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QUANTIFICATION OF EFFECTIVENESS

DAVID W. TAYLOR NAVAL SHIP
RESEARCH AND DEVELOPMENT CENTER

Bethesda, Maryland 20084



QUANTIFICATION OF EFFECTIVENESS

by

Paul Hubai

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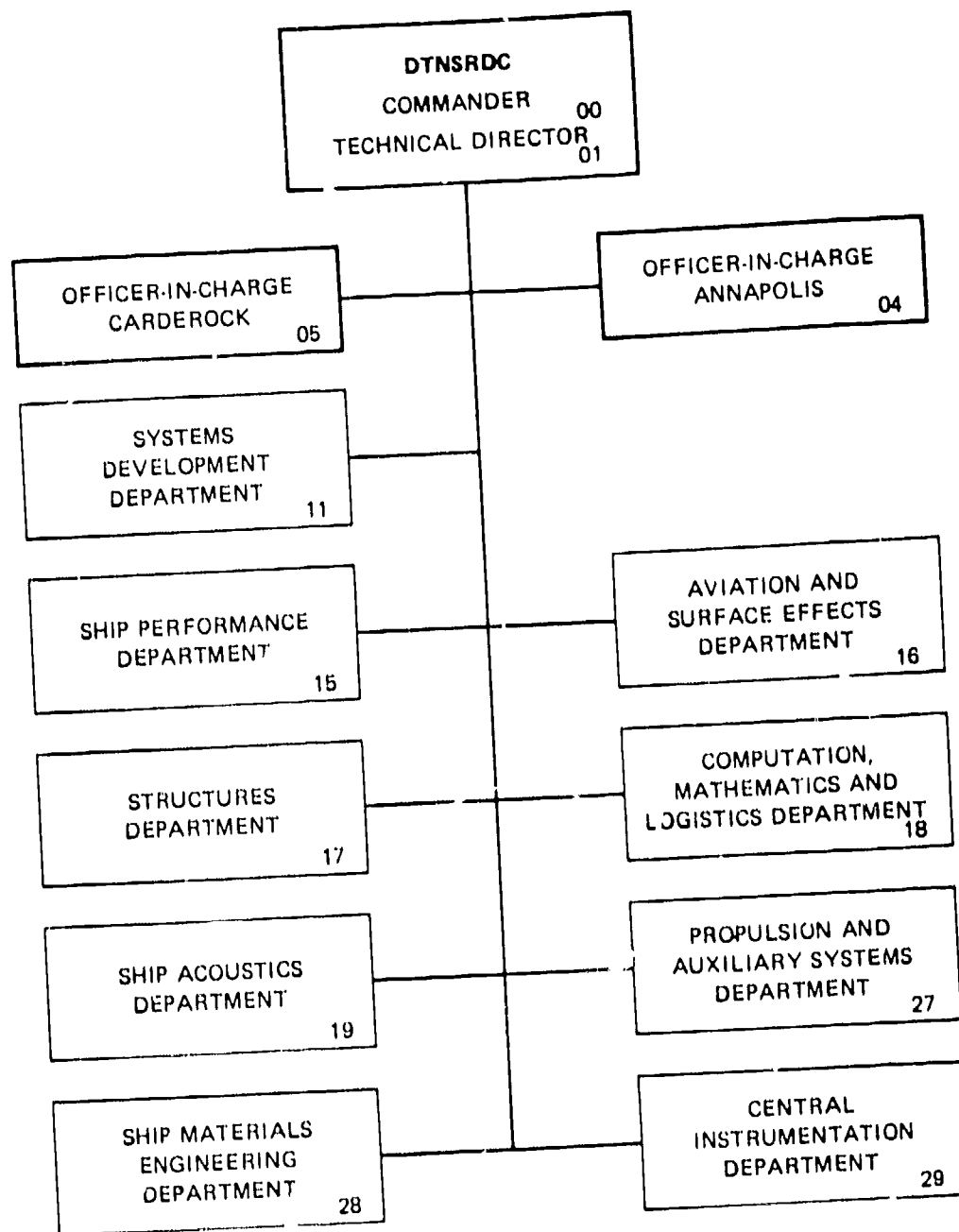
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general method to be developed. The second approach involved the identification of the logistics factors that influence systems effectiveness and the reallocation of resources among the most sensitive of the logistics factors. This report describes the methodologies employed in the two approaches, discusses the problem, and presents the results.

