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Guidelines for Automating Command and Control Functions in Field Units

ARI Field Unit at Fort Leavenworth, Kansas

SYSTEMS RESEARCH LABORATORY

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to describing the basic principles that apply to the use of computer support into information systems in general, and to military systems in particular, this document also provides a section on information system theory and terminology.



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FOREWORD

The Army Research Institute for the Behavioral and Social Sciences (ARI) maximizes combat effectiveness through research in the acquisition, development, training, and utilization of soldiers in military systems. The ARI Field Unit at Ft Leavenworth supports the Combined Arms Center by developing research products designed to increase the combat effectiveness of command groups and command staff operations by improving command and control performance capabilities. Of special interest is research in the use of automation to improve command and control operations.

The Combined Arms Center is responsible for integrating efforts to develop automated command and control systems, to include informal efforts, characterized as field unit initiatives. The Army Command and Control Initiatives Program (TACIP) was established to capitalize on the experience and lessons learned of field units experimenting in automation. As the various Corps and Division initiatives got underway one common problem began to emerge. This involved the lack of readily available practical guidance on how to go about the system development process within the context of command and control operations. In response to this need, the Combined Arms Center requested that ARI summarize the findings of their past and ongoing projects in order to develop guidelines for automating command and control functions in field units. The product would be a manual that would describe known concepts and principles useful to field units in their desire to develop automation support for command and control. It is towards this end that this document was developed. More specifically, this document describes the command and control process in information system terms. Information system tools and techniques are described and discussed to show their utility in guiding selected changes to the procedures, organization, personnel and technological components of the command and control system in order to enhance its effectiveness. The guidelines presented were designed to assist field users in smoothing the transition to new systems by providing insights into the problem of building man-machine systems which take full advantage of all system components, and by providing tools which can be used to accomplish the necessary system integration.

The application of principles set forth in this document will assist users in achieving more quickly the improved command and control performance standards inherent in Future Battle Doctrine.



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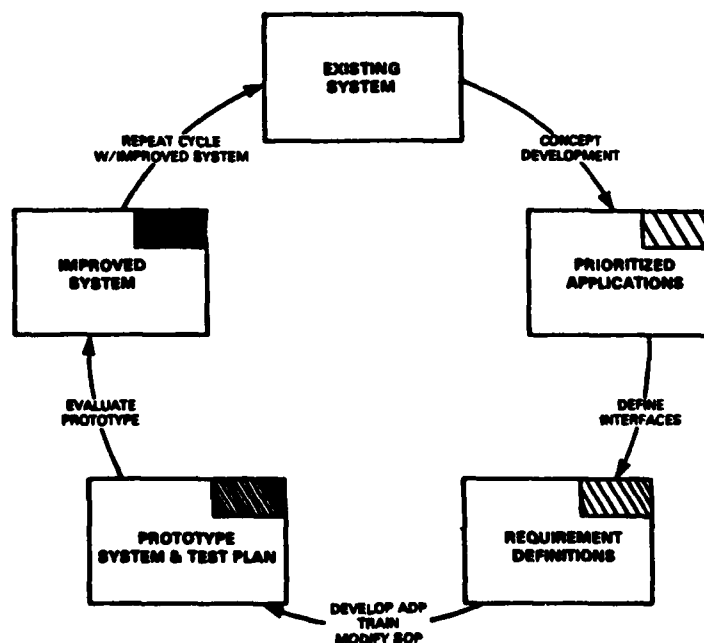
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EXECUTIVE SUMMARY

This manual has been prepared to assist officers in the field who are wrestling with the problem of incorporating automation into command and control functions in an endeavor to meet the significantly improved performance standards inherent in the Airland Battle Doctrine. It is based on the experience of others who have already been involved in that endeavor. It contains information that should be useful to commanders, staff officers and especially the project officers charged with the task of overseeing the introduction of computer support into units in the field. It is not designed to teach the elements of computer programming or software design. Experts can be found to do those tasks. Rather, it is designed to provide insights into the problem of building man-machine systems which take advantage of new tools that provide previously unavailable capabilities to help tactical decision makers in their performance of command and control operations. It cannot at this stage be as detailed or prescriptive as a maintenance manual or even a manual on tactical operations. In effect, your unit is about to embark on an experiment to find out how automation can best assist you. It does, however, provide suggestions and describes some techniques which can assist you in conducting this experiment in a rational, effective manner.

This manual consists of three sections. The first is a brief introduction. Section 2 is the "How to" portion of the manual. Described in it are basic principles that apply to the introduction of computer support into information systems in general, and to military systems in particular. It is the distillation of experiences of Tactical Command and Control Initiatives Program (TACIP) participants and participants in other Army, OSD, and private sector automation programs. Section 3 is a description of the tactical command and control (C²) system in information system terms. The description proceeds by postulating and answering nine questions about the tactical C² system. In doing so a model of the operations of a TOC in information processing terms is developed for use as a descriptive tool in designing a combined man-machine system which will exploit computer support to facilitate and improve C² performance. The parallel between this model and the decision process described in FM 101-5 is stressed. A general discussion is also provided of some needed improvements in C² and points out how automation can help implement these needed improvements. Section 3 was included for those officers who may be unfamiliar with information system theory and terminology. Review of it provides the foundation or basis for more thorough understanding of the principles and concepts discussed in Section 2. This discussion of "theory" was intentionally placed after the "practice" material to allow readers already familiar with the theory to proceed directly to the substance of the manual.

Section 2, as pointed out above, is the practical application part of the manual. It begins with a horrible example of automation in the home which violates every precept of successful and acceptable application of a computer support. It then lays out a series of operational principles which must be followed if the implementation of automated support is to be successful and accepted in tactical units. Following these general principles permits implementation of the system development cycle shown in the figure below. This cycle represents a systematic methodology for conducting field C² system experimentation. Improved goals for C² are identified, candidate applications - of manageable size or broken down into a series of steps each of which is doable within time and resource constraints - are defined and prioritized. The applications are then developed and tested to determine whether or not improvement goals have been met. The improved system then becomes the baseline for enhancements that will be designed in the next iteration of the cycle.



DEVELOPMENT CYCLE

Section 2 then goes on to discuss the kinds of assets required to prosecute this kind of an effort and then suggests some possible sources for this kind of expertise. Especially stressed is the need for the rare individuals who have both military experience and staff training as well a sufficient technical knowledge to enable them to converse intelligently with the technicians who have the required expertise in hardware and software. A number of our younger officers have this rare combination of skills in sufficient degree so they can translate between military and computer expertise, thus greatly facilitating the effort. A suggested ad hoc organization to carry out this effort is described. Also discussed are a number of enabling principles which should help in carrying out the effort. These are incorporated into a "road map" which lays out the five phases of the development cycle and 13 tasks that need to be performed. Techniques for performing a number of these tasks are discussed. The section concludes with the reminder that the whole object of the procedures is to gain initial, and to maintain continuing acceptance of the new modes of operation that will inevitably evolve from incorporating automated support. A set of precepts which summarize the manual and are based on the experience of others is stated; these include:

- You must inspire confidence in the ability of automated support to assist you in tactical operations.
- You must avoid even the appearance of adding to the workload.
- You must overcome "computer anxiety" by exposing the ultimate operators to the equipment as early as possible.
- You must have adequate technical expertise available; this is part and parcel of sizing your application to fit available resources.
- While not letting communication difficulties unduly affect your initial trials, you must be ever aware of the ultimate constraints imposed by your commo net.

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SECTION 1

INTRODUCTION

1.1 WELCOME TO THE CLUB

So your unit is considering the selection of data processing equipment to see how it can be used to improve tactical operations in the field -- and you, whether you are the

- Commander
- Head of the lead staff section, or
- Project Officer

are the guy stuck with making it work. Well, welcome to the club; you are not alone -- others have been and are charged with similar responsibilities in other units. All of you have one major factor going for you; you are experienced tactical decision makers who understand staff procedures at your echelon. You are keenly aware that the tactics visualized in Airland Battle doctrine require a clarity of perception, recognition of opportunities for exercising your initiative, and degree of responsiveness, that seem unachievable with the current manual command and control (C²) system. You have the gut feeling that, somehow, computer support could help you achieve goals such as:

- Reducing the lag time between the occurrence of battlefield events and your recognition of those events (particularly delays in your own HQs).
- Assist the staff by reducing and spreading out the peak workloads associated with the morning and evening briefings.
- Speed and improve the estimate process by:
 - Providing memory aids which permit consideration of more alternatives
 - Providing a war gaming capability for better evaluation of alternatives
 - Providing better and more rapid extrapolations of current trends
 - Providing more rapid dissemination of only that hard copy needed by the staff
- Speed the implementation of decisions by performing many of the time consuming calculations needed to

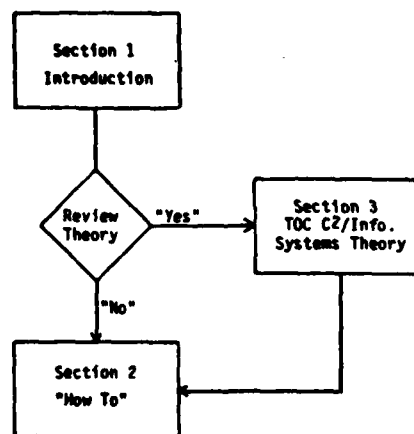
transform a concept of operations into an operations order.

And the list goes on and on. But you also know intuitively that the mere addition of computer hardware and software will not miraculously achieve such goals. Somehow these tools must be integrated into TOC operations to create a man-machine system that takes advantage of the unique capabilities of both and avoids their respective limitations.

1.2 PURPOSE

It is the purpose of this manual to assist you in this effort by making available to you the experience of others who have wrestled with the problem of introducing automation into operations, be they military or industrial. It is not a "how to" manual designed to teach you the elements of computing programming or software design. You can find experts to do that for you. It is designed to provide insights into the problem of building man-machine systems which take advantage of new tools that provide previously unavailable capabilities to perform command and control operations.

The figure below shows in shorthand form what this manual contains and options which are available to you for proceeding with your review of those contents. Following this



Organization of Manual and Options for Proceeding

introduction, there are two major additional sections. Section 2 is the "How to" portion of this manual. It provides certain basic principles that apply to the introduction of computer

support into information systems, in general, and to military systems in particular. It is the distillation of experience of others in absorbing this new technology. To effectively utilize the material contained in Section 2, however, requires that you have a thorough familiarity with basic notions of information systems theory and how the tactical C² system fits within the context of this theory. This general theoretical content is what is contained in Section 3. It is for this reason that the figure directs you to Section 3 after you have completed this introduction. You should scan Section 3 in order to make a decision; i.e., "yes", I need to review this material before going on to Section 2 or "no" I know this material and review is unnecessary. We built in this option or decision strategy to insure that we did not force already knowledgeable readers to wade through the theory before getting into the practical applications arena. Be sure that you are familiar with Section 3's contents. Otherwise, you will not share the same frame of reference from which Section 2's contents were developed.

SECTION 2

HOW TO ORGANIZE THE EFFORT

At this stage of our experience with automation, you probably realize that our knowledge of how to do this is still inadequate to write a complete, step-by-step "How to" manual. You have, in effect, been charged with conducting an experiment in improving tactical operations in your command by providing computer support to appropriate tasks performed by the commander and his staff. It is the purpose of this section to provide some suggestions, lay out some tasks, and describe some techniques which will assist you in performing this experimentation in a rational, effective manner.

The remainder of this section is organized as outlined below:

<u>Section #</u>	<u>(Page #)</u>	<u>Subject</u>	<u>Content</u>
2.1	2-2	Horrible Example	What Not To Do
2.2	2-4	Personnel & Organization	Types of Expertise Needed & Project Staff Organization
2.3	2-6	Basic Guidelines	Overview of System Development Principles
2.4	2-8	Implementing Sequence	Lays Out Actions Sequence
2.5	2-8	Commander (User) Involvement	How To Involve Commander & Senior Staff; Why?
2.6	2-12	Concept Development	Detailed Discussion Of How To Accomplish
2.7	2-26	Requirements Definition	Detailed Discussion Of How To Accomplish
2.8		Initial Development	Detailed Discussion Of How To Accomplish

2.9	2-35	Initial Demo & Trials	Detailed Discussion Of How To Accomplish
2.10	2-37	Evolutionary Development	Discussion of Development Cycle
2.11	2-39	Insuring Acceptance	Principles Leading To Acceptance

2.1 HORRIBLE EXAMPLE

The following excerpt provides an object lesson in what happens when you ignore some of the basic rules for the introduction of automation.

WASHINGTON POST, 14 JULY 1983
CAPITOL PUNISHMENT SOFTWARE, SHMOFTWARE¹ by Art Buchwald

The home computer business is in a lot of trouble. It would be nice to blame the Japanese for it all, but they never really got into the action.

One of the reasons that business got into difficulty is the female gender problem. Women still don't appreciate the value of a home computer and what it can do to make their lives easier.

When I set up my brand-new computer one night, my wife asked why I bought it.

"This is going to change our lives. We can do our taxes on it."

"H&R Block did them already."

"Well, we can do them next year," I said. "We also can compute our household expenses on this machine. Give me all our bills and I'll start programming them."

"You have to be kidding. It will take me three months to find all our bills. Would you take my word for it that we spent \$10,000 more than you made in 1982?"

"All right, I'll put that into the computer."

"What does the computer say about that?"

"It says we spent \$10,000 more than I made. Why don't I

try balancing your checkbook? Give me all your stubs."

"What for?"

"The bank's computer could have made a mistake and we can take our computer printout to the president and show it to him."

She came back and threw her check stubs on my desk and stomped out of my study.

Three hours later she came back. "How are you doing?"

"I'm up to Lord & Taylor's stub for March. So far everything checks out. Maybe I'll make up your calendar for the week. What have you got on for the next few days?"

"I have a hairdresser's appointment on Thursday".

"Good, now I'll just feed that information into the computer, and then when you want to know what you have got on for Thursday, you must put this floppy disk into this slot, put your finger on CODE, then hit this button, and you'll know you have a hairdresser's appointment on Thursday."

"I already know it."

"Okay, forget the calendar. Let's take an inventory of everything we have in the house."

"At 11 o'clock at night?"

"Why not? Once we record it on a disk, and we have a fire, we'll know what was lost."

"Suppose the computer gets burned up in the fire?"

"We won't keep the disk in the house. We'll put it in my office, and a printout in the bank's safety deposit box."

"What else can your computer do?"

"I can key into a bulletin board and talk to anyone in the United States who has a compatible communications terminal."

"You can do that by phone. You still haven't told me why you bought this computer."

"If you must know, I bought it for the children. Kids have to grow up these days with computer knowledge."

"Our children are all grown up and they don't live here anymore."

"You never know when they'll come back home."

The home computer is still in my study, but I don't seem to use it as much as I thought I would. I made a friend in Minneapolis with it one night, but just when we were getting to know each other, his wife made him come to bed.

2.2 PERSONNEL AND ORGANIZATION

The following suggestions are based on observations of and discussions with units in the field which have already wrestled with the problem of incorporating automation into their tactical operations. They include the concepts that seem to have worked best in organizing the required personnel and skills. Since the object is to provide support to the commander's decision making, i.e., an integrating system, the effort does not fall totally within the province of any single staff section or special support group (e.g., AMO).

As in organizing any such wide-ranging effort, the key factor is getting the right people assigned, people with the required interest, skills, and time to devote to it. Basically, three different groups of personnel are of concern for this effort:

- The Users: These must include:
 - The commander and senior staff who are the ultimate users of the tactical information system and will be the principal beneficiaries of improvements in staff operations.
 - Other members of the staff whose activities will be affected or changed by computer support.
- The Technicians: These are the experts in both hardware and software. They know, in a technical sense, both the capabilities and limitations of automation.
- The Change-Agents: These are those few rare individuals who can speak both "militarese" and "computerese" and thereby facilitate communication between the first two above.

Of the three classes of personnel cited, the technicians are the most obvious shortfall in your current TOE. There are three possible sources for such hardware and software expertise:

- The Force Modernization/Force Development (FM/FD) personnel assigned to your unit.
- The Automation Management Office or Officer(s) (AMO) assigned to your unit.
- Contractor support.

The first two groups named above operate differently in different commands, so you will have to adjust your requests to the local ground rules. FM/FD personnel have been trained in system analysis and may or may not have extensive ADP experience in their backgrounds. AMO personnel, on the other hand, have definitely had extensive training and experience in automation. Although they have been primarily concerned with some of the large, centralized data processing systems, they can also be of assistance in the development of automated support to the tactical C² systems. Funding for contractor assistance is available to USAREUR units from the CINC Initiatives Program and from TRADOC/CACDA at Fort Leavenworth. CONUS units can obtain such funding from TRADOC/CACDA.

Of the three groups of personnel cited above, the last -- the change-agents --, although the smallest in number, is in many ways the key ingredient because it forms the bridge between the first two. The successful implementation of computer support to the C² system is a classic example of the joint effort of two completely different kinds of expertise. Only the military expert understands the true nature of what the system is trying to accomplish and its operating environment -- to include the limitations of human processors with which he is only too familiar. The technical expert in hardware and software, on the other hand, is completely familiar with the capabilities and limitations of automation but has difficulty expressing these in the operational terms familiar to the military expert. Getting these two groups to communicate is the real key to producing a useful system design which is acceptable to the user. This process can be expedited by making available the few individuals who have even limited expertise on both sides of the fence. Such an individual is often called a change-agent. Frequently this will be an officer who, even though he is relatively junior and has limited staff experience, has had enough exposure to automation so that he can talk to the technicians. Such an individual can act as expeditor or catalyst to get the dialog between military and technical experts started and, in effect, to translate from one set of expertise into the other. Here again, top-down or command emphasis is the key to making this rare resource available even on an ad hoc basis.

Figure 2-1 shows one suggested way in which personnel from the above groups can be organized. It shows a steering committee and a project officer with direct access to the office

of the CG/CS. The steering committee is chaired by the CG/CS; members include the coordinating staff chiefs and the project officer. The latter can be accompanied by the senior technical person. Under the project officer is a user group with representatives from the affected staff sections and one or more senior technicians -- which ones to be determined by the application being defined. Also under the project officer is a Technical Group including the technicians and representatives from the immediately affected staff sections -- which ones to be determined again by the application under development. The project officer must, for such an organization to be effective, be of the change-agent type. The more of these that can be identified and assigned throughout this organization, the more rapidly the users and technicians will be able to function together effectively. It is most important to impress them with the idea that their mission is to make data processing technology useful to the user and to translate military requirements into terms the technicians can understand. Their function is not to become system salesmen.

2.3 BASIC GUIDELINES

Successful introduction and implementation of automated support for the tactical C² system is based on the application of the following operational principles:

- You must first develop a system concept.
Just as a successful OPLAN must be based on a carefully selected, clearly enunciated concept of operations, so also must the initial implementation (and subsequent iterations) of automated support be tied to a carefully developed concept of "information operations" when the C² system is supported with automation.
- Commander and senior staff must be personally involved.
No change to the C² system -- and the introduction of automation will introduce some profound changes -- can succeed without the personal involvement of the commander and senior affected staff officers. After all, the C² system exists solely for the purpose of facilitating the making of tactical decisions by the commander and senior staff; it is their system; it must help them solve their problems in their unique mode of decision making. Unless they have helped develop the concept and have interest in its implementation, the concept will fail.

IF YOU FAIL TO APPLY THIS PRINCIPLE, YOU MAY AS WELL ABORT THE EFFORT NOW!

