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Designing a Decision-Making System for Exceptional Events: the Case of Medical Disaster Mutual Aid

Jeffrey W. Herrmann, Alpa Kothari, Sana Shaikh
Institute for Systems Research
University of Maryland
College Park, MD 20742, USA

Abstract

Service enterprise engineering often involves designing systems that perform routine decision-making, as in business processes. However, exceptional events, which require effective decision-making to coordinate the response, are not routine. This paper presents a systematic, scenario-based methodology for designing a decision-making system in which decision-makers collect information about an exceptional event and authorize necessary actions. The approach is based on the operational procedure methodology that has been used for developing avionics systems. The paper discusses an application to the case of medical disaster mutual aid, in which multiple hospitals must coordinate activities to respond to a mass casualty incident.

Keywords
Service enterprise engineering, decision-making, emergency preparedness

1. Introduction

Natural disasters, severe weather, and terrorist attacks are exceptional events during which organizations need to make non-routine decisions quickly. Most organizations have little practice making such decisions. Thus, when such exceptional events do occur, decision-makers often perform poorly. They fail to gather relevant information and include a variety of perspectives. They generate few alternatives and distort information. They respond using inappropriate routines and get into conflicts with others. Surprise, stress, limited cognitive abilities, and groupthink contribute to these errors [1].

To avoid these problems, organizations need to plan their response to exceptional events. While emergency plans provide basic information and assign responsibilities for specific tasks, standard operating procedures (SOPs) complement these plans by specifying how things should be done. However, exceptional events will require decision-making that is not covered by existing SOPs, especially when collaborating with other organizations. For example, hospitals have SOPs for triaging patients that arrive to an emergency department; they generally do not have SOPs for providing mutual aid to other hospitals. A manufacturing firm may have SOPs for all of its manufacturing processes but no SOPs for collaborating with its suppliers to determine the best way to continue production after a hurricane. Relying on SOPs designed for routine operations can lead to poor decision-making during an exceptional event, but developing new flexible SOPs prepares organizations for these events and prevents some of the common problems [1].

How can one design procedures for decision-making in the case of exceptional events? This paper presents a systematic, scenario-based methodology that involves the stakeholders in the process of designing the decision-making system. The resulting design is based on the operational procedure methodology that has been used for developing avionics systems. We have used our methodology successfully to design a medical disaster mutual aid system. The application of this methodology may be fruitful in other settings where exceptional events require new decision-making structures.

Our methodology assumes that the organizations and individuals involved in the decision-making system are working together cooperatively to achieve some objective that is desirable by all. The types of decisions that need to be made depend greatly upon the nature, extent, and impact of the event; therefore, it is not feasible to use routine decision-making processes. Of course, events that may be exceptional for one organization (such as a fire that destroys a firm's warehouse) may be routine for others (the firefighters who respond), due to their mission and training.

The paper will first discuss the problem of decision-making in exceptional events (Section 2) and the methodology that was used in this study (Section 3). Section 4 presents the application of this methodology to the case of medical disaster mutual aid, in which multiple hospitals must coordinate activities to respond to a mass casualty incident. Section 5 concludes the paper.

2. Decision-Making Systems for Exceptional Events

To prevent decision-making pathologies during a crisis, Smart and Vertinsky [1] recommend creating a decision-making structure designed especially for crisis decision-making. The decision-making system must enable participants to make effective decisions. In general, decision-making is a multi-step iterative process [2] that includes gathering information about the current situation, the relevant objectives, and the alternatives available; choosing the best alternative; considering other possible outcomes through sensitivity analysis; and implementing the choice. Therefore, designing the decision-making system must identify the important participants, define roles and responsibilities, specify communication channels, and identify the information to be shared. To avoid unnecessary effort, designing the decision-making system may make use of existing SOPs for ordinary, well-defined tasks that are needed.

This problem is closely related to organizational design [3]. Following the ideas of contingency theory, we frame the problem as one of finding an effective design for a particular environment. Although the research on information and decision processes in organizations does not provide detailed methodologies for designing decision-making systems, it does provide some guidelines. For instance, Simon [4] emphasizes the need to create an organization pattern for the tasks that provide information for the decisions that need to be made. Huber and McDaniel [5] present organizational design guidelines that follow from a decision-making perspective. The following three are most relevant to the problem discussed here:

- If both routine and nonroutine decisions must be addressed, create and formalize a dual structure, one with rigid processes for routine decisions and the other with flexible processes for nonroutine decisions.
- Maximize the performance of the decision-making system as contrasted with the information processing system.
- Formally decide what to decide.

