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MASS CONFLAGRATION: AN ANALYSIS AND ADAPTATION OF THE SHIPBOARD DAMAGE CONTROL ORGANIZATION

by

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by

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The author presents an analysis of a typical shipboard Damage Control (DC) organization, with emphasis placed on the general failure of the organization to cope with the variety generated by a Mass Conflagration. Two environmental scenarios, the Main Space Fire and the Mass Conflagration, are compared using an Environmental Analysis Framework. The organization is then discussed in terms of its applicable command and control characteristics, and how each of these contributes to the overall ability to cope with the two scenarios described above. After all analyses have been performed, the author then presents recommended adaptations to the organizational technology and command and control characteristics of the DC organization, with the goal of expanding variety handling capacity to meet the more complex environment posed by a Mass Conflagration.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is twofold: first, to give the reader an understanding of the basic principles of command and control architecture design, and second, to analyze the current structure of a typical ship's Damage Control organization and its ability to combat Mass Conflagrations. This will be accomplished by first providing the methodology of architectural analysis, and then applying this methodology step-by-step to the environment and organization in question.

The intent of this thesis is to provide a generic guide to improvements that could be implemented on a ship at the lower levels, and to introduce a somewhat different perspective on the Navy's Damage Control philosophy.

B. BACKGROUND

The Damage Control organization onboard today's ships is a formal organization designed to cope with nearly every type of structural emergency, from fire and flooding to chemical and biological attacks. Due to the great number of ships that were lost to progressive flooding in World War II, the Navy placed its emphasis on battling the type of danger in which the damage, if unchecked, would slowly spread out to adjoining areas of the ship, eventually causing complete combat degradation. In light of the relatively unsophisticated weapons and warheads being faced at the time, this was a sound principle, and it worked quite well for decades. Within the last five years, however, the ability of anti-ship weaponry such as cruise missiles and advanced torpedoes to inflict massive damage upon impact has raised serious doubts as to ship survivability. The attack on the USS STARK by a French-made Exocet missile and the damage caused to the USS SAMUEL B. ROBERTS by a relatively cheap Iranian mine highlight the concern over the ability of today's ships to survive a single hit.

On a less dramatic level, Fleet Training Group (FTG) routinely runs each ship undergoing refresher training through a Mass Conflagration (MASS CONFLAG) Exercise. Most ships have difficulty passing this graded exercise, and many ships fail. According to the Senior Damage Control Instructor at FTG San Diego, two of the most common reasons for failure are:

- The weak control and supervision of the ship's force personnel during the Mass Conflagration is too slow and unresponsive to be effective.
- The average crewmember did not know where to go or what to do if he was not assigned to a locker, and received very little guidance from the chain of command. [Ref. 1]

While the reasons for failure are varied, most of the fault for the above listed items can be traced back to the inability of the Damage Control organization to adapt to the situation and properly manage the ship's force in fighting the conflagration. The ships that are successful, meanwhile, have almost universally altered and restructured their Damage Control teams into more flexible, adaptive organizations. [Ref. 1] The problem that arises regarding these successes is that they lack continuity; rarely if ever does the same successful plan get used on more than one ship, and even on the same ship the plan will change or be forgotten due to a rotation of leadership. This thesis is intended to provide a design framework whereby a ship's leadership could not only design fundamental organizational changes to its Damage Control structure, it could also format these changes into a basic template that could be retained to provide "corporate knowledge" of the solution.

C. THESIS ORGANIZATION

Each chapter will lead the reader systematically from the basics of architecture design through their application to the proposed solutions. A brief description of each chapter is given below.

1. Chapter I

Chapter I provides a brief discussion of the purposes of the thesis and a general background of the current problem being analyzed.

2. Chapter II

Chapter II will describe the basic principles, terms, and definitions used in designing a Command and Control architecture, and will illustrate the ways in which these can be applied to existing organizations. The focus here will be on establishing a fundamental framework by which to break down the Damage Control organization and its associated environment into parameters that can be quantified and compared.

3. Chapter III

Chapter III will apply the established definitions to two different scenarios: the Main Space Fire (MSF), a common term for a fire in the ship's engineering spaces and one that the Navy has a formal, effective doctrine to combat, and the Mass Conflagration (Mass Conflag), a fire in which often more that one third of the ship is damaged, and one for which there exists no formal doctrine. These two scenarios will be compared, and all parametric changes quantified within the architectural design framework.

4. Chapter IV

This chapter will continue with the architectural analysis, expressing the typical Damage Control organization in terms of the defined framework and determining in which particular areas the organization is unable to cope with change in environment from Main Space Fire to Mass Conflagration.

5. Chapter V

Finally, Chapter V will use the results of the above analysis to propose possible solutions and/or adaptations to the current organization in order to make it more viable and responsive to the increased threat environment. All of these proposed adaptations will be referenced with respect to both the tenets of architectural design and their "real world" application.

II. ARCHITECTURAL DESIGN

A. DESIGN PRINCIPLES

Before beginning to define an organization or an environment, certain basic principles must be examined. These principles are inherent in nearly all aspects of architectural design, and are necessary to the creation of an organization that can survive and be successful in a given environment.

1. The System-in-Focus

The main thrust behind the concept of the system-in-focus is that, given that a particular system is the focus of attention, boundaries must be drawn around that system. By defining the boundaries around a system, anything that falls within those boundaries is part of the system, while anything outside those boundaries is part of the environment. Figure 1 illustrates this concept. Boundaries are particularly important, as they allow the designer to avoid confusing the interrelated forces of other organizations as part of the system itself.

Communications across these boundaries between the system and the environment must often be altered, or reinterpreted, in order to fit into the communications pattern of the system-in-focus. This process is known as transduction, and the mechanisms that perform this task are called transducers.

2. The Design Problem

Once the system has been bounded, it is necessary to define exactly what the organization being designed is required to do. To this end, the architectural design problem should be stated in a way that takes into account the environment, any and all resources, and the actual design itself. [Ref. 2:pp. 21-22] The problem itself is frequently expressed in terms of an equation, an example of which is shown in Figure 2.

3. Functional Analysis

For each subsystem block of the system-in-focus, there is a corresponding functional task. The Structured Analysis and Design Technique (SADT) breaks down the inputs to each into controls, resources, and inputs from other tasks, with outputs to other tasks. This function box, and its attendant inputs and outputs, is shown in Figure 3. By using this method of functional analysis, it is possible to trace each and every major task faced by the organization as a whole, and decompose it into smaller tasks, thus showing a direct chain of action and pointing out to the designer possible conflicts, chokepoints, etc.

4. Equilibrium and Stability

The basic idea of equilibrium is a balancing of forces (both organizational and environmental) in such a way that there is little or no change, i.e., equilibrium exists when the system-in-focus is in balance with its environment. [Ref. 3:p. 13] Stability is the property of a system that causes it to return to equilibrium whenever outside events upset the balance with the environment. Figure 4 illustrates a system in equilibrium, and

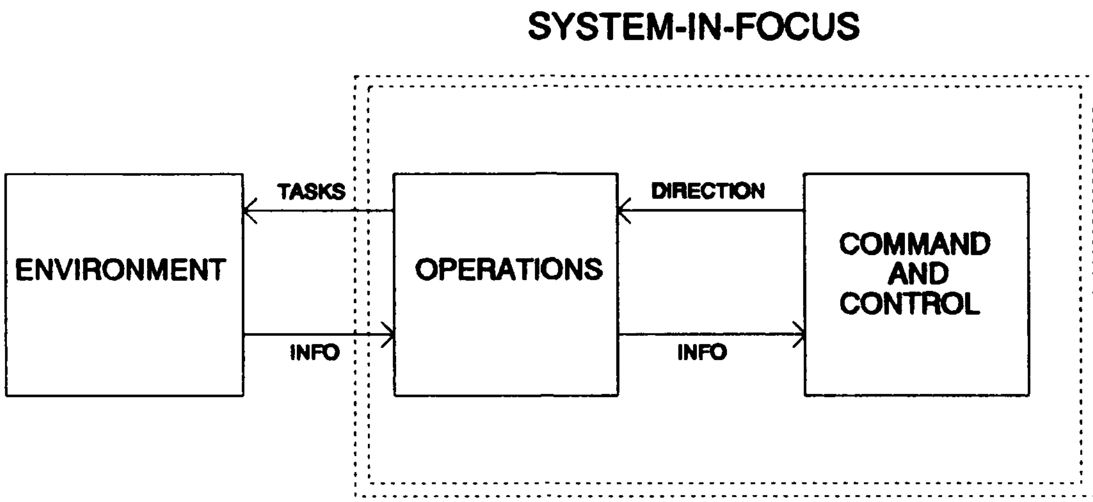

Figure 1: The System-in-Focus Concept

MAXIMIZE: ORGANIZATIONAL EFFECTIVENESS

SUBJECT TO:

ORGANIZATIONAL AVAILABLE TECHNOLOGY

RESOURCES USED ≤ RESOURCES AVAILABLE

ENVIRONMENTAL CHARACTERISTICS

Figure 2: The Design Problem Equation

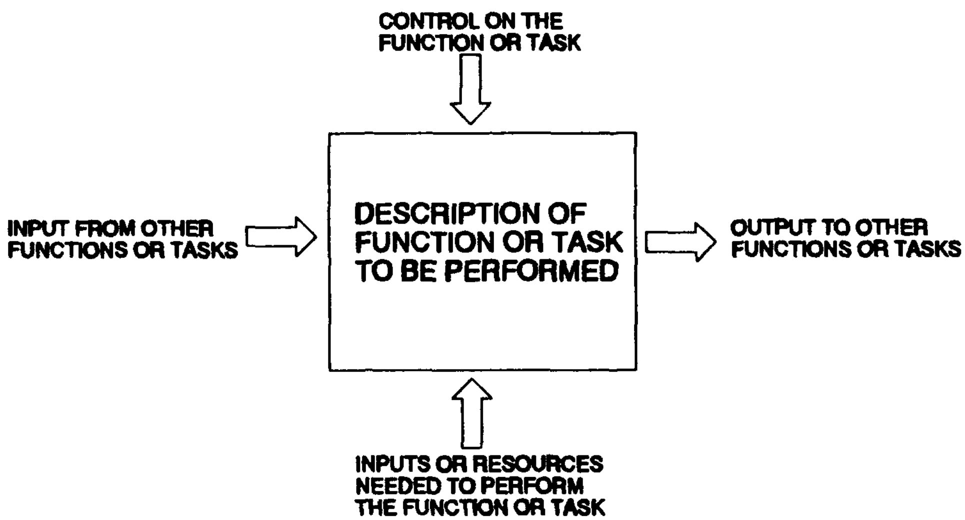

Figure 3: The SADT Function Box

its subsequent behavior upon the introduction of a change of state in the environment. Note that in a stable organization the tendency is always towards equilibrium, and each oscillatory response must be smaller than the one before. [Ref. 3:p. 16]

5. Variety and Information

The concept of variety was developed in order to measure complexity by focusing on all of the states of nature present in the environment, and is tied directly to information processing. In terms of architectural design, information and data are vital concepts. Information is defined as that which alters or reinforces understanding [Ref. 4:p. 309], while data are merely the discernible "bits" of the perceived environment. High data quantity does not necessarily mean that information quantity is high as well; voluminous data may contain little in the way of semantic content. Concurrent with the idea of information quantity is information richness, a concept that is a measure of the amount of understandable knowledge of the environment which is being conveyed via a particular communication method. High information richness is often associated with qualitative information, while low information richness can be associated with more quantitative information.

Variety is also used in designing systems to ensure that the system will remain in equilibrium with its environment. [Ref 3:p. 14] This is accomplished by ensuring that each subsystem can match each subenvironment in its variety level. These variety levels can be measured and compared either quantitatively or qualitatively, as long as the designer remains consistent throughout his analysis. The concept of variety and the need

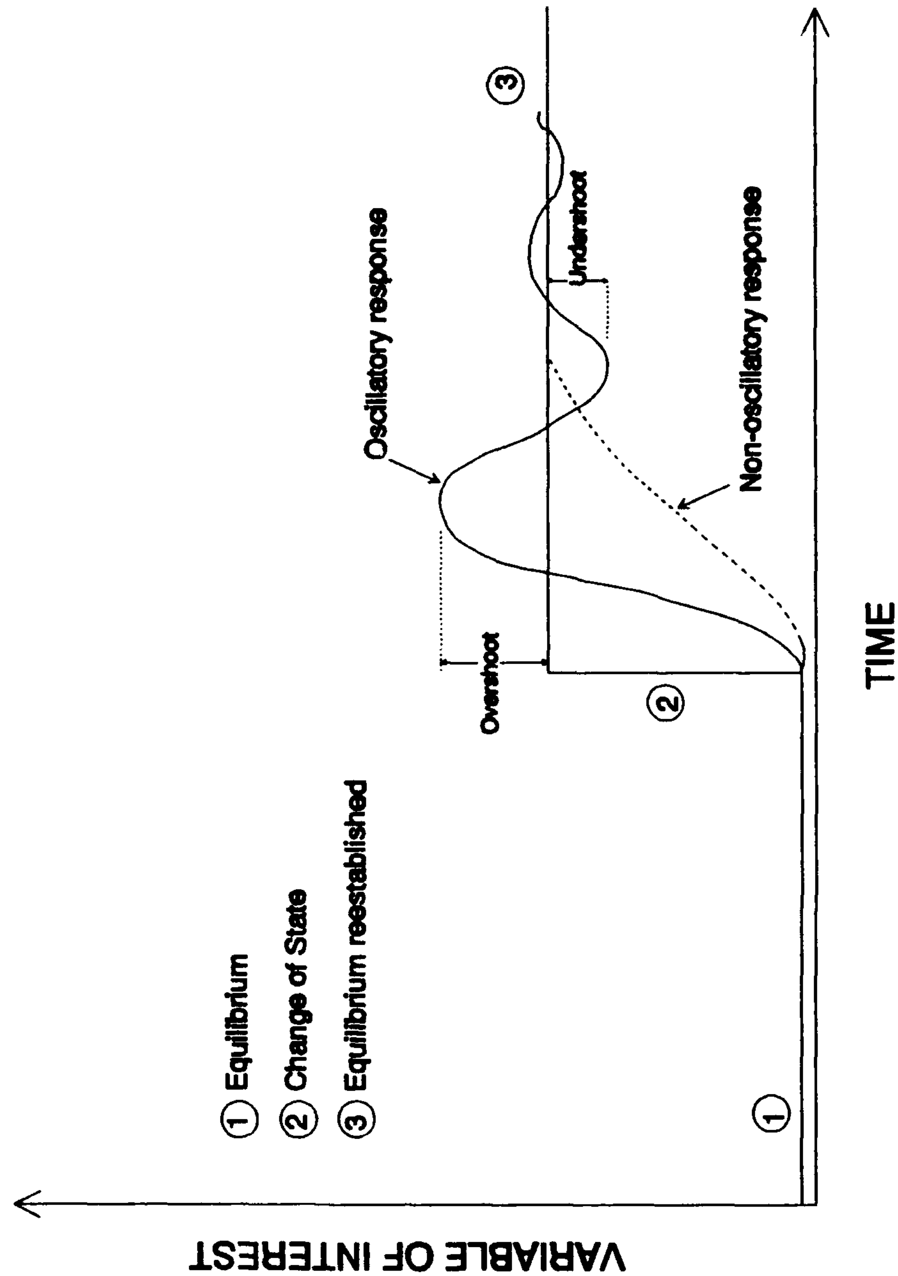

Figure 4: Organizational Equilibrium and Stability

to cope with environmental variety lead to the following fundamental precepts, or axioms, of architectural design:

- A viable system-in-focus is designed such that the environmental variety is absorbed.
- All channels carrying information between the command and control function, the operations function, and the environment must have a higher capacity to transmit information at the relevant variety level than the functions or environment can generate. The same holds true for all transducers whose function is to transmit information across boundaries.
- The system must not only be able to absorb all variety generated by the environment, it must also be able to absorb any variety generated by each subsystem.
- The operation of the above three principles must be cyclically maintained through time without hiatus or lag.

B. DEFINING THE ENVIRONMENT

As mentioned before, the environment includes anything outside the boundaries of the organization. In order to design an architecture capable of dealing with the environment, it is necessary to fully define the relevant characteristics of the environment, so that they may be combined and categorized. [Ref. 5:p. 294] By doing this, it is possible to build a framework with which to analyze the environment.

