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Designing Command and Control: A Systems Theory View of Health Emergency Response

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COALITION COMMAND AND CONTROL IN THE NETWORKED ERA

Designing Command and Control: A Systems Theory View of Health Emergency Response

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Abstract

A particularly complex problem set is posed by the command and control (C2) relationships and activities within a large organization such as a state Health Emergency Response System. These are further complicated by the growing external requirements levied by the Department of Homeland Security. This situation closely parallels C2 problems within coalition and interagency activities. Systems theory allows researchers to describe and discover emergent concepts within such complex problem sets that are excluded using analytical methods. In this paper, a systems theoretical view is taken to investigate the command and control functions of a state health emergency management network laboring to meet the requirements placed on it by the Department of Homeland Security. A general Organization –Information – Technology (O-I-T) model is adopted for describing the interactions between the physical (computing and communications infrastructure), informational and social networks that represent the multiple facets of a command and control system in toto that may be applied to other complex (to include multinational and coalition) C2 implementations. A campaign of experimentation is described to provide prescriptive results.

Introduction

In order to construct an effective command and control organization for the state of New Jersey's Department of Health and Senior Services, a layered model is developed to describe the supporting relationships and interrelationships among the human, organizational and technological entities within a Health Emergency Response Network. Using this model, the current organizational structure can be tested against existing models of network and organizational efficacy and refined through a proposed campaign of experimentation and evaluation.

Under consideration is the information system underlying the entire response network organization as well as the organization itself. The information system will be treated holistically whenever possible, as the data contained within it may be usable in multiple parts of the organization at any time. Conversely, the organization will be investigated at the cell level, looking for emergent capabilities resulting from the grouping of individuals into cells (and comparison of those capabilities to other cell designs), and from the network of cells that form the entire response network.

Galbraith's explanation of contingency theory (1973) as modified by Shoonhover (1981) and others (Schonberger, 1980; Venkatramen, 1989) as well as Goodhue and Thompson's task-technology fit concerns (1995) and Perrow's framework (1967) guide the discussion of organizational efficacy. Zigurs and Buckland (1998) provide a basis for judging this task-technology fit specifically in a group decision support role, as we have here. Ultimately, this paper hopes to shed light upon the appropriate considerations requisite when designing a command and control system that includes informational, technological and organizational concerns and present a framework for modeling other organizations.

Layered Models

The use of layered models is prevalent in many disciplines to describe the complex interactions between nodes. In many cases, these layered models are adopted in order to simplify interactions between nodes that do not directly connect to each other, but which rely upon other network members to connect. Most importantly, layered models allow us to abstract away some complex interactions at low levels to focus on interactions at higher levels. This is a manifestation of Wheeler's famous aphorism that "all problems in computer science can be solved by another level of indirection."[1] In order to better develop the requirements for designing and implementing a Health Emergency Response Network for the state of New Jersey, a survey of layered models is taken. A synthesis of several models will be used to develop one appropriate for understanding the interrelationships between people and technology to enable experimentation and refinement. Experimental validation of this model, including construct validity is proposed as future study.

Since the NJ Health Emergency Response Network is a hybrid network of both humans and information services, some exploration of both is required. A summary of models discussed can be found in Table 1. In the technology realm, a classic example of a layered model is the 7-layer OSI model used to describe interactions between networked computer and communications devices (1981). In this model, the only connection between devices occurs at the lowest "physical" layer, although information may be relayed between the connected nodes at any layer.

A related model is the DoD networking model (Ennis, et al., 1982), which conveys the same concept in a simpler (4-layer) model. In both cases, the power of the model is actually in the interfaces between the layers. By strictly defining the inputs expected to each successive

[1] David Wheeler, Computer scientist at Cambridge University. This quote is often misattributed to Butler Lampson (Harvard).

layer, it is possible to divorce the actions at higher levels from dependency on lower level changes. In this model, for instance, a web application (top layer) doesn't know or care if it is being sent over Ethernet, wireless, ATM (all lower-level technologies), or any mixture thereof.