Directly relevant to this problem are some specific guidelines presented by Smart and Vertinsky [1]. They suggest creating new flexible SOPs, using special communication channels, including in the crisis decision-making group a diverse set of members who communicate with others in their own organizations, and having exercises to simulate crises.

Although these types of guidelines are useful, designing a decision-making system for exceptional events poses an interesting methodological challenge. A number of factors contribute to this: First, the decision-making system will span multiple organizations that do not typically work together closely. (It is the exceptional event that motivates them to collaborate.) Second, although a conceptual design may be specified, important details exist primarily in the minds of various domain experts and are inaccessible to others. Third, there exist no accepted performance measures for the decision-making system, unlike routine decision-making processes, which can be measured by decision quality or speed. Fourth, the decision-making system will involve human beings performing non-routine actions in a unique setting, so it is not valid to model them as simple processors.

Based on these factors, we conclude that the challenge requires a creative, participatory design process that integrates different perspectives, not a quantitative, problem-solving approach. The stakeholders must participate throughout the project not only to review the system that is designed but also to improve it. Such a process falls into the category of interpretive approaches [6]. Moreover, our methodology attempts to follow the suggestions of Meredith [7], who describes a “relativist” research approach that is more suitable for a poorly understood problem situation like this one. It recognizes the limited (and perhaps biased) understanding that a researcher can achieve and emphasizes the client’s role in validating the research results. The consequent benefits of increasing understanding are certainly relevant since organizations have little experience handling exceptional events.

3. Methodology

We believe that defining a design methodology for decision-making systems will be a useful advance in organizational design and service enterprise engineering. Our methodology employs the following important techniques. First, to define the decision-making system, we apply ideas from the operational procedure methodology, a systems engineering approach created to help design avionics systems that are used to control aircraft [8][9]. The operational procedure methodology defines a mission as a set of operational procedures. The operational procedures specify how the reactive system should behave in given scenarios. The progression of an exceptional event may be very difficult to know in advance and can change quickly. Reacting to the environment's stimuli with logical decision-making is an extremely important part of responding effectively in this situation. Thus, decision-making during an exceptional event is a type of operationally embedded reactive system (like a modern avionics system), which makes the operational procedure methodology highly relevant.

Second, to represent the operational procedures, we use process diagrams with swimlanes. This special type of flowchart (like a UML activity diagram) adds more detail about who does which activities by visually separating different roles [10]. We have used these process diagrams successfully for studying decision-making systems in product development [11][12] and in production scheduling [13][14].

Our design methodology is a team activity. The design team consists of emergency preparedness planners and similar representatives from the participating organizations. One or more assistants support the design team. The steps of our design methodology follow:

1. Define the mission and scope of the decision-making system: during which types of events will it needed, which organizations will be involved, which objectives are relevant, what types of actions will they be considering? Define scenarios, which are subsets of the state space, in terms of external events or in terms of conditions inside the organization. The design team performs this step.

2. Create operational procedures for these scenarios to support the mission. Each operational procedure is a set of information-gathering and decision-making activities made by various participants. The result of each decision must be communicated to those who must act and make other decisions based on the result of the first decision. The operational procedures are not an information system. The assistants create these with input from the design team.

3. Model the decision-making processes that will occur in each operational procedure using process diagrams with swimlanes. This requires clearly defining different roles, identifying which roles make which decisions, which information will be gathered and shared, and how to use effectively the critical infrastructure provided by information technology, including databases and communication systems. The assistants create these models.

4. Rapidly improve the operational procedures. A key component of the proposed approach is to organize an *improvement workshop* during which the design team considers the models of the operational procedures, analyzes them, and identifies feasible, desirable changes that will accelerate decision-making, reduce the chance of errors, and eliminate unnecessary effort. Note that this improvement workshop is not an exercise because it does not simulate the decision-making processes. This step is important because it simultaneously brings multiple perspectives to bear on the problem. The assistants update the operational procedures.

5. Plan and execute an exercise to test the operational procedures. A design team member or assistant with experience in exercise planning leads this activity. The exercise should include those individuals who will actually participate in the decision-making system when it is implemented. It is therefore necessary for the design team to make them familiar with the operational procedures. Based on the results of the exercise, the design team will suggest improvements to the operational procedures, which the assistants will implement.