1. Variable Characteristics

In general, state variables are used to describe all aspects of the environment. They can represent specific, discrete items such as tanks, missiles, etc., or they can represent the relative size of entities within the environment, such as windspeed or damage level. Diversity is the quantitative measure of the number of state variables present in the environment, while complexity is a measure of the number, and sometimes type, of interrelationships existing between the state variables. [Ref. 6:p. 143]

2. Time Characteristics

The idea of time span is to ensure that the system is designed to remain viable for as long as the environment will exist in its current state; in addition, the system design should not exceed the planning horizon, as this calls for resources and/or methods that are not necessarily needed. [Ref. 7:p. 95] Time span can be measured as either discrete or continuous. During this time span the environmental state variables will change in either number or nature, and this is quantitatively expressed as the average time rate of change of the environment.

3. Hostility

Hostility is simply the malevolence of the environment; however, it is important to note that hostility as defined here implies intelligence, and an antagonist who is actively causing changes to the state variables of the environment. For example, a hurricane might seem on the surface to be quite hostile, but because of the lack of intelligent direction it is considered to have no hostility for the purposes of architectural design. Hostility tends to increase the number of state variables, their complexity, and their diversity.

4. An Environmental Analytical Framework

By combining the above characteristics of diversity, complexity, and hostility into one general characteristic called variance [Ref. 6:p. 147], an analytical framework can be constructed by comparing variance to the time rate of change in an environment. The results of this comparison yield a measure of the level of variety present in the environment. As shown in Figure 5, if variance is classified as ranging from simple to complex, and time rate of change is similarly classified as ranging from static to dynamic, then the combination of these two yield levels of variety ranging from simple-static (low variety) to complex-dynamic (high variety). Thus, the environmental variety can be evaluated, and taken into account during the organizational design process.

C. DEFINING THE ORGANIZATION

1. Technology

For any given organization, technology represents the interactive relationship between the inputs, such as intelligence data, and outputs such as manpower. The technology of an organization determines its ability to process, as well as transmit, variety from the environment. This ability, as illustrated in Figure 6, is a direct function of two factors - variety handling capacity (VHC) and analyzability.

a. Variety Handling Capacity

The ability to process variety to and from the environment is a direct indicator of an organization's effectiveness, and is one of the most critical factors in organizational design. This capacity is directly related to the quantity of information that is being received and transmitted by the organization.

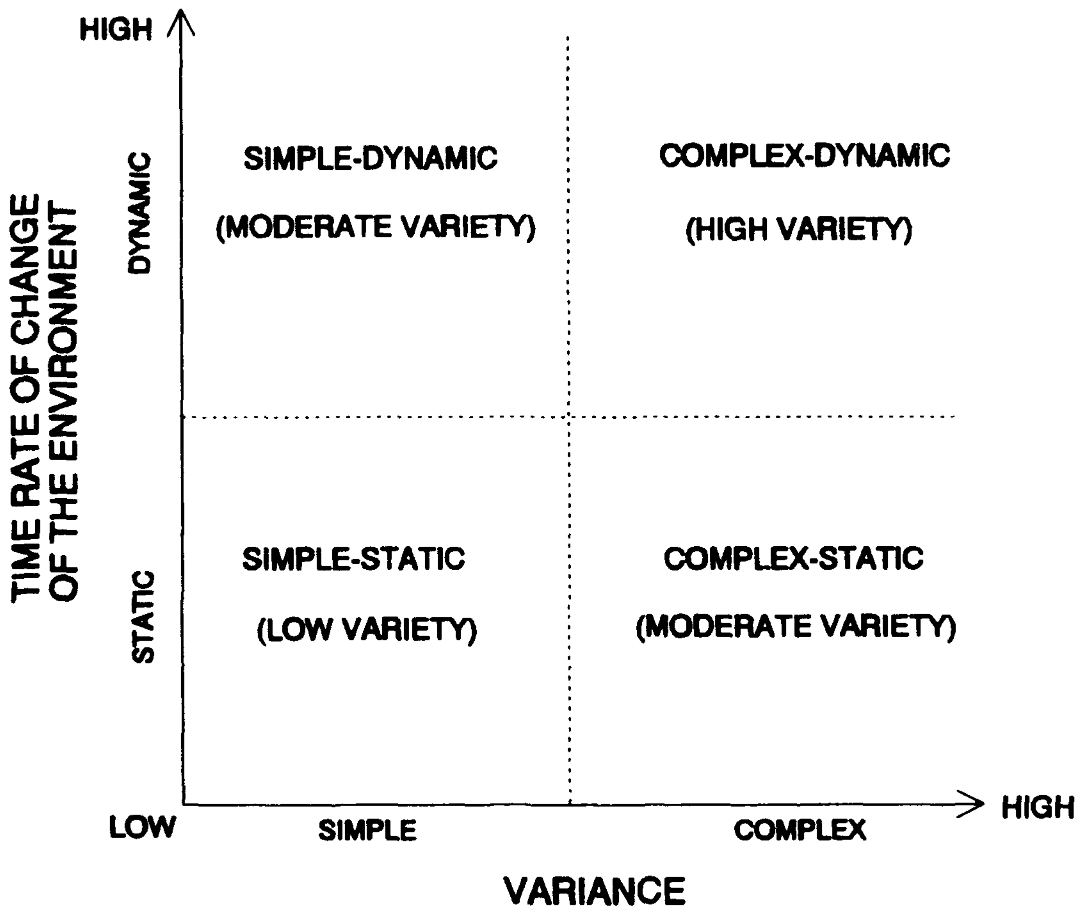

Figure 5: Environmental Analytical Framework

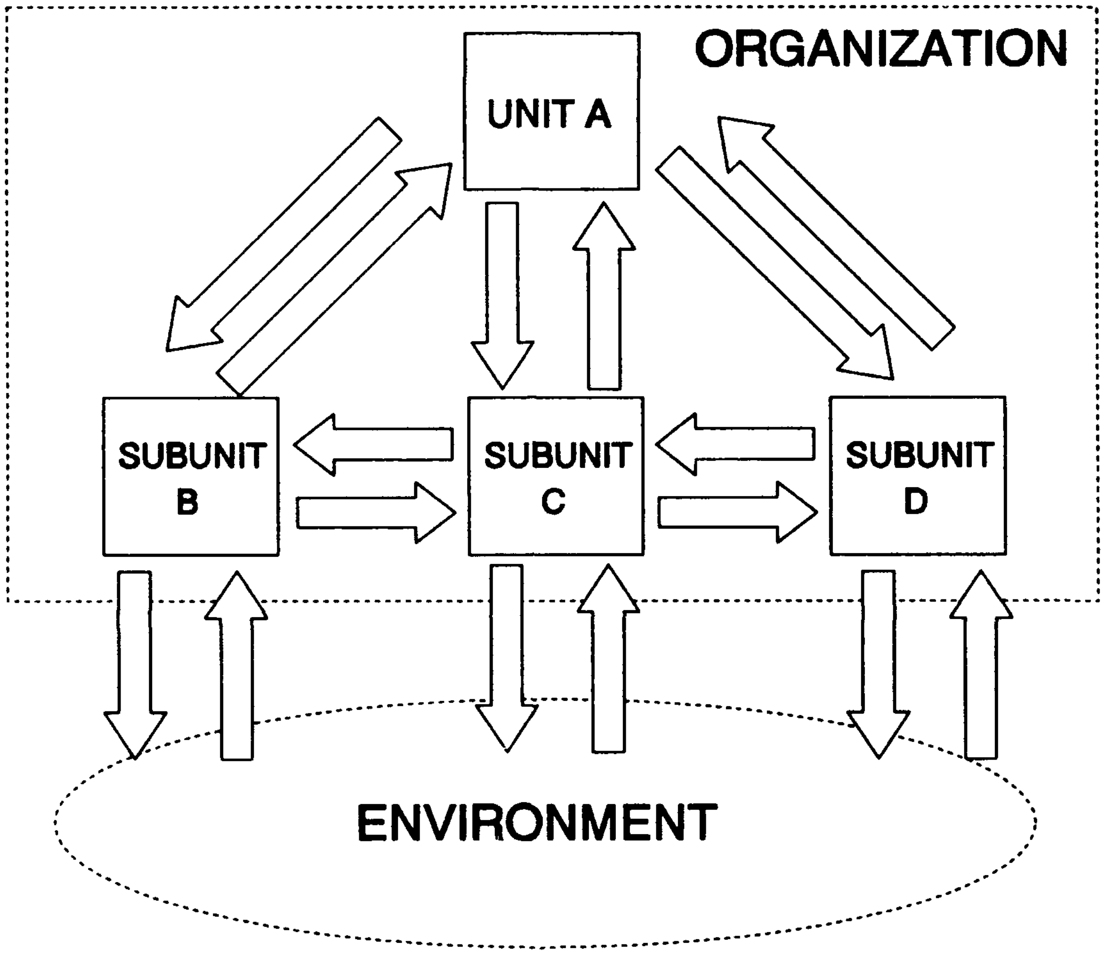

Figure 6: Organization/Environment Interaction

b. Analyzability

Analyzability is the level to which the workings of the organization can be understood. Since this understanding increases as information processing becomes less complex, analyzability is inversely related to the richness of the information processed by an organization. Figure 7 shows the relationships between the above-mentioned factors.

c. Types of Organizational Technology

By combining analyzability and variety handling capacity, four separate types of organizational technologies emerge: Craft, Routine, Nonroutine, and Engineering. [Ref. 7:p. 78-79] These technologies and their relationship to analyzability and variety handling capacity are illustrated in Figure 8.

(1) Routine. Routine technology has a high degree of analyzability and a low variety handling capacity, while processing very little low-richness information. The tasks faced are relatively simple, and the information processed is quantitative, as in the case of a mass-production line. [Ref. 6:p. 192]

(2) Craft. Craft technology has a low analyzability and low variety handling capacity, while a low quantity of very rich information can be handled. While the tasks remain simple in nature, a relatively high degree of qualitative information is required, as in the case of a craftsman's workshop.

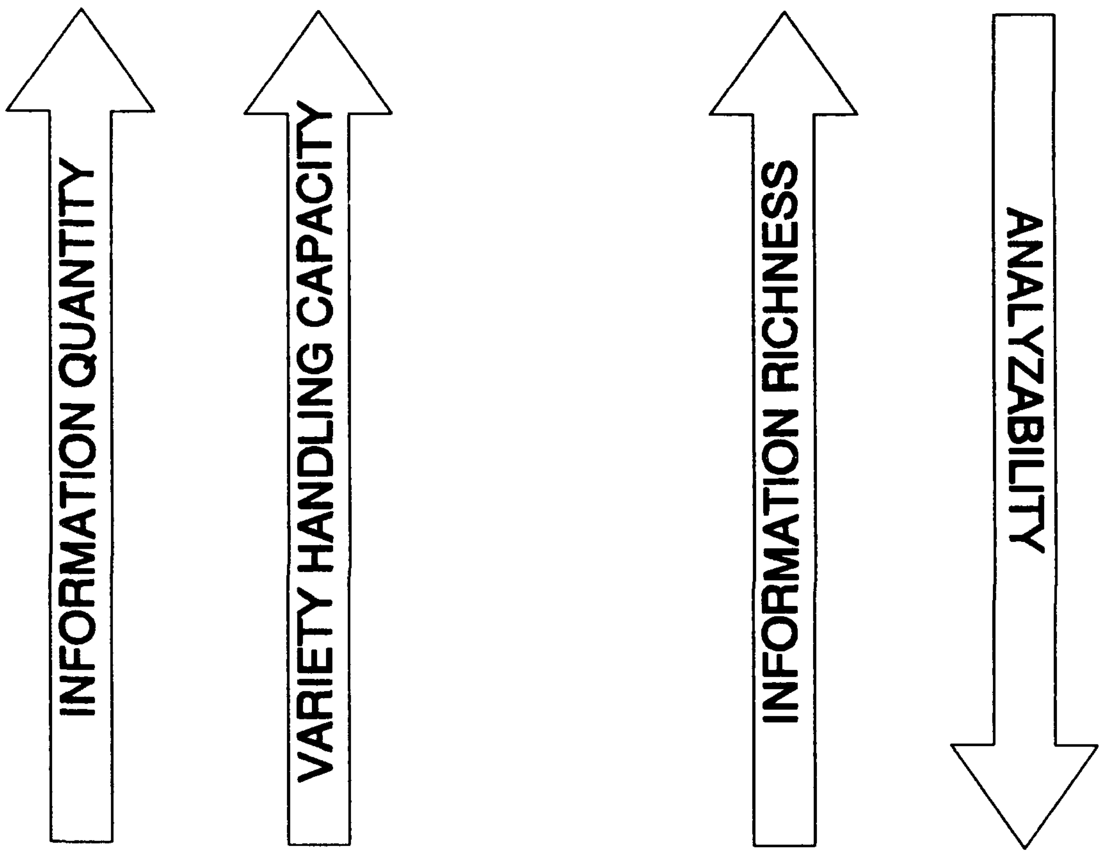

Figure 7: Analyzability and Variety Handling Capacity versus Information

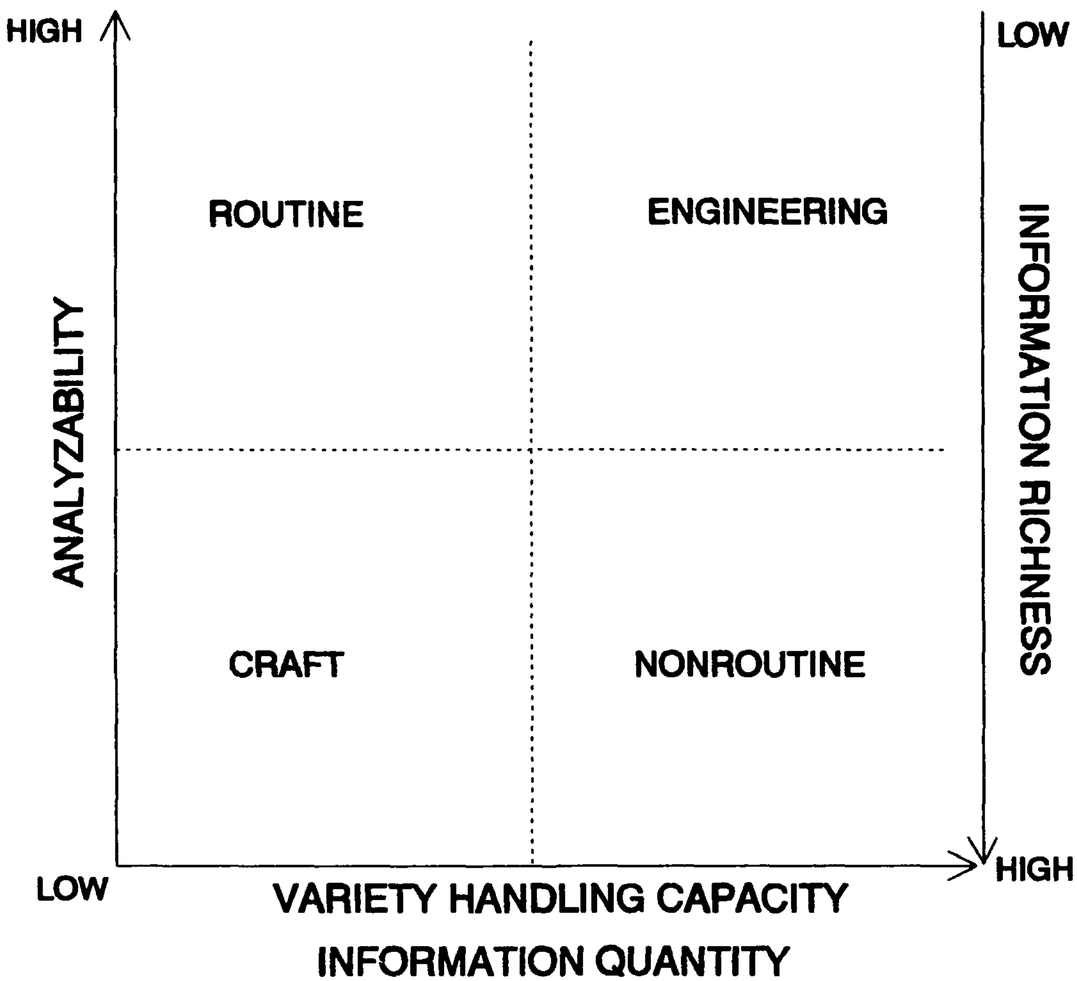

Figure 8: Organizational Technology Framework

(3) Nonroutine. This type of technology has a low analyzability and a high variety handling capacity, while a large quantity of rich information can be processed. Nonroutine technology involves tasks that are complex in nature, and a high degree of qualitative information is required. Examples of this are a corporate think-tank or a troubleshooting team. [Ref. 6:p. 195]

(4) Engineering. Engineering technology, like nonroutine, has a high variety handling capacity, but is much more analyzable. While a large quantity of information can be processed, it is not information of a very high richness. This type of technology involves tasks that are complex, but primarily quantitative, such as in the case of accounting firms or statistical analysis. [Ref. 7:p. 82]

2. Command and Control Characteristics of a Technology

In order for the organization or system to be viable, that is, to be able to effectively interact and cope with its environment, certain characteristics must be determined about the type of organizational technology currently in use by that organization. These characteristics are:

(1) Flexibility. This characteristic ranges from very flexible (organic) to inflexible (mechanistic).

