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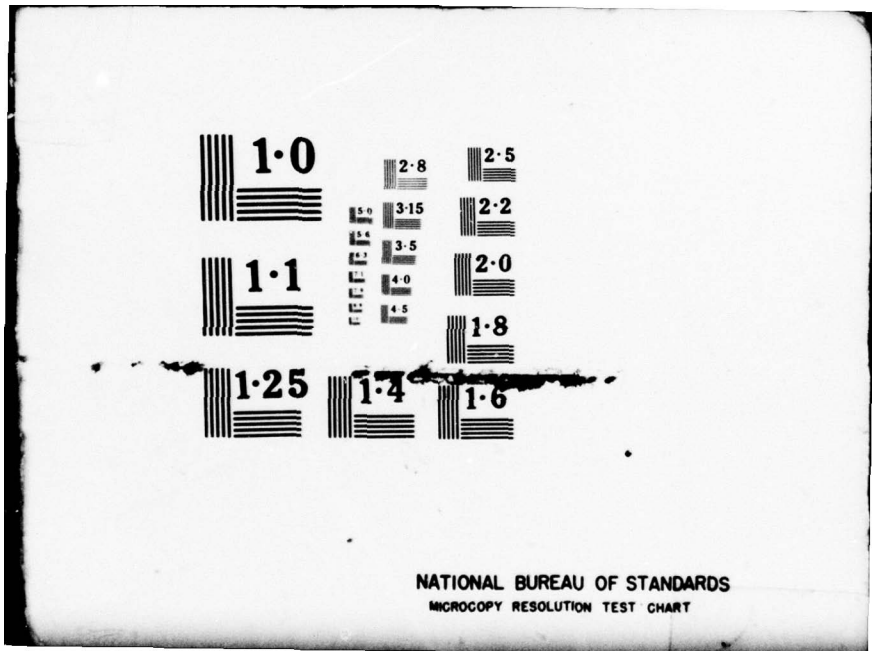
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AUTOMATED DATA SYSTEMS (ADS) MANAGEMENT METHODOLOGY

Vol. I: Automated Data Systems Concept Phase Document Preparation Methodology

Naval Warfare Research Center

Final Report

December 1977

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AUG 7 1978
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By: David L. Harvey, Terrance M. Keen, Edward H. Means, William Schubert, and Graham F. Wallace

Prepared for:

Commandant of the Marine Corps
Headquarters Marine Corps
Washington, D.C. 20380

Attention: Chairman, "Automated Data Systems (ADS) Management Methodology" Study Advisory Committee

Contract N00014-76-C-1119

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AUTOMATED DATA SYSTEMS (ADS) MANAGEMENT METHODOLOGY.

Vol. I: Automated Data Systems Concept Phase Document Preparation Methodology.

Naval Warfare Research Center

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December 1977

132 p.

By: David L. Harvey, Terrance M. Keen, Edward H. Means, William Schubert, Graham F. Wallace

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DEPARTMENT OF THE NAVY
HEADQUARTERS UNITED STATES MARINE CORPS
WASHINGTON, D.C. 20380

IN REPLY REFER TO
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24 JUL 1978

From: Commandant of the Marine Corps
To: Distribution List

Subj: Automated Data Systems (ADS) Management Methodology Study

Encl: (1) ADS Management Methodology Study

1. The Automated Data Systems (ADS) Management Methodology Study was initiated to produce a set of procedures and documentation to be utilized in the Conceptual Phase of ADS development.

2. The enclosed study has accomplished the stated objective. The methodologies proposed by the study would be beneficial to any ADS development effort. Certain portions of the study, such as the Resource Estimating Procedure, will require changes to reflect recent Department of Defense instructions.

3. The Marine Corps intends to utilize the ADS Management Methodology Study as a base for revision of current orders pertaining to ADS development. Appropriate modifications will be made to Marine Corps orders to reflect changes in policies and procedures.

4. A copy of this letter will be affixed inside the front cover of each of the subject study prior to its distribution.

L. F. Snowden

L. F. SNOWDEN
Chief of Staff

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PREFACE

Analysis by the Marine Corps has indicated that the growing demand for ADS has outstripped the available management capability to support application of the existing technology. For example, the growing demands for systems documentation and analysis during ADS development may be beyond the current capabilities of the Marine Corps to support satisfactorily, because of the shortage of qualified personnel and inadequate staffing at the Headquarters level. One manifestation of this is that the cost and time necessary to develop and implement an ADS are consistently underestimated.

