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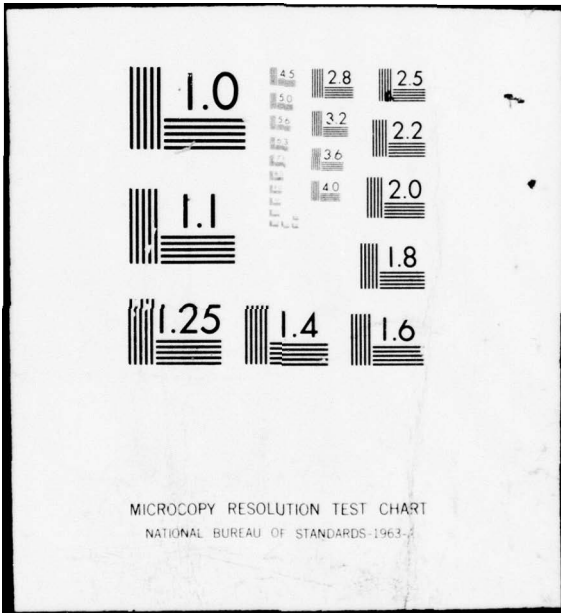
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PROGRAM MANAGEMENT COURSE INDIVIDUAL STUDY PROGRAM

HUMAN FACTORS PROGRAMS
IN NAVY SYSTEMS ACQUISITION

STUDY PROJECT REPORT
PMC 76-2

Stephen C. Merriman
GS-13 DNC

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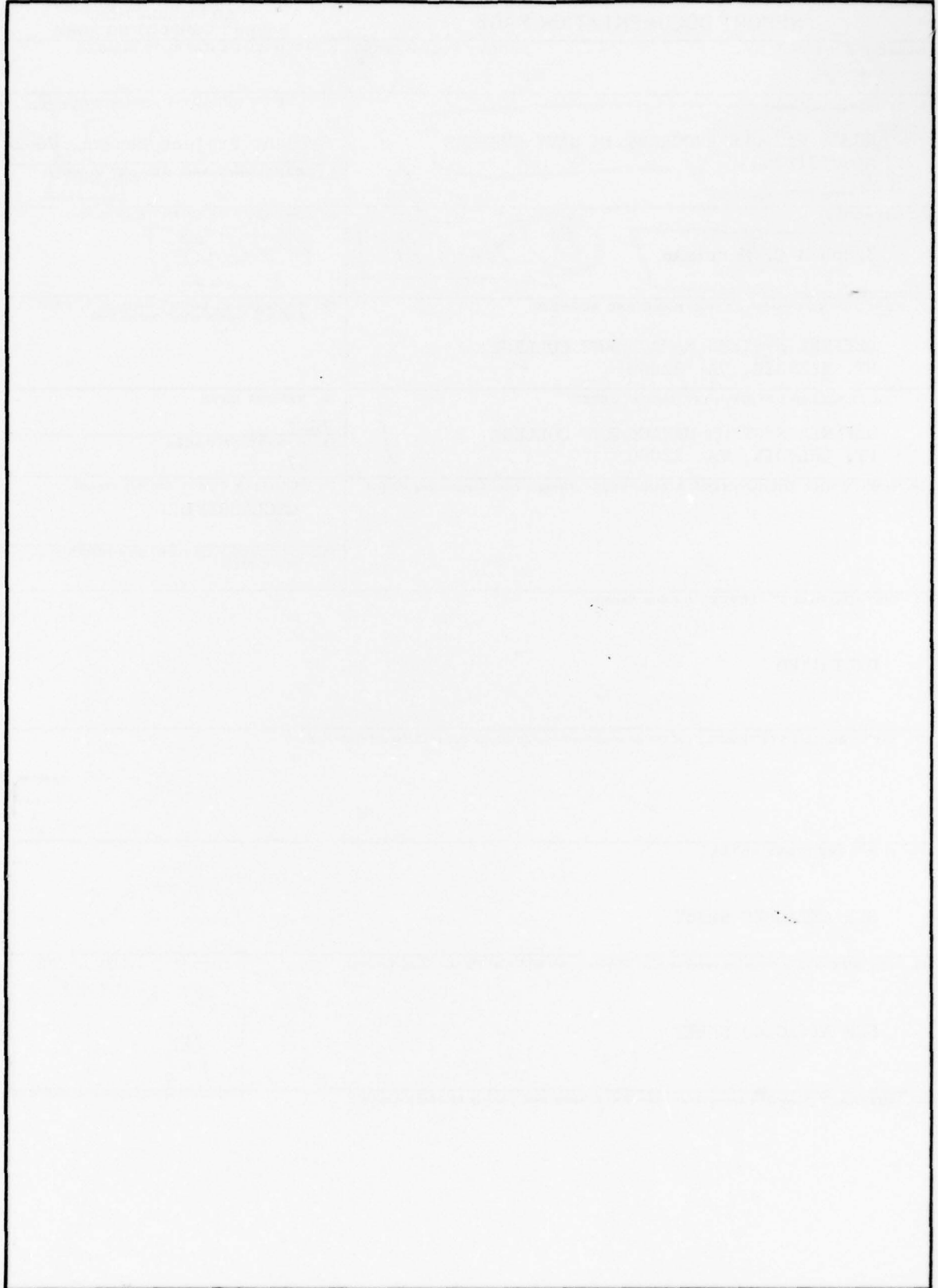
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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: HUMAN FACTORS PROGRAMS IN NAVY SYSTEMS ACQUISITION

STUDY PROJECT GOALS:

To define major functions of the human factors program manager during Navy aircraft system acquisition; to evaluate implications of current DOD policy on these human factors functions; and to discuss these human factors functions in the context of the overall systems acquisition process.

STUDY REPORT ABSTRACT:

This report examined the role that human factors programs play in Navy systems acquisition. It focused upon the conceptual and validation (advanced development) phases of the acquisition process since it is during this period when the great majority of system design decisions are made. Based upon previous analyses, interview data and the author's personal experience, human factors program activities appropriate to the conceptual and validation phases were identified and discussed relative to key acquisition process milestones; e.g., Development Proposal (DP) and Decision Coordination Paper (DCP) preparation, Defense Systems Acquisition Review Council (DSARC) preparation. Department of Defense and Navy systems acquisition policy was briefly reviewed in terms of its effects on the conduct of human factors programs. Past and present human factors programs were reviewed and critiqued. Current trends and major problem areas were identified and discussed.

It was concluded that present human factors programs, although significantly more successful than those conducted during the period 1969-1974, continue to be of limited effectiveness; it was further concluded that four factors are primarily responsible. Recommendations included the development of Navy human factors policy; suggested areas of policy emphasis were also presented.

KEY WORDS: HUMAN FACTORS, HUMAN ENGINEERING, SYSTEMS ANALYSIS, MAINTAINABILITY, TRAINING, PROGRAM MANAGEMENT, WEAPON SYSTEM ACQUISITION.

NAME, RANK, SERVICE	CLASS	DATE
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HUMAN FACTORS PROGRAMS
IN NAVY SYSTEMS ACQUISITION

Study Project Report
Individual Study Program

Defense Systems Management College
Program Management Course
Class 76-2

by

Stephen C. Merriman
GS-13 DNC

November 1976

Study Project Advisor
Lt Col Donald S. Fujii, USAF

This study project report represents the views, conclusions and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management College or the Department of Defense.

EXECUTIVE SUMMARY

This report examines the expanding role of human factors in Navy systems acquisition. While past system acquisition projects emphasized human factors only during the full scale development phase, there is an increasing tendency to consider them earlier in the acquisition process. This report focuses upon the conceptual and validation (advanced development) phases during which major system design and configuration decisions are made. It is during this period that the contributions made by human factors specialists will have their greatest impact on system performance and system effectiveness.

Section I of this report describes the purpose and goals of this study project, defines "human factors" and provides some insight into Navy human factors program management.