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ABSTRACT

The Quantification of Effectiveness (QUEF) program was initiated to develop a simplified method of measuring systems effectiveness and to determine the sensitivity of systems effectiveness to logistics factors. The initial approach was to quantify systems effectiveness from the equipments' mission essential hardware characteristics. This approach was discontinued because the hardware characteristics identified were too detailed to allow a general method to be developed. The second approach involved the identification of the logistics factors that influence systems effectiveness and the reallocation of resources among the most sensitive of the logistics factors. This report describes the methodologies employed in the two approaches, discusses the problem, and presents the results.

ADMINISTRATIVE INFORMATION

The Quantification of Effectiveness (QUEF) project was initiated by the Naval Air Systems Command (NAVAIR 340C). Funding was provided under AIRTASK Number A3400000/010B/1F60532000. The David Taylor Naval Ship Research and Development Center (DTNSRDC) undertook the project in FY-80; the Logistics Division (Code 1870) of the Computation, Mathematics and Logistics Department was the performing organization.



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SECTION 1 INTRODUCTION

The Quantification of Effectiveness (QUEF) program was initiated in FY-80 with the broad objective of developing a simplified approach to quantifying systems effectiveness and performing trade-off analyses of logistics support alternatives. Current methods of quantifying systems effectiveness are very complex and cumbersome, involving detailed system descriptions and large amounts of data. The complexity of the approach often makes people reluctant to perform the analysis. The NAVAIR sponsor felt that, if a simplified method could be developed which would allow systems effectiveness to be determined without the complexity of the present approach, equipment developers and managers would be more likely to perform a systems effectiveness analysis. For this reason the initial approach considered quantifying systems effectiveness by the mission essential hardware characteristics of the equipment.

In today's environment of tight budget control, the operating and support costs associated with weapons systems are coming under closer examination. The logistics support associated with a weapons system greatly affects the systems effectiveness and cost effectiveness of equipment. The second approach considered for the QUEF project was to identify the logistics factors which affect systems effectiveness and to perform trade-off analyses and sensitivity studies of these logistics factors for selected equipment. In this way program managers would be able to determine early in development which logistics factors drive the operating and support costs, and managers of operational systems would be able to make logical decisions regarding reallocation of logistics support resources.

This report presents a brief description of systems effectiveness, including the availability, dependability, and capability functions, and discusses the effectiveness disciplines (reliability, maintainability, and logistics support) which contribute to systems effectiveness technology. It describes the methodologies employed in the two approaches, discusses the problem, and presents the results.

SECTION 2 SYSTEMS EFFECTIVENESS

During the acquisition of a new weapons system, comparison of the effectiveness of the various configurations per unit cost gives a relative ranking of the values of the configurations. The cost of the system includes both acquisition and operation and support costs. The need to calculate both the effectiveness and the cost of the system begins during the conceptual phase and continues throughout the life of the system.

Systems and cost effectiveness can be used together as a decision-making tool for management. The systems and cost effectiveness procedures permit many system designs and use criteria, such as mission requirements, technical performance parameters, design factors, and resource allocations, to be integrated and evaluated against similar criteria for other systems/configurations. The use of systems and cost effectiveness during a system's life cycle provides management with information to be used in making important design and operating decisions.

Systems effectiveness is defined as the probability that a system can successfully meet an operational demand throughout a given period when operated under specified conditions. An alternative definition is that systems effectiveness is a measure of the degree to which an item can be expected to meet a set of specific mission requirements, and may be expressed as a function of availability, dependability, and capability. For a detailed discussion of systems effectiveness the reader is referred to Hanifan^{1*} and Chop², which provide excellent background material.

To evaluate systems effectiveness, a Figure of Merit (FOM) must often be defined. An FOM is a measure of systems effectiveness related to one or more of the missions the system will be required to perform. Different types of aircraft might have the following typical FOM's:

- o Transport Aircraft - expected number of ton miles per unit of time
- o Tactical Aircraft - probability of providing timely troop support over
x miles with y sorties

* A complete listing of references is given on page 27.

- o Interceptor Aircraft - probability of destroying n out of m enemy aircraft of a specific type per engagement.

FOM's must be defined very carefully so as not to bias the results of the analysis.

2.1 AVAILABILITY

Availability is defined as the degree to which an item is operable and committable at the start of a mission, when the mission is called for at an unknown (random) time. Another definition is the probability that the system is in an "up" and ready state at the beginning of the mission when the mission occurs at a random time; i.e., the system is ready to operate within allowable response time with all mission-required functions capable of operating within design specifications.

Inherent (or ideal) availability is expressed in terms of MTBF (mean time between failures) and MTTR (mean time to repair):

$$A_i = \frac{MTBF}{MTBF + MTTR}$$

Inherent availability assumes only active components of corrective maintenance; i.e., no waiting for spares and technicians, no detection or administrative time, no downtime due to preventive maintenance or servicing, immediate availability of technical manuals, test equipment, and software, etc.