The problem is multifaceted, and it appeared that the most immediate remedy might result from first tackling the problem of ADS development management. Current management is guided by the Marine Corps Automated Data Systems Manual (ADSM). However, specific statements of duties, tasks, operational definitions, and deliverables for individuals and work teams are not specified in the ADSM in sufficient detail to allow for a high degree of efficiency for the average developer.

As a consequence, HQMC contracted with SRI International to conduct a systems analysis study of the conventional management concepts expressed in the ADSM. The study was to develop a methodology, operational definitions,* and a definitive statement of tasks and duties for ADS development. Benefits accruing to the Marine Corps from a successful completion of the study effort were to be both economic and operational:

(1) Economic--if the efficiency of automated systems development is increased, there will be a reduction in the time and cost of developing any given ADS.

---

*Operational Definition: A specification of the activities of a worker or a team in developing and using a component of an ADS development plan. Alternatively, an operational definition assigns meaning to a concept by specifying the activities and operations necessary to produce a usable component of an ADS development plan. Thus, an operational definition provides a bridge between theory and application.

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(2) Operational--if the effectiveness of automated systems development is improved, the systems that are developed in the future will better conform to valid mission requirements.

The specific objectives of the research were as follows:

(1) Operationally define the management and analysis tasks and duties that must be performed in the preparation of an ADS Development Plan;

(2) Operationally define a procedural methodology for developing ADS objectives and associated measures of objective fulfillment;

(3) Develop specific methodologies needed to guide developers and decision makers for ADS systems so that the anticipated value of the proposed system can be assured and its total cost impact estimated and controlled; and

(4) Assist HQMC to translate the study results into procedures and policies.

The study was begun in mid-1976 and completed in late 1977. It consisted of the following five tasks:

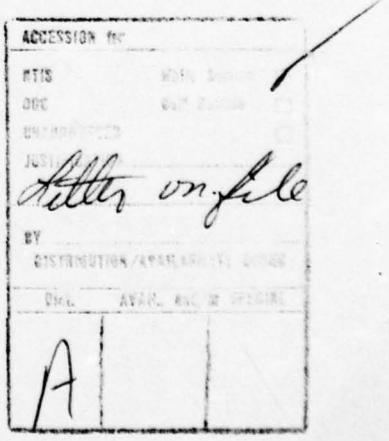
- Task 1: Objective-Writing Methodology
- Task 2: Resource Requirements Estimating Methodology
- Task 3: ADS Action-Document Preparation Procedures
- Task 4: ADS Project Evaluation Methodology
- Task 5: Integration and Refinement of ADS Management Methodology.

SRI reported on the results of Tasks 1, 2, and 3, in individual Technical Notes issued during the course of the project, namely, NWRC-TN-73, "Objective-Writing Methodology for USMC ADS Development," July 1977; NWRC-TN-72, "Resource Requirements Estimating Methodology," May 1977; NWRC-TN-75, "Concept Phase Procedures and Action Documents," September 1977.

This, the project's final report, has been published in two volumes. Volume I addresses Study Tasks 1, 2, and 3, and is designed for use by originators/users in presenting the case for a proposed ADS. The material originally contained in the Technical Notes has been restructured, simplified, and oriented as much as possible to the nontechnical ADS user. Those desiring more detailed explanations of the results of Tasks 1 through 3 are encouraged to consult the Technical Notes.

Volume II synthesizes and compiles the results obtained under Study Tasks 1, 2, and 3 in order to address the objectives of Tasks 4 and 5. It is suggested that an originator/user of a proposed ADS concept can profit from reading both volumes of the report, since the evaluation criteria presented in Volume II should, if possible, be satisfied by the proposal documents treated in Volume I.

The study was conducted within SRI International's Naval Warfare Research Center, A. Bien, Director. The Project Leader was David L. Harvey. Study team members included Terrance M. Keen, Edward H. Means, William Schubert, and Graham F. Wallace.



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EXECUTIVE SUMMARY

General

The ADS management methodology presented in this final report is designed to be used in the ADS Concept Phase of development.