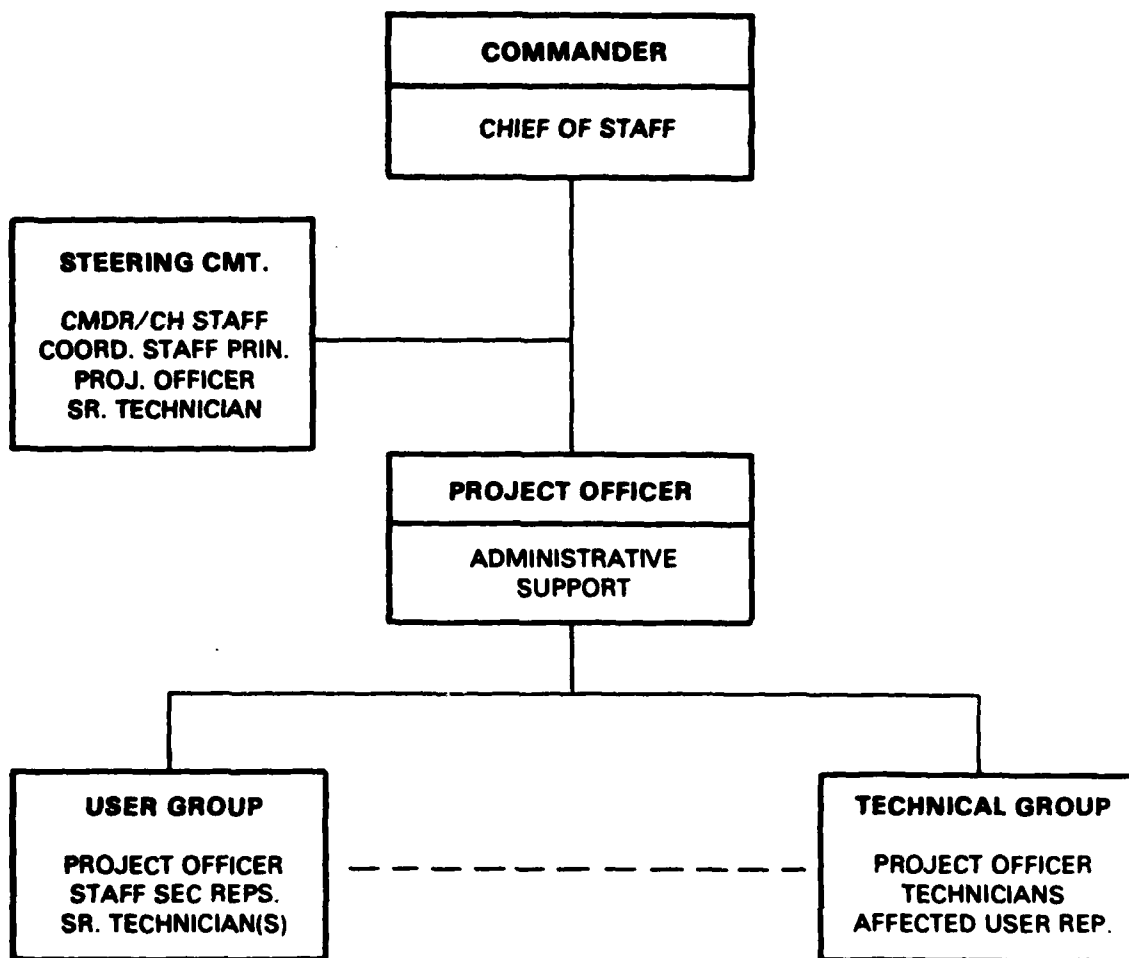


Figure 2-1. A SUGGESTED OVERALL ORGANIZATION

- Automation must be integrated into total system operation.
There is much more to the introduction of automated support than merely making data processing gear available to the staff. Even though the initial concept may be limited to providing support for only one or two applications, the impact on the remainder of the system of providing that limited support must be assessed if the potential benefit is to be in any way exploited.
- Implementation must be phased in gradually.
The introduction of automation is frequently a classic case of the "eyes being bigger than the stomach." Even though any degree of automation requires a total system evaluation, the concept implementation must be carefully phased so that the effort does not exceed man, machine, or system capabilities at any stage. It is far better to have potential customers waiting for their favorite application than to promise something you can't deliver.
- System development must be an evolutionary process.
Phased implementation, in turn, requires evolutionary development; establish initial goals, develop the needed support, try it out, improve it and then go on to new goals. It should be noted that the development of a C² system will never be finished or completed.

The application of the above principles to the tasks inherent in the development is discussed in greater detail in the following paragraphs.

2.4 IMPLEMENTING SEQUENCE

In addition to the Basic Guidelines enunciated above, one needs to follow a logical sequence of stages and tasks in implementing the effort. Such a sequence is provided by Figure 2-2 which is sort of a roadmap. It lists five stages which should be followed for each incremental application of automation to the C² system and indicates who has the lead for each stage. Then it shows tasks required in each stage and suggests techniques appropriate for each. The remaining paragraphs of this section discuss the application of the basic guidelines to this framework and describe some applicable techniques.

2.5 COMMANDER (USER) INVOLVEMENT

Figure 2-3 shows the suggested involvement by the commander, Chief of Staff and Senior Staff in the task sequence

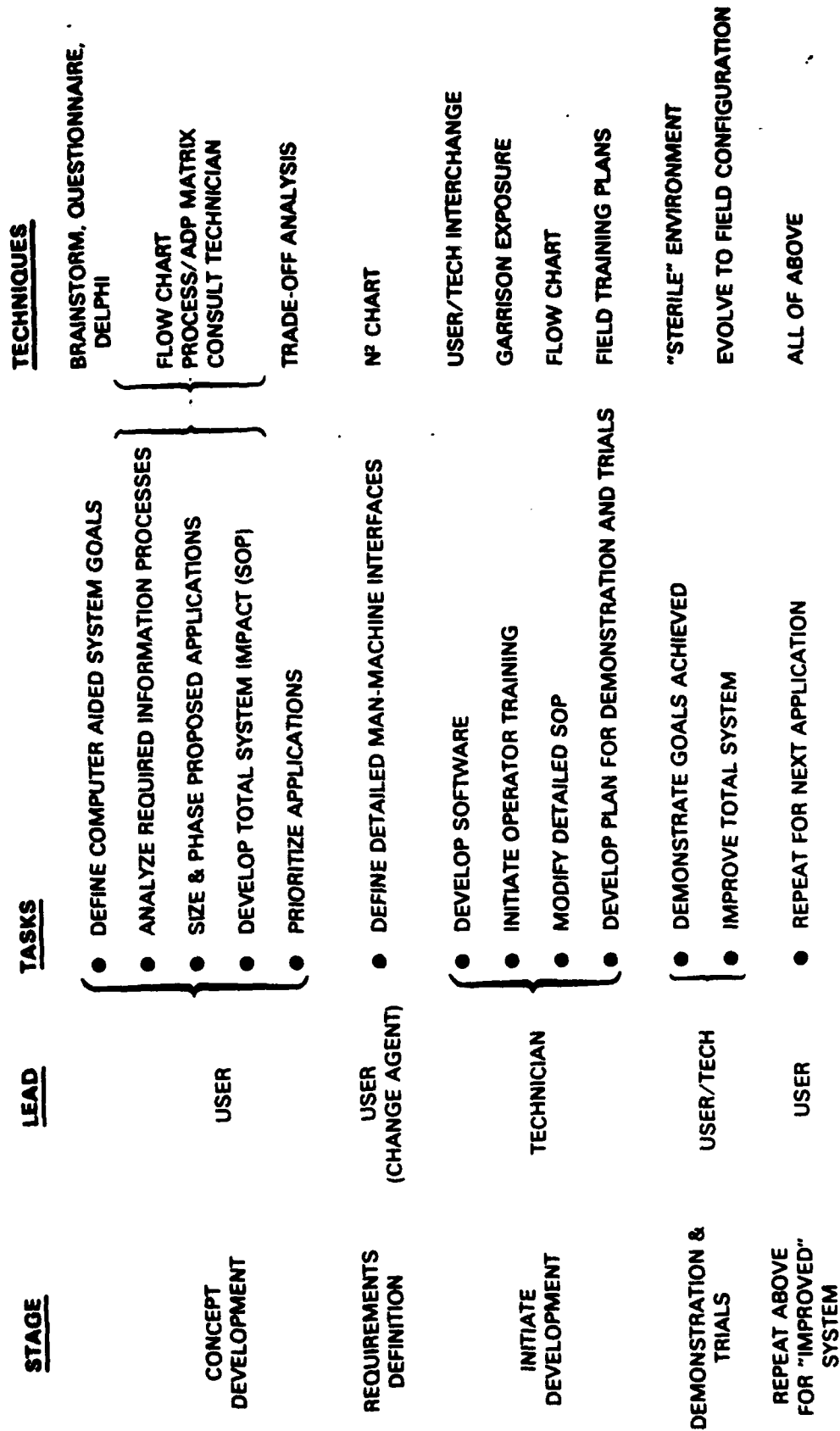


Figure 2-2. ROAD MAP FOR ORGANIZING EFFORT

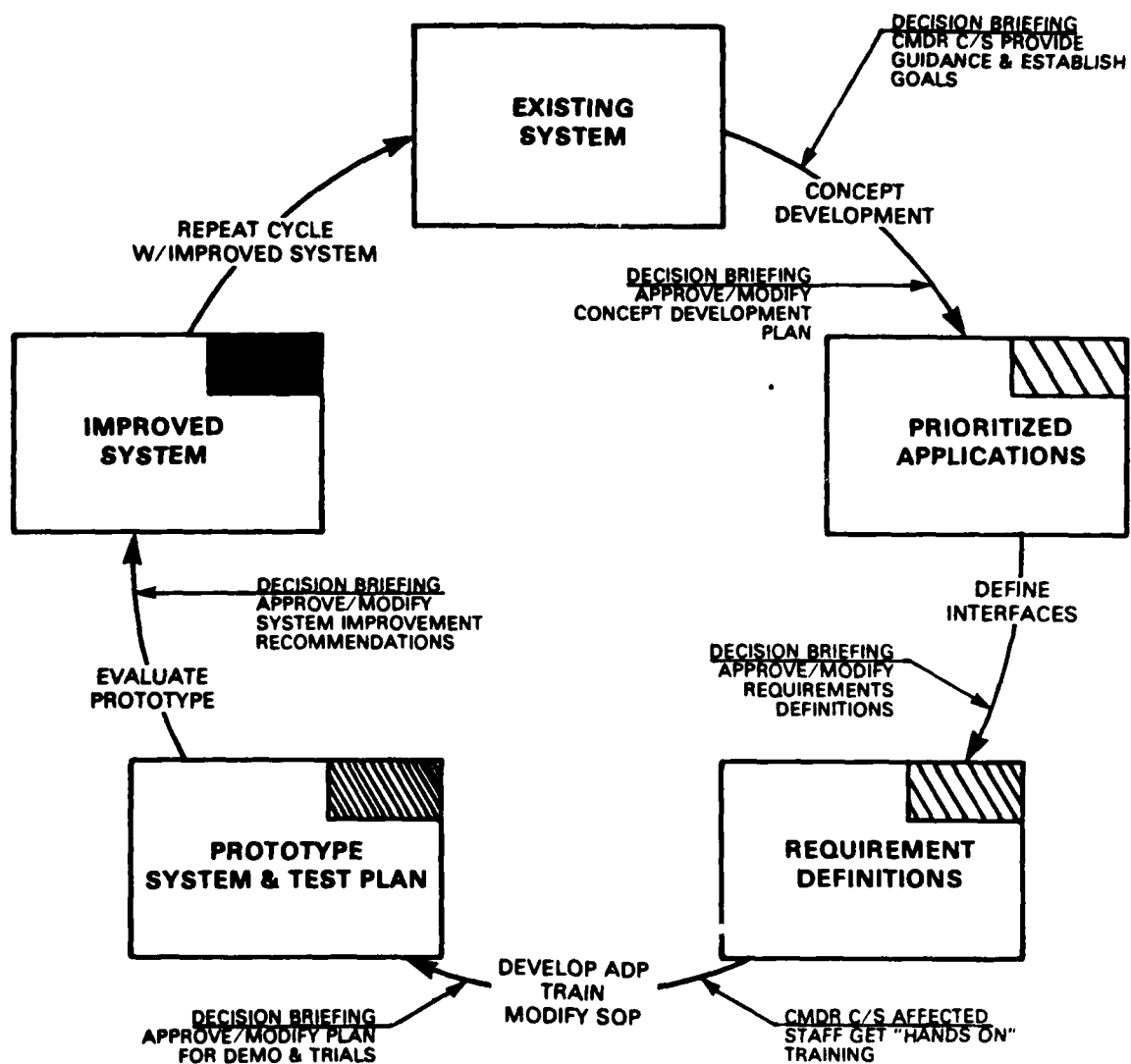


Figure 2-3. SENIOR USER INVOLVEMENT DURING DEVELOPMENT

portrayed in Figure 2-2. It indicates the nature of each contact and its purpose. The contacts with senior users indicated in the figure are the absolute minimum; other progress briefings are clearly indicated for some of the longer stages such as concept development and software/system development.

The goals, i.e., the output products, selected in concept development for improvement through computer support must be of major concern to the commander and principal staff. Since the tactical C² system exists to support their decision making, they are the principal users and, hence, very properly make the final decisions as to how that system will function and be organized. It is, therefore, of the utmost importance that they select the initial package of staff outputs, from now on called applications, to be assisted through automation. Furthermore, it is to the commander and senior staff that the improvements achieved must be demonstrated. Therefore, they must also be involved in the selection of measures used to demonstrate that improvement. It is not sufficient to have a top-down approach to system design; there must also be top-down involvement in its implementation or the effort will surely fail.

The initial briefing is certainly the most important since it will set the stage for the entire development. It should take place as soon as possible after receipt of the mission. The project officer(s) should do enough spadework prior to the briefing so that he can discuss the nature of the effort required, the major capabilities and limitations of automation in the TOC, and some candidate applications and goals. He should indicate the nature of and estimate the size of the resources required and outline the proposed organization of the effort. Many of the illustrations and tables in this manual can be adapted as slides for this briefing.

Almost as important as the initial briefing is the "hands on" experience during the initial operator training and the later demonstrations and trials. If the initial application to be implemented is to demonstrate improvements achieved through automation, several of this senior group (Commander, Chief of Staff, and senior staff officers) must be involved at the terminals. There is no better or faster way to gain an appreciation of the potential for improvement. The remainder of the briefings are decision briefings at key points in the development cycle.

2.6

CONCEPT DEVELOPMENT

	CONCEPT DEVELOPMENT
TASKS	1. Define Computer Aided System Goals
	2. Analyze Required Information Processes
	3. Size & Phase Proposed Applications
	4. Develop Total System Impact (SOP)
	5. Prioritize Applications

A detailed concept must include:

- A clear definition of what is to be accomplished through computer support in terms of measureable, demonstrated improvement of some intermediate or final output product of the commander and staff. A proper goal might be the improvement of the SITMAP and other visible displays to be measured by reduced lag time between event and perception, reduced error rates, more complete representations, and a reduction in the number of misperceptions. This goal is attained through improved processing of incoming messages, particularly, spot reports and SITREPS, but the latter is not the measureable goal, only the means to it.
- A careful analysis of the processes required to produce the particular staff output(s) product selected above. Normally, this will be some portion, or all, or even iteration of the processes shown in Figure 2-4.
- Careful selection of which of the above processes are to be assisted through automation. This requires a tradeoff between the capabilities shown in Table 3-1 and the constraints inherent in your available resources.

- A detailed set of procedures for performing both the machine and human processing required to produce the measureable product. This will, of course, have to be modified as the development proceeds and, most certainly, as a result of the initial trials. It is important to note that this set of procedures will almost certainly be different from the procedures used in all-manual processing.

The whole notion of having to develop a formal concept of "information operations" is somewhat foreign to us; after all, we have been organizing and training staffs (the decision nodes in the tactical C² system) for years without prescribing a detailed set of operational procedures for carrying out the necessary information processes. Such detailed procedures were developed as we needed them. A formal SOP was usually prepared to cover such special requirements as displacement, enemy attack on the CP, nuclear release, chemical attack, and vitally needed reports, but the routine processing took care of itself. FM 101-5 describes the duties, responsibilities, and functions of commanders and staffs and describes in some detail what has to be done. Appropriate TOEs list the assets authorized to perform these tasks. The ARTEPS provide performance standards and, hopefully, personnel assigned are qualified in their MOS.

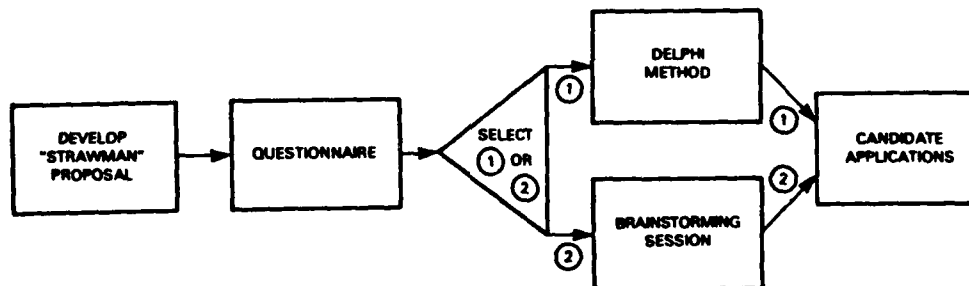
None of the above documents, however, provide much guidance on how to carry out the doctrinally prescribed tasks other than a few formats for the major staff products and what can be inferred from MOS specified skills. Staff organization and procedures have tended to follow the same pattern of development followed by other free-form groups consisting primarily of human components. Such groups strive to structure their work environments to reduce the amount of stress they must face by directing their activities toward a more workable and predictive level of certainty and clarity. Group members, interacting over a period of time, will develop standard work patterns in which routine and precedent play a relatively large part.

This somewhat casual approach to the detailed ordering of the information processing is understandable and reasonably successful when "machine" support is limited to voice and teletype communication, typewriters, manual displays and files, and possibly a Xerox or two. In such a manual system information processes are all performed by human beings which are among the most highly variable, nonstandard parts from which a system can be formed. Furthermore, humans are almost infinitely adaptable; whenever one or more members of the team change, the rest adapt to the skills, limitations (and prejudices) of the replacements -- especially of the senior members. As a result, no two staffs process information in exactly the same way nor do the two shifts of the same staff operate in an identical manner.

The advent of automated support changes all this. Even though software can be made somewhat flexible and adaptive, still, to the degree that information processing is performed by machine, the information system now contains "standard" parts which impose a degree of discipline in system design and operation far greater than was required when it was populated only by people. This does not mean that automation alone can drive your systems design. Clearly it must respond to the commander's wishes and accommodate the real world situation. However, without a detailed concept of just how the information processing is to be improved through computer support, the effort will flounder; very little, if any, improvement will result and many, many resources and much time will have been wasted.

It is the purpose of this paragraph to show how such a concept may be developed. Clearly, the ball is on the user side of the house for the tasks in this phase (Figure 2-2); the spadework can be accomplished by the User Group and approval of the Steering Committee must be obtained.

2.6.1 Identifying Applications



There are a number of ways to get this effort off the ground. These include brainstorming sessions, questionnaires, and the Delphi Method, the latter being one of the means which can provide a consensus if you stick to written questionnaires. You can also use a combination of these means. The key to getting users to submit original and useful suggestions, regardless of which means are used to elicit them, is to stimulate the user by providing some well thought out "strawmen." People are always more willing to comment on proposals made by someone else than they are to initiate original suggestions -- and in the process of commenting they will frequently be stimulated to come up with some new ideas. The group solicited for suggestions must include the commander and senior staff as well as other members of the staff. Although the suggestions from the commander and senior staff have, ipso facto, priority, the lower level participants may well provide valuable insights and plug gaps in the submissions of their seniors. One possible sequence (out of many

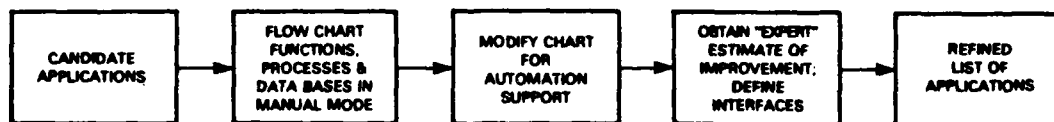
others equally good depending on time and circumstance) would be to use a questionnaire to elicit comments and suggestions on a set of applications you have provided as a strawman. Then, after you have listed a modified set of applications based on the questionnaires (anonymous, of course) convene a brainstorming session of the user group and later of the steering committee to gain a consensus, or follow the alternate route using the Delphi Method to gain the consensus.