(2) Formalization. The degree to which procedures are governed by a documented set of criteria is called formalization. [Ref. 6:p. 211] Formalization is inversely related to variety handling capacity.

(3) Centralization. Centralization is indicative of the level within the organization at which decisions are made. As decision making gets closer to the top of the heirarchy, centralization increases. [Ref. 6:p. 212]

(4) Skill level of personnel. In general, as the skill level of individuals within the operational portion of the organization grows, the skill level of the comand & control portion must increase proportionally

(5) Span of control. This characteristic is a measure of the number of personnel reporting to and working for an individual supervisor. Variety handling capacity increases as the span of control narrows, as each supervisor is able to better monitor the actions and environment of his subordinates.

(6) Communciation and coordination. In order for an organization to increase its variety handling capacity, the quantity of communication and coordination within the organization must likewise increase. This area is addressed more fully later in the chapter.

Table 1 provides a comparison of the four types of operational technologies and their relation to the above-listed characteristics.

TABLE 1
C2 CHARACTERISTICS OF OPERATIONAL TECHNOLOGIES

Characteristic	Routine	Craft	Engineering	Nonroutine
Flexibility	Mech.	Organic	Mech.	Organic
Formalization	High	Moderate	Moderate	Low
Centralization	High	Moderate	Moderate	Low
Skill Level of Personnel	Low	Medium Work-based	High Formal	High
Span of Control	Wide	Moderate	Moderate	Moderate
Communications Coordination	Vertical Low	Horizontal Moderate	Horizontal Moderate	Horizontal High

3. Decision Making and Uncertainty

The decision making process of an organization relates directly to many of the command and control characteristics mentioned in the previous section. Organizational decision making is the process or processes by which the organization identifies and solves problems. As uncertainty increases, organizational complexity and internal dynamics must increase. [Ref. 8:p. 616] These two major factors - problem identification and problem solution - are tied directly to the concepts of goal consensus and technical knowledge. Organizations use information to clarify a situation and come to a consensus about how to react. [Ref. 9:p. 554-555] Goal consensus is simply the degree to which the members of the organization are able to agree on where the problem lies. If goal consensus is high, then the level of uncertainty surrounding problem identification is comparatively low, while low goal consensus makes problem identification very uncertain. Technical knowledge represents the degree of understanding between the organization's actions and the results of those actions, i.e., the cause-and-effect relationships. When technical knowledge is high, problem solution is relatively certain, while low technical knowledge creates high uncertainty in solving problems.

The above factors of technical knowledge and goal consensus combine to form four different models of organization decision-making processes: the Garbage Can Model, the Carnegie Model, the Management Science Model, and the Incremental Decision Model. These models and how they are related to technical knowledge and goal consensus are shown in Figure 9. [Ref. 4:p. 363]

a. The Garbage Can Model

This model represents low levels of both goal consensus and technical knowledge, and could be referred to as "organized anarchies". [Ref. 10:p. 285] Problem identification and problem solution are both difficult, and little if any formal standardization exists to aid the decision makers. This type of decision making involves decisions and choices being made at nearly every level of the organization. [Ref. 4:p. 373]

b. The Carnegie Model

This model, developed at Carnegie Mellon University, involves low goal consensus, but high technical knowledge - once the problem is identified, a solution will relatively easy to find. This type of decision-making process entails coalitions within the organization bargaining and negotiating in order to determine the organization's goals. [Ref. 11:p. 330] An example of the Carnegie model is shown in Figure 10.

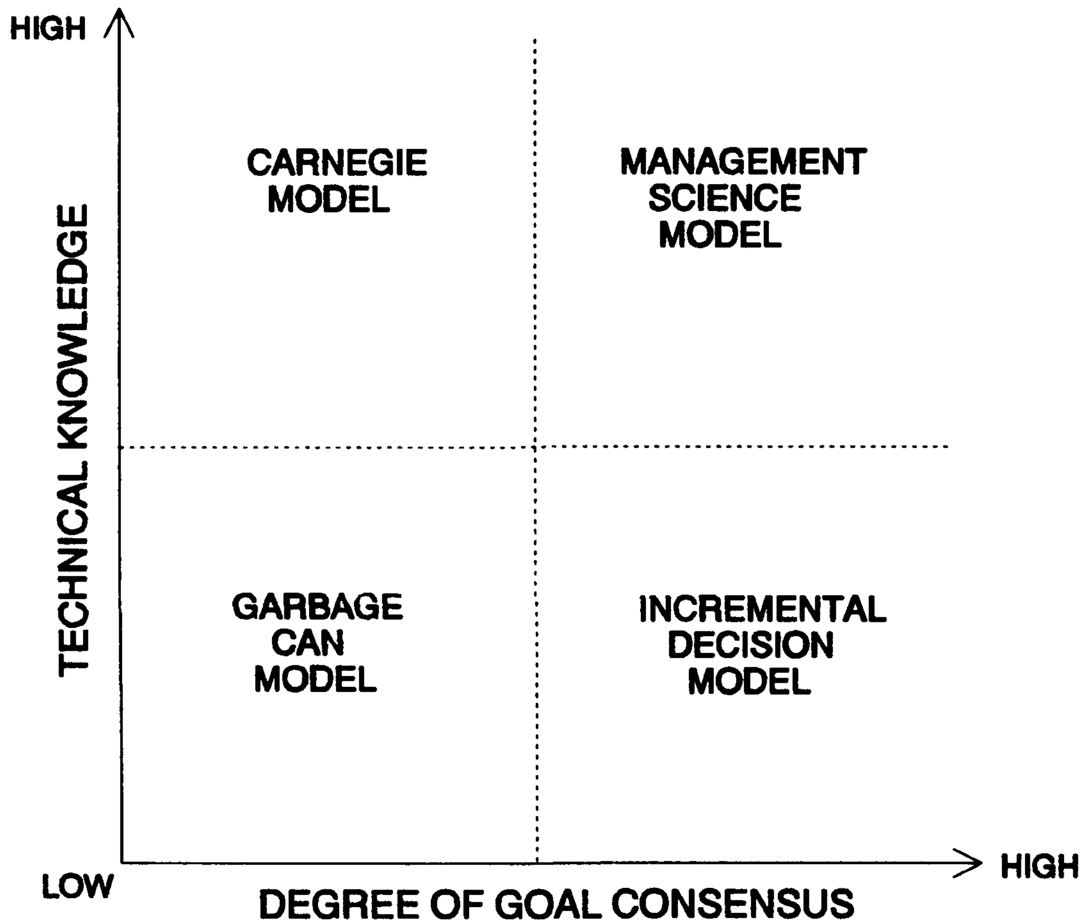

Figure 9: Organizational Decision Making Models

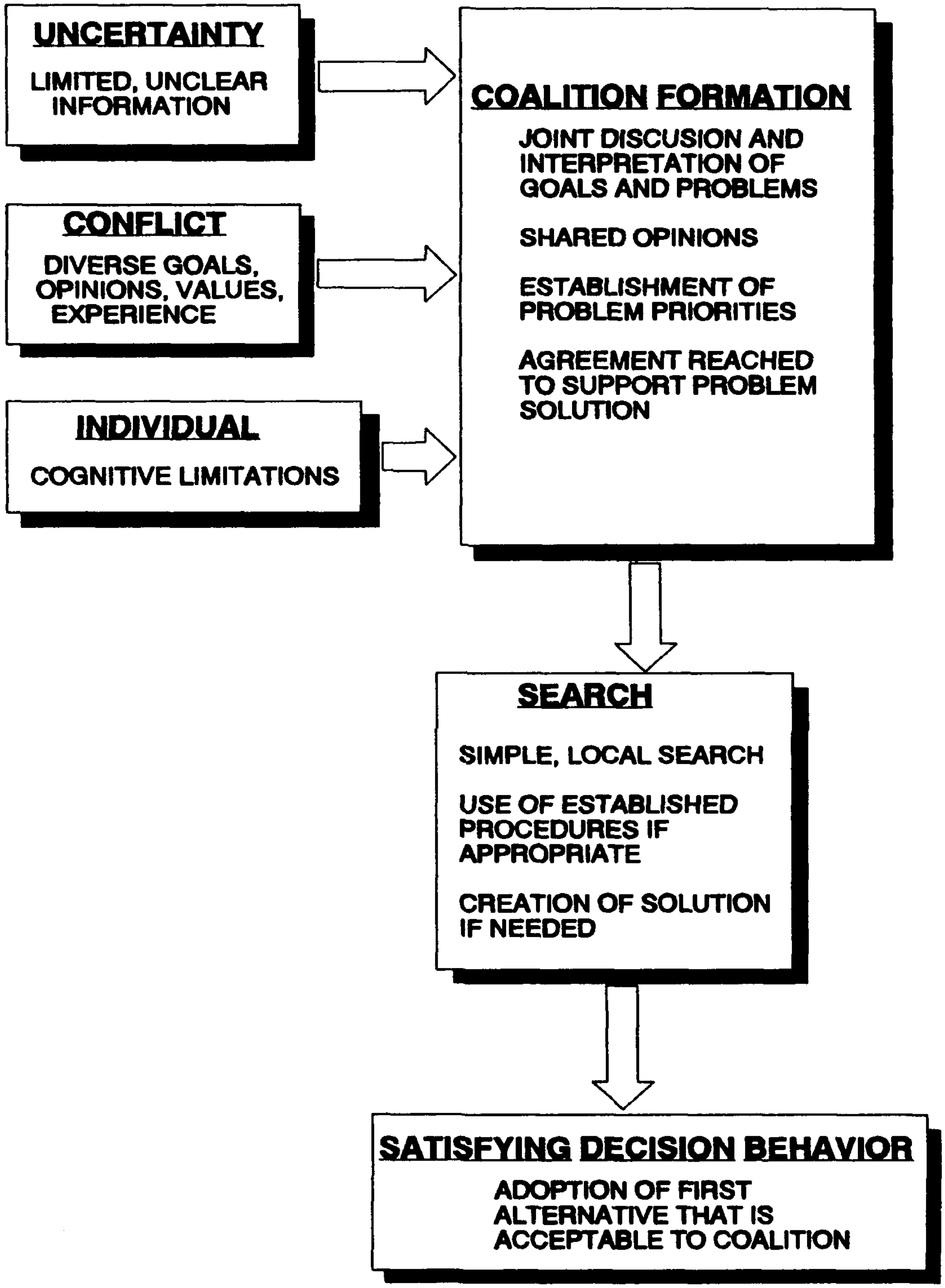

Figure 10: The Carnegie Decision-Making Model

c. *The Incremental Decision Model*

This model represents nearly the opposite of the Carnegie model - goal consensus is high, but technical knowledge is low. In essence, the organization is certain of the problem, but is unsure on how to solve it. In order to reduce the detrimental effects of making a wrong decision, a process of trial-and-error is used, whereby each decision is evaluated, and the next decision is made on the basis of this evaluation. [Ref. 4:p. 369] An example of this process is shown in Figure 11.

d. *The Management Science Model*

The Management Science Model involves the combination of high goal consensus and high technical knowledge - problem identification and problem solution are both relatively straightforward. In this model a rational, computed decision is reached by the decision makers, often based on a prior formal doctrine or methodology. [Ref. 4:p. 364] While no decision process is completely devoid of personal judgement, this type of process comes the closest to programmed decision making.

An integrated framework describing the various levels and types of uncertainty, as well as the decision making processes associated with them, can be constructed through the combinations of goal consensus and technical knowledge. An integrated organizational decision making framework combining the four types of models with problem uncertainty is shown in Figure 12.