The final report is divided into two volumes, one representing the management problem from the viewpoint of the proponents (Volume I) and the other (Volume II) from that of the evaluators of a proposed ADS. Volume I, therefore, treats the subjects of concept development and action document preparation. Also included in this volume are considerations of special problems, specifically, objective specification and resource estimating. Volume II specifies the procedural steps to be taken in the continuing process of project evaluation and executive approval/rejection at any of several milestones in that process.

The Problem

The USMC ADS development process is guided generally by MCO P5200.15 (ADSM) and MCO 5230.8 (Maintenance and Modification ... Applications Software ...) which require further definition and operational specificity.

A number of USMC, U.S. Navy, and DoD orders, instructions, and directives relate specifically to the ADS software development process.* Procedures and requirements dictated by those documents are not clear, or are not specified in sufficient detail, to allow for a high degree of efficiency for the typical Marine officer who is often assigned the ADS

*SECNAVINST 5233.1A, DODINST 4120.7, DODINST 4120.17, SECNAVINST 7000.14B, SECNAVINST 5231.1, DODINST 5010.27 (79XX.SS), DODINST 7041.3.

development or evaluation tasks as adjuncts to his regular duties. Specific problem areas for which this study is designed either to alleviate or assist USMC users to function within the constraints imposed are:

- Clearly stated requirements and procedures for preparing the specified action documents
- Clearly defined review and approval procedures
- Additionally, the methodology should facilitate specific USMC staffing concerns of:
  - Personnel shortage leading to inadequate staffing
  - Insufficient interest and support by involved parties
  - Division of responsibility between USMC divisions
  - Personnel turnover during development process.

Assumptions/Limitations

This methodology is limited to the management of new ADS and major ADS modifications and maintenance projects that are covered under the ADSM directives.

The applicability of this methodology is described in Section 1.2. The ADSM procedures apply to: all new and replacements to existing ADS, all tactical ADS, all purchased software costing more than $15,000, all maintenance/modifications of existing ADS requiring more than three man-months of analysis and programming effort, and any ADP resource expenditure exceeding $100,000. This methodology likewise applies in the aforementioned circumstances except that the research has been specifically limited to non-tactical ADS, and non-imbedded computer. Recommendations for changing those criteria are also discussed in Section 1.2 and listed in this summary under "Recommendations."

Generally, the procedures specified here and in the ADSM require a minimum (but not trivial) effort in preparing an ADS development plan. That means that the assigned staff must have some familiarity with ADS development procedures and terminology, and with alternative approaches. The proposed format for the action documents is specified in explicit detail with lead-in sentences, and fill-in blanks with instructions as to what is to be filled in. This format is considered to be extremely

important in order to standardize the method by which ADS plans are developed and evaluated. The imposed structure may appear awkward, excessive, and/or redundant in a number of applications, and at times it may appear too brief. This limitation should be viewed as a necessary expense to ensure adequate management control across a wide application of a standardized methodology. It is possible, of course, to respond in the prescribed format with the comment, "not-applicable," or in short paragraphs when the information demanded is either inappropriate or obvious.

Results

ADS development management control is achieved through the prescribed research, preparation, and approval/rejection action taken in prosecuting the following documents:

- Requirements Statement (RS)
- Feasibility Study (FS)
- ADS Development Plan (ADSDP), consisting of:
  - Body of plan plus appendices:
    (a) Functional Description (FD)
    (b) Data Requirements Document (RD)
    (c) ADP Equipment Specifications (ADPES)
    (d) Economic Analysis (EA).

Sample forms and specific instructions for each of the preceeding documents are contained in Section 4.

Two specific problems in this process that were considered from the onset of this study to be of sufficient importance to warrant separate reports:

- Defining explicit objectives for an ADS being developed to meet perceived information processing requirements.
- Resource estimating methodology.

To assist the Marine officer in preparing portions of the Feasibility Study and ADS Development Plan, Section 5 presents a technique termed "Objective-Writing," to be used for defining the objectives of an ADS being developed to meet a user's perceived information processing requirements. Whether or not the use of this technique is warranted is a matter of individual judgment. Its specific purpose is to provide a systematic approach to producing a body of objective statements that avoids the possibility that

- Objectives might not be explicitly stated
- Objectives might not fully cover user requirements
- Objectives might be contradictory
- The fulfillment of objectives might not be measurable.

