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THESIS

A SIMULATION OF INFORMATION LOAD
AND ITS AFFECT ON TACTICAL DECISION MAKING

by

Christopher C. Hassler

June 1983

Thesis Advisor: R.H. Weissinger-Baylon

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This thesis examines the problems associated with the abundance of information generated by decision aids, and utilizes James G. March's model of organizational decision making as a medium to examine information. The emphasis is on choice situations resulting in "flight", "oversight", and "resolution" conditions and how the related provisions of information load prejudice the above-mentioned conditions. The foundation and the resultant

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The intent of this research is to provide a more realistic depiction of information usage by simulating the effects of various levels of information load on the choice process. This study recognizes information load as a condition which affects Naval tactical decision processes and hence has applicability, at least by association, to TDSS (Tactical Decision Support Systems) design.

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A Simulation of Information Load and its Affect on Tactical Decision Making

by

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June 1983

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This thesis examines the problems associated with the abundance of information generated by decision aids, and utilizes James G. March's model of organizational decision making as a medium to examine information. The emphasis is on choice situations resulting in "flight", "oversight", and "resolution" conditions and how the related provisions of information load prejudice the above-mentioned conditions. The foundation and the resultant perspective of this thesis is predicated upon a survey of over fifty government funded studies on decision making, tactical decision aids, tactical information requirements analysis, modeling criteria, organizational behavior, and the influences they have on choice outcomes.

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I. INTRODUCTION

Despite the continued attempts and the voluminous products of years of research in the field of decision theory and decision methodology, no singular approach has gained complete acceptance, nor has this research yielded the ideal model with which Decision Support Systems could be built and utilized within the realm of C^3I (Command, Control, Communications, Intelligence)[1] without many serious shortcomings. Inadequate recognition of the problems of over-information in model selection is one such shortcoming.

A complete understanding of the tactical decision maker's decision making processes is imperative in order to design tools that truly support/aid the decision maker. Often the tactical decision maker is hampered by too much information rather than not enough. Thus, as decision aids and tactical decision support systems[2] become more abundant,

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[1] C^3I is used synonymously with C^2 (Command and Control), C^3 (Command, Control and Communications) and C^4 (Command, Control, Communications and Computers).

[2] A specialized Management Information System designed to support a decision maker's activities and decision processes by utilizing computer-based technology, the emphasis of such a system is to aid personnel faced with complex and unstructured tasks in a tactical (combat) environment.

the quantity of information that can be handled effectively by the decision maker will become as important as what types of information are provided.

This thesis is an examination of information load and how it influences the decision process. This concept of information load (I_T) is applied to James G. March's "Garbage Can" model[3], which will be discussed at considerable length in Chapter IV.

The methodologies commonly used to determine information requirements in the past, by their very nature, have endorsed a model of decision theory. One particular theory/model seems to have been more frequently utilized than others. That theory, the rational actor, will be referred to at a later point. For the present, however, the reader should contemplate several seemingly obvious, but nonetheless realistic considerations:

a. Simple problems may be solved with simple solutions.

b. Complex problems frequently require complex solutions.

c. The majority of Naval decisions are complex and demand the "proper" and timely allocation of scarce resources

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[3] Reference to James G. March or the team of Cohen, March, and Olsen is considered to refer to the same model, i.e., "The Garbage Can"; and should be viewed as interchangeable identifiers.

which leads, many times to a condition known as "satisficing".[4]

d. In order to achieve resolution, prior identification of the need to seek resolution is necessary.

e. Humans by nature are not rational beings.

f. Over-information frequently "clouds" issues and adds to the complexity of choice opportunities.

g. The environmental conditions which surround the choice process must be considered, and mutual coexistence between the choice process and environment must be assumed. Its effect may be limited to only perceptual influences rather than tangible and easily quantifiable entities.

As mentioned previously, the foundation of this thesis is March's theory of decision making known as the "Garbage Can". This is not titled as such to imply that decisions are garbage, nor is it intended to reflect discredit upon those faced with making complex Naval decisions. Rather, this title suggests that it is a repository of many discarded and usually dissimilar items. This thesis utilizes the "Garbage Can" as a means to examine information load, and apply the latter concept to the tactical decision

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[4] A term developed by Nobel laureate Herbert Simon to denote problem-solution situations where decision makers are obligated to choose a less than optimal solution; normally a method where the first alternative solution is chosen that meets the requirements of the problem satisfactorily, yet not optimally. The optimal solution is sacrificed.

process. Further references to the March model (not adapted to a military context) will be referred to as the "Garbage Can" theory, while the military (Naval) adaptation will be specifically referenced as such.

Before proceeding further, it is necessary to describe the contents of this thesis and the structure/approach that will be utilized to tie many seemingly dissimilar ideas and/or philosophies together to yield a coherent and acceptable document.

Chapter I, the introduction, outlines the structure of this thesis and the order that issues are addressed.

Chapter II is an exposé of the present, and the problems currently being experienced within the C^3I community. The contents of this chapter, although oriented toward C^3I, have similar implications to TDSS (Tactical Decision Support Systems) and operational decision aids in that these components are information dependent. Further, it provides the reader with examples of current commentary which concerns the development of information producing devices/systems.

Chapter III is a review of several subtleties which effect the selection of decision models. This is not an all-encompassing account since the number of problems and models in existence are numerous and highly specialized. Rather, a limited discourse is presented on the philosophical assumptions which are associated with the rational actor model and the Carnegie theorists.

The Cohen, March, and Olsen "Garbage Can" model will be presented in Chapter IV. It will be presented with an explanation which permits an understanding of the model and its underlying assumptions yet without presenting it in such detail that the entire thesis is dominated solely by this purest form--yet providing the foundation upon which this thesis and simulation are founded. The concept of load on choice opportunities is examined for the first time in this chapter.

Chapter V is a expansion of load. Here, a more quantifiable (yet not rigorous mathematical) account will be presented in support of a more exact definition of what components comprise total information (I_T). The ensuing discussion on the timing of information load and its influence on choice situations serve as a basis for information load simulations.

Chapter VI is the presentation of the "Garbage Can" theory with modifications. Here the concepts of I_T and E_T (developed in Chapter V) are introduced as enhancements to the "Garbage Can" prior to applying this model to a Naval organizational environment. The commentary specifically examines the Combat Information Center/Flag Tactical Plot as shipboard locations which endorse the "Garbage Can" model. Other enhancements/modifications to the March model in the military application include the concepts of telecommunications dependent participation, volume, gain, and information load.

Chapter VII includes the data generated by the simulation of the "Garbage Can" model under five information loads (Appendices A, B, and C). Commentary relevant to this data accompanies the data.

Chapter VIII will consist of conclusions. Included are the author's summary opinions regarding the impact of information load with regard to the choice outcomes generated by the simulation and the applicability of those outcomes to TDSS.

II. AN EXAMINATION OF PRESENT CONDITIONS

The Office of the Secretary of Defense (OSD) sponsored a series of three colloquiums to discuss the state of understanding the technology with regard to command and control. Leaders from both the academic and business communities participated.

> "The main issue that emerged, centered around a single theme, with variations: there is not adequate foundation for a theory of command and control and, hence, no guiding principles for systems design and evaluation." [Ref. 1]

The problems and issues identified in the colloquiums confirmed several fundamental conditions and/or considerations. They

> "...confimed an earlier perception that command and control is not a collection of sensors, processors, displays, and data links. Rather, command and control was an extension of basic human decision processes..." [Ref. 2]

The fundamental point here is that if C^3I is an extension of human processes and past design and development has been less than completely satisfactory, then further attention must be given to how the dynamic and unique decision process of Naval commanders is performed. Joseph G. Wohl, senior member of IEEE in his paper "Force Management Decision Requirements for Air Force Tactical Command Control" stated that...

> "...the theory of command and control must start with a theory of decision making..." [Ref. 3]

The introduction of this thesis was intended to indicate what preliminary perceptual assumptions have been made, and to introduce the order of topics so that a miscegenation of disciplines may be envisioned. This chapter's primary goal is to provide a sense of credibility to assertions proposed by the author that new viewpoints and considerations must be adopted if the aspirations may hold for C^3I/TDSS[5] are to be translated into reality. The author recognizes that revisionistic proposals are frequently met with opposition; this paper recognizes this and attempts to present conceptual ideas in a manner which reduces this type of objection. Yet inadequate research exists within particular areas addressed in this paper and should be viewed as areas of further investigation, rather than areas which proposefully avoid quantitative qualification, and thus fail to merit serious consideration. Additionally, it is prudent to recall that not all thematic entities are quantifiable.

The remaining portion of this chapter is dedicated to establishing an appropriate frame of reference by which to consider following chapters. Although this chapter may seem to dwell of the negative rather than positive attributes of tactical decision support, it is the negative

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[5] This symbolic notation indicates the fusion of the C^3I and TDSS concepts, where TDSS's serve as an integral portion of the C^3I concept. It may also be interpreted to mean that the comment is also equally applicable to either C^3I or TDSS when viewed independently.

which obviously causes the problems. Additionally, it is of fundamental importance to properly portray the C^3I/TDSS environment, its problems, and the inherent complexity of the interdependent forces that comprise this area of study. Moreover, an examination of the inadequacies discussed in later pages will be better understood if adequate attention is given now to the findings of past studies--thereby providing a historical frame of reference.

A study which presents such findings and thus of considerable relevance, was completed by Manpower Research and Advisory Services of the Smithsonian Institute in July of 1977. It yielded a document entitled Operational Decision Aids: A Programmed Research for Naval Command and Control Systems [Ref. 4] and was authored by H. Wallace Sinaiko. Mr. Sinaiko consolidated numerous findings by a variety of firms under contract with the ONR (Office of Naval Research) and the ODS (Operational Decision Aids) program. Mr. Sinaiko's document stated that the ODA project consisted of complex objectives without precedence. One such objective of this project was to bring together

> "several desperate but related technologies...its emphasis (was) on recent and technological developments in four areas: computer science, decision analysis, systems analysis, and organizational psychology." [Ref. 4]

This was significant in that it indicates early endorsement of an integrated approach--a modified "web" analysis.[6] The products of this study was less encouraging however. The Naval Warfare Research Center (NWRC) of the Stanford Research Institute under contract with ONR provided some seredipitous findings.

> " 'For example, task force commanders rarely work in real time; instead they concentrate most of their effort on advanced planning. This suggests that decision aids need not emphasize instantaneous response rates. Task force commanders are deluged with information so that providing or increasing communications flow is not indicated. The element which is not handled well by task force command systems is that of uncertainty. Furthermore, high-level tactical decision makers are highly idiosyncratic in their approaches--a fact that is too often ignored by systems designers, and more often than not constrains flexibility rather than enhances it. A great deal of attention will have to be paid to the process of introducing a new decision aids into existing Naval systems'." [Ref. 5]

This type of commentary ignores the realities of combat and fails to envision the needs of the future by discounting the need for real-time aids. The military technology that demands real-time responses to be successful in combat exists--as was demonstrated in 1982 during both the Falkland Island and the Lebanon-Israeli conflicts. The military technology of the 1980's has enabled parties to wage a

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[6] A term developed by Robert Koing which referes to the multi-faceted examination of a computer/computing environment which considers societal implications as an interwoven or web structure. For amplification of this concept, consult the bibliography.

rapid, high-tech, multi-threat engagement where the rapidity of battle has never before reached such far-reaching dimensions. To discount this inevitability in the mid-'70s as did the NWRC indicates a very myotic and simplistic view of the possible contributions of C^3I/TDSS and its time critical dependencies. Further, it suggests the possibility that a complex problem such as excessive information can be easily avoided by stating the symptom rather than addressing the problem. The latter portion of that quotation has great importance, however, in that idiosyncratic approaches are addressed, a characteristic which is relevant to the "Garbage Can" model. A model which considers individuality and yet aids the decision process in a combat environment is far more valuable than a model which is restrictive and is consistently predictable. This view of idiosyncratic approaches is supported by numerous sources listed in the bibliography of this thesis. NWRC also observed that:

> "...rapid solutions tend to ignore detail and consequently have lower asymtotic values while highly refined solutions, possessing a great wealth and richness of structure, (and) require more time to execute." [Ref. 6]

This has considerable relevance, and will be addressed at a later point in regard to information load conditions, and the militarized adaptation of March's "Garbage Can" theory.

Sinaiko also noted that:

> "...decision makers in these systems (TDSS) remain as central elements and their traditional model of operating were not drastically changed...in fact, there seems to be a general reluctance to incorporate information into tactical decision systems, even in the face of ever tightening constraints facing these systems...another important observation, and the one that flies in the face of an earlier point, is that there appears to be an overabundance of tactical data being generated. The technology for filtering and processing is certainly available and understood; but the resistance to using it is what has not been overcome." [Ref. 7]

One possible explanation for the previously mentioned resistance to available technology may be due to the poorly documented, but generally accepted fact that the introduction of automated elements into organizations causes considerable turbulance. It is this author's contention that fear is partially responsible for this resistance--fear that automation will either replace the decision maker or at least weaken (lessen power) the decision maker's role in the organization. This suggests that job status may be viewed as being threatened by these new operational decision aids. However, this was not completely supported by the findings of CACI, Inc., while operating on the ONR/ODA project. The following is a quotation from a portion of Mr. Sinaiko's paper [Ref. 4] in which he commented on the findings of CACI:

> "In its review of literature of organizational behavior, CACI found both inconclusive and ambiguous statements about how the decision aids affect organizational structures. This lead to the investigators development of their own model for determining the most appropriate organizational structure for a technical, i.e., automated environment. The model says that the form of the organization should be cognizant upon its mission, its staff, and the technology available to the staff." [Ref. 8]

A noteworthy omission exists in the CACI model--the decision maker. A factor which will be given serious consideration in this paper. Two questions which the reader should consider in regard to the above quotation and the role of decision maker and supporting participants follows. Is the traditional role of the staff in support of the tactical decision making in need of organizational restructuring and/or are the task functions which are typically accepted as "proper" in need of revision? The second question concerns the latter portion of the above quotation (e.g., technology available to the staff). Statements which fail to address the decision maker (as above) carry an implication that the relationship between decision maker, technology and supporting participants must be clearly established in a model. Further, omissions of this type serve as an inaccurate reflection of the organization being modeled. As well be seen in Chapter IV the relationship of participants to choices, and choices to problems, is a complex matrix structure. To only recognize the staff and not delineate the relationship between the decision maker and staff was based on some philosophical assumption which clearly abstracted the most crucial component of the decision process. TDSS designers must be concerned with how decision makers and their staffs are changing in regard to automation as a composite whole. This must be addressed now to enable data collection on today's younger generations

weaned on devices such as video games and home computers. These younger generations and their perceptual view of automation may be entirely different than the view held by present tactical decision makers. This may suggest that there will be less resistance in future years to tactical decision makers using highly automated decision aids. Such possibilities indicate to this author that preliminary design considerations and information requirements analysis performed in the 1980's will impact on the finished product which will be operational in the neighborhood of the year 2000. Thus, some of this paper should be viewed as a commentary towards designing systems for the youth of the 1980's which will be using systems in the 2000's. Failure to do so will result in a resistance to automation in the year 2000, but for fundamentally different reasons. Reasons that we can avoid if our creativity is not solely technology driven; but rather, is centered around Mr. Wohl's previous comment [Ref. 9] that an accurate theory of decision making (and a corresponding model) is necessary for effective C^3I/TDSS.

Returning to previous comments on the fear mechanisms--an interim "bandage" for present task force commanders with little or no exposure to automated aids could be applied by having specialists assigned rather than having the commander's complete staff retrained; on the other hand, a commander with extensive experience in the use of ODAs might be best served

by putting the aids directly under his control and not to install an intervening specialist. Regardless of the approach which is adopted, the structure of participation is altered and denotes a condition which must be considered by designers. Poorly understood structures creates organizational uncertainty, fosters ambiguous accountability and responsibility relationships, and does not lend itself to military organizations which demand strict accountability for important decisions. The topic of access and decision structures is examined in greater detail in Chapter IV. The findings of CACI, Inc., after examining four Navy systems showed that there were a number of consistent themes all of which had rather serious implications for decision aids which were in the development process at the time of their research.

First, they noted that the most neglected aspect of introducing automated decision elements was a lack of training and a failure to develop a strategic implementation plan. Both of which are fundamental tools for generating familiarity and minimizing uncertainty. Further, they found that few resources were available to support these systems. [Ref. 9] The above conditions support the pre-conditions to the "Garbage Can" which are addressed in Chapter IV.

Another finding by CACI, Inc., which endorses present organization structure as well as the manner in which training and experience is obtained, follows:

> "...Automatic aids created an environment that centralized decision making and that the command authority itself, although it is not necessarily the most efficient organization model for solving problem." [Ref. 10]

Since that time however, the CWC (Composite Warfare Commander)[7] concept has been adopted in an attempt to decentralize tactical decision making, and alter the influences of loosely coupled communications[8] and its embilical relationship to the "Garbage Can".

Considerable organizational complexity is introduced into organizational structures when systems that create a centralized environment are used in support of a decentralized decision methodology (CWC). Examples of complex structures are provided in Chapter IV.

The points conveyed thus far hopefully provide the reader with the feeling that there are few absolutes and that the previous comment that stated that complex problems most likely

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[7] CWC is the organization scheme where C^2 is functionally distributed and may also consist of physical distribution. For a more in depth explanation, consult Ref. 10, p. 12.

[8] The concept of loosely coupled systems was developed by Weick. In this view organizations are viewed as being comprised of stable, and unstable subassemblies; these subassemblies are connected by large numbers of loose couplings. For additional information and the relevance of Naval operations, consult bibliography for paper by Weissinger-Baylon.

have complex solutions is indeed the case when discussing Tactical Decision Support Systems. Further, it is hoped that, it is recognized that a need exists--there must be a continuing process to search for a "better" decision model that satisfactorily portrays how tactical decision makers make their decisions.

Of at least equal importance is how these systems have to operate to be accepted by the user? Human considerations must be accounted for if a user friendly product is to be developed. A thorough examination of these factors is not within the realm of this thesis. They are, however, considerations that the reader should recognize as important influences in model selection and its accompanying perspective.

The significance of this chapter is simply to present a cursory view of selected problems (assumptions) surrounding TDSS, to indicate why finding the appropriate decision model is so elusive, and to familiarize the reader with commentary that is an indicator of present conditions. This chapter is not meant to recognize the considerable advances in computer related technologies and decision making, rather a chapter that indicates areas of improvements and one which recognizes that humans really do not understand themselves as well as they may think. A serious drawback when designing a system which is to serve as an extension of the human process.

The point that Joseph G. Wohl made in regard to C^3I and a theory of decision making applies to TDSS and the tactical arena in general. Such a theory should consider the complexities of information load, as well as account for the less than optimal decisions (nonrational choices) that are generated when the choice process is burdened with excessive information.

Moreover, the contents of this chapter provide an indication of the type of critical philosophical assumptions which accompany the design of decision tools (e.g., NWRC). The failure to view the human decision maker as a sensor and processor with limitations to assimilate information reemphasizes the criticality of information load as a condition which must be recognized and dealt with effectively.

Using this chapter as a "springboard", the subtle implications of philosophical assumptions in modeling are addressed in Chapter III.

III. THE PHILOSOPHICAL IMPLICATIONS OF MODEL CHOICE

Prior to presenting the "Garbage Can" in Chapter IV, it is important to first describe a void this author feels presently exists, by addressing other models, and by providing a mini treatise on several modeling criteria. Through an examination of their associated weaknesses the value/contributions of the "Garbage Can" is more clearly understood.

At this point it should be apparent as a result of the previous two chapters that the nature of C^3I is very involved and does not endorse any totally agreed upon decision model to serve as a basis for Tactical Decision Support System design. Present approaches reflect numerous problems and are related to the failure to adopt an universally acceptable model. The task of selecting such a model requires that agreement first be achieved among the myriad of philosophical views of the tactical decision process. Limited agreement, however, does exist in certain areas. Part of the problem, and yet a point that most will agree on, is the complex nature of tactical decisions. It is the author's view that whatever perspective is adopted, it must account for the quantity of information that the decision maker must "digest".

Supporting a particular model requires avowal of a particular philosophical point of view. The philosophical approach which is sanctioned is as important, possibly more important, than simply sanctioning a model. The implied significance of a model is how it treats the idosyncratic behavior of humans. This chapter is a discussion of such philosophical dogma and the non-superficial influences that such beliefs have on model selection.

The primary question which pervades this chapter, this thesis, and essentially all of TDSS design and development is based on this assumption: The C^3I/TDSS composite is information related. The fundamental philosophical question which accompanies this assumption follows: Is the human character capable of assimilating vast quantities of information in a rational manner and act upon it to yield consistently rational conclusions? This question and the answer one obtains requires the previously mentioned endorsement of a philosophical view of the decision maker. Examination of mankind's record to make rational choices which ultimately result in resolution[9] is in need of improvement. History has indicated that decision makers frequently are faced with recurring choice situations which, if not exactly alike, certainly are "favored" by similar characteristics. This

[9] The proper pairing of problem and solution so that the same problem does not recur.

not only applies to the types of decisions TDSS's are expected to aid, but also the decisions that have affected the model selection for TDSS. The recurring choice situations which are pertinent to TDSS are choice opportunities such as: How do we engage hostile aircraft, or do we alter the ASW screen (anti-submarine screen)? or how should the task force be allocated? This author contends that these are DSS (Decision Support System) related questions and not MIS (Management Information System) queries in that they are unstructured unique choices. Since time variance exists between choice opportunities, environmental circumstances can not be replicated exactly, and hence qualify successive decisions as unique choices. They are unstructured in the sense that although they are recurring, they rarely endorse the same assumptions or yield identical outcomes.

It is this author's contention that too frequently a philosophical perspective has been endorsed that assumes that since military leaders hold a reputation as disciplined individuals then they also exercise a high degree of rational behavior. According to Graham T. Allison:

> "...the influence of unrecognized assumptions upon our thinking...the assumptions we make, categories we use, our angle of vision...channel our thinking." [Ref. 11]

He further states that:

> "...each frame of reference is, in effect a 'conceptual lens'." [Ref. 12]

This can be coupled with a comment made by Robert Kling and Walter Scacchi in "The Web of Computing: Computer Technology as Social Organization" which states:

> "Differences in perspectives have tremendous significance for the sense one makes of the dynamic aspects of computing developments (DSS selection) in organizations." [Ref. 13]

Additionally, in reference to adopted models and to perspective compatibility, Kling and Scacchi state that:

> "Different models have different conceptual languages." [Ref. 14]

The significance of the previously mentioned quotations is that if military decision makers are always rational beings then they always generate rational choices. Further, it implies that, if rational they are able to exercise this rationality in a combat environment. Yet, if this rationality is assumed, and system performance is inadequate, then there is strong evidence to suggest that part of past problems is that military decision makers may not be completely rational. Moreover, it suggests, even if only by association, that rational decision making may not be a realistic expectation, due to the irrational environment frequently imposed by combat.

The significance of the "Garbage Can" and the influence of James G. March upon this model is that he does not view

> "...decision-making in the economists' terms of rational choice from known alternative, but in terms that they (March, Cyert, Simon-Carnegie theorists) feel reflect more accurately the manager's real limitations."