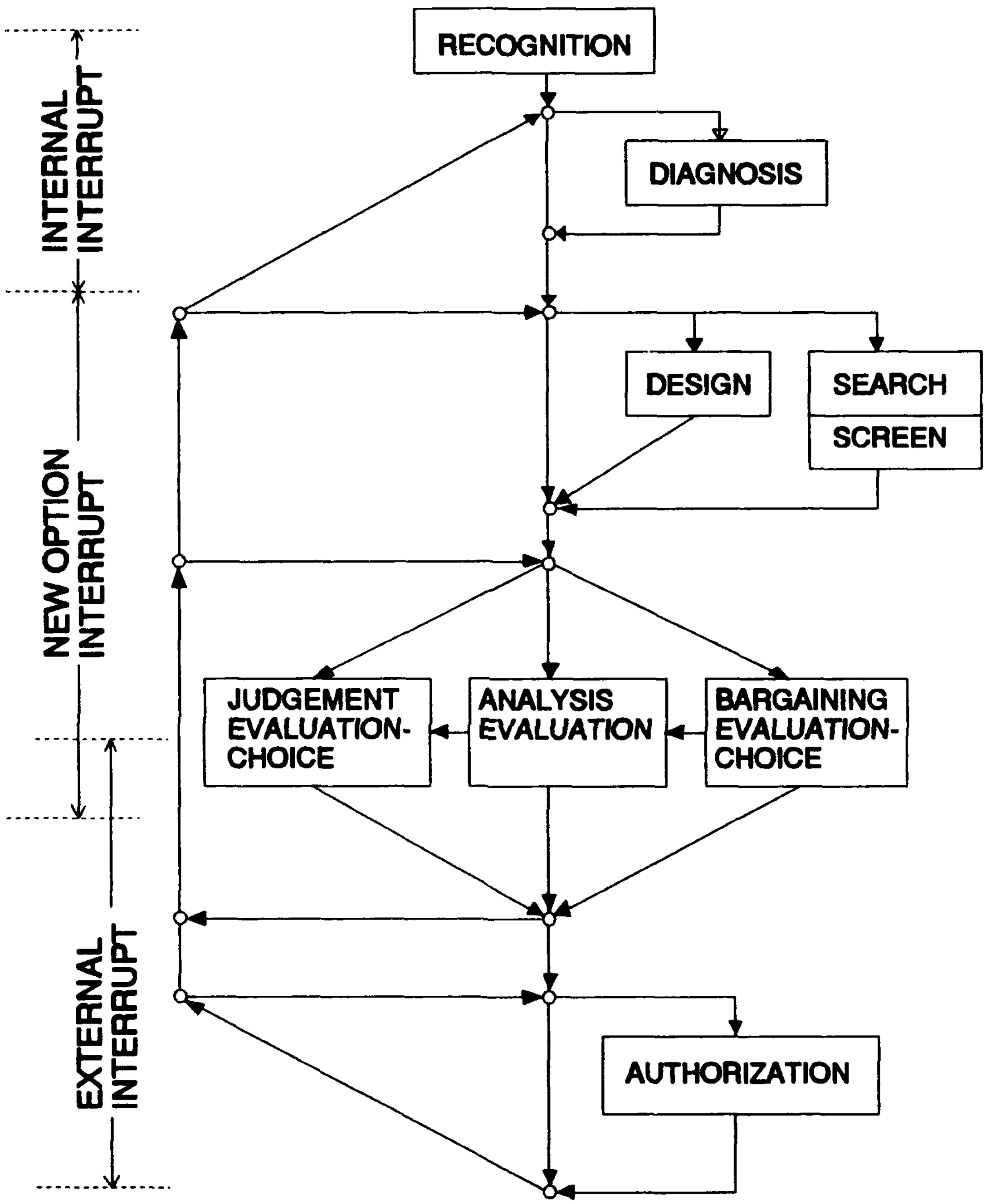

Figure 11: The Incremental Decision-Making Model

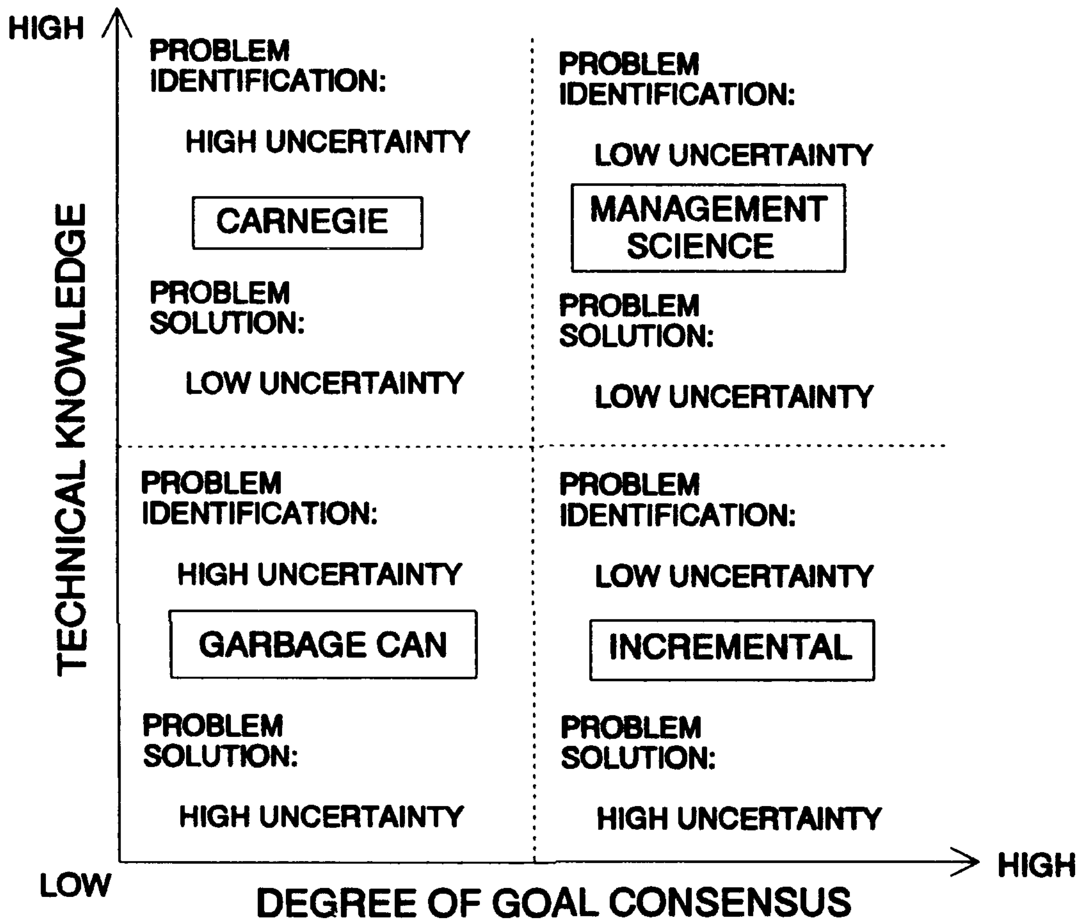

Figure 12: The Integrated Organizational Decision Making Model

4. Internal Dynamics

Internal dynamics describes the interactions between and within the various heirarchal levels of an organization. Encompassed within this realm are the concepts of coordination, linkage, and interdependence. These three areas are themselves interrelated, and many basic philosophies that govern the role of a particular type of linkage arrangement will also come into play for a certain style of interdependence. [Ref. 3:p. 188]

a. Coordination Methods

Having established a framework for the decision-making process, it is now necessary to explore the internal dynamics by which the organization provides information, support, and direction. In order to provide unity of effort, the decision makers within an organization must have some way of integrating their decisions to meet the intent of the organization as a whole. In general, there are four types of cordination: direct supervision, mutual adjustment, standardization, and ideology. [Ref. 7:p. 48]

(1) Direct Supervision. This method of coordination consists of a centralized, individual authority to whom all subordinates provide information. In turn, the central authority makes all decisions, and passes these back down to the lower levels of the chain of command.

(2) Mutual Adjustment. Mutual adjustment occurs when two or more individuals possessing no formal heirarchal authority with respect to one another solve

problems and share resources together. Even in a hierarchy, mutual support may still take place with respect to minor decisions and/or problems.

(3) Standardization. Coordination via standardization involves a formalized set of routines or procedures which govern the decision-making of some or all levels within an organization. This can occur through many methods such as instruction, regulations, doctrine, etc.

(4) Ideology. Ideology is simply a set of values or mores that govern and influence the behavior of the organization. This coordination may or may not be formal, but in either case is designed to create a strong sense of unity of purpose within the organization.

While the four types of coordination described above are separate and distinct, they are by no means mutually exclusive. Many organizations employ most if not all of these methods, especially in cases where the size of the organization is considerable, or where timeliness of action is a factor. Nor can one particular type of coordination necessarily be thought of as "better", or more important, than another. For instance, the constant, daily influence of ideology might not seem to have as much effect on a soldier or sailor as the impact of a direct order from his superior, but it is the ideological basis of the environment in which he lives that gives the person the underlying framework of beliefs and values. Figure 13 illustrates these coordination methods within an organization.

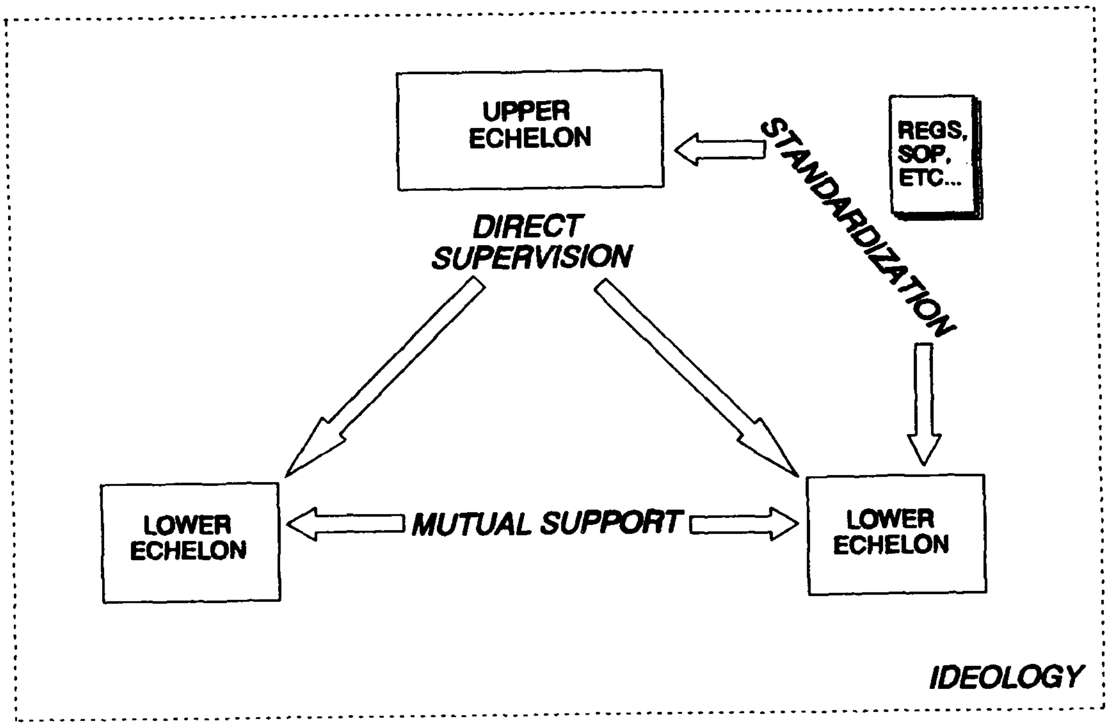

Figure 13: Coordination Methods

b. Linkage

Linkage is a concept that defines the method or methods whereby control, direction, and support are accomplished. There are two types of linkage: vertical and horizontal. [Ref. 6:p. 21] Vertical linkage is established between different levels of the organization, and is related to direct supervision method of coordination. Types of vertical linkage include:

- Hierarchal Referral
- Rules and Procedure
- Plans and Schedules
- Level or Positions Added to the Hierarchy
- Vertical Information Systems

An important thing to remember about vertical linkage is that the linkage within an organization must be able to handle at least as much variety as all of the horizontal linkages below and above it. This information handling capacity is directly related to the degree of vertical control and coordination required. The various forms of vertical linkage, and their relationship to information handling capacity & degree of control required, can be seen in Figure 14.

Horizontal linkage is associated with the mutual support that takes place between the various sub-organizations on a particular level, and can take on many different forms. This type of linkage is concerned primarily with the communication which takes place among those elements on the same level in a hierarchy. As in the case of vertical linkage, the degree of horizontal coordination required is directly proportional

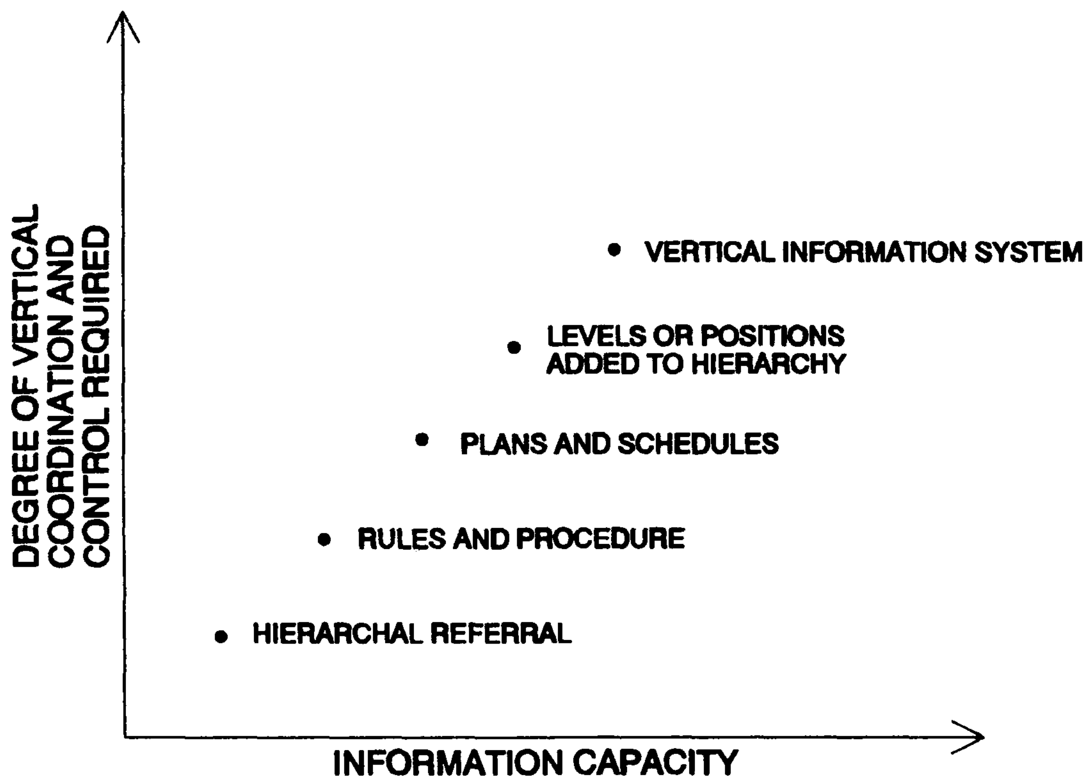

Figure 14: Types and Capacities of Vertical Linkage

to the information handling capacity for each form of horizontal linkage. Types of horizontal linkage include:

- Messages
- Direct Contact
- Liaison Roles
- Task Forces
- Full-time Integrators
- Teams
- Matrices

Figure 15 shows the relationship between each of these forms of linkage and its information capacity & degree of coordination required.

c. ***Interdependency***

In terms of functional decomposition, each function area within an organization must occasionally interact with another function area. The concept that describes this interaction is interdependency. Interdependency is similar to linkage in that it describes the manner in which different groups coordinate; however, linkage is concerned with communications and coordination among groups, while interdependency relates to the allocation of resources between the different functions associated with those groups. There are three styles of interdependency, and each depends in large part on the type of coordination and communications demand that exist within the organization, and the nature of the decision-making processes taking place at the appropriate levels. Additionally, it is often possible for a very large organization to possess all three kinds

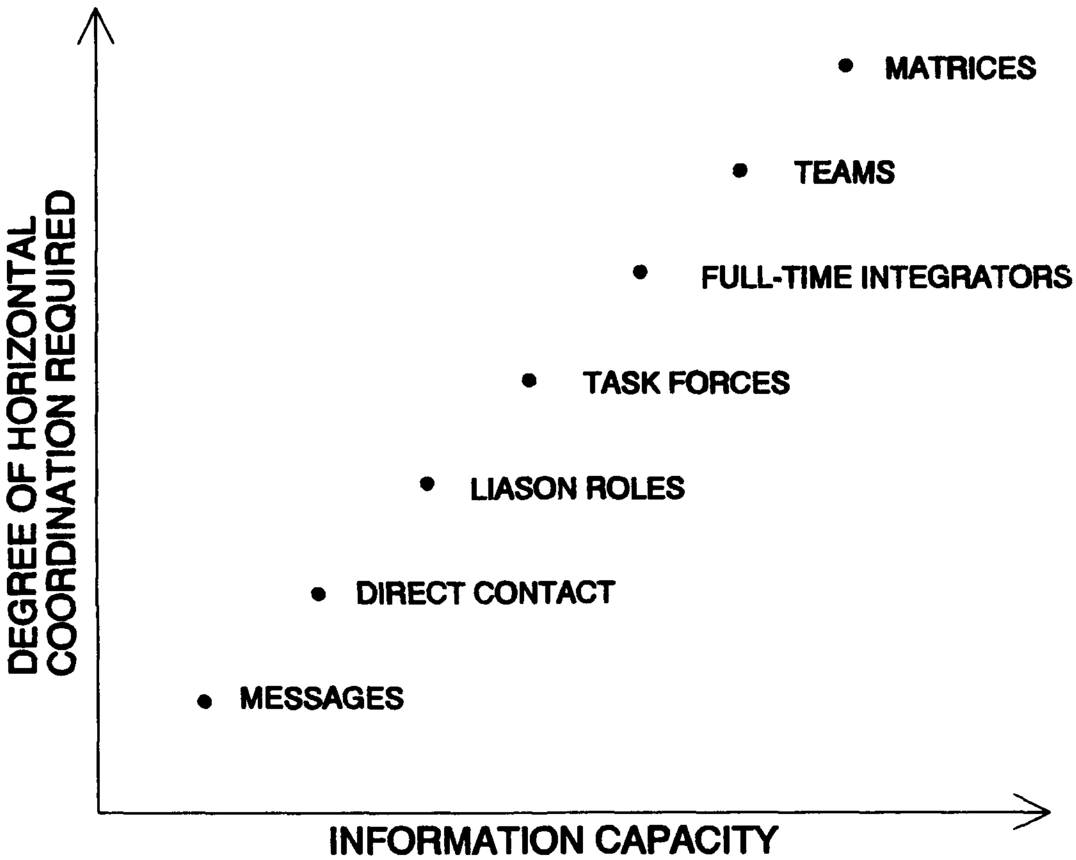

Figure 15: Types and Capacities of Horizontal Linkage

of interdependcies, each taking place at different levels within the organizational hierarchy. These three classes of interdependency are described below, and are illustrated in Figure 16. [Ref. 2:p. 21] The relationship between these various interdependencies and certain C2 characteristics is shown in Table 2.

(1) Pooled Interdependency. When little communication (except concerning a pooled resource) is required, and a number of groups can operate independently with little or no horizontal coordination, then pooled interdependency usually exists. In this method, resources are combined into a common "pool" and each function area takes scarce resources from the pool as needed. Organizational units do not need to be very close in proximity in order to utilize this method, but the information processing capacity is relatively low. This type of interdependency is similar to a "Star" network. [Ref. 12:p. 168]

(2) Serial Interdependency. In this method, functional areas operate such that the output and/or resources of one function becomes the resources and input of another, and so on. This type of scheme is equivalent to a linear network, [Ref. 12:p. 168] and has a moderate information and variety handling capacity. Units must be closer in proximity than those using pooled interdependence.