Section II describes the conceptual and validation phases of Navy system acquisition with emphasis placed upon development of key documentation and preparation for major project development milestones. Based upon previous analyses, interview data and the author's personal experience, human factors program activities appropriate to these acquisition phases are identified and discussed. Emphasis is placed upon the relationship which should exist between human factors and system development activities. Department of Defense and Navy system acquisition policies affecting the conduct of human factors programs are briefly discussed.

Section III examines past and present human factors programs relative to the activities described in Section II. The S-3A anti-submarine warfare aircraft and F-18 fighter/attack aircraft projects are used for illustrative

purposes. Significant trends and current problem areas are identified and discussed.

Section IV concludes that four factors are largely responsible for the limited effectiveness of Navy human factors programs: (1) vague definition of human factors program scope, (2) inadequate project manager awareness/consideration of human factors, (3) lack of intensive development team effort during the conceptual and validation phases and (4) lack of Navy human factors policy. The primary recommendation of this study project is to develop a SECNAV- or OPNAV-level instruction which clearly defines the role that human factors programs should play during Navy systems acquisition; suggested areas of emphasis are presented. Secondary recommendations are also made.

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SECTION I

INTRODUCTION

The complex process of major systems acquisition requires intensive management of a wide variety of resources over considerable periods of time. Contributing to this process are a diverse assortment of highly skilled personnel in numerous analytical, design, engineering and scientific disciplines. One of these disciplines is human factors. Viewed within the context of the overall systems acquisition process, human factors is seldom regarded to play a key role. Historically, the human factors discipline has been tolerated, avoided or excluded entirely from system development projects.

Recently, human factors has enjoyed increased recognition as a valid and worthwhile contributor toward the development and operational success of Navy systems; however, in terms of relative emphasis, funding and staffing, human factors continues to play a fairly minor role in the Navy acquisition process. In part, this may be attributed to the following:

- Human factors is but one of several important specialty or "ility" disciplines which should be considered during system development
- Current emphasis upon several of these other "ility" areas (e.g., reliability, maintainability, survivability/vulnerability) tends to overshadow human factors
- The nature of human factors tends to resist quantification

- Navy project managers and other key systems acquisition management personnel are not generally familiar with the definition, scope and objectives of human factors

HUMAN FACTORS DEFINED

In broad terms, human factors consists of "those elements which influence the efficiency with which people can use equipment to accomplish the functions of that equipment." In order to appreciate the broad scope of this terse definition, one needs only to replace the word "people" with terms such as operator, maintainer or support personnel and substitute terms such as aircraft, ship, submarine, etc. for the word "equipment."

(Ref 1, p 5) The primary elements of human factors are (Ref 1, pp 5, 6):

- The Equipment - the physical characteristics of the equipment with which personnel must interact (or interface); e.g., the layout of controls, displays and workspace
- The Environment - the physical surroundings in which the equipment must be operated, maintained, controlled or supported; e.g., the noise, lighting, temperature, radiation and acceleration characteristics of the workspace
- The Task - the characteristics of the functions (jobs, roles) which the personnel must perform in order to accomplish performance goals; e.g., duration and complexity of procedures
- The Personnel - the capabilities and limitations of the system operators, maintainers, controllers and supporters; e.g., their intelligence, sensory activities, motor abilities, training, motivation and decision-making ability

Parenthetically, it should be noted that nearly every general textbook which discusses human factors advances a new definition of the term. (Refs 2, 3, pp 4-5, Refs 4, 5). One of the reasons why definitions vary widely is that each may define human factors in terms of its major elements (as above), in terms of the academic disciplines involved (Ref 6) or in terms of the activities conducted by human factors specialists.

HUMAN FACTORS IN THE NAVY

As defined by NAVMAT Instruction 3900.9, "the term 'human factors' refers to those activities required to integrate the human operator and maintainer into a system.". The broad nature of human factors usually dictates that these activities be performed by persons of differing academic training. In fact, human factors personnel assigned to support a system development project might consist of psychologists, anthropologists, engineers, systems analysts, physiologists, simulation experts, logisticians and even physicists. The interdisciplinary team approach has come to be typical of human factors support efforts.

By convention, human factors is usually defined as consisting of three or more interrelated sub-areas. NAVMAT Instruction 3900.9 defines three such areas as follows:

Human Factors Engineering is concerned with the analysis and design of systems to achieve operability and supportability with the human operator/maintainer in the system. The efforts begin with the performance requirements analysis and includes information flow analysis, function allocation, maintenance/maintainability analysis, equipment design, crew station design, test and evaluation.

Life Support Engineering is concerned with the operator and maintainer crew station environment requirements and design, such as the broad medical and biological sciences consideration of operator and maintainer health, physiological training, and safety and survival equipment.

Personnel Management is concerned with the prediction, selection, training and assignment of personnel to operate and maintain systems. Personnel management is concerned also with the relationship between personnel motivation and moral and the recruitment and retention of system personnel. (Ref 7).

The combined efforts of the Naval Material Command, Bureau of Medicine and Surgery, Bureau of Naval Personnel and many other Navy activities are required to support all aspects of human factors. The Naval Material Command is primarily responsible for human factors engineering, portions of life support engineering and certain training aspects (training plan development, implementation and verification) of personnel management. It is these areas which are directly supported by system project funding and it is these areas which are the major concern of this report.

COMPLICATIONS IN NAVY HUMAN FACTORS PROGRAM MANAGEMENT

Ideally, the combined responsibilities of human factors (human factors engineering, life support engineering and training) should be managed by a single individual. However, as it often happens when the sub-areas of a discipline are defined separately, different organizational elements may be established to manage them. For example, within the Naval Air Systems Command (NAVAIRSYSCOM), human factors engineering and life support engineering are the responsibility of NAVAIRSYSCOM's Material Acquisition Group (MATACQ); training functions are assigned to

the Integrated Logistics Support (ILS) Group. The division of responsibility, which has existed since 1966, results in "human factors" being organizationally defined as human factors engineering and life support engineering; training is recognized as a separate entity. Human factors program management within NAVAIRSYSCOM therefore, requires close coordination and communication between these two organizational elements to ensure that the support provided to system project offices is integrated. For the purposes of simplicity and clarity, human factors program management is treated in the present report as if it were under the management control of a single person, group or organizational element.

PURPOSE OF THE STUDY PROJECT

It is the purpose of this study project to examine the major functions of the human factors program manager in supporting Navy systems acquisition projects.

SPECIFIC GOALS OF THE STUDY PROJECT

In order to accomplish the purpose of this study project, three specific goals will be achieved: (1) definition of major human factors functions which should be accomplished in support of Navy systems acquisition projects, (2) evaluation of existing DOD and Navy policies as they affect the accomplishment of these functions, and (3) identification of trends and problem areas based upon an evaluation of past and present human factors programs.

LIMITATIONS OF THE STUDY PROJECT

Time and availability of research materials were the most severe limitations of this study project. Time constraints necessitated limiting the scope of study to the early phases of Navy aircraft systems acquisition. However, lest the reader conclude that the scope of this study project is unduly limited, the following points should be noted:

- The great majority of system design decisions are made during the early phases of the systems acquisition process. Once a system has entered the full scale development phase, major changes to system design or operational/support concepts are rarely approved.
- The leading Navy Systems Command in the human factors area is NAVAIRSYSCOM. Navy aircraft systems have historically received a considerable level of human factors attention during the acquisition process.

Research material was generally limited to that available through the Defense Systems Management College library although a few materials were obtained through other sources. A limited number of personal interviews were conducted at the NAVAIRSYSCOM, Washington, D.C. to supplement written material. The author imposed a further limitation that no classified or sensitive material would be included in the report. Classified human factors data describing the adverse operational effects of human factors system deficiencies did not appear to be of much relevance to the present study; however, it should be noted that the existence of such deficiency descriptions provided a major impetus for conducting the study.