Further, the philosophical assumptions which comprise Dr. March's frame of reference acknowledge

> "... that managers do not have explicit goal systems or preference functions; that a most important and neglected part of the decision-making process is the step to define a problem...that choices are made to satisfy constraints (and) not to maximize objectives." [Ref. 15]

Additionally, James March's view of decision making as is endorsed by the "Garbage Can" recognizes "managerial work as complex where the stimulus is often ambiguous and the response is essentially one of groping for a solution..." [Ref. 16] a point addressed by Simon, 1965, and March and Simon, 1958.

These are well founded perspectives by renowned theorists, and although only briefly discussed they serve as the foundation of many of the assumptions which had to be made prior to developing the "Garbage Can" model. They serve as the "conceptual lens" which should be used to view the philosophical assumptions of this model.

The "Garbage Can", addresses indirectly the political environment in that it recognizes fluid participation, energy and access structures. Consideration of these factors is essentially acknowledging alliances and factors other than the immediate choice opportunity, such as altering positional power relationships.

As will be observed in latter portions of this thesis a complexity compensation factor known as "load" is present in the "Garbage Can" simulation. The philosophical

perspective of this thesis is one which recognizes this load factor not simply as a measure of complexity, but as a qualified measure of information dependent complexity. This is a measure of complexity induced by information quantity which recognizes that decision makers must sort through the information to determine what information is applicable and/or relevant. This need to sort must consider the human/behavioral realities of highly idiosyncratic processes which are frequently nonrational, yet very human and have political/power implications due to the manner in which staff (supporting participants) must adjust to, compensate for, the circumstances imposed upon them.

As will be portrayed in the next chapter, the "Garbage Can" exhibits a substantial bias on the outcomes of choice situations. Specifically, it endorses a perspective that most choices do not yield resolution, while providing a believable and realistic explanation for outcomes other than resolution. This accounting of less than optimal choices violates optimal-rational perspectives by conceding that non-resolution outcomes are more frequent than resolution outcomes. Certainly, this is a very real and very important distinction, and one which must be addressed if reality is to be closely approximated. The theme of optimal-rational perspectives suggests that given the correct information the decision maker is going to generate a rational choice. By

association, a rational choice should then yield resolution. Achieving resolution may also be by chance and hence not always an indicator of a previously made rational choice.

According to Simon [Ref. 17]

> "...no cut and dried method for handling (a) problem exists (that) hasn't risen before, or because its precise nature and structure are elusive..."

suggesting that TDSS serves only as the name applies. Not as a surrogate decision maker, and hence needs to be modeled in a manner which supports unquantifiable human variables/ limitations.

IV. THE COHEN, MARCH, AND OLSEN MODEL: THE GARBAGE CAN

The "Garbage Can" model is a description of organizational decision making. Further, it is an examination of the factors that lead to those decisions/choices. The "Garbage Can" model was originally conceived as an explanation of how universities and the decision process inherent to the universities/bureaucratic environments make choices. There are three preconditions which are fundamental to the understanding of this particular model. These conditions are:

a. Problematic preferences

b. Unclear technology

c. Fluid participation

In regard to problematic preferences, Cohen, March, and Olsen state:

"It is difficult to impute a set of preferences to the decision situation that satisfies standard consistency requirements for theory of choice. The organization operates on the basis of a variety of inconsistent and ill-defined preferences. It can be described better as a loose collection of ideas than a coherent structure. Preferences are discovered through action as much as being a basis of action." [Ref. 18]

Their comments on Item B follow:

"Technology is often unclear. Although the organization managers, to survive and even produce, its (the organizations) own processes are not understood by its members. It operates on the basis of simple trial-and-error procedures, the residue of learning from the instances of past experience, and pragmatic inventions of necessity." [Ref. 19]

The third term, fluid participation, is described thus:

> "Participants vary in the amount of time and effort they devote to different domains; involvement varies from one time to another. As a result, the boundaries of the organization are uncertain and changing; the audiences and decision makers for any particular kind of choice change capriciously." [Ref. 20]

According to Cohen, March, and Olsen, no single participant dominates a choice situation in all of the preconditions. Further, they note that the three previous properties have often been identified in studies of numerous organizations.

Another observation of considerable importance is that these characteristics (behaviors) are a fundamental part of any organization; however, it is important to note that they are not necessarily equivalent trade offs. Further, the findings of Cohen, March, and Olsen indicate that these criteria are particularly noticeable in organizations which operate within a political or hierarchical bureaucracy. It is appropriate to continue to define the terms which surround this model; this will be achieved by providing an additional series of quotations to ensure that there is a minimum possibility for misunderstanding. The next term of considerable importance is the definition of the choice situation (choice opportunity). Here, it is defined as:

> "A meeting place for issues and feelings looking for decision situations in which they may be aired, solutions looking for issues to which they may be an answer, participants looking for problems or pleasure." [Ref. 21]

This particular definition has considerable significance. It implies that choice situations are fundamentally

ambiguous while also suggesting the manner in which choices, problems and participants are introduced. Further, it provides an indication that the outcomes of choices, change as a function of their inputs and their respective flow rates. When considered in the context of the three conditions previously mentioned, the concepts of ambiguity and of decision relevance come into play. Additionally, the patterns of available energy become dependent on fluid participation. This fluid participation as previously stated varies in the amount of time and effort that participants are able to devote to different choices. Specifically, those key individuals with considerable inherent power within the organization have a wider span of control and thus, theoretically, have greater opportunity to be involved in choice situations. This higher level of involvement in the choice processes suggests that the time available per choice is less, since a finite quantity of time must be allocated relative to the number of choice situations pending at a particular time. If this is allied with unclear technology[10], then the process becomes more complicated and certainly more ambiguous. The ambiguous nature of complex decision making and the interrelatedness of problems frequently causes a

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[10] Technology in an organizational sense refers to the managerial methodology utilized and the sophistication of that methodology.

crisis, particularly if it concerns the allocation of scarce resources (i.e., time). If scarce resources by their very nature have limitations placed upon them then the organization must determine the criteria of preferences which will govern their utilization. Unclear technology results when events cannot be clearly separated so that traditional doctrine can be applied.

When relevance becomes ambiguous, then the events which are concerned with choice situations become context dependent. The terminology which Cohen, March, and Olsen use to describe the process which incorporates these three conditions is that of a puzzle or mozaic.

It is this author's contention that this concept of interrelatedness is typified by the Kling philosophy of web analysis. This is brought up at this point not to detract from the March model, and not to confuse "web" theory and "Garbage Can" theory. Rather, it is noted so that the underlying idea in "web" analysis is that the organizational context must be considered as a woven fabric of numerous entities. This may be considered as analogous to the mozaic suggested by March and associates. If this philosophical point of view of the computer environment is adopted as vaible and then applied to the "Garbage Can" and the puzzle analogy, then the conceptual viewpoint of the "Garbage Can" as a decision model is then enhanced. If the discrete

entity approach is utilized, in the examination of the verbal portions of the "Garbage Can", then the value of this model is degraded considerably.

Of considerable importance, also, is the mix of various problems and solutions that enter the "Garbage Can". This mix is partially dependent on streams/flows from other choice situations as well as the labels that have been attached to the various other choice situations. This is not completely historical in nature, it also depends on what is being produced at the moment. In the words of Cohen, March, and Olsen, it depends on the mix of cans available and on the speed at which these flows are collected. The concept of input flow rates in the military environment will be addressed at a later point in this thesis in Chapter V. This fundamental concept of flow rates and its relationship to time and quantity of information will be examined from the viewpoint of information load. In extreme conditions--conditions of under-information and over-information--choice situation effectiveness is degraded. The choice opportunities that receive these input flows that yield extreme conditions, in turn, eventually yield "flight"[11] and "oversight"[12] results.

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[11] A condition where a choice is unsuccessfully associated with a problem. The problem leaves the choice seeking to be attached elsewhere. No resolution results, see next page.

[12] A choice which is activated when problems are attached to other choices and there is energy to make a new choice quickly. Making a choice without proper attention to existing problems is known as "flight".

In an interview with Dr. James G. March, at the Hoover Institute, Stanford University, on February 25, 1983, he stated that the relationship of problems and solutions was:

> "...fundamentally related by the temporal proximity of those entities..." [Ref. 22]

which implies again that time of arrival of streams[13] is of considerable significance here. Further discussion of this model will be concerned with these input flows (problems solutions, energy, and participants) and the resulting structures.

Below is a diagram that describes graphically the process in which these definitions apply in a physical sense.

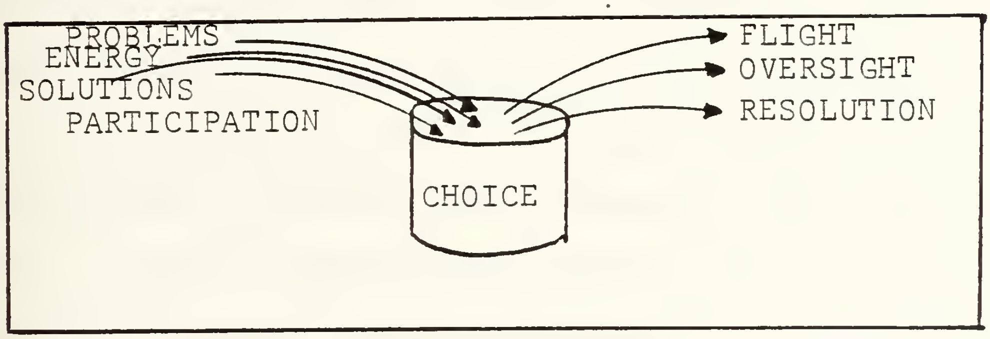

Figure 4.1 PHYSICAL REPRESENTATION OF THE GARBAGE CAN

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[13] Streams are the primary inputs to the "Garbage Can" model.

Entering this "Garbage Can", or receptical, are flows of problems, solutions, energy, and participants. Out of that can are three conditions known as resolution, flight, and oversight (the products of the choice).

Resolution implies a correct matching of problems and solutions, indicating that further effort (energy) is not needed to rectify that particular choice situation.

The flight condition, however, implies a fleeing mechanism--that a resolution condition has not resulted due to the inability to match problem to solution or match solution to the problem. This mismatching occurs when high uncertainty exists--uncertainty as to what exactly the choice involves. It equates to the idea that one cannot find an answer until one has formulated the question. According to Weick [Ref. 23], frequently one cannot find the answer until one has formulated the question, and thus in organizational settings people frequently must work in reverse. We have heard the statement: "I'll believe it when I see it." However, within the context of this examination, it is more appropriate to consider this: "I'll see it when I understand it." This concept of: "I'll see it when I understand it," has another important underlying theme: although streams are not dependent on one another, they are not completely independent of one another either. One stream does not dictate or depend on the presence of another; however if a critical stream is not present, resolution will

not result. This implies that their meeting is largely by coincidence, as is the process of "seeing it". Oversight is obviously neither resolution or flight, which places it is the "gray" area in between. Here a choice is made, however, it does not yield a lasting solution as typified by resolution. The rationale which produces such a choice may be described by: "I'll make a decision, because making a decision has to be better than no decision at all". Additionally, conditional meetings are largely influenced by access matrices.

As stated in <u>Ambiguity and Choices in Organizations</u>:

> "Streams of problems, choice opportunities, solutions participants are channeled by organizational and social structure." [Ref. 24]

Included in these structural influences is the time pattern which portrays the arrival (via streams) of problems, choices, solutions, or decision makers/decision influencers (participants), as well as by access and decision arrays. This is achieved by altering the allocation of energy (which is allocated by participants); and by the linkages among the various streams.

Such a structural influence has historical precedent since past practices in the technology of an organization shape perceptions and affect the process by which technology is applied, i.e., decision makers learn via the trail-and-error process (past experiences).

Organizational structure also provides legitimacy and the right to participate in choice situations. Although these rights are not absolutely necessary for actual involvement in a decision process, they form a biasing mechanism for those people most likely to be included as participants. Whether those participants formally designated to make the decision at hand are qualified frequently becomes a case in which a participant is designated according to the organizational structure and is therefore limited in the attention he/she can provide when a choice opportunity is presented. Whenever a participant has the time to devote to the choice, personal power is enhanced, even if it is in violation of accepted organizational structure. This elevation of a traditionally lower level decision maker to a higher level not only alters the established access structure of the organization, but also creates a methodology that alters implied relative power structures.

The following is an examination of the structural (organizational) considerations of the "Garbage Can".

The organizational structure, via its construction, specifies the rights of participants to gain access to a choice opportunity. They should be,

"...viewed as invitations to participation." [Ref. 25]

Whether the invitation is accepted or not is dependent upon the availability of participants and their ability to direct their talents toward the choice at hand. If the

participant(s) is/are preoccupied with another task, the invitation could be rejected. If a void is created, an individual with available time may participate; this member may fill a void created by a member who would normally participate, yet has been obligated to reject the invitation. This alters traditional, or at least delineated, relative power schemes.

> "...Invitations may be extended either to individuals as decisionmakers or to problems and solutions as decision issues." [Ref. 26]

In the former case, when invitations are extended to problems and solutions, the decision structure is the emphasis area rather than the access structure. Whereas...

> "...The decision structure is a mapping of individuals on choice opportunities (or classes of choice opportunities)." [Ref. 27]

If N potential participants and M classes of choices exist then a N-by-M array is created. This array delineates the choices available to participants and signifies which of the participants has a right (claim) to participate.

The number of possible decision structures is great, and it is not possible to represent all variations without incurring excessive complexity. However, three principle participation structures were identified by Cohen, March, and Olsen for use in the "Garbage Can" model and its accompanying simulation, including:

1. Unsegmented participation: This structure allows any decision maker to participate in any <u>active</u> choice opportunity. The structure is represented by the array below in which $d_{ij} = 1$, if the i^{th} participant is eligible to contribute to the j^{th} choice opportunity.

CHOICES

(most important--least important)

```
                 1111111111     P  most
                 1111111111     A  important
                 1111111111     R
                 1111111111     T
D1 =             1111111111     I
                 1111111111     C
                 1111111111     I
                 1111111111     P
                 1111111111     A
                 1111111111     N
                                T  least
                                S  important
```

2. Hierarchial participation: Here the structure creates a hierarchy so that only important choices are made by important decision makers, and important decision makers have invitation to numerous choice opportunities.

CHOICES

(most important--least important)

```
                 1111111111     P  most
                 0111111111     A  important
                 0011111111     R
                 0001111111     T
D2 =             0000111111     I
                 0000011111     C
                 0000001111     I
                 0000000111     P
                 0000000011     A
                 0000000001     N
                                T  least
                                S  important
```

The hierarchial structure will have considerable importance in further analogies to the military in that it most accurately depicts the structure in use by military organization. For example, an Admiral may (is eligible to) act as an important decision maker; an Ensign on the other hand is severely limited in decision making power, relative to the Admiral, as depicted by the hierarchial matrix. The first row depicts the invitations available to an Admiral. The last row those available to the Ensign.

3. Specialized participation: In this structure decision makers are limited to choices within their speciality, as denoted by the single 1 at the intersection of a unique decision maker/choice pairing.

CHOICES

(most important--least important)

	10000000000	P	Note: all participatns in this matrix are of equal importance.
	01000000000	A	
	00100000000	R	
	00010000000	T	
$D_3 =$	00001000000	I	
	00000100000	C	
	00000010000	I	
	00000001000	P	
	00000000100	A	
	00000000010	N	
	00000000001	T	
		S	

In actual decision structures, a more complicated array would be required.

Acting simultaneously is one of three corresponding access structures. These structures are named similarly:

unsegmented, hierarchical and specialized. The function and/or meaning assigned an access structure is different than a decision matrix. Here, the rules that specify the rights of access of problems and solutions to choice opportunities are portrayed. They are represented as follows:

1. Unsegmented access: This structure is represented by a similar N-by-M matrix, however, the dimensions are 10-by-20 vice 10-by-10, thus agreeing with the simulation (Appendix A). It should also be interpreted to mean that more problems exist than solutions. The 10-by-20 matrix allows two problems to enter per time periods of simulation. To reflect this unique modeling assumption the following three access structures are displayed in a manner which is in agreement with the simulation. This matrix delineates the access structure or rules that specify the rights of access of problems and solutions to choice opportunities. Here any active problem (or solution) has access to any active choice opportunity; that is, $a_{ij} = 1$ if the i^{th} problem (or solution) has access to the j^{th} choice opportunity:

CHOICES

(most important--least important)

most important

problems(solutions)

$$A_0 = \begin{matrix} 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \\ 1111111111 \end{matrix}$$

least important

2. Hierarchial access: In this structure both choices and problems (or solutions) are arranged so that important problems (solutions have access to many choices, and important choices are accessible to important problems.

CHOICES

(most important--least important)

	1111111111	most important
	1111111111	
	0111111111	
	0111111111	
	0011111111	
	0011111111	
	0001111111	
	0001111111	
	0000111111	
A_1 =	0000111111	problems(solutions)
	0000011111	
	0000011111	
	0000001111	
	0000001111	
	0000000111	
	0000000111	
	0000000011	
	0000000011	
	0000000001	
	0000000001	least important

3. Specialized access: As before, the specialized matrix format yields unique pairing. This time, however, each problem (or solution) has access to only one choice and each choice to only two problems. It is represented as follows:

CHOICES

(most important--least important)

	1000000000	most important
	1000000000	
	0100000000	
	0100000000	
	0010000000	
	0010000000	
	0001000000	
	0001000000	
A_2 =	0000100000	problems(solutions)
	0000100000	
	0000010000	
	0000010000	
	0000001000	
	0000001000	
	0000000100	
	0000000100	
	0000000010	
	0000000010	
	0000000001	
	0000000001	least important

In actual organizations, access rules are quite complex and reflect an altered (more complex) access structure. At this point, the above structures are presented to emphasize that organizations range from unsegmented to highly segmented constructs.

An example of a more complex access structure in a military organization might be to reflect geographical constraints placed upon the organizational structure. In the United States Navy various fleets are designed/assigned to specific geographical regions. Thus, decisions concerning the operation of Naval forces within such regions are the responsibility of the respective fleet commander. The associated access structures would reflect this jurisdiction

criteria. In particular regions as they become focal points of high geo-political value (Indian Ocean-Iranian hostage crisis) units from different fleets may be assigned to that region. Under such circumstances the organizational structure of the Navy is altered to reflect this condition. This may occur in one of several methods available. The important matter is that unity of command result. Failure to do so results in overlapping areas of jurisdiction, and hence overlapping access structures on one extreme. The other extreme being a situation where a void is created because one fleet assumes the other fleet is "handling" particular issues. Either case creates the need for elaborate access structures to ensure that problems reach those eligible to make choices. The access structures which are clearly defined support the concept of unity of command, which in turn enables better coordination between units and allows effective maneuver in pursuit of an agreed upon objective. If critical problems are not capable of being assigned to the correct choices in a timely manner, and hence not acted upon, then one could expect the most severe consequences.

Integrated decisions of a tactical nature demand that access structures provide/enable necessary problems to reach not only to the correct location, but do so at the correct time. Having a problem become assigned to a choice

after the fact in a rapid multi-threat military engagement could result in a considerable loss of lives.

Access structures may be further delineated. Decisions may fall into several categories. Both the planning and execution of plans demand that choices be made within these areas. The significance of such phases is that two different access structures result. Certain access strucutres may concern the planning phase and its problems and choices, while another access structure may concern the execution phase and its problems and choices. Ambiguity and unclear technology affect these structures, and particularly the relationship between the two structures.

In unclear technology results in the hinderance of problem arrival,[14] choice arrival, or participation then redundant and conflicting information can be expected in an attempt to seek clarification. The generation of excess information places additional duties upon the decision makers and their supporting staffs. The effort expended to sort and integrate excess information depletes available energy, which in turn affects choice outcomes. As will be indicated in Chapter V, excess information becomes intermeshed with the total stream of information entering a choice--a condition which can be minimized if access structures are clearly and accurately formulated.

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[14] Arrival refers to the time a stream enters a choice.

V. INFORMATION: ITS NATURE, UTILIZATION AND IMPACT IN LOAD CONDITIONS

A. THE QUALITIES OF INFORMATION: WHAT IS IT?

Before embarking on a discussion of how information affects the decision or choice process, it is appropriate to first define it. According to The American Hertiage Dictionary of the English Language, information is defined as follows:

> "1) The act of informing or the condition of being informed; communication of knowledge; 2) Knowledge derived from study, experience, or instruction; 3) Knowledge of a specific event or situation; 4) A service or facility for supplying facts or news...6) A non-accidental signal used as an input to a computer or communications system; 7) A numerical measure of the uncertainty of an experimental outcome."

A dictionary definition does not provide the degree of precision needed in this work. It does provide a general "feeling" that it is a medium which conveys data which has meaning, purpose and/or value. Its meaning, however, may not be applicable to the situation to which it is applied and still retain value via-a-vis some other circumstance. The worth of information is predicated on whether it is capable of providing insight, regardless of whether that insight is positive or negative.

In regard to decision theory, specifically the "Garbage Can", some medium, a carrier wave of sorts, must transport

problems and solutions to the choice domain. It is this author's hypothesis that information is that medium. The following is the author's view of I_T (total information) and its integral components.

Information need not be solely restricted to a transport function. Rather, it may be instructive (informative) in nature. This is a function of time, in the sense that although it may simply endorse a condition, fact, or state of nature, it has the potential to serve as a problem or solution at some point in the future. In fact, its arrival should not be solely futuristically oriented. If it had preceded the present, it merely should be considered in the domain of another choice situation.

Graphically:

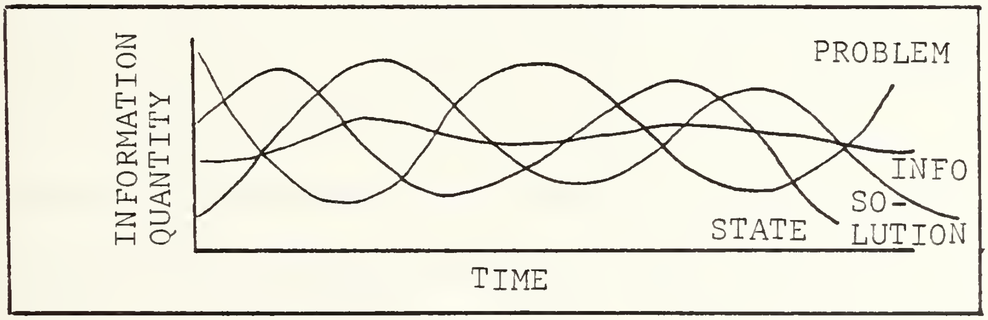

Figure 5.1 PHYSICAL REPRESENTATIVE OF I_T (TOTAL INFORMATION)

Samples of Information

Examples:	The helicopter is almost out of fuel:	Problem 1
	It is raining:	State of Nature
	USS Neversail has an aviation refuel capability:	Solution 1

Meaning can be transported with the potential to influence a choice and as a result has potential value. Thus it should be considered as component of information. Whether it is categorized as a problem, solution, or state--it is a function of the context in which it applies (i.e., "it is raining" is neither a problem or solution...unless it hinders or resolves another state or event).

If rain prevents one from sunbathing, it could rightfully be interpreted as a problem. If one's garden is dying due to lack of rain, then notification of rain may not only indicate a new state, but also a solution to the previous condition.