(3) Reciprocal Interdependency. In this mode, function areas mutually dependent on one another, and the input/output are looped, much as if a serial "chain" were joined to another serial chain, but running in the opposite direction. This setup is similar to a web network, [Ref. 12:p. 168] and, while the units in question must be in

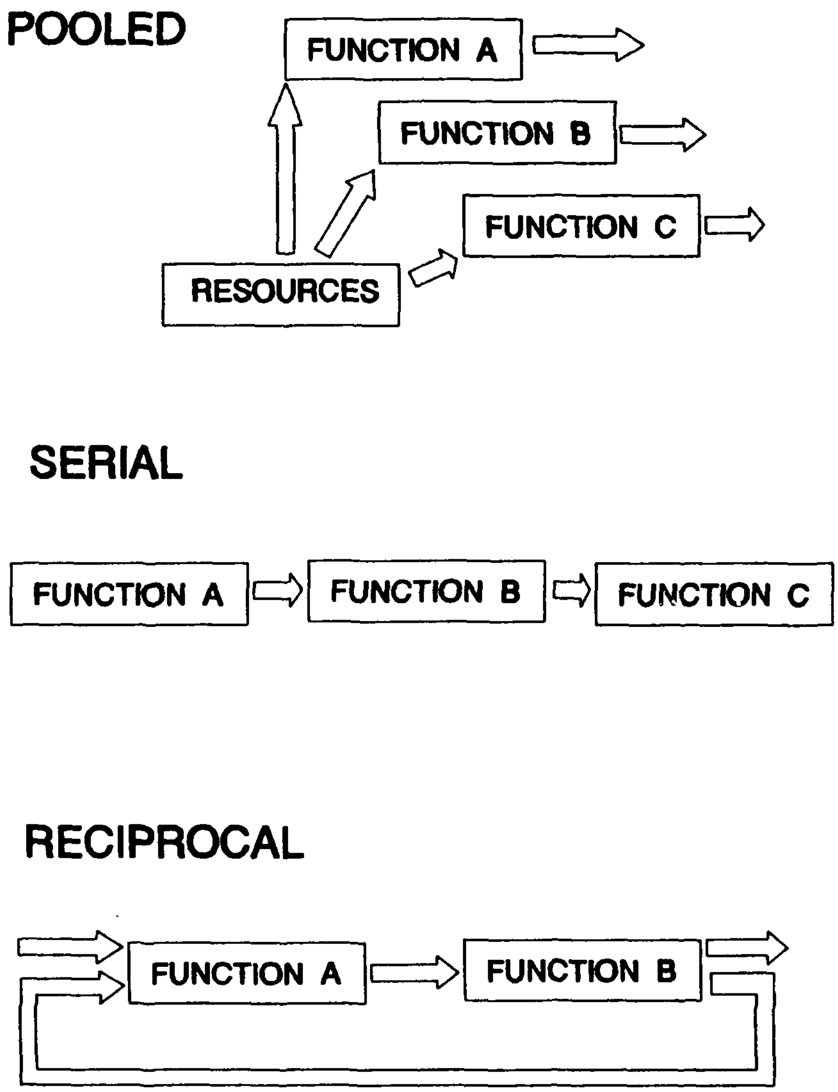

Figure 16: Types of Interdependency

very close proximity in order for it to work, this type of interdependency can process the most information, and therefore handle the most variety.

TABLE 2
TECHNOLOGICAL INTERDEPENDENCY AND C2 CHARACTERISTICS

Form of Interdependency	Communications Demand	Coordination Type Required	Priority of Close Location
Pooled	Low	Standardization Rules Procedures	Low
Serial	Medium	Plans Schedules Feedback	Medium
Reciprocal	High	Mutual Adjustment Unscheduled Meetings	High

D. SUMMARY

We have now established an analytical framework with which to define an organization and determine the amount of variety it is able to process. The single most important quality of an effective, viable command and control system is its ability to "absorb", or cope with, its environment, and this ability is best expressed in terms of variety handling capacity. This capacity in turn is influenced by a number of factors, and is a result of the combination of these factors. Figure 17 recaps some of the more important aspects covered in this chapter, and shows their relationship to variety handling capacity. By determining exactly which characteristics an organization possesses, and to what degree it possesses them, a detailed analysis of the strengths and weaknesses of that organization can be performed. In addition, by comparing an organization to the environment it must cope with, it is possible to pinpoint those areas and properties that could be modified or adjusted in order to increase the overall effectiveness of the organization.

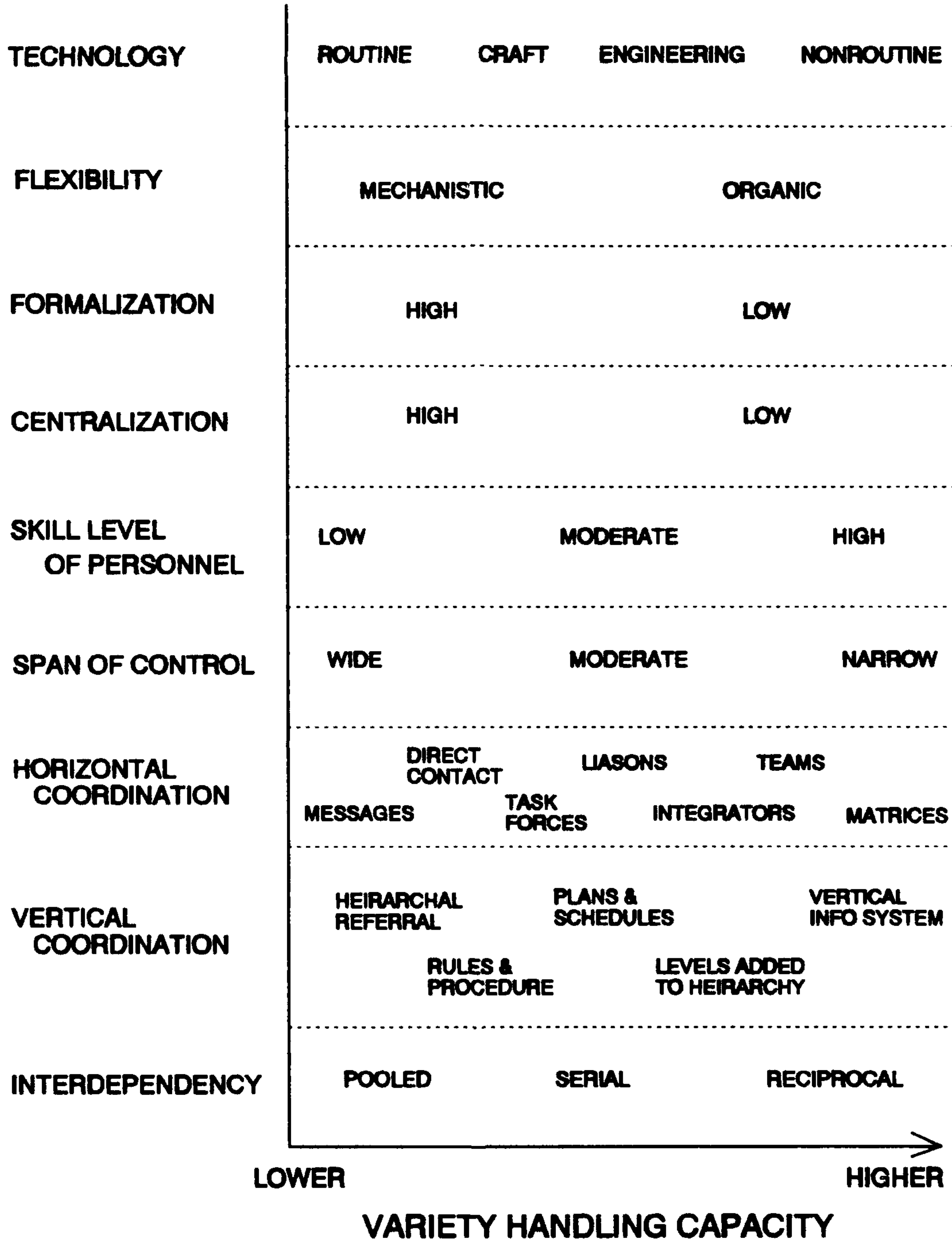

Figure 17: Organizational Characteristics versus Variety Handling Capacity

III. ANALYZING THE DAMAGE CONTROL ENVIRONMENT

A. TWO SCENARIOS: MAIN SPACE FIRE AND MASS CONFLAGRATION

Throughout the next section, two types of environmental scenarios will be described and compared: the Main Space Fire (MSF) and the Mass Conflagration (Mass Conflag). The Main Space Fire is particularly useful for comparison, because, like the Mass Conflag, it is an extremely hazardous fire with far-reaching impact upon the ship's operational readiness. Unlike the Mass Conflag, however, the Main Space Fire is more straightforward. As its name implies, a Main Space Fire is one that occurs in primary engineering spaces such as the Engine Room, Machinery Rooms, etc. Since the number of spaces is relatively small, the actions of nearly every member of the DC organization can be pre-scripted to a large degree; in fact, every ship has and maintains a Main Space Fire Doctrine (MSFD), which details precisely the required actions and procedures for a fire in each engineering space onboard. For instance, the MSFD lists each and every valve, by number and location, that must be closed in order to achieve mechanical isolation of the space, and every breaker and bus tie that must be thrown in order to remove electrical power from the area. All potential hazards are readily identified, and special precautions and warnings are posted for each step of the operation. It is this fundamental difference that separates the two types of fires and highlights the deficiencies of the average DC team to cope with a Mass Conflagration.

B. STATE VARIABLES

The state variables apply to both scenarios, and are easily defined. They do not need to be precisely quantified, and there is no specific equation available to determine the exact amount and type of effort required to combat them. The state variables for our environment apply to both scenarios, and can be broken down into four categories:

- Heat
- Smoke
- Mechanical/structural damage
- Electrical damage

Each of the above variables can be defined with respect to the two factors of location and intensity. Figure 16 shows these two factors and their impact on the importance of a state variable. While intensity is the primary factor affecting the relative importance of a fire, location can, and often does, play a key role in determining the urgency of effort needed. For instance, a small fire located in the ship's torpedo magazine is certainly of more concern than any fire in an administrative workspace which is relatively isolated from hazardous material storage areas.

C. EXPANSION AND GROWTH OF A FIRE

A key element in the difficulty of combating a large fire can be found in the manner and nature by which a fire expands. Figure 17 shows a fire in a single space (A), comprised of the four state variables. Assuming that expansion via conduction, convection, or radiation will take place only among adjacent bulkheads, the fire is capable

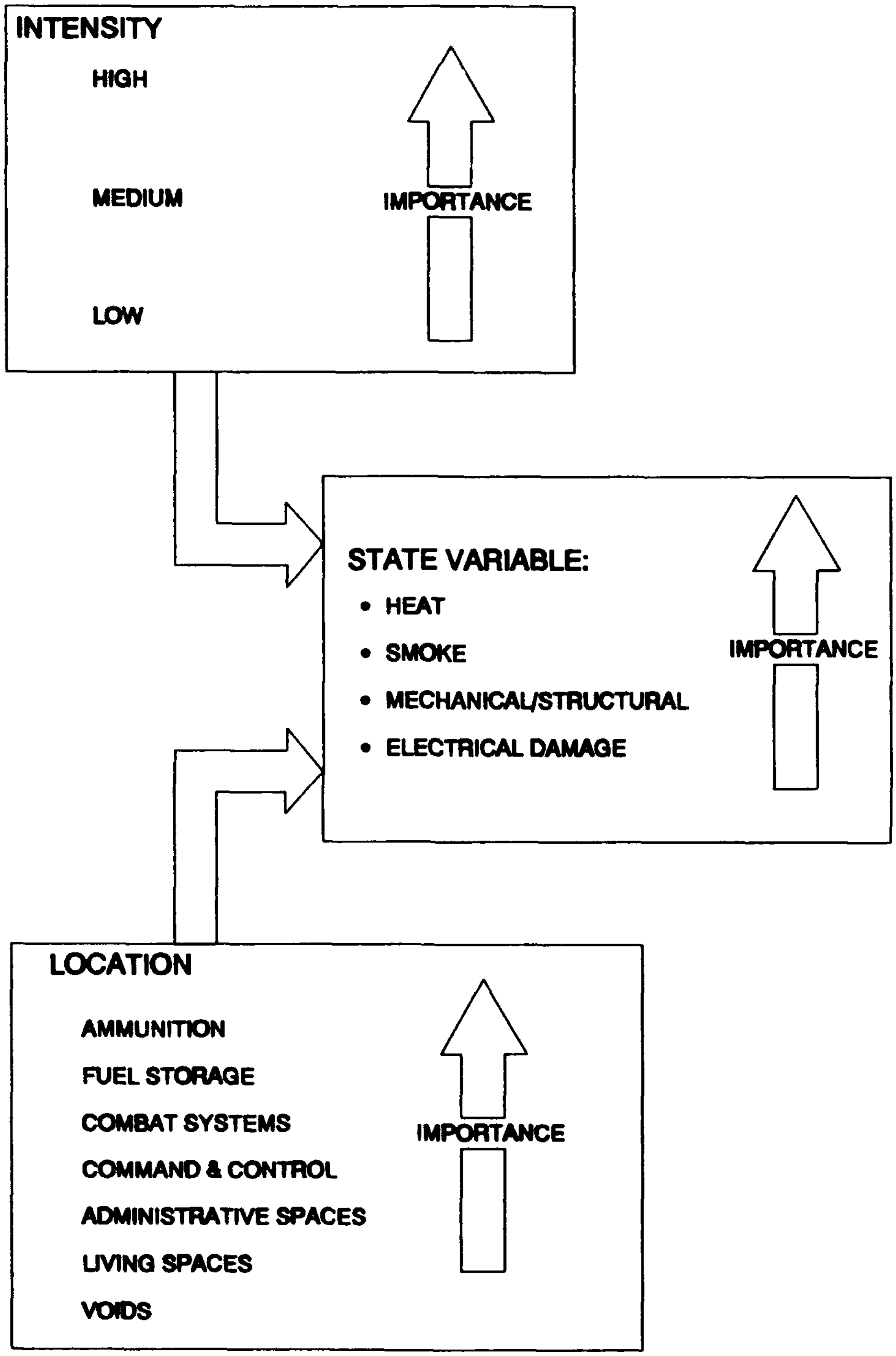

Figure 18: State Variables and Factors

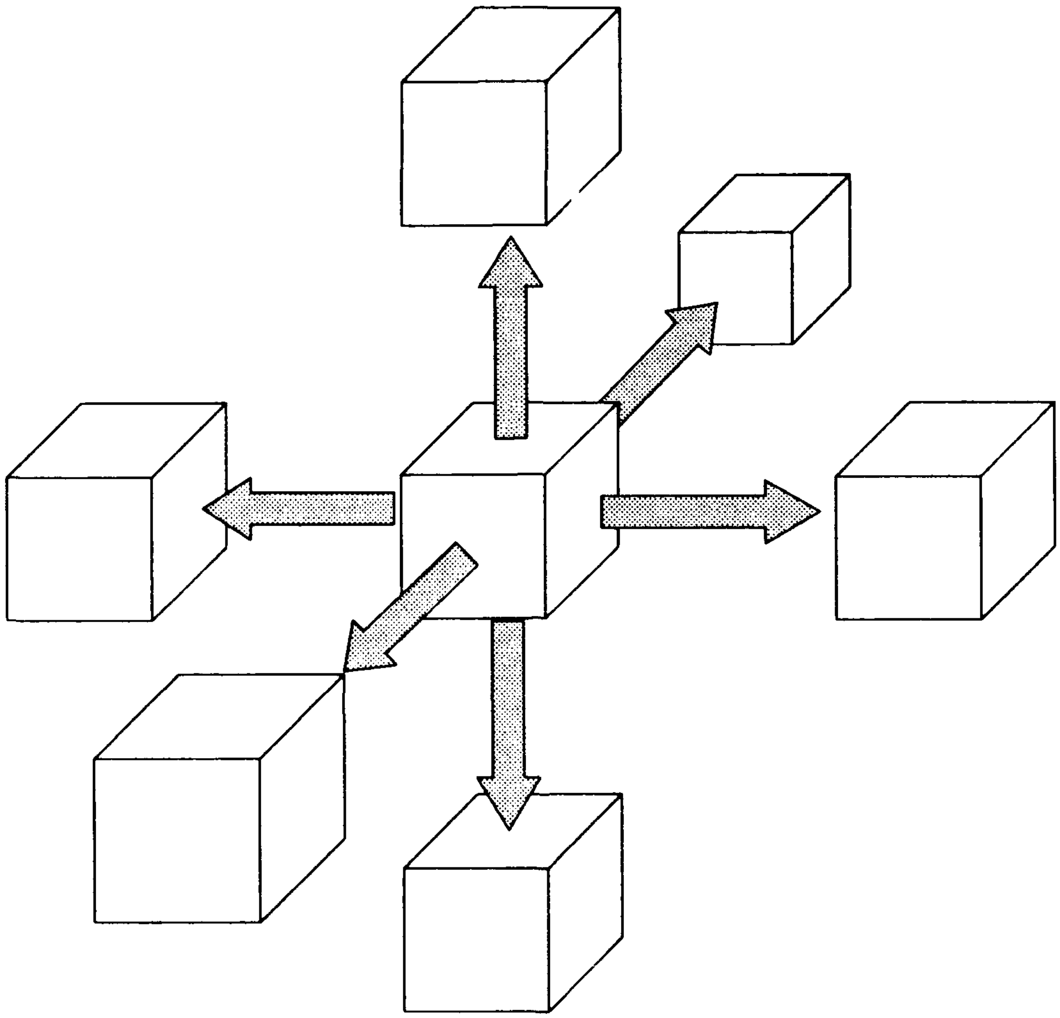

Figure 19: Fire Expansion and Adjacency

of spreading along six different paths. If this occurs, the number of locations, and therefore the number of factors times state variables, increases by a factor of six. Should the fire continue to spread to adjacent compartments along all available routes, the number of state variables increases again by a factor of eighteen.