Each candidate application must be expressed in terms of clearly identified products of the TOC that are to be improved through automated support. These could be products produced as outputs from the TOC (e.g., plans, orders, reports) or they could be internal products that appear at major internal interfaces within the TOC (e.g., estimates, daily briefing, SITMAP). In addition to identifying the candidate output which is to be improved, the submission must specify exactly how this product is to improve. If possible this improvement goal should be expressed quantitatively:

- Reduce staff preparation time for this ____ to less than 30 minutes.
- Reduce lag time between input message and ____ to less than 5 minutes.
- Reduce discrepancies between friendly input locations and displayed locations to less than 1%.

If it is not possible to express the improvement quantitatively, the improvement goal must be described in sufficient detail so that there can be no doubt when the desired level of improvement has been demonstrated.

2.6.2 Applications Analysis



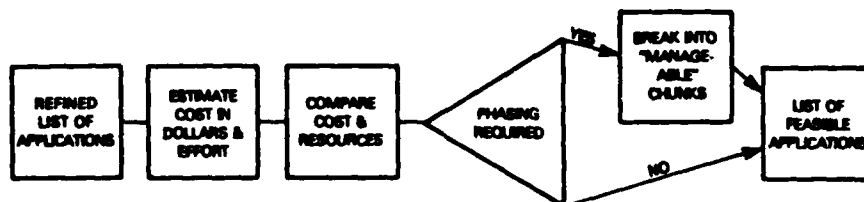
The candidate applications must now be analyzed to determine:

- Which of the processes required for each application can be supported by automation
- The probable contribution of each toward the application goal
- The probable cost in time and dollars

A suggested way to initiate this analysis is to develop a flow chart of the functions, processes, and data bases required to produce the output(s) identified in the specific applications. The general model of C² group processing steps shown at Figure 2-4 provides the building blocks for this effort. Do this initially to show how these outputs are produced in the manual mode. Be sure to include all of the processing needed all the way back to the data stream, both in and out. An example of such a flow chart is provided in paragraph 3.9.

Modify the above flow chart to reflect how you visualize it will be changed when supported by the proposed automation. This will be an iterative procedure as you examine several different candidate processes for automation and recall that an automated data base must be shown separately to support the processes you intend to automate. A preliminary estimate of the potential payoff to be gained by providing automation support to the various processes included in your flow charts can be gained by referring to Table 3-1. This table lists the key limitations and capabilities of man alone, machine alone, and man-machine together for the performance of each process. When you have narrowed your configurations down to the few that show the most promise toward achievement of your application goals you have arrived at the stage where you need to get some solid data processing expertise from senior technicians. They can provide quite definitive estimates of how much progress toward your goal can be achieved by each likely configuration of automation supported processes. In general, it will be necessary to identify a separate data base for those data elements that are going to be processed by machine. The major change from the manual flow chart is the identification of the interfaces which will become man-machine terminals. Remember that you must ultimately provide for every data element needed as input into the automated data base and for every desired output.

2.6.3 Sizing and Phasing



Your senior technician will also be able to give you guidance on the cost, both in terms of time and effort as well as money. This is the principle reason that one or more should be included in both the User Group and the Steering Committee. Another factor that will become apparent early on in this stage of the analysis is the data base implication of automating almost any of the processes or of assisting a man in carrying out any of the processes by means of automation. A digital data base must be established for every such process. One of the hidden costs that must be minimized is that of maintaining dual (manual and automated) data bases for the same subject matter.

For the larger applications such as the Commander's briefing (see paragraph 3.9 for a discussion of the commander's briefing problem) it will be clear that the ultimate goal cannot be achieved in a single iteration. Such a single massive leap into automation is neither practicable nor desirable. Not only would it exceed currently available resources, but, even more important, it would require a period of time to plan, design, develop, and implement far longer than available. If improvement of the operation through computer support cannot be demonstrated in some measureable degree during the current tour of duty of the commander and senior staff the effort will most assuredly have to start all over again from scratch at some future time. This leads us to the fourth basic guideline; the effort to provide computer support must be phased. This means not so much curbing the appetite for automation as breaking it into chunks of manageable size. Each application considered should lie well within your resources both in terms of dollars and available technical expertise and it must also be doable and demonstrable within a reasonably short period of time. The initial application should also be selected on the basis that it is a logical first step toward whatever ultimate goal has been established for achievement through computer support.

Defining and phasing the successive applications which will lead you to the ultimate goal that has been established requires that you start with that goal and then develop an appro-

priate phasing strategy by which that goal can be reached. For example, if the ultimate goal is a dispersed command post, you could follow the general strategy which is sketched in paragraph 3.9, and is essentially based on providing automated support for a series of staff products, viz., commander's briefing (incrementally), commander's and staff estimates, staff data bases (finally integrated into a common, distributed data base); preparation of OPLAN/ORDERS and reports; and finally input and output processing (frequently called "electronic mail"). Another strategy might be the successive physical separation of TOC components beginning with automation of selected traffic between TOC at MAIN and TAC. The incremental applications should again be tied to clearly identified staff products. Whatever strategy is selected -- this will depend largely on the commander's guidance -- there are some basic system design rules which should be observed in implementing the strategy:

1. Each successive application (not just the first) must demonstrably improve the performance of the C² system.

In general, this means that the application must be tied to one or more staff products and specified quantitative improvements in their production.

2. In planning successive applications, each should exploit the capabilities already provided by its predecessors.

It cannot be repeated too often that the incremental introduction of automated support means the incremental transition from all-manually created to automated data bases. The latter should, of course, be common (accessible by anyone who needs the information) and distributed (for survival). Successive applications must provide for an orderly transition from one to the other with minimal duplication of labor at each intermediate stage.

3. In planning successive phases keep in mind that commo capacity is not a "free good"; USE COMMO CHANNELS ONLY FOR THE TRANSMISSION OF DYNAMIC INFORMATION -- never for the transmission of static information which should be stored locally.

In plainer english, do not use the commo system to transmit complete formats, displays, or charts. Instead, transmit only that information required to keep the data elements in the data base current. Ideally, the user should be able to display the data he needs in a format of his choice; the system retrieves the updated data elements needed to complete it. As an obvious example, transmit only the data on the overlay -- not the entire map underneath it.

4. A top-down approach to providing automated support, i.e., beginning with products that require the decision processes (Figure 2-4), then the pre- and post-decision processes, and finally the input and output processes, will lead to a more efficient system design.

Numerous visits to units participating in the TACIP program have emphasized this principle. Defining the commander's needs first makes the determination of what data are needed, where to get them, and how to sort, correlate, and aggregate them for presentation a relatively straightforward task. Starting at the bottom with "electronic mail" tends to include every possibility at the lower levels and then ignore those not needed as the system is developed upward.

The above discussion has concentrated on the question of defining a logical progression of applications aimed at the achievement of a larger goal. The discussion at paragraph 2.6.5 provides additional information on sizing and prioritizing applications.

For such larger applications it will be necessary to break the job down into a series of smaller tasks. This really amounts to redefining the application into a series of steps with intermediate goals for each. This, in turn, requires drafting a series of flow charts, one for each product that is to be produced with automation assistance. Note which is the highest level function that is involved in preparing the product, i.e., does it involve commander decision making, the highest level of info processing and decision making; mid-level (staff) decision making/info processing; or only lower level message input/output processing? Figures 2-5, 2-6, and 2-7 have been designed to assist you in drafting the flow charts after you have determined the function level(s) involved. Figure 2-5 shows partial automation to assist the commander's decision function. It indicates that the information flow between the commander and the staff is partly through an automated data base and partly manual. For example, if only the staff estimates and the commander's guidance were to flow between commander and staff via automated terminals, any additional decision processing by the commander (additional alternatives, answering other "what if" questions) would have to flow over the manual interfaces indicated. Figure 2-6 similarly presents the middle or staff processing level of the C² Info Processing/Decision Making System. Figure 2-7 similarly presents the lower layer, i.e., the input/output and pre-/post-decision processes which might be partially automated by means of "electronic mail." Your flow charts are not finished until you have identified every information transfer across each automated and manual interface needed for the product under consideration. A technique for further identifying the needed interfaces and displaying them is discussed in paragraph 2.7 below. A logical

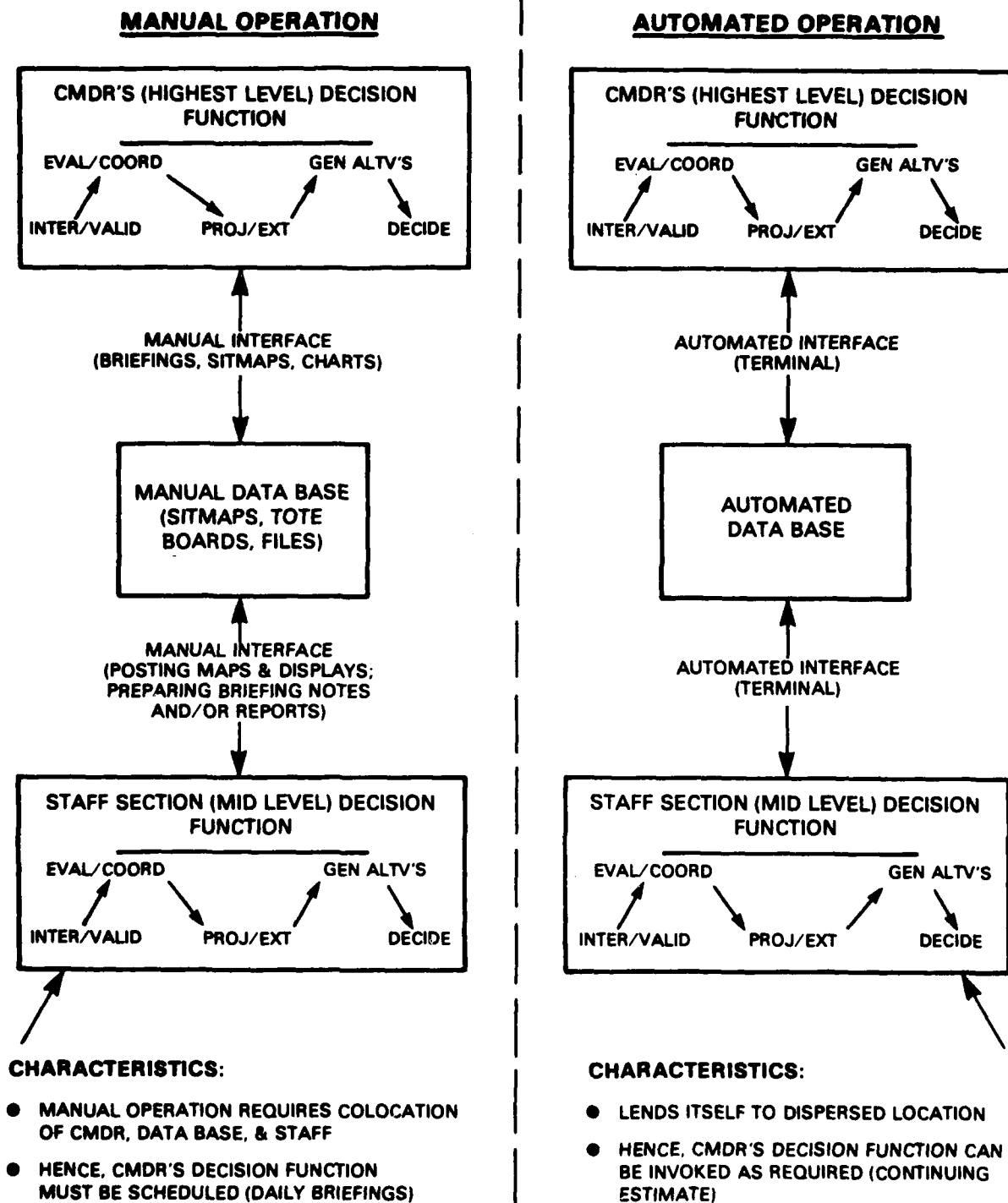


Figure 2-5. PARTIAL AUTOMATION — CMDR'S DECISION FUNCTION

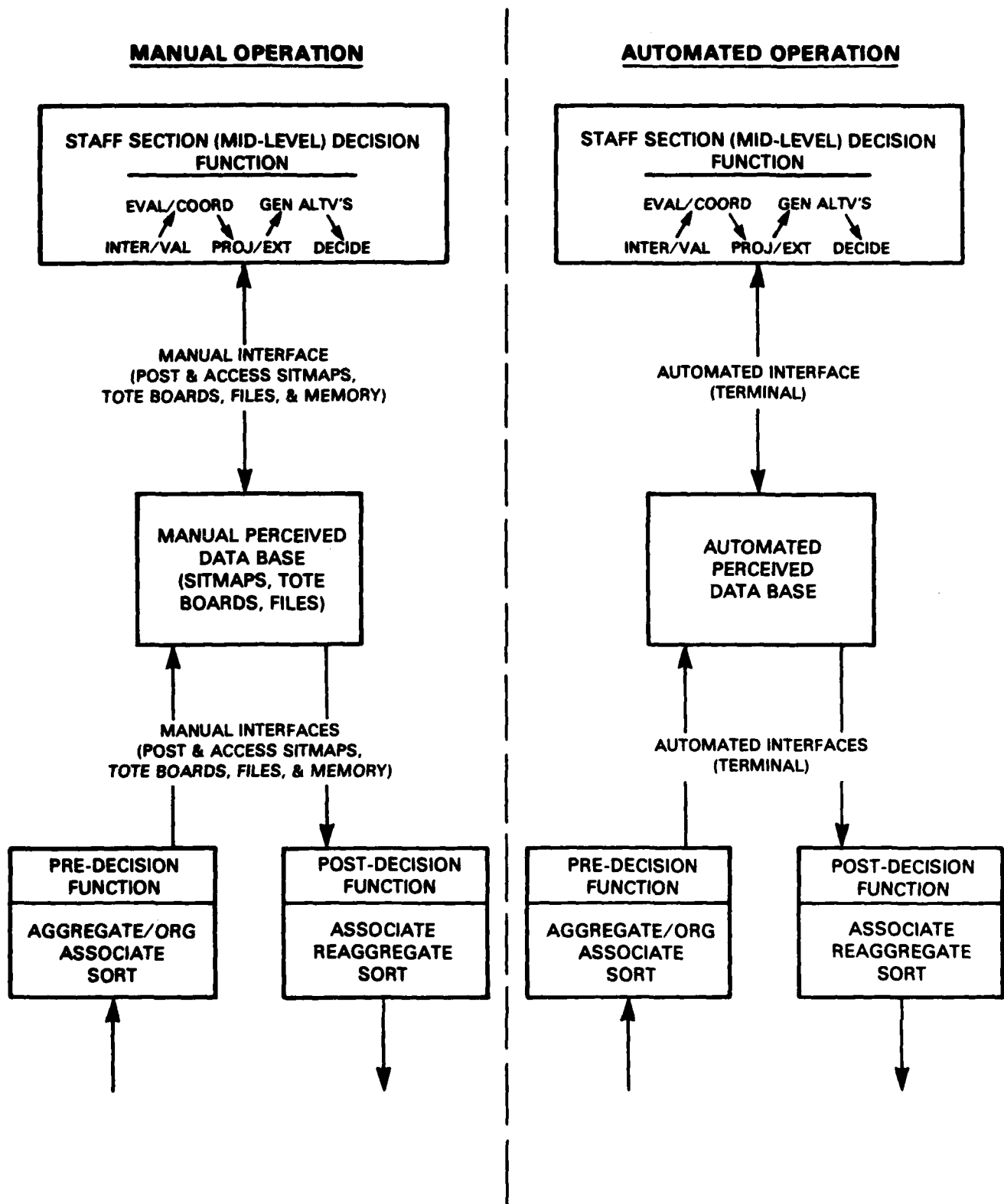


Figure 2-6. PARTIAL AUTOMATION — STAFF DECISION AND PRE-/POST- DECISION FUNCTIONS

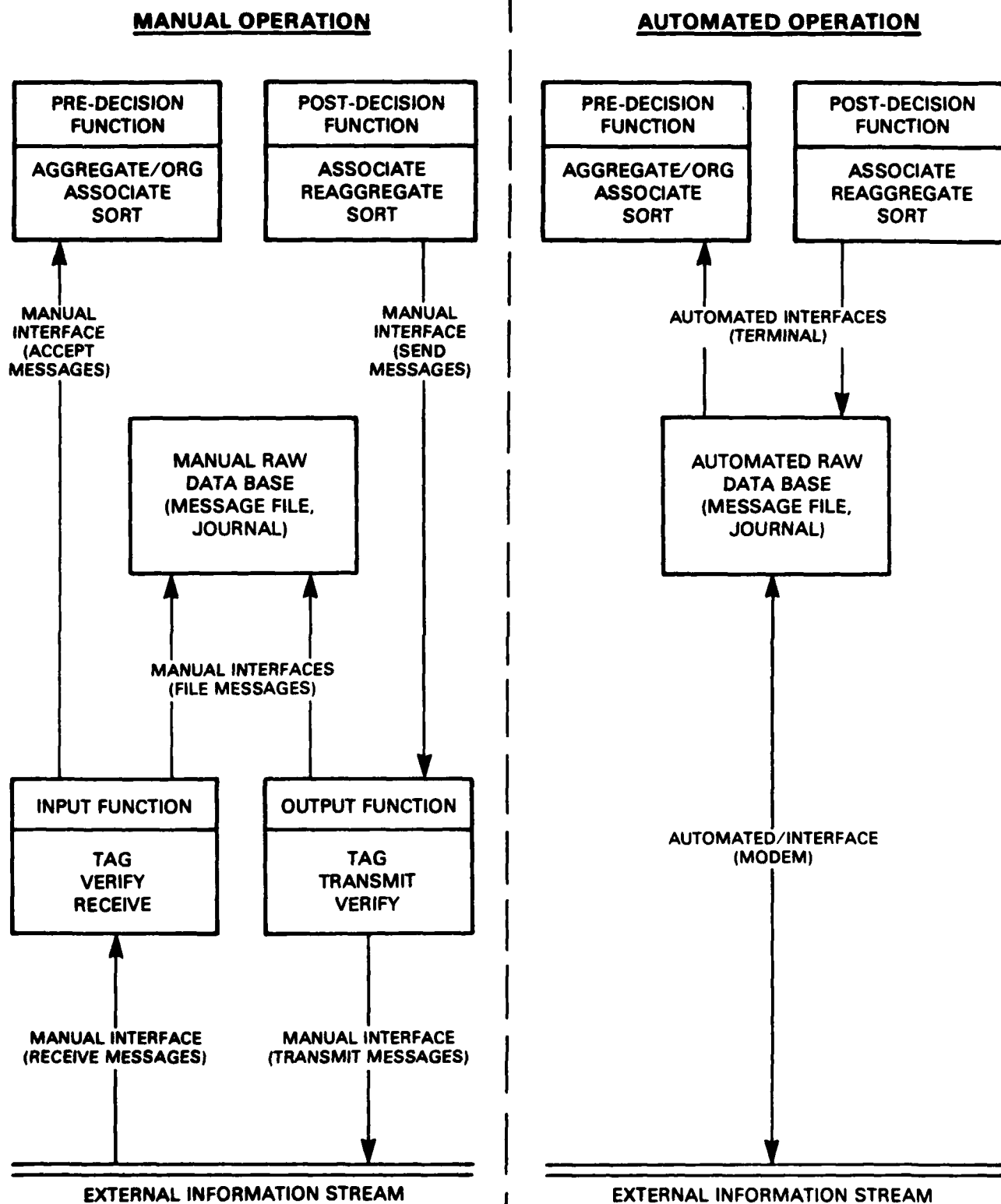


Figure 2-7. PARTIAL AUTOMATION — PRE-/POST- DECISION AND INPUT/OUTPUT FUNCTIONS

development sequence can now be determined by grouping together into single applications those products which share the largest number of automated data transfers. Applications can, in turn, be sequenced by adding them in the sequence which provides assistance to the largest number of high priority products with the smallest addition of automated data transfers.