6. Once the operational procedures are accepted, conduct exercises to maintain readiness and develop additional enhancements. The participating organizations are responsible for this step.

The above methodology satisfies guidelines for an interpretive systems methodology [6]. It constructs models of "human activity systems" (the process diagrams) and uses these to initiate debate about the operational procedures (in the improvement workshop). It does not depend upon quantitative analysis, it recognizes the need for continuous improvement and the importance of learning, and the stakeholders participate throughout the methodology.

4. Medical Disaster Mutual Aid

Six hospitals and other health service providers in Montgomery County, Maryland, have formed the Montgomery County Healthcare Collaborative on Emergency Preparedness (MOCEP). The participants have agreed to provide mutual aid in case of a medical disaster, which is an overwhelming incident that exceeds the effective response capability of a participating hospital. The MOCEP memorandum of understanding (MOU) describes the relationship between the participating hospitals, the Montgomery County Fire Rescue Services, and the Montgomery County Department of Health and Human Services. To prepare for medical disasters, the MOCEP participants wanted an Emergency Mutual Aid System (EMAS) to specify more precisely how decisions will be made and what information will be available.

In this case, the design team consisted of twelve representatives from the MOCEP participants. The authors and an expert on exercise planning assisted the design team. We followed the methodology described above to create and test the operational procedures in approximately three months. We investigated hospital mutual aid plans, mass casualty incident response plans, Maryland EMS plans, and other relevant topics. We began drafting the operational procedures and asked the design team to review them. As directed by the MOU and the design team, we considered various scenarios, including the following: a hospital running out of pharmaceuticals, supplies, or equipment; a hospital with insufficient staff; and a hospital that needs to transfer patients to another. Some scenarios were considered beyond the scope of the EMAS; one much-discussed one was the imminent shutdown of an entire hospital, which would require assistance from the State of Maryland following other emergency plans.

At the improvement workshop, the design team discussed the Emergency Mutual Aid System mission and all of the draft operational procedures. As changes were proposed during the discussion, we modified the corresponding process diagrams using a tablet laptop computer that was displaying the diagram to the group, who could discuss and revise the suggestions immediately (see Figure 1 for an example). This workshop yielded a number of useful and important changes to the draft operational procedures.

A tabletop exercise was held six weeks after the improvement workshop to evaluate the operational procedures. In a tabletop exercise, participants from multiple organizations gather in one room and respond to information about a simulated event by playing their roles. Up to ten individuals from each MOCEP organization participated, along with representatives from other county and state agencies, neighboring jurisdictions, observers, and invited guests. The simulated event was a multi-hazard event including severe weather, power outages, auto collisions, a media event, a mass-casualty transportation accident, and the release of a hazardous material. The tabletop exercise was deemed highly successful by the participants in reviewing the procedures, assessing the strengths and weaknesses of the integration of their internal plans with the EMAS, and helping to build depth in their organizations with newly trained individuals. A major recommendation of the After Action Report was the need for additional training of hospital staff on the operational procedures and their internal disaster plans in preparation for a multi-jurisdictional regional exercise scheduled for two months later.

The methodology led to many useful discussions about roles and responsibilities, especially in areas where guidelines in the MOU were vague or impractical. For example, the draft operational procedures (following the MOU) indicated that a representative from a county agency would allocate mutual aid resources in many scenarios. The design team saw problems with that, due to the difficulty of tracking five hospitals' resources and the possibility for conflict. They then redefined that role to one of sharing and monitoring the requests for mutual aid (to ensure that they did not get forgotten), while each hospital's logistics chief decided which resources (such as pharmaceuticals, supplies, and equipment) were available to share with others.

In the end, we created eleven operational procedures. During the course of the project, it became useful to group the operational procedures into four "phases" that proceed in order.

- The Activation phase refers to the period immediately following the incident. One or more hospitals may be receiving (or preparing to receive) patients, but the participating hospitals have not yet activated the EMAS.
- The Launch phase begins upon activation of the EMAS. All participating hospitals have activated their Hospital Incident Command Systems (HICS), are establishing communication links, and sharing key information.
- The Operations phase begins when participating hospitals begin requesting mutual aid.

- The Deactivation phase begins when the operations related to the incident are complete and further mutual aid is not necessary.