Achieved availability includes preventive maintenance:

$$A_a = \frac{MTBM}{MTBM + MADT}$$

where MTBM is mean time between maintenance events (both corrective and preventive) and MADT is mean active downtime, which includes the active (non-waiting) time element of both preventive and corrective maintenance.

Operational availability is expressed by MTBM and MDT (mean downtime):

$$A_{oh} = \frac{MTBM}{MTBM + MDT}$$

Mean downtime includes all non-operable time, active and inactive, including "software" downtime, supply and administrative delay times, and corrective and preventive maintenance times. A_{oh} assumes the availability of an operator if one is required.

Factors influencing availability include manning, operations, maintenance, and logistics support.

2.2. DEPENDABILITY

Dependability is defined as the probability that an available system will continue to operate throughout the mission either without a system-level failure or if the system fails, with restoration to operation within some critical time interval which, if exceeded, would result in mission failure. The various kinds of dependability depend on the criteria for system failure, and each kind requires a different model. The following examples of such criteria are given by Hanifan¹:

- o no failure allowable
- o no system-level failures allowable, but certain element failures may occur without repair
- o no system-level failures allowable, but certain element failures may occur with repair a given number of times
- o system-level failures allowable if downtime is less than a specified time

Other criteria also exist.

Dependability is a function of the reliability and maintainability characteristics of a system. The references describe many models which reflect different systems, missions, and criteria for failure.

2.3 CAPABILITY

Capability is the probability that the system's designed performance will meet mission demands successfully, assuming that the system is available and dependable. This term takes into account the adequacy of the system elements to carry out the mission when operating in accordance with the system design specifications as affected by the environment. Both machine and human modules of the operable system are included.

The human capability term is the probability that the operator will respond successfully to mission demands, assuming that he is dependable and that the hardware is both dependable and capable. This term includes human error and reflects the effects on operator performance of training, experience, change of performance as a function of mission stress and duration, motivation forces, etc.

Hardware capability is the probability that the hardware will successfully meet mission demands, assuming it is available and dependable, and assuming the operator is available, dependable, and capable. Overall system capability is the product of human capability and hardware capability.

2.4 EFFECTIVENESS DISCIPLINES

Some of the factors discussed by Hanifan¹ which affect systems effectiveness are shown in Figure 1. Availability depends on both operator availability and hardware availability. Dependability and capability also have operator and hardware components. Hardware availability and hardware dependability are generally affected by the same factors, the effectiveness disciplines, some of which are discussed in the following paragraphs.

2.4.1 Reliability

Reliability is defined as the probability that an item will perform its intended function for a specified interval under stated conditions. Reliability is a well-established effectiveness discipline, with program activities structured to provide an item with failure characteristics compatible with system availability and dependability requirements. The key parameter from a reliability analysis is MTBF, which relates directly to availability and dependability.

If predicted reliability is unsatisfactory, redundancy, parts selection and screening, derating, cooling, and special designs are some of the cost-effective methods used to achieve the desired reliability characteristics. In designing an item to maximize inherent reliability, particular attention is paid to parts selections, control and screening, temperature and stress derating, environmental control, redundancy, and design simplifications.

2.3.2 Maintainability

Maintainability is a characteristic of design and installation which is expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources. Maintainability is also a well established effectiveness discipline, with the key parameter, MTTR, being directly related to availability and dependability.