SIGNIFICANCE OF THE STUDY PROJECT

The following quotation seems to place the importance of human factors during system acquisition in its proper context:

Technology is effective to the extent that men can operate and maintain the machines they design. Equipment design which consciously takes advantage of human capabilities and constrains itself within human limitations amplifies and increases system output. If it does not, system performance is reduced and the purpose for which the system was designed is endangered. This consideration is even more significant today than in the past because the highly complex systems that we develop are pushing human functions more and more to their limits of efficient performance. (Ref 1, p vii).

Expensive and sophisticated systems are being acquired by the DOD today because that is what is demanded by the present environment. But, expensive, sophisticated hardware by itself does not guarantee that the system will be effective. As often as not, it is the misinterpreted bit of information, the overcontrolled response, the slow decision or the momentarily forgotten tactic that limits system performance and system effectiveness. Thus, there is a need for a study which examines the extent to which human factors should be and are actually considered during the early stages of system acquisition. To discount the importance of human factors by believing that large, completely automatic defense systems are "just around the corner" is to delude oneself. As systems become more and more complex and computer-dependent, the decision-making role of man becomes increasingly more critical. It is imperative that these systems be designed in a manner which ensures that the proper decisions can be made reliably -- and exactly when they are needed.

ORGANIZATION OF THE REPORT

The report is organized into three sections, not including the introduction. The second section discusses the conceptual and validation phases of the systems acquisition process, describes the major human factors functions which should be accomplished during each phase, and briefly reviews Navy policy with regard to human factors programs. The third section describes two past human factors programs conducted in support of major aircraft acquisition projects and identifies the major trends occurring in human factors programs. The fourth section presents major conclusions and recommendations of the study project.

Appendix A provides definitions and explanations for several of the key terms and abbreviations used throughout the study report.

SECTION II

HUMAN FACTORS IN NAVY AIRCRAFT SYSTEM ACQUISITION (Refs 8, 9)

The purpose of this section is to briefly discuss the early phases of the current Navy systems acquisition process and to define, in the opinion of this author, the human factors functions appropriate to each. Overall, there are five phases in the systems acquisition (or weapons system life cycle) process (Ref 10, pp 2-11, 2-12):

- Conceptual Phase - during which alternative system concepts are identified and defined; threat, mission, risk, feasibility and cost trade-offs analyses are performed; and, experimentation and test of critical subsystems/key components is conducted.
- Validation (or Advanced Development) Phase - during which extensive analysis and hardware development is conducted to validate major program characteristics.
- Full Scale Development Phase - during which the entire weapons system (including all items necessary for its support - e.g., handbooks, training systems and test equipment) is designed, fabricated and tested. An essential activity of this phase is contractor and Navy test and evaluation.
- Production Phase - during which the weapon system, including all training equipment, publications, support equipment, spare parts, etc. is produced for operational fleet use
- Deployment Phase - during which the weapon system is provided to and used by operational units.

Overall, the Navy systems acquisition process represents a well-defined, orderly progress with sufficient checks and balances to prevent premature commitment of funds prior to critical decision points. As stated above in Section I, this report addressed human factors considerations during the first two phases of the weapon system life cycle.

THE CONCEPTUAL PHASE

This phase can be conveniently subdivided into two chronologically distinct parts: The first may be referred to as "requirements generation" which is followed by "concepts development."

A. Requirements Generation - This stage is characterized by technology "push" and requirements "pull." (Ref 10, p 2-13). Research and exploratory development is conducted to determine what is technologically feasible. During the same time, through intelligence gathering and continuous assessment of Navy capabilities, an estimation is made of what developments are required to solve operational problems; e.g. meet new threats, improve current capabilities.

Inputs to this stage consist of broad force level and policy guidance from the Secretary of Defense (SECDEF) in the form of the Defense Policy and Planning Guidance (DPPG), strategic objectives of the Chief of Naval Operations (CNO) in the form of the Navy Strategic Study (NSS) and CNO's amplification of the DPPG in the CNO Policy and Planning Guidance (CPPG). From these inputs, Navy Research and Development Plans and Science and Technology Objectives (STOs) are developed by the Director, Research, Development, Test and Evaluation (DRDT&E) which form the basis for mid- and

long range Chief of Naval Material (CNM) exploratory development programs. Likewise, these inputs form the basis for Resource and Mission Sponsor plans which set forth current FYDP approved force levels, procurement and modification plans and 15-year extended mission projections of those plans which require R&D solutions. When these exploratory development programs which are structured to focus on requirement need areas begin to bear fruit, the emphasis begins to shift from technology base development toward system concept development (Refs 11, 10, pp 2-4 to 2-15).

B. Concepts Development - Based upon the preceding Research and Development (R&D) efforts, CNM annually submits to CNO and Commandant Marine Corps (CMC) a Navy Advanced Concepts (NAC) which is composed of many individual Advanced System Concepts (ASCs). The ASCs each address an operational need and an advanced system concept which will be technologically ready for advanced development within five years. Annually, several ASCs are selected for advanced development. Subsequent to their selection, an Operational Requirement (OR) is drafted, approved by the CNO and the CNM is requested to prepare a Development Proposal (DP). (Ref 11, p 3) [Advanced Systems Concepts are not required in order to initiate ORs; ORs may be drafted by any fleet activity or Navy command and submitted through channels to CNO for consideration.] Once an OR has been approved, however, CNM is required to respond with a DP. The DP is generally developed by the appropriate Systems Command based upon preliminary techniques conceptual studies which were conducted both prior to and subsequent to promulgation of the OR. When NAVAIRSYSCOM is assigned responsibility for DP preparation by CNM, an advanced development program officer (ADPO) is immediately designated. The ADPO is assigned full responsibility for DP preparation. Upon designation,

the ADPO forms a support team composed of research and technology (R&T) experts in a wide variety of technology areas and material acquisition (MATAcq) experts to assist in DP preparation. When completed, the DP must address operational need, program objectives, alternate approaches investigated (with advantages and disadvantages described), risks, cost estimates, program and T&E plans and the rationale for selection of the solution recommended by CNM.

If the DP is considered acceptable by the CNO, the Resource and Mission Sponsor is directed to prepare a Navy Decision Coordinating Paper (NDCP) (Ref 12) to support the subsequent decision-making process. For non-major CNO and SECNAV designated programs, the NDCP is the final approval and control document. For non-major programs designated by the Director, Defense Research and Engineering (DDR&E) or other appropriate Defense Systems Acquisition Review Board (DSARC) principal, a Program Memorandum (PM) is usually required. For major programs such as new aircraft developments and other programs designated by SECDEF or DEPSECDEF, a Decision Coordinating Paper (DCP) will usually be required. (Refs 13, 14) The NDCP, however, contains all essential information required for PMs and DCPs. Promulgation of the NDCP announces CNO's decision to proceed with conceptual development and makes the first commitment of OPNAV resources to the program. (Ref 11, p 5 & Ref 10, p 2-18) The CNM/Cognizant SYSCOM completes the required conceptual studies (often via contract with industry) to better define program costs, risks, need, alternatives and plans. A draft DCP is written based upon the approved NDCP and additional study results and forwarded to the CNO where a "For Comment" draft is written and distributed. Finally, a "For Coordination" draft is prepared, reviewed at DSARC I and forwarded to the SECDEF for his decision. Approval of the DCP terminates the conceptual phase.

HUMAN FACTORS DURING THE CONCEPTUAL PHASE

During requirements generation, human factors exploratory research and development is conducted. This R&D is structured to develop human factors information and technology applicable to a wide variety of future system applications; e.g., human performance data collection, human performance criterion development, training technology development, human factors T&E technology development and the like.