Bauer and Patrick seek to extend these models into the human domain (2004). They suggest three layers atop the OSI stack to deal with such ideas as human needs, performance and interfacing, which they term the Human-Computer Interaction (HCI) model. This extension is particularly powerful as it suggests at least one way to deal with the interfaces between the humans and the technology systems with which they interact. Further extensions to cover the sub-organizational, organizational, inter-organizational, etc., levels may allow this model to cover the complete space in which we are interested. Massink and Faconti go even further by extending the OSI model to a continuous interaction paradigm (2002).

Model	**Year**	**Domain**	**# Layers**
OSI	1981	IT/Networking	7
DoD	1982	IT/Networking	4
HCI	2004	People and Technology	3 (+7)
Continuous Interaction	2002	People and Technology	5
IW Domains	2001	Information Warfare	3
Knowledge Pyramid	1989	Knowledge Management	3
Von Bertalanffy	1968	Systems	Multiple
Weaver	1949	Communications	3
Kim	1993	Causation	Multiple

Table 1

Alberts, et al. even use a three-layered model to describe three "domains" in which we deal when prosecuting Information Warfare (IW) (2001). In their model, the Physical Domain, Information Domain, and Cognitive Domain exists as separate layers within the IW space. This model begins to grapple with the flow of information, and their treatise on the subject covers a number of "primitives," such as 'sensing' or 'decisions' by showing how data moves up and down between domains as it takes different forms. Unfortunately, their model creates some amount of confusion, in that the physical elements of an information system are not in the physical domain, and that such tools as decision-support aids, which by some argument could belong in the cognitive domain, are relegated to the information domain. This model relates very well, too, to the "Knowledge Pyramid" (Lucky, 1989 for a good example.)

Some very early research also touches upon layered models. Von Bertalanffy, in his discussion of "levels" of organization, and with only a little thought on the relationships between emergent behaviors and those levels, practically invites a layered model for discussing inter-level connections (1968). Even earlier, Weaver, in his appendix to Shannon's seminal work on communications theory, explicitly describes three levels of the "communications problem" (1949). In this case, he breaks communications into Technical (transmission of symbols), Semantic (interpretation of symbols) and Effectiveness (meaning transfer) levels. His further discussion suggests that symbols are, in fact, all that can be transmitted, and that choice of symbols to be transmitted is the only way to enhance actually communications. Errors, too, introduced at a lower level inherently affect the amount of effective communication that can occur at higher levels. Both of these concepts reinforce systems thinking and require an investigation of the communications problem at multiple layers.

Somewhere in between, Kim has specifically addressed the sort of inter-level relationships for which the OSI model was originally designed to explain, but in the physical world (1993). He proposes a multi-layer model and spends significant time discussing emergence and how it applies to all systems at all layers.

A New Approach

What, then, is missing? Even with the various models describe here, there is no complete model to describe the Decision-Human-Information-IT interrelationships, and this is a prerequisite for appropriately modeling the interactions in the New Jersey Health Emergency Response system. Starting from the three “domains” posited by Alberts, et al. seems a fruitful direction for development of an integrated model. A major failing of the Alberts model is that as structured, the three layers do not directly interface with each other—there is something missing at both existing interfaces.

To address this deficiency for our purposes, between the Physical and Informational domains, we posit a Technology[2] layer. Analogously, the realm between Informational and Cognitive domains is populated by Decision Support concerns. It should become clear through further discussion what the requirements are of these layers, and their relationships to other well-known models. To begin, though, it is enough to say that the Technology layer contains those technologies rooted in the physical domain which process, store and manage data and information, while the Decision Support layer consists of systems and processes used to shape information into something usable at the cognitive layer. While the current focus is on IT solutions in these spaces, it can easily be shown that the Technology layer could represent a manual (human) data collection and management apparatus, and decision support tools “do include decision rules, policy manuals,

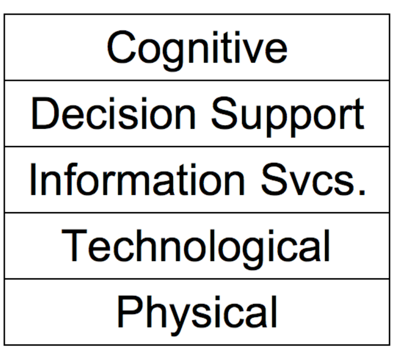

Figure 1: A Five-Layer Model

[2] In much other organizational research, technologies are taken as the tasks actually performed to turn inputs into outputs. To prevent confusion, in this paper, those tasks will remain *tasks*, and *technologies* will refer to information processing technologies such as IT systems and the like.

recollection and staff analysts" (Huber, 1981). This resulting framework is shown in Figure 1.