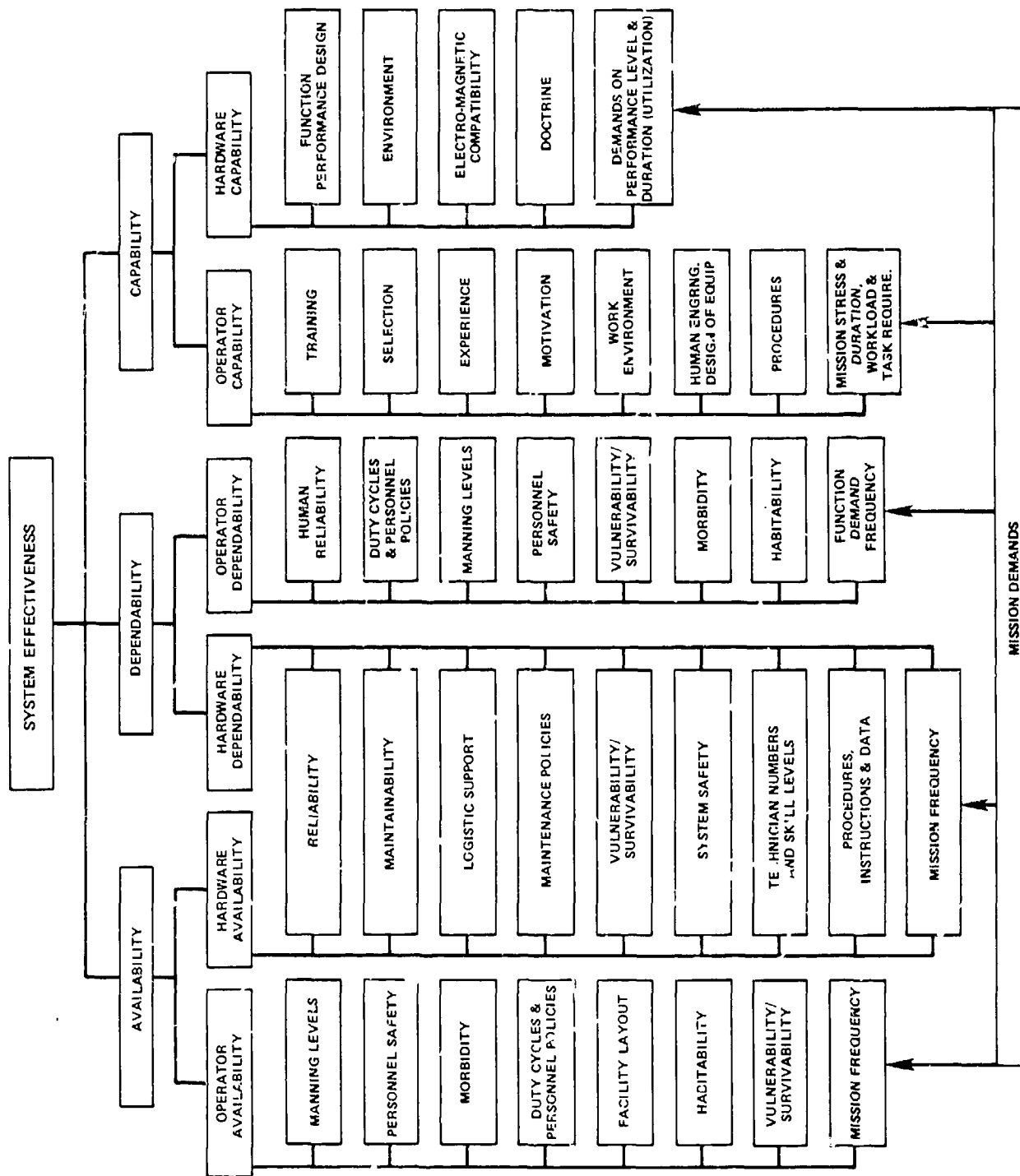


Figure 1 - Some Factors Affecting Systems Effectiveness

Maintainability analysis ensures that a system's maintainability characteristics are consistent with systems effectiveness goals. Typical trade-offs performed include repair vs. discard of failed modules, location of module or equipment repair (shipboard, tender, depot, contractor, etc.), test point location, type and location of failure detection devices and test equipment (manual vs. automatic, special vs. general, built-in vs. portable), technician numbers and skill levels, special support equipment, tools and jigs, location and types of maintenance data and instructions, and level of modulization and degree of standardization.

In order to improve maintainability, particular attention is paid to fault isolation times, skill requirements, speed of replacement, interchangeability, and repair quality.

2.4.3 Logistics Support

Shortages of spares and delays in obtaining spares, technicians, tools, support equipment, data, and other supporting elements are responsible for most system downtime in many operational systems. Since mean downtime (MDT) is a contributing term to operational availability and dependability, it can be seen that logistics support is a major factor in systems effectiveness. The effectiveness of many systems is highly sensitive to the design of the logistics support systems, as is the life cycle cost. For this reason the Integrated Logistic Support (ILS) system is being used to provide effective support throughout the life cycle of a system. The ILS function is supported by the systems effectiveness analysis function, which provides the essential analytic framework for making rational logistics support decisions within an overall operational context. Some of the logistics support costs which are examined are initial and pipeline spares cost, replacement spares cost, on-equipment maintenance cost, inventory entry and supply management cost, support equipment cost, cost of personnel training and training equipment, and cost of management and technical data.