The following discourse, although very simplistic is an examination of information. It reflects this author's opinions and is an attempt to better define what comprises information. It is a difficult task in that various academic groups have avoided definition on the grounds that it will not be intellectually acceptable, while industry defines information to satisfy specific special interest and groups. Failure to place boundaries, even if to a limited degree,

discounts the value of a significant component of computerization. For the purposes of this thesis using set notation, the following applies:

$$\text{Total Information} = I_{T_n} = (I_{P_n}, I_{S_n}, I_{K_n})$$

where: I = Information
P = Problem
S = Solution
K = State of Nature (Condition)
n = nonrelevant
r = relevant

Further, I_T may have subscripts of r or n, where r = relevant and n = nonrelevant. The use of the subscript n above is only for illustrative purposes and to indicate the locations of a secondary subscript. The subscript n or r is an indicator of relevance. I_T may consist of the empty set, or a mixture[15] of P, S, and K; as well as a mixture of relevant or nonrelevant qualifiers.

For example, $I_{T_n} = (I_{K_n})$ indicates conditional information where I_T has meaning, but no value; it carries the subscript n to reflect no relevance to the present and hence no value to the present choice.

<u>or</u>

$I_{T_r} = (I_{P_r}, I_{S_r})$ where relevance is determined on a time

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[15] Combinations vice permutations, as well as varying quantities of components.

continuum and time zero equates to the present time quantum, minus values to some time quantum prior to the present, and positive values to some point in the future. The previous equation rewritten to include numeric relevance indicators to indicate the present state is of the form:

$$I_{T_0} = (T_{P_0}, I_{S_0}).$$

If the choice situation has passed (and resolution has occurred), and information arrives after that choice then the information is not applicable to the present and is irrelevant. If the choice situation has occurred and resulted in "flight" or "oversight", it has created a choice pending a condition in which a negative subscript may indeed be relevant, in that a choice still exists requiring resolution. If the subscript is positive, it denotes irrelevant information unless the information addresses future plans. This is a relative measure which should be viewed in terms of minutes in the tactical environment and in terms of one time period in the simulation. It (the relevance indicator) applies to immediate value.

Additionally:

P_T = Total Participation = (P_I or $P_T = P_M \times P_I$) (see comments below)

and

E_T = Total Energy = (P_T, T)

where P_M = Participation (member)

P_I = Participation (Individual)

T = Time available (non-subscript)

T(subscript) = total

Choice = (I_T, E_T) where I_T = Total Information and

E_T = Total Energy

That is, choice is some set of information consisting of problems, solutions, states of nature, and total energy and where the total energy applied is comprised of some set of total participation and time. P_M is the number of member entities (organizational entities, e.g. ships) or number of participants (individuals); and P_I is the measure of individual participation expended in a particular choice.

The summation of members denotes the total number of participants which were involved in a particular choice. Most likely these participants contributed various amounts of energy to the choice in question. Thus, the total energy applied to a choice is equal to the summation of all individual energy contributions. If all members contributed equal energy then the product of the number of members and the standard energy level would equal the total energy expended.

P_M is included for two primary reasons:

1. As P_M increases, a diffusion of responsibility occurs, thus suggesting a propensity to increase risk.[16]

2. To serve as an indicator of fluid participation.

P_I serves multiple purposes as well:

1. A measure of individual contribution under conditions of unequal contributions (i.e., a combination of both important and less important members).

2. A relative measure of individual power within the organization.

3. A measure of effort/attention available to expend on one choice (degree of preoccupation with other choices).

Information relevance aids or hinders the "ambiguity of relevance" concept previously mentioned in Chapter IV. Although it was stated that $I_{T_N} = 0$ was relevant, it should be recalled that contextual criteria on information was also established as a precondition. Since the possibility of several choice situations occurring simultaneously is a very real condition, further quantification other than time on the choice situation must exist within the decision maker's cognitive realm. A new subscript must be considered. But first assume that:

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[16] For additional information on this assumption, consult papers by Pruitt (1971) in the risk supplement to the <u>Journal of Personality and Social Psychology</u>.

$$I_T = \text{Total Information} = (I_P, I_S, I_K)$$

and relevance is assigned according to:

$$\text{Total Relevance Information} = I_{T_r} = (I_{P_r}, I_{S_r}, I_{K_r})$$

$$= (I_{P_r}, I_{S_r})$$

$$= (I_{P_r}, I_{K_r})$$

$$= (I_{S_r}, I_{K_r})$$

$$= (I_{P_r})$$

$$= (I_{S_r})$$

$$= (I_{C_r})$$

and the availability of inputs. Note also that by substituting the r with an n we have an expression of total nonrelevant information.

Additionally, it is important, at this point, to discern between data and information. For the purposes of this discussion, data is considered as a collection of elements of information not yet processed to provide immediate meaning. It should be viewed as having potential value or potential meaning--but until processed into a coherent form

(i.e., video, voice, formatted telemetry) it should be viewed only as a state or condition. This conditional status may be altered via processing to provide information representing a problem, solution, or state. The rules of relevance apply to data as previously stated.

The third subscript indicates to which realm of choice information is to be applied. It is expressed as a numeric character, such that (e.g., $I_{P_{r_1}} = I_{P_{0_1}}$) it indicates relevant problem information for choice 1, thus enabling simultaneous information inputs for choices within the same system to be assigned properly.

Below is an illustration which is a physical representation of the "Garbage Can" (choice opportunity) scenario modified to reflect the concepts presented thus far in this chapter.

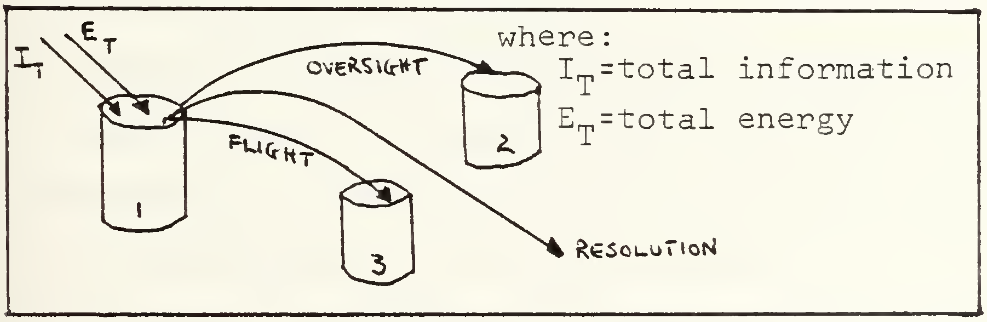

Figure 5.2 GARBAGE CAN WITH I_T AND E_T AS INPUTS

Here, the initial choice as depicted in Chapter IV has been altered to reflect I_T and E_T as inputs and the three possible outcomes of a choice. The implication being that both choices two and three contain information carried by their respective "oversight" and "flight" inputs and await additional information and energy to alter their inputs into resolution. Insufficient information, or excessive information, will effect the degree of ambiguity and alter the requisite amount of total energy required to generate resolution. If the above is viewed as a system with geographic (physical) separation and each "Garbage Can" represents a realm of choice, then consider the affect of not providing the participation needed for resolution in choices two and three. They would be destined to remain as the starting points in a changing of "oversight" and "flight" outcomes. To collect the energy to prevent this chain reaction scenario from occurring is dependent upon informing members of the need to participate.

The failure to include all participants, failure to include a participant, failure to supply accurate information to a participant, the inability to communicate information needed to a participant in a choice situation, or to provide it after a choice, are examples of degraded loosely-coupled communications. The aforementioned are essentially cases of incorrect choice classification. Where failure to input can be considered as the empty set for that type of information

input, or as is the failure to communicate a choice. Failure to communicate simply inputs the empty set into the choice situation of another decision maker's domain and falsely biases his choice situation, which affects joint coordination efforts and increases perceived risk and uncertainty. These conditions are represented by the third subscript. Failure to provide/receive accurate information results in dis-functional system performance. An input of type I_K may be required to enable decision maker "x" to be aware of the conditions which surround his/her particular choice while enabling coordination with decision maker "y". The passing of I_K should be thought of as a type of overhead that is required if coordination between members is to be preserved. Excessive I_K complicates the sorting and relevance determination task of a decision maker by increasing ambiguity.

For example, choice 1 could concern as ASW (Anti-submarine Warfare) choice, while choice 2 was concerned with an AAW (Anti-war Warfare) choice--both within the same system (task force), both receiving the same information (NTDS)[17], both on the same time reference, but distinct

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[17] Naval Tactical Data System; a computerized display of tactical data.

choices nonetheless. This is consistent with the CWC (Composite Warfare Commander) concept[18].

An examination of processes within the "Can" follows.

B. THE TEMPORAL PROXIMITY OF PROBLEMS AND SOLUTIONS

The following theoretical suppositions are designed to provide an illustrative mechanism to describe how problems and solutions align according to the timely application of energy. This explanation is this author's and should not be considered as part of the "Garbage Can". It was conveniently influenced by notions from other disciplines reflecting a natural order, as well as entropic characteristics. Suppose, momentarily, that the streams of problems, solutions, energy and participants could be described utilizing many of the laws from other disciplines.

The following is such a set of suppositions and/or hypotheses. They are metaphorically related to laws from other fields of endeavor and seek to provide a sense of order to the manner in which problems, solutions, and states of nature position themselves in relationship to one another

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[18] Distinct AAW and ASW choice are consistent with CWC concept only to the extent that they most likely are made by separate individuals. If a conflict occurs higher authority must negate either choice, then a third distinct choice occurs (whether to negate or not) due to the entry of a new problem (the conflict). For additional information on the CWC concept consult the Allen and Ranndells thesis cited in the bibliography.

within the choice. These suppositions are in no way a reiteration of the Cohen, March, and Olsen model, nor are they intended to refute or weaken their model. Rather, they should simply be viewed as this author's opinions. It is a conscious attempt to expand on a comment made by Dr. James G. March, at the Hoover Institute, Stanford University, on February 25, 1983. He stated that...

> "...problems and solutions are related in some way...I think they align according to their temporal proximities."

It is this author's view that this temporal relationship is a function of the time of arrival of streams and the intensity and the timing of the energy which is applied to the entities which enter the choice.

The following is an illustration to describe this implied order, while addressing the concept of perceptual cognition.

First, however, examine the diagram below:

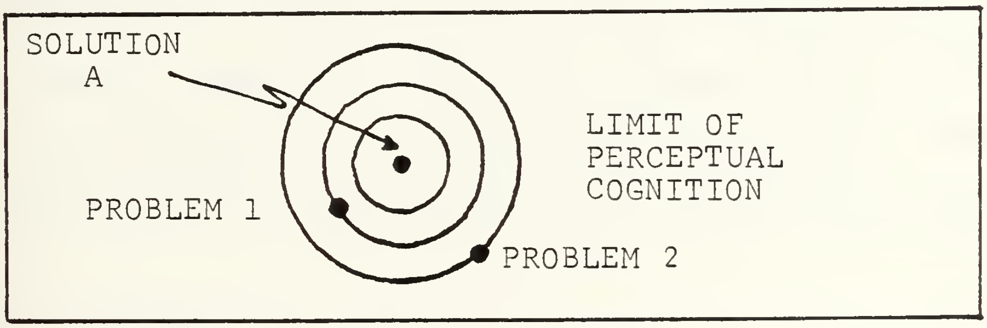

Figure 5.3 SORTING BY ENERGY LEVELS

If the above may be examined metaphorically as a non-conservative force field (atom field management), consider the following as an illustrative extension of that concept/mechanism.

Suppose that the outermost ring denotes a boundary. The inner field equates to a region of perceptual cognition[19] and the outer field denotes a region which is not considered within the realm of a choice situation. Using this concept, inject relevant information types into the inner field and nonrelevant to the region beyond cognitive perception (outside boundary) to provide a method of primitive preliminary sorting. This boundary is established not by what should be included as relevant, but by what the decision maker is capable of assimilating. Inclusion is predicated upon the individual's perceptions, personality, risk taking philosophy, view of uncertainty, reaction to ambiguity, and success/failure reaction mechanisms.

Expanding this schema, let us suppose that streams (March model: problems, solutions, energy, participants) enter this creation with a great deal of disorder. This sorting process is then applied in accordance with the

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[19] Cognition is used here to describe the process or processes by which a person acquires knowledge. Perceptual cognition implies ones perception of events, recognizes the need to, or the capability of, acquiring that knowledge.

decision maker's predisposition and energy. Recall that problems and solutions may be viewed as components of I_T. This predisposition would account for why something which is not a problem might get assigned as one. A decision maker who is looking for a problem, whether or not one actually exists, will frequently assign it to a premade solution.

The boundary is simply defined in terms of individual perceptive attitudes and not as a physical constraint. The random nature of these components are free to transverse the boundary conceptually, yet are acted on only if recognized. The recognition process, once again, is achieved only if applicable to the choice presently in progress, and thus classified as perceptually[20] relevant. The rate at which problems and solutions enter the realm of relevance is a function of the rate with which they enter the choice situation.

Additionally, if this is assumed, then it is possible to associate this potential increase of information with an increase in entropy of the choice scenario. In an attempt to control, or bring order to, this chaotic state the

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[20] Relevance in this section is a function of an individual's perception, as opposed to time dependent relevance discussed in the previous section.

perceptual cognition boundary may recede; or it may remain as positioned initially and greater energy may be applied and hence greater participation may be required instead. Recall the relationship between energy and participation and time, e.g., $E_T = (P_T, T)$.

Increased energy expenditure essentially creates a field with distinct energy levels. This field and the associated energy levels provide an "order" depicted by orbitals with which the positioning of problems and solutions is effected. Assuming that fewer solutions than problems exist, it is appropriate to have the solution of a particular choice situation serve as the nucleus and have the problems serve as the orbiting bodies. The more energy which is applied to a problem "kicks" that problem into a higher energy level (an interior movement). If a problem receives little attention, or is not recognized as a problem then it has insufficient energy to maintain its orbit. Hence, instead of gravitating inward to a solution, it escapes into the outer field only to be attracted to another choice situation with available energy to attract it into its domain of influence. If a problem "escapes" then "flight" has occurred and essentially the problem will not be resolved until it receives recognition by participants and, thus, the requisite energy.

If on the other hand excessive energy is applied to a problem orbiting (in relative proximity to a solution) it may be temporarily mated to a solution in the nucleus. This condition of an unstable pairing of problem to solution will remain only as long as the requisite energy for bonding remains. A choice/decision has been made whenever bonding/ pairing is accomplished. Should the energy level begin to decrease when participant energy is redirected then the orbital will expand until an outer field status is achieved. Moreover, this pairing is only temporary in nature, and although a pairing has occurred it represents the misallocation of participant energy. The energy expended to achieve this match allowed other problems to disassociate themselves with this choice situation and to drift from their orbitals enabling classification as "flight" problems. The temporarily bonded problem and solution eventually lack the necessary energy (attraction) to remain bonded in their unstable condition and thus separate. This temporary remedy, applying excessive energy to the "wrong" problem and solution match, served only as a temporary fix not yielding resolution and accommodated an "oversight" condition, upon separation.

The optimal and desired condition is "resolution", in which energy is "properly" applied to a problem enabling it to gravitate toward a solution, thus facilitating a stable bond which remains stable after the energy level has been redirected (reduced).

Further, in this metaphoric scenario it can be assumed that several problems may attach themselves to a single solution and create a situation as depicted below:

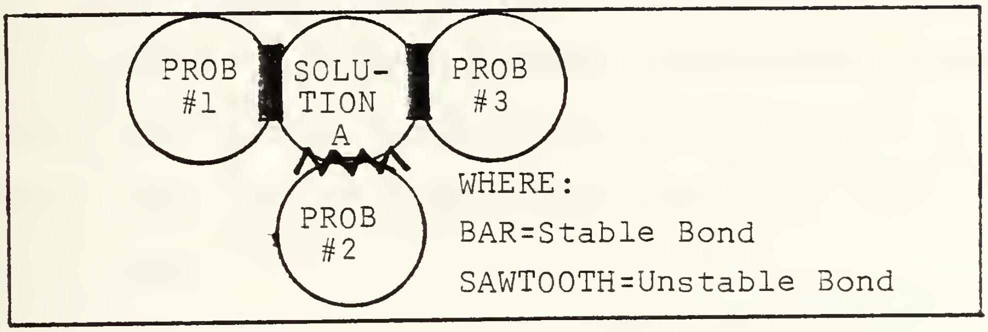

Figure 5.4 ALIGNMENT OF PROBLEMS AND SOLUTIONS

In the above diagram, the solid bar indicates a stable bonding between problems 1 and 3 and solution A; the sawtooth indicates an unstable bonding condition between problem 2 and Solution A. If problem 1 was an ASW threat to the South, and problem 2 was an enemy surface threat to the South, and solution A was a maneuver to the North to remain out of Southern force's conbat radius while refueling and rearming aircraft, then conscience resolution could be considered achieved for problems 1 and 2. However, if by maneuvering to the North the task force entered the combat radius of

land-based patrol aircraft, an overall "satisfying" condition is created in which only two of the three problems could be resolved (considered as partial resolution). The solution A--problem 3 match is unstable with pending "oversight" potential (i.e., risk of detection exists).

The significance of the above "satisfying" scenario is that this reflects a common dilemma encountered in combat. The importance of this concept is that the number of different <u>types</u> of solutions is less than the number of different <u>types</u> of problems.

This is largely due to the decision maker's limited ability to incorporate solutions which may contrary to personal perceptions which are firmly entrenched within his personality; eg. you see only what you want to see.

One solution is frequently assigned to different problems regardless of its correctness, if conditions of rigidity or high ambiguity exist.

C. INFORMATION AND ITS RELATIONSHIP TO RISK, SEARCH, TIME AND AMBIGUITY

In the early portions of this chapter, information was defined and a conceptual ordering of problems and solutions was provided in an effort to explain the manner in which problems and solutions are associated--a process which considers participation, energy and the concept of cognitive perception.

The following is an examination of the human element in the decision process. Topics to be discussed include risk and ambiguity, in relationship to information load conditions. This is of considerable importance due to the effect these subjects have on the establishment of cognitive perception boundaries and the decision maker's success or failure in digesting or sorting various quantities of information while operating in a time constrained environment. The critical variable in the forthcoming discussion is time.

Risk: According to Siegfired Streufert and Glenda Nogami [Ref. 28] risk increases with a length of time spent on a task. This raises the question whether decision makers are aware of their increasing riskiness. This and other commentary based on Siegfried Streufert and his variuos other research associates is based on a game/experiment known as TNG (Tactical Negotiations Game). Here, Siegfried Streufert, in a series of technical reports generated under contract with the Office of Naval Research, compiled data and examined trends of behavior related to the decisions of the decision makers. The game required players to make political, military, and economic decision with various types of information, various qualities of information, i.e., various information loads (I_T).

Reference 29 noted that as participants of this game became more adept and more familiar with their environment, risk taking increased over time. This was accompanied by an

increased perception of risk by the subjects in regard to their decisions. It was also noted in [Ref. 30] that subjects were able to differentiate, but in only two dimensions.

> "Once success levels or failure levels became very high, however, they dropped their risk taking behavior in one of these dimensional areas and concentrated on the other. In other words, subjects (or groups of subjects) seemed to be quite able to differentiate between dimensions (military and economic) of a task setting and they utilized a differentiative process in risky decision making when the task requires." [Ref. 31]

Another related concept is the idea of "risky shift" and the 1961 discoveries of Stoner. Stoner addresses the propensity to take greater risk in a group setting where a possible diffusion of responsibility is present. This is mentioned so that it may be considered when various structures are discussed in regard to load conditions. Should the reader desire to examine this area further research by Prewitt or Stoner should be consulted.

In 1968 Streufert and Streufert demonstrated that shifts in risk occur with the amount of information available to decision makers. Additionally, Streufert and Streufert noted that subjects which were making either military or economic decisions made higher risk decisions as either success or failure increased, and found that groups made higher risk decisions. In the next diagram, S. Streufert illustrates the decision makers propensity to take risks versus his/her success or failure in past choices.

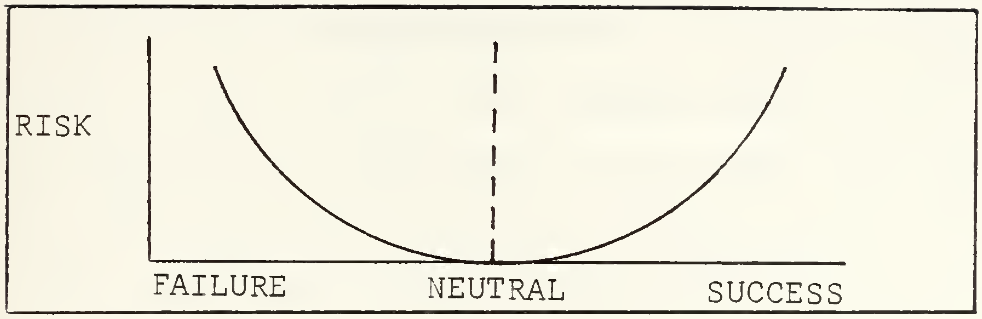

Figure 5.5 RISK vs. SUCCESS AND FAILURE

Other research conducted by Streufert and Streufert in their laboratory indicates that similar dimensional differentiation is an effect of time. [Ref. 32]

The presence of increased risk, under conditions of increased success or failure, was reexamined in reference 33. Here, complexity theory was tested as proposed by Driver, Streufert and Schroeder. The theory postulates an inverted U-shaped function which relates environmental complexity (information load, success, failure) to complex perceptions and behavior. In general, the theory has been supported,

and of primary consideration was found to hold for information load (technical report numbers 2, 18, 20)[21] when complex decision making was measured, or when complex perceptions were measured. Risk as predicted increased under conditions of increasing failure (technical reports numbers 10, 11, 12, 20)[22]. The U-shaped function did not provide as accurate a prediction of risk with increased success. The following quote from Reference 34 is in regard to the data generated by the previously mentioned studies.

> "Data appears to suggest that the failure and success components of what complexity theorists call 'environmental complexity' may be reducible to load (with failure increasing, with success decreasing) information load level."

Additional studies by Streufert and associates concluded that...

> "...information transmission among groups varied in part with information load..." [Ref. 35]

Although only a cursory discussion of the research surrounding risk and information load, the research of Siegfried Streufert and associates has considerable relevance to the forthcoming simulation results.

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[21] Reports 2, 18, and 20 are additional research papers by S. Streufert and C. H. Castore between 1967 and 1969.

[22] Denotes other technical reports by Siegfried Streufert and associates, should the reader desire to investigate this topic further. This author consulted only technical reports 4, 11, and 47.

Load and deadlines: When Siegfried Streufert and Susan Streufert [Ref. 36] examined the effects of information load (low, medium, high) and time urgency (absent, moderate, high) they utilized three measures of information search/information activity. The measures were:

1. The number of information search decisions generated.

2. The number of integrations based on previous information search.

3. The number of respondent actions generated that were information search related

They concluded the following points which were distributed in Reference 37. This author has reformatted the following into a listing for brevity.

> "1. Previously reported data showing that intermediate load levels result in optimal integrative performance were corroborated.
>
> 2. Increases in time emergency resulted in decreases in search activity in general, and in integrative utilization of information obtained through search in particular.
>
> 3. High levels of time urgency in association with high load levels resulted in fewer search decisions in complete absence of integrative utilization, but produced an increase in the respondent actions.
>
> 4. The data suggests that a optimal environment for high level decision makers with planning responsibility should contain optimal intermediate load levels, but should be kept relatively free of time urgency."