While this model is better, it doesn't fully address the remaining relationships among human and organizational needs, these five layers and the technology stack that will be implemented in support of them. Accordingly, the OSI + HCI model is adopted with some minor modifications as adjunct to these five layers.

The Physical Layer

In the five-layer model, the physical layer is directly analogous to layers 1 and 2 (*Physical* and *Data Link*) of the OSI model. In the case of non-computer-networking systems, this physical layer also contains such items as phone lines, hard copy of reports and data (but not the data themselves!) or the actual sound waves in voice communications between people. The physical layer is really most of what we can touch in this model, and as is common with layered models such as this, it is the layer at which all communication ultimately takes place. The physical layer also represents actions and activities that can be sensed or effected occurring in the material world.

The Technological Layer

The technological layer contains the systems for moving bits around. It is where, in network terms, the topology becomes logical. It is layers 3 and 4 of the OSI model, describing the *Network* and *Transport* mechanisms. In a less computer-oriented view, this is where the file cabinets and folders are as well as routing envelopes and inboxes. The technological layer allows the information and data to move within a data system, from one node to another in a meaningful way. While perhaps non-intuitive, automated collection mechanisms reside in this layer as well, such as sensors and systems designed to capture and input data automatically.

The Information Services Layer

Although called the Information Services Layer in this model, this layer is the domain of both information and data. In fact, for the purpose of this model, information, data and some types of explicit knowledge can all be interchangeably used. It is the representation--not the content, the context or the ability to take action--that is important at this layer. Here, however, the OSI model fails us, so we will adopt some new language for the sublevels in information. Information in this layer is represented as *traffic flows* and available *services*.[3]

Traffic flows are the bulk information moving within a system. At this level of abstraction, the content of the traffic flows are irrelevant, and, for instance, management of this level of the model would mean ensuring that the flows arrive at their destination in a timely manner and as prescribed, regardless of, and without a requirement to understand, the content of the flows. Services, however, have some context. They represent the first ability to do things with the information flows, and represent the packaging of traffic flows for use in a service oriented architecture or existence of "services" in a client-server model.

The Decision Support Layer

The decision support layer contains the applications with which the user interacts (OSI, layer 7) and the physical man-machine interface (HCI, layer 8). Aside from the physical layer, this is the only layer that contains entities we can touch and manipulate. It also represents the top of the technology stack; everything above this point is about the decision-maker. *Applications* at this layer are dependent upon the services exposed and the traffic flows within the information layer, but serve to manipulate the raw data, adding context and creating

[3] These sub-layers come from a discussion with Michael Clement, to whom I am grateful. I do not, however, use them in precisely the same sense he does in his paper submitted for this conference.

information, or coalescing and enriching information to be presented in a manner suitable for knowledge formation. The display and input devices of the *display* sub-layer contain the information manifestations to be presented to the human and are the point at which the human in the loop can add other data, metadata and rules to the system to return via the services sub-layer to the information flow.

The Cognitive Layer

The cognitive layer is the locus of decision-making. "This is the place where perceptions, awareness, understanding, beliefs, and values reside and where, as a result of sensemaking, decisions are made." (Alberts, 2001) Ultimately all information to be acted upon by humans must reach the cognitive layer to processed and synthesized. Human *needs* and human *performance* (HCI layers 9 and 10) are also reflected in this layer, as are the existing prejudices, historical and social influences of the decision-maker. Human needs, here, only apply to those needs that require interface with the technology stack, and shouldn't be interpreted with any larger meaning. A broader definition of needs is absorbed within the discussion of task, below.

Task

It isn't always customary to explicitly place the task(s) under consideration within the model, but without this explicit mention, it is easy to miss the relationships that exist between task, organization and systems. Additionally, if we are to be prescriptive with our model, it is clear that the type of information systems and the sub-tasks it will be required to perform are heavily dependent upon the primary task or tasks of the organization. Hopefully, this will also cause us to more carefully consider the breadth of tasks confronting an organization in the design of both its information systems and itself in accordance with the task-technology-fit concept (Huber, 1990; Goodhue and Thompson, 1995; Goodhue, 1995).