During the period in which ASCs are developed, the human factors program manager should direct and coordinate efforts in support of initial system engineering; (Ref 15) i.e., the iterative process of mission requirements analysis, functional analysis and function allocation. (Refs 16, 17) Threat analyses, mission analyses, mission profiles and/or mission scenarios which may have been developed by OPNAV, the Navy Intelligence Support Center (NISC), other government agencies or Navy field activities should be utilized (or if not available, they should be developed) to determine system operational characteristics, mission objective(s) and minimum acceptable functional requirements. The system functions and sub-functions should then be progressively identified independent of the means by which they are to be accomplished. As more detailed mission requirements are developed the functions should be sequentially (chronologically) related to one another by means of functional-flow or decision-action diagramming. At this point in time, the following general types of information should be identifiable:

- the general organization of the alternative systems
- the majority of system mission requirements

- system mission segments (e.g., search, land, penetrate)
- system functional performance criteria
- special system features or constraints on system alternatives which may require radical departures from existing operational, maintenance or support concepts

The next step focuses upon the identification of existing and evolving technologies which are potentially applicable to the system concept. Based upon their knowledge of man's capabilities and limitations, human factors specialists should assist in the initial allocation of system functions to man and machine. Many techniques have been developed to assist in this process, (Ref 3, pp 69-71, Ref 18) but the basic method of allocating major system functions is usually dependent upon subjective ratings and judgments supplemented by a variety of costs, reliability and historical data. Although one might believe function allocation to be an easy task, many human factors experts consider man-machine function allocation to be the weakest link in the system engineering process. For, once the initial major allocations have been made and the system definition process advances to the more detailed levels, it is extremely difficult, time-consuming, complicated and costly to reverse the initial decisions.

When the allocation of major system functions has been completed for each system alternative, a number of follow-on activities should be initiated by the human factors program manager:

- The implications of the functions assigned to man should be evaluated to estimate the number of personnel required to operate, maintain and support each system alternative.

- Gross skill level and training requirements for these personnel should be defined and compared to existing Navy personnel and training resources.
- A reassessment of the human factors data base should be made to determine what additional information may be required.

After DRDT&E promulgates the OR (which defines achievable system performance goals), limited gross operator task analysis should be conducted to refine and validate the initial allocation of man-functions for each system alternative. [In order to perform these gross task analyses, many assumptions normally must be made regarding system hardware, software and procedures.] The Computer Aided Function-Allocation Evaluation System (CAFES) (Refs 19, 20) currently under development by the Naval Air Development Center should be considered as a primary tool for these gross task analyses. In situations where conceptual studies are performed under contract, these gross analyses may still be accomplished (since several aerospace firms have developed their own computer-based systems to validate allocation schemes). Upon completion of these gross analyses, the following additional information should be available (Ref 21):

- Operator, maintainer, support personnel general task descriptions and task sequences
- Operator decisions required during "typical" missions
- Information required to support these operator decisions
- Gross information display requirements
- Major subtasks under each task
- Potential areas for human error, task overload, malfunctions, etc.

When the preliminary conceptual studies have been completed and DP/NDCP preparation is underway, the human factors program manager should be responsible to the ADPO for providing (or assisting others in providing) human factors and human-factors-related data which are required in the DP/NDCP back-up documentation. At the present time, the following information is required (Ref 22):

- Impact on support personnel skill levels and numbers identified and defined
- Uncertainties with regard to performance risk identified
- Maintainability parameters specified and justified
- Recommended operational and developmental test plan provided
- Manning considerations and requirements coordinated with the Bureau of Naval Personnel (BuPers)
- Training considerations and requirements coordinated with CNET or CNTT as appropriate
- Requirements for training simulators coordinated with Naval Training Equipment Center
- Built-in test and training capabilities addressed
- Participating Navy laboratories identified and roles described, e.g., Naval Training Equipment Center, Naval Air Development Center, etc.
- Critical logistic milestones achievable; e.g., manual preparation and delivery

THE VALIDATION PHASE (ADVANCED DEVELOPMENT)

Once the SECDEF has given approval and released requisite funding to enter into the validation phase, the primary concern becomes the elimination or reduction of technical and program risks. During the McNamara era, the primary activity in this phase was detailed paper study. Under current systems acquisition policy, however, the preferred approach to risk definition/reduction is through total system or component/subsystem prototyping. The general consensus is that actual hardware development and evaluation provides a better definition of program characteristics, higher confidence that risks have been minimized and greater confidence in the ultimate outcome. (Ref 10, p 2-12) In an ideal case, two or more competitively-developed total system prototypes would be demonstrated successfully prior to entering the full scale development phase. While this might be possible for low-to-moderate complexity programs, compromises are always required for large systems such as new aircraft. While the complete airframe might be prototyped to demonstrate aerodynamic performance, handling characteristics and the like, the full complement of electronic systems would not be developed. System simulation, however, provides a significant opportunity to establish system functional characteristics and interfaces without the expense of total system prototyping.

Competitive industry prototyping is conducted to determine whether or not alternative system concepts can meet the minimum requirements stated in the OR and validation requirements stated in the Request for Proposals (RFP). In order to conserve funds during this phase, military specifications and standard requirements are held to an absolute minimum. The

emphasis must clearly be placed upon system definition and design, risk reduction, trade-offs, test, evaluation and demonstration. During the validation phase, system development objectives include (Ref 21, pp 60-61):

- Preparation of electronic and mechanical design specifications
- Development of operational and maintenance concepts
- Establishment of interfaces between equipment and the physical interfaces between personnel and equipment in terms of display, control and communication requirements
- Selection or design of components
- Development of personnel planning information concurrently with system design specifications
- Fabrication of prototype equipment
- Development of T&E requirements
- Development of logistic support requirements
- Documentation of system specifications and required technical manuals

During the validation phase, requirements reviews, technical reviews, mock-up reviews, preliminary design reviews and demonstrations should be conducted to monitor contractor progress. These reviews, along with required contractor data, serve to assist in preparing requirements for full scale development. Contractor proposals, along with the prototype test results, are utilized in order to evaluate the technical and managerial readiness of the program to proceed. Toward the end of the validation phase (often during proposal evaluation), the DCP is updated

to reflect current information for the preferred and alternate system designs; (Ref 14, Op 3-4; Ref 23) e.g., whether or not -

- the system still satisfies the military need -- considering the changes which have occurred since DSARC I
- technical problems, critical issues and risks posed at DSARC I have been resolved
- valid design-to-cost goals have been established
- sufficient test data exist to ensure that system requirements can be met
- reliability and maintainability requirements have been defined
- program thresholds in the DCP are appropriate and well defined
- the program management structure and plan are sound
- proposed fall-back positions, if any, have been reassessed and found suitable
- issues to be resolved prior to DSARC III have been identified

Review of the updated DCP is accomplished at DSARC II. Approval of the updated DCP by SECDEF terminates the validation phase. Full scale development officially begins when the required funds have been appropriated, the winning contractor is announced and the full scale development contract is signed.

HUMAN FACTORS DURING THE VALIDATION PHASE

There are four key functions within the validation phase which should be performed by the human factors program manager:

- preparation of validation phase Request for Proposal (RFP) requirements
- evaluation of validation phase results
- preparation of full scale development RFP requirements
- evaluation of full scale development proposals

Human factors requirements for this phase should be based upon the results of Navy, Federally Contracted Research Center (FCRC) or contractor-assisted conceptual studies. The validation phase requirements specified in the RFP should focus upon analysis, human performance and design areas:

- *Analysis Requirements* - Sufficient information should be provided to the bidders to indicate the level of function allocation analysis already performed by the Navy. Requirements should specify that the function allocation process must be continued (for each design concept) down to the level where shared man/machine functions no longer exist. This will ensure that, independent of detailed design, the contractor can identify all operator, maintainer and support personnel tasks. Requirements should also include detailed task analysis for the system operator(s) and organizational level maintainers. Requirements for information-action data should be included to ensure that appropriate attention is paid to man-machine interface requirements. Manning and training analyses should be required to update plans, quantitative manpower estimates, Navy Enlisted Code (NEC) requirements and training media requirements. Crew station and maintenance area environmental analysis/prediction should be required to identify possible health, safety and injury hazards.