The decrease in search/sorting activity may be analogous to the author's suggestion of a narrowing cognitive perception in an attempt to narrow the scope of choice situation. One

can certainly understand why search activity decreases when time is at a premium. If this behavior is applicable to the combat scenario, then it is certainly understandable why "flight" and "oversight" should exceed "resolution" when inadequate time is allowed to search properly.

In reference to item three C. F. Jaques (1978) stated that respondent actions are quite useful in emergencies, yet they tend to reflect lower level managerial decisions and are not adequate when the situation demands high level decision making. He further stated that respondent actions are utilized frequently. A similar concept was mentioned by James G. March (interview of February 25, 1983) and suggests to this author that upper level decision makers tend to become preoccupied with decisions which should be dealt with by subordinates. One possible explanation, if one refers to the "Garbage Can" model, is that inadequate energy exists to solve the "big" problems, so small low level problems are acted upon instead. If, however, upper level managers left those decisions to subordinates then possibly the requisite upper level energy would exist and could be applied selectively to a few major choices. It seems to be an exercise in allocating a scarce resource: energy (attention).

Related to the previous commentary on information search and information load (I_T) is another important concept--ambiguity. Here, the quality and quantity of information is examined, but from a different viewpoint. What is ambiguous

to one person may not be the case with another individual. Nonetheless, if the information is impartial or ambiguous and the decision maker receiving the information has a low tolerance for ambiguity, then a lengthened search process should be expected, thus accentuating the information assimilation process. Poor quality information or large quantities of information enhance the ambiguity of the information provided.

Pertinent points extracted from Reference 38, an annotated bibliography on ambiguity, provided the following quotations; although limited in scope, they have considerable value to the pending examination of various load patterns. The following quotes are from that source:

> "1. Those individuals who were tolerant of ambiguity tended to select unstructured fields...while those less tolerant of ambiguity tended to chose relatively structured fields.
>
> 2. Those individuals who thought of themselves as conventional were more intolerant of ambiguity than those who were unconventional.
>
> 3. Intolerance of ambiguity was positively associated with authoritarianism."

The concept of I_T (total information) as a medium which includes information concerning problems, solutions and states is closely related to the concept of ambiguity.

The importance of viewing the entry of problems, solutions and states as a single entity (I_T) is essential to the understanding of information load conditions. First, and of primary importance, is that problems, solutions, and states

rarely enter a choice as discrete streams in "real world" choice situations. Secondly, if one does assume they enter as discrete and clearly defined entities then the complex and time demanding task of sorting problems from solutions, solutions from problems, symtoms from problems, and the manifestation of solutions from true solutions is ignored.

Proven/successful decision makers are those individuals who have the unique talent of getting to the "root of the problem". These individuals are able to digest the information presented to them and quickly determine what is relevant and what is not; and are able to assimilate seemingly disjointed ideas/problems/solutions/concepts and produce integrated decisions which yield resolution. This process can be improved upon if the information load (I_T) is maintained at a level commensurate with the level of expertise of the decision maker.

As was stated in Reference 39, the Admirals interviewed by Allen and Rannells support this concept in that they stated the TFCC (Tactical Flag Command Center) is supported by information. They did not state that it was supported by separate discrete streams of problems and solutions.

Getting to the "root of the problem" demands that the decision maker separate I_T (total information) into its component parts. This is not a task which is frequently performed for the decision maker. This classification and separation process is significantly influenced by the degree

of ambiguity of the information (I_T) that the decision maker must work with, as well as the decision maker's tolerance for ambiguous information. The process of converting ambiguous information into meaningful information is an energy intensive process, which detracts from energy being utilized more effectively on choices. This process is also time consuming and thus impacts upon the time available to study alternatives should a deadline be involved. The decision maker's tolerance for ambiguity should be viewed as one of the many factors which produce idiosyncratic decision styles. Within the military services ambiguity must be recognized as an influence which accompanies information and increases the complexity of that information load.

Ambiguity is a particularly powerful influence when individuals view themselves as conventional decision makers, and operate in an authoritarian organization setting such as the Naval service. The ability to deal with ambiguity is highly personality dependent and as such, systems design must account for the role of the decision maker; not omit them as CACI, Inc. did in Chapter II. Such as omission reflects serious philosophical weaknesses, in that the concepts of sorting, ambiguity and the myriad of other influences which impace the decision process are minimized.

VI. APPLICATION OF THE GARBAGE CAN TO A MILITARY ENVIRONMENT

One of the fundamental purposes of this thesis has been to present the militarized version of the "Garbage Can". It is an examination not only of the "Garbage Can" But also of the way hierarchical structures are altered under several information load conditions.

Before proceeding, a review is necessary. Up to this point, the examination of present conditions has been presented in an attempt to show the levels of sophistication within a community which has the responsibility of modeling decisions, decision processes, and the organizations which support these decisions. This has been presented in an attempt to allow the reader to recognize the complexities and the nature of the task that was being attempted. Further, an examination of philosophical model assumptions was presented in the hope that the reader would recognize a facet of the model selection process which is rarely addressed. This has led to an explanation of the "Garbage Can" and, in this author's opinion, it is a model which has considerable relevance to a process that occurs in tactical decision-making.

The prior discussion on information was deemed necessary, in that there are various interpretations of what information really is, how it is used, and what types exist.

By presenting the author's view of information and applying these concepts to the "Garbage Can" model a more realistic dipiction of the tactical process is facilitated.

To have completely accepted the "Garbage Can" as a militarized version would have discounted many of the unique problems that face Naval tactical decision makers. It is this author's opinion that the manner that information flows is one such distinguishing trait. Not to make this modification would have required a degree of abstraction that was felt to be an unfair representation of the complexities of real time tactical decision making and an sttempt to stretch the "Garbage Can" to a situation which might not have been initially conceived. The "Garbage Can" endorses as its unique environment university bureaucracies. Naval tactical decision making is a demanding task which also requires a thorough understanding of its unique environment and the decision process with which it interfaces.

The selection of a model which gives credit or recognizes its environment is of the utmost importance. The "Garbage Can" model was originally seen to describe the process and the products thereof within the context of a university bureaucracy. Although there are considerable similarities between that process and the process of a large organization such as the Navy there are also several key distinctions which must be emphasized.

One of the first and most fundamental considerations is that Naval tactical decision making occurs primarily on board ship. To fully understand this, the concept of a ship must first be understood. A ship is far more than hardware and people, it is an inseparable combination of the two. A smooth running ship works as a composite entity reflecting the leadership and individual personalities of that vessel. Although a behavior which initially endorses a leadership style or reflects the leadership style that is utilized on that ship, it is more than that. Over time, a ship develops a personality of its own, certainly a situation difficult to describe unless someone (the reader) has been emotionally involved as a member of such a vessel.

What is unique and important about this concept of a ship as an entity with a personality is that it is essentially a self-sustaining community. It is a container which requires little from the outside in order to exist. This idea of a ship as a container which "contains" several garbage cans acting in a coordinated fashion has several parallels to the idea that March and Olsen presented in their analogy of the bureaucratic decision process as a succession of garbage cans. Just as in the "Garbage Can", ships also receive problems, solutions, energy and participants. Ships do not necessarily receive these intputs in the same manner. Shipboard inputs are highly dependent upon telecommuncations and their associated weaknesses (eg. fading, atmospheric conditions,

distance, equipment failure), while still being sensitive to the same governing criteria.[23] How these streams enter is an important distinction, and hence the need to emphasize this difference. Here, however, the participation which links this isolated and self-sustaining community to its environment may be terminated, or minimized, by either intentional or overt action.

Previously, it was mentioned that the idea (metaphoric symbol) of a garbage can was described as a container into whick many discarded and dissimilar ideas were deposited. The same holds true of the concept of a ship as a container of several "Garbage Cans". Within the ship there are several critical locations or spaces which need to be identified. Two such places are the Combat Information Center (CIC), which is a space designated to the examination and utilization of tactical sensor and navigational information. All ships of the line have such centers and are reserved primarily for their own use. Larger ships which embark Flag Officers[24] have such a space, as well as an additional one which is designated for the sole use of embarked Flag Officers and is known as Flag Plot.

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[23] Governing criteria--unclear technology, fluid participation and ambiguity of relevance.

[24] Officers of the rank of Commodore (O-7) or above.

Although the distinctions between a Combat Information Center and Flag Plot are great, there are also many similarities. For the purposes of this examination, this author wishes to consider the similarities. Both are places where decision makers are continually faced with tactical choice opportunities. They are both points on board ship where problems and solutions are funneled, acted upon, and the results of choice situations are conveyed. This notification of the decision made may be achieved internally or transmitted to other vessels by flag hoist, flashing light or radio broadcast.

Operating within a Combat Information Center or Flag Tactical Plot is a unique experience and one which should be required of all people who are involved in the decisions which lead to the design of a tactical decision support system.

Within these confined areas, many people operate in cramped conditions to analyze tactical information gathered from a multitude of sensors. Tactical decisions are made based on these sensor inputs. These sensor inputs should be considered as information since they have the potential to carry value, meaning, and serve as a medium to transport problems and solutions. The remaining examination of this special case of the "Garbage Can" in this section will be made with no organizational distinction between Flag

Tactical Plot and CIC and, henceforth, will be referred to as interchangeable entities unless specifically identified.

Within these shipboard spaces, numerous overhead radio speakers broadcast information. At times, one speaker may be providing the sole input. At other times, a condition may exist where all speakers are simultaneously broadcasting. This latter condition creates a very unique situation unlike that faced by a corporate executive or university president at a board meeting where he may control the rate at which he receives his input be requesting that the individuals in attendance speak one at a time. The commanding officer of a ship, or a Flag Officer with control of numerous vessels, may thus be forced to make important tactical decisions on information that is received under less than ideal conditions. The information load (I_T) and the rate at which this decision maker must assimilate information creates unique and demanding restrictions on the choice process. Frequently, a response is required almost instantaneously. These input streams must be sorted to identify issues and identify problems and solutions. Additionally, hypotheses must be generated, options evaluated, and a choice (response) must result. Decisions in combat often concern inflicting damage on others or minimizing damage to one's own forces. Thus, the consequences of these decisions are not only in terms of dollars, but in terms of human life. In this case two very important modifications to the originally conceived "Garbage Can" exist:

1. The decisions are frequently irreversible in that if the wrong decision is made, human life is unnecessarily lost.

2. The rate at which the information is presented to the decision maker is frequently in a near real time environment and adequate study is frequently not possible.

According to Shapiro and Gilbert [Ref. 40] individuals under stress reduce information search, consider fewer alternatives, overact to isolated pieces of information and generally engage in what would/should be considered to be suboptimal choice generation and selection. To reduce the behavior mentioned by Shapiro and Gilbert requires the extensive use of contingency planning and effective delegation of decision authority.

When examined from another viewpoint, the problems and solutions that enter into this choice opportunity are typically injected from the external environment which surrounds not just the Combat Information Center but the entire ship. In regard to a Flag Tactical Plot which is responsible for decisions not of just one ship but on numerous vessels, then the input to this decision arena should be viewed as entering from the external environment that surrounds the Naval organization for which the Flag Tactical Plot has responsibility.

In order to make timely decisions in a combat environment, the tactical decision maker must integrate information from numerous sources very effectively. This must be done with

great rapidity and requires that the decision maker be able to analyze a problem quickly by identifying the key issues in a real time environment.

This requires a sorting process. A process in which the decision maker sorts through the information as it is presented to him and he must be able to recognize from that information what the problem is, as well as generate corrective action. When time is of the essence, frequently, this process is far more difficult that it may outwardly seem. It requires a clear understanding of objectives which frequently are not adequately presented to the tactical decision maker. Initial objectives are frequently altered during the course of a military engagement and are not modified as the engagement proceeds. Yet, this tactical decision maker is required to get to the crux of the problem in a nearly instantaneous fashion and frequently must rely on the advice of staff members who are also confronted with similar situations in their specific specialty areas. Nonetheless, the need to delegate alters decision and access structures, as well as reducing the traditional importance of the individual delegating while empowering the less important individual who is the recipient of the delegation.

There are numerous subtle distinctions between the military and university scenarios. Moreover, many of the decisions in

the military case are technology[25] driven (i.e., are frequently dependent upon the reliability of transmission to even to be able to delegate, and be kept informed).

The Naval (military) scenario should be distinguished from the pure "Garbage Can", although it is essentially endorsing many of the same concepts, due to the importance of time in the tactical scenario. Many of these differences between the university and military cases are simply a matter of relative importances (areas of emphasis).

In the "Garbage Can", Cohen, March, and Olsen speak of <u>load</u> as a measure of complexity and view decision structures and access structures as static entities in their simulation. This <u>load</u> is a measure of the complexity of the decision at hand. A fundamental and very important distinction between the Naval application and the university conception is that load in the Naval case refers to <u>information load</u>. It is this author's contention that increased <u>information load</u> increases the complexity of the decision since a decision is made more difficult with more information. The integrative process is strained, and the demands on the

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[25] Technology in this sense referes to scientific and industrial advancements, as opposed to the term unclear technology used in Chapter V to indicate the uncertainty surrounding the choice of an appropriate managerial methodology.

sorting process are accentuated that much more. The sorting and selective utilization of information is dependent upon trigger mechanisms in addition to the concept of cognitive perception.[26] This was presented as an influence which this author feels cannot be discounted because it is an initial condition which affects the manner in which decision makers integrate and process information. Interestingly enough, there is a possible relationship between this concept and the "Garbage Can". Cohen, March, and Olsen utilize the term energy which this author has defined as a function of participation. Nonetheless, energy in the "Garbage Can" can be thought of not only as a prerequisite to action, but also as a mechanism which sorts--determines which opportunities have the necessary energy. If the reader desires, both energy and cognitive perceptions may be considered as processes which aid in developing alternatives, and which frequently result in a "satisfying" condition.

If one looks at information load as a measure of complexity in decision making, then an important distinction has been made. Adoption of these points of view recognizes the possibility of incurring ambiguity, increased risk, relevance determinations, increased sort time, and time

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[26] For additional information on triggers in Garbage Can tactical applications, consult "Toward a Theory of Military Decision-Making", Barbara J. Bowyer, NPS Thesis, June 1983.

restrictions. Not only does an increasing load situation increase the complexity of the decision process, it also increases the complexity of the organizational structure which is tasked with handling this increasing load. With an increasing load condition, the interaction among the organizational members who are aiding the decision maker in sanitizing information is significant and creates additional communicative skill requirements. Not only must the information which is being injected into this organization be digested, but the information flow between actors must also be coordinated. This requires new energy demands and new participative requirements. It is the author's view that the concept of teamwork is stressed here far more than in any civilian situation. Key actors in this type of organization must not only be able to communicate with external sources, in a real time environment, but also among themselves.

Additionally, with the CIC or Flag Tactical Plot scenario, there are some unique qualities that are associated with voice telecommunications and are not present in most civilian or university board rooms, and that is the concept of gain. In this context, the term "gain" is used so as to be distinguished from the word volume. Henceforth, volume will be referred to as a measure of quantity, whereas gain will be used as an indicator of the loudness with which verbal information is received. A point that

this author was not able to find discussed in any research reports concerning Tactical Decision Support System design was the concept of gain. It is this author's view that gain should be viewed as a biasing mechanism, which alters cognitive boundaries by altering the emphasis placed on specific kinds of information.

Consider the following scenario: you are operating in a Flag Tactical Plot on board an aircraft carrier and within this confined space various circuits are broadcasting via overhead loud speakers. Additionally, information is being received by various operators via various sensor consoles.

Imagine the confusion that exists when seven to ten speakers are simultaneously broadcasting. It is felt that consideration of the location of those speakers relative to the location of the key decision maker is of the utmost importance and the gain of those speakers is of equal importance. The speaker closest to the decision maker will be more easily heard than the speaker which is the farthest corner, assuming that both are being broadcast at equal gain. If in this integrated process, the decision maker fails to hear information which is critical to the choice process, then essentially his perception about the situation has been altered. Consider also that all speakers are broadcasting at equal gain and the decision maker has acclimated himself to that environment and then, unknowingly, someone increases the gain to a particular speaker; the information being

received via that speaker must certainly impact the view of the decision maker in that it is more readily heard. This not only biases the environment by giving greater prominence to the loudest speaker, it diminishes the value of the other transmissions of reduced gain. It is the biasing of the external environment under these circumstances that may attract the attention of the decision maker, as well as altering the temporal proximity that problems and solutions which are enfused to this choice opportunity.

This concept of varying gain for broadcast information has considerable importance in the way problems and solutions align themselves. If a solution is not heard (not permitted to enter the choice) and a problem exists, then a choice may be made which improperly assigns the problem to another solution yielding an "oversight" condition. Another possibility exists under such circumstances--"flight".

This suggests, even if only by association, that the timing of input at least the timing as far as when the decision maker receives inputs, as opposed to when they are actually received within the organization, may affect the allocation of energy and have the potential to affect the outcome of that choice opportunity. If one recalls the quote which referenced Dr. March, and stated that the manner in which problems and solutions align themselves is related to their temporal proximities. It is this author's contention that the concept of gain should be viewed as a biasing

mechanism. This is a condition which must be addressed and accounted for when one examines the concept of information load. The absence of gain, or a silenced speaker due to equipment malfunction, illustrates an extreme case scenario--yet this is frequently a realistic occurrence in combat and should also be viewed as a biasing influence.

For a further examination on the value of communications between sources in regard to broken communications, consult the bibliography and the unpublished paper by Dr. Roger Weissinger-Baylon which discussed Naval communications and loose couplings.

Not only should the absence of a critical source of information such as an overhead broadcast speaker be considered from the standpoint of gain, but also as partial degradation of the system to present problems and solutions. It should be viewed as a mechanism which severs energy (prevents participants fron contributing). If energy is, in fact, a function of participation, then you must consider the possibility that a Flag Officer in a Flag Tactical Plot may be obligated to call upon a circuit and request to speak to the commanding officer on another vessel. This enables that Flag Officer confronted with a tactical decision to access information from somebody who may be more familiar with the circumstances in a specific area. For example, a Flag Officer may be confronted with making a decision on whether he should reallocate his resources

and send several ships to the South, knowing full well that such a decision will fragment his force structure. In order to make such a decision, he may desire to speak to the commanding officer on a vessel South of him, for an assessment of the situation in that region. If communications are severed due to equipment malfunction, or jamming on the part of the enemy, then he cannot solicit that opinion. This essentially is the same as stating that the commanding officer himself is unable to participate and thus is unable to contribute the energy which has already been expended, on his part, in examining the environment with which he is most familiar. Essentially severed communications is an alteration of the access matrix. It is for this reason that this author in the previous chapter defined energy as a function of participation. Further, this author feels that the delegation of portions of a choice is essentially a method of reallocating energy to mini choices (portions of a larger choice) in a manner that matches available energy to a choice (mini choice). This enhances the possibility that outcomes of mini choices will be resolved. However, choices must then be conveyed to higher authority if that mini choice outcome is to serve as a component of a more global choice opportunity. In delegating authority, the important decision maker holds in reserve his energy for use on important choices. However, if delegated choice opportunity outcomes cannot, or are not,

transmitted back to the delegator, then energy is not conserved and the summation of participatory energy cannot be applied to a global choice.

This also serves as an example of why a distinction was made between relevant and nonrelevant information. If this Flag Officer made the decision, the circuit began to broadcast and it was discovered that resources were not needed (i.e., to the South) and yet had been sent, then the information is not relevant to the extent that the decision has already been made. This is not to say that a new choice situation is not presently available in which a previous decision may be reversed, but rather the information which was required at t_1 was not available until t_2.

Granted the volume of information as well as the gain of the information which is received are important factors in determining the manner in which problems and solutions inject themselves into the decision point (eg., a ship or a Combat Information Center). The quality of the transmission received must also be considered. If information received is garbled, or is hampered with excessive static, then a degree of ambiguity is introduced into the information that is being received. For example, suppose that a transmission is received over a particular speaker indicating a particular problem, but the entire situation is not presented to the decision maker as a result of a momentary break or a weak transmission. This is in keeping with the findings of

Mintzberg [Ref. 41] where he states that information streams presented to the decision maker are predominately ambiguous verbal constructs. The result is that the full implications of the problem being presented are not clearly understood, resulting in the introduction of ambiguity, uncertainty, as well as risk and/or the perception of risk. The introduction of risk occurs when a wrong decision might result because of the fact that the situation is not clearly understood.

Not only should participation be considered in the previous context in that participation is possible via electronic communication, but participation should also be viewed from the standpoint of the geographic location of vessels. For example, consider a task force organization where of a discrete number of vessels are steaming in a formation in support of one another. As the course of events proceed, various vessels (assets) are dispatched--this should be viewed as a decrease in the potential to participate. If a particular vessel is unable to participate, resolution may not be possible. For example, should a vessel which has a unique offensive capability be required in a choice situation, and yet, is geographically unavailable to participate, then certainly its ability to provide a possible solution to an immediate threat is diminished.

A condition which is not present in a boardroom or university environment and is very real condition in the

military is a condition known as EMCON. EMCON is the acronym which stands for Emissions Control. If EMCON is set, then the use of radio frequencies or electromagnetic radiation (radar, sonar) devices is reduced or prohibited. This is done so as to deprive the enemy of the ability to monitor those types of transmissions via their sensors. Under EMCON, geographical location (visual proximity) gains considerable importance since the ability to communicate is dependent on visual means such as flag hoist or flashing light. If a vessel has been detached and is required to provide input, i.e., to participate and thus provide energy to a choice situation while EMCON is in existence, then participation and energy are once again degraded (if outside visual signaling range). These are all factors which affect the relevance, the ambiguity, and the riskiness of the decision maker's information as well as the perception of his choice opportunity. There are also conditions which certainly make the military decision process a very complex one.

The manner in which human beings adjust to various information load conditions is of paramount significance. In the Cohen, March, and Olsen "Garbage Can" model and its accompanying simulation, three load conditions are examined: low, medium, and high.

In their model, these are considered as measures of complexity and are expressed as constants. This considers choices of equal complexity, and not complexity introduced

by information load. For the purposes of this thesis they are viewed as measures of information load in a steady state condition.

Rarely is the information load constant. At one moment, the decision maker may be faced with making a crucial decision on inadequate information, and the next moment be overburdened with information. The ability to transition between those two conditions and adjust one's decision style is certainly paramount in the tactical environment. This need to be flexible lends credence to the concept that decision structures and access structures should be viewed as dynamic entities rather than as static ones. In the next chapter, the results of several runs on the Cohen, March, and Olsen simulation will be presented, representing various information load conditions.

VII. THE GARBAGE CAN SIMULATION

Before commencing an analysis of the data generated by the "Garbage Can" simulation, it is first helpful to describe the contents of the following appendices which contain the simulation and its accompanying results. The order of appendicies is by increasing load.

Appendix A: The content of this appendix include the simulation which served as the constant information load bench mark. This consists of the base program and output for the first three runs. First run was executed with a low constant load condition (1.1), the second run with a medium constant condition (2.2), and the third run with a high constant load condition (3.3). All three runs assume a constant load for twenty time intervals/periods (of an unspecified duration). It may be helpful, however, to view each time period as being one minute.

Appendix B: Includes modification one, Mod 1, of the "Garbage Can" simulation. Here an increasing load condition exists from time period zero through time period five (1.1, 1.5, 2.0, 2.6, 3.6), a decreasing load condition from time period five through time period nine (2.6, 2.0, 1.5, 1.1), and a constant low load condition (1.1) from time period nine through time period twenty.