Organizations in the Model

Ultimately, this model must represent organizational actions and interactions with the technology systems, but until now, the organization has not been mentioned as part of the model. As discussed, this model does not specifically describe a support mechanism for an organization, much less a command and control organization. What it does describe, however, is the layered model for *any* information-based decision support system, regardless of whether it supports a single user or an organization and regardless of the tasks to be completed.

Organization – Information – Technology

While the HCI model is primarily driven by the interactions of a single user and a computer system, we can easily substitute organizational needs and organizational performance in at layers 10 and 9 respectively. Additionally, if the decision support system is taken to be a collaborative space (organizational applications), or providing shared situational awareness (organizational display), layers 7 and 8 also apply across the organization. These substitutions, though, all only reflect the organization as a consumer of the installed technology. In this and many cases, the organization is much more than a consumer that interacts with technology to make a decision. The organization actually *is part of* the decision-support system, fulfilling roles at the top two layers and controlling information flows and providing services within the Information Services level. Since the members of the organization can actually transport information (or choose not to), and since they are clearly manifest in the physical domain, it becomes fairly obvious that the organization spans all layers of the model, both as consumers of the information and decision support system as well as part of the system. The complete organizational – informational – technological (O-I-T) model, then, is given as figure 2.

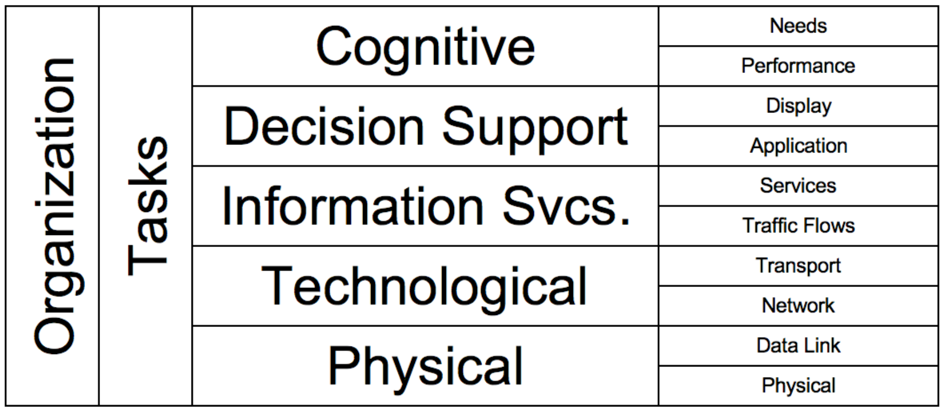

Figure 2 The O-I-T Model

The Organization as a Decision-Support System

The O-I-T model still, to some extent, abstracts away the complexities of the organization, by treating it as a monolithic entity. In practice, however, this is seldom the case. A more complete understanding is available only if we are willing to understand the organization, too, as a system composed of multiple levels. At this stage, there are two significant manifestations of the organization within the New Jersey Health Emergency Response Network comprised of the formal organization and the informal organization.

It is cogent to understand that the Health Emergency Response Network is not a full-time organization; it is a crisis-response organization, activated only occasionally for emergencies and exercises. It draws from the New Jersey Department of Health and Senior Services and the local hospitals and affiliated agencies to staff its crisis cells. As such, the members of the organization all have “day jobs” and bring with them to the Health Emergency Response Network an informal organization which is strongly related to, but in no way coincident with, the formal hierarchical organization of block diagrams and responsibilities specified. This informal organization is best understood as a networked organization with little reflection of the imposed hierarchical constraints of either their day-to-day jobs or the formal Health Emergency Response Network. This is the same situation faced by member organizations within a coalition.

When modeling this organization with a goal of optimizing it, we must consider the effects of the disjointedness of these two organizational structures on the overall capability of the organization. As such, it is important that the information system support the organizational structure as well as the informal organizational structure support the formal one. This view of the system turns the O-I-T model on its side. The organizations in this model must also be analyzed as networked systems to fully explain all the interactions. Figure 3 is a simplified version of this modification for the New Jersey Health Emergency Response Network.

Another area that seems to be missing from the literature on layered models, perhaps due to the predominance of technology systems being modeled, is the requirement for systems in the lower layers to correctly support higher layer processes. They are, in fact, purposely designed with little regard for the relationships between the layers, defining only the interface requirements.