Each operational procedure is fully specified in a document that describes the operational procedure, the scenario in which the operational procedure should be invoked, and the goal of the operational procedure. It lists those who should participate, specifies the decision-making process, provides options, and explains the associated tasks for each role in job action sheets. A key component of the operational procedure is its process diagram, which uses swimlanes to identify the tasks that each participant performs. In addition, each operational procedure has a reference sheet that shows the decision-making process and describes the roles of those who participate in the operational procedure.

The primary challenges in this effort were the ambiguity and uncertainty about how the individuals involved in medical disaster decision-making would react, despite our effort and the design team's collective expertise. Although the scenario-based approach was effective at a fairly high level, it was impossible to describe details for every possible situation. In the end, the operational procedures must be adapted as necessary to the actual conditions of the medical disaster.

Advanced analytical methods to support the decision-making activities were not developed. The discussions during the project and the tabletop exercise did not reveal any urgency for them. The operational procedures were the most important priority. However, specific decision-makers may find advanced analytical methods useful, and such work may be a way to enhance medical disaster decision-making.

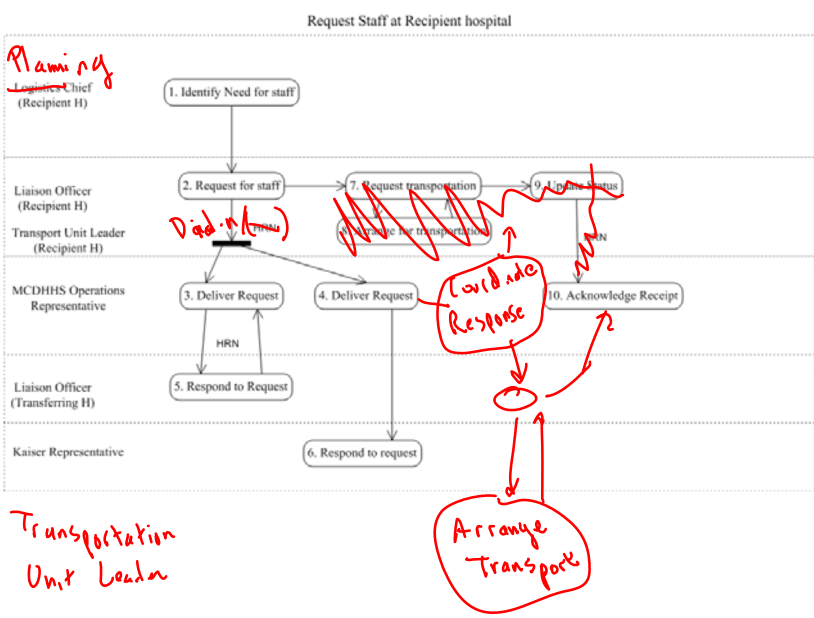

Figure 1. Example of modifying a process diagram for an operational procedure during the improvement workshop.

5. Summary and Conclusions

The design methodology proposed here is effective. It was used successfully to create operational procedures for medical disaster decision-making. The participatory nature of the methodology contributed to its success, leading to a design that was shaped by the collective expertise and consensus of the participants. Descriptive models were used to represent designs, start debate, and document solutions. It is inconceivable to us that a design proposed by outsiders could be as practical and acceptable. The methodology does require time and effort. However, it is a smart investment. Creating and practicing a separate decision-making system for exceptional events follows established organizational design guidelines [1][5].

Organizations are full of decision-making systems. As producing goods becomes a smaller part of the economy and organizations become more aware of the indirect consequences of their activity, the decision-making process in an organization becomes more and more important [4].

We expect that the methodology proposed here will be helpful to any organizations that want to improve decision-making systems and other service processes when the problem is poorly defined, valid quantitative models are hard to find, and building consensus among different groups is valuable. Designing an extremely large decision-making system may be too difficult to do all at once. Therefore, we recommend decomposing the system into relatively uncoupled subsystems. Although industrial engineering techniques have emphasized using models to evaluate alternatives and find optimal solutions, modeling is also an effective process for communication and increasing understanding. However, using the proposed methodology may be inappropriate for routine decision-making systems in well-understood environments where objective data about decision-making quality and the information processing activities is available. In such cases, an analyst should be able to develop improvements to the decision-making system in a more traditional process re-engineering approach.

It is not possible to prove the superiority of a design methodology unless one could use different methodologies to solve the same real-world problem, which is nearly impossible. We have based our methodology on well-established theories and approaches, adapting them to create a novel approach, and have demonstrated its usefulness. We hope that others will take our contribution, apply it in their setting, and share the results so that we can continue to improve this methodology and increase our ability to design effective processes.

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