in an incident. Although some consider team awareness to be part of situation awareness, we separate it out to highlight its importance to coordinating operations. Awareness of the participants’ status and availability is critical for coordination in joint actions.

The collaboration capability of team awareness was lacking during the NWA188 example. The participants often didn’t know who else was involved, who was doing what, what had been accomplished, or when.

Collaboration Capability 11: Providing automation support means providing the automated tools to improve workflow and collaboration. There is often inadequate automation support for joint crisis operations, including the unavailability of functional, usable, interoperable collaborative tools. Crisis operations centers often rely on a central white board visible to those members within a partner’s team, but unavailable to other collaborating partners except through phone call discussions. This is time-consuming and labor-intensive. Needs Analyses should include a determination of the set of functions required for crisis operations and development of the tools required. Tools should support multiple events and cross-organizational decision-making.

Collaboration Capability 12: Providing appropriate procedural support means enabling the performance of a coordinated concept of operations by creating a set of sensible procedures for implementing it and reinforcing adherence to them. Although each partner had procedures for their own actions, we found inadequate procedural support for joint crisis operations, resulting in inflexible rules during crisis mode, no universal decision-reversal procedures, standard operational procedures not written in terms of what the security partners can actually affect, and inadequate backup procedures for crisis operations. Teams must find the “seams” in collaboration, where things often tear under stress; joint training exercises will help discover crisis mode exceptions and create flexible procedures for them. Joint exercises will also reveal where individual and collaborative decision-reversal procedures are needed.

Collaboration Capability 13: Providing joint training support refers to knowledge of cross-organizational capabilities and capacities. Although the partners we interviewed all had excellent training programs within their own organizations, we found inadequate joint training and training standards. For example, there was inadequate knowledge of cross-organizational situational capabilities and capacities, such as who to call under different conditions. Standard training certification would ensure partners all know the common protocols, jargon, and tools. Joint training exercises where partners worked through difficult scenarios would improve the team’s effectiveness.

3. Identifying and Addressing Collaboration Capability Shortfalls

The collaboration capabilities above represent Part I of our Collaboration Framework, and are shown along the top of the pyramid in Figure 1. Part II, which cannot be presented in detail in this paper due to space limitations, identifies and describes three types of supporting elements that can be leveraged to develop specific collaboration capabilities that may be lacking: knowledge (people), skills (people performing processes), and technology features (automation). See the inner core of Figure 1. Part III of the Collaboration Framework will describe the criticality of each element for enabling the collaboration capabilities.

Figure 1. Collaboration Framework

Full details on the supporting elements are provided elsewhere (see Beaton et al., 2010). However, here we will use one each of the supporting skills, knowledge areas, and technology features to illustrate how crisis management collaboration could have been improved, enabling those three example collaboration capabilities that were lacking during the NWA188 incident. The ultimate goal is
to help crisis collaboration partners focus their attention and limited resources on specific gaps in their collaboration capabilities, and on those skill sets, knowledge areas, and technology features most likely to address those gaps.

Returning to the example of NWA188’s NORDO and overflight, we have shown that this aviation security incident revealed major shortfalls in at least three of the collaboration capabilities:

- Capability 3: Support efficient situation awareness of senior management (part of Getting and Sharing Information)
- Capability 5: Cue for appropriate attention to relevant information (part of Understanding Information)
- Capability 10: Facilitate team awareness (part of Coordinating Operations).

Our Collaboration Framework identifies seven skills that support the collaboration capabilities. Two of these skills relate to successful teaming - ‘Be aware of partners’ and ‘Call in the right organizations depending on the situation’ - and are deemed critical for cueing (Capability 5). The skill to be aware of partners is also critical to team awareness (Capability 10).

Poor execution of these two skills was a major factor in the delay in coordinating operations to ensure national security. The military should have been brought into the situation early on; it is responsible for protecting the homeland and needed to make sure that NWA188 hadn’t been commandeered by someone with ill intent and was thereby deliberately out of radio contact. However, NORAD didn’t receive timely notification and did not know what was happening until late in the incident. Had this been something other than the inattention of the pilots, the safety of the United States could have been compromised.

The Collaboration Framework also identifies three knowledge areas that support collaboration capabilities. One of these is ‘Know partners’ information needs’ and is deemed critical for supporting management situation awareness (Capability 3), and important for supporting effective cueing (Capability 5).

If all the participants in the NWA188 incident had known the information needed by their partners, Denver Center would have known they had to tell Minneapolis Center that participants on the DEN teleconference hadn’t yet been notified. Senior management could have been informed earlier, and the right people could have been alerted in a timely manner.

Finally, the Collaboration Framework identifies 19 technology features that support the collaboration capabilities. One technology feature that supports connecting with others is “workflow automation with tailorable alerting.” Workflow automation facilitates the joint completion of interdependent tasks by explicitly incorporating any inherent subtask ordering and handoffs into the collaborative process, and can include tailored alerts for the different crisis management partners. We consider this technology feature to be critical for all three of the missing collaboration capabilities (Capability 3: management situational awareness; Capability 5: cueing, and Capability 10: team awareness).

In the example of NWA188, imagine that participants had such automated workflow and alerting in place. Such a feature could have been set to alert the DEN teleconference participants automatically when a NORDO continued beyond the FAA’s five-minute rule. This would ensure that the very people who are busiest at the time—the front-line controller trying to establish contact with the aircraft—would not have to remember to check the time to figure out when to alert the supervisor, who then tells the Operations Manager, who then reports it on the DEN.

4. Conclusions and Future Work

This paper fills a gap in the crisis management collaboration literature by identifying and describing critical collaboration capabilities. The proposed framework emphasizes the distinct characteristics of crisis management collaboration: synchronicity, non-collaboration, unrelated organizations, and time sensitivity. Based on the existing literature, a governance review, and 19 interviews at diverse stakeholder organizations, we provide an analysis of collaboration capabilities that we hypothesize are needed to support an example crisis management domain - aviation security.

We used as an example the NWA188 overflight incident to illustrate the capabilities. Procedures are now in place to address these shortcomings.

We provided a brief look into Part II of the framework, which identifies and describes three types of supporting elements that can be leveraged to develop specific collaboration capabilities: knowledge (people), skills (people performing processes), and technology features (automation). Part III of the Collaboration Framework, currently in progress, will describe how these elements support the capabilities. The next phase of this research will involve experimenting with particular technology features or skills within a simulated event to evaluate the impacts on collaboration outcomes.

We could claim validation of the utility of the set of collaboration capabilities and supporting elements if their application in a controlled experiment provides quantifiable improvements.

Future work also needs to be done in defining knowledge and skills at the next level of detail. For example, what exactly do collaborators need to know about their partners’ contexts? What detailed skills need to be taught, and what are the best ways of teaching them to busy, cross-organizational, non-collaborated teams?

We expect that domains that must manage cross-organizational, time-sensitive, safety-critical collaboration, such as disaster response, aviation security, or joint military command and control, will be able to use this framework to organize information about collaboration challenges and solutions. This set of collaboration capabilities can provide guidance to organizations regarding where to allocate their scarce resources to improve collaboration. For example, they can choose which technology features to acquire depending upon which collaboration capabilities they are most concerned about improving.

Finally, if the framework can help collaboration partners develop more effective capabilities through training and technology, they should see improved abilities to determine responsibilities and lines of authority rapidly during a crisis, easier coordination and collaboration of actions, reduced juggling and jockeying amongst partners, and a more timely response.

5. Disclaimer

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6. References