This problem also arises because many systems in our society are not natural or self-organizing. The hierarchy that exists is artificial and imposed, creating a situation wherein higher levels of the system may not

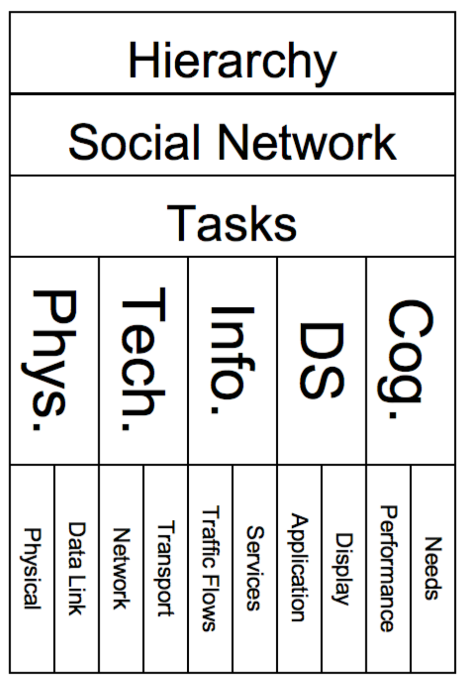

Figure 3

properly reflect the lower-level organization, and where the lower layers may not have the same goals or direction as upper layers. This means that for an organization to be successful as a *system for objective accomplishment* (Johnson, et al., 1964), it must artificially create alignment at all layers as it artificially creates the layers themselves. This is precisely the situation created for us in this case, as the pre-existing organization does not fill the same purpose as the Health Emergency Response Network and the technologies may not be optimally aligned either. Future investigation is contemplated to determine a method for measuring the amount of alignment between layers in order to then correlate alignment or misalignment with organizational capability.

Design Considerations and Parameters

Since ultimately, the decision support system, information and technology are all only destined to support the goals of the individual or the organization, ultimately, we must create a measurement framework based on the ability of the organization to fulfill its mission. Although modeling the complex relationships and dependencies within the O-I-T model is uncharted territory, organizational design certainly is not, and there are many experimental parameters, the modification of which can have significant impacts on the performance of the organization.

Organizational Models

Galbraith (1973) presents a very simple mechanistic model for understanding organizational design based on contingency theory. Contingency theory of organizations makes two simple propositions: 1) There is no one best way to organize; and 2) Any way of organizing is not equally effective. The mechanistic model presupposes that the organization has a large number of tasks to be done which can be subdivided in some way to organizational members to perform. Additionally, the task of the organization becomes one of information processing and decision-making among these disparate members. Due to information-sharing and decision-making ability constraints, such an organization must take some effort to increase its efficiency and capability if it is to grow beyond just a few members. Ultimately, the organization must embark on one, or a mixture of several, of the following:

- Creation of Slack Resources[4]
- Creation of Self-contained Tasks
- Investment in Vertical Information Systems[5]
- Creation of Lateral Relations
  (Galbraith, 1973)

A detailed discussion of each is beyond the scope of this paper, but all must be considered as sources of potential variables for designing and optimizing an organization.

One must also be concerned with the decision-making model being employed. Most information systems and decision support systems make an implicit assumption that decision-making will be rational, unfortunately, that is not always the case. In order to understand the efficacy of our information system in supporting our organization, we must consider the decision-making style of the organization as well. We will adopt Huber's taxonomy of styles for the purpose of understanding our organization (1981). Do they follow the rational, political, program or garbage can model in their decision-making? Each of these drives a different set of questions that must be answered to judge how well the information system supports the decision maker.

Additionally, much work has already been done in linking systems theory to management and organizational design. Johnson, et al., very early (1964), suggested the applicability, even

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[4] Originally from March and Simon, (1958).

[5] "Vertical," as given in the original, is to specify information systems that improve communications flow up and down an organization. This is without (and previous to) the negative connotation that is elicited by a "stove-piped" vertical information system.

exploring the "hierarchy of levels" (from Boulding, 1956) and its ability to help understand the business enterprise as a social system. They go so far as to call system concepts "pervasive" in the business world. It should be a small step, only, to extend these business applications to other organizations. In order to accomplish this, the relationships will be mapped for all nodes in the network, showing reciprocity, or lack thereof, frequency of contact, mode (formal or informal) and method (technology) of contact, much as in Drabek (1985).

