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Supporting Teams in Crisis with It: A Preliminary Collaboration Framework

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SUPPORTING TEAMS IN CRISIS WITH IT: A PRELIMINARY COLLABORATION FRAMEWORK

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To support their teams in crisis, organizations seek to leverage advances in information technology. These advances include *automation* support to the warfighting team (e.g. an electronic checklist for a flight crew), as well as *collaboration* support such as linking engaged combat troops to intelligence services. While automated support is rapidly developing, very little consideration has been given to enhancing the collaboration support for teams that face crisis. Here we suggest a preliminary set of IT system attributes to support collaboration for teams that face crisis. These attributes are based on two frameworks that have been developed to mitigate the effects of crisis. One is an organizational approach called the High Reliability Organization (HRO), the other, a team approach based on Crew Resource Management (CRM). Here we suggest attributes of an IT system to support teams that face crisis based on these two approaches.

Introduction

To support their teams in crisis, organizations seek to leverage advances in information technology. These advances include *automation* support to the warfighting team (e.g. an electronic checklist for a flight crew), as well as *collaboration* support such as linking engaged combat troops to intelligence services.

Understanding how to support teams that face crisis is essential. Currently IT support includes display systems (Hamblin, 2003; Sarter & Schroeder, 2001; Vicente, 2003), intelligent support systems (Koester & Mehl, 2003; Palmer & Degani, 2001; Wischusen et al., 2003), decision support systems (Smith, Johnson, & Paris, 2004), and a wide variety of other technical solutions (Stoner, et al., 2004). These systems give automated support to teams in crisis. However, very little consideration has been given to enhancing the collaboration support for teams that face crisis (Huang, 2004; Nunamaker, 1997).

Collaboration

Collaborative support for these teams in the past was limited by the available technology. Historically, flight crews, military teams, or surgical units could not be collaboratively supported as only the team in crisis knew the local conditions and had access to the stand alone computers that produced the crisis data. In the past, teams in crisis had only their immediate resources at hand or preprogrammed automated support. Now, with advances in network capacity and sensors, IT has stretched that hand and teams that face crisis can obtain collaboration support from others in the organization. These organizational experts can now see real-time data from the crisis, interact with knowledge bases, and reliably communicate with the team.

To date, IT support for crisis teams has focused exclusively on automated support. Teams are supported with a variety of tools such as electronic checklists, self contained expert systems, and agent technology. However, we suggest one fundamental principle of crisis is that it is unexpected, unpracticed, and unprogrammable (McKinney & Davis, 2003). Whereas an engine failure or low oil temperature on an engine may be an emergency, examples of crisis include being shot, responding to a novel terrorist attack, facing an engine failure over a combat zone, or responding to novel combinations of systems failures. Emergencies are predefined and therefore amenable to automated support. With an emergency, we know what is wrong and we can optimize and train a specific response and support that response with automated support such as a checklist or sensor or display device. Crisis by its uniqueness reduces the utility of automated support. The challenges are figuring out what is happening, and thinking through irrevocable decisions. As a result, automated support while valuable should not be the only available support for teams that face crisis. Collaboration with other human experts is necessary to aid problem discovery and to consider ramifications of responses.

Teams that Face Crisis

As an organizational component, crisis teams inherit the organization's resources, culture, and goals. Characteristics of the organization have been shown to have a significant effect on crisis team performance. For example, organizational culture has been shown to affect team performance (Bierly & Spender, 1995), and organizational goals and strategy also significantly impact team behaviors (Kozlowski, 1998). If team performance is strongly affected by organizational aspects, a framework to support teams

in crisis should be based in part on organizational activities that support these teams.

most extensive insight into organizational activities that mitigate the effects of crisis has been labeled High Reliability Organizations (HRO). Weick and Sutcliffe (2001) originated the HRO framework. They trace the success of organizations that have teams that face crisis to five activities. These include preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise. The first three reduce crisis incidence while the last two enhance resilience. More detail on these five activities will follow. In later sections, attributes of the collaborative support system will be organized under these activities. Supporting crisis teams with IT should be based on these five "team-organizational" activities.