If risk of those hazards is low, then full use of the five objective writing techniques is certainly unnecessary. However, even the most straightforward proposal would likely benefit by the use of one or more of the techniques offered.

ADS resource estimating is another area in which there are no generally accepted standards or procedures. The recommended procedure presented in Section 6 is based on taking the best features of the U.S. Army's Fort Lee method and the USMC Kansas City resource estimating procedure, current micro- and macroestimating techniques for use in the concept phase for estimating both development, and operations and support costs. The use of those techniques is not a requirement for either the feasibility study or economic analysis; however, through the repeated use of this estimating approach, resource estimates will, in time, become more accurate and reliable.

Actual management control in the concept formulation phase is exercised through the approval/rejection action taken at each succeeding step from the statement of user requirements, (RS), to the Milestone 4 decision, (approval/rejection of the ADSDP).

The measure of a good methodology is its ability to terminate uneconomic proposals while expediting those that are needed and warranted.

That is the quality sought in the recommended "*Project Evaluation* Methodology" (Volume II of this report). The first issue concerns need and feasibility, basically,the question, "Should it be done?" The second issue, provided it is approved to this point, concerns the establishment of priorities for the new project with respect to the other, ongoing, ADS projects drawing on USMC programmer-analyst resources.

Recommendations

(1) The methodology set forth in these two volumes should be incorporated into a revised ADSM.

(2) All future ADS proposals should be processed in accordance with the revised ADSM, with the thresholds based on the suggested criteria presented in Section 4, Volume II, of this study.

(3) Until the ADSM is revised, the ADSM/5230.8 thresholds as summarized in Section 1 should be applied in determining whether ADSM procedures, as modified by this study, or 5230.8 procedures are appropriate for a proposed ADS.

The Concept Phase is characterized by a series of subphases and events listed in Section 3. Implicit in them are four decision points where resources must be committed before further concept development can continue. Three of the decision points can be linked to a corresponding action document as follows:

- Section 3.1 - Requirements Development Subphase; identify and document user requirements.

  Action document - *Requirements Statement* (RS).

- Section 3.2 - Feasibility Study - develop and evaluate alternative approaches and select preferred approach.

  Action document - Feasibility Study (FS).

- Section 3.3 - Prepare the ADS Development Plan.

  Action document - Subsidiary action documents for the ADSDP.

Approval of the action document should be explicit approval for resources needed to complete the next activity/event. A procedure for authorizing the commitment of resources is discussed in Volume II. The

fourth decision point (Milestone 4 of the ADSM) is the approval or rejection of the ADSDP, which, if approved, authorizes resources needed to proceed with the Analysis and Design (Milestone 5) of the proposed ADS.

SECTION 1. INTRODUCTION

1.1 General. As pointed out in the Preface, this volume is a compilation of a series of Technical Notes prepared during the conduct of the study. Those documents presenting interim results were published as specific tasks of the study and were completed in accordance with a stipulated schedule. The Technical Notes have provided the basis for the individual sections of this report, described below.

Sections 2, 3, and 4 discuss the overall ADS development process, the Concept Phase in particular, and the action documents required in the Concept Phase. As guided by the Study Directive, the sections operationally define and document the management and analysis tasks that are essential in the preparation of the action documents. The procedures specified in the sections satisfy all applicable external and internal directives. They are as simple as possible, given the complexity of the subject matter, and they are not form-bound. They are designed for easy incorporation into a revised USMC ADS Manual, if that is desired. Some of the action document preparation procedures require reference to Department of Defense Manual (DODM) 4120.17-M, "Automated Data System Documentation Standards Manual," December 1972, and Department of Defense Instruction (DODI) 7041.3, "Economic Analysis and Program Evaluation for Resource Management," 18 October 1972. This reference material should be at hand for users of this document.

Having been presented the overall picture of ADS development, the reader/user of this document is given his first step in ADS implementation. This is done in Section 5, "Objective-Writing Methodology for USMC ADS Development." The section addresses two overall concerns: (1) how to develop and express objectives for an ADS being newly developed or modified (objective-writing), and (2) how such ADS objectives properly enter into the process of USMC systems development.