SECTION 3 HARDWARE CHARACTERISTICS APPROACH

3.1 BACKGROUND

The initial systems effectiveness project for which DTNSRDC was tasked involved the prediction of systems effectiveness as a function of the equipment's hardware characteristics. During the acquisition of a weapons system, a continuous requirement exists to evaluate trade-offs between cost and systems effectiveness of many alternatives associated with design and logistics support. Costs can be quantified, but systems effectiveness is obtainable only through subjective evaluation. Currently there is no consistent method for the evaluation of systems effectiveness. Any evaluation that is accomplished is done subjectively with no guarantee that all important factors of systems effectiveness are considered or that the factors are given consistent weights. In the past, efforts at quantifying systems effectiveness have ranged from intuitive thinking to extremely sophisticated mathematical models requiring large amounts of time and information for implementation. Most of these efforts lie at one end of this spectrum and are difficult or impossible to accomplish because of the work load generated. For these reasons it was decided to attempt to develop a method to quantify systems effectiveness on the basis of hardware characteristics.

3.2 METHODOLOGY

3.2.1 Objective

The objective was to determine the feasibility of quantifying systems effectiveness and of performing trade-off analyses of logistics support alternatives by identifying mission essential hardware characteristics and by establishing the probability that these characteristics will be operable in a combat environment.

3.2.2. Approach

Perform the project as follows:

1. Conduct a literature search to acquire the necessary information on systems effectiveness.

2. Identify mission essential hardware characteristics.
3. Determine a weighting factor for each mission essential hardware characteristic.
4. Develop a method of calculating the probability that each mission essential hardware characteristic will be operable in a combat environment.
5. Select representative equipment to demonstrate the method and to perform trade-off analyses.

3.3 DISCUSSION

3.3.1 Literature Search

Literature searches were conducted of the data bases maintained by the Defense Logistics Systems Information Exchange (DLSIE) and the Defense Technical Information Center (DTIC). The following keywords were used to search the data bases:

- o Systems effectiveness
- o cost effectiveness
- o maintainability
- o reliability prediction
- o design factors
- o system design parameters
- o hardware characteristics

The bibliographies provided by these two services contained many reports with general information in the area of systems effectiveness and many reports of very detailed work in specific areas, but no reports on work similar to the present task. Many reports were ordered, the most important being the ones used as references for this report.

3.3.2 Hardware Characteristics

From the review of many reports it is possible to make some generalized statements. First, equipment has physical characteristics, such as

- o weight
- o volume
- o shape

- o energy levels
- o mechanical and electrical packaging
- o environmental capabilities

Second, equipment has performance characteristics, 8

- o accuracy
- o speed
- o range
- o capacity
- o power output
- o discriminations

The following additional hardware characteristics were encountered in various reports:

- o engineering design
- o complexity
- o number and accessibility of test points
- o standard/non-standard parts
- o modules
- o maintenance philosophy
- o number of components
- o stress levels
- o space/environment conditions
- o redundancy
- o failure rate
- o repair time

Obviously, many different hardware characteristics can be used to describe a weapons systems, some very general, some very specific. Many apply to all types of equipment, but some apply only to certain types of equipment. The task of compiling a list of all hardware characteristics that apply to all systems is formidable.

No attempt was made in this phase of the project to determine which hardware characteristics are essential to all missions. Analysis of data from many types of systems would be required to make this determination.

3.3.3 Weighting Factors

If hardware characteristics are selected which apply to all Navy equipment, it is apparent that certain characteristics will be more important to some equipment than to others. Therefore, weighting factors are needed to apply the hardware characteristic in the proper degree to each type of equipment. The scheme envisioned is shown in Table 1. The hardware characteristics are the same for all types of equipment and for this example are numbered 1 to n. Each type of equipment (e.g., radio, radar, computer) will have a weighting factor associated with each characteristic. The weighting factors will have the same value within an equipment type, but the value of the weighting factor can vary among types. For example, the value of the weighting factor for characteristic 1 for radios may be 10, but for radars it may be 5. Characteristic 2 may be valued at zero for radios, but 20 for radars. In this way the values of the weighting factors for the characteristics may be tailored for each type of equipment. The weighting factors for each type will sum to 100.

In this approach, all types of equipment will have the same hardware characteristics, but the importance of the characteristics will vary with the type of equipment.

TABLE 1 - SYSTEMS EFFECTIVENESS HARDWARE CHARACTERISTICS WEIGHTING FACTORS

TYPE OF EQUIPMENT	WEIGHTING FACTORS							N	TOTAL
	1	2	3	o	o	o			
Radio "A"	F_{A1}	F_{A2}	F_{A3}					F_{AN}	100
Radio "B"	F_{B1}	F_{B2}	F_{B3}					F_{AN}	100
Radar "C"									
Radar "D"									
Computer "E"									
Computer "F"									
o									
o									
o									

3.3.4 Probabilities

The task of calculating the probability of each mission essential hardware characteristic being operable under combat environment would best be done using operational data for the equipment being analyzed. However, early in development these data are not available. Other sources of these data would be design data, test data, operational data of similar equipment, or expert opinion from knowledgeable people.