While support for these team-organizational activities is important to crisis team success, it is also valuable to consider what might, by contrast, be labeled team only needs. The activities of teams in crisis have been the object of flightdeck research for 25 years. This research effort, labeled Crew Resource Management (CRM) suggests that team-only needs might include situational awareness, decision making, communication, team work, personal resources and leadership.

Here, we combine these two models and present IT principles to support collaboration needs using both the HRO team-organization activities and the CRM team activities. Due to space limitations, we only explain the HRO activities in depth as CRM activities are more familiar to this audience.

IT System Attributes

The following list of IT system attributes is based on a review of the HRO and CRM activities. An explanation of the HRO activities and their corresponding system attributes are further discussed after the list.

System Attributes Based on HRO Activities

1: Encourage widespread near miss and error reporting and analysis that lead to improved processes
2: Permit recording of detailed accounts of near misses or errors that allows new attributes to be collected and analyzed
3: Provide the opportunity to retain and display unsimplified data and disconfirming evidence
4: Track and display a wide variety of data for a variety of expert interpretation
5: Increase the visibility of operational performance measures and reward operational enhancements that lead to continual improvements
6: Reward operational change and adapt to changes in operations
7: Allow simultaneous action and diagnosis while supporting on going activities
8: Permit depth of analysis and mental simulation of courses of action
9: Identify and match experts with on going problems
10: Supports ad hoc team communication and analysis among experts

System Attributes Based on CRM Activities

11: Be simple--don't overly filter or over process the original data, just put the data into meaningful form
12: Help reduce mental effort by supporting feature matching and story telling
13: Display information cues and historical trends in such a way that the load on an operator's short term memory is minimized
14: Provide a mechanism to direct the attention of an operator to important events minimizing the cognitive costs of interruption
15: Provide a mechanism to mitigate the effects of confirmation bias
16: Suggest actions that would provide diagnostic feedback from situations in which information cues are equivocal, thereby mitigating the tendency to attend only to the information we want to believe
17: Compensate for deficiencies in action selection (what to do about it)
18: Enable communication value sharing
*19:*Aid increased vertical communication during crisis
*20:*Support communication of effective dissent or alternative hypotheses
*21:*Enhance accuracy and sharing of common models on the state of affairs

Principles of HRO-Organizational Activities and System Attributes

In the following sections, the activities of successful HROs are outlined. Within each section, the attributes of an IT system to support each activity are also presented. Examples of successful HROs from the aviation industry are also included. Descriptions of HRO activities are based on *Managing the Unexpected* by Karl Weick and Kathleen Sutcliffe (2001).

1. Preoccupation with failure

Members of HROs constantly worry about failure and distrust success. They look hard for lapses or minor incidents that, if ignored, could later recur and lead to significant failures. This preoccupation with failure is impervious to success. HROs distrust success as it tends to narrow perception and breed overconfidence. This misplaced confidence in judgment and in existing procedures limits changes to the organization and its processes. One way HROs fight the lethargy of success is by establishing attribution-free error reporting procedures. Anyone in the organization can report errors and are assured that those errors will not lead to sanction. These error reports are never automatically or thoughtlessly processed by the HRO. Rather the data collected is turned into active incident reviews and in depth analysis that are widely communicated.

A manifestation of preoccupation with failure in the airline industry is error reporting (Chidester, 2003). The Aviation Safety Reporting System (ASRS) is one national system, and all major airlines have their own internal systems. Pilots make inputs to the systems via anonymous reports (see ASRS at http://asrs.arc.nasa.gov/). Data from these systems are then analyzed by trainers and researchers. Their reports are widely shared and the results of the studies have had significant impacts (Gunther, 2003). The ASRS is just one of several examples of airline preoccupation with failure. Training departments at airlines continually develop new error frameworks and mitigation processes (Chidester, 2003). Further, they are increasingly active in analysis and communication of errors and abnormal situations (Haney & Gertman, 2003; Muthard & Wickens, 2003).