Appendix C: Consists of modification two, or Mod 2, of the "Garbage Can" simulation. Here, an increasing load condition is simulated for the first ten time periods (1.1, 1.2, 1.4, 1.6, 1.8, 2.1, 2.4, 2.7, 3.1, 3.6) and then, from time periods ten through twenty, a constant high load condition exists (3.6).

The reader, before proceeding, may desire to examine the three previous mentioned appendices. Before doing so, it is necessary to recognize that only one access and decision structure are examined in following commentary and hence only printout supporting these structures are included in these three appendices. Specifically the hierarchical decision structure and hierarchial access structure are only included, in that the author recognized a need to limit the analysis. The motive and/or assumption which supports this limitation is that these two structures best reflect the organizational structures utilized in military organizations.

A. COMPUTERIZED SIMULATION SUMMARY DATA ANALYSIS

The folloiwng commentary based on data summaries generated by the simulation, which may also be observed in Appendices A, B, and C. It is an analysis of summary statistics which are also displayed in the following table (Table 7.1) entitled Data Summary Statistics. This table consists of ten categories down the lefthand column versus the five computer simulation runs (low[Appendix A], medium [Appendix A], high [Appendix A], Mod 1 [Appendix B], Mod 2 [Appendix C]).

The ten categories are described as follows:

Category 1 is a count of the number of choices which were activated yet were not made. This is an analysis of the number of choice failures that existed in the last time period.

Category 2 is a count of choices which were activated and not made for the entire simulation.

Category 3 measures decision maker activity. It is a count of decision makers moving from choice to choice.

Category 4 indicates the number of problems not resolved by period twenty.

Category 5 is a measure of problem activity--a count of how often problems moved from choice to choice.

Category 6 is the number of problems that entered yet did not attach to a choice. That is, problems which entered into the choice and were not examined--no participant examined them.

Category 7 is the measure (count) of the number of times a problem is activated and attached yet is not solved.

Category 8 is the number of times a decision maker is not attached to a choice, therefore the decision maker is not used for any choice.

Category 9 is the measure of energy reserve, that is energy that was not utilized by participants during the simulation.

Category 10 is a measure of energy wasteage. Here, a measure is presented indicating that more energy was utilized than was necessary, to obtain the results from the choices which were made. This should be interpreted as the measure of wasted participation, a measure of excess participation.

The summary statistics suggest several interesting relationships. The first being that choice failures in the last period (Category 1) occurred under both high constant load and increasing load simulations (Mod 2).

TABLE 7.1

DATA SUMMARY STATISTICS

	Garbage Can Low	Garbage Can Med	Garbage Can High	Mod 2	Mod 1
1	0	0	1	1	0
2	12	39	51	40	27
3	51	62	61	63	63
4	2	2	16	17	2
5	47	64	68	51	52
6	27	26	0	16	27
7	57	165	266	235	108
8	99	32	20	21	70
9	38.27	18.83	11.40	12.53	31.61
10	7.93	7.57	18.72	13.09	8.19

The second point of interest is that during the high and Mod 2 runs, the number of choices activated but not made is considerably higher count than for the other three runs. This measure (Category 2) can possibly be viewed as a measure of indecision. If this is a valid assumption, then one may conclude that under conditions of high load, or Mod 2', the decision maker has a difficult time determining which choice

is in fact relevant to the environment. This results in a considerable number of choices being considered (activated) but not being made.

When examining the third category, there seems to be a trend towards greater decision maker movement (activity) with increasing load; that is, movement from choice to choice as load increases. The value for medium constant load is 62 and the value for constant high load is 61. This incongruity weakens such an argument, however, if examined on the spectrum from low load with a count of 51, to a high load, with a decision making activity value of 63, then a spectrum or range has been established indicating that choice activity over that range does increase. However, to substantiate this trend additional data points are needed.

Category 4 which is a count of the number of problems not solved by the last period shows that the high constant load and Mod 2 runs had the highest number of problem-failures. These two runs had approximately eight times the number of problem failures as the other three runs. If applied to a "real world" scenario, this could be interpreted as the difficulty of a decision maker to allocate their talents to making choices early in a choice opportunity, rather than expending them on adjusting to the environmental constraints imposed upon them. The other three runs each had two problem-failures during the last period. Of the three runs,

two had constant loads (low and medium), and the remaining had a load within that range for the majority of the run. Although the load had momentarily increased in Mod 1, it also decreased in that run and thus allowed adequate time to recover from the temporary increase in load.

In examining Category 5, no clear trend appears in regard to problem activity.

In regard to Category 6 which is a measure (count) of the number of problems which are not looked at, it is interesting to note that more problems were not looked at under the low, medium, and Mod 1 runs. It is the author's view that there is an inconsistency here in that the run under high constant load indicates zero problems which were not examined. This seems to be an unusual condition. One possible explanation is that all problems were looked at due to the scores received in Categories 2 and 3 (high activity), but this preoccupation restricted the ability to apply energy to resolution.

Category 7 when examined indicates that the number of time periods a problem was activated and attached and not solved. The two highest conditions here appeared under the high constant load and Mod 2 runs. When these figures in Category 7 are compared to Category 9 which is energy reserve, it is interesting to note that the runs with the highest number of problems which were activated/attached

but not solved are also the runs which had the lowest values of reserve energy, indicating a possible misallocation of energy and/or participation.

In examining Category 8, which is the number of times the decision maker is not attached to a choice, the two highest vlaues are for low constant load and Mod 1. This is not surprising, in that Mod 1 returned to a low constant load for time period nine through twenty. Further, the two runs having the highest values in Category 8 are also the two runs which have the highest energy reserve in Category 9. The two runs which had the highest wasted energy were high load and Mod 2. It is also these runs which had the highest number of time periods where problems were activated and attached but were not solved. This might suggest that energy was wasted due to the misallocation of the participants, or to the fact that the high degree of indecision of choice activities which was noted in Category 2 resulted in the energy being utilized for transitting between choices, and not on resolving choices.

B. COMPUTERIZED SIMULATION CHOICE OUTCOME ANALYSIS

The following data (Table 7.2) was developed by analyzing the choice activation matrix and the problem history matrix in Appendices A, B, and C. Here, the author determined in what periods "resolution", "flight", or "oversight" occurred in an attempt to try to establish some correlation between

TABLE 7.2

CHOICE OUTCOME ANALYSIS

Highest Oversight Highest Flight

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Garbage Can Low	20R 8R	14R		9OV	OV			17R 7R,16 9R, 11R, 12R, 13R, 15R	F			1R,2R 3R,4R 5R,6R 10R								
Garbage Can Medium	8R 20R	14R						OV	13R, 16R, 17R 15R	F		F		F						10R 1R,2R 3R,4R 5R,6R 7R,9R, 11R, 12R
Garbage Can High			OV	F				OV, F	F	17R, 18R, 19R, 20R			F							F
Mod 1	8R 20R			OV				OV	9R,11R 12R, 15R, 16R, 17R 13R			F					1R, 2R,3R 4R,5R 6R, 7R			
Mod 2	18R 20R	14R		OV				OV	F,F	F	F									F

Time Periods

R - Resolution
F - Flight

OV - Oversight
- The problem which resulted in one of the above conditions.

when these three conditions occurred and the information load at that instant (time period) that these outcomes occurred. A considerable number of resolutions occurred in the first time period for the low, medium, Mod 1 and Mod 2 runs. This indicates that resolution was possible when information load conditions were between 1.1 and 1.2. Mod 1, Mod 2, and low load runs all commenced at a 1.1 load level, while the medium load commenced in time period one with a load factor of 2.2. In the case of high constant load--it commended in time period one with a value of 3.3. The load (information load) in the high run may be viewed as being too extreme (no adjustment period) to result in anything but "oversight" and "flight" until time period ten, which at this time four resolutions occurred. The high constant load which only had four resolutions and which occurred at time period ten may indicate a possible "real world" situation where considerable adaptation by decision makers is required to adjust to the complexity (information burdens) of their environment prior to making appropriate choices. Once this adjustment had been made, however, resolution was possible. The remaining ten time periods provided only "flight" in time periods thirteen and twenty, possibly indicating that inadequate energy exists, after adjustment and the initial resolution, which could be applied to choice opportunities in significant quantity to yield anything except "flight".

In run Mod 1, other than the initial resolutions to problems eight and twenty in period one, nothing else other than "oversight" occurred until period nine, which at this time seven resolutions occurred prior to the load leveling out to a low constant value (1.1). In this particular run, it was not until period seventeen that additional resolution was possible, and seven resolution conditions again occurred. Consult Table 7.2 to examine this trend.

The previously mentioned concepts of ambiguity, risk and uncertainty apply to "oversight" and "flight" outcomes. The "oversight" condition can be associated with reduced search, or poor decisions due to ambiguous information. "Flight" may be related to "real world" avoidance behavior due to high (unacceptable) risk. Both are suboptimal outcomes which appear in the simulation with greater frequency in high information load runs. The occurrance of both "flight" and "oversight" under high I_T compare in a manner which parallels similar "real world" conditions. Thus, it can be stated that this simulation is a reasonable representation of suboptimal choice outcomes under high information load. Although not performed in this simulation, additional research needs to be pursued in regard to access and decision which change dynamically as information load is altered.

For run Mod 2, "resolution" occurred in periods one and two as the load increased. At time period four an "oversight" occurred and then in periods eight, nine, ten,

and eleven, one "oversight" and three "flight" conditions resulted (respectively) prior to the load leveling off to a constant high load condition. This high load condition did not enable a higher degree of success according to this simulation. This run yielded an additional "flight" outcome in period twenty. When the number of "resolutions" are examined for the five runs, the low and medium (constant loads) and Mod 1 (a close second) yielded the highese number of resolutions with eighteen and sixteen (respectively). The lowest number of "oversights" occurred with medium constant load. The lowest occurrence of "flight" occurred in the los constant load and Mod 1 runs. The highest number of "oversight" conditions existed in high constant load and in Mod 2, both yielding five "oversights".

It is significant to note that problems entered the simulation two at a time or during the first ten time periods. By the end of the tenth time period all problems had entered, and no new problems entered the simulation in time periods eleven through twenty. However, this did not mean these problems were not free to still be acted upon after period ten. This does, however, partially account for why the majority of "resolutions" occurred prior to time period ten. Time periods fifteen through nineteen were essentially void of any fruitful activity with the exception of the seven resolutions which occurred in the low run in period seventeen, the eleven resolutions in period twenty,

and the seven resolutions in period seventeen for the medium load run. It should be noted that periods of reduced activity or nonactivity seem to follow periods of activity. At least to the extent that "resolution" occurs in clusters and is then followed by period yielding only "flight" or "oversight" until "resolution" once again results. This behavior suggests a "real world" condition previously stated which eluded to a decision maker's behavior under conditions of continued success. Further examination is certainly needed in this area. The previous comment is simply an attempt to validate simulation results. As is hopefully recognized, simulation results are only as good as the simulation itself. This simulation like all simulations has weaknesses/limitations and possibly the most significant point here is to see whether the simulation, with the restrictive bounds placed upon it, endorses the decision maker's behavior and his/her reactions to information load.

Another underlying assumption in this simulation is that the most important decision makers become the least important decision makers as time progresses. This is an attempt to show that with time these people must relinquish traditional roles and traditional power and thus weaken their normal positions by delegating certain activities to less important decision makers.

A considerable number of "flight" conditions exist from periods ten through period fourteen, suggesting that a large number of decisions fleeing from problems--problems which entered in periods one through ten. Prior to period ten, the majority of decisions resulted in either "resolution" or "oversight". This is an interesting pattern, in that, prior to all problems being injected into the choice, "oversight" occurred with greater frequency than "flight" suggesting a "real world" pressure to make a premature decision. After all problems were entered, the tendency was to make choices resulting in "flight". An additional observation which may be made is that the majority of activity occurred in the first ten time periods, as problems entered the choice opportunity. Of significant, also, is that the seven "resolution" conditions which occurred in Mod 1 (time period nine) occurred at a time when the load factor had once again reached 1.1. For Mod 1 seven resolutions also occurred at the load factor of 1.1 in time period seventeen. This suggests that the majority of resolutions which occurred, occurred in the low, medium, and Mod 1 runs and suggested that a load that was predominently within the range of 1.1 and 2.2 yielded the highest number of resolutions. This closely coincides with the previous commentary mentioned by Siegfried Streufert and associates in which it was stated that an intermediate load (information load) yielded the optimal environment for the decision maker.

This simulation data supports that contention and is one of the few consistent themes that can be derived from the results generated here. It is also interesting to compare the number of "resolutions" which were achieved in low and medium runs, and then compare that number to the Category 10 results of the previous table (Table 7.1). The significance point here is that the two runs which had the highest number of "resolutions" also had the lowest amount of energy wasted.

The significant point when referring to indecision and its possible relationship to the sorting process is that of Category 2 data. This category has a range of values from 12 to 51 with the two lowest values being 12 and 27, and they are associated to the low load and Mod 1 runs. In the case of low constant load, the load factor remained 1.1 for the entire twenty time periods. In regard to Mod 1, the load was 1.1 from time period nine to time period twenty. The benefits of low load suggest that lower levels of indecision occur in lower load conditions. It is also interesting to examine Category 2, which addressed choices activated not made, in regard to the number of resolutions which occurred in the high load and Mod 2 runs, having only four and three "resolutions" respectively.

When examining the data for Category 8, a count on decision makers which were not used, the highest count occurred for the high load condition. The next highest count for Category 8 occurred for Mod 2 which had ten time periods at a load factor

of 3.6 over ten periods. The point to be made here is that those runs with a high load, or at least a high load for the predominance of the run, had the lowest energy reserve values, and highest energy wasteage, while also having the highest count in Category 2 and Category 7.

The significance of these results suggests that information load is related to the allocation of energy, (related to the degree of participation) which has a significant impact on the number of resolutions. This suggests that participation levels are critical factors within the organizational structure and hence organizations must be capable of accommodating the demands placed upon them. To solely rely on this data as an absolute indicator of any particular trend is inappropriate--additional data points need to be collected. However, it is noteworthy that there are in fact significant variations in the data with various load conditions.

It is also necessary to recall that problems enter the simulation in the first ten time periods. Altering the manner in which these problems enter could seriously impact the statistics which have been developed.

Thus, it is this author's opinion that they are several areas that must be examined further if the simulation is to be fully understood. Those areas being the point of entry and rate at which streams enter the choice.

If nothing else, the simulation data indicates that the number of "resolutions" achieved is a function of the load factor. Those computer runs which had low load factors had the highest degree of resolution, while those computer runs with the highest load factor had the highest number of "flight" choices made.

VIII. CONCLUSIONS

This thesis has provided a "web" analysis of a condition known as information load. It has examined the school of thought which is responsible for creating devices which produce and/or utilize information; it has examined several systems and the modeling assumptions which accompany them; it has examined weaknesses in these philosophical assumptions. Moreover, it has related information (I_T) and its components to the tactical environment. This is not the only environment that information must interface with effectively, and as such the human environment was addressed in regard to risk, ambiguity and the role of individual perceptions.

Offered in postulatum was the "Garbage Can" model of Cohen, March, and Olsen; which as a theoretical model of organizational decision making provided a means (via verbal discussion and simulation) to examine less than optimal choice outcomes ("flight", "oversight") under various information load conditions.

Additonally, a modification of the "Garbage Can" was presented. This modification consisted of several subtle distinctions:

1. It protrayed inputs as streams which were largely telecommunication dependent.

2. Recognized problems and solutions not as separate discrete entities, but as components of total information (I_T).

3. Presented participation as a subset of energy and thereby permitting the regulation of participation and energy by altering the availability and/or quality of telecommunication transmissions.

Despite these modifications the underlying theme of both the "Garbage Can" model and its associated simulation apply.

The simulation was executed for five runs. Here, however, the load factor was depicted as a measure of information load. Under either name the choice process reflected the imposed increase in complexity as load/information load variables were increased. The information load when high (3.3 or above) impeded the choice process by requiring that energy be expended on peripheral activities, and hence depleting the finite amount of energy allotted to a choice. This expenditure of energy created an energy reserve which was below the threshold which was necessary for resolution, and as a result "flight" and "oversight" dominated the runs where high information load was imposed.

As with all simulations, the goal is to replicate a condition or event. It is this author's view that this does an acceptable job of representing a portion of the "real world". This is not to say that it does not have limitations. The data generated by this simulation does however suggest several important concepts. These are as follows:

1. Different information loads effect choice outcomes.

2. High information load reduces the number of "resolutions" produced by decision makers.

3. "Flight" occurs in greater frequency when inadequate energy exists to obtain "resolution".

4. High information load conditions consume large quantities of energy.

5. Considerable amounts of energy are wasted under high information load conditions, suggesting that it is utilized on other activities than making choices.

This author feels that the above five points are an accurate reflection of the tactical decision making environment and offers the following view: That system designers in both the C^3I and TDSS communities recognize that the primary concern is no longer simply supplying information. Rather, recognize that human processes are reaching their information processing limit, and a need exists which merits redirecting their design efforts (changing their philosophical assumptions). This change should recognize that if C^3I/TDSS is an extension of human processes [Ref. 42], then critical human factors which limit this extension must be considered. Finally, the emphasis must be on providing properly sanitized (filtered) and accurate information within the low to medium information load range if "resolution" is to be expected. The technology is present, only the resistance to using it by all parties remains.