- Performance Requirements - Based upon the Navy-developed typical mission scenarios and initial gross task analyses (e.g., utilizing CAFES), operator performance estimates and criteria should be developed and specified in the RFP. Even though these criteria are little more than goals at this point in the development process, their inclusion in the RFP will indicate NAVAIRSYSCOM's concern for man-machine system performance (as opposed to airframe performance). The requirements should indicate that after initial design and task analysis is complete, demonstration of achieved performance will be required. While the preferred method for demonstrating achievement of required human performance and acceptable workload levels is via manned simulation, computer simulation results may prove to be sufficient depending upon the sophistication of the model. Maintainer performance requirements should be stated in terms of removal and replacement time and mean-time-to-repair (MTTR). In addition, requirements should specify, for mission-critical and safety-of-flight equipment, that maintainability demonstrations will be required on the prototype vehicle.
- Design Requirements - The RFP should indicate that human engineering MIL-SPEC/MIL-STD design requirements will be invoked during the full scale development phase although they are not applicable during validation. The RFP should specify the anthropometric characteristics of the operator and maintain populations in percentiles; inter-correlational data should also be provided for critical parameters. Stated in this manner, the anthropometric data should allow the contractor considerable flexibility

in his detail design, while ensuring that the required minimum percentage of operator and maintainer personnel will be accommodated. Requirements should also be included to demonstrate human engineering design adequacy utilizing the prototype system or system mock-up.

Human factors data requirements during the validation phase should be held to an absolute minimum. To ensure that the contractor's approach is reasonable, and to provide data which can be used to verify adequate contractor progress, the following information should be specified as deliverable:

- Summary human factors plan
- Operator/maintainer task analysis results
- Manning/training requirements analysis results
- Operator workload analysis results

During the validation phase, analytical results should be verified by supporting Navy laboratories. Contractor compliance to design and performance requirements can best be determined through attendance at mock-up reviews, demonstrations and on-site progress reviews.

The last function required by the human factors program manager prior to release of the validation phase RFP is to ensure that sufficient threat analysis, mission analysis and mission scenario data will be provided to the bidders; these data are extremely helpful during system design development, manned simulation and trade-off activities. Without these data, the bidders would have great difficulty determining system functional requirements and determining the extent to which their design will satisfy the military need.

Toward the end of the validation phase, the human factors manager, with laboratory assistance, should develop the requirements for full scale development. Based upon contractor reviews, demonstrations and data, the high risk aspects and problem areas with each design should be identified and defined. These should be synthesized to determine where emphasis needs to be placed during full scale development. Through these means, human factors programs and design requirements can be better tailored to fit the specific characteristics of the program. System performance data and results of Navy operational testing should be utilized to refine mission functional requirements, mission segment definitions, typical scenarios and human performance criteria. The typical scenarios and human performance criteria should be included in the RFP as human performance demonstration requirements. [Since an infinite variety of different operational missions could (theoretically) be flown by the system, it is important to differentiate these performance demonstration requirements from design requirements.] Contractor and Navy test requirements should be developed which will directly support the DSARC III decision process. Data requirements should be minimized by requiring time-phased reviews of contractor progress.

Training requirements should be specified to ensure that operator and maintainer training systems are fully developed, validated and delivered at the end of the full scale development phase.

Detailed design requirements should be identified in the RFP; these, too, should be tailored to emphasize known problem areas. Historical data from previous system development programs should be obtained to assist in the tailoring process. Computer-based systems have been demonstrated to

be extremely useful in identifying those design areas where problems typically arise. Since detailed design and test are the major objectives of full scale development, it is especially important that these requirements be stated clearly and unambiguously.

SUMMARY OF CONCEPTUAL AND VALIDATION PHASES

The above discussion of selected human factors functions during the conceptual and validation phases has indicated that the Navy manager should, in an iterative fashion:

- determine or refine human factors requirements
- evaluate progress toward those requirements
- provide information and guidance when requested

The human factors manager must function as an active member of the Navy project team to ensure that requirements remain consistent with overall objectives and progress remains consistent with the overall schedule. Good communication with the project team must be maintained to ensure that the human factors program is conducted as an integrated effort within the total project.

POLICIES/DIRECTIVES GOVERNING NAVY HUMAN FACTORS PROGRAMS

At the present time, there is no DOD, SECNAV or OPNAV policy (directives or instructions) directly pertaining to definition, implementation or execution of human factors programs in the Navy. This absence of policy with regard to human factors is unique to the Navy since

both other Services have regulations (Refs 24, 25) which establish the applicability, scope and objectives of human factors programs and assign specific responsibilities to appropriate Service components. The Army regulation, which was recently updated, describes in specific terms the manner in which human factors programs are executed during each phase of the systems acquisition process; additionally, this regulation describes system project manager responsibilities with regard to the conduct of human factors programs. Although there is an effort underway in OPNAV to fill the Navy's human factors policy void, issuance of an instruction in the near future is not expected.

The NAVMAT instruction on human factors mentioned in Section I of this report is currently more than seven years old. Beyond defining the human factors discipline, it has had little or no impact upon human factors in the Navy. Specifically, NAVMAT Instruction 3900.9 was vague with regard to the scope and content of human factors programs. Additionally, no continuing action requirements were specified to ensure that human factors programs would actually be conducted in support of system acquisition projects. Another major deficiency of this instruction was that it failed to describe the interface which should exist between human factors and other programs (e.g., system engineering, maintainability, safety, reliability, systems analysis, test and evaluation, etc.). While MIL-H-46855 (Ref 26) and MIL-STD-1472 (Ref 27) appear to give adequate general guidance to contractors in the conduct of required human factors programs, basic internal Navy guidance and policy is weak.

The general lack of Navy human factors policy is difficult for this author to rationalize, especially in the light of recent efforts by the

DEPSECDEF (Ref 28) to improve the planning and management (thereby reducing costs) of human factors and other programs. These efforts, while primarily directed toward cost reduction objectives, imply strongly that all of the Military Services need to improve their capabilities to:

- better define human factors program requirements, and
- improve procedures and policies for imposing human factors requirements upon development contractors

In essence, the DEPSECDEF's strong desire is that human factors requirements be tailored "to the specific operational needs of the end item or system." (Ref 28, p 2) While certain changes have already been instituted to improve this situation in general, (Refs 29, 30) strengthened Navy human factors policies have yet to be promulgated which deal directly with the problem.

SECTION III

PAST AND PRESENT HUMAN FACTORS PROGRAMS

The previous section described human factors program functions considered by this author to be appropriate and required during the conceptual and validation phases of Navy aircraft system acquisition. This section briefly describes past and present human factors programs conducted by the NAVAIRSYSCOM since 1966, identifies significant problems experienced during the conduct of these programs and discusses major trends and "lessons learned" which led this author toward the formulation of the approach described in Section II above.

Human factors programs conducted in support of two major aircraft acquisitions will be discussed. The first program contributed to the development of the S-3A, a four crewman, carrier based sophisticated anti-submarine warfare aircraft. The concept and contract definition phases of the S-3A development cycle were conducted during the mid-1960s with full scale development initiation in 1969.

Prior to describing the S-3A human factors program, three important factors should be noted. First, NAVAIRSYSCOM was created through a Navy reorganization in 1966. Prior to that time, NAVAIRSYSCOM contained no organizational element charged with the specific responsibility for human factors. Second, until 1968 this human factors element was understaffed and incapable of adequately defining and conducting effective human factors programs. Third, this organizational element (as described in Section I above) included only the human factors engineering and life support engineering sub-areas; training was assigned to a separate office.

THE S-3A HUMAN FACTORS PROGRAM

During the concept and contract definition phases of S-3A development, little or no attention was paid by the Navy to human factors considerations. Although the full scale development RFP contained one paragraph of "boilerplate" in the human factors area, no effective guidance or specific requirements were included. Subsequent to proposal evaluation and selection of the best overall system design, the newly appointed human factors program manager was successful in adding a limited number of human factors analysis, design and test efforts to the contract statement of work. The contractor staffed a small human factors group to perform the work, a program plan was submitted to NAVAIRSYSCOM, approval was granted and the work began.