3.3.5 Demonstration

Once the essential hardware characteristics are identified and the weighting factors and probabilities determined, representative equipment should be selected to demonstrate the method. Several alternatives should be developed for the chosen equipment, and the systems effectiveness calculated as shown in Table 2. In this way the relative worth of each alternative can be examined.

TABLE 2 - SYSTEMS EFFECTIVENESS HARDWARE CHARACTERISTICS QUANTIFICATION

ALTERNATIVES	HARDWARE CHARACTERISTICS							TOTAL
	1	2	3	o	o	o	N	
A	V_{A1}	V_{A2}	V_{A3}				V_{AN}	100
B	V_{B1}	V_{B2}	V_{B3}				V_{BN}	100
C								
o								
o								
o								

3.4. RESULTS

Examination of the literature provided the background information on systems effectiveness and many of the hardware characteristics that should be considered. The next steps involved determining the mission essential hardware characteristics and the weighting factors for each. However, because of the close association between reliability and systems effectiveness, it was decided to first investigate the prediction of reliability characteristics and to determine whether the characteristics used to predict reliability could also be used to predict systems effectiveness.

A report from the Army Material Command³ describes reliability prediction techniques and compares the analyses performed by each method. A report published by the Naval Air Development Center⁴ presents a method for predicting reliability of non-avionics equipment using existing field data and a reliability technology improvement factor. Most non-avionics subsystems of the aircraft were considered in this report. Of significance to the systems effectiveness analysis was a list of aircraft characteristics (including engine) and operational characteristics used in the formulation of the reliability prediction equations.

A report published by the Hughes Aircraft Company⁵ presented results of a study to develop a reliability prediction technique to estimate system complexity based on system performance data derived from design specifications, detailed parts summaries, and detailed handbook predictions. Four major types of equipment were considered: radars, computers, displays, and communications. The design parameters used to predict reliability for each type of equipment are listed in Table 3. The only characteristic which appears for every type of equipment is

TABLE 3 - EQUIPMENT CHARACTERISTICS FOR FOUR TYPES OF EQUIPMENT

RADAR	COMPUTER		DISPLAY		COMMUNICATION	
	Multiple Target Resolution (Range)	Memory Cycle Time (Speed)	Display Area	Transmit Level (max)	Receive Level (min)	Receive Bandwidth
Detection Range (Target = 1 sq m)	Memory Access Time	Spot Size				
RF Peak Power	Add/Subtract Time	Writing Speed				
Pulse Width	Multiply Line	Power Dissipation				
Antenna Gain	Divide Time	Design Year				Prime Power
3-dB Beamwidth (Azimuth)	Input/output Transfer Rate					Design Year
Receiver Dynamic Range	Power Dissipation					
Noise Figure (dB Max)	Number of Instructions					
Design Year	Design Year					

design year. All other characteristics are specifically related to the type of equipment. Since reliability is closely associated with systems effectiveness, it is believed that the lack of correspondence in detailed hardware characteristics found in reliability prediction will also be found in the prediction of systems effectiveness. Although it might be possible to determine hardware characteristics which will enable systems effectiveness to be predicted for specific equipment, broad general hardware characteristics which could be used to predict systems effectiveness for a wide range of equipments could not be developed. Consultation with sponsors and supervisory personnel led to the decision to abandon this approach to systems effectiveness analysis at least for the present.

SECTION 4 LOGISTICS FACTORS APPROACH

4.1 BACKGROUND

The next approach was to study the feasibility of quantifying the changes in systems effectiveness resulting from reallocation of logistics support resources. The initial attempt to develop measures of effectiveness (MOE's) that reflect the logistics aspects of systems effectiveness was refocused as the program progressed on the logistics factors that influence systems effectiveness.

During the design and development of a weapons system many trade-offs are made between the capabilities of a system, the logistics support requirements of the system, and the cost of the system, both initial investment cost and operating and support costs. The Integrated Logistic Support (ILS) and Life Cycle Cost (LCC) concepts are used during the acquisition phase to provide the system with the most effective logistics support in the most cost effective manner, consistent with mission objectives.