APPENDIX A

COMPUTER PROGRAM AND OUTPUT FOR LOW, MEDIUM AND HIGH CONSTANT INFORMATION LOAD CONDITIONS

```
$JOB           IC,XREF,EXT
C     THE GARBAGE CAN MODEL. VERSION 5
C     ***
C     IU IS 1 FOR SUMMARY STATISTICS ONLY
C     IU IS 2 FOR SUMMARY STATISTICS PLUS HISTORIES
C     ***
C     NA IS 1 WHEN PROBS AND DMKRS BOTH MOVE
C     NA IS 2 WHEN DMKRS ONLY MOVE
C     NA IS 3 WHEN PROBS ONLY MOVE
C     NA IS 4 WHEN NEITHER PROBS NOR DMKRS MOVE
C     ***
C     IL IS A FACTOR DETERMINING PROB ENERGY REQ
C     ***
C     VARIABLES
C         ***
C         NUMBERS
C             COUNTERS  UPPER LIMITS     NAME
C             ***
C                I           NCH          CHOICES
C                J           NPR          PROBLEM
C                K           NDM          DECMKRS
C                LT          NTP          TIME
C         ***
C         ARRAYS
C             CODE           DIMEN        NAME
C             ***
C             ICH            NCH          CHOICE ENTRY TIME
C             ICS            NCH          CHOICE STATUS
C             JET            NPR          PROB.ENTRY TIME
C             JF             NPR          PROB. ATT. CHOICE
C             JFF            NPR          WORKING COPY JF
C             JPS            NPR          PROB. STATUS
C             KDC            NDM          DMKR. ATT. CHOICE
C             KDCW           NDM          WORKING COPY KDC
C             XEE            NCH          ENERGY EXPENDED
C             XERC           NCH          CHOICE EN. REQT.
C             XSC            NTP          SOLUTION COEFFICIENT
C         ***
C         2-DIMENSIONAL ARRAYS
C             ***
C             CODE           DIMEN        NAME
C             ***
C             IKA            NCH,NDM      DECISION STRUCTURE
C             JIA            NPR,NCH      ACCESS STRUCTURE
C             XEA            NDM,NTP      ENERGY MATRIX
C         ***
C         ***
C         ***
C     ***
C     SUMMARY STATISTICS FOR EACH VARIANT
C             COL  1: KZ: TOTAL DECISIONS NOT MADE
C             COL  2: KY: TOTAL NUMBER ACTIVE CHOICE PERIODS
C             COL  3: KX: TOTAL NUMBER CHANGES BY DECISION MAKERS
C             COL  4: KW: TOTAL PROBLEMS NOT SOLVED
C             COL  5: KV: TOTAL NUMBER CHANGES BY PROBLEMS
C             COL  6: KU: TOTAL NUMBER LATENT PROBLEM PERIODS
C             COL  7: KT: TOTAL NUMBER ATTACHED PROBLEM PERIODS
C             COL  8: KS: TOTAL NUMBER PERIODS DMKRS RESTING
C             COL  9: XR: TOTAL AMOUNT OF UNUSED ENERGY
C             COL 10: XS: TOTAL AMOUNT OF WASTED ENERGY
```

```
C     ***
C      INPUT BLOCK, READ-IN AND INITIALIZATIONS.
      DIMENSION ICH(20),JF(20),XERC(20),XEE(20),XSC(20),JFF(20),XERP(20
     *),JET(20),JPS(20),ICS(20),KDC(20),KDCW(20),JIA(20,20),IKA(20,20),
     *XLA(20,20),KADC(20,20),KBBC(20,20),KCBC(20,20)
 1001 FORMAT(5(I3,1X))
 1002 FORMAT(10(I3,1X))
 1003 FORMAT(25(I1,1X))
 1004 FORMAT(10F4.2)
      NTP=20
      NCH=10
      NPR=20
      NDM=10
    8 READ(5,1002)(ICH(I),I=1,NCH)
      READ(5,1004)(XSC(LT),LT=1,NTP)
      READ(5,1002)(JET(J),J=1,NPR)
      READ(5,1003) NA, IO
      WRITE(6,1050) NA
 1050 FORMAT('1      DEC.MAKER MOVEMENT CONDITION (NA) IS  ',I1/)
      DO 998 IL=1,3
      IB=IL-1
      DO 999 JEB=1,3
      JE=JEB-1
      JAB=2
      JA=1
      JDB=2
      JD=1
      XR=0.0
      XS=0.0
      KS=0
      DO 10 I=1,NCH
      XERC(I)=1.1
      XEE(I)=0.0
   10 ICS(I)=0
      DO 20 K=1,NDM
      KDC(K)=0
   20 KDCW(K)=KDC(K)
      DO 40 J=1,NPR
      XERP(J)=IL*1.1
      JF(J)=0
      JFF(J)=0
   40 JPS(J)=0
C      SETTING UP THE DECISION MAKERS ACCESS TO CHOICES
      DO 520 I=1,NCH
      DO 510 J=1,NDM
      IKA(I,J)=1
      IF(JD.EQ.1) GO TO 502
      IF(JD.EQ.2) GO TO 504
      GO TO 510
  502 IF(I.GE.J) GO TO 510
      IKA(I,J)=0
      GO TO 510
  504 IF(J.EQ.I) GO TO 510
      IKA(I,J)=0
  510 CONTINUE
  520 CONTINUE
C      SETTING UP THE PROBLEMS ACCESS TO CHOICES
      DO 560 I=1,NPR
      DO 550 J=1,NCH
      JIA(I,J)=0
```

```
      IF(JA.EQ.1) GO TO 532
      IF(JA.EQ.2) GO TO 534
      JIA(I,J)=1
      GO TO 550
  532 IF((I-J).GT.(I/2)) GO TO 550
      JIA(I,J)=1
      GO TO 550
  534 IF(I.NE.(2*J)) GO TO 550
      JIA(I,J)=1
      JIA(I-1,J)=1
  550 CONTINUE
  560 CONTINUE
      DO 590 I=1,NCH
      DO 580 J=1,NTP
      XEA(I,J)=0.55
      IF(JE.EQ.1)GO TO 580
      XXA=I
      IF(JE.EQ.0)GO TO 570
      XEA(I,J)=(11.0-XXA)/10.0
      GO TO 580
  570 XEA(I,J)=XXA/10.0
 580  CONTINUE
 590  CONTINUE
C     *** FINISH READ INITIALIZATION
      DO 994 LT=1,NTP
 1006 FORMAT(2X,6HCHOICE,2X,I3,2X,6HACTIVE )
C     CHOICE ACTIVATION
      DO 101 I=1,NCH
      IF(ICF(I).NE.LT) GO TO 101
      ICS(I)=1
  101 CONTINUE
C     PROB. ACTIVATION
      DO 110 J=1,NPR
      IF (JET(J).NE.LT) GO TO 110
      JPS(J)=1
  110 CONTINUE
C     FIND MOST ATTRACTIVE CHOICE FOR PROBLEM J
      DO 120 J=1,NPR
      IF (JPS(J).NE.1) GO TO 120
      IF(NA.EQ.2) GO TO 125
      IF(NA.EQ.4) GO TO 125
      GO TO 126
  125 IF(JF(J).NE.0) GO TO 127
  126 S=1000000
      DO 121 I=1,NCH
      IF (ICS(I).NE.1) GO TO 121
      IF(JIA(J,I).EQ.0) GO TO 121
      IF(JF(J).EQ.0) GO TO 122
      IF(JF(J).EQ.I) GO TO 122
      IF((XERP(J)+XERC(I)-XEE(I)).GE.S)GO TO 121
      GO TO 123
  122 IF((XERC(I)-XEE(I)).GE.S) GO TO 121
       S=XERC(I)-XEE(I)
      GO TO 124
  123 S=XERP(J)+XERC(I)-XEE(I)
 124  JIF(J)=I
 121  CONTINUE
      GO TO 120
  127 JFF(J)=JF(J)
  120 CONTINUE
```

```
      DO 130 J=1,NPR
  131 JF(J)=JFF(J)
  130 JFF(J)=0
      LTT=LT-1
      IF(LT.EQ.1)LTT=1
C     FIND MOST ATTRACTIVE CHOICE FOR UNKR K
      DO 140 K=1,NDM
      IF(NA.EQ.3) GO TO 145
      IF(NA.EQ.4) GO TO 145
      GO TO 146
  145 IF(KDC(K).NE.0) GO TO 147
  146 S=1000000
      DO 141 I=1,NCH
      IF(ICS(I).NE.1) GO TO 141
      IF(IKA(I,K).EQ.0) GO TO 141
      IF(KDC(K).EQ.0) GO TO 142
      IF(KDC(K).EQ.1) GO TO 142
  148 IF((XERC(I)-XEE(I)-(XEA(K,LTT)*XSC(LTT))).GE.S)GO TO 141
      GO TO 143
  142 IF((XERC(I)-XEE(I)).GE.S) GO TO 141
      S=XERC(I)-XEE(I)
      GO TO 144
  143 S=XERC(I)-XEE(I)-XEA(K,LTT)*XSC(LTT)
  144 KDCW(K)=I
  141 CONTINUE
      GO TO 140
  147 KDCW(K)=KDC(K)
  140 CONTINUE
      DO 150 K=1,NDM
  151 KDC(K)=KDCW(K)
      IF(KDC(K).NE.0) GO TO 150
      XR=XR+(XEA(K,LT)*XSC(LT))
      KS=KS+1
  150 KDCW(K)=0
C     ESTABLISHING THE ENERGY REQUIRED TO MAKE EACH CHOICE.
      DO 199 I=1,NCH
      IF(ICS(I).EQ.0) GO TO 199
      XERC(I)=0.0
      DO 160 J=1,NPR
      IF(JPS(J).NE.1) GO TO 160
      IF(JF(J).NE.I)GO TO 160
      XERC(I)=XERC(I)+XERP(J)
  160 CONTINUE
      DO 170 K=1,NDM
      IF(IKA(I,K).EQ.0) GO TO 170
      IF(KDC(K).NE.I) GO TO 170
      XEE(I)=XEE(I)+XSC(LT)*XEA(K,LT)
  170 CONTINUE
  199 CONTINUE
C     MAKING DECISIONS
      DO 295 I=1,NCH
      IF (ICS(I).NE.1) GO TO 299
      IF(XERC(I).GT.XEE(I))GO TO 299
      XS=XS+XEE(I)-XERC(I)
      ICS(I)=2
      DO 250 J=1,NPR
      IF(JF(J).NE.I) GO TO 250
      JPS(J)=2
  250 CONTINUE
      IF(NA.EQ.3) GO TO 261
```

```
      IF(NA.EQ.4) GO TO 261
      GO TO 255
  261 DO 262 K=1,NDM
      IF(KDC(K).NE.1) GO TO 262
      KDCW(K)=1
  262 CONTINUE
  299 CONTINUE
      DO 200 I=1,NCH
  200 KABC(LT,I)=ICS(I)
      DO 210 K=1,NDM
      KBBC(LT,K)=KDC(K)
      IF(KDCW(K).EQ.0) GO TO 210
      KDC(K)=0
  210 KDCW(K)=0
      DO 220 J=1,NPR
      KCBC(LT,J)=JF(J)
      IF(JPS(J).EQ.0) GO TO 230
      IF(JPS(J).EQ.1) GO TO 220
      KCBC(LT,J)=1000
      GO TO 220
  230 KCBC(LT,J)=-1
  220 CONTINUE
  994 CONTINUE
C     FINISH TIME PERIOD LOOP. BEGIN ACCUMULATION OF 10 SUMMARY STATISTICS
      KZ=0
      KY=0
      KX=0
      KW=0
      KV=0
      KU=0
      KT=0
      DO 310 I=1,NIP
      DO 320 J=1,NCH
      IF(KABC(I,J).NE.1) GO TO 320
      KY=KY+1
      IF(I.NE.NIP) GO TO 320
      KZ=KZ+1
  320 CONTINUE
  310 CONTINUE
      DO 330 I=2,NIP
      DO 340 J=1,NDM
      IF(KBBC(I,J).EQ.KBBC(I-1,J)) GO TO 340
      KX=KX+1
  340 CONTINUE
  330 CONTINUE
      DO 350 I=1,NIP
      DO 360 J=1,NPR
      IF(KCBC(I,J).EQ.0) GO TO 351
      IF(KCBC(I,J).EQ.-1) GO TO 360
      IF(KCBC(I,J).EQ.1000) GO TO 352
      KT=KT+1
      GO TO 360
  351 KU=KU+1
      GO TO 360
  352 IF(I.NE.NIP) GO TO 360
      KW=KW+1
  360 CONTINUE
  350 CONTINUE
      KW=NPR-KW
      DO 370 I=2,NIP
```

```
227              DO 380 J=1,NPR
228              IF(KCBC(I,J).EQ.KCBC(I-1,J)) GO TO 380
229              KV=KV+1
230         380  CONTINUE
231         370  CONTINUE
          C      BEGIN WRITEOUT OF MATERIALS FOR THIS ORGANIZATIONAL VARIANT.
232        1000  FORMAT(1H1)
233        1019  FORMAT(2X,'LOAD=',I1,' PR.ACC.=',I1,' DEC.STR.=',I1,' EN.DIST.=',
                *I1,2X,'STATS 1-10',3X,8I5,1X,2F6.2/)
234              WRITE(6,1019)IB,JA,JC,JE,KZ,KY,KX,KW,KV,KU,KT,KS,XR,XS
235              IF(IO.EQ.1) GO TO 995
236        2000  FORMAT(' CHOICE ACTIVATION HISTORY',34X,'DEC.MAKER ACTIVITY HISTOR
                *Y'/' 20 TIME PERIODS,10 CHOICES',33X,'20 TIME PERIODS,10 DEC. MAKE
                *RS'/' 0=INACTIVE,1=ACTIVE,2=MADE',33X,'0=INACTIVE,X=WORKING ON CHO
                *ICE X'//9X,'  1 2 3 4 5 6 7 8 9 10',30X,'1 2 3 4 5 6 7 8 9 10'/)
237              WRITE(6,2000)
238        2001  FORMAT( 5X,I2,3X,10I2,25X,I2,3X,10I2)
239              WRITE(6,2001)(LT,(KABC(LT,J),J=1,NCH),LT,( KBBC(LT,J),J=1,NOM),
                * LT=1,NTP  )
240        2002  FORMAT(/' PROBLEM HISTORY:ROWS=TIME,COLS=PROBS., -1=NOT ENTERED,,
                *O=UNATTACHED,X=ATT.TO CH.X,**=SOLVED'/10X,
                *'  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20'/)
241              WRITE(6,2002)
242        2003  FORMAT(20(5X,I2,3X,20(1X,I2)/))
243              WRITE(6,2003)(LT,(KCBC(LT,J),J=1,NPR),LT=1,NTP)
244              WRITE(6,1000)
245         995  CONTINUE
246         998  CONTINUE
247              STOP
248              END
**WARNING**  FORMAT STATEMENT   1001 IS UNREFERENCED
**WARNING**  FORMAT STATEMENT   1006 IS UNREFERENCED

                                   *** WATFIV CROSS REFERENCE ***

*** '#' INDICATES VARIABLE DID NOT APPEAR IN A TYPE STATEMENT

     VARIABLE     - REFERENCES

     *I      *#    10   27   28   29   30   39   41   45   46   48   49   52   54   57   59   60   62   63   64
                   67   69   71   73   75   80   81   82   95   96   97   99  100  102  103  105  106  122  123
                  124  126  127  129  130  132  133  144  145  146  149  150  153  154  155  158  159  160  161
                  162  164  171  175  176  198  200  202  206  208  212  214  215  216  221  226  228
     *IB     *#    17  234
     *ICH    *#     1   10   81
     *ICS    *#     1   30   82   56  123  145  159  162  176
     *IKA    *#     1   41   46   49  124  153
     *IL     *#    16   17   35
     *IC     *#    13  235
     *J      *#    12   34   35   36   37   38   40   41   45   46   48   49   53   54   57   59   60   62   63
                   64   68   69   73   75   84   85   86   88   89   93   97   98   99  100  105  106  109  111
                  112  113  147  148  149  150  163  164  165  182  183  184  185  186  188  199  200  207  208
                  213  214  215  216  227  228  239  243
     *JA     *#    21   55   56  234
     *JAB    *#    20
     *JC     *#    23   42   43  234
     *JCB    *#    22
     *JE     *#    19   10   72  234
     *JEB    *#    18   19
```

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*JET     *#     1    12    85
*JF      *#     1    36    93    58    99   109   112   149   164   183
*JFF     *#     1    37   106   109   112   113
*JIA     *#     1    54    57    60    63    64    97
*JPS     *#     1    38    86    89   148   165   184   185
*K       *#    31    32    33   116   120   124   125   126   127   132   133   136   138   139   140   141   143   152   153
              154   155   170   171   172   177   178   179   180   181
*KABC    *#     1   176   200   239
*KBBC    *#     1   178   208   239
*KCBC    *#     1   163   186   188   214   215   216   228   243
*KDC     *#     1    32    33   120   125   126   136   139   140   154   171   178   180
*KCCW    *#     1    33   133   136   139   143   172   179   181
*KS      *#    26   142   234
*KT      *#   197   217   234
*KU      *#   196   219   234
*KV      *#   195   229   234
*KW      *#   194   222   225   234
*KX      *#   193   209   234
*KY      *#   192   201   234
*KZ      *#   191   203   234
*LT      *#    11    78    81    85   114   115   141   155   176   178   183   186   188   239   243
*LTT     *#   114   115   127   132
*NA      *#    13    14    90    91   117   118   167   168
*NCH     *#     7    10    27    39    53    80    95   122   144   158   175   199   239
*NDM     *#     9    31    40    67   116   138   152   170   177   207   239
*NPR     *#     8    12    34    52    84    88   111   147   163   182   213   225   227   243
*NTP     *#     6    11    68    78   198   202   206   212   221   226   239   243
*S       *#    94   100   102   103   105   121   127   129   130   132
*XEA     *#     1    69    73    75   127   132   141   155
*XEE     *#     1    29   100   102   103   105   127   129   130   132   155   160   161
*XERC    *#     1    28   100   102   103   105   127   129   130   132   146   150   160   161
*XERP    *#     1    35   100   105   150
*XR      *#    24   141   234
*XS      *#    25   161   234
*XSC     *#     1    11   127   132   141   155
*XXA     *#    71    73    75
STATEMENT NUMBER - FEFERENCES

   *      8*    10
   *     10*    27    30
   *     20*    31    33
   *     40*    34    38
   *    101*    80    81    83
   *    110*    84    85    87
   *    120*    88    89   108   110
   *    121*    95    96    97   100   102   107
   *    122*    98    99   102
   *    123*   101   105
   *    124*   104   106
   *    125*    90    91    93
   *    126*    92    94
   *    127*    93   109
   *    130*   111   113
   *    131*   112
   *    140*   116   135   137
   *    141*   122   123   124   127   129   134
   *    142*   125   126   125
   *    143*   128   132
   *    144*   131   133
```

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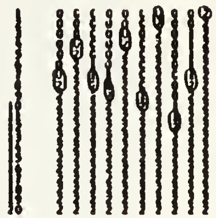
*     145*     117   118   120
*     146*     119   121
*     147*     120   136
*     148*     127
*     150*     138   140   143
*     151*     139
*     160*     147   148   145   151
*     170*     152   153   154   156
*     199*     144   145   157
*     200*     175   176
*     210*     177   179   181
*     220*     182   185   187   189
*     230*     184   188
*     250*     163   164   166
*     261*     167   168   170
*     262*     170   171   173
*     299*     158   159   160   169   174
*     310*     198   205
*     320*     199   200   202   204
*     330*     206   211
*     340*     207   208   210
*     350*     212   224
*     351*     214   219
*     352*     216   221
*     360*     213   215   218   220   221   223
*     370*     226   231
*     380*     227   228   230
*     502*      42    45
*     504*      43    48
*     510*      40    44    45    47    48    50
*     520*      39    51
*     532*      55    59
*     534*      56    62
*     550*      53    58    59    61    62    65
*     560*      52    66
*     570*      72    75
*     580*      68    70    74    76
*     590*      67    77
*     994*      78   150
*     995*      18   235   245
*     998*      16   246
*    1000*     232   244
*    1001*       2
*    1002*       3    10    12
*    1003*       4    13
*    1004*       5    11
*    1006*      79
*    1019*     233   234
*    1050*      14    15
*    2000*     236   237
*    2001*     238   239
*    2002*     240   241
*    2003*     242   243

                                   *** END OF WATFIV CROSS REFERENCE ***
     $ENTRY
```

DEC.MAKER PUVENTAL CONCITTCN LOAT IS 1
LOAD=0 PR.ACC.=1 DEC.STR.=1 EN.DIST.=0 STATS 1-10   0 12 91 2 47 27 97 99 30.27 7.93

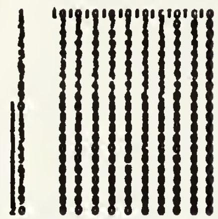
CHOICE ACTIVATION HISTORY
20 TIME PERIODS,10 CHOICES
0=INACTIVE,1=ACTIVE,2=PALE

1 2 3 4 5 6 7 8 9 10



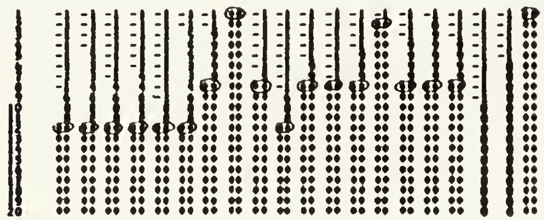
DEC.MAKER ACTIVITY HISTORY
20 TIME PERIODS,10 DEC. MAKERS
0=INACTIVE,X=WORKING ON CHOICE X

1 2 3 4 5 6 7 8 9 10



PROBLEM HISTORY(ROWS=TIME,COLS=PROBS., -1=NOT ENTERED, 0=UNATTACHED,X=ATT.TO CH.X,**=SOLVED

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20



LOAD=1 PR.ACC.=1 DEC.STR.=1 EN.DIST.=0 STATS 1-10 0 39 62 2 64 27 165 32 18.83 7.51

CHOICE ACTIVATION HISTORY
20 TIME PERIODS,10 CHOICES
0=INACTIVE,1=ACTIVE,2=PACE

	1	2	3	4	5	6	7	8	9	10
1	0	0	0	0	0	0	0	0	0	2
2	0	0	0	0	0	0	2	0	0	2
3	0	0	0	0	0	0	2	0	1	2
4	0	0	0	0	1	0	2	0	1	2
5	0	1	0	0	1	0	2	0	1	2
6	0	1	1	0	1	0	2	0	1	2
7	1	1	1	1	1	0	2	0	1	2
8	2	1	1	1	1	0	2	0	1	2
9	2	1	1	2	2	1	2	0	2	2
10	2	1	1	2	2	2	2	1	2	2
11	2	1	1	2	2	2	2	1	2	2
12	2	1	2	2	2	2	2	1	2	2
13	2	1	2	2	2	2	2	1	2	2
14	2	2	2	2	2	2	2	1	2	2
15	2	2	2	2	2	2	2	1	2	2
16	2	2	2	2	2	2	2	1	2	2
17	2	2	2	2	2	2	2	1	2	2
18	2	2	2	2	2	2	2	1	2	2
19	2	2	2	2	2	2	2	1	2	2
20	2	2	2	2	2	2	2	2	2	2

DEC.MAKER ACTIVITY HISTORY
20 TIME PERIODS,10 DEC. MAKERS
0=INACTIVE,X=WORKING ON CHOICE X

	1	2	3	4	5	6	7	8	9	10
1	10	10	10	10	10	10	10	10	10	10
2	7	7	7	7	7	7	7	0	0	0
3	9	9	9	9	9	5	5	9	9	0
4	5	5	5	5	5	9	9	9	9	0
5	2	2	9	9	9	9	5	9	9	0
6	3	3	3	5	5	9	9	9	9	0
7	4	4	4	4	5	9	9	9	9	0
8	1	4	4	4	5	9	9	9	9	0
9	6	6	6	6	6	6	5	9	9	0
10	8	8	8	8	8	8	8	8	0	0
11	3	3	3	8	8	8	8	8	0	0
12	2	2	8	8	8	8	8	8	0	0
13	8	8	8	8	8	8	8	8	0	0
14	8	8	8	8	8	8	8	8	0	0
15	8	8	8	8	8	8	8	8	0	0
16	8	8	8	8	8	8	8	8	0	0
17	8	8	8	8	8	8	8	8	0	0
18	8	8	8	8	8	8	8	8	0	0
19	8	8	8	8	8	8	8	8	0	0
20	8	8	8	8	8	8	8	8	0	0

PROBLEM HISTORY:ROWS=TIME,COLS=PROBS., -1=NOT ENTERED, 0=UNATTACHED,X=ATT.TO CH.X,**=SOLVED

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	-1	-1	-1	-1	-1	-1	-1	**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**
2	-1	-1	-1	-1	-1	-1	-1	**	-1	-1	-1	-1	-1	**	-1	0	-1	-1	-1	**
3	-1	-1	-1	-1	-1	9	9	**	-1	-1	-1	-1	-1	**	-1	9	-1	-1	-1	**
4	-1	-1	-1	-1	-1	5	5	**	-1	-1	-1	-1	-1	**	9	9	9	-1	-1	**
5	-1	2	-1	-1	-1	5	5	**	-1	-1	-1	-1	9	**	9	9	9	-1	-1	**
6	-1	2	-1	-1	-1	3	5	**	-1	-1	9	-1	9	**	9	9	9	-1	0	**
7	-1	2	-1	4	-1	3	5	**	5	-1	9	-1	9	**	9	9	9	-1	0	**
8	-1	2	4	4	-1	3	5	**	5	-1	9	9	9	**	9	9	9	-1	0	**
9	6	2	6	6	-1	3	6	**	6	6	6	6	**	**	**	**	**	-1	0	**
10	8	2	8	8	8	3	8	**	8	8	8	8	**	**	**	**	**	0	0	**
11	3	2	3	2	3	3	8	**	8	8	8	8	**	**	**	**	**	0	0	**
12	2	2	2	2	8	8	8	**	8	8	8	8	**	**	**	**	**	0	0	**
13	2	2	2	2	8	8	8	**	8	8	8	8	**	**	**	**	**	0	0	**
14	8	8	8	8	8	8	8	**	6	8	8	8	**	**	**	**	**	0	0	**
15	8	8	8	8	8	8	8	**	8	8	8	8	**	**	**	**	**	0	0	**
16	8	8	8	8	8	8	8	**	8	8	8	8	**	**	**	**	**	0	0	**
17	8	8	8	8	8	8	8	**	8	8	8	8	**	**	**	**	**	0	0	**
18	8	8	8	8	8	8	8	**	8	8	8	8	**	**	**	**	**	0	0	**
19	8	8	8	8	8	8	8	**	8	8	8	8	**	**	**	**	**	0	0	**
20	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	0	0	**

LOAD=2 PR.ACC.=1 DEC.STR.=1 EN.DIST.=0 STATS 1-10 1 51 61 16 68 0 266 20 11.40 18.72

CHOICE ACTIVATION HISTORY
20 TIME PERIODS,10 CHOICES
0=INACTIVE,1=ACTIVE,2=MADE

	1	2	3	4	5	6	7	8	9	10
1	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	1	0	1	1
3	0	0	0	0	0	0	1	0	2	1
4	0	0	0	0	1	0	2	0	2	1
5	0	1	0	0	1	0	2	0	2	1
6	0	1	1	0	1	0	2	0	2	1
7	0	1	1	1	1	0	2	0	2	1
8	2	1	1	2	1	0	2	0	2	1
9	2	1	1	2	2	1	2	0	2	1
10	2	1	1	2	2	2	2	1	2	2
11	2	1	1	2	2	2	2	1	2	2
12	2	1	1	2	2	2	2	1	2	2
13	2	2	1	2	2	2	2	1	2	2
14	2	2	1	2	2	2	2	1	2	2
15	2	2	1	2	2	2	2	1	2	2
16	2	2	1	2	2	2	2	1	2	2
17	2	2	1	2	2	2	2	1	2	2
18	2	2	1	2	2	2	2	1	2	2
19	2	2	1	2	2	2	2	1	2	2
20	2	2	2	2	2	2	2	1	2	2

DEC.MAKER ACTIVITY HISTORY
20 TIME PERIODS,10 DEC. MAKERS
0=INACTIVE,X=WORKING ON CHOICE X

	1	2	3	4	5	6	7	8	9	10
1	10	10	10	10	10	10	10	10	10	10
2	7	7	7	7	7	7	7	10	10	10
3	7	7	7	9	9	5	5	9	9	10
4	5	5	5	5	5	10	10	10	10	10
5	2	2	5	5	5	10	10	10	10	10
6	3	3	3	5	5	10	10	10	10	10
7	4	4	4	4	5	10	10	10	10	10
8	1	5	5	5	5	10	10	10	10	10
9	6	6	6	6	6	6	10	10	10	10
10	8	8	8	8	8	8	8	8	10	10
11	3	3	3	8	8	8	8	8	0	0
12	2	2	3	8	8	8	8	8	0	0
13	3	3	3	8	8	8	8	8	0	0
14	3	3	3	8	8	8	8	8	0	0
15	3	3	3	8	8	8	8	8	0	0
16	3	3	3	8	8	8	8	8	0	0
17	3	3	3	8	8	8	8	8	0	0
18	8	8	8	8	8	8	8	8	0	0
19	8	8	8	8	8	8	8	8	0	0
20	8	8	8	8	8	8	8	8	0	0