Problems surfaced almost immediately. The requirements to perform function allocation analysis and task analysis proved to be little more than academic exercises in design documentation. Neither detailed task analyses nor crew workload analyses were performed. Major design efforts received little human factors input; contributions by the human factors specialists were limited to detailed human engineering design areas such as crew station lighting, crew station arrangement, panel labeling and control design. In the opinion of this writer, the S-3A human factors program was relatively ineffective for the following reasons:

- The lack of a NAVAIRSYSCOM human factors group during concept and contract definition phases resulted in little or no in-house Navy human factors analysis effort; little or no Navy human factors guidance to the contractor; little concern for human factors by

NAVAIRSYSCOM and contractor project management personnel; and therefore little human factors impact upon the basic S-3A design.

- When the human factors requirements were finally imposed, many were inappropriate to the full scale engineering development effort; e.g., data requirements for human factors analysis. While some of these data were generated, the efforts required could have been more productively applied to more relevant design tasks.
- Since most of the major design decisions had been made prior to full scale development, the human factors program was considered to be of low priority by Navy and contractor project managers alike. This "back burner" treatment further contributed to the ineffectiveness of the human factors program.
- Since the full scale development requirements had been prepared and added to the contract in a "rush rush" manner, they were not properly tailored to the system characteristics; this resulted in many requirements being overspecified or underspecified. This ad hoc application of requirements also led to interface and duplication-of-effort problems between the contractor's human factors, training, safety, reliability and maintainability programs.

Although these problems severely limited the overall effectiveness of the S-3A human factors program, it should be noted that the contractor's efforts did result in many detail design improvements during the full scale development phase.

S-3A HUMAN FACTORS POSTMORTEM AND LESSONS LEARNED

The "bottom line," so to speak, of any human factors program is reflected by the number of problems identified during operational testing, production acceptance testing and actual fleet use of the aircraft. Navy Board of Inspection and Survey (INSURV) trials conducted just prior to the S-3A production phase identified many human factors deficiencies in the aircraft. While (happily) only a few represented serious safety-of-flight or mission critical problems, the total number of human factors deficiencies was large. More than 30 percent of all BIS deficiencies (several hundred) represented human factors problems. Since most of them were not discovered until late in the full scale development phase, high correction costs (associated with formal engineering changes) will prevent the great majority from ever being fixed.

The major lessons learned concern the functions which should be performed by the Navy human factors program manager prior to full scale development. As discussed above, the failure to perform many of these functions can have disastrous effects upon the contractor's efforts. In order to prevent this from happening, the Navy human factors program manager should:

- Begin preparing for full scale development well in advance;
- Ensure that the requirements invoked during a particular development phase are appropriate and tailored to the characteristics of the system project;

- Ensure that the Navy and contractor project management personnel understand the basic scope and objectives of human factors programs;
- Ensure that human factors requirements cover all of the major sub-areas; i.e., human factors engineering, life support engineering and training;
- Ensure that good working interfaces are established between the human factors, safety, and maintainability programs in order to minimize duplication of effort;
- Ensure that contract data requirements are minimized and that they convey useful information; e.g., historical records of long-past decisions are not desirable.

HUMAN FACTORS IN TRANSITION

Lessons learned from the S-3A and other programs conducted during the same timeframe had a major impact upon the approach taken for the F-18 project. Several other factors, however, contributed significantly toward changing peoples' attitudes toward human factors in the time period 1970 to 1974. [In the absence of Navy human factors policy, the attitudes held by Navy and industry project management personnel become major determinants of the scope and importance of human factors programs.]

First, human factors problems came to be recognized as being responsible for a significant percentage of Navy aircraft accidents. Naval Safety Center statistics for the period July 1970 to March 1974 indicated

that approximately one-half of the non-combat related accidents were caused by "pilot error." These accidents resulted in the loss of 228 aircraft and substantial damage to another 90. They also resulted in the death of 249 aircrewmen and 52 serious injuries. Accidents caused by "pilot error" are usually attributable to human engineering design errors, training deficiencies and other human factors causes.

Second, public recognition of the importance of human factors increased. For example, Rear Admiral F. T. Brown, then Commander of the Naval Air Test Center, remarked during a 1975 display symposium that:

The man-machine interface has been recognized as pivotal in advanced weapons systems. But recognition isn't the same as solution, and solution is the real challenge. Man has been in the loop for a long time, sometimes as a nuisance or, at best, an inconvenience to the engineers. Frankly, we're at the end of that road. If we are to achieve the tactical edge in our future systems, then we must recognize the imperative for considering man's information needs. (Ref 31).

Third, the characteristics of human factors specialist groups changed. Whereas during the late 1960s when many human factors groups consisted of reactive academicians, human factors specialists in the early 1970s were more system-oriented and more motivated to participate as members of the core system development team.

Fourth, many of the Navy and industry project management personnel who previously had worked on aircraft development programs where human factors considerations were inadequate became assigned to new project offices. Their past experiences with attempting to correct human factors deficiencies during production and deployment phases had convinced many of them that early consideration of human factors was essential.

These factors, in combination, produced an atmosphere which was more receptive to the conduct of human factors programs. One such program is currently supporting the F-18 aircraft project.

THE F-18 HUMAN FACTORS PROGRAM

The early stages of the F-18 acquisition process bore little resemblance to the systematic, step-by-step procedures dictated by current DOD policy. Original requirements for a new Navy fighter/attack aircraft were established in 1974 and a program called VFAX was initiated. During Navy preparation for the validation phase, Congress redirected the effort and limited the choice of system alternatives to outgrowths of the Air Force Lightweight Fighter (LWF) program. Since neither the YF-16 nor the YF-17 LWF prototypes had been designed for carrier operations, the Navy modified its VFAX requirements and issued an RFP to develop carrier compatible derivatives of the LWF prototype aircraft. During the period prior to RFP release, NAVAISYSCOM personnel responsible for training and human factors attempted to integrate their requirements and expand the scope of the traditional human factors domain. As defined in the RFP, the F-18 human factors approach consisted of analysis, simulation, design and test and required that major human factors program emphasis be directed to:

- early definition of F-18 mission objectives and functional requirements;
- early definition of operator/maintainer functions and tasks;
- early definition of operator/maintainer manning and training; requirements, instructional strategies and training media;

- early definition and verification of man-machine interface; requirements through analysis, mock-up efforts, manned simulation and flight testing.

The selection of the F-18 (a derivative of the LWF YF-17 prototype) caused considerable Congressional disquietude (Ref 32) which delayed the initiation of full scale development by several months. During this period the Navy human factors program manager established close working relationships with other NAVAIR personnel to ensure that the human factors program would interface with and provide support to the training and maintainability efforts. Likewise, the contractor's human factors manager was afforded some time to plan, organize, schedule, staff and implement a balanced and effective human factors approach. (Ref 33).

At the time of this writing, the F-18 full scale development effort has been underway for approximately one year. The human factors program, which was scheduled to be consistent with and support major program milestones, has thus far played a significant role in F-18 design development. Some of the reasons for this are considered to be as follows:

- F-18 human factors requirements were tailored to fit the needs of the project;
- Human factors personnel are part of the core system development team;
- The human factors staff contributed significantly to the development of F-18 mission requirements and F-18 functional analysis;

- The human factors staff reviews all preliminary designs and human factors recommendations are being implemented;
- Human factor's personnel attend all major mock-up reviews, program reviews and design reviews and contribute to trade off analyses;
- Human factors emphasis on task analysis, computer modeling and manned simulation has allowed for considerable early development testing of hardware and software alternatives;
- Human factors personnel are responsible for all operator and maintainer training analysis and training system test, evaluation and verification;
- Human factors personnel are responsible for assuring that F-18 design affords ease of maintainability by appropriately trained personnel;
- Navy and contractor project management personnel support the conduct of the F-18 human factors program.