D. FITTING THE ENVIRONMENTS INTO AN ANALYTICAL FRAMEWORK

1. Variance

Having defined the state variables, it is now possible to rate the relative levels of diversity and complexity inherent in the two environmental scenarios being analyzed. Hostility, as it affects variance, is not a factor in this analysis, as a fire possesses no intelligent direction and cannot be thought of as "hostile". Note, however, that a fire is not totally random either; since a fire will spread in the direction of fuel and oxygen, its movements can be somewhat predicted and countered.

As shown in the previous section, the Main Space Fire, since it primarily is concerned with one space, contains few state variables, and, despite the inherent complexity of an engineering space fire, is relatively simple in nature. Using the illustration from the preceding section, a Mass Conflagration can be thought of as an "instant expansion" into a far more complex environment, with a significantly greater number of combinations of state variables and factors. As this diversity increases, the complexity swells accordingly.

2. Time Rate of Change

A Main Space Fire is quite dynamic at the start, but the use of automatic and remote firefighting equipment such as Aqueous Film F)rming Foam (AFFF) sprinklers and Halon discharge systems virtually guarantee the containment of all but the most severe engineering fires. In view of this, the Main Space Fire can be considered a relatively static fire, with little chance of changing dramatically. No such installed systems exist, however, for combatting a Mass Conflagration, and it is by definition a fire out of control. Due to the size and intensity of the Mass Conflagration, it can spread rapidly, and the threat can change dynamically.

3. Variety

Having now defined a Main Space Fire as simple-static, and a Mass Conflagration as complex-dynamic, these two scenarios can be placed on the Environmental Analytical Framework. As shown in Figure 18, this placement indicates a low amount of variety for a Main Space Fire, while a Mass Conflagration is shown to contain a high level of variety. This fundamental difference in variety level is a vital key to analyzing the reason why an organization might be unable to cope with a Mass Conflagration, and will be addressed in the next chapter.

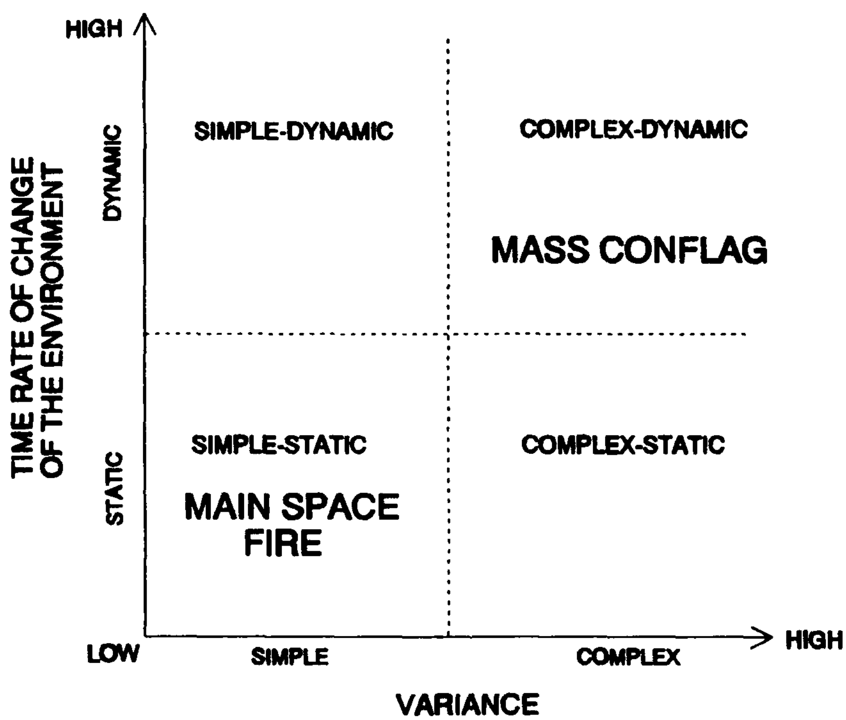

Figure 20: Environmental Analytical Framework (with Scenarios)

IV. ANALYZING THE DAMAGE CONTROL ORGANIZATION

A. THE DAMAGE CONTROL ORGANIZATION

The Damage Control Organization onboard a ship is responsible for ensuring that the ship does not suffer a loss of combat ability due to fire, flooding, or Chemical, Biological, and Radiological (CBR) attack. There are few DC personnel whose sole responsibility is Damage Control; rather, the organization consists of personnel from the other departments and divisions throughout the ship. Before beginning an detailed analysis of a ship's Damage Control organization, it is necessary to establish some basic definitions and delineate the general makeup of certain components within the organization. Certain features common to nearly every ship in the Navy are Damage Control Central, the Repair Locker, and the Repair Party. The organizational makeup of a typical Damage Control organization can be seen in Figure 21.

1. Damage Control Central

DC Central is the hub of the Damage Control network, and is normally located near the main Engineering control center. From DC Central, the Damage Control Assistant is able to monitor, evaluate, and control the damage and repair efforts of each of the ship's Repair Lockers, as well as communicate directly to Engineering control and the Bridge. While there is little in the way of damage control equipment *per se* in DC Central, a great deal of informational resources such as system diagrams, charts, etc, are available.

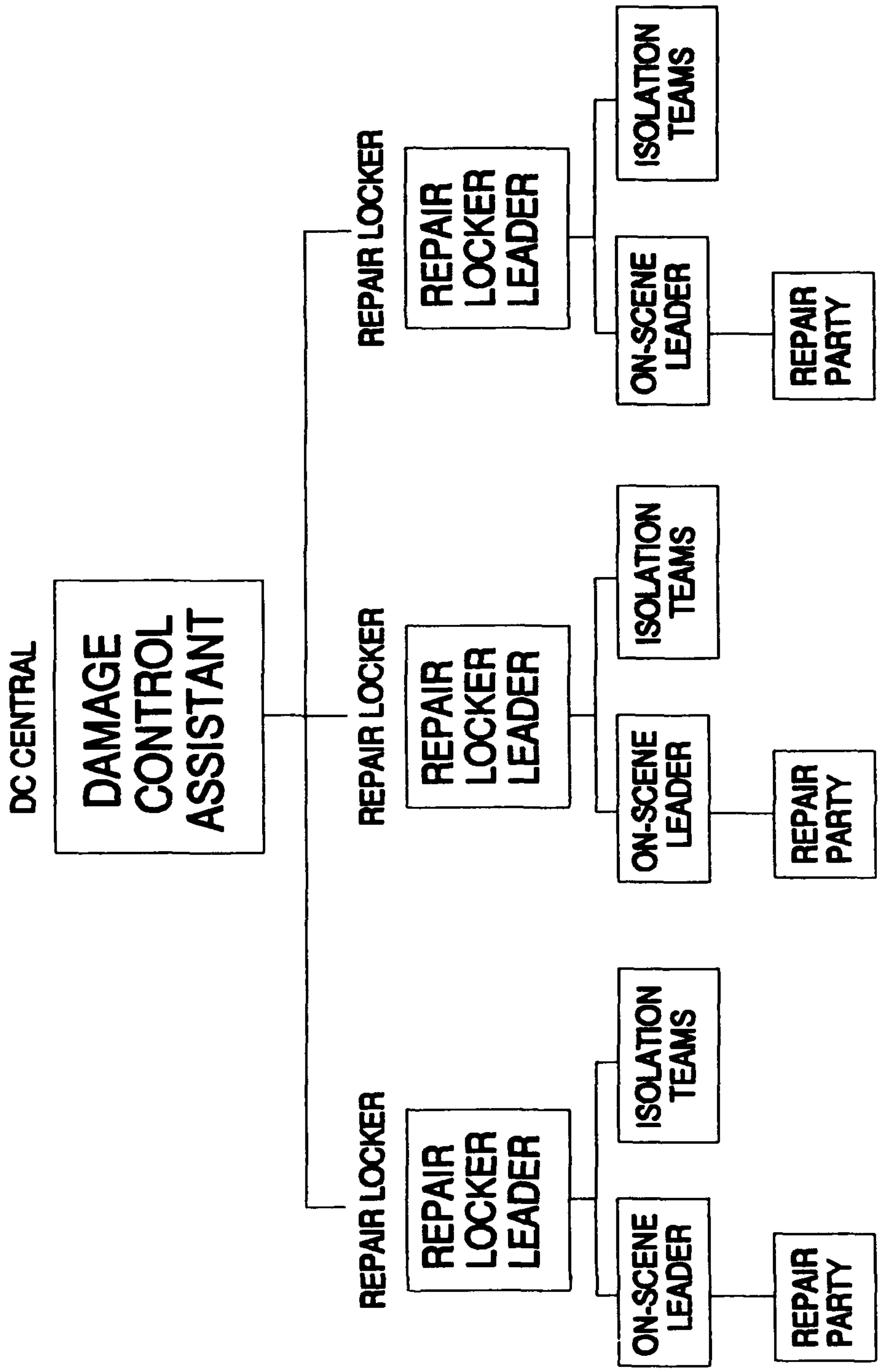

Figure 21: Damage Control Organizational Chart

2. The Repair Locker

The Repair Locker is the basic organizational unit responsible for controlling damage to the ship. In general, the ship is divided into a certain number of areas or regions of responsibilities, and a Repair Locker is designated to handle each region. The number of Repair Lockers onboard is directly proportional to the size of the vessel. Each Repair Locker is managed by a Repair Locker Leader, with various phone talkers, messengers, and plotters to assist in the control of the locker.

The Repair Locker contains all of the equipment, personnel, etc. necessary to contain and control typical damage within its area of responsibility. Resource allocation is usually the same in each Locker, although certain special function Repair Lockers, such as Repair V (Engineering spaces) and Repair VIII (Electronics) contain additional special equipment and personnel. In addition to repair parties, each locker normally has assigned to it at least one Electrician's Mate (EM), one corpsman (HM), and two Hull Technicians (HT). Figure 22 shows a breakdown of some of the personnel assignments and duties found within a Repair Locker.

3. The Repair Party

The Repair Party is a designated collection of ship's force personnel created to perform a specific task. Each party is normally led by an On Scene Leader (OSL), whose primary responsibilities are to control the actions of his team and to report to the Locker Leader. Since the number of personnel within a Repair Locker is often limited, many of the Repair Party members often perform more than one function within the

LOCKER LEADER

ADMINISTRATIVE:

- PHONE TALKER (TO DCC)
- PHONE TALKER (TO SCENE)
- PLOTTER
- ASSISTANT LOCKER LEADER

BOUNDARYMEN:

- FIRE BOUNDARIES
- SMOKE BOUNDARIES
- FLOODING BOUNDARIES

FIRE PARTY:

- ON-SCENE LEADER
- NOZZLEMEN
- HOSE HANDLERS
- GAS-FREE ASSISTANT
- ELECTRICIAN

ISOLATION TEAMS:

- MECHANICAL
- VENTILATION
- ELECTRICAL

ADDITIONAL:

- CORPSMAN
- MESSENGERS
- STRETCHER BEARERS
- OBA RELIEFS

FLOODING REPAIR PARTY:

- ON-SCENE LEADER
- PIPE PATCHING TEAM
- BULKHEAD PATCH TEAM
- DEWATERING TEAM
- ELECTRICIAN

Figure 22: Repair Locker/Party Assignments

Locker, e.g., the #1 Nozzleman in the Fire Party might also serve as the Box Patch man for a Flooding Party, or serve as the mechanical isolator for another fire party. Some of the Repair Party assignments can also be found in Figure 22.

B. THE SYSTEM-IN-FOCUS

In the scenarios as defined, the system in focus is the command and control hierarchy that extends from the Damage Control Assistant (DCA) in Damage Control Central down to the On Scene Leader (OSL) at the actual site of the fire. This, in turn, establishes the actual boundaries of the system, thereby relegating all external factors such as the ship's combat and operational chain of command, in addition to the fire itself, to the environment. Figure 23 shows a diagram of the system-in-focus described above, as well as the normal sound-powered communications used by the system. Note that the simplified organization shown in this figure can be increased in size simply by *adding* more repair lockers in order to represent the DC organization on larger platforms. Due to the varying nature of the size of Damage Control organizations within the fleet and in order to keep the following analysis generic, this figure is kept relatively simplified.

C. THE DESIGN PROBLEM

The design problem, as normally stated, must be modified in order to reflect the actual goal of the DC organization. The effectiveness of Damage Control onboard a ship depends primarily on its ability to keep the ship from suffering a degradation in its operational readiness, and this effectiveness translates directly into minimization of damage. Thus, the goal is not to maximize effectiveness as much as it is to minimize

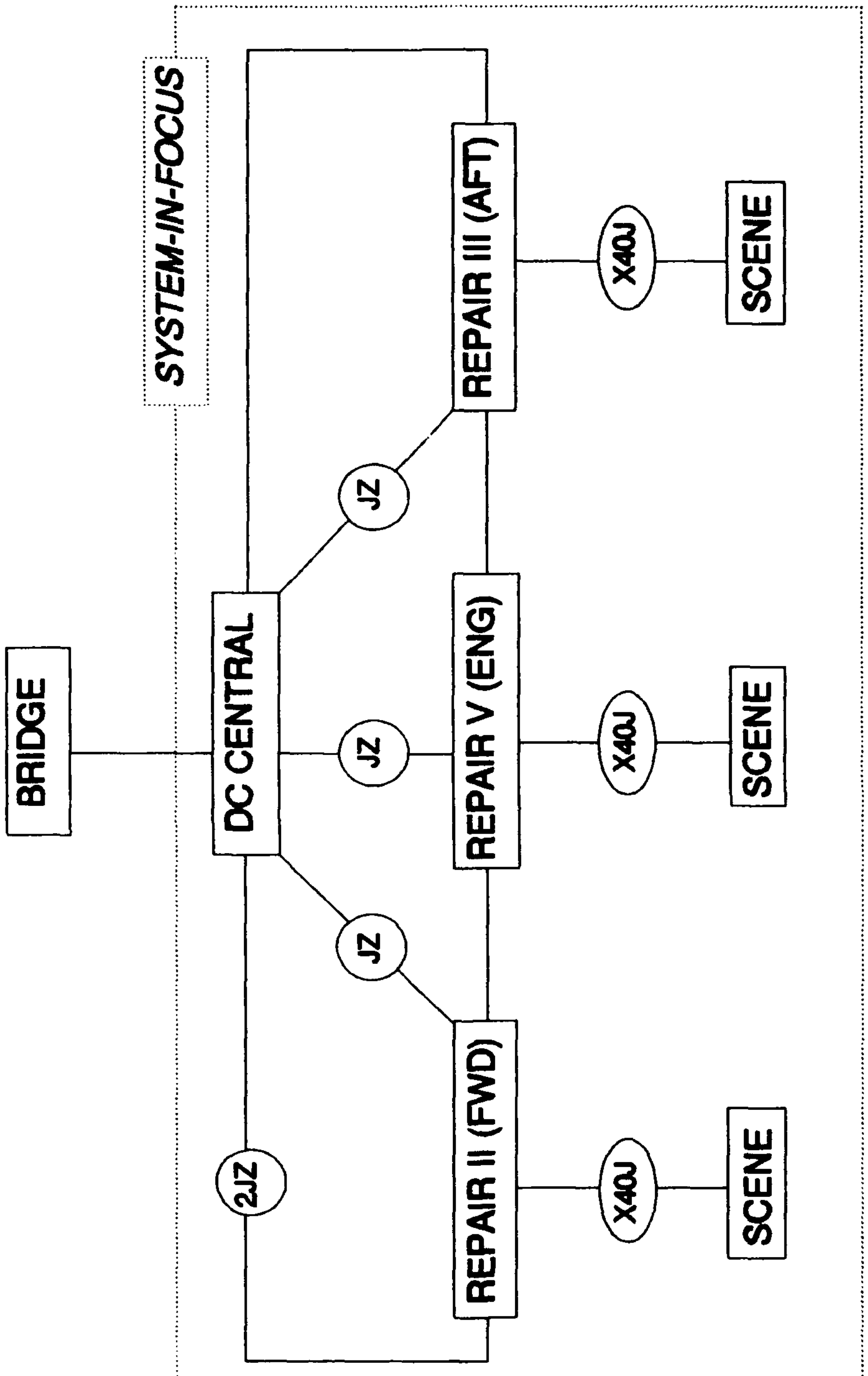

Figure 23: The Damage Control System-in-Focus (With Communications)

effect. Resources fall primarily into three categories: personnel, equipment, and time. Of the three, personnel is perhaps the most important, especially with respect to the number of highly-trained personnel. This resource is limited, non-expendable, and slowly decreases with time (due to fatigue, injury, etc.). In fact, these personnel are often the first casualties of a Mass Conflagration, leaving the remainder of the relatively untrained ship's force to combat the fire.