Several things will be noted about flow charts constructed in this fashion:

- All flow charts for products that involve the same functions will be essentially identical; the differences will lie in the needed data exchanges.
- As you automate more and more products in one of the large, phased applications, the data flow will tend to flow more and more over the automated channels and the manual exchanges will tend to disappear.
- Although shown as separate data bases for each of the function levels, this is a purely functional representation. The automated data bases at each level need not be physically separated, nor physically collocated with the information functions and processes they support (as do the manual data bases).

2.6.4 Total System Impact

How Will ADP Application Affect SOP?
Do Redundant Data Bases Increase Workload?
What Effect Does Application Have On Workload Schedule?
How Does Application Affect Task Assignment?
How Does Application Affect TOC Layout?
How Does Application Facilitate TOC Dispersion?
How Does Application Affect Required Communications?

The flow charts developed as described above are also very useful for assessing total system impact. To be complete they should, of course, include that part of the operation that remains manual as well as that which is proposed for automation. One needs now to develop a detailed SOP for system operation in the computer assisted mode in order to determine how automation affects the entire operation. In some cases the proposed automation could add to the manual workload, e.g., by requiring personnel to maintain duplicate data bases, or instead of smoothing out workload it could cause it to pile up at critical nodes. Careful study of the flow chart can disclose such potential pitfalls before they arise in actual practice. What you are doing here is assessing system costs that are outside the actual

automated part of the revised system.

Whenever automation is used to process information continuously rather than on a scheduled basis (e.g., a continuously updated appreciation of the situation from spot reports instead of periodic summary reports) there will be a tendency to smooth out peaks in the loading. A dramatic example of such a shift in information loading is discussed in paragraph 3.9.1.

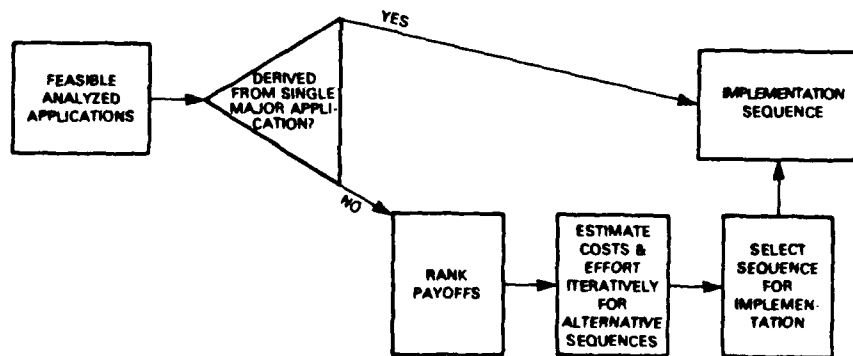
This step will also help you identify changes in workload and needed changes in task assignment and layout of the TOC. It will also help avoid the fiasco of designing a system more difficult to operate than the manual mode.

Finally, note any possible changes in location of TOC elements that would be facilitated by the automation introduced by the initial (later) applications -- especially changes leading to the desirable goal of CP dispersion.

As part of this last step you must, of course, also make an estimate of the changes needed in your communication support to permit such dispersion.

Carrying out these steps will go a long way toward insuring a smooth transition to computer supporter operations when you are ready to bring your application on line and will help avoid unpleasant surprises because of some factor that has been overlooked. It is recognized that you may not be able to identify all problems at this stage of the development process. However, major problems that could affect system operation and/or user acceptance should be identified at this time.

2.6.5 Prioritization



The last step in concept analysis and its final product is putting the candidate applications into the sequence in which

they should be implemented. Now, if your individual applications are all phases of a single larger application and have been developed as indicated in paragraph 2.6.3 above, you have already accomplished this prioritization. If, however, they are separate applications small enough not to require phasing, you need to consider the question of the sequence in which they should be implemented. To do this you need estimates of the payoff of each and their relative cost. By this time, you should already have a consensus of the Steering Committee as to their ranking of the payoffs expected from each of the candidate applications. You must now also estimate the relative cost. The costing of diverse applications, both in terms of dollars and time, is not as straightforward as it might appear. This difficulty arises from the inevitable overlap in both hardware and software. The same hardware can serve more than one application and, frequently, the same package of software is required for more than one. This means that, after the initial application has been implemented, there are significant sunk costs which can reduce the total acquisition cost of later increments. Thus, the incremental cost of adding any single application is a function of what has been acquired for applications already implemented. This will be a major determinant of a logical sequence for the phased implementation.

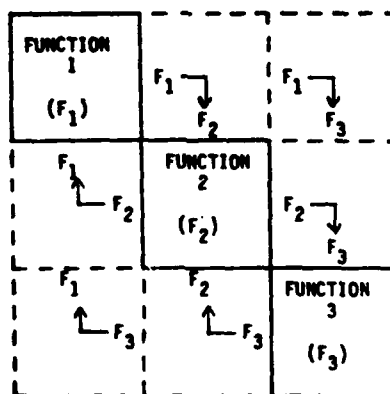
A way to approximate these costs has already been laid out in the discussion in paragraph 2.6.3 above. Instead of going back to the actual hardware and software costs, use the number of information transfers required for the products included in each application as a surrogate for actual costs. That sequence of applications which adds the smallest number of transfers for each incremental application will be the easiest to live with from a costing point of view, provided you also pay attention to the design rules stated in paragraph 2.6.3 above. If the sequence determined in this way differs substantially from the sequence of "druthers" arrived at by the Steering Committee, you need to go back to them and make a trade-off in much the same way as you select a course of action in making a staff estimate, that is by comparing the advantages (payoffs) vs the disadvantages (costs). Above all, do not violate the cardinal rule: DO NOT SELECT AN INITIAL INCREMENT WHICH CANNOT BE DEMONSTRATED PRIOR TO ROTATION OF THE COMMANDER AND/OR AFFECTED SENIOR STAFF.

2.7 REQUIREMENTS DEFINITION

During this step in the development the initiative must remain with the users, but with an increasing amount of expert guidance and information being provided by the senior technicians. It is at this stage that the change agent becomes of paramount importance in facilitating effective communication between them. In fact he is probably best qualified to employ the suggested technique. This technique which will assist the user in formulating his requirements in a manner understandable

to the technician and which will insure complete consideration of all the requirements is a technique adapted from the technicians themselves. It is used by systems analysts in designing automated system architecture, but is equally useful to you in your capacity as the total (man/machine) system designer. It is called the N^2 chart. In a sense it is the complement to the flow charts with which you are already familiar. Flow charts are built up of components: functions and data bases; arrows connecting these show the information flow between them. Hence a flow chart tends to emphasize functions and data bases. The N^2 chart, as you will see, emphasizes the interfaces (information transfers) between functions and data bases; the latter simply serve as pegs on which to hang the interfaces.

The N^2 chart is one of those notions which is very simple but hard to describe without sounding complex. You don't have to draw very many flow charts before you discover that placement of the components (function and data base boxes in our case) is critical if you want to avoid confusion and crossovers in drawing in the interface arrows. This is especially true if there are many such interconnections. If, however, we draw the function and data base boxes along the diagonal of a large square, then every other small square off the diagonal represents a potential interface between the function/data base boxes.



If the diagonal runs from left to right downward, the small squares above and to the right of the diagonal represent potential interface transfers from an upper diagonal square to a lower one, and vice versa for the off-diagonal squares to the left and below the diagonal. Thus, there is an off-diagonal small square for every possible interface between function/data base boxes on the diagonal.

This is easier to understand if we use a concrete example. Figure 2-7 is the N^2 chart corresponding to the flow chart of the operation section's processing contribution to the commander's briefing shown at Figure 3-7. The latter shows nine major components to be considered for the commander's briefing, so Figure 2-7 shows a 9 X 9 matrix with the function/data base boxes drawn as solid squares along the diagonal. All the other boxes in the matrix are outlined by dotted lines and represent all of the possible interfaces between the nine major components. There are $9 \times 9 = 81 - 9 = 72$ such potential interfaces. Granted, not all of these will actually exist, but the advantage of the N^2 chart is that it reminds you that they can and makes you justify every empty interface box where no interface occurs. Where an interface between components actually occurs a circle has been entered into the dotted square and the direction of information flow is indicated by an arrow. The circle is entered in the same row as the component originating the information flow and in the same column as the component to which that flow is routed. Therefore, the flow is to the right and down for components to the right and down along the diagonal; to the left and up for components above and to the left of the originating component. If there are more than one interface indicated along any path between two components only the interface at the corresponding row and column pertains. Other interfaces along that path pertain to other pairs of components. The same names have been entered in the diagonal component boxes as are used in Figure 3-7. The interface entries have been numbered and the letter used to identify the interfaces in Figure 3-7 has also been entered near the bottom of each circle in the interface boxes. Note that the N^2 chart has reminded us of four interfaces which are ignored in Figure 3-7 so that four circles (3, 4, 5, and 17) contain no letters. These represent the distinct possibility that pre- and post-processing may need to retrieve previously filed whole messages from the raw data base.

To continue the example, note that the flow shown in Figure 3-7 represents Case 1 in which the automated briefing data base (labeled BRIEFING SOFTWARE in Figure 2-7) provides the commander only selected predecision processed information and information subjected to the staff decision processes. It does not assist his own decision making by allowing him to repeat or expand staff decision processing by asking "what if" questions of the BRIEFING SOFTWARE. Only four man/machine interfaces are shown on the chart (11, 13, 14, and 16) and these have been marked with an asterisk. These are, of course, functional designations; 11 and 13 would be multiple terminations for the several staff sections.

Table 2-1 can now be developed from the N^2 chart. It describes each of the major components and then describes the nature of every information exchange, i.e., the inputs to the

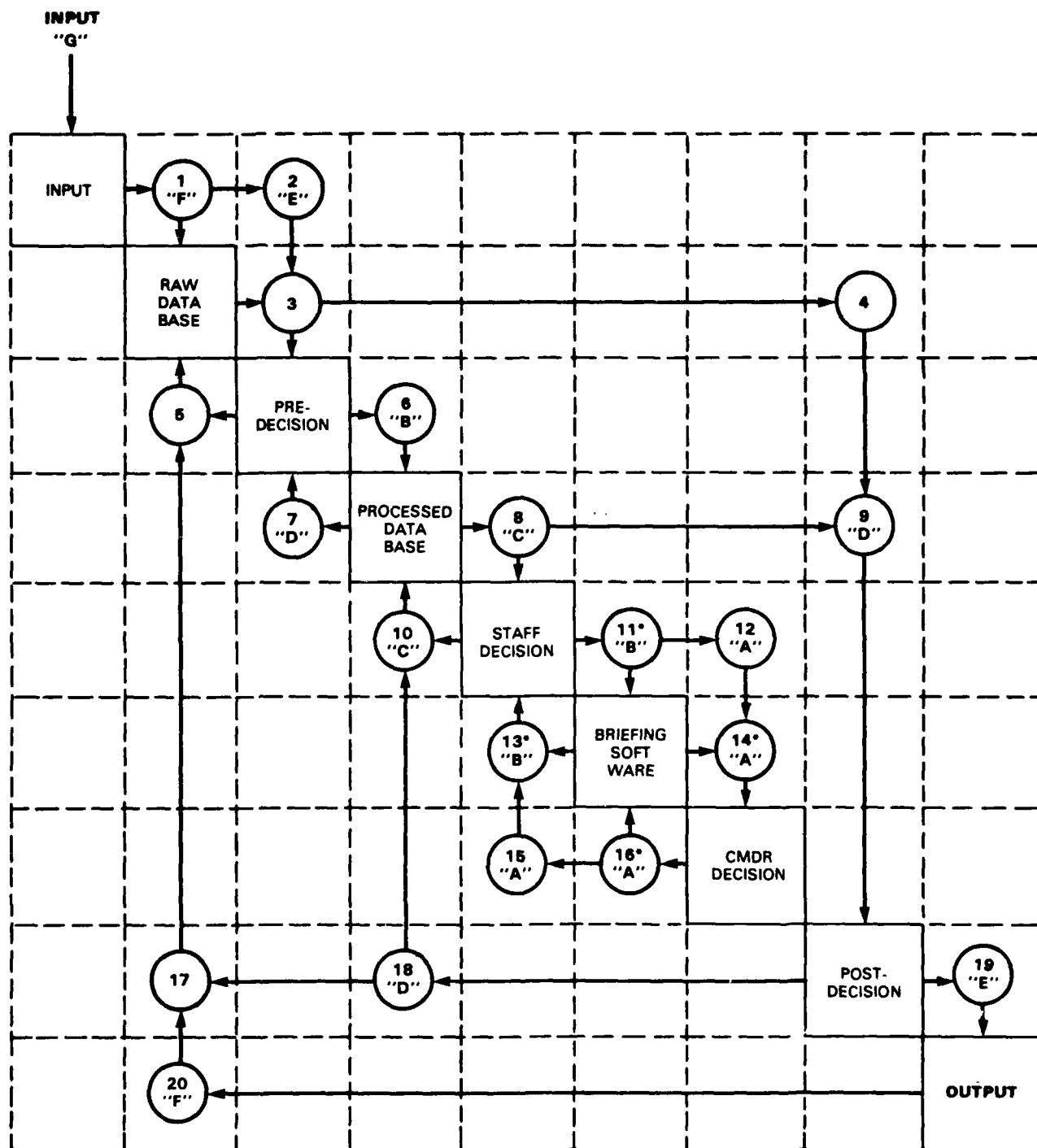


Figure 2-8. N² CHART OF THE COMMANDER'S BRIEFING

TOC, the numbered interfaces, and the TOC outputs. Since all but four of the numbered interfaces represent manual data exchanges, these descriptions are in very general terms. In this connection the term "processed information" is shorthand for the information produced by the pre- and post-decision functions and "manipulated information" is shorthand for the output of the decision processes. The latter is distinguished by the fact that the decision processes contain information that was not contained in the incoming message stream (hypotheses, interpretations, extrapolations, etc.). It is when we come to the man-machine interface descriptions that requirements definition really begins. The power of the N² techniques springs from the fact that, once the inputs and outputs to the automated portion of the system have been adequately described, the technician can (with the operator-user's help) organize the needed data base and define the algorithms needed to convert input into output. For the present example this conversion is fairly simple, although outputs may well be in different format from inputs -- or even provide a capability to construct new formats from scratch.

The descriptions of the four automated interfaces shown in Table 2-1 are only the beginning. These must now be expanded to include every element of data to be transferable from staff to commander and return through the automated terminals and every format to be employed. If self-formatting is to be available, the range of such formatting must be agreed upon. You will note that Interfaces 15 and 12 provide the loop from commander to staff around the automated system. Since you cannot and do not desire to stop the commander from asking questions he cannot get answered through the automated terminal, it is this route that will be taken to get such information by voice communications. In deciding what information to transmit through the terminal, you are making a trade-off between these two means of communication, and you are adding to the workload involved in STAFF DECISION by requiring the staff to maintain two data bases -- as was pointed out in Section 2.6. You will also note that this loop provides the back-up in case the automated system goes down -- it represents the original manual way of conducting the briefing.

Using this technique the user and technician working together can develop a statement that both understand and that avoids many of the gaps that all too frequently plague requirements drafted without dual participation.

2.8 INITIAL DEVELOPMENT

As you move into the development phase of the initial implementation the ball is definitely in the technicians' court. It is they who must now assume primary responsibility for adhering to the schedule that should have been established as part of the initial concept development. They should also have planned for the arrival of the necessary hardware needed to initiate development. This does not mean that the user can sit on his

TABLE 2-1. FUNCTION, MANUAL DATA BASE, AND INTERFACE
DESCRIPTIONS FOR THE COMMANDER'S BRIEFING

FUNCTIONAL AND MANUAL DATA BASE DESCRIPTIONS

INPUT

- Receives, verifies, and tags incoming messages
- Enters messages in RAW DATA BASE
- Passes messages to PRE-DECISION

RAW DATA BASE (MANUAL)

- Stores messages in retrievable form
- Retrieves and passes selected messages to PRE-POST-DECISION

PRE-DECISION PROCESSING

- Sorts, associates, and aggregates/organizes information
- Files processed information in PROCESSED DATA BASE (manual)
- Queries RAW DATA BASE for selected messages

PROCESSED DATA BASE (MANUAL)

- Stores processed information in retrievable form
- Provides information to PRE-POST-DECISION
- Stores manipulated information from STAFF DECISION
- Provides processed and manipulated information to STAFF DECISION

STAFF DECISION

- Retrieves processed and manipulated data from PROCESSED DATA BASE
- Files manipulated data in PROCESSED DATA BASE
- Files processed and manipulated data to BRIEFING SOFTWARE through terminal
- Provides processed and manipulated data to COMMANDER DECISION by voice commo in response to queries
- Receives queries from COMMANDER DECISION by voice commo

TABLE 2-1 (Continued)

BRIEFING SOFTWARE

- Stores processed and manipulated data received from STAFF DECISION through terminal
- Responds to queries received from STAFF DECISION and COMMANDER DECISION through terminals
- Provides processed and manipulated information to STAFF DECISION and COMMANDER DECISION in response to queries through terminal

COMMANDER DECISION

- Receives processed and manipulated information from BRIEFING SOFTWARE through terminal
- Receives processed and manipulated information from STAFF DECISION by voice commo
- Queries BRIEFING SOFTWARE and sorts manipulated information there (including decisions) through terminal
- Queries STAFF DECISION and announces decisions by voice commo

POST-DECISION

- Receives processed and manipulated data from PROCESSED DATA BASE
- Receives selected messages from RAW DATA BASE
- Queries PROCESSED DATA BASE for selected information
- Files processed information in PROCESSED DATA BASE
- Queries RAW DATA BASE for selected messages
- Composes outgoing messages and forwards to OUTPUT

OUTPUT

- Files outgoing messages in RAW DATA BASE
- Transmits, verifies, and tags outgoing messages

INPUTS

- Incoming communications traffic

TABLE 2-1 (Continued)

INTERFACES

1. Incoming messages
2. Incoming messages
3. Selected whole messages
4. Selected whole messages
5. Requests for selected messages
6. Processed information and requests for stored information
7. Requested information
8. Requested information
9. Requested information
10. Manipulated information
11. *Selected information in following categories:
 - Weather data and extrapolations
 - Terrain data and extrapolations
 - Friendly unit locations, status, capabilities
 - Enemy unit locations, status, capabilities
 - Mission
 - Organization for Combat
 - Order of Battle
 - Logistic Status
 - Admin Status
 - Courses of action considered
 - Enemy intentions/capabilities considered
 - Staff recommendations
 - Staff requests for any of above or for commander's entries
12. Staff responses to commander's requests for information not available from BRIEFING SOFTWARE
13. *Selected information in following categories:
 - Commander's planning guidance and decisions entered at Interface 16
 - Any categories entered at Interface 11

TABLE 2-1 (Continued)

14. *Selected information in following categories:
 - Any categories entered at interface 11
 - Commander's planning guidance and decisions entered at Interface 16
15. Requests to staff for information not available from BRIEFING SOFTWARE; planning guidance and decisions not enterable at Interface 16.
16. *Selected information in following categories:
 - Requests for any categories entered at Interface 11
 - Requests for previously entered commander's planning guidance and decisions
 - Planning guidance and decisions
17. Requests for selected messages
18. Processed information and requests for stored information
19. *Outgoing messages*
20. *Outgoing messages*

OUTPUTS

- Outgoing communications traffic

haunches during the development phase -- far from it. He is still needed to provide advice and guidance to the technician, to confer on what the user will find acceptable, to evaluate the proposed interfaces -- especially, displays, and to be available for "hands-on" training especially for the operators of the equipment. Don't forget that in the example cited above the principal operators are the commander and the senior staff. These operators should be exposed to the automated support almost as soon as the first displays can be brought up on the equipment. Do not wait until the system is ready to be operated in the field. Initial exposure should be in garrison and should be continuing throughout the development phase. In addition to giving the future operators experience and confidence in computer support, thus minimizing "computer anxiety" (the fear of bringing the whole system down or looking foolish before others because of a stupid mistake) this early user involvement will pay tremendous dividends in fielding a more useable system and insuring much earlier user acceptance.