By far, the last item listed is the most important reason why the F-18 human factors program is effective. Project management support ensures that the tasks are conducted, that results are utilized and that required staff and funding levels are maintained.

Since the F-18 human factors program represented a significant change from tradition (in terms of expanded scope, responsibility and level of effort), there may be a tendency for the program to regress to the old ways

of doing business. This tendency may be equally strong within Navy and contractor organizations alike. For example, as noted above in this report, the areas of human engineering, training and maintainability were traditionally managed within NAVAIRSYSCOM as separate and distinct elements. In the F-18 program, an attempt was made to integrate these areas in order to eliminate redundancy, save money and increase the efficiency of the dependent process. But, since this approach differs from tradition, personal commitment to the change may be less than complete. The telltale signs of reversion (e.g., reduced communication between groups) must be recognized by the Navy human factors program manager and acted upon quickly. Otherwise, the effectiveness of the human factors program may dwindle rapidly, project management support may be lost and the final product (and ultimately the fleet user) will suffer.

The F-18 human factors program is considered by this writer to represent significant improvements over past programs. The major reasons for these improvements are considered to be:

- Increased time to prepare for full scale development,
- Project Management support, and
- Consideration of Training and Maintainability within the scope of the human factors program.

The potential for future problems in the F-18 human factors program will always exist, but close surveillance should minimize the probability of their occurrence.

CURRENT TRENDS AND PROBLEMS

The F-18 discussion illustrates the current state of human factors programs during the full scale development phase of systems acquisition. Due to its Air Force origin, however, the F-18 program provides little insight into the Navy conceptual and validation phases.

Based upon information obtained through a limited number of interviews with NAVAIRSYSCOM personnel, human factors activities during the conceptual phase vary widely depending upon the availability of appropriate funding, the time-criticality or urgency for moving rapidly into the validation phase, the quality of communication between NAVAIRSYSCOM personnel and the level of interest in the concept expressed by Navy laboratories. The trend at NAVAIRSYSCOM is toward improved communication between the personnel responsible for development of advanced aircraft concepts and the personnel responsible for exploratory/advanced human factors research and development.

With regard to the validation phase, human factors personnel are increasingly being requested to participate in DP development efforts. When human factors contributions are desired by the ADPO, a human factors program manager is designated as a DP development team member. Currently, DP development teams are fairly loose-knit. All of the members have other, primary responsibilities and, as a result, the team meets irregularly at widely spaced intervals. Team member intercommunication is low and there appears to be a lack of cooperative, integrated team effort.

Human factors research and/or analysis efforts required to support specific DP developments may vary considerably with regard to funding levels and funding sources. The ability to conduct supporting human factors

research and analysis seems to depend upon three factors:

- The level of funding available to the ADPO for research and analysis efforts;
- The extent to which research and analysis results could be generalized to benefit other potential applications;
- The level of interest in the project expressed by Navy laboratory personnel.

While the funding uncertainties may not pose critical problems for all DP development efforts, it would seem advantageous to provide the ADPO with sufficient funds to ensure that research and analysis requirements could be met without depending upon other, questionable, sources of funding.

In summary, it would seem that current trends are toward increasing human factors participation during the conceptual and validation phases. The biggest problem area appears to be uncertainty in acquiring the funds necessary to support DP development efforts.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Section II of this report identified human factors functions which should be performed during conceptual and validation phases of Navy system development. Section II indicated that, on past project development (e.g., the S-3A), little or no attention was devoted to human factors. This resulted in large numbers of system problems being identified during Navy test and evaluation. Review of the F-18 project indicated that improved planning immediately prior to full scale development can result in a human factors program which is an integral part of the overall project, more cost-effective and (hopefully) more capable of identifying and resolving most human factors deficiencies prior to Navy test and evaluation. Although improvements over the past six to eight years have been significant, Navy human factors programs continue to receive an abundance of "lip service." The present study has led this author to conclude that the following reasons are responsible.

First, the broad definitions generally applied to the field of human factors make it appear that "human factors" includes a little of everything: training, biomedicine, personnel management, crew station design engineering, logistic support, maintainability, reliability, and so on. The problem is that human factors scope has not been clearly defined in the Navy. Its interfaces with other disciplines seem to vary from program to program. This lack of definition has two effects: the human factors

specialist often has difficulty in determining what he is responsible for and the system project manager is reluctant to fund poorly-defined efforts.

Second, the Navy project manager is often not aware of his responsibility to fully support human factors. Neither DOD directives nor Navy instructions regarding systems acquisition specifically refer to human factors as an area which must be addressed in the DP, NDCP, Project Master Plan or project manager charter. While training is always addressed, the other sub-elements of human factors (human factors engineering, life support engineering) are generally overlooked; and therefore, they are not included in project budgetary estimates. When the human factors specialist requests full support from the project manager, the budget is usually sufficient to fund only the training effort.

Third, human factors participation in conceptual and validation phases is limited. Since many of the Navy personnel responsible for initial system development seem to confuse "human factors" with "knob and dial design human engineering," it may be difficult for them to understand the role which human factors should play. When human factors personnel do participate in early system design efforts, the management of those efforts themselves tends to limit human factors contributions. For example, the loose-knit composition of DP development teams (which meet irregularly at wide intervals) tends to compartmentalize all disciplines and actually discourages integrated team effort. This problem is not limited to DP development; until a project office is officially chartered, regular team meetings are unusual. It seems to this author that failure to establish close-knit, dedicated teams early in the acquisition process is largely responsible for the limited role of human factors during conceptual and validation phases.

Finally, while the Air Force and Army have had Service regulations pertaining to human factors for more than six years, the Navy has yet to issue its first SECNAV or OPNAV instruction on the subject. To a large extent, this lack of service level policy contributes to each of the other three problem areas listed above.

Development and issuance of a SECNAV or OPNAV instruction on human factors in systems acquisition is considered essential.

RECOMMENDATIONS

It is recommended that appropriate SECNAV or OPNAV personnel establish an ad hoc group to develop and propose Navy policy with regard to human factors in Navy systems acquisition; the end result of this effort should be a SECNAV or OPNAV instruction similar in purpose to existing Air Force and Army regulations, AFR 800-15 (C1) and AR 602-1, respectively.

The major thrusts of this instruction should be to define the elements of human factors as they relate to and support systems acquisition, to describe the interfaces (in terms of interdependencies, input and output requirements) between human factors and other major disciplines (e.g., system safety, maintainability, etc.), to establish the human factors activities required during each phase of the Navy systems acquisition process (with emphasis upon Project Manager responsibilities to identify major human factors tasks and project resources used to accomplish them) and to assign specific responsibilities to Navy commands, bureaus, offices and major field activities and laboratories for the support, conduct and management of human factors programs.

This instruction should incorporate the following information with emphasis as noted:

- SCOPE - A statement identifying the commands, bureaus, offices and field activities/laboratories to which the instruction applies. This statement should be phrased in terms of activity charter or responsibility (such as in Army Regulation 602-1, paragraph 2.a.).

Definition of major human factors activities, major elements of human factors and major products of each element supporting the systems acquisition process. Within the body of the instruction, major human factors activities should be identified (similar to AR 602-1 paragraph 2.b.). Major elements of human factors should be provided as enclosure to the instruction (similar to Air Force Regulation 800-15 (C1)).

- OBJECTIVES - Specific objectives should be listed which are oriented toward system benefit or human factors program output/results (similar to AR 602-1, paragraph 3.). Definition of objectives in terms of human factors activities (such as in AFR 800-15(C1), paragraph 4.) should be avoided since focus tends to become diluted.

- POLICY - A statement requiring development and application of human factors principles during all phases of the systems acquisition process (such as in AR 602-1, paragraph 4.a.). Stress should be placed upon human factors being assigned an associate priority with other system characteristics.

Separate statements defining required human factors resources and activities in each phase of systems acquisition.