PROBLEM HISTORY:ROWS=TIME,COLS=PROBS., -1=NOT ENTERED,. 0=UNATTACHED,X=ATT.TO CH.X,**=SOLVED

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	-1	-1	-1	-1	-1	-1	-1	10	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	10
2	-1	-1	-1	-1	-1	-1	-1	10	-1	-1	-1	-1	-1	7	-1	10	-1	-1	-1	10
3	-1	-1	-1	-1	-1	7	7	10	-1	-1	-1	-1	-1	7	-1	10	-1	-1	-1	10
4	-1	-1	-1	-1	-1	7	5	10	-1	-1	-1	-1	-1	10	10	10	10	-1	-1	10
5	-1	2	-1	-1	-1	5	5	5	-1	-1	-1	-1	10	10	10	10	10	-1	-1	10
6	-1	2	-1	-1	-1	3	5	5	-1	-1	10	-1	10	10	10	10	10	-1	10	10
7	-1	2	-1	4	-1	3	4	4	5	-1	10	-1	10	10	10	10	10	-1	10	10
8	-1	2	5	5	-1	3	5	5	5	-1	10	10	10	10	10	10	10	-1	10	10
9	6	2	6	6	-1	3	6	6	6	6	6	6	10	10	10	10	10	-1	10	10
10	8	2	8	8	8	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
11	3	2	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
12	2	2	2	2	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
13	3	3	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
14	3	3	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
15	3	3	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
16	3	3	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
17	3	3	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
18	3	3	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
19	3	3	3	3	3	3	8	8	8	8	8	8	8	8	8	8	**	**	**	**
20	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	**	**	**	**

APPENDIX B

COMPUTER PROGRAM AND OUTPUT FOR MOD 1 INFORMATION LOAD

MOD 1

```
$JOB            IC,XREF,EXT
C      THE GARBAGE CAN MODEL. VERSION 5
C      ***
C      IU IS 1 FOR SUMMARY STATISTICS ONLY
C      IU IS 2 FOR SUMMARY STATISTICS PLUS HISTORIES
C      ***
C      NA IS 1 WHEN PROBS AND DMKRS BOTH MOVE
C      NA IS 2 WHEN DMKRS ONLY MOVE
C      NA IS 3 WHEN PROBS ONLY MOVE
C      NA IS 4 WHEN NEITHER PROBS NOR DMKRS MOVE
C      ***
C      IL IS A FACTOR DETERMINING PROB ENERGY REQ
C      ***
C      VARIABLES
C        ***
C        NUMBERS
C            COUNTERS  UPPER LIMITS     NAME
C            ***
C               I             NCH       CHOICES
C               J             NPR       PROBLEM
C               K             NOM       DECMKRS
C               LT            NTP       TIME
C        ***
C        ARRAYS
C            CODE             DIMEN     NAME
C            ***
C            ICH              NCH       CHOICE ENTRY TIME
C            ICS              NCH       CHOICE STATUS
C            JET              NPR       PROB.ENTRY TIME
C            JF               NPR       PROB. ATT. CHOICE
C            JFF              NPR       WORKING COPY JF
C            JPS              NPR       PROB. STATUS
C            KDC              NOM       DMKR. ATT. CHOICE
C            KDCW             NOM       WORKING COPY KDC
C            XEE              NCH       ENERGY EXPENDED
C            XERC             NCH       CHOICE EN. REQT.
C            XSC              NTP       SOLUTION COEFFICIENT
C        ***
C        2-DIMENSIONAL ARRAYS
C            ***
C            CODE             DIMEN     NAME
C            ***
C            IKA              NCH,NOM   DECISION STRUCTURE
C            JIA              NPR,NCH   ACCESS STRUCTURE
C            XEA              NOM,NTP   ENERGY MATRIX
C        ***
C        ***
C        ***
C      ***
C      SUMMARY STATISTICS FOR EACH VARIANT
C            COL  1: KZ: TOTAL DECISIONS NOT MADE
C            COL  2: KY: TOTAL NUMBER ACTIVE CHOICE PERIODS
C            COL  3: KX: TOTAL NUMBER CHANGES BY DECISION MAKERS
C            COL  4: KW: TOTAL PROBLEMS NOT SOLVED
C            COL  5: KV: TOTAL NUMBER CHANGES BY PROBLEMS
C            COL  6: KU: TOTAL NUMBER LATENT PROBLEM PERIODS
C            COL  7: KT: TOTAL NUMBER ATTACHED PROBLEM PERIODS
C            COL  8: KS: TOTAL NUMBER PERIODS DMKRS RESTING
C            COL  9: XR: TOTAL AMOUNT OF UNUSED ENERGY
C            COL 10: XS: TOTAL AMOUNT OF WASTED ENERGY
```

```
C        ***
C        INPUT BLOCK, READ-IN AND INITIALIZATIONS.
         CIMENSICN ICH(20),JF(20),XERC(20),XEE(20),XSC(20),JFF(20),XERP(20
        *),JET(20),JPS(20),ICS(20),KDC(20),KDCW(20),JIA(20,20),IKA(20,20),
        *XEA(20,20),KADC(20,20),KBDC(20,20),KCBC(20,20)
 1001    FORMAT(5(I3,1X))
 1002    FORMAT(10(I3,1X))
 1003    FORMAT(25(I1,1X))
 1004    FORMAT(10F4.2)
         NTP=20
         NCH=10
         NPR=20
         NDM=10
  8      READ(5,1002)(ICH(I),I=1,NCH)
         READ(5,1004)(XSC(LI),LI=1,NTP)
         READ(5,1002)(JET(J),J=1,NPR)
         READ(5,1003) NA,IO
         WRITE(6,1050) NA
 1050    FORMAT('      DEC.MAKER MOVEMENT CONDITION (NA) IS  ',I1/)
         DO 997 JAE=1,3
         JA=JAE-1
         DO 996 JOE=1,3
         JO=JOE-1
         DO 995 JEE=1,3
         JE=JEE-1
         IL=1
         IB=IL-1
         XR=0.0
         XS=0.0
         KS=0
         ZEBRA=1.1
         DO 10 I=1,NCH
         XERC(I)=1.1
         XEE(I)=0.0
  10     ICS(I)=0
         DO 20 K=1,NCM
         KDC(K)=0
  20     KDCW(K)=KDC(K)
         DO 40 J=1,NPR
         XERP(J)=1.0*1.1
         JF(J)=0
         JFF(J)=0
  40     JPS(J)=0
C        SETTING OF THE DECISION MAKERS ACCESS TO CHOICES
         DO 520 I=1,NCH
         DO 510 J=1,NDM
         IKA(I,J)=1
         IF(JC.EQ.1) GO TO 502
         IF(JC.EQ.2) GO TO 504
         GO TO 510
 502     IF(I.GE.J) GO TO 510
         IKA(I,J)=0
         GO TO 510
 504     IF(J.EQ.I) GO TO 510
         IKA(I,J)=0
 510     CONTINUE
 520     CONTINUE
C        SETTING UP THE PROBLEMS ACCESS TO CHOICES
         DO 560 I=1,NPR
         DO 550 J=1,NCH
```

```
      JIA(I,J)=0
      IF(JA.EQ.1) GO TO 532
      IF(JA.EQ.2) GO TO 534
      JIA(I,J)=1
      GO TO 550
  532 IF((I-J).GT.(I/2)) GO TO 550
      JIA(I,J)=1
      GO TO 550
  534 IF(I.NE.(2*J)) GO TO 550
      JIA(I,J)=1
      JIA(I-1,J)=1
  550 CONTINUE
  560 CONTINUE
      DO 590 I=1,NDM
      DO 580 J=1,NTP
      XEA(I,J)=0.55
      IF(JE.EQ.1)GO TO 580
      XXA=I
      IF(JE.EQ.0)GO TO 570
      XEA(I,J)=(11.0-XXA)/10.0
      GO TO 580
  570 XEA(I,J)=XXA/10.0
 580  CONTINUE
 590  CONTINUE
C     *** FINISH READ INITIALIZATION
      DO 994 LT=1,NTP
      IF(LT.GE.2.OR.LT.LE.8) GO TO 90
      GO TO 102
 90   IF(LT.NE.2.AND.LT.NE.8) GO TO 91
      ZEBRA=1.5
      GO TO 99
 91   IF(LT.NE.3.AND.LT.NE.7) GO TO 92
      ZEBRA=2.0
      GO TO 99
 92   IF(LT.NE.4.AND.LT.NE.6) GO TO 93
      ZEBRA=2.6
      GO TO 99
 93   IF(LT.NE.5) GO TO 94
      ZEBRA=3.6
      GO TO 99
 94   GO TO 102
 99   DO 100 J=1,NPR
      XERP(J)=ZEBRA
 100  CONTINUE
 102  CONTINUE
 1006 FORMAT(2X,6HCHOICE,2X,I3,2X,6HACTIVE )
C     CHOICE ACTIVATION
      DO 101 I=1,NCH
      IF(ICH(I).NE.LT) GO TO 101
      ICS(I)=1
  101 CONTINUE
C     PROB. ACTIVATION
      DO 110 J=1,NPR
      IF (JET(J).NE.LT) GO TO 110
      JPS(J)=1
  110 CONTINUE
C     FIND MOST ATTRACTIVE CHOICE FOR PROBLEM J
      DO 120 J=1,NPR
      IF (JPS(J).NE.1) GO TO 120
      IF(NA.EQ.2) GO TO 125
```

```
      IF(NA.EQ.4) GO TO 125
      GO TO 126
  125 IF(JF(J).NE.0) GO TO 127
  126 S=1000000
      DO 121 I=1,NCH
      IF (ICS(I).NE.1) GO TO 121
      IF(JIA(J,I).EQ.0) GO TO 121
      IF(JF(J).EQ.0) GO TO 122
      IF(JF(J).EQ.1) GO TO 122
      IF((XERP(J)+XERC(I)-XEE(I)).GE.S)GO TO 121
      GO TO 123
  122 IF((XERC(I)-XEE(I)).GE.S) GO TO 121
       S=XERC(I)-XEE(I)
      GO TO 124
  123 S=XERP(J)+XERC(I)-XEE(I)
 124  JFF(J)=I
 121  CONTINUE
      GO TO 120
  127 JFF(J)=JF(J)
  120 CONTINUE
      DO 130 J=1,NPR
  131 JF(J)=JFF(J)
  130 JFF(J)=0
      LTT=LT-1
      IF(LT.EQ.1)LTT=1
C     FIND MOST ATTRACTIVE CHOICE FOR DMKR K
      DO 140 K=1,NCM
      IF(NA.EQ.3) GO TO 145
      IF(NA.EQ.4) GO TO 145
      GO TO 146
  145 IF(KCC(K).NE.0) GO TO 147
  146 S=1000000
      DO 141 I=1,NCH
      IF(ICS(I).NE.1) GO TO 141
      IF(IKA(I,K).EQ.0) GO TO 141
      IF(KDC(K).EQ.0) GO TO 142
      IF(KDC(K).EQ.1) GO TO 142
  148 IF((XERC(I)-XEE(I)-(XEA(K,LTT)*XSC(LTT))).GE.S)GO TO 141
      GO TO 143
  142 IF((XERC(I)-XEE(I)).GE.S) GO TO 141
      S=XERC(I)-XEE(I)
      GO TO 144
  143 S=XERC(I)-XEE(I)-XEA(K,LTT)*XSC(LTT)
  144 KDCW(K)=I
  141 CONTINUE
      GO TO 140
  147 KDCW(K)=KCC(K)
  140 CONTINUE
      DO 150 K=1,NCM
  151 KDC(K)=KCCW(K)
      IF(KCC(K).NE.0) GO TO 150
      XR=XR+(XEA(K,LT)*XSC(LT))
      KS=KS+1
  150 KDCW(K)=0
C     ESTABLISHING THE ENERGY REQUIRED TO MAKE EACH CHOICE.
      DO 155 I=1,NCH
      IF(ICS(I).EQ.0) GO TO 199
      XERC(I)=0.0
      DO 160 J=1,NPR
      IF(JPS(J).NE.1) GO TO 160
```

```
      IF(JF(J).NE.1)GO TO 160
      XERC(I)=XERC(I)+XERP(J)
  160 CONTINUE
      DO 170 K=1,NDM
      IF(IKA(I,K).EQ.0) GO TO 170
      IF(KDC(K).NE.1) GO TO 170
      XEE(I)=XEE(I)+XSC(LT)*XEA(K,LT)
  170 CONTINUE
  199 CONTINUE
C     MAKING DECISIONS
      DO 299 I=1,NCH
      IF (ICS(I).NE.1) GO TO 299
      IF(XERC(I).GT.XEE(I))GO TO 299
      XS=XS+XEE(I)-XERC(I)
      ICS(I)=2
      DO 250 J=1,NPR
      IF(JF(J).NE.1) GO TO 250
      JPS(J)=2
  250 CONTINUE
      IF(NA.EQ.3) GO TO 261
      IF(NA.EQ.4) GO TO 261
      GO TO 299
  261 DO 262 K=1,NDM
      IF(KCC(K).NE.1) GO TO 262
      KDCW(K)=1
  262 CONTINUE
 299  CONTINUE
      DO 200 I=1,NCH
  200 KABC(LT,I)=ICS(I)
      DO 210 K=1,NDM
      KDBC(LT,K)=KDC(K)
      IF(KDCW(K).EQ.0) GO TO 210
      KDC(K)=0
  210 KDCW(K)=0
      DO 220 J=1,NPR
      KCBC(LT,J)=JF(J)
      IF(JPS(J).EQ.0) GO TO 230
      IF(JPS(J).EQ.1) GO TO 220
      KCBC(LT,J)=1000
      GO TO 220
  230 KCBC(LT,J)=-1
 220  CONTINUE
 994  CONTINUE
C     FINISH TIME PERIOD LOOP. BEGIN ACCUMULATION OF 10 SUMMARY STATISTICS
      KZ=0
      KY=0
      KX=0
      KW=0
      KV=0
      KU=0
      KT=0
      DO 310 I=1,NIP
      DO 320 J=1,NCH
      IF(KABC(I,J).NE.1) GO TO 320
      KY=KY+1
      IF(I.NE.NIP) GO TO 320
      KZ=KZ+1
  320 CONTINUE
  310 CONTINUE
      DO 330 I=2,NIP
```

```
      DO 34C J=1,NOM
      IF(KBBC(I,J).EQ.KBBC(I-1,J)) GO TO 340
      KX=KX+1
  340 CONTINUE
  330 CONTINUE
      DO 350 I=1,NIP
      DO 36C J=1,NPR
      IF(KCBC(I,J).EQ.0) GC TO 351
      IF(KCBC(I,J).EQ.-1) GC TO 360
      IF(KCBC(I,J).EQ.1000) GO TO 352
      KT=KT+1
      GO TC 36C
  351 KU=KU+1
      GO TC 360
  352 IF(I.NE.NIP) GO TO 36C
      KW=KW+1
  360 CONTINUE
  350 CONTINUE
      KW=NPR-KW
      DO 37C I=2,NIP
      DO 38C J=1,NPR
      IF(KCBC(I,J).EQ.KCBC(I-1,J)) GO TO 380
      KV=KV+1
  380 CONTINUE
  370 CONTINUE
C     BEGIN WRITEOUT OF MATERIALS FOR THIS ORGANIZATIONAL VARIANT.
 1000 FORMAT(1H1)
 1019 FORMAT(2X,'LCAD=',I1,' PR.ACC.=',I1,' DEC.STR.=',I1,' EN.CIST.=',
     *I1,2X,'STATS 1-1C',3X,8I5,1X,2F6.2/)
      WRITE(6,1C19)IB,JA,JC,JE,KZ,KY,KX,KW,KV,KU,KT,KS,XR,XS
      IF(IU.EQ.1) GO TO 995
 2000 FORMAT(' CHOICE ACTIVATION HISTORY',34X,'DEC.MAKER ACTIVITY HISTOR
     *Y'/' 20 TIME PERIODS,10 CHOICES',33X,'20 TIME PERIODS,10 DEC. MAKE
     *RS'/' 0=INACTIVE,1=ACTIVE,2=MADE',33X,'0=INACTIVE,X=WORKING ON CHO
     *ICE X'//9X,' 1 2 3 4 5 6 7 8 9 10',30X,'1 2 3 4 5 6 7 8 9 10'/)
      WRITE(6,2C00)
 2001 FORMAT( 5X,I2,3X,10I2,25X,I2,3X,10I2)
      WRITE(6,2001)(LT,(KABC(LT,J),J=1,NCH),LT,( KBBC(LT,J),J=1,NOM),
     * LT=1,NIP )
 2002 FORMAT(/' PROBLEM HISTORY:ROWS=TIME,COLS=PROBS., -1=NOT ENTERED,.
     *0=UNATTACHED,X=ATT.TC CH.X,**=SOLVED'/10X,
     *' 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20'/)
      WRITE(6,2C02)
 2003 FORMAT((20(5X,I2,3X,20(1X,I2)/)))
      WRITE(6,2C03)(LT,(KCBC(LT,J),J=1,NPR),LT=1,NTP)
      WRITE(6,1C00)
  995 CONTINUE
  996 CONTINUE
  997 CONTINUE
      STOP
      END
**WARNING**  FORMAT STATEMENT   1001 IS UNREFERENCED
**WARNING**  FORMAT STATEMENT   1006 IS UNREFERENCED

                              *** WATFIV CROSS REFERENCE ***

*** '#' INDICATES VARIABLE DID NOT APPEAR IN A TYPE STATEMENT

    VARIABLE     - REFERENCES
```

```
*I      *#   10   28   29   30   31   40   42   46   47   49   50   53   55   58   60   61   63   64   65
             68   70   72   74   76  100  101  102  115  116  117  115  120  122  123  125  126  142  143
            144  146  147  149  150  152  153  164  165  166  169  170  173  174  175  178  179  180  181
            182  184  191  155  196  218  220  222  226  228  232  234  235  236  241  246  248
*IB     *#   23  254
*ICH    *#    1   10  101
*ICS    *#    1   31  102  116  143  165  179  182  196
*IKA    *#    1   42   47   50  144  173
*IL     *#   22   23   36
*IC     *#   13  255
*J      *#   12   35   36   37   38   39   41   42   46   47   49   50   54   55   58   60   61   63   64
             65   69   70   74   76   95   96  104  105  106  108  109  113  117  118  119  120  125  126
            129  131  132  133  167  168  169  170  183  184  185  202  203  204  205  206  208  219  220
            227  228  233  234  235  236  247  248  259  263
*JA     *#   17   56   57  254
*JAB    *#   16   17
*JC     *#   19   43   44  254
*JCB    *#   18   19
*JE     *#   21   71   73  254
*JEB    *#   20   21
*JET    *#    1   12  105
*JF     *#    1   37  113  118  119  129  132  169  184  203
*JFF    *#    1   38  126  129  132  133
*JIA    *#    1   55   58   61   64   65  117
*JPS    *#    1   39  106  109  168  185  204  205
*K      *#   32   33   34  136  140  144  145  146  147  152  153  156  158  155  160  161  163  172  173
            174  175  190  151  192  197  198  199  200  201
*KABC   *#    1  196  220  259
*KBBC   *#    1  158  228  259
*KCBC   *#    1  203  206  208  234  235  236  248  263
*KCC    *#    1   33   34  140  145  146  156  159  160  174  191  198  200
*KCCW   *#    1   34  153  156  159  163  192  199  201
*KS     *#   26  162  254
*KT     *#  217  237  254
*KU     *#  216  239  254
*KV     *#  215  249  254
*KW     *#  214  242  245  254
*KX     *#  213  229  254
*KY     *#  212  221  254
*KZ     *#  211  223  254
*LT     *#   11   79   80   82   85   88   91  101  105  134  135  161  175  196  198  203  206  208  259
            263
*LII    *#  134  135  147  152
*NA     *#   13   14  110  111  137  138  187  188
*NCH    *#    7   10   28   40   54  100  115  142  164  178  195  215  259
*NCP    *#    9   32   41   68  136  158  172  150  197  227  259
*NPR    *#    8   12   35   53   95  104  108  131  167  183  202  233  245  247  263
*NTP    *#    6   11   69   79  218  222  226  232  241  246  259  263
*S      *#  114  120  122  123  125  141  147  149  150  152
*XEA    *#    1   70   74   76  147  152  161  175
*XEE    *#    1   30  120  122  123  125  147  143  150  152  175  180  181
*XEHC   *#    1   29  120  122  123  125  147  149  150  152  166  170  180  181
*XEFP   *#    1   36   96  120  125  170
*XR     *#   24  161  254
*XS     *#   25  181  254
*XSC    *#    1   11  147  152  161  175
*XXA    *#   72   74   76
*ZEERA  *#   27   83   86   89   92   96
```

STATEMENT NUMBER - REFERENCES

8	10					
10	28	31				
20	32	34				
40	35	39				
90	80	82				
91	82	85				
92	85	88				
93	88	91				
94	91	94				
99	84	87	90	93	95	
100	95	97				
101	100	101	103			
102	81	94	98			
110	104	105	107			
120	108	109	128	130		
121	115	116	117	120	122	127
122	118	119	122			
123	121	125				
124	124	126				
125	110	111	113			
126	112	114				
127	113	129				
130	131	133				
131	132					
140	136	155	157			
141	142	143	144	147	149	154
142	145	146	145			
143	148	152				
144	151	153				
145	137	138	140			
146	139	141				
147	140	156				
148	147					
150	158	160	163			
151	159					
160	167	168	165	171		
170	172	173	174	176		
199	164	165	177			
200	195	196				
210	197	199	201			
220	202	205	207	209		
230	204	208				
250	183	184	186			
261	187	188	190			
262	190	191	193			
299	178	179	180	189	194	
310	218	225				
320	219	220	222	224		
330	226	231				
340	227	228	230			
350	232	244				
351	234	239				
352	236	241				
360	233	235	238	240	241	243
370	246	251				
380	247	248	250			
502	43	46				
504	44	45				

```
*    510*    41    45    46    48    49    51
*    520*    40    52
*    532*    56    60
*    534*    57    63
*    550*    54    59    60    62    63    66
*    560*    53    67
*    570*    73    76
*    580*    69    71    75    77
*    590*    68    78
*    994*    79   210
*    995*    20   255   265
*    996*    18   266
*    997*    16   267
*   1000*   252   264
*   1001*     2
*   1002*     3    10    12
*   1003*     4    13
*   1004*     5    11
*   1006*    99
*   1019*   253   254
*   1050*    14    15
*   2000*   256   257
*   2001*   258   259
*   2002*   260   261
*   2003*   262   263

                              *** END OF WATFIV CRCSS REFERENCE ***
    $ENTRY
```