Design Parameters

A proposed list of potential design variables follows as Table 2. In many cases, these are not direct design variables, but derived parameters that can be readily measured during operation of the system. Some discussion follows about those that may not be obvious or which are deserving of discussion. Measures labeled as "Qual." (qualitative) are important, but in many cases may be difficult to acquire. Most will be recorded via interview or survey method. A seven-point scale (as in Schoonhoven, 1981) will be utilized for questions such as "Quality of decisions." The research team will apply a similar scale to measure such items as "heterogeneity" or "formalization," for comparison to the self-reported values. Participants will be asked to rate not only their own cells/decisions, but also all those of which they have significant knowledge. Self-selection of "significant knowledge" will follow using the same guidelines as Tushman (1978). Further questions about the quality of the information system and its fit to the task will be elicited following the guidelines in Goodhue (1995).

Variable	**Unit of Measure**
Performance Criteria:	
Cost	Dollars
# of Personnel Required	#

Space required	Sq. Ft. or Buildings/rooms
Time to make decisions	Minutes
Quality of decisions	Qual.
Time to realize a decision point	Minutes
Missed decision points	#
Network parameters:	
Network link density	#
Betweenness	#
Closeness	#
Centrality	#
Size of Clusters	#
Size of Network	#
Length of informal information chain	#
Length of formal information chain	#
Design Parameters (observational):	
Number of data pulls executed/required	#
Number of people contacted to make a decision/length of information chain	#
Percentage of decisions made within a cell	%
Percentage of decisions made without escalation	%
Number of cell elements participating in decision-making	#
Size of cells	#/ea.
Heterogeneity of cells	Qual.
Frequency of contact within the cell	1/min
Duration of contact within the cell	Minutes
Use of the information system	Qual.
Frequency of contact outside the cell	1/min
Duration of contact outside the cell	Minutes
Number of times a single piece of information must be entered into a system	#
Database scope	Qual.

# of different datasets	#
Decision frequency	1/min
Formalization	Qual.
Differentiation	Qual.
Integration	Qual.
Decision mechanism:	
% of decisions made using IS	%
% of decisions made within formal hierarchy	%
% of decisions made within informal organization	%
% of decisions made outside all known organizations	%
Scope of Information System (Local->Global)	Qual.
Timing (Continuous->Long periodic)	1/min

Table 2

Database Scope. This reflects the breadth of data encompassed within the information system. Is it only local (local defined both geographically and according to organizational network topology. *Decision Frequency*. This is a variable that isn't a design variable as much as a potential influence on the system. How often do decisions need to be made? By the same person/cell? *Formalization*. To what degree is the information and decision process formalized for this problem?

Differentiation and Integration. As described in Lawrence and Lorsch, differentiation and Integration measure the extent to which sub-organizational units differ from each other and how well they are reintegrated into the whole (1967). *Decision Mechanism*. Was the decision made using the information system? Was it made within the formal organization without using the IS? Within the informal organization? Outside all these? (Carroll, 1967, in Galbraith)

Number of Data Pulls. How many different queries, phone calls, etc. did a single cell/organization have to make during a decision? *Number of people contacted/length of formal/informal information chain.* How many people had to be contacted, or through how many people/cells did the information need to pass to make a decision? How many would it have taken were the informal/formal chain used instead?

Network Link Density. Number of network links within a cluster as compared to the number of possible links. These clusters are likely to be within the informal organization, and as such may cross cells and levels of the hierarchy giving us the weak ties necessary for a robust organization (Barabasi, 2003). *Betweeness, closeness and centrality*. Measures of nodes and clusters and their relationships with other nodes and clusters (Everett and Borgatti, 2005).

Relationships

A number of relationships must be posited about causal relationships between these design parameters and our expected operational criteria. Fortunately, a great deal of work has been done in this area as well. Huber, as an exemplar of the existing work, has set out a number of propositions relating design variables to performance (1990). These will serve as the starting point for analysis of relationships, in addition to work by Lucas (1975), Ein-Dor and Segev (1982) and Dodds, Et al. (2003).