Detailed planning for the demonstration and trials of the initial development is another activity that must take place during the development phase. Some of the factors that must be considered in such planning are discussed in the next paragraph.

2.9 INITIAL DEMONSTRATION AND TRIALS

This phase of the development is without doubt the most important milestone in the entire effort. If the commander and senior staff do not have the impression that computer support can improve their C² operation, the entire effort is clearly in trouble. Here are a few rules that will help avoid such an outcome:

1. A thorough and complete plan for the demonstration and trials must have been completed while the proposed computer support was being developed

Planning for the initial trials is somewhat similar to planning for an FTX or a map exercise. The scale of the trials will be determined by the nature of the applications being tested. Trying out a movement order generator does not require a full-blown CPX; trials of an automated briefing system probably does -- at least a reduced scale exercise on the grounds of home station. There must be means for providing an information load to the system. How elaborate this is again depends on the application being tested. This could range from a simple scenario to a full-blown Master Incident List to a battle simulation.

You must begin with a set of test objectives tied directly to the changes in C² performance sought by means of the automation support being tested. These will indicate the nature and extent of the combat environment to be simulated in order to

load the TOC and to provide the information needed to generate the products to be tested. In addition to fielding the TOC, the plan must also provide for the umpires or controllers necessary for simulating the battle events and for the data collectors necessary to gather the quantitative measures of goal achievement. One reason for starting your planning early is to take advantage of the assistance that can be provided by TRADOC COMBINED ARMS TEST ACTIVITY (TCATA) in running the demonstration and field trials -- especially in the area of test data collection. Your chain of command will have information on how to go about tasking that agency.

2. Remember that you are conducting an experiment; good experimentation requires a controlled (scientists would call it "sterile") environment. This means you must minimize the effects of all variables except those you are trying to measure.

This second rule is probably the one most difficult to apply. Whenever any tactical exercise is proposed there is always the tendency to hang on every bell and whistle in the training catalog. This must be avoided for the initial trials and is another cogent reason for the personal involvement of the commander and senior staff. The activity most closely tied to C² is, of course, communication, but discovering the training deficiencies of the signal battalion or brigade is not the objective of the initial trials of the computer support application. The initial trial should take place in garrison or with hard wired, reduced distance communication so that the disturbing effects of everything but the computer support of operations is held to a minimum. Later experimentation with alternative communication nets is certainly warranted to discover optimal C³ configurations, but the initial trials of a new automation application must eliminate as far as possible the uncontrolled variables of a full-blown communication system. The same principle applies to any other possible source of impact on the C² system. The objective of the initial trials must be to measure the change in performance resulting from the computer support to C2 operations -- don't dilute it by trying to determine the effect of other changes. Reducing the scale of the exercise to the minimum needed to reach that objective will, of course, reduce the expenditure of limited training funds and, thus, the pressure to add other purely training objectives.

3. A detailed SOP for use with the computer support must have been developed; the initial trials are a test of that SOP as well as of the computer support.

You will already have initiated compliance with the third rule when you analyzed the total system impact of automation, especially the initial increment, during the concept development. Looking at the changes in SOP inevitably associated with

your initial application was part of that exercise. This needs to be extended and modified as the development proceeds to take into account the inevitable changes in requirements and new insights provided as the user gets involved during the development phase. The important point is that everyone involved must have a clear idea of what the application is to be used for, who operates the equipment, and how it is to be employed. Well trained equipment operators who have already had extensive experience with the equipment in garrison are part and parcel of this rule.

4. The entire staff (not just the operators and data collectors) must have been oriented in advance as to the test objectives, the goals of the effort, and the measures of accomplishment.

The entire staff -- that is, everyone involved in the trials -- must be oriented on what the demonstration and trials are all about. Not only will this improve the trial, but it is amazing what insights toward improvement of the whole operation can be provided by knowledgeable persons who have been adequately briefed even though not immediately associated with the computer support. This rule also reinforces the importance of the operating principle stated back in paragraph 2.2, namely, that automation must be phased in gradually in steps sufficiently small that they can be absorbed by the staff without completely changing their method of operation in one fell swoop. Nothing can be more devastating to acceptance of computer support than trying to impose too much change in the first step.

2.10 EVOLUTIONARY DEVELOPMENT

Figure 2-9 displays the above procedures as a development cycle to emphasize its iterative nature. After the initial trials and demonstration and after you have corrected the deficiencies uncovered and modified your interim system to incorporate the lessons learned, you are ready to tackle the next application(s). At this stage it is appropriate to review your original concept to see whether the experience gained with the initial application provides a basis for modifying the concept -- or even for changing your original priorities. This is even more important if, in the meantime, your unit has had a change in mission, or there have been changes in senior personnel. Remember you must be ever ready to answer the question, "What has automation done for me lately?"

In carrying through the next iteration you will, of course, apply not only what you have learned about system design, but also what you have learned about how to manage such an effort in terms of pre-planning, user training, and how to run demonstrations and trials.

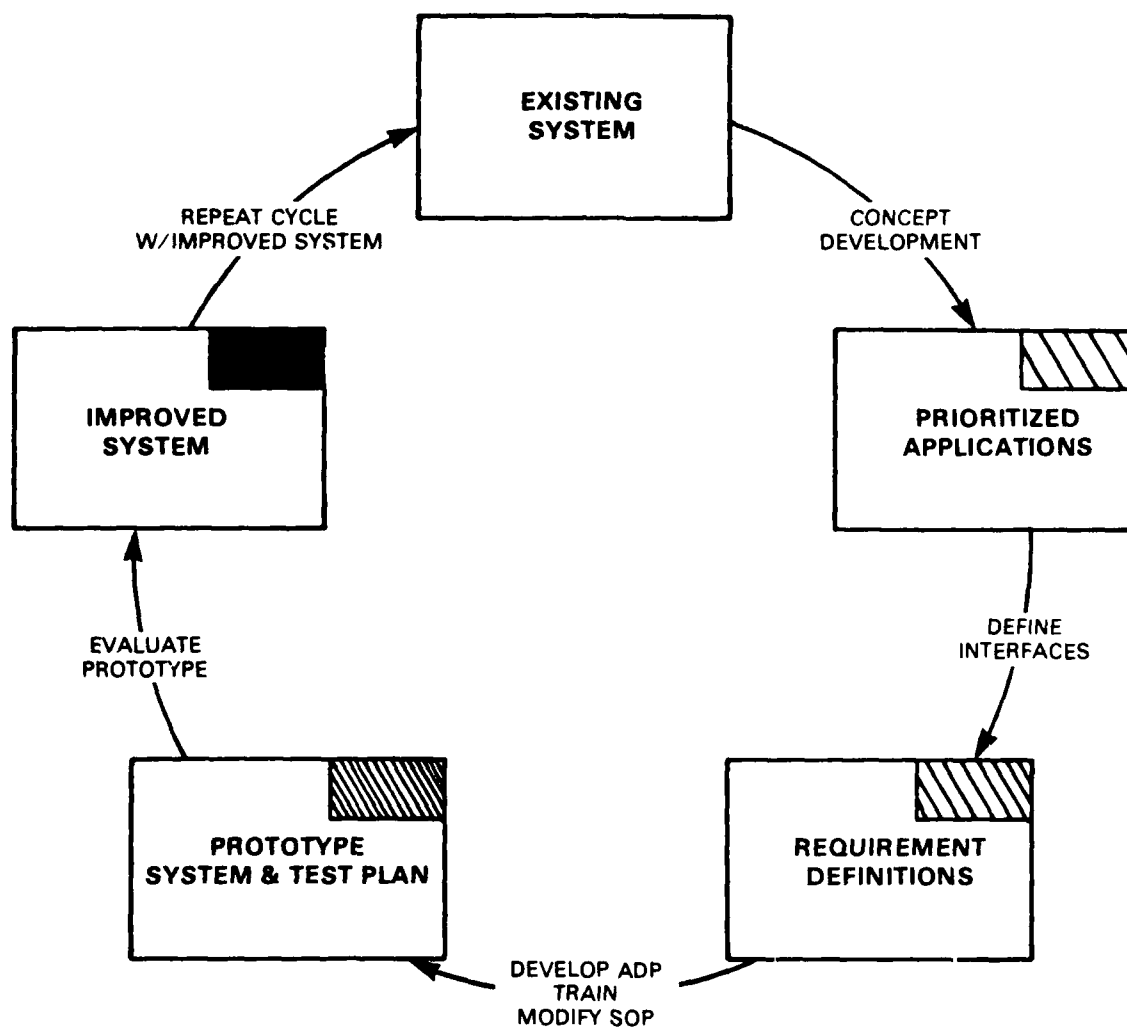


Figure 2-9. DEVELOPMENT CYCLE

Still another important factor in adding computer support to your operation is the matter of continuing user familiarity and training in the use of the computer support while succeeding applications are under development. In many cases some portion of the application already developed will be applicable to peacetime operations in garrison. This use should be encouraged and will pay handsome dividends in user acceptance.

2.11 INSURING ACCEPTANCE

The whole purpose of this manual is to assist you in gaining initial and maintaining continuing acceptance of the new modes of operation that will inevitably accompany the introduction and assimilation of automation into your unit C² operations. In particular, both the basic guidelines and task sequence discussed above are efforts to encapsulate the experiences of others in trying to absorb this new technology into ongoing operations. The following observations and conclusions were arrived at as a result of visits to TACIP units both in Europe and the CONUS.

The following set of principles summarizes and highlights the experience of others in making this transition successfully:

- You must inspire confidence in the ability of automated hardware and software to assist in tactical operations. Don't bite off more than you can chew initially; it is far better to have people panting for the next application than to swamp them with more than they can absorb.
- You must avoid even the appearance of adding to the workload; "If it doesn't make my job easier, it's no good."
- You must overcome "computer anxiety" by exposing the ultimate operator to the equipment as soon as possible. He must be thoroughly familiar with it prior to the initial demonstration and trials.
- You must have adequate technical expertise available. This is part and parcel of sizing your application(s) to the available resources.
- While you must not let communication difficulties unduly affect your initial demonstration and trials, you must be ever aware that the ultimate constraints imposed by your communication net must be considered in your total command and control system design.

Figure 2-10 illustrates the applications of these principles to

SYSTEM DEVELOPMENT		ACCEPTANCE PRECEPTS	INSPIRE CONFIDENCE	EASE/SMOOTH WORKLOAD	OVERCOME "COMPUTER ANXIETY"	HAVE TECHNICAL EXPERTISE AVAILABLE	CONTROL COMMO IMPOSED VARIABLES
STAGES	TASKS						
CONCEPT DEVELOPMENT	GOAL DEFINITION	X					
	ANALYZE	X					
	SIZE & PHASE	X				X	
	SYSTEM IMPACT	X	X			X	
	PRIORITIZE	X	X				
REQUIREMENT DEFINITION	DEFINE INTERFACES		X			X	
DEVELOPMENT	DEVELOP ADP					X	
	TRAIN	X	X	X			
	MODIFY SOP	X					
	PLAN TRIALS	X	X	X	X	X	X
DEMO & TRIALS	EVALUATE	X	X	X	X	X	X
ITERATE	ITERATE	X	X	X	X	X	X

Figure 2-10. APPLICATION OF ACCEPTANCE PRINCIPLES

the individual tasks in the development cycle.

Familiarity with the confidence in a system seem to be the primary factors in user acceptance -- that is, assuming the system's utility in aiding user functions has been perceived. If the system is perceived to create additional workload, user resistance will be difficult to overcome.

When the user becomes aware of how the system will assist him in the performance of his job, the next hurdle seems to be overcoming "computer anxiety." The latter is primarily the result of two common fears: the fear of pushing the wrong button and thus causing system failure, and the fear that when some simple error is made the whole world will know (or the fear of not knowing exactly who will know). Developing a familiarity with the computer to overcome these fears is the first step in training. Training cannot be effective until the user is at ease and comfortable with the machine.

Another major factor in user acceptance is confidence in the system. This is related to perception of utility. When the user is not confident in the system he takes precautions against its failure, i.e., maintains the manual system also. This creates additional work and the computer, because of its perceived lack of reliability, is blamed for the increase. To some extent increased familiarity will lead to increased confidence; however, the system must, in fact, be reliable. Periodic failures, loss of data, and nonavailability when needed will be amplified in the mind of the user and must be minimized to develop confidence that the system is, and will be, a worthwhile tool for the user.

Expertise in hardware, software, and systems analysis must be available to the project manager. Command interest in a project is not sufficient if it doesn't extend to providing the expertise required to accomplish the desired results. Development is slow and generally insufficient when developers have to learn as they are developing the system. In order for these programs to have significant results in the near term, expertise must be made available so that the developer can respond to user desires in defining the problem, developing a solution, testing that solution, and training the users.

The user's exposure to the computer system must be continuous in order to develop and maintain familiarity with its use. System applications must be developed for use in garrison to facilitate this. A system which is used only in field operations creates a training/relearning problem prior to and in the early stages of every exercise. "User friendly" is a catchy phrase which has different meanings for different people and always requires tremendous overhead within the computer system. We are a long way from having computer systems which can carry on

human-like conversations and, therefore, are forced to learn to talk to the computer in ways it can understand. If we expect the computer to be of use in a "come as you are" war, users must be totally familiar with and comfortable with the system. There will be no time to get up to speed in its use.

Communications capability is rapidly becoming the limiting factor in the transfer or exchange of data in organizations using automated data systems. In order to realize the full benefit of computers, data must be transferred between locations rapidly. Decision support in tactical command and control can require large data transfers, especially when such transfers are not limited to the dynamic data elements and include large blocks of relatively stationary data which could have been stored locally. It has become evident in some of the initiatives that hand carrying large files on magnetic disk could relieve system congestion and even save time in the transfer. Possibilities for communication upgrades must be examined and fielded to take full advantage of the automated data capabilities.

SECTION 3

THE TACTICAL COMMAND CONTROL (C²) SYSTEM

In order to put your problem into context and to have a common basis for assessing potential payoffs relative to costs and risks, it is necessary to describe the tactical C² system in information system terms. You may well wonder why we have to go through the effort of dissecting TOC operations on the basis of information processing rather than the much more common classifications based on the kinds of information being processed (admin, intel, ops, log, and all their subclassifications) or on a basis of input and output message types. The reason for this approach is that we need a tool in the form of a model of TOC operations which is independent of the kind of information being processed and which applies to all input messages that need to be processed as well as to every output that needs to be produced. Such a model can be used to portray the information processing operations of any decision making node in the tactical C² system whether it be a TOC or in some other element of the CP. For those of you who have decided to read this section before tackling the "how to" portion of the manual in Section 2, having such a model of TOC operations will be extremely useful when we address the problem of developing concepts for the improvement of the C² system through automation and evaluating such concepts in terms of their costs and risks.

The remainder of this section describes the tactical C² system as an information system by posing and answering the nine questions shown immediately below.

THE TACTICAL COMMAND CONTROL (C²) SYSTEM

Section #	(Page #)	Questions
3.1	3-2	What is it?
3.2	3-2	What does it do?
3.3	3-3	What is it for?
3.4	3-3	What does it look like?
3.5	3-3	How does a TOC process information?
3.6	3-11	How does it differ from business management?
3.7	3-16	What's wrong with it?
3.8	3-17	How can automation help?
3.9	3-21	What's an example of automation?

3.1 WHAT SYSTEM IS IT?

There seems to be little agreement on what precisely is the tactical C² system; observers tend to describe the portion of the elephant nearest them. The engineer refers to an assemblage of hardware; the ADP system designer refers to a collection of hardware and software. The user tends to describe it at a particular echelon of command or as a "functional" system, e.g., an intelligence system, a fire support system, or a communication system. At the other extreme there is frequent confusion between the command control system and the forces being commanded and controlled. For our purposes let us define the C² system to include commanders at all echelons, their staffs, and all communications, sensors, personnel, equipment, facilities and procedures used in planning, directing, coordinating, and controlling the assigned forces. A convenient analogy is that the C² system is essentially the nervous system of the tactical force. It informs when the force needs replenishment or rest. It controls and coordinates the muscles. Above all, it is the repository of force goals and past experience and makes decisions to take actions to achieve those goals.

3.2 WHAT DOES IT DO?

It is useful to examine the functions of combat in the light of the above general definition to see if they can help us differentiate between the C² system and the remainder of the force in a functional sense. Following is a commonly accepted list of combat functions together with their inputs (what triggers the function?) and outputs (does it produce physical action or information?).

<u>INPUT</u>	<u>COMBAT FUNCTION</u>	<u>OUTPUT</u>
Information	Fire	Physical Action
Information	Move	Physical Action
Information	Support	Physical Action
Physical Action	Sense	Information
Information	Communicate	Information
Information	Plan, Direct, Coordinate, Control	Information

This listing clearly differentiates the last three functions, which output information, from the first three which output physical action. It is these last three information outputting functions that have been included in the C² system definition of the preceding paragraph. Thus, the C² system is an information system. What does it do? It processes information.

3.3 WHAT IS IT FOR?

The key to answering this question lies in the operative words of the preceding definition: planning, directing, coordinating, and controlling. All of these activities involve the gathering, transmitting, and processing of information to reduce uncertainty, to facilitate decision making under conditions of uncertainty, and to supervise the execution of decisions. The principal nodes of this system are the commanders and staffs at the several echelons of command. It is these nodes which:

- Collect, sort, aggregate, and organize information for decision making.
- Interpret, project, and extrapolate information and suggest and evaluate alternative courses of action, make decisions, and
- Prepare and distribute instructions for implementing decisions (plans, orders, directives) and monitor the execution of decisions.

3.4 WHAT DOES IT LOOK LIKE?

Figure 3-1 is a schematic of tactical C² system at a single echelon of command. Central to the system is the tactical operations center (TOC) containing a data base with status, mission and plans. Its many functions have been aggregated into situation recognition and action selection. It is coupled to the outside world through effectors that initiate physical actions which produce real events. These produce observables which may be fed back as information by sensors. There is, of course, a hierarchy of such loops in the military structure. At each echelon this system tries to achieve the set of goals prescribed in its mission.