Section 6, "Resource Requirements Estimating Methodology," discusses the requirement for, and means of, achieving accurate and reliable estimates of ADS life cycle resources (manpower and dollar outlays) needed

to develop and operate ADS systems. Life Cycle Cost (LCC) estimates are particularly critical in the early system development or initiation stages because it is during this phase that management has the greatest opportunity to select and optimize satisfaction of a requirement among alternative solutions. For this reason, first-cut LCC estimates are specified as early as the feasibility study stage.

There are numerous DoD, SECNAV, and USMC directives specifying a requirement for Life Cycle Cost estimates. However, there appears little consensus among either industry or DoD agencies as to how those estimates are to be provided. Section 6 presents two estimating techniques (macro and micro), which, although not mutually exclusive, tend to be applied at different times in the development of the ADS concept into an ADSDP (Automated Data System Development Plan). The approaches parallel, and, we hope, contribute to, efforts within DoD agencies and within industry in the continuing attempt to develop resource estimating standards.

1.2 Applicability of the ADS Management Methodology. The recommended ADS mangement methodology set forth in these two volumes is a detailed, thorough process designed to prevent costly mistakes in the introduction of new or modified USMC ADS. Accordingly, the methodology is not fully applicable to all ADS proposals, particularly those that are so small (in their development cost or potential benefits) that application of the full process described herein would not be economically warranted.

This consideration requires that there be established some definite criteria whereby the sponsor of a proposed ADS may determine the review and approval methodology that is applicable to his proposal at the outset. Under the current directives, the ADSM and MCO 5230.8, the criteria are difficult to understand, and their clarification is sorely needed.

As we read them, the existing directives set the following applicability rules:

a. The ADSM procedures apply to:

(1) All new ADS.

(2) All replacements of existing ADS.

(3) All tactical ADS.

(4) Commercially acquired software costing more than $15,000.

(5) Maintenance or modification ADS projects (except changes directed by higher authority) requiring more than three man-months of analysis and programming effort.

(6) Any ADP resource expenditure exceeding $100,000.

b. MCO 5230.8 procedures presumably apply to all other ADS proposals, particularly maintenance and/or modifications of existing ADS, however.

c. Apparently not covered by either the ADSM or MCO 5230.8 are:

(1) Maintenance efforts required to correct abnormal endings (abends) which are considered to be "self-justifying."

(2) Systems designed purely to support research and development projects that do not:

(a) Involve acquisition of ADPE with RDT&E funds

(b) Include an ADS as an end item or product of the project.

Additionally, neither document offers guidelines for determining how much effort should be expended on proposal preparation and review. This issue as well as item (3) above is discussed in Section 4 Volume II, of this report.

SECTION 2. ADS DEVELOPMENT

2.1 Context. The USMC ADS development process is organized into three consecutive major phases: the Concept Phase, the Development Phase, and the Operation Phase. Within each major phase are several subphases, which are not always consecutive, but are sometimes parallel or overlapping. These phases and subphases are illustrated in Figure 2-01.

The methodology developed in this study is designed to be applied in the Concept Phase. Major improvements have been made in the definition of the Concept Phase. One of them comes from the recognition that the Concept Statement--heretofore specified under ADSM procedures as the initial action document in any ADS development--did not provide an adequate vehicle for defining the prospective user's information processing requirements. Thus, the Concept Statement had a tendency to focus attention on an information system solution without an adequate statement of the problem to be solved. This inadequacy has been addressed by specifying a Requirements Statement as the document needed to initiate an ADS development. This provision for the explicit statement, validation, and approval of the user's requirements as the logical starting point for an ADS development is a significant improvement in the development process. Another improvement results from the separation of unlike concerns. This is achieved at several points in the process. An example is the disentangling of feasibility considerations from those of user need. The prospective user should be free to articulate his need or requirement without being diverted by questions of feasibility, which should be investigated independently. This situation is formalized by the provision of separate requirements development and feasibility study subphases. This illustrates an underlying philosophy of the ADS development instructions, namely, that activities or responsibilities should not be levied on persons or groups, who, by their nature, are not well-suited to them. This philosophy has two major implications. One is that the prospective user (i.e., the person or group that recognizes an apparent information system need and that initiates an ADS development) is left as free as possible of requirements that presuppose ADP knowledge on his part or

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