Equipment is a limited, expendable resource, and is normally present in sufficient quantity to cope with the environment. One exception to this is the Mass conflagration, in which such expendable equipment resources as AFFF cannisters, Oxygen Breathing Apparatus (OBA) cannister, etc. often reach critically low levels of reserver.

Time, as a resource, is defined for our purposes as the time needed to contain the fire or, conversely, the time remaining until the fire burns out of control. By its very nature, time is a limited, expended resource, and the amount of time available depends primarily on environmental factors.

Having determined the various factors of the design problem, it can now be defined in terms of resources, the environment, and organizational technology. Figure 24 shows the design problem for a Damage Control organization.

D. TECHNOLOGY AND COMMAND & CONTROL CHARACTERISTICS

In order to determine the sort of organizational technology currently employed by the typical Damage Control organization, an analysis of the existing command and control characteristics must be conducted. Once it has been determined where the DC

MINIMIZE DAMAGE

SUBJECT TO:

ORGANIZATIONAL TECHNOLOGY

EQUIPMENT USED ≤ EQUIPMENT AVAILABLE

PERSONNEL USED ≤ PERSONNEL AVAILABLE

TIME USED ≤ TIME AVAILABLE

CHARACTERISTICS OF THE DAMAGE ENVIRONMENT

Figure 24: The Damage Control Design Problem

organization falls within each of these characteristics, the type of technology (and, therefore, the variety handling capacity and analyzability) can be ascertained.

1. Flexibility

The organization in question cannot be thought of as very flexible, and is, in fact, very mechanistic in its methodology. Due to the dangerous nature of the environment, strict safety procedures must be followed at all times. In addition, the possibility exists that an overabundance of effort could cause as much damage as it combats, as in the case of an excessive use of firefighting water. These factors, along with others, do not leave much room for flexibility.

2. Formalization

The DC organization is highly formalized, in the sense that most actions and decisions are expressly governed by a specific set of written criteria. Using the Main Space Fire as an example, nearly every single action taken by the Repair Party, from space entry to desmoking and toxic gas checks, is predetermined and controlled by the Main Space Fire Doctrine. This document is often highly detailed and specific to the point of listing, for example, each and every valve, fuse, and relay that must be shut to isolate the space involved.

3. Centralization

While decisions are made at all echelons of the DC chain of command, most are made at the higher levels. The degree to which this is accomplished can vary, as each ship tailors its organization, but standard Navy guidelines often dictate that decisions involving dangerous or hazardous conditions be made by higher authority.

4. Skill Level of Personnel

Repair Locker personnel are, in general, highly trained in their jobs. In a well-run DC organization, training and evaluation takes place weekly, with emphasis on repetition of vital and important areas. Ship's force personnel outside of the Repair Lockers, on the other hand, are relatively untrained. Despite a requirement that all ship's force personnel maintain general DC qualifications, the average crew member, comparatively speaking, does not have the level of knowledge and experience found in Repair Locker personnel, and is not able to respond to change in the environment as effectively.

5. Span of Control

In this instance, span of control is slightly ambiguous. Due, once again, to the variable nature of ship and organization size, a Repair Locker can contain anywhere between 25 and 250 people. Another way of viewing span of control involves the number of functions reporting to and working for an individual. Using this as the criterion, the span of control for the DC organization can be evaluated somewhere between wide and moderate. This is primarily due to the fact that the Locker Leaders are required to control a large number of various teams, functions, and equipment; while the On Scene Leader (OSL) directs the immediate actions of the repair party, he is also a relay point for directives from the DCA and Locker Leader.

6. Communication and Coordination

Within the typical Damage Control hierarchy, vertical communication and coordination dominates. In fact, for the Main Space Fire, horizontal communication is virtually nonexistent. Nearly all allocation of resources and support is principally controlled by Damage Control Central. Figure 23 emphasizes this trend towards isolation of subordinate units and the pivotal role of DC Central. Interdependence, when it does exist, is pooled, and mutual support and other coordination efforts are almost entirely absent unless coordinated through the Damage Control Assistant.

Using Table 1 from Chapter II, we see that the technology that best fits the DC organization as described above matches a Routine technology in five of the six categories. The one exception, skill level of personnel, would seem to create a paradox, at least on the surface. Normally a formal, centralized organization operates as such because of the relatively low levels of personnel skill. This does not always have to be the case, however. The Navy's mechanistic organizational approach results primarily from an underlying concern with military discipline and ship safety, not because personnel skill levels require it to operate in such a manner.

E. THE DAMAGE CONTROL DECISION MAKING PROCESS

1. Problem Uncertainty

Problem identification is a relatively straightforward process in Damage Control, given that the location and nature of the damage have been accurately and properly reported. Problem solution is well-defined, and is covered by various standard procedures for each type of damage scenario (as long as the size is not unmanageable). For example, there are four basic classes of fires encountered onboard:

- Class Alpha - ash-producing fires involving material such as wood, paper, etc.
- Class Bravo - fuel and other petroleum fires
- Class Charlie - electrical fires.
- Class Delta - special fires such as magnesium fires and deep-fat fryer fires.

The recommended firefighting agent for each class of fire has been predetermined, and procedures for fighting each class have been laid out in numerous doctrines. Problem uncertainty, therefore, is quite low.

2. Goal Consensus and Technical Knowledge

Following the above discussion on problem uncertainty, the related parameters of goal consensus and technical knowledge are both very high. For a shipboard fire of "normal" proportions, the ship's leadership is able to agree almost completely on the actions necessary to put out the fire, as well as contain any collateral damage. Using the framework shown in Figure 12, it can be seen that the decision-making process normally employed by a typical Damage Control organization can be best represented by the Management Scienct Model. The Management Science method of decision making is well-suited for this type of mission-oriented, understandable organization, and is quite effective when dealing with damage of moderate proportions. A Mass Conflagration, however, introduces a more chaotic note into the DC problem, and lends itself less readily to a cut-and-dried solution process. This topic, and the recommended changes necessary to deal with it, will covered further in Chapter V.

F. SUMMARY

Table 3 shows a synopsis of the above organizational analysis. The DC organization has been classified as a Routine technology with primarily vertical linkage and pooled interdependence, with decision making based on the Management Science model. Comparing the variety handling capacity of our organization to the variety generated by the two damage scenarios described in Chapter II, we can see that, while the current methods employed by the Damage Control organization are adequate for the Main Space Fire, they fall well below the requirements needed to cope with a mass Conflagration. Chapter V will look more closely at this disparity, and will advance certain changes and adaptations to the DC organization in order to effectively deal with the more complex environment.

TABLE 3
SUMMARY OF DC ORGANIZATIONAL CHARACTERISTICS

C2:	
Flexibility	Mechanistic
Formalization	High
Centralization	High
Skill Level of Personnel	High/Medium
Span of Control	Wide
Communications	Vertical-High
Coordination	Vertical-Moderate
Decision Process:	
Problem Identification Uncertainty	Low
Problem Solution Uncertainty	Low
Goal Consensus	High
Technical Knowledge	High
Model Most Applicable	Management Science
Technology Employed	Routine
Variety Handling Capacity	Low/Medium

V. ADAPTING THE DAMAGE CONTROL ORGANIZATION

A. ORGANIZATIONAL FLEXIBILITY

A review of Table 3 in Chapter IV points out the fundamental problem experienced by the shipboard DC organization: a Routine technology does not possess the variety handling capacity (VHC) necessary to cope with the demands of a Mass Conflagration. Quite simply, the organization is too mechanistic to respond and act sufficiently in the face of a highly chaotic situation. Obviously, what is needed is to shift the organizational technology towards greater VHC while maintaining the inherent military protocol and procedure which are mandatory in any shipboard organization. In order to accomplish this, Figure 17, which provides a list of organizational characteristics and their relationships to variety handling capacity, can be utilized as a template to determine which adjustments can be made to the organization. Certain of these characteristics will be addressed, and recommended modifications proposed.

B. DECENTRALIZATION

One of the most common errors made by ships is that the key leadership personnel onboard are often situated in two or three vital spaces around the ship, and loss of one of these spaces could effectively decapitate the command and control organization. [Ref 1] Since a Mass Conflagration can, and often does, isolate the forward and aft ends of the vessel, steps should be taken to ensure that key personnel, such as the Commanding

Officer, Executive Officer, and Chief Engineer, are not located in close proximity. Not only does this reduce the likelihood of losing all of the principal leaders to one casualty, it also establishes the framework for instituting an expanded C2 network for damage control efforts.

C. THE SPAN OF CONTROL

The Damage Control Assistant often assumes the role of micromanager, controlling the most minor details and receiving progress reports on nearly every phase of the DC operation. [Ref. 1] The same is true of the Locker Leader and Bridge. While this arrangement might work fine for smaller damage scenarios, the personnel in charge can quickly find themselves overwhelmed by minutiae when confronting a more complex, dynamic situation. For example, consider the means by which most DC information is transmitted and recorded: the Damage Control Triangle. As can be seen in Figure 25, the DC Triangle is a fast, effective way of relating data about damage, while its simplicity makes it applicable to everything from fires to stretcher bearers. The major drawback to this method is that a typical fire in one space can encompass DC Triangles relating to numerous subjects:

- Fire
- Smoke
- Electrical isolation
- Mechanical isolation
- Ventilation

- Personnel casualties
- Stretcher bearers
- Equipment damage
- Firefighting water (flooding)
- Boundaries
- Time remaining on Oxygen Breathing Apparatuses
- Desmoking and gas freeing procedures

If the above items of information are relayed for every space or area on fire during a Mass Conflagration, the DCA and Locker Leaders will quickly become overwhelmed. The DC Triangle is data, not information, and the solution is to redefine the nature of the information. To do this, two properties about each piece of data need to be determined: the scope of its effects, and the danger it represents. For instance, only those items of information whose scope includes ship wide systems or major areas of the ship should be relayed to the DCA; similarly, only those items which pose a danger to vital ship's systems should be relayed. Concurrent with this change should be a shift in the level at which decisions are made. While it is true that the DCA should be concerned with all damage, no matter how minor, he does not have the time to make every decision for the ship, just as the Locker Leader does not have the time to make every decision for his area of responsibility. By refining the data at the lowest levels into useful information, the key leaders will have the time to review the information, weigh options and make decisions.

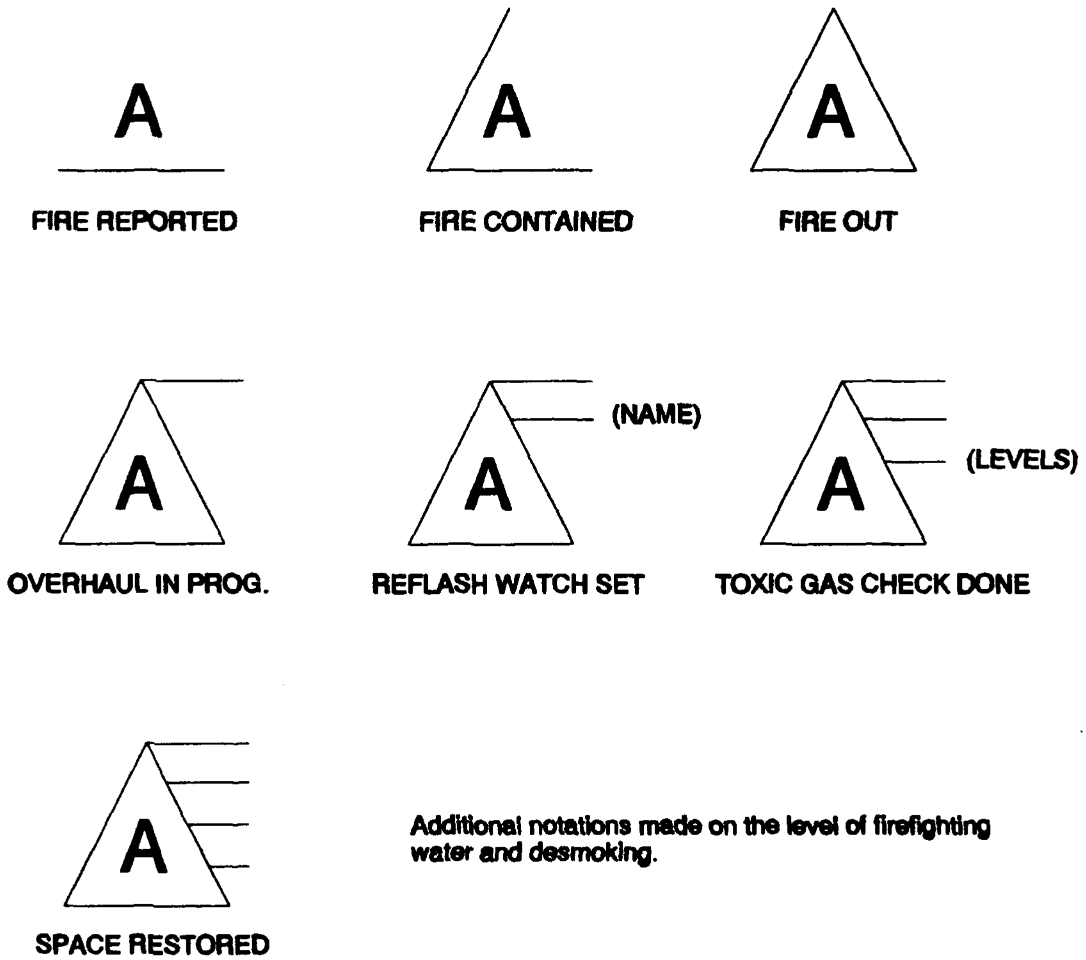

Figure 25: An Example of the Damage Control Triangle

D. COORDINATION AND INTERDEPENDENCY

1. Vertical and Horizontal Linkage

As shown in Figures 14 and 17, the current form of vertical linkage used by the typical DC organization - the Vertical Information System - has the highest variety handling capacity; unfortunately, it also calls for a very high degree of vertical coordination. Conversely, the current form of horizontal linkage most commonly used - messages - has the lowest VHC while requiring the least amount of horizontal coordination. Variety handling capacity can be increased, but only at the cost of increasing the amount of coordination (either vertical or horizontal) required.

2. Integrating Managers and Liaisons

One solution which achieves an optimum combination of variety handling capacity, increased horizontal coordination, and decreased vertical coordination is the establishment of liaisons and integrating managers between the On Scene Leader and Locker Leaders levels of the hierarchy. Figure 26 illustrates the basic idea behind these concepts. [Ref. 3:p. 98] Junior officers and senior enlisted personnel should be placed in these positions, with the primary purpose of acting as "Sub-Locker" Leaders, i.e., they keep the Locker Leader informed on important information, while also coordinating the efforts of the various DC parties in their area. Figure 27 shows an organizational diagram which includes the use of integrating managers and liaisons. Certainly, the vertical information system and message procedures will remain in place, but the addition of integrator/liaisons will have the following effects on the organization:

- The amount of vertical coordination is reduced, freeing the upper levels of the command chain to concentrate on more critical issues.

- The span of control is narrowed, thereby increasing variety handling capacity.

- The integrator/liaisons also receive and relay information from the scene, refining the data from the On Scene Leader and thereby reducing the information flow up the hierarchy.

- Two or more liaisons within a Repair Locker can coordinate with each other (under the cognizance of the Locker Leader), resulting in a more efficient allocation of personnel and other resources

3. Interdependency

The difficulty with the current form of interdependency - pooled - lies not as much with the type of interdependency as with the level at which resource allocation is made. As mentioned before, a Mass Conflagration often isolates sections of the ship, and both serial and reciprocal interdependency require a closer proximity of units. If, however, pooled interdependency were to occur at the integrator/liaison level, then interdependency at the Locker and ship-wide levels can be viewed as reciprocal. Figure 28 shows an example of this concept. If Integrator A has been given the task of containing the fire in his location, but discovers that he has more hosehandlers or investigators than he needs, he can reassign these resources to a more needy repair party in Integrator B's area. As long as each Integrator/liaison ensures that the current task is being fulfilled, they can coordinate with each other and share resources as needed. This also establishes a mechanism whereby the Locker Leader and/or the DCA can accomplish resource reallocation more efficiently.