3.5 HOW DOES A TOC PROCESS INFORMATION?

The individual decision node (TOC), as indicated in Figure 3-1, can be thought of as a black box embedded in a communication net. This black box has at its boundaries easily discernable inputs and outputs. However, inside the black box some sort of transformation takes place which we can label simply "processing" so that the TOC as a whole can be described as an input-process-output or IPO model. The inputs and outputs are observable and can be specified but the internal processes are not observable nor can they be specified until we take a look inside the black box. But we also know that the TOC is populated by a group of individuals and a set of equipments used by the individuals to facilitate the interior processing. Groups of individuals engaged in such information processing, just like

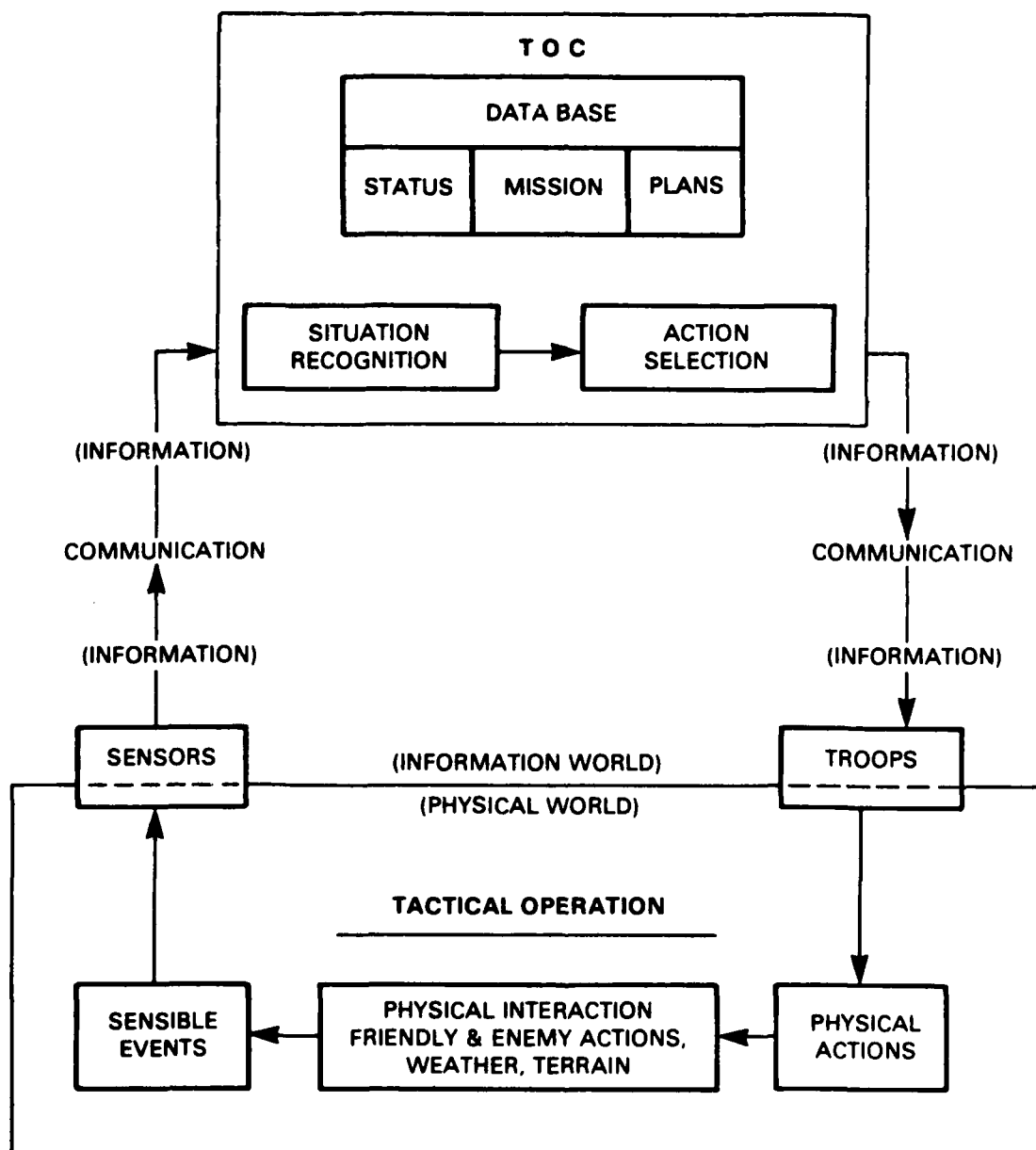


Figure 3-1. A SCHEMATIC OF THE C² SYSTEM

groups engaged in any other joint activity tend to organize themselves into specialties. A division of labor follows which takes advantage of the special skills and experience -- and place in the pecking order -- of each individual. In other words, an organizational structure emerges. Specialized sub-clusters of individuals are formed. The sub-clusters referred to here are quite separate from the usual division of the TOCs of larger units into separate staff sections and groups of specialists such as the FSE, DAME, etc. The sub-groups resulting from the division of information processing labor exist within each of the above and consist of personnel with different skill levels such as RTOs, clerks, NCOs, and officers. Each such sub-cluster and, finally, each individual can be thought of as an IPO model with observable inputs and outputs. In such a structure, information must be passed between sub-clusters and between individuals and to data storage devices (files, maps, displays, terminals). An examination of these internal inputs and outputs can provide insights into the nature of the information processes actually being performed. This amounts to breaking the TOC down into a hierarchy of IPO models in which the individual is the lowest level of concern. In the next paragraph we shall develop this notion at the sub-cluster level and in the following paragraphs we shall proceed to the level of the individual as a component of the TOC. In this way we can dissect the total TOC processing, first into functions performed by sub-clusters, and then into individual processes performed by individuals in conjunction with data storage and retrieval devices.

3.5.1 Sub-Cluster Functions

The major functions that can be distinguished within the sub-cluster are input and output, pre- and post-decision processing, and decision making. These are illustrated in Figure 3-2. Incoming messages are throughput by the input function to a raw data base (message file) and to the pre-decision function. The pre-decision function extracts data from the incoming messages and enters it in structured form into the processed data base thereby creating and continually updating the useable data base (section files and displays in the manual mode). The decision function extracts information in structured form from the data base, manipulates it and augments it by adding new structures, making assumption to cover the gaps, and reinterpreting the results in order to select the action(s) to be implemented. The post-decision function converts decisions into messages and further updates the data base. The output function throughputs the messages into the information stream and into the message file.

Lest one fall into the trap of regarding the TOC as an entirely reactive entity, one must recognize the arrows shown in Figure 3-2 indicate only information transfers among the components of the TOC. They neither imply that this is a continuous

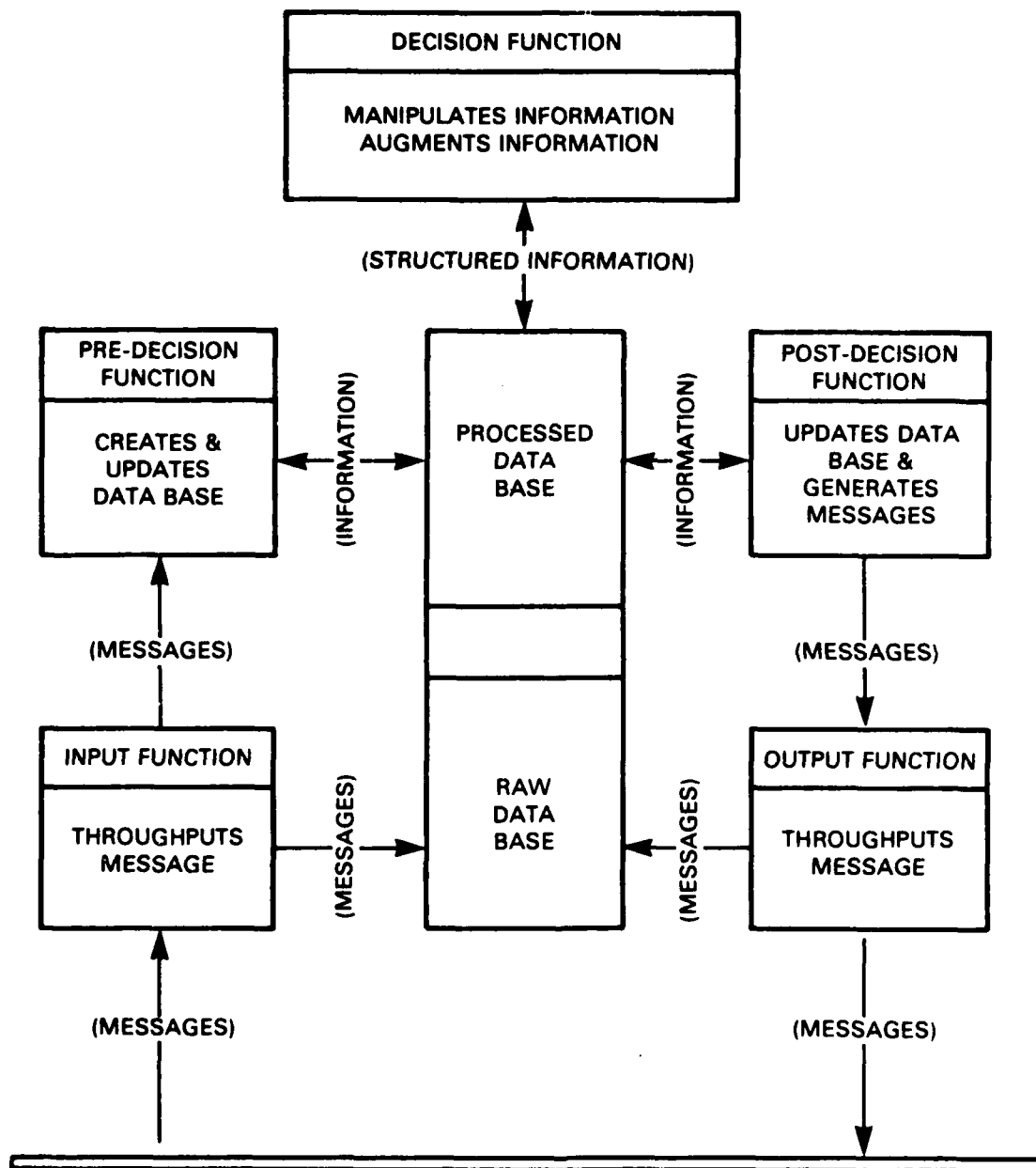


Figure 3-2. TOC FUNCTIONAL SUB-GROUPING

process nor that every input produces an output, nor even that all outputs can be traced to specific inputs. Just as individual human reactions are not necessarily always triggered by external stimuli, group outputs can be triggered by internal stimuli which can vary in complexity from periodic reports triggered by an internal clock to actions taken as a result of profound insight or hypotheses generated long after the arrival of the latest segment of raw data that has been considered.

3.5.2 Individual Processes

The division of labor does not, however, stop with the functions identified in Figure 3-2. The functions identified there are not always performed by a single individual so that processes comprising each of these functions can also be identified. Figure 3-3 expands the model to show the information processes inherent in each function. The following table describes its components, its attributes, and the product on which it operates. This will be done in the sequence indicated in the figure rather than alphabetically. Although an effort will be made to keep the discussion general, i.e., so that it applies both to manual and ADP assisted groups, the initial discussion will concentrate on the manual mode; changes resulting from automation will be discussed later. The definitions of the model components follow:

COMMAND CONTROL GROUP: An assemblage of more than one individual and the equipment (communication terminals, files, displays, data processing equipment, etc.) needed to function as a decision node in a tactical command control system. Members of the group are collocated so that non-verbal communications are facilitated. Conversely, members are in some degree shielded from non-verbal communication with nonmembers of the group. Military staffs of larger units usually function as a number of separate and distinct command control groups (staff sections).

EXTERNAL INFORMATION STREAM: This includes all information received by the command control group from sources outside itself and all transmitted by the group to recipients outside itself. It includes all means of communication (oral, written, electrical, gestures) and includes information to and from other command control groups (staff sections) within the same headquarters -- to include the grim visage of the CG who is still waiting for the chopper he ordered 30 minutes ago. Most of the information flowing in this external stream is in the form of communications traffic.

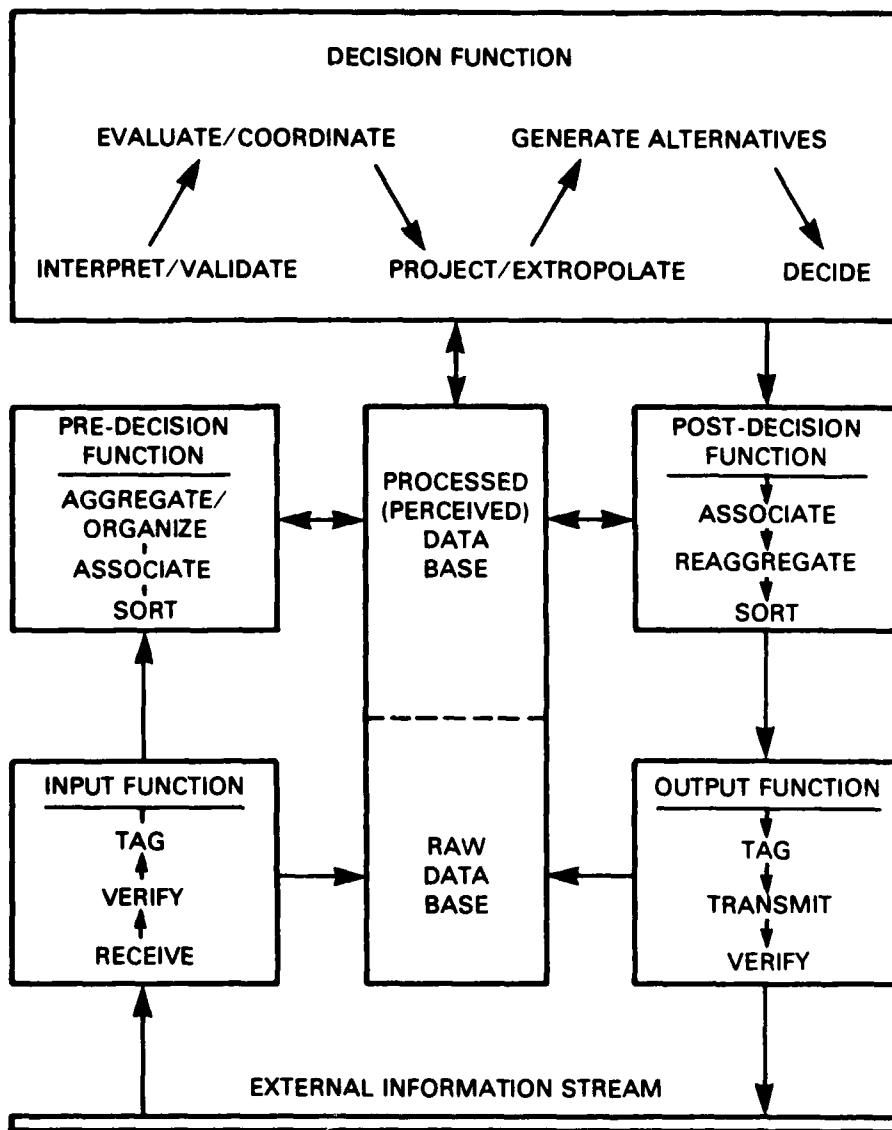


Figure 3-3. COMMAND CONTROL GROUP PROCESSING STEPS

MESSAGE: An ordered selection from an agreed set of signs (alphabet) intended to communicate information.

RECEIVE: The process of accepting the string of signs or symbols that constitute a message -- or the process of making a one-for-one transformation of the incoming string, e.g., copying an incoming voice message or repeating aloud an incoming message. This process does not include transforming the string of symbols into information.

VERIFY: The process of ensuring that the accepted string of signs or symbols agrees precisely with the string to be transmitted by the sender. This process may require transmission of procedural signs or even retransmission of the message string by the receiver. It is this process which reduces uncertainty in the sense of Shannon's Communication Theory.

TAG: To affix an identifier (frequently a sequence number) to a message to facilitate retrieval from the raw data base.

RAW DATA BASE: A file containing incoming and outgoing messages processed only through the verification and tagging stages.
Example: Staff Journal.

SORT: To arrange entire messages or segments of messages according to a predetermined classification scheme. This is the lowest level process requiring some perception of message content -- at least at the level of the classification scheme. Example: Extracting unit location from a SITREP.

ASSOCIATE: To relate a package of sorted information to other information in the same or allied class. Example: Is the 1st Battalion of the 32nd Tank Regiment part of the 20th Guards Tank Division?

AGGREGATE/ORGANIZE: To combine associated information and array/display it in a manner that facilitates the decision processes. Example: Update the Order of Battle.

INTERPRET/VALIDATE: To hypothesize cause-and-effect relationships between ordered sets of information and to assess the probability of their correctly representing ground truth. Since ground truth is usually not accessible, validity must be assessed in terms of consistency with past experience, or against independently derived hypotheses from within or outside the group. This process is significantly different from "reduction of uncertainty" in the Shannon sense. Example: How can the 2/31 Battalion continue to advance at over 5 km/hr against two regiments when it has sustained a reported 60 percent casualties?

EVALUATE/COORDINATE: To determine whether the perceived situation warrants consideration of taking further action or of shar-

ing the perception with another command control group or of both.
Example: Does the gap apparently opening up on our right flank warrant issuing a frag order, or notifying the adjacent unit, or both?

PROJECT/EXTRAPOLATE: To estimate probable future situations based on current or predicted trends. Example: Where and when must I lay on the next ammunition resupply operation if present expenditure and movement rates continue?

GENERATE ALTERNATIVES: To postulate alternative courses of action for both friendly/enemy forces which could conceivably lead to mission accomplishment. Enemy missions must usually be inferred or multiple missions within his capability must be considered. The latter process is usually referred to as, "determining enemy capabilities."

DECIDE: The process of determining which of the alternatives considered is most likely to yield the greatest success in accomplishing the assigned mission.

ASSOCIATE (POST-DECISION PROCESSING): To relate fully processed information during preparation of output messages, and to update impacted data bases. Example: The decision "main effort on the right" might be transformed into "2d Brigade attacks in zone, makes main effort .. priority of fires to 2d Brigade."

REAGGREGATE: To combine fully processed, relevant, and needed information into preparation of an output message. Example: Revise the Organization for Combat in accordance with the decision.

SORT (POST-DECISION PROCESSING): To arrange segments of an outgoing message in the selected format and to determine distribution.

TRANSMIT: The process of entering into the external information stream the string of signs or symbols that constitute the message.

VERIFY (OUTPUT PROCESSING): Same as for the input processing.

3.5.3 Information Processes Related to Military Decision Making

It is instructive to examine the military decision making process in terms of the model described above to see whether all of the decision making process can be expressed in those terms. Since the decision making process (as described in Chapter 5 (Figure 5-1) of FM 101-5, Coordinating Draft, 3 June 1981 and in CGSC text, FUNDAMENTALS OF STAFF OPERATIONS, pp

191-208, April 1983) is the single most complex activity of tactical staffs, a check to see whether the model adequately represents this activity will insure its comprehensiveness. Figure 3-4 does this at the level of the functional subgroups. The steps in the military decision process are listed across the bottom; the functions are the row headings. The function(s) required to perform each step in the decision process is indicated by an entry in the appropriate box, the entry indicating whether that function is performed by the commander or the staff. The information transfer between functions is indicated by an arrow and the nature of each transfer is indicated.

In Figure 3-5, a similar check is made at the information process level. In the left column are listed the ten steps of the decision process. The next seventeen columns list the previously defined information processes. In the right-hand column are listed the tangible products produced at each step. This last listing is reasonably complete; not all of these products are produced for every major decision, depending on time available and echelon. The check mark entries indicate which information processes are sufficient (not always necessary) to carry out the step and to produce the indicated product(s). The single or double check is a judgment call as to the relative effort usually required for the indicated process with reference to a single decision. The figure does assume a sufficiently well trained staff so that the commander does not have to perform much pre- or any post-decision processing.

To go one level of detail deeper, Figure 3-6 compares the sequence of steps in the commander's estimate, as formulated on pages F-2 to F-8 of FM 101-5, with the five decision processes. It will be noted that not only is there a good fit, but the sequence is the same as postulated in Figure 3-3.

3.6 HOW DOES IT DIFFER FROM BUSINESS MANAGEMENT?

In looking about for other similar activities to which automation has already been applied with some success, one is struck with the similarity between a business office and a command post. The function of both is to regulate the activities of subordinates through decisions/orders to accomplish selected goals. Both contain the following elements:

- One or more decision makers
- Professional support staff
- Secretarial staff
- Equipment and office machines
- Internal working environment (operating methods, procedures, etc.)