The effectiveness of a system can be measured by its availability, dependability, and capability. In many cases these functions become reliability, maintainability, and performance characteristics. Until the deployment of a weapons system, the logistics factors which influence these effectiveness functions are often difficult to measure or predict accurately. Only when the system is operational in its actual environment can the effect and cost of the logistics factors be accurately measured.

However, in the operational phase budgetary considerations often make the various logistics support requirements compete for available funds. Then it would be useful to have a method to aid equipment managers in making funding decisions that provide maximum effectiveness at minimum cost or at a fixed cost. This program attempts to provide that capability.

4.2 METHODOLOGY

4.2.1 Objective

The objective was to develop a method to quantify the change in systems effectiveness resulting from reallocation of logistics support resources.

4.2.2 Approach

The project involved the following steps:

1. Identify logistics factors that contribute to systems effectiveness
2. Determine how the logistics factors relate to the systems effectiveness functions
3. Select representative system(s) for detailed analysis
4. Determine the sensitivity of systems effectiveness to the logistics factors
5. Derive cost relationships between the logistics factors and systems effectiveness
6. Perform sensitivity studies on the cost of logistics factors and systems effectiveness
7. Develop a method for reallocating resources
8. Apply results to an example of reallocation of logistics resources

4.3 DISCUSSION

4.3.1 Logistics Factors

The type of logistics factors that should be examined can initially be selected from those considered in the ILS elements. The ILS elements and representative logistics factors are as follows:

THE MAINTENANCE PLAN

- o Maintenance concept
- o Reliability and maintainability parameters and requirements
- o Maintenance tasks (time and skill)
- o Descriptions of maintenance organizations
- o Broad support and test equipment requirements
- o Maintenance standards
- o Broad supply support requirements
- o Facilities requirements
- o Replace/repair/discard criteria
- o Non-economic engineering evaluations
 - item size
 - safety requirements

- technical feasibility of repair
- support and test equipment requirements
- o Economic cost factors
 - operations
 - preventive maintenance
 - repair
 - inventories
 - documentation
 - disposal
- o Scheduled maintenance concepts
- o Significant items
- o Remove/replace level
- o False alarm rate
- o Task time
- o Fault isolation technology
- o Minimum maintenance requirements
- o Condition monitoring
- o Deferrable maintenance policy
- o Software requirements
- o Modularity
- o Unscheduled maintenance
- o Logistics delay time

MANPOWER AND PERSONNEL

- o Personnel quantities needed
- o Skill levels
- o Skill specification
- o Manhours authorized
- o Manhours available
- o Percent utilization/productivity
- o Manhours per flight hour
- o Cross-training
- o Navy Enlisted Classifications (NEC)/MOS
- o Accession/attrition rates
- o Civilian skills

SUPPLY SUPPORT (including initial provisioning)

- o Spare and repair parts provisioning
- o Consumption and usage rates
- o Recommended allowances
- o Supply storage requirements
- o Operations consumable supply requirements
 - fuel
 - lubricants
 - oxygen
- o Requirements for each system for
 - storage space
 - supply facilities
 - equipment
 - personnel
 - procedures
- o Rotable pool factor
- o IMA turnaround
- o Resupply time
- o Number of items required
- o Quantity per use
- o Mission essentiality code
- o Weight
- o Cube
- o IMA/depot pipeline quantities
- o Number of end items supported
- o Initial stockage quantity
- c Stock levels
 - o Number of demands
 - o Number of items repaired IMA
 - o Number of items repaired depot
 - o Average/maximum IMA repair times
 - o Number of backorder days
 - o Number of units demanded
 - o Percent off-the-shelf
 - o Percent demands not satisfied

- o Number of cannibalizations
- o Long lead-time items
- o Retrograde factor

SUPPORT AND TEST EQUIPMENT

- o Equipment identification
- o Maintenance level
- o Quantity required per organization per location
- o Equipment function and capability
- o Calibration requirements
- o Spares and repair parts listed
- o Skill levels to operate and maintain equipment
- o Average utilization (%)
- o Average length of time used (hours)
- o Cost per unit
- o Hours authorized
- o Hours available
- o % used - scheduled maintenance
- o % used - unscheduled maintenance
- o % unused
- o Number of units demanded
- o % on hand
- o % demands not satisfied
- o Hours backlog
- o Length, width, height, and weight of unit

TRAINING AND TRAINING DEVICES

- o Training requirements
- o Training facilities
- o Training materials
- o Types of courses
- o Number of courses
- o Duration of courses
- o Number/skill level of students
- o Training equipment required

- o Training concept
- o Training aids
- o Training cycle
- o Depot training factors
- o Factory training