LOAD=0 PR.ACC.=1 DEC.STR.=1 EN.DIST.=0 STATS 1-10 0 27 63 2 52 27 108 70 31.61 8.19

CHOICE ACTIVATION HISTORY
20 TIME PERIODS,10 CHOICES
C=INACTIVE,1=ACTIVE,2=PAGE

	1	2	3	4	5	6	7	8	9	10
1	0	C	C	0	0	0	1	0	0	2
2	0	C	C	0	0	C	2	0	0	2
3	0	0	C	0	1	0	2	0	1	2
4	0	0	0	0	2	0	2	0	1	2
5	0	1	0	0	2	0	2	0	1	2
6	0	1	1	0	2	C	2	C	1	2
7	1	1	1	1	2	C	2	C	1	2
8	2	1	1	1	2	C	2	C	1	2
9	2	1	2	1	2	1	2	1	2	2
10	2	1	2	2	2	1	2	2	2	2
11	2	1	2	2	2	1	2	2	2	2
12	2	2	2	2	2	1	2	2	2	2
13	2	2	2	2	2	1	2	2	2	2
14	2	2	2	2	2	1	2	2	2	2
15	2	2	2	2	2	1	2	2	2	2
16	2	2	2	2	2	1	2	2	2	2
17	2	2	2	2	2	2	2	2	2	2
18	2	2	2	2	2	2	2	2	2	2
19	2	2	2	2	2	2	2	2	2	2
20	2	2	2	2	2	2	2	2	2	2

DEC.MAKER ACTIVITY HISTORY
20 TIME PERIODS,10 DEC. MAKERS
O=INACTIVE,X=WORKING ON CHOICE X

	1	2	3	4	5	6	7	8	9	10
1	10	10	10	10	10	10	10	10	10	10
2	7	7	7	7	7	7	7	0	0	0
3	9	9	9	9	9	5	5	9	9	0
4	5	5	5	5	5	9	9	9	9	0
5	2	2	9	9	9	9	9	9	9	0
6	3	3	3	9	9	5	5	9	9	0
7	4	4	4	4	9	9	9	9	9	0
8	1	3	3	4	9	9	9	9	9	0
9	4	4	4	6	6	6	9	9	9	0
10	6	6	6	6	6	6	8	8	0	0
11	2	2	6	6	6	6	0	0	0	0
12	6	6	6	6	6	6	0	0	0	0
13	6	6	6	6	6	6	0	0	0	0
14	6	6	6	6	6	6	0	0	0	0
15	6	6	6	6	6	6	0	0	0	0
16	6	6	6	6	6	6	0	0	0	0
17	6	6	6	6	6	6	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0

PROBLEM HISTORY:ROWS=TIME,COLS=PROBS., -1=NOT ENTERED,. 0=UNATTACHED,X=ATT.TO CH.X,**=SOLVED

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	-1	-1	-1	-1	-1	-1	-1	**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**
2	-1	-1	-1	-1	-1	-1	-1	**	-1	-1	-1	-1	-1	**	-1	0	-1	-1	-1	**
3	-1	-1	-1	-1	-1	5	9	**	-1	-1	-1	-1	-1	**	-1	9	-1	-1	-1	**
4	-1	-1	-1	-1	-1	5	9	**	-1	-1	-1	-1	-1	**	9	9	9	-1	-1	**
5	-1	2	-1	-1	-1	9	9	**	-1	-1	-1	-1	9	**	9	9	9	-1	-1	**
6	-1	2	-1	-1	-1	3	9	**	-1	-1	9	-1	9	**	9	9	9	-1	0	**
7	-1	2	-1	4	-1	3	4	**	5	-1	9	-1	9	**	9	9	9	-1	0	**
8	-1	2	3	3	-1	3	4	**	5	-1	9	9	9	**	9	9	9	-1	0	**
9	4	2	4	4	-1	4	4	**	**	6	**	**	**	**	**	**	**	-1	0	**
10	6	2	6	6	6	6	6	**	**	6	**	**	**	**	**	**	**	0	0	**
11	2	2	2	2	6	6	6	**	**	6	**	**	**	**	**	**	**	0	0	**
12	6	6	6	6	6	6	6	**	**	6	**	**	**	**	**	**	**	0	0	**
13	6	6	6	6	6	6	6	**	**	6	**	**	**	**	**	**	**	0	0	**
14	6	6	6	6	6	6	6	**	**	6	**	**	**	**	**	**	**	0	0	**
15	6	6	6	6	6	6	6	**	**	6	**	**	**	**	**	**	**	0	0	**
16	6	6	6	6	6	6	6	**	**	6	**	**	**	**	**	**	**	0	0	**
17	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	0	0	**
18	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	0	0	**
19	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	0	0	**
20	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	0	0	**

APPENDIX C

COMPUTER PROGRAM AND OUTPUT FOR MOD 2 INFORMATION LOAD

MOD 2

```
$JOB            IC,NREF,EXT
C      THE GARBAGE CAN MODEL. VERSION 5
C      ***
C      IO IS 1 FOR SUMMARY STATISTICS ONLY
C      IO IS 2 FOR SUMMARY STATISTICS PLUS HISTORIES
C      ***
C      NA IS 1 WHEN PROBS AND DMKRS BOTH MOVE
C      NA IS 2 WHEN DMKRS ONLY MOVE
C      NA IS 3 WHEN PROBS ONLY MOVE
C      NA IS 4 WHEN NEITHER PROBS NOR DMKRS MOVE
C      ***
C      IL IS A FACTOR DETERMINING PROB ENERGY REQ
C      ***
C      VARIABLES
C          ***
C          NUMBERS
C                COUNTERS  UPPER LIMITS     NAME
C                ***
C                   I           NCH        CHOICES
C                   J           NPR        PROBLEM
C                   K           NDM        DECMKRS
C                   LT          NTP        TIME
C          ***
C          ARRAYS
C                CODE           DIMEN      NAME
C                ***
C                ICH            NCH        CHOICE ENTRY TIME
C                ICS            NCH        CHOICE STATUS
C                JET            NPR        PROB.ENTRY TIME
C                JF             NPR        PROB. ATT. CHOICE
C                JFF            NPR        WORKING COPY JF
C                JPS            NPR        PROB. STATUS
C                KCC            NDM        DMKR. ATT. CHOICE
C                KCCW           NDM        WORKING COPY KCC
C                XEE            NCH        ENERGY EXPENDED
C                XERC           NCH        CHOICE EN. REQT.
C                XSC            NTP        SOLUTION COEFFICIENT
C          ***
C          2-DIMENSIONAL ARRAYS
C                ***
C                CODE           DIMEN      NAME
C                ***
C                IKA            NCH,NDM    DECISION STRUCTURE
C                JIA            NPR,NCH    ACCESS STRUCTURE
C                XEA            NDM,NTP    ENERGY MATRIX
C          ***
C          ***
C          ***
C      ***
C      SUMMARY STATISTICS FOR EACH VARIANT
C                COL  1: KZ: TOTAL DECISIONS NOT MADE
C                COL  2: KY: TOTAL NUMBER ACTIVE CHOICE PERIODS
C                COL  3: KX: TOTAL NUMBER CHANGES BY DECISION MAKERS
C                COL  4: KW: TOTAL PROBLEMS NOT SOLVED
C                COL  5: KV: TOTAL NUMBER CHANGES BY PROBLEMS
C                COL  6: KU: TOTAL NUMBER LATENT PROBLEM PERIODS
C                COL  7: KT: TOTAL NUMBER ATTACHED PROBLEM PERIODS
C                COL  8: KS: TOTAL NUMBER PERIODS DMKRS RESTING
C                COL  9: XR: TOTAL AMOUNT OF UNUSED ENERGY
C                COL 10: XS: TOTAL AMOUNT OF WASTED ENERGY
```

```
C      ***
C      INPUT BLOCK, READ-IN AND INITIALIZATIONS.
       DIMENSION ICH(20),JF(20),XERC(20),XEE(20),XSC(20),JFF(20),XERP(20
      *),JET(20),JFS(20),ICS(20),KDC(20),KDCM(20),JIA(20,20),IKA(20,20),
      *XLA(20,20),KABC(20,20),KBBC(20,20),KCBC(20,20)
 1001  FORMAT(5(I3,1X))
 1002  FORMAT(10(I3,1X))
 1003  FORMAT(25(I1,1X))
 1004  FORMAT(10F4.2)
       NTP=20
       NCH=10
       NPR=20
       NUM=10
  8    READ(5,1002)(ICH(I),I=1,NCH)
       READ(5,1004)(XSC(LI),LI=1,NP)
       READ(5,1002)(JET(J),J=1,NPR)
       READ(5,1003) NA,IU
       WRITE(6,1050) NA
 1050  FORMAT('1         DEC.MAKER MOVEMENT CONDITION (NA) IS   ',I1/)
       DO 997 JAB=1,3
       JA=JAB-1
       DO 996 JDB=1,3
       JD=JDB-1
       DO 995 JEB=1,3
       JE=JEB-1
       IL=1
       IU=IL-1
       XR=0.0
       XS=0.0
       KS=0
       ZEBRA=1.1
       DO 10 I=1,NCH
       XERC(I)=1.1
       XLE(I)=0.0
 10    ICS(I)=0
       DO 20 K=1,NCM
       KDC(K)=0
 20    KDCM(K)=KCC(K)
       DO 40 J=1,NPR
       XERP(J)=IL*1.1
       JF(J)=0
       JFF(J)=0
 40    JPS(J)=0
C      SETTING UP THE DECISION MAKERS ACCESS TO CHOICES
       DO 520 I=1,NCH
       DO 510 J=1,NCM
       IKA(I,J)=1
       IF(JC.EQ.1) GO TO 502
       IF(JC.EQ.2) GO TO 504
       GO TO 510
 502   IF(I.GE.J) GO TO 510
       IKA(I,J)=0
       GO TO 510
 504   IF(J.EQ.I) GO TO 510
       IKA(I,J)=0
 510   CONTINUE
 520   CONTINUE
C      SETTING UP THE PROBLEMS ACCESS TO CHOICES
       DO 560 I=1,NPR
       DO 550 J=1,NCH
```

```
      JIA(I,J)=0
      IF(JA.EQ.1) GO TO 532
      IF(JA.EQ.2) GO TO 534
      JIA(I,J)=1
      GO TO 550
  532 IF((I-J).GT.(I/2)) GO TO 550
      JIA(I,J)=1
      GO TO 550
  534 IF(I.NE.(2*J)) GO TO 550
      JIA(I,J)=1
      JIA(I-1,J)=1
  550 CONTINUE
  560 CONTINUE
      DO 590 I=1,NCH
      DO 580 J=1,NIP
      XEA(I,J)=0.55
      IF(JE.EQ.1)GO TO 580
      XXA=I
      IF(JE.EQ.0)GO TO 570
      XEA(I,J)=(11.0-XXA)/10.0
      GO TO 580
  570 XEA(I,J)=XXA/10.0
 580  CONTINUE
 590  CONTINUE
C     *** FINISH READ INITIALIZATION
      DO 994 LT=1,NTP
      IF(LT.NE.1) GO TO 93
      GO TO 102
 93   IF(LT.NE.2) GO TO 94
      ZEBRA=ZEBRA+0.1
      GO TO 99
 94   IF(LT.GT.5) GO TO 95
      ZEBRA=ZEBRA+0.2
      GO TO 99
 95   IF(LT.GT.8) GO TO 96
      ZEBRA=ZEBRA+0.3
      GO TO 99
 96   IF(LT.NE.9) GO TO 97
      ZEBRA=ZEBRA+0.4
      GO TO 99
 97   IF(LT.NE.10) GO TO 98
      ZEBRA=ZEBRA+.5
      GO TO 99
 98   GO TO 102
 99   DO 100 J=1,NPR
      XERP(J)=ZEBRA
 100  CONTINUE
 102  CONTINUE
 1006 FORMAT(2X,6HCHOICE,2X,I3,2X,6HACTIVE )
C     CHOICE ACTIVATION
      DO 101 I=1,NCH
      IF(ICH(I).NE.LT) GO TO 101
      ICS(I)=1
  101 CONTINUE
C     PROB. ACTIVATION
      DO 110 J=1,NPR
      IF (JET(J).NE.LT) GO TO 110
      JPS(J)=1
  110 CONTINUE
C     FIND MOST ATTRACTIVE CHOICE FOR PROBLEM J
```

```
      DO 120 J=1,NPR
      IF (JPS(J).NE.1) GO TO 120
      IF(NA.EQ.2) GO TO 125
      IF(NA.EQ.4) GO TO 125
      GO TO 126
  125 IF(JF(J).NE.0) GO TO 127
  126 S=1000000
      DO 121 I=1,NCH
      IF (ICS(I).NE.1) GO TO 121
      IF(JIA(J,I).EQ.0) GO TO 121
      IF(JF(J).EQ.0) GO TO 122
      IF(JF(J).EQ.1) GO TO 122
      IF((XERP(J)+XERC(I)-XEE(I)).GE.S)GO TO 121
      GO TO 123
  122 IF((XERC(I)-XEE(I)).GE.S) GO TO 121
       S=XERC(I)-XEE(I)
      GO TO 124
  123 S=XERP(J)+XERC(I)-XEE(I)
 124  JFF(J)=I
 121  CONTINUE
      GO TO 120
  127 JFF(J)=JF(J)
  120 CONTINUE
      DO 130 J=1,NPR
  131 JF(J)=JFF(J)
  130 JFF(J)=0
      LTT=LT-1
      IF(LT.EQ.1)LTT=1
C     FIND MOST ATTRACTIVE CHOICE FOR DMKR K
      DO 140 K=1,ND4
      IF(NA.EQ.3) GO TO 145
      IF(NA.EQ.4) GO TO 145
      GO TO 146
  145 IF(KDC(K).NE.0) GO TO 147
  146 S=1000000
      DO 141 I=1,NCH
      IF(ICS(I).NE.1) GO TO 141
      IF(IKA(I,K).EQ.0) GO TO 141
      IF(KDC(K).EQ.0) GO TO 142
      IF(KDC(K).EQ.I) GO TO 142
  140 IF((XERC(I)-XEE(I)-(XEA(K,LTT)*XSC(LTT))).GE.S)GO TO 141
      GO TO 143
  142 IF((XERC(I)-XEE(I)).GE.S) GO TO 141
      S=XERC(I)-XEE(I)
      GO TO 144
  143 S=XERC(I)-XEE(I)-XEA(K,LTT)*XSC(LTT)
  144 KDCW(K)=I
  141 CONTINUE
      GO TO 140
  147 KDCW(K)=KDC(K)
  140 CONTINUE
      DO 150 K=1,ND4
  151 KDC(K)=KDCW(K)
      IF(KDC(K).NE.0) GO TO 150
      XR=XR+(XEA(K,LTT)*XSC(LTT))
      KS=KS+1
  150 KDCW(K)=0
C     ESTABLISHING THE ENERGY REQUIRED TO MAKE EACH CHOICE.
      DO 155 I=1,NCH
      IF(ICS(I).EQ.0) GO TO 199
```

```
      XERC(I)=0.0
      DO 160 J=1,NPR
      IF(JPS(J).NE.1) GO TO 160
      IF(JF(J).NE.I)GO TO 160
      XERC(I)=XERC(I)+XERP(J)
  160 CONTINUE
      DO 170 K=1,NCM
      IF(IKA(I,K).EQ.0) GO TO 170
      IF(KDC(K).NE.1) GO TO 170
      XEE(I)=XEE(I)+XSC(LT)*XEA(K,LT)
  170 CONTINUE
  199 CONTINUE
C     MAKING DECISIONS
      DO 295 I=1,NCH
      IF (ICS(I).NE.1) GO TO 299
      IF(XERC(I).GT.XEE(I))GO TO 299
      XS=XS+XEE(I)-XERC(I)
      ICS(I)=2
      DO 250 J=1,NPR
      IF(JF(J).NE.I) GO TO 250
      JPS(J)=2
  250 CONTINUE
      IF(NA.EQ.3) GO TO 261
      IF(NA.EQ.4) GO TO 261
      GO TO 295
  261 DO 262 K=1,NDM
      IF(KCC(K).NE.I) GO TO 262
      KDCW(K)=1
  262 CONTINUE
 299  CONTINUE
      DO 200 I=1,NCH
  200 KABC(LT,I)=ICS(I)
      DO 210 K=1,NDM
      KBBC(LT,K)=KCC(K)
      IF(KDCW(K).EQ.0) GO TO 210
      KDC(K)=0
  210 KDCW(K)=0
      DO 220 J=1,NPR
      KCBC(LT,J)=JF(J)
      IF(JPS(J).EQ.0) GO TO 230
      IF(JPS(J).EQ.1) GO TO 220
      KCBC(LT,J)=1000
      GO TO 220
  230 KCBC(LT,J)=-1
 220  CONTINUE
 994  CONTINUE
C    FINISH TIME PERIOD LOOP. BEGIN ACCUMULATION OF 10 SUMMARY STATISTICS
      KZ=0
      KY=0
      KX=0
      KW=0
      KV=0
      KU=0
      KT=0
      DO 310 I=1,NIP
      DO 320 J=1,NCH
      IF(KABC(I,J).NE.1) GO TO 320
      KY=KY+1
      IF(I.NE.NIP) GO TO 320
      KZ=KZ+1
```

```
  320 CONTINUE
  310 CONTINUE
      DO 330 I=2,NIP
      DO 340 J=1,NOM
      IF(KBBC(I,J).EQ.KBBC(I-1,J)) GO TO 340
      KX=KX+1
  340 CONTINUE
  330 CONTINUE
      DO 350 I=1,NIP
      DO 360 J=1,NPR
      IF(KCBC(I,J).EQ.0) GO TO 351
      IF(KCBC(I,J).EQ.-1) GO TO 360
      IF(KCBC(I,J).EQ.1000) GO TO 352
      KT=KT+1
      GO TO 360
  351 KU=KU+1
      GO TO 360
  352 IF(I.NE.NIP) GO TO 360
      KW=KW+1
  360 CONTINUE
  350 CONTINUE
      KW=NPR-KW
      DO 370 I=2,NIP
      DO 380 J=1,NPR
      IF(KCBC(I,J).EQ.KCBC(I-1,J)) GO TO 380
      KV=KV+1
  380 CONTINUE
  370 CONTINUE
C     BEGIN WRITEOUT OF MATERIALS FOR THIS ORGANIZATIONAL VARIANT.
 1000 FORMAT(1H1)
 1019 FORMAT(2X,'LOAD=',I1,' PR.ACC.=',I1,' DEC.STR.=',I1,' EN.DIST.=',
     *I1,2X,'STATS 1-10',3X,8I5,1X,2F6.2/)
      WRITE(6,1019)IO,JA,JC,JE,KZ,KY,KX,KW,KV,KU,KT,KS,XR,XS
      IF(IO.EQ.1) GO TO 995
 2000 FORMAT(' CHOICE ACTIVATION HISTORY',34X,'DEC.MAKER ACTIVITY HISTOR
     *Y'/' 20 TIME PERIODS,10 CHOICES',33X,'20 TIME PERIODS,10 DEC. MAKE
     *RS'/' 0=INACTIVE,1=ACTIVE,2=MADE',33X,'0=INACTIVE,X=WORKING ON CHO
     *ICE X'//5X,' 1 2 3 4 5 6 7 8 9 10',30X,'1 2 3 4 5 6 7 8 9 10'/)
      WRITE(6,2000)
 2001 FORMAT( 5X,I2,3X,10I2,25X,I2,3X,10I2)
      WRITE(6,2001)(LT,(KABC(LT,J),J=1,NCH),LT,( KBBC(LT,J),J=1,NOM),
     * LT=1,NIP )
 2002 FORMAT(/' PROBLEM HISTORY:ROWS=TIME,COLS=PROBS., -1=NOT ENTERED,.
     *0=UNATTACHED,X=ATT.TO CH.X,**=SOLVED'/10X,
     *' 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20'/)
      WRITE(6,2002)
 2003 FORMAT(20(5X,I2,3X,20(1X,I2)/))
      WRITE(6,2003)(LT,(KCBC(LT,J),J=1,NPR),LT=1,NTP)
      WRITE(6,1000)
  995 CONTINUE
  996 CONTINUE
  997 CONTINUE
      STOP
      END
**WARNING**  FORMAT STATEMENT   1001 IS UNREFERENCED
**WARNING**  FORMAT STATEMENT   1006 IS UNREFERENCED

                                  *** WATFIV CROSS REFERENCE ***
```

```
*** '#' INDICATES VARIABLE DID NOT APPEAR IN A TYPE STATEMENT
    VARIABLE    - REFERENCES
    *I      *#    10   28   29   30   31   40   42   46   47   49   50   53   55   58   60   61   63   64   65
                  68   70   72   74   76  103  104  105  118  115  120  122  123  125  126  128  129  145  146
                 147  145  150  152  153  155  156  167  168  169  172  173  176  177  178  181  182  183  184
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CHOICE ACTIVATION HISTORY
20 TIME PERIODS,10 CHOICES
0=INACTIVE,1=ACTIVE,2=MADE

	1	2	3	4	5	6	7	8	9	10
1	0	0	0	0	0	0	0	0	0	2
2	0	0	0	0	0	0	2	0	0	2
3	0	0	0	0	0	0	2	0	1	2
4	0	0	0	0	2	0	2	0	1	2
5	0	1	0	0	2	0	2	0	1	2
6	0	1	1	0	2	0	2	0	1	2
7	0	1	1	1	2	0	2	0	1	2
8	2	1	1	1	2	0	2	0	1	2
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16	2	1	2	2	2	2	2	2	1	2
17	2	1	2	2	2	2	2	2	1	2
18	2	1	2	2	2	2	2	2	1	2
19	2	1	2	2	2	2	2	2	1	2
20	2	2	2	2	2	2	2	2	1	2

DEC.MAKER ACTIVITY HISTORY
20 TIME PERIODS,10 DEC. MAKERS
0=INACTIVE,X=WORKING ON CHOICE X

	1	2	3	4	5	6	7	8	9	10
1	10	10	10	10	10	10	10	10	10	10
2	7	7	7	7	7	7	7	0	0	0
3	9	9	9	9	9	9	9	9	9	0
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7	4	4	4	4	9	9	9	9	9	0
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17	2	2	9	9	9	9	9	9	9	0
18	2	2	9	9	9	9	9	9	9	0
19	9	9	9	9	9	9	9	9	9	0
20	9	9	9	9	9	9	9	9	9	0

PROBLEM HISTORY:ROWS=TIME,COLS=PROBS., -1=NOT ENTERED, 0=UNATTACHED,X=ATT.TO CH.X,**=SOLVED

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	-1	-1	-1	-1	-1	-1	-1	**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	**
2	-1	-1	-1	-1	-1	-1	-1	**	-1	-1	-1	-1	-1	**	-1	0	-1	-1	-1	**
3	-1	-1	-1	-1	-1	9	9	**	-1	-1	-1	-1	-1	**	-1	9	-1	-1	-1	**
4	-1	-1	-1	-1	-1	9	9	**	-1	-1	-1	-1	-1	**	9	9	9	-1	-1	**
5	-1	2	-1	-1	-1	9	9	**	-1	-1	-1	-1	9	**	9	9	9	-1	-1	**
6	-1	2	-1	-1	-1	3	9	**	-1	-1	9	-1	9	**	9	9	9	-1	0	**
7	-1	2	-1	4	-1	3	4	**	9	-1	9	-1	9	**	9	9	9	-1	0	**
8	-1	2	3	4	-1	3	4	**	9	-1	9	9	9	**	9	9	9	-1	0	**
9	6	2	6	6	-1	6	6	**	6	6	6	6	9	**	9	9	9	-1	0	**
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18	2	2	2	2	9	9	9	**	9	9	9	9	9	**	9	9	9	9	0	**
19	2	2	2	2	9	9	9	**	9	9	9	9	9	**	9	9	9	9	0	**
20	9	9	9	9	9	9	9	**	9	9	9	9	9	**	9	9	9	9	0	**

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