Statements to ensure human factors activity and resource requirements/considerations are appropriately reflected in system requirement documents, development plans (e.g., DP, NDCP, PM, DCP), test and evaluation plans, integrated logistic support plans, project charters and project master plans.

Statement regarding the extent to which human factors activities should be managed as an integrated effort during system acquisition (i.e., should human factors elements be managed independently or be managed by a single person or organizational element?).

- RESPONSIBILITIES - Statements of specific responsibility for each command, bureau, office or major support activity/laboratory. Where possible, these statements of responsibility should make reference to specific human factors activities, resources, planning, documentation, etc. and be oriented toward supporting the systems acquisition process. System development agency responsibilities should emphasize project manager responsibilities, tailoring of human factors requirements to fit system characteristics and provision of sufficient human factors personnel to adequately support development projects.

- ACTION - Statement establishing a reasonable deadline for implementation of this policy.

It is further recommended that a CNM instruction be developed to provide specific guidance to the Systems Commands in implementing this Navy policy statement. The CNM instruction should emphasize project manager responsibilities with regard to human factors, the need to manage human factors sub-elements in an integrated fashion and the need to tailor human factors requirements to fit the characteristics of individual system acquisition projects.

It is recognized that development and implementation of new Navy policy will not occur overnight. In order to obtain near-term improvements in human

factors program effectiveness, it is recommended that immediate action be taken in two areas. First, DP/NDCP development teams should receive greater emphasis. Team member responsibilities should be more clearly defined and a higher level of communication/cooperation between team members should be required. Second, the interfaces and interdependencies which should exist between human factors engineering, training, life support engineering, maintainability, reliability and system safety programs should be more clearly defined. Clearer role definition should result in reduced duplication of effort between these programs and simplified Navy/development contractor program management.

APPENDIX A

ABBREVIATIONS AND DEFINITIONS

- ADPO - Advanced Development Program Officer. A single individual within the Naval Material Command or supporting Systems Command who is assigned responsibility for preparation of a Development Proposal.
- ASC - Advanced System Concept. Description of a possible system which will satisfy a projected Navy or Marine Corps need and will be ready to enter Advanced Development within five years. Annually, ASCs are assembled into the Navy Advanced Concepts (NAC) and submitted to Chief of Naval Operations/Commandant Marine Corps for consideration in initiating advanced development projects.
- BIS - Board of Inspection and Survey. An organization, consisting of a permanent President and Staff, which conducts acceptance trials of aircraft as directed by the Chief of Naval Operations, (Same as INSURV).
- BUMED - Bureau of Medicine and Surgery.
- BUPERS - Bureau of Naval Personnel.
- CMC - Commandant of the Marine Corps.
- CNET - Chief of Naval Education and Training.
- CNO - Chief of Naval Operations; Office of the CNO is OPNAV.
- CNM - Chief of Naval Material; Headquarters Naval Material Command is NAVMAT.
- CNTT - Chief of Naval Technical Training
- CPPG - CNO's Policy and Planning Guidance. It presents (annually) basic concepts, objectives and assumptions on which the Department of the Navy Five-Year Defense Program is to be based. In essence, the CPPG provides Secretary of Defense policy and planning guidance as it pertains to the Navy, gives CNO's views on strategic objectives, gives specific CNO objectives and gives broad guidance on force levels and force structure.
- DCP - Decision Coordinating Paper. The basic DOD program proposal and control document. A short (20 page) document which presents program issues, considerations supporting the operation need, program objectives, program plans, performance parameters, areas

of risk and development alternatives. The DCP is developed in an iterative process by the principal developing Activity, CNM and CNO to support major program decisions by the Secretary of Defense. It is based upon the NDCP and serves as the primary documented input to the DSARC at major program milestones.

- DEPSECDEF - Deputy Secretary of Defense.
- DP - Development Proposal. A document developed by CNM/Systems Command in response to promulgation of an Operational Requirement. The DP presents to the Office of the CNO results of technical studies and alternative solutions to the given problems stated in the Operational Requirement.
- DPPG - Secretary of Defense Policy and Planning Guidance. This document, issued annually, sets forth basic concepts, principles and objectives which comprise the assumptions on which the Department of Defense Five-Year Defense Program is to be structured. It lays out force level and force structures required to meet (fiscally unconstrained) DOD objectives. Issuance of the DPPG begins the DOD planning cycle.
- DRDT&E - Director, Research, Development, Test and Evaluation.
- DSARC - Defense Systems Acquisition Review Council. An advisory body to the Secretary of Defense on systems acquisition policy and on certain major defense system acquisition programs. The DSARC principals consist of the Director of Defense Research and Engineering (DDR&E), Assistant Secretary of Defense (Installations and Logistics), Assistant Secretary of Defense (Comptroller) and Director (Planning and Evaluation). For programs within their areas of responsibility, the Assistant Secretary of Defense (Intelligence) and/or Director, Telecommunications and Command and Control Systems are also principals. Other key officials also participate in DSARC reviews. Major program decision/review points include program initiation, initiation of full scale development, initiation of limited (pilot) production and major production go-ahead.
- FYDP - Five-Year Defense Program; for Navy it is the DNFYDP.
- INSURV - Board of Inspection and Survey. An organization consisting of a permanent president and staff, which conducts acceptance trials of naval vessels, (Same as BIS).
- Major Program - A program may be designated as "major" by the Secretary of Defense. Three factors are considered in making this determination: dollar value (programs which have an estimated RDT&E cost exceeding 200 million dollars; all in Fiscal Year 1972 dollars); national urgency; and recommendations by DOD component heads or Office of the Secretary of Defense officials. "Less-than-major" programs are those failing to meet at least one of these criteria (also referred to as "non-major" programs).

- NAC - Navy Advanced Concepts. Document consisting of many Advanced System Concepts (ASCs) which presents a wide "menu" of possible systems to satisfy Navy and Marine Corps needs. The NAC is submitted annually to CNO/CMC to assist in selection of projects for advanced development.
- NDCP - Navy Decision Coordinating Paper. The basic Navy program approval and control document. For CNO and SECNAV designated programs, the NDCP is the final document, prepared for approval of the Acquisition Review Committee (ARC), a sub-panel of the CNO Executive Board (CEB), and updated for program reviews at designated milestones or periodically for level-funded programs. The NDCP contains all information required for the Decision Coordinating Paper (DCP) or Program Memorandum (PM). NDCP approval by CNO represents the first commitment of OPNAV Research, Development, Test and Evaluation (RDT&E); this is the only process by which such resources are committed. The NDCP presents program issues, considerations supporting the operational need, program objectives, program plans, performance parameters, areas of risk and development alternatives.
- NSS - Navy Strategic Study. Provides concepts and philosophy concerning future naval contributions to national defense and basic guidance for Navy long range and mid-range planning. The NSS is issued annually on 1 January, covering the period five to twenty years in the future from the end of the current fiscal year. It is the primary basis for Navy inputs into DOD level long range strategic and Research and Development documents.
- OR - Operational Requirement. Concise statement of operational needs, usually limited to three pages. The OR is the basic requirement document for all Navy acquisition programs requiring Research and Development effort. They are near and mid-term (0-10 years in the future) statements concerning needed operational capabilities. While normally prepared by OPNAV staff, they may be submitted by any fleet activity or other command via normal chain of command. Marine Corps statements of operational need are documented in a Required Operation Capability (RPC).
- PM - Program Memorandum. The program memorandum is the basic approval and control document for programs designated by the Director of Defense Research and Engineering. It is based upon the NDCP.
- SECDEF - Secretary of Defense
- SECNAV - Secretary of the Navy

STO - Science and Technology Objectives. Long-range (10 to 20 years) statements of Navy needs and problems. Each STO presents anticipated threat environment, broad operational problems, limitations to existing systems, capabilities required and the relative importance of the effort needed to attain the capabilities. STOs are based upon the projected role of the Navy derived from the CPPG, DOD long-range research and development plans and standing documents (e.g., Technology Coordinating Papers; Area Coordinating Papers, Mission Coordinating Papers).

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