There are, however, some significant differences which must be kept in mind rather than trying blindly to copy the

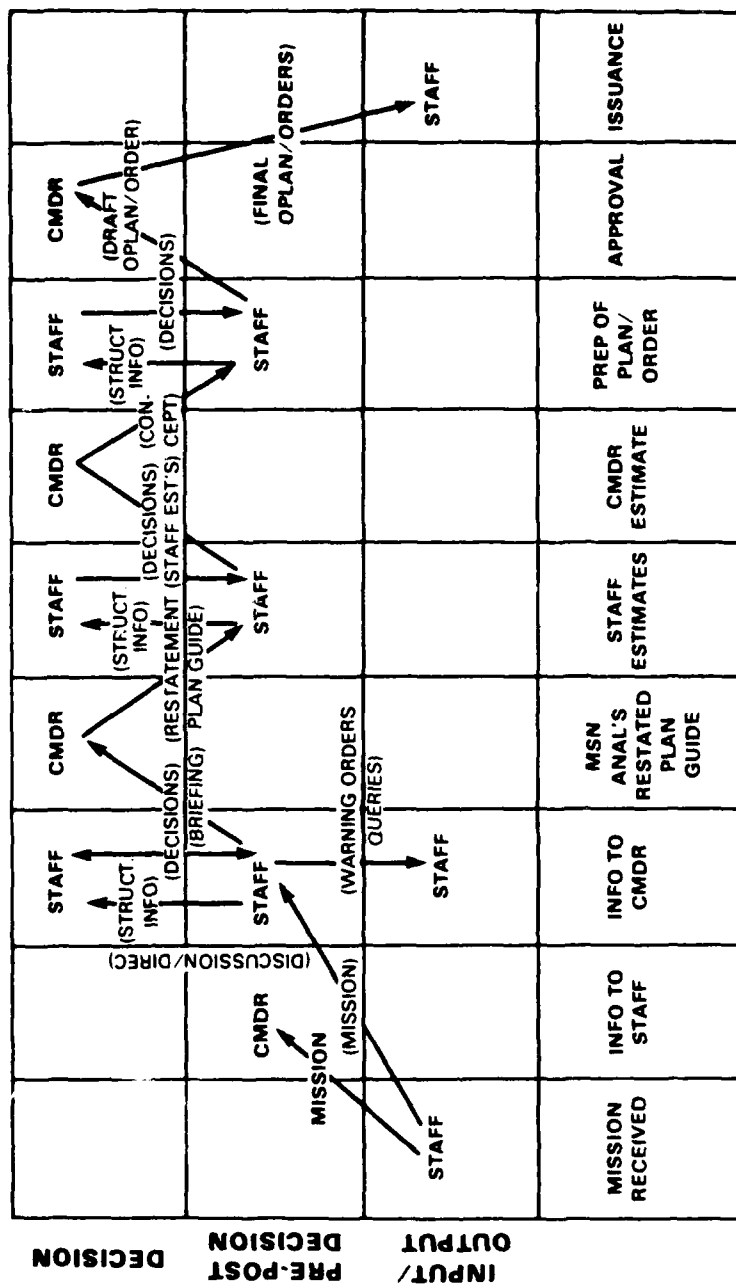


Figure 3-4. INFORMATION FUNCTIONS RELATED TO MILITARY DECISION MAKING

STEPS IN DECISION MAKING	INFORMATION FUNCTIONS AND PROCESSES																	C ² PRODUCTS
	INPUT PROCESS			PRE-DEC PROCESS			DECISION PROCESS				POST-DEC PROCESS			OUTPUT PROCESS				
	RECEIVE	VERIFY	TAG	SORT	ASSOCIATE	AGGREGATE/ORGANIZE	INTERPRET/VALIDATE	EVALUATE/COORDINATE	PROJECT/EXTRAPOLATE	GENERATE ALTERNATIVES	DECIDE	ASSOCIATE	AGGREGATE	SORT	OUTPUT TAG	TRANSMIT	VERIFY	
MISSION RECEIVED	•	•	•															MISSION STATEMENT
INFORMATION TO STAFF				•	•	•												DISCUSSION/INSTRUCTIVES
INFORMATION TO COMMANDER				•	•	•	•	•	•	•	•	•	•	•	•	•	•	DISCUSSION (BRIEFING) WARNING ORDERS, QUERIES
MISSION ANALYSIS, RESTATED MISSION, PLANNING GUIDANCE							•	•	•	•	•							RESTATED MISSION, PLANNING GUIDANCE
STAFF ESTIMATES	•	•	•	•	•	•	•	•	•	•	•							FORMAL ESTIMATES OR BRIEFING
CMDR'S ESTIMATE, DECISION, CMDR'S CONCEPT							•	•	•	•	•							CMDR'S CONCEPT
PREPARATION OF PLANS/ORDERS							•	•	•	•	•	•	•	•				DRAFT OPLAN/ORDER
APPROVAL							•	•	•	•	•							APPROVED OPLAN/ORDER
ISSUANCE OF PLANS/ORDERS															•	•	•	FINAL OPLAN/ORDER (FRAG ORDERS)
SUPERVISION	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	FRAG ORDERS, REPORTS, QUERIES, REQUESTS

Figure 3-5. INFORMATION PROCESSES RELATED TO MILITARY DECISION MAKING

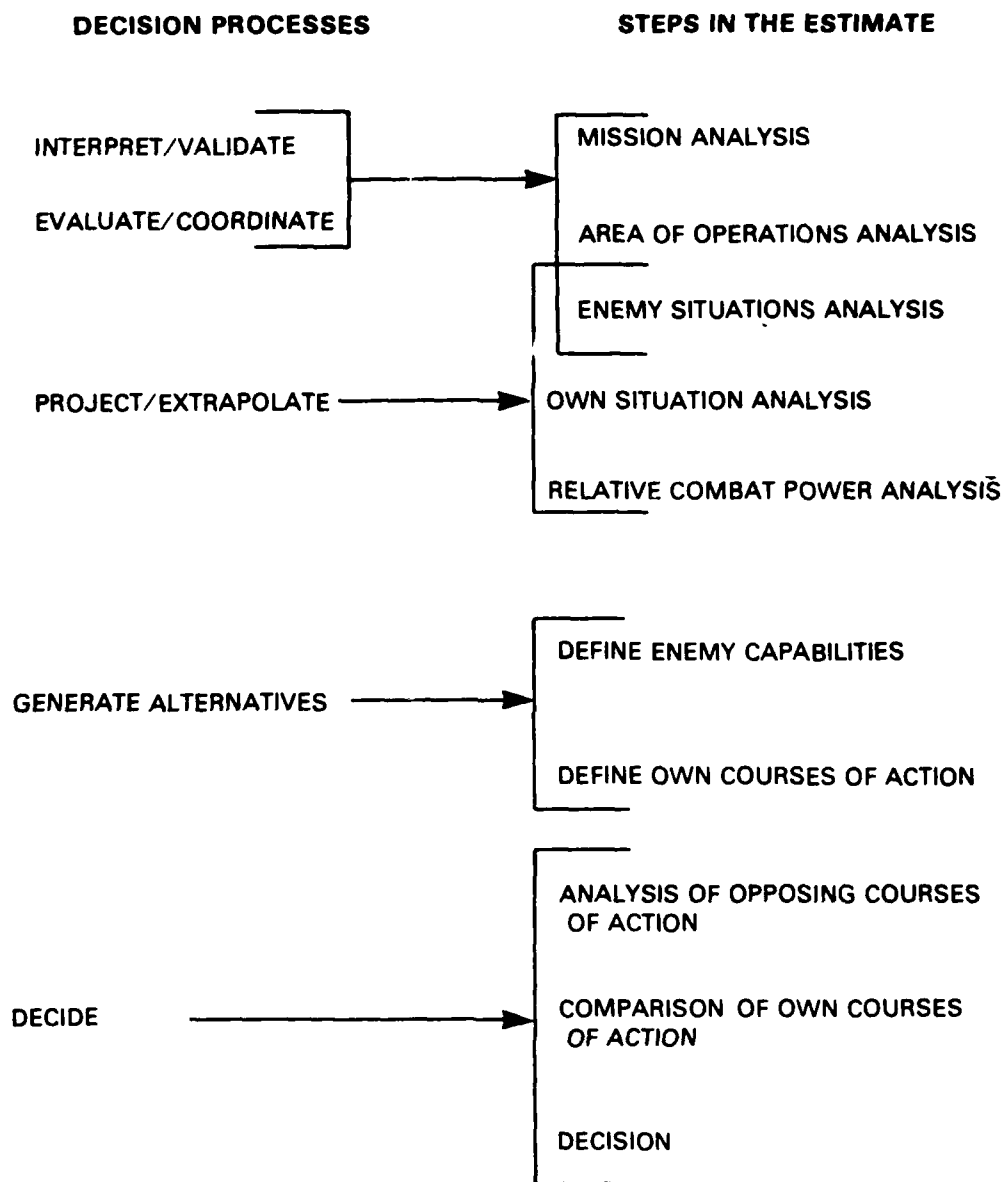


Figure 3-6. DECISION PROCESSES IN THE ESTIMATE OF THE SITUATION

methods of business management. These arise from the vastly different environment within which these organizations operate, the most significant of which is the time compression associated with the conduct of battle. Comparing a modern division comprising nearly 20,000 men with an industrial organization of comparable size or capital investment discloses significant differences:

- Continuity of Operations

Business operations are more or less continuous. "Emergencies" normally comprise a small percentage of day-to-day operations. Battles, on the other hand, are highly intermittent and unique. Commanders and staffs are concerned with planning for and handling "emergencies." In industry a base of management experience can be built which permits "management by exception," running battles is the "management of exceptions."

- Command Control in Mobile Warfare

The mobility of modern combat forces is a principal driver of many of the special requirements of a tactical C² system. The control of forces executing highly mobile operations requires an extremely dynamic data base both as a result of enemy induced changes to the situation and from frequent changes in mission and force structure. Finally, the C² system, just as any other portion of the force, is under enemy attack so that the capability of the C² system itself varies over time. This is exacerbated by the frequent need to relocate command posts thereby reducing the CP duty cycle.

- Planning Horizon

The same factors that necessitate the requirement for a highly dynamic data base also require a short planning horizon. The division planning horizon is normally 24 hours. Compare this with the typical planning horizon of 1-5 years for a comparable industrial organization.

- Provision for Centralized and Decentralized Control

Natural limits on the span of control demand a hierarchical management structure, which implies that some measure of decentralization will always exist. This is equally true for the military. There are, however, two additional factors contributing to the requirement for a tightly structured hierarchical C² system. The first of these arises from the high variability in the degree of uncertainty that exists under different tactical situations. Under conditions whereby only subordinate commanders can acquire the information required for rapid and responsive decisions, control must be decentralized. Under conditions which require extremely tight coordination between all elements of the

division, control must be highly centralized. This requirement for rapid change in the very nature of the control being exercised augments the need for a hierarchical structure. The second factor is the fact that the C² structure itself can be degraded by enemy action; thus a decentralized structure must exist to provide continuous command and control in the event of losses of individual nodes or links. These requirements demand that the tactical, automation supported C² system be compatible with both centralized and decentralized operations with minimal transition effort.

3.7 WHAT'S WRONG WITH IT

To put it crudely but succinctly, "It's simply too damn slow." Two projections of the nature of future combat combine to emphasize the necessity for reducing C² timelines and increasing the accessibility and accuracy of the data base used for decision-making. The first is the extension of the battlefield both in-depth and forward in the time dimension as described in recent TRADOC writings. The second is the projection of future battle dynamics set forth in TRADOC's Milland Battle doctrine. Attacks against follow-on echelons are made with the objective of creating "windows for action" during which friendly superiority exists and the initiative can be seized with enough time to act. Recognition of the "windows" created, execution of these attacks, and execution of coordinated actions at the FLOT combine to present a monumental C² problem for which every possible assistance must be provided to the commander.

Essential to the success of U.S. forces is the ability to disrupt the flow of enemy combat power and strike quickly given favorable conditions. This clearly implies recognition, coordination and decision processes which are beyond the capability of current procedures to execute on a sustained basis. Also implied are continuous calculations -- movement times for forces of both sides, force ratios, damage predictions, fire plan coverage, logistical requirements, and so on -- for numerous courses of action, repeated at frequent intervals. Failure to properly monitor these fundamental relationships and requirements can negate timely recognition of an opportunity and/or the ability to capitalize when presented. It is through such calculations that the opportunity can be anticipated rather than reacted to.

This need for improved timeliness and quality in tactical decision-making leads directly to the following basic goals to be achieved through the incorporation of ADP in the C² system:

1. Reduce timelines throughout the tactical C² system, but especially the response times of the decision-making nodes (TOC).

2. Improve the capability to "manage uncertainty," i.e., provide decision aids which facilitate selection of alternatives with the highest probability of success.
3. Reduce the uncertainty of the data base (basis for decision-making) through better management of data collection and processing.

The achievement of such a broad set of goals is of course impossible in one fell swoop across the entire spectrum of C² activities. In fact, one of your first tasks will be the development of a concept which prioritizes the list of feasible applications of automation into a phased series of changes that insure substantial progress toward goals at acceptable cost and risk.

3.8 HOW CAN AUTOMATION HELP?

We have now reached the point where we can develop some answers to questions such as, "Can automation really help us achieve the goals stated in the preceding paragraph and, if so, why and how?" To do so we will use the model of TOC (or any other decision node) information processing developed in paragraph 3.5 above. Since this was developed to provide a complete statement of the information processes needed to process any incoming message or to produce any needed output of a C² decision node, it will be useful to examine the question of the relative capability of man and the machine to perform these processes. Our intuition tells us that there are probably a number of processes that the machine cannot perform, but that there are undoubtedly some which it can perform much better than man. We should also look at the question of which of these processes can probably be performed even better when a machine supports a human processor.

Such comparison is made in Table 3-1. Listed in the first column at the left are the information processes required for the input, pre-decision, and decision functions. The processes required for the post-decision and output functions have not been repeated since they are the same as for inputs, but in essentially inverse order. The second column lists the dominant characteristics of unaided man in carrying out each process while the third column lists the dominant characteristics of the automated system (machine) by itself. The fourth column rates the potential payoff of combining the complementary capabilities of both man and machine, i.e., of providing computer support to the process.

The table shows that complete automation of the first three, input and output, processes offers substantial improvement except for the loss of the "personal" dimension so clearly a

Table 3-1. COMPARISON OF MAN AND MACHINE PROCESSING CAPABILITIES

PROCESS		MAN UNAIDED BY MACHINE	MACHINE WITHOUT MAN	MAN-MACHINE INTERACTION LEVERAGE
INPUT & OUTPUT	RECEIVE, TRANSMIT	COMMUNICATES MOOD OF SENDER	INCREASED EFFECTIVE CHANNEL CAPACITY; HARD COPY	LITTLE*
	VERIFY	SLOW; ERROR PRONE	FAST; VIRTUALLY ERROR-FREE	LITTLE*
	INPUT/OUTPUT TAG	SLOW; ERROR PRONE	FAST; VIRTUALLY ERROR-FREE	LITTLE*
PRE AND POST-DECISION	SORT	CAN SORT ON CONTENT; CAN GENERATE SORTING KEYS; SLOW; ERROR PRONE	CAN SORT ONLY ON KEYS	SIGNIFICANT
	ASSOCIATE	CAN GENERATE ALGORITHMS, BUT SLOW AND ERROR PRONE AT ASSOCIATED OPERATIONS SUCH AS FILE/POST/PLOT/RETRIEVE	LIMITED TO PREDETERMINED ALGORITHMS, BUT VERY MUCH FASTER AND ERROR-FREE AT ASSOCIATED OPERATIONS	SIGNIFICANT
	AGGREGATE/ORGANIZE	CAN GENERATE ALGORITHMS AND FORMATS, BUT SLOW AND ERROR PRONE AT ASSOCIATED OPERATIONS: FILE/POST/PLOT/RETRIEVE/CALCULATE	LIMITED TO PREDETERMINED ALGORITHMS AND FORMATS, BUT VERY MUCH FASTER AND ERROR-FREE AT ASSOCIATED OPERATIONS	SIGNIFICANT
DECISION	INTERPRET/VALIDATE	ONLY MAN CAN FLESH OUT INCOMPLETE PATTERNS AND GENERATE NEW HYPOTHESES AND TESTS FOR THEM	CAN ONLY EXTEND HUMAN MEMORY (ASSOCIATED OPERATIONS) AND FACILITATE HYPOTHESIS TESTING (CALCULATION)	TREMENDOUS
	EVALUATE/COORDINATE	ONLY MAN CAN INTERPRET IN CONTEXT AND GENERATE HYPOTHESES AND INSIGHTS	CAN ONLY EXTEND HUMAN MEMORY AND FACILITATE COORDINATION BASED ON A PRIORI RULE	SIGNIFICANT

*MACHINE CAN PERFORM THESE PROCESSES WITHOUT AID OF MAN.

Table 3-1. COMPARISON OF MAN AND MACHINE PROCESSING CAPABILITIES (CONT'D)

<u>PROCESS</u>	<u>MAN UNAIDED BY MACHINE</u>	<u>MACHINE WITHOUT MAN</u>	<u>MAN-MACHINE INTERACTION LEVERAGE</u>
PROJECT/EXTRAPOLATE	ONLY MAN CAN DEFINE PROJECTION AND EXTRAPOLATION PARAMETERS; INVOLVES HYPOTHESIS GENERATION	CAN ONLY EXTEND MEMORY AND FACILITATES CALCULATIONS	TREMENDOUS
GENERATE ALTERNATIVES	ONLY MAN CAN GENERATE NEW HYPOTHESES	CAN ONLY EXTEND MEMORY PERMITTING CONSIDERATION OF LARGER DATA BASE; RETRIEVE A PRIORI ALTERNATIVES FOR EVALUATION; FACILITATE REORDERING IN HARD COPY	TREMENDOUS
EVALUATE ALTERNATIVES AND DECIDE	MAN EXCELS AT STRUCTURING PROBLEMS TO BE SOLVED AND ESTABLISHING BOUNDARY CONDITIONS; MAN MUST MAKE FINAL DECISION	CAN ONLY PERMIT MUCH MORE RAPID CALCULATION WITH MORE SOPHISTICATED MODELS; CAN APPLY DECISION CRITERIA MORE RAPIDLY; LESS ERROR	TREMENDOUS

DECISION

basic component of voice communication. The latter can, of course, be extremely important in commander to commander exchanges. Nevertheless, the bulk of the routine traffic could be handled far more rapidly and expeditiously over digital links -- provided the rest of the system could handle the increased information load. One of the corollaries to Parkinson's Laws is that military traffic inevitably expands to the limits of the available channel capacity.

We note that the next three processes, which are invoked for pre-and post-decision processing, are distinctly complementary with respect to man vs machine processing. Only man can provide the basis for sorting and the needed sorting keys, the association algorithms, and the formats and algorithms needed for aggregating and organizing. On the other hand, man is very slow and error prone in the actual conduct of these processes, while the machine is very fast and error free once the needed sorting keys, algorithms, and formats have been provided. Clearly, these are processes which can profit from joint man-machine processing. Fortunately, too, the bulk of the human processing required can be done "off-line", that is, the sorting keys, algorithms, and formats can be developed in advance and stored in the computer. The bulk of this pre-and post-decision processing can therefore be shifted to the machine and the human processor needs to assist only on an exception basis. Note, however, that this also shifts some of the burden to the message originator who must now format or otherwise provide sorting keys.

When we examine the last five, the decision processes themselves, we note that not only are man's creative talents required, but that they must be applied on-line as the information is being processed. On the other hand, the computer provides the ideal medium to be used as a memory and mind "extender" in support of the decision maker. Not only can it retrieve any data item in memory, but it can display it in whatever manner the decision maker desires, it can operate on it according to instructions to perform calculations without error, and, finally, it can accept new items created by the decision maker as he develops and tests alternative hypotheses. At a still higher level of sophistication it can store and retrieve both enemy and friendly behavior patterns -- just a bunch of fancy words for enemy and friendly doctrine -- to still further assist the decision maker. When stored in the computer with tests and rules for their application, these become artificial intelligence, put at the disposal of the decision maker. The result of this combination provides a tremendous amount of leverage as compared to the decision maker trying to operate with the standard "manual" aids consisting of manually prepared overlays and displays, and oral briefings. Interactive, man-machine decision making not only leads to faster but also to better decision making in that all the available and pertinent data can be accessed rapidly and, together, man and machine can better cope

with the remaining uncertainty.

The above discussion has demonstrated that automation can help achieve the basic goals for the tactical C² system outlined in the preceding paragraphs. It has, however, also demonstrated that achieving these goals may not be quite as simple as we would like it to be. Any system or organization composed of men and machines really has four distinct variables or dimensions which can be manipulated in order to best accomplish the assigned mission. These manipulable variables are:

- The personnel and human skills available
- The technological "skills" available
- The breakdown into the individual tasks
- The structure, to include the procedures for accomplishing the tasks required by the mission

These four variables are what are being manipulated in any endeavor to improve the functioning of the system. Any such effort involves a whole series of compromises and trade-offs between the capabilities and limitations of the system components. Change any one of these variables; for example, technology, and the compromises previously worked out may no longer be valid. In general, a change in any one requires changes in all the others in order to exploit the potential improvement to the utmost. Think of the profound changes in personnel skills, task assignment, and structure introduced into military forces between 1918 and 1939 by the introduction of the tank and the tactical radio. An example with respect to the C² system has already been cited; automation of the input/output processes alone will almost immediately overload the rest of the decision making node. One must never overlook that the tactical C² system is a system and that the total system impact on any change must be considered. The following section will attempt to show how this can be done.