A Pareto Set of Criteria

Although the idea of optimizing an organization seems tempting, it is not strictly realizable. If, however, we are able to experimentally determine the relationship between our design parameters and criteria, we should expect that an "optimum" organization for NJ Health Emergency Response is one that can be implemented with a minimum of resources (cost, people, space, etc.), and a maximum of effect. Effect can be further refined by: minimizing the time necessary to recognize a decision point, minimizing missed decision points, minimizing the time required to make decisions, maximizing the quality of decisions and minimizing overt reliance on outside actors in the decision-making process. Additionally, while the overall goal is the optimization of the decision-making process, a sub-goal must be the optimization of the information system.[6] Ultimately the success of an information system can be judged by its use (Ein-Dor and Segev, 1978) and only through observing its use can we discover its worth and fit to task.

Experimental Design

Two experiments are proposed to get an initial understanding of the situation with the NJ Health Emergency Response Network. The first is a small-scale, "tabletop" exercise as recommended by Moyer (2005). While he was discussing water system incidents (including potential bioterror and chemical contamination), his method will allow the researcher to better understand the relationships and interplay among cells within the organization and between the organization and outside entities involved in the health emergency system. This experiment would model a catastrophic medical scenario within the state of New Jersey, simulating the effect of a major chemical release in the northern region of the state. Principals and designees will (as individuals) simulate the cells that would be activated in the case of an actual emergency. Real computer systems will be used when appropriate, but geographically separated cells will be able to directly contact one another without the use of the phone.

Due to the simplicity of staging such a scenario, and the proximity of all players, the entire proceedings should be recorded, electronically, if possible, to permit off-line review and

[6] Of course, as one may potentially come at the expense of the other, we only seek to optimize the information system insofar as it does not degrade the overall efficiency of the system.

supplement real-time data collection. The scenario can be modified or repeated within pre-selected alternatives as performance and time allows, testing failures in redundancy, expected modes of communications, or challenging presumptions that arise through the experiment.

This tabletop exercise will allow better formulation of the follow-on experiment. This large-scale exercise will need to engage at least one entire region of the system to ensure fidelity and some reflection of the entire scale of the system involved. A potential scenario involves the NJ Health Emergency Response Network in the TNT experimentation campaign as the destination of a suspected chemical or nuclear contaminant inbound on a ship. This experiment will require the real-time application of systems within the Health Emergency Response Network, but will test the ability of the experiment team to collect data. Since the Network is necessarily geographically separated, researchers may need to be located at multiple sites to collect all data for the experiment.

Follow-on experiments would be designed to stimulate capture of previously unavailable variables or to test hypotheses suggested by early experiments. Through a campaign of experimentation, the various segments of the Health Emergency Response Network will be mapped and observed. By utilizing such an experimentation campaign as suggested in Alberts and Hayes (2005) potential changes in the organization, the information system and the underlying technologies could be carefully recorded and studied.

TOPOFF

A unique capability afforded the research team is an externally run exercise called TOPOFF (Top Officers). TOPOFF is an annual exercise that simulates emergencies in many facets of public administration. The New Jersey Department of Health and Senior Services has often been a part of these exercises. By observing their performance in this exercise outside the campaign of experimentation, we will be able to observe a higher fidelity and much lower-controlled scenario than previously encountered. Since the exercise is outside the experimenters' controls, it also affords an opportunity to look for unexpected results that were, perhaps, stifled by the experimental design in previous experiments.

Conclusion

This paper has presented a multi-layer model for describing the support relationships among Organization, Information and Technology within an organization. This model will allow the application of Systems Theoretical, Contingency Theoretical, Social Network Analysis and Task-Technology Fit concepts to hypothesis and experimental design for the purpose of improving and evaluating the New Jersey Department of Health and Senior Services Health Emergency Response Network both along technological and social-organizational lines. The experimental campaign as presented will allow for the testing of these hypotheses and the refinement of the model.

While the organization of interest in this case is a command and control organization and its principle outputs are decisions, the model as described should be broadly applicable, as it was developed without regard for the specifics of the task to be preformed. The interrelationships between the social network and hierarchical organizational forms in an organization and their results on the effectiveness of an organization may illuminate other unexpected organizational phenomena. Further research into the applicability of this model to other organizational forms is invited as well.

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