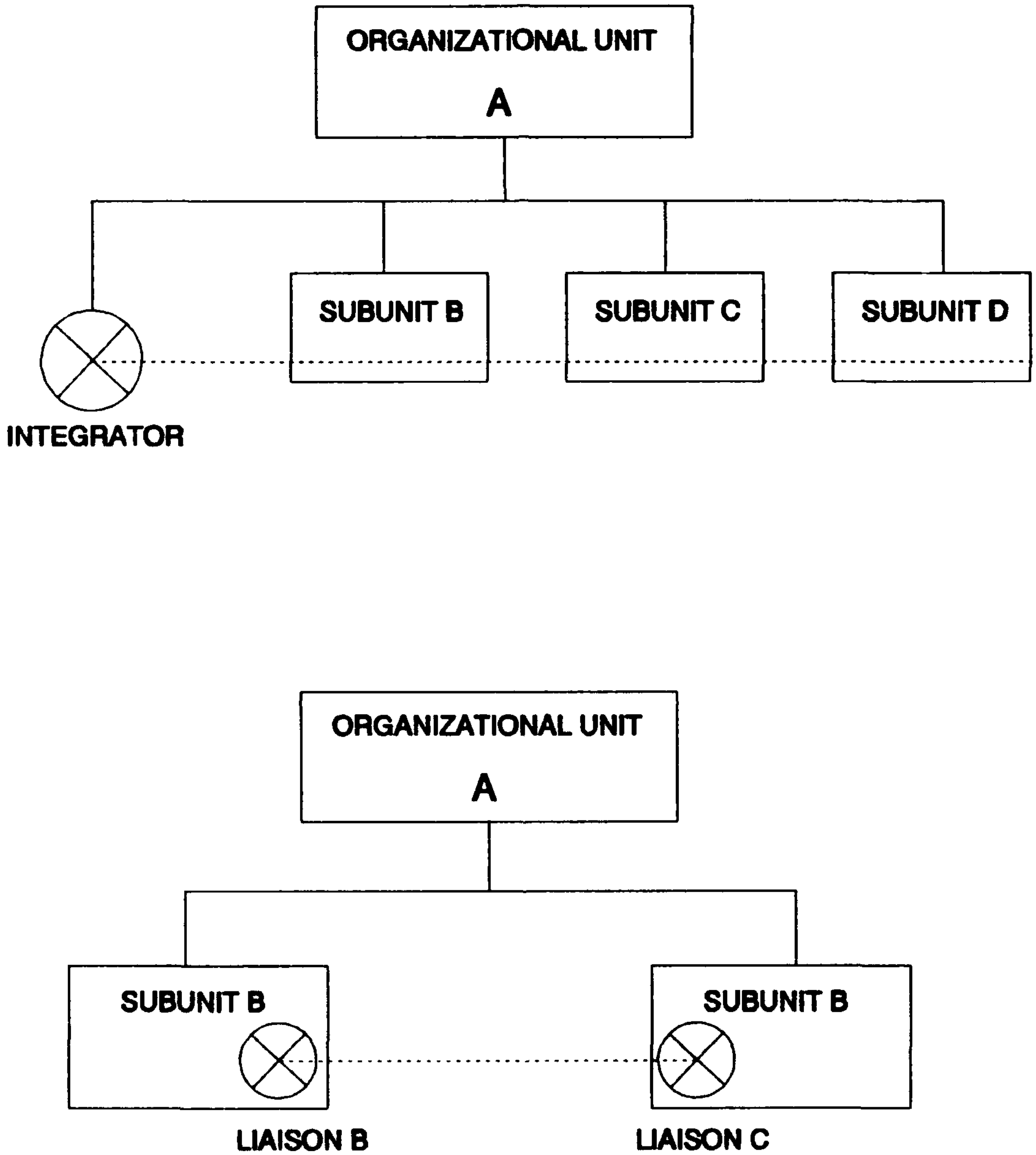

Figure 26: Liaisons and Integrating Managers

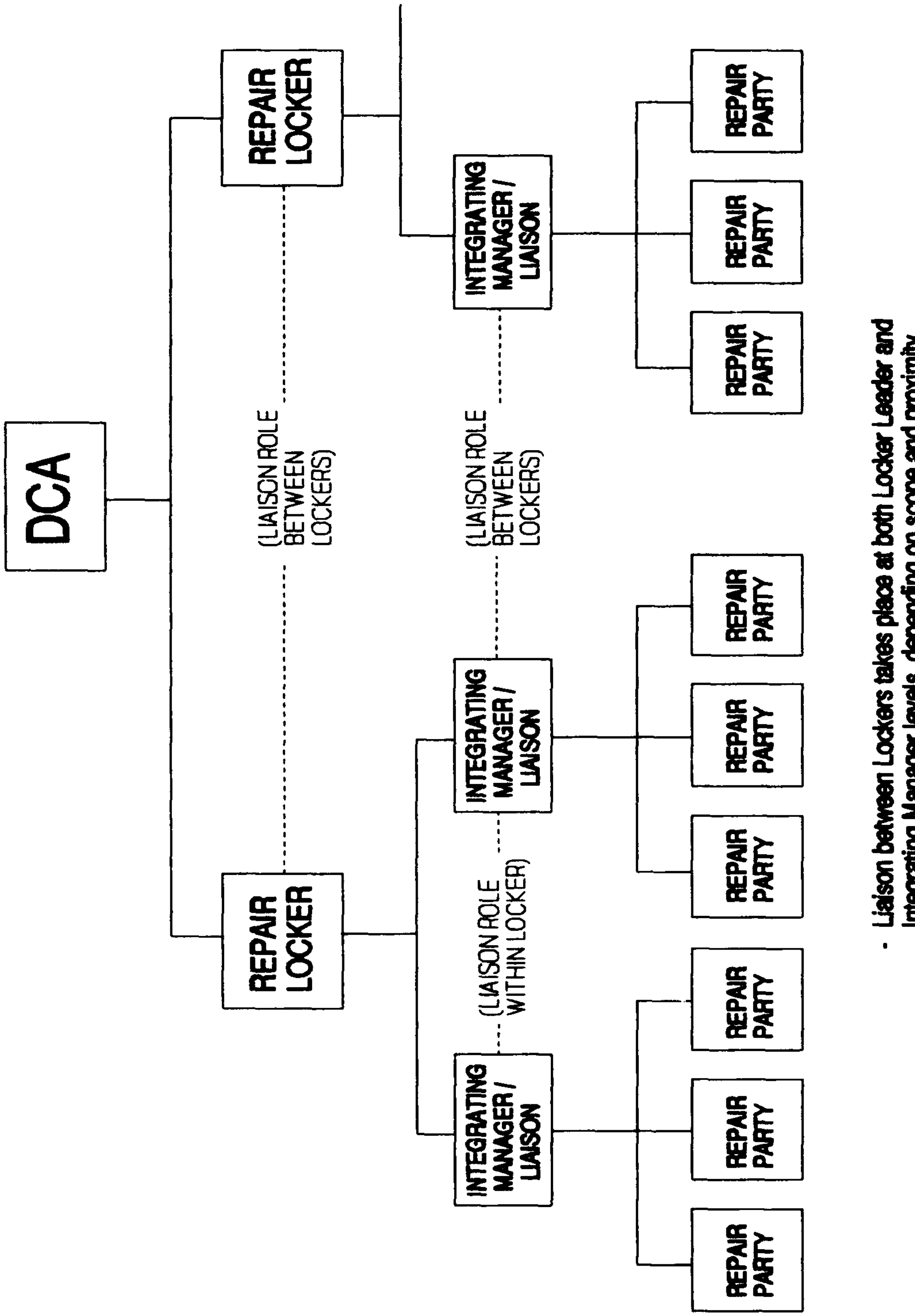

Figure 27: Revised Repair Locker Organization

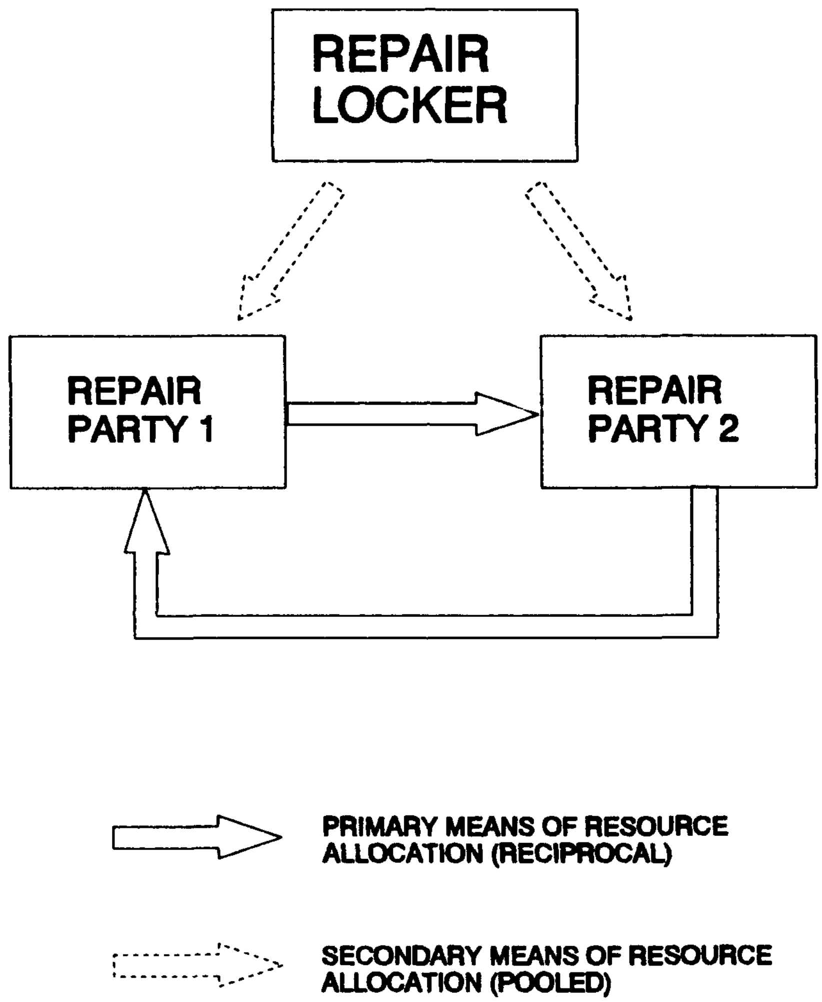

Figure 28: Example of Proposed Interdependency

4. Communications

Of course, given the expanded and more complex nature of the changes mentioned above, communications must also expand to meet the requirements of more horizontal coordination. The numerous sound-powered phone circuits, walkie-talkies, and ship's announcing (MC) circuits found on most ships make the establishment of a flexible communications network feasible, if somewhat complex. One system in particular, the Damage Control Wire-Free Communications (DC WFCOM) system, makes the establishment of such a network relatively simple. A key point to remember in designing the DC communications network for Mass Conflagration is to ensure that it is flexible and adaptable. Primarily, this means building redundancy into the system; a major casualty to the ship often destroys one or more of the normal intra-ship communications system, and secondary and even tertiary circuits must be provided for when available. Also, the ship's DC organization should not become too reliant on one particular system. Some ships that had DC WFCOM were unable to react and adapt to a casualty to that system during MASS CONFLAG exercises, because they had relied on it exclusively, and had to build another network from the ground up, causing numerous vital delays. [Ref. 1]

E. FORMALIZATION AND PERSONNEL SKILL

Paradoxically, of all the command and control characteristics discussed in this chapter, formalization is the one which remains unchanged. The ship's Damage Control organization is part of a formal military one, and any organizational changes that take place must do so within this context. This constraint is necessary, and must be taken into account when modifications to the DC organization are made. It should also be pointed out that these modifications apply only to Mass Conflagrations and other damage scenarios of that scope, and the current setup used by the Navy does not need to be redrawn from scratch; the basic DC organization has proven to be highly efficient for most types of damage scenarios, and should remain unchanged for those situations.

The changes described above will only be effective in the long run if they are made an integral part of the formal ship's organization. In order to ensure that this is achieved, each ship should create an addendum to the Ship's Battle Bill, particularly the General Quarters (GQ) assignments, which assigns each person onboard a duty station in the event of a declared Mass Conflagration. This administrative modification would seem, on the surface at least, to be nothing more than additional paperwork headache. It is critical, however, that the changes and adaptations described above be institutionalized. Many ships have employed some of these changes for Mass Conflag drills, or have been forced to do so by combat circumstances, but there was little or no "corporate memory", i.e., continuity was not maintained. Formalizing not only ensures continuity, it provides for the constant turnover in personnel experienced by every ship.

The Mass Conflag plan should also include communications assignments and areas of responsibility, while remaining flexible enough to allow for other demands on the ship's personnel, such as those in key combat roles. This change to the Ship's Bill should have an inherent redundancy built in to personnel assignments, so that the ship is ensured of having each billet within the DC organization filled regardless of personnel casualties, combat assignments, etc. Since the circumstances, as well as the impact upon the GQ Bill, are different for each ship, the administrative change should be tailored to the specific vessel; for example, an amphibious warship might simply include embarked Marines into its Mass Conflag DC organization, while a reserve Perry-class Frigate will need to make fundamental modifications to its personnel assignments during GQ.

In conjunction with this, personnel training must be expanded to include Mass Conflagration. Personnel turnover on every ship is a constant influence, and only a controlled, mandatory training program will be able to lessen the confusion during a major casualty to the ship. This program is not as involved as it may seem; each person onboard is already required to maintain a General DC qualification, and additional training in firefighting, coordinating, etc., can be conducted by those personnel permanently assigned to Repair Lockers. The key here is that each person must be aware of his assigned duty, trained to perform that duty, and able to shift on short notice into his Mass Conflag station.

F. SUMMARY

If done properly, the inclusion of the modifications described above into the typical Damage Control organization will increase the ability of that organization to cope with the increased environmental variety intrinsic to a Mass Conflagration. To summarize the changes needed:

- Decentralize the ship's battle organization to prevent loss of leadership.
- Lower the level at which decisions are made and resources are allocated, with a commensurate reduction in the amount and nature of information relayed up the chain of command.

- Establish integrating managers and liaisons to assist the Locker Leaders and On Scene Leaders, and use them to increase the amount of horizontal coordination between Repair Parties.

- Create a flexible, adaptable communications network which can still operate upon the loss of primary, or even secondary, circuits.

- Formalize these changes, creating a Mass Conflagration Bill as an addendum to the Ship's Battle Bill.

- Establish a program of personnel training so that the above changes can be instituted with a minimum of confusion.

Most ships will be able to improve their chances of surviving by instituting a formal doctrine that anticipates the chaotic environment of a Mass Conflagration.In this era of modern warfare, with its hard-to-detect, difficult-to-kill weapons, ship survivability has come to depend more and more on the ability of the ship's personnel to deal with massive damage, and the Damage Control organization must adapt to this environment in order to keep the ship afloat.

LIST OF REFERENCES

1. Telephone conversation between LT William D. Tyree, Senior Damage Controller, Fleet Training Group San Diego, and the author, 5 February 1991.

2. Obel, B., *Issues of Organizational Design: A Mathematical Programming View*, Pergammon Press, 1982.

3. Pasmore, W.A., *Designing Effective Organizations: The Sociotechnical Systems Perspective*, Wiley and Sons, 1988.

4. Daft, R.L., *Organization Theory and Design*, West Publishing Company, 1989.

5. Mintzberg, H., *The Structuring of Organizations: A Synthesis of the Research*, Prentice-Hall, 1979.

6. Hall, R.D., *Organizations: Structure and Process*, Prentice-Hall, 1972.

7. Perrow, C.D., *Organizational Analysis: A Sociological View*, Wadsworth Publishing Co., 1970.

8. Daft, R.L., and Lengel,R.H., "Organization Information Requirements, Media Richness and Structural Design," *Management Science*, v.32 (May 1986), pp. 554-571.

9. Tushman, M.L., and Nadler, D.A., "Information Processing as an Integrating Concept in Organizational Design," *Academy of Management Review*, v.3 (July 1978), pp. 613-624.

10. March, J.G., and Olsen, J.P., "Garbage Can Models of Decision Making in Organizations," in *Ambiguity and Command*, ed. March, J.G. and Weissinger-Baylon, pp.11-35, Pitman Publishing Inc., 1986.

11. Allison, G.T., "Conceptual Models and the Cuban Missile Crisis," in *Decision Making: An Organizational Behavior Approach*, ed. Pennings, J.M. pp. 311-340, Markus Wiener Publishing Inc., 1986.

12. **Beam, W.R.,** ***Command, Control, and Communications Systems Engineering*****,** **McGraw-Hill, 1989.**

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