TECHNICAL DATA

- o System/equipment design
- o Operations
- o Maintenance
- o Supply support
- o Types of manuals/data
- o Contents of manuals/data
- o Publication concepts
- o Procedures
- o Philosophy
- o Scheduling
- o Implementation
- o Number of manuals
- o Standardization
- o Types of media
- o Update/revision methodology

COMPUTER RESOURCES SUPPORT

- o Computer resources support requirements
- o Computer resources support facilities
- o Computer resources support materials
- o Computer resources support manpower

Packaging, Handling, Storage, and Transportation

- o Equipment physical dimensions
- o Container requirements and codes
- o Storage and storage space
- o Preservation and packaging requirements
- o Handling constraints

- o Time
- o Distance
- o Mode
- o Speed
- o Environment
- o Frequency
- o Protection
- o Storage area

FACILITIES

- o Facilities required for system testing, training, operation, and maintenance
- o Requirements for
 - mobile, portable, and air transportable vans
 - mobile maintenance facilities
 - shops
 - training facilities
 - supply storage
 - bulk storage containers
- o Facilities identification and description
- o Facility design criteria
- o Facility costs
- o Lead times
- o Facility utilization (%)
- o Average number of personnel using the facility
- o Maximum number of personnel using the facility
- o Facility space dimensions
- o Power requirements (electrical, air, hydraulic, and vacuum)
- o Safety requirements
- o Storage space
- o Maintenance communications
- o Work environment
- o Servicing - Location/Quantity
- o Composite repair facility requirements
- o Utilities required

4.3.2 Systems Effectiveness Analysis

Performing a systems effectiveness analysis requires an analytical tool with which to perform the analysis, usually a computer program which models the systems effectiveness characteristics of the equipment under investigation. The Handbook of Systems Effectiveness Models⁶ lists many models which are used in systems effectiveness analysis. The types of models include cost, ILS, effectiveness, availability, reliability, maintainability, and others. Many of these models were developed by government agencies and would probably be available for use by other government agencies. Also, since this handbook was compiled in 1972, many models have probably been written since the handbook was published. However, this handbook is still a useful starting point in the search for systems effectiveness models. Other sources of systems effectiveness models would probably be the SYSCOMS, equipment oriented organizations, and contractors.

Once the models are available and operational, equipment to be analyzed must be selected. This is best done in consultation with project sponsors, SYSCOM managers, and operational organizations. The data required for a systems effectiveness analysis are developed throughout the life-cycle of a weapons system. Early approximations of the data are used in the concept formulation phase and are refined and improved as the system undergoes further development. In the operational phase actual usage data are gathered for specific organizations (e.g., 3M, VAMOSC) by using units. Most of these data are reliability, maintainability, availability, and cost data.

Data are also required on the development of the systems effectiveness equations. For operational equipment these data are probably in the custody of the equipment manager. Types of data needed are the figure of merit definitions and the variables and equations used in the availability, dependability, and capability computations. Since the sensitivity of systems effectiveness to changes in logistics factors is to be examined, it would be useful to select equipments which are used on several types of aircraft to determine the effect of aircraft type on the analyses.

With the model, equipment, and data available, the systems effectiveness can be computed. After the results are validated, the sensitivity of systems effectiveness to the logistic factors can be determined for the particular equipment. Generalization of results to other equipment and other aircraft can be done only after many systems have been analyzed. Once the sensitivities are

known, resources can be reallocated to determine whether systems effectiveness can be improved. For instance, some of the major causes of systems downtime are shortages of and delays in obtaining spares, technicians, technical data, tools and test equipment, and training. Alternatives can be developed, as shown in Figure 2, changing the resources allocated to each of these factors to determine whether systems effectiveness can be improved. In this way decisions can be made which can optimize the systems effectiveness at a specified resource level.

4.4 RECOMMENDATIONS

When the project had passed the logistic factors identification stage, and the identification and search for systems effectiveness models and data was begun, it quickly became evident that the level of effort dedicated to this project was not sufficient to accomplish the objective and increased manpower and funding were requested. However, the project sponsor, considering this to be a high risk area, did not feel that the potential payback warranted committing additional resources to the project, and the project was terminated.

RESOURCES

Alternative	Spare Parts	Technicians	Technical Data	Tools and Equipment	Training	Systems Effectiveness
A	A ₁	A ₂	A ₃	A ₄	A ₅	SE _A
B	B ₁	B ₂	B ₃	B ₄	B ₅	SE _B
C	C ₁	C ₂	C ₃	C ₄	C ₅	SE _C

Figure 2 - Development of Logistics Support Alternatives

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