3.9 WHAT'S AN EXAMPLE OF AUTOMATION?

The preceding paragraph has examined the potential impact of automation on the individual information processes. We need to develop some insights as to the potential impacts of automation on the system as a whole. This is probably best done by means of an example.

The commander has expressed the desire that the information heretofore provided him at the morning and evening briefing be made available to him through a computer terminal. He has also seized on the possibility that by this means he can, in effect, receive as much as he wants of the briefing at any time without waiting for the schedule briefing time and the information provided will be current, i.e., represent the latest staff

perceptions and recommendations, whenever he requests it. Surely, this would be the epitome of the continuing estimate. We need, however, a method for assessing the impact of such a change on the entire TOC -- some sort of global representation of all the TOC operations that produce the twice daily briefings.

The general model of all of the tactical information processes shown in Figure 3-3 provides the building blocks for such a representation. Each staff section must carry out all of the processing shown in that figure because many decisions are required in the preparation of the briefing: Which information should be presented? What additional information do we need? What is the most likely interpretation of what we know? What are the most appropriate courses of action? What recommendation should we make? In making these decisions, each staff element is determining what information to include in the briefing and, effectively, creating a special "briefing data base." In the manual mode this briefing data base consists of the briefing maps, overlays, and charts plus the information conveyed to the commander from the memory of the briefing officer(s). Such a data base covers the entire spectrum of the operations of the command as a whole, but will be less detailed than the processed (perceived) data bases of the separate staff elements.

Figure 3-7 illustrates a flow chart of the information processing required for the briefing for a single staff element. Notice that the lower two thirds of this figure is identical to Figure 3-3 and represents the processing needed to create the staff section's own perceived data base -- its working files and displays. In addition, Figure 3-7 has added another output from the staff section decision processes: the briefing data base. This is, in turn, accessed by the commander's decision processes and further updated to reflect his decisions. It is this briefing data base and access to it both by the commander and staff that we are proposing to automate. It must be noted that Figure 3-7 shows the processing of only a single staff element, in this case operations. Each of the other coordinating staff sections and special staff elements must go through the same series of processes (if they don't contribute to the briefing why are they in the TOC?). Also some of this processing may go on at locations other than the TOC; e.g., the bulk of the G-1 and G-4 sections are usually at Rear.

Also indicated in Figure 3-7 are the major interfaces or data exchanges that need to take place. These have been indicated by letters A through G. In most cases these take place between functions and data bases except for the interface between input/output and pre- post-decision processing which do not share a common data base. An examination of the changes occurring at these interfaces can tell us a lot about the system impact of automating portions of this application.

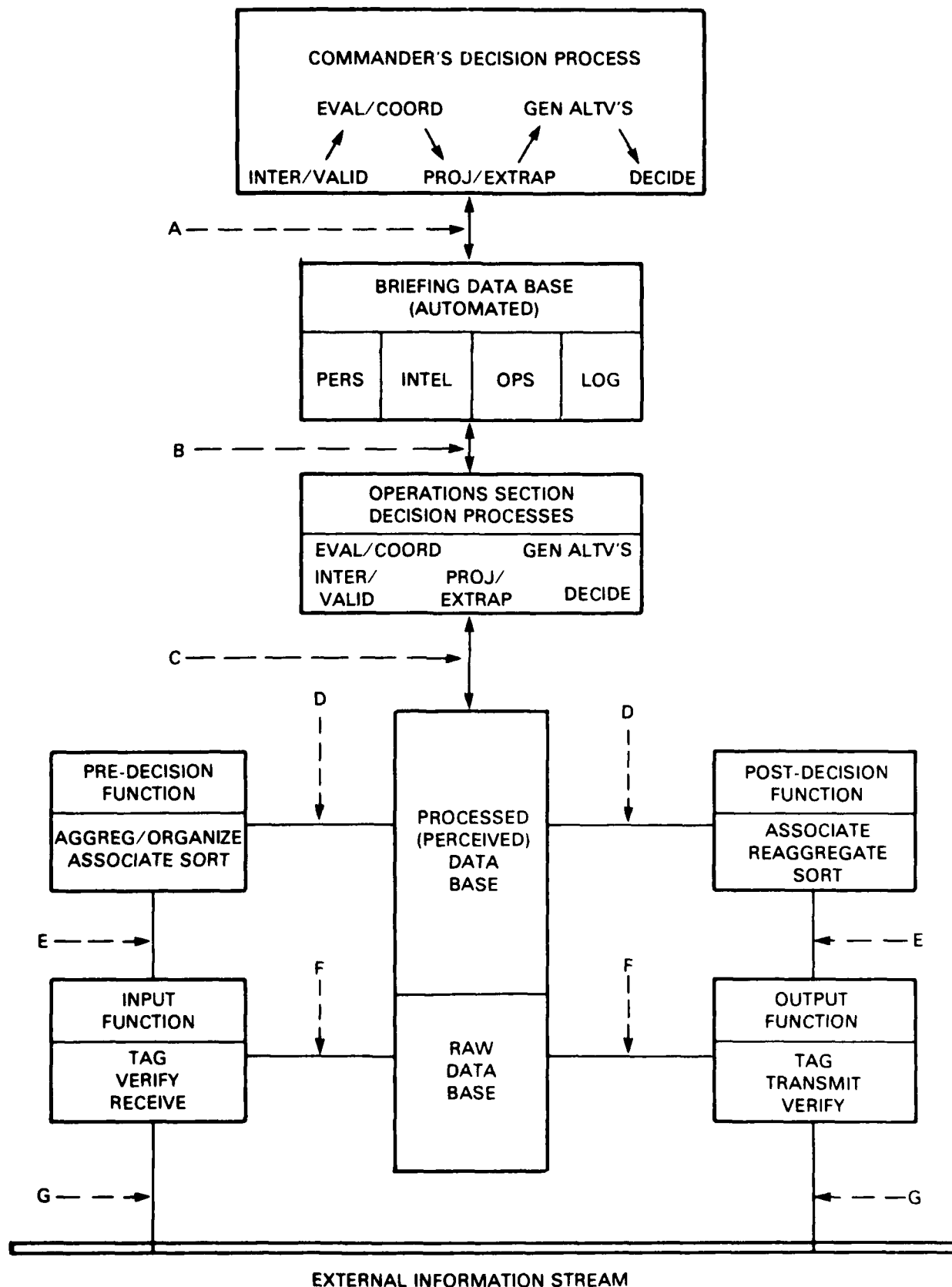


Figure 3-7. OPERATIONS SECTION PROCESSING

We are now ready to examine the potential impacts of automating the briefing data base on the rest of the system.

3.9.1 Changes in Processing Load

In the manual, twice-daily briefing mode, the interface at A (Commander-Briefing Data Base) consists of two discrete exchanges per day between the commander (commander group) and the staff briefers. Let's assume in our hypothetical staff that these occur at 0630 and 1830. Obviously, the staff must start building its briefing data base some time prior to the briefings. The result is the loading of the staff and of the communication channels which looks something like Figure 3-8. Sometime prior to each briefing the load peaks, usually at channel capacity (Did you ever try to get a "flash" message into a corps TOC about 30 minutes before the evening briefing?).

Now let's consider what is likely to happen if we implement the commander's desire to automate the briefing data base and to keep it continuously current. The staff will now be updating the briefing data base (Interface B in Figure 3-7) as events occur and interpretations made. The commander will access these data and staff recommendations and enter his decisions through Interface A. Because the staff is continuously updating the briefing data base -- at the same time it is updating its own -- the processing load will be spread out over time with no peaks induced by scheduled briefing times. Both commo and staff activity will tend to follow much more closely the tempo of combat rather than an artificially imposed briefing schedule.

3.9.2 Data Base and Procedural Changes

The fact that a new digital data base must be constructed to meet the commander's briefing needs has already been alluded to. Just what will be in this data base and how comprehensive it becomes depends largely on which of the commander's decision processes it is designed to support. Let's examine two extremes:

- Case 1

The commander can only request information that has already been interpreted, validated, evaluated, coordinated, projected and extrapolated by the staff. He can evaluate only alternatives already generated by the staff and the computer provides no help in their evaluation, i.e., he has no capability to use the computer to generate answers to "what if" questions.

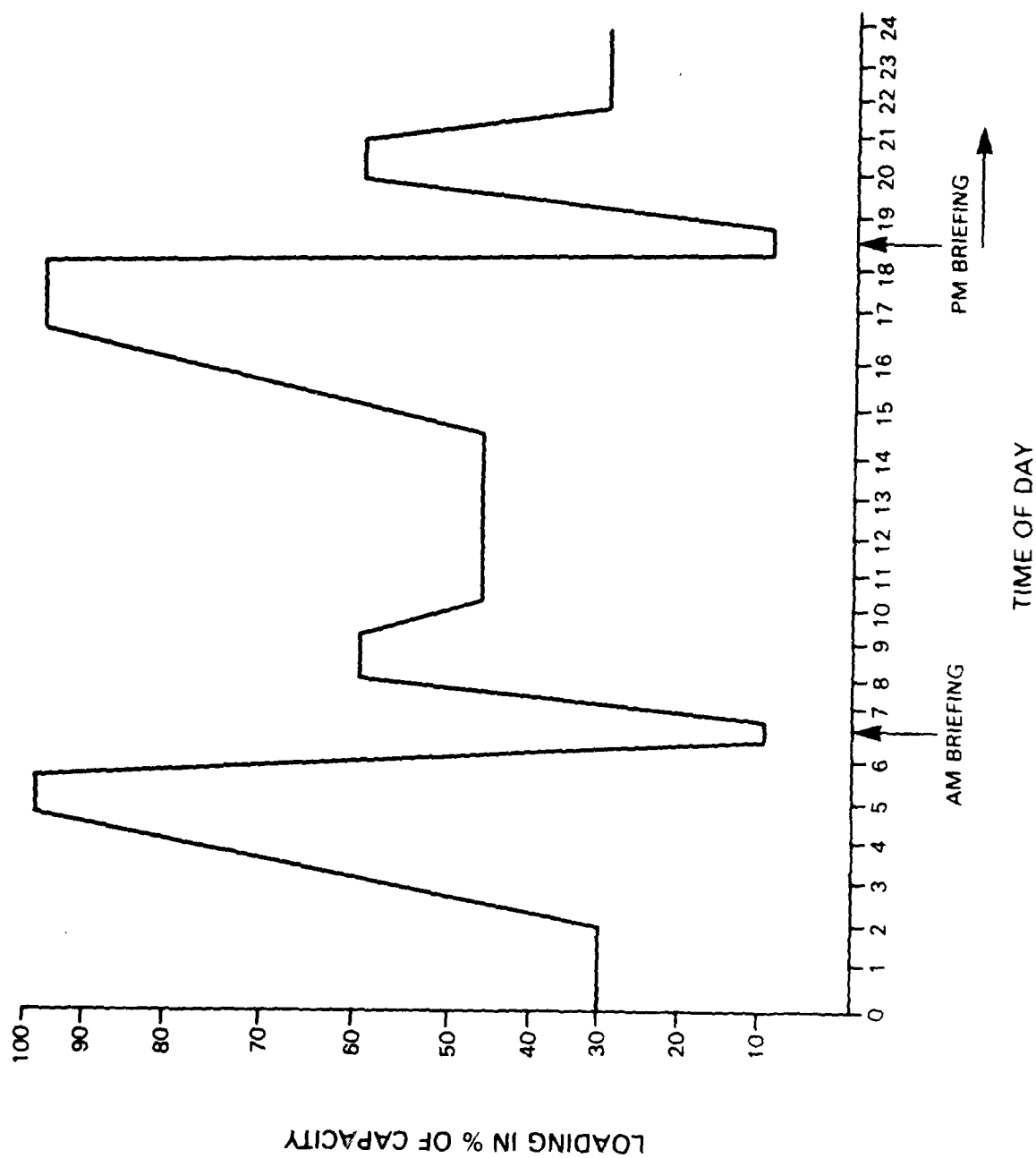


Figure 3-8. TOC & COMMO ACTIVITY RELATIVE TO BRIEFING CYCLE

● Case 2

At the other extreme, the commander has the capability of conducting a dialog with the computer. He can query to get the additional information needed for his personal interpretation, validation, and coordination just as he might during repartee at the briefing. He can ask the computer to project current trends and to make extrapolations as to likely future situations. He can enter new alternatives not considered by the staff and evaluate the probable outcome of various alternatives by obtaining answers to various "what if" questions. In other words the computer support has become a true decision aid.

Now let's examine the impact of these two extremes on the operation of the TOC. For Case 1 the commander's briefing data base will be a compilation of relatively small subsets of the data contained in the various staff section files. The only information that the staff sections will retrieve from the briefing data base will be any decisions entered by the commander and they might use it to refresh their memories as to "what did we last tell the old man?" There will be very little tendency for the staff sections to view the briefing data base as being in any way a substitute for their own section data base. The operation continues essentially as shown in Figure 3-7.

For Case 2 an entirely different situation will prevail. The briefing data base will tend to contain more and more information as the commander probes deeper into what the staff is telling him. As it grows the staff will discover how much faster and easier it is to retrieve the information they need for their own decision processes from the briefing data base rather than from their own manual files. Also, they can hardly be prevented (nor should they) from using the computer's capability to answer "what if" questions for their own staff decision making. The result of this will be that the staff will ignore its manually maintained, perceived data base and rely more and more on what is the, now automated, briefing data base. Figure 3-9 illustrates what has happened and shows the changes that have taken place in the original TOC operation depicted in Figure 3-7. The separate staff section data bases have completely disappeared. All sections and the commander now rely on a common perceived and automated data base. Interface B (STAFF-BRFG Data Base), which previously incorporated the transition from manual to digital data is now completely digital; interface C (STAFF-Section Data Base) has disappeared or it can be viewed as having been incorporated into Interface B. The transition of manual to digital has now shifted to Interface D (Pre-Post Decision-Automated Data Base). All of the staff section information processing above the

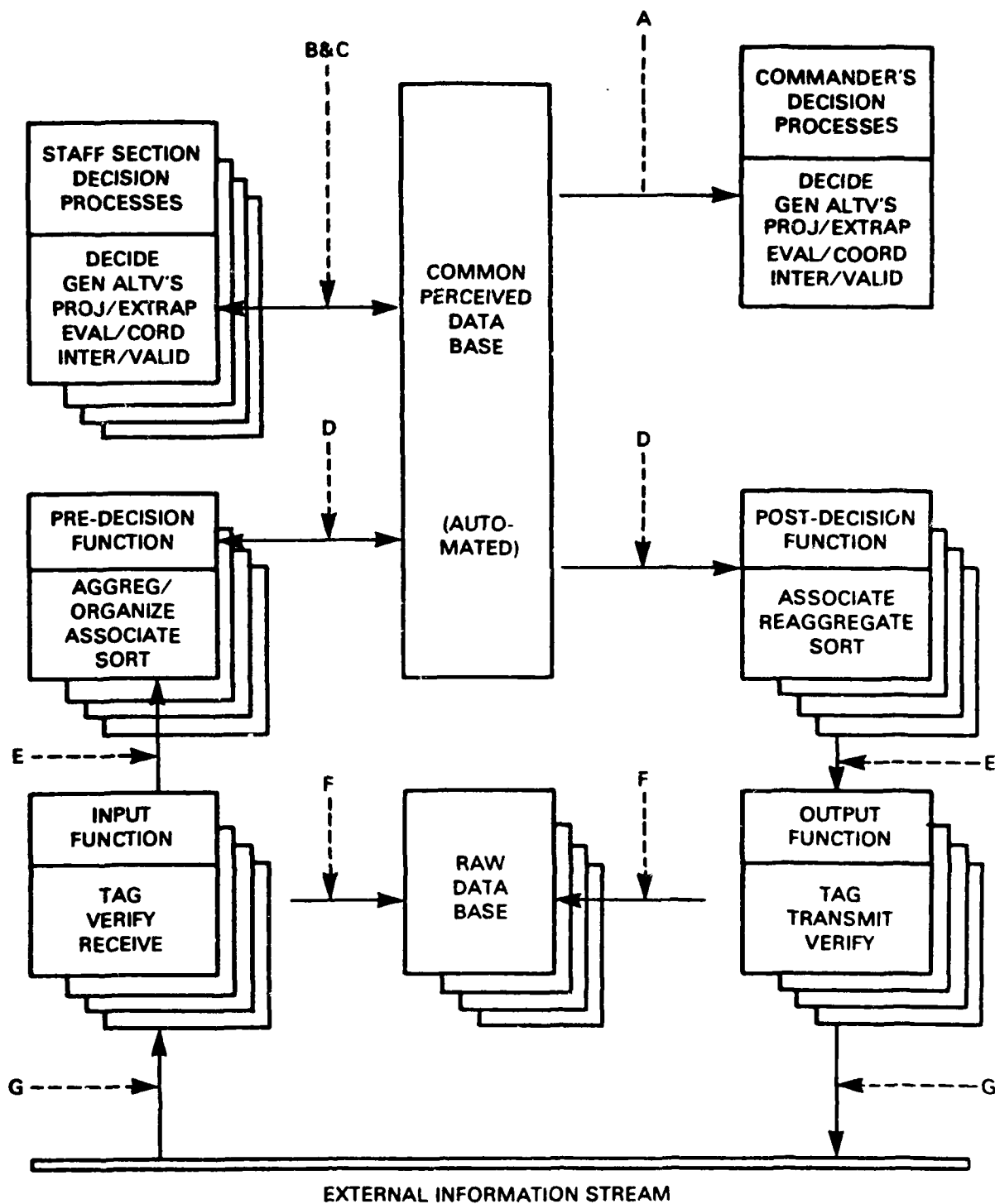


Figure 3-9. CASE 2 INFORMATION PROCESSING

this represents a major change in the TOC operation and will require very careful review of SOPs.

It should be noted that nothing has been said about the physical location either of the information processes or of the data bases. The discussion up to this point has been on a purely functional basis. The third potential impact of the computer is on the location of TOC activities which is the subject of the next subparagraph.

3.9.3 Dispersed Operations

The third major potential impact of computer support is on the location of the various TOC activities. The ever broadening scope of the battlefield, both in terms of its size and the variety of sensors and weapons to be controlled and coordinated, coupled with the ever increasing pace of modern warfare have caused us to depend on larger and larger amounts of data. But we still have the same human limitations on the number of different factors that we can juggle simultaneously in making tactical decisions. We must depend increasingly on memory extenders (displays and files) and on information processing by others to aggregate, concentrate, and identify and key factors to be considered in our decision making. If we do this manually we are physically tied to our information processing system. Staff sections are tied to their manual data bases. When they move the data base deteriorates rapidly and is not again useable until some time after they have gone back on-line and begun the slow process of updating it by hand. It takes significant time intervals to transfer current data from Alternate to Main and vice versa when we must depend on voice communication channels to make the transfer. Similarly, if the information collected and processed by the staff is presented to the commander by means of visual displays at briefings, all must be collocated -- usually in the vicinity of the TOC. For much the same reasons, if the separate staff section data bases are to stay coordinated they must also be collocated -- again in the TOC.

Operating in the mode of Figure 3-9 is, however, quite a different story. Not only can the commander be located remotely from the common data base and still access the information he needs through automated interface "A", but the staff sections can also be separately located communicating with the common data base through automated interfaces "B-C" and "D". Nor need the common data base, shown in the figure as a single functional entity, be all in one place. It, too, can be distributed among several locations reducing still further the vulnerability of the TOC. All this is subject to two caveats. First, the physically separated functional components and data bases must be interconnected with a network of digital communication which can also be made quite resistant to enemy interference through netting and automatic switching. Second, digital communication can replace a

major fraction of current voice communication, but it can never replace it entirely. Some voice communication must be provided to fill the very human need for human interaction in times of stress.