System attribute 1:

Encourage widespread near miss and error reporting and analysis that lead to improved processes

These near misses and errors may contain warnings of future problems but in the din of daily activity appear as only weak signals of impending crisis. The IT system must be designed to find and amplify these weak signals. Unfortunately, weak signals, by their nature, are not readily found as they defy easy classification or categorization. If categories or attributes of errors were already known to the organization, the errors that occur would also be known and procedures established to respond. For example, jet engines break down, and therefore airlines have learned to classify these failures as engine problems. However, most weak signals are not easily classified (e.g. how should a small crack, or mistyped clearance be classified?). As a result, most organizations can not respond until the wing crack leads to a break and a crisis occurs. Thus, the crisis IT system should permit detailed descriptions or detailed reporting of odd events, near misses, and weak signals. From these details, common attributes, such as the length of a "must repair" crack, or the frequency of clearance errors can later emerge. Once these new attributes are known, tolerances can be set for future inspections and reporting and attention can shift to finding new attributes or categories.

System attribute 2:

Permit recording of detailed accounts of near misses or errors that allows new attributes to be collected and analyzed

2. Reluctance to simplify

High reliability organizations refuse to simplify the complex events in which their teams participate. Although all coordination requires some simplification, in HROs, participants minimize this simplification. Instead, they constantly seek to see more, and render more complete and detailed their understanding of both their actions and the environment. When actions are taken they avoid the common simplifying process of seeking confirming evidence that their actions were appropriate. Rather, they seek disconfirming evidence that expectations and experience can conspire to hide.

System attribute 3:

Provide the opportunity to retain and display unsimplified data and disconfirming evidence

One way HROs generate disconfirming evidence for their teams is by assigning members with varied and overlapping backgrounds to the crisis team. The variety in backgrounds tends to increase the data that are scrutinized and thereby increase the variety of what can be noticed. By creating teams with members who have overlapping experiences the team is able to see a more complete perspective on their actions and the environment. In addition to variety in the team members, one other source of variety is organizational expert variety. The crisis IT system brings this variety of organizational experts online with the crisis team, allowing them to notice, to suggest, and to think ahead with those in the crisis. With varied backgrounds comes varied experiences and expectations and skepticism of simplification. In addition to the variety of the team, and variety of organizational experts, the search for disconfirming evidence is also enhanced by a varied search of a wide variety of sources. Therefore, an IT system that limits simplification would have a variety of

sensors that records a variety of data for a variety of participants.

System attribute 4:
Track and display a wide variety of data for a variety of expert interpretation

3. Widespread sensitivity to operations
HROs value operations above strategy. This focus on current operations is designed to find hidden or underlying lessons about weaknesses in the operation. These latent failures may be found in many areas including poor supervision, inadequate procedures, and deficient training. In addition to finding and correcting these significant operational failure points, HROs also demonstrate their commitment to operations by their focus on correcting even minor issues. The result is continuous improvement in operations. To sustain this incremental improvement, HROs seek operational suggestions from the whole organization. They widely disseminate and seek feedback on both operational performance and performance measures. This operational priority is evident in other ways-- in the attention devoted to even small interruptions in operations, in the frequent meetings on operational status, and in organization structure designed to widely distribute real time information about operations.

Airlines are an example of HROs committed to operations. At major hub airports, airline ground support centers demonstrate this sensitivity to operations. These centers refuel, clean, restock, and support all passenger and flight activities at the hub. Operational performance of the hub is closely tracked and widely disseminated throughout the company. For example, the on-time departure percentage of the first set of flights leaving the hub are calculated and compared to benchmarks and to other hubs at the airline. Every hub center knows how they compare real time to other hub operations. They work collectively to constantly refine gate allocation algorithms, refueling procedures, and clearance conflicts to continually improve operational measures such as on-time performance and resource use.

Not only should operational performance data be available for local use, IT systems supporting teams in crisis should be designed to widely disseminate the state of current operations within the organization. The system should make operational data, training schedules, and other process information increasingly available for oversight and improvement. This should result in improvements to operational procedures from a variety of sources.

System attribute 5:
Increase the visibility of operational performance measures and reward operational enhancements that lead to continual improvements

One key implication of operational process change is that the IT system itself must change. Therefore, the system must be flexible enough to adapt to changes to operations.

System attribute 6:
Reward operational change and adapt to changes in operations

4. Commitment to resilience

HROs are built on the premise that error is inevitable. As a result, HRO managers take pride in engaging in putting out fires. Unlike managers in other organizations who see fire fighting as a failure of planning and a drain on resources, HRO managers know that recovery from error is their primary activity. Because of this priority they seek deep knowledge of their technologies, processes and people. In addition, they excel at adapting to swift feedback, learning quickly without error, recombining existing responses, and mentally simulating courses of action. Further, they have learned to treat while diagnosing and to adapt to threats based on feedback from action.

The professional aviation community has realized that error is inevitable. In fact, one report estimates the frequency of pilot error at 5-10 mistakes per hour (Amalberti, 1996). As a result, flight systems, training, technical systems, and procedures are designed to respond and recover from emergencies. Further, pilots are taught detailed knowledge about their aircraft systems, and their environment in order to more accurately diagnose crisis and think through courses of action.

System attribute 7:
Allow simultaneous action and diagnosis while supporting on going activities

System attribute 8:
Permit depth of analysis and mental simulation of courses of action

5. Deference to expertise
As implied earlier, HROs deliberately employ a wide variety of expertise to avoid simplification when responding to crisis. Not mentioned earlier is how

HROs are organized to deploy that expertise. Expertise is not employed in a rigid organizational structure, rather experts are expected to self organize around a problem. In addition, they are permitted to make changes without multiple levels of oversight common in more hierarchical organizations. By pushing responsibility and authority down and out to where the organization meets its environment errors are noted earlier and problems more quickly addressed. Moreover, operating dynamics are such that when the signals emanating from the crisis are noticed, experts find the problem and resolve it at a low level. Quick and accurate decisions by those closest to the action are emphasized. Westrum call this coordinate leadership (Westrum, 1997).

Currently airlines provide a poor example of deference to expertise. Aircraft operational decisions are vested in the captain, and the crew, with only limited support from other organizational experts. While crews can use their two way radio to ask for maintenance or weather support, the crew is cut off from other experts in the organization and is alone responsible for finding all potential problems. A better system would allow crews to have on going collaborative support that during a crisis would grow to include a number of company experts.

To support better use of expertise the IT system for teams in crisis must permit data and analysis to migrate to appropriate experts. It should encourage signal watchers close to the action to alert the right experts in the organization about anomalies. As a result, exception reporting, and other signals of problems should not just go to executives but be shared widely within the organization.

System attribute 9:
Identify and match experts with on going problems

In addition, the IT system must be configurable to these ad hoc collaboration teams. In contrast to supporting these ad hoc teams, traditional IT systems have the effect of making organization decision making rigid and predefined. However, the goal for a crisis system should be to support the analysis needs of a variety of experts in ad hoc teams.

System attribute 10:
Supports ad hoc team communication and analysis among experts

Summary

To date, little work has investigated supporting the collaborative needs of teams that face crisis. The uniqueness of the crises event suggests that in addition to automated support, teams that face crisis would benefit from real time collaboration from other experts in the organization.

The goal of this report was to develop an initial list of IT system attributes to support teams in crisis. To accomplish this, two main frameworks of crisis were reviewed. The first model, High Reliability Organizations, suggests that to mitigate the effects of crisis teams should be preoccupied with failure, avoid simplifications, attend to operations, commit to resilience, and defer to expertise. The second, Crew Resource Management (CRM) posits that effective decision making, communication, and a shared situational assessment contribute to an effective response to crisis. Using these eight activities, 21 specific and distinct attributes of a crisis IT system were presented. Future research should further refine this list, evaluate its completeness, and assess its generalizability. As with other studies of crisis, it is difficult to collect observations or conduct experiments. On the other hand, as cockpit voice recorders and flight data recorders become more common, more scientific analysis of the system attributes suggested here will be possible.

References
(Full list available from author)

Bierly, P. E., & Spender, J. (1995). Culture and High Reliability Organizations: The case of the nuclear submarine. Journal of Management, 21, 4, 639-656.

Cohen, S. (1980). Aftereffects of Stress on Human Performance and Social Behavior: A Review of Research and theory. Psychological Bulleting, 88, 82-108.

Davis, R., Driskell, J.E., & Salas, R. (1991). Group decision making under stress. Journal of Applied Psychology, 76, 473-478.

Driskill, J., Salas, E., & Johnston, J. (1999). Does Stress Lead to a Loss of Team Perspective? Group Dynamics, 3, 1-12.

Esterbrook, J. A. (1959). The Effect of Emotion on Cue Utilization and the Organization of Behavior. Psychological Review, 66, 183-201.

Festinger, L., & Carlsmith, J. M. (1959). Cognitive consequences of forced compliance. Journal of Abnormal and Social Psychology, 5, 203-210.

Hirokawa, R., & Poole M. (Eds.) (1996). Communication and group decision making. Thousand Oaks, CA: Sage.

Huang, Q. (2004). "Embedded Simulation for Decision Support." Proceedings of 13th Conference on Behavior Representation in Modeling and Simulation, Arlington VA, 399-400.

Jehn, K. (1999). A multimethod examination of the benefits and detriments of intragroup conflict. Administrative Science Quarterly, 40, 256-282.

Matthews, K., & Cannon, L. (1975). Environmental Noise Level as a Determinant of Helping Behavior. Journal of Personality and Social Psychology 32, 571-577.

McKinney, E., & Davis, K. (2003). "The Effects of Deliberate Practice on Crisis Decision Performance." Human Factors, Winter, 45, 398-416.

McKinney E., Barker, J., Smith, D., & Davis, K. (2004). "The Role of Communication Values in Swift Starting Action Teams: IT Insights From Flightcrew Experience." Information & Management, 41, 8, 1043-1056.

McKinney, E., Barker, J., Smith, D., & Davis, K. (2004). "How Swift Starting Action Teams Get off the Ground: What Airline Flightcrews can tell us about Team Communication." Unpublished manuscript, Bowling Green State University.

Morrison, J., Kelly, R., Moore, R & Hutchins, S. (2000). "Implications of decision-making research for decision support and displays," in J. A. Cannon-Bowers and E. Salas (Eds.), Making Decisions under stress: implications for individual and team training. Washington DC: APA books.

Nunamaker, J. (1997). Future research in group support systems, International Journal of Human Computer Studies, 47, 3, pp. 357-385.

Olson, W., & Sarter, N. (2001). Management by consent in human-machine systems: When and why it breaks down. Human Factors, Summer 2001, 43, 255-266.

Orasanu, J. M. (1990). *Shared mental models and crew decision making.* (CSL Report No 46). Princeton NJ: Princeton Univ.

Rosenthal, U., & 't Hart, P. (1991). Experts and decision makers in crisis situations. Knowledge: Creation, Diffusion, Utilization, Vol 12, 4, June, 350-372.

Rotton, J., Olszewski, D., Charleton, M., & Soler, E. (1978). Loud speech, Conglomerate Noise and Behavioral Aftereffects. Journal of Applied Psychology, 63, 360-365.

Seeger, M., Sellnow, T., & Ulmer, R. (2003). Communication and Organizational Crisis. Westport Connecticut: Praeger

Smith, C. A. P., Johnston, J., & Paris, C. (2004). Decision support for air warfare: Detection of deceptive threats. Group Decision and Negotiation, 13, 129-148.

Te'eni, D. (2001). Review: A cognitive affective model of organizational communication for designing IT. MIS Quarterly, June, pp., 251-313.

Tolcott, M. A. (1992). Understanding and Aiding Military Decisions. Inn S. C. Collyer (Ed.) The 27th International Applied Military Psychology Symposium: a focus on Decision Making research (ONR Europe Report 92-4 W, pp. 33-48). London: Office of Naval Research.

Vicente, K. (2003). Less is (sometimes) more in cognitive engineering: the role of automation technology in improving patient safety. Quality and Safety in Health Care, August, 12, 291-295.

Walton, R. E., & McKersie, R. B. (1965). A Behavioral Theory of Labor Negotiations: An Analysis of a Social Interaction System. New York: McGraw Hill.

Weick, K. & Sutcliffe, K. (2001). Managing the Unexpected, San Francisco CA: Jossey Bass.

Weick, K. E. (1990). The Vulnerable System: An Analysis of the Tenerife Air Disaster. Journal of Management, 16, 571-593.

Westrum, R. (1997). "Social Factors in Safety Critical Systems." In Human Factors in Safety Critical Systems, Redmil, R. and Rajan J. (Eds.) London: Butterworth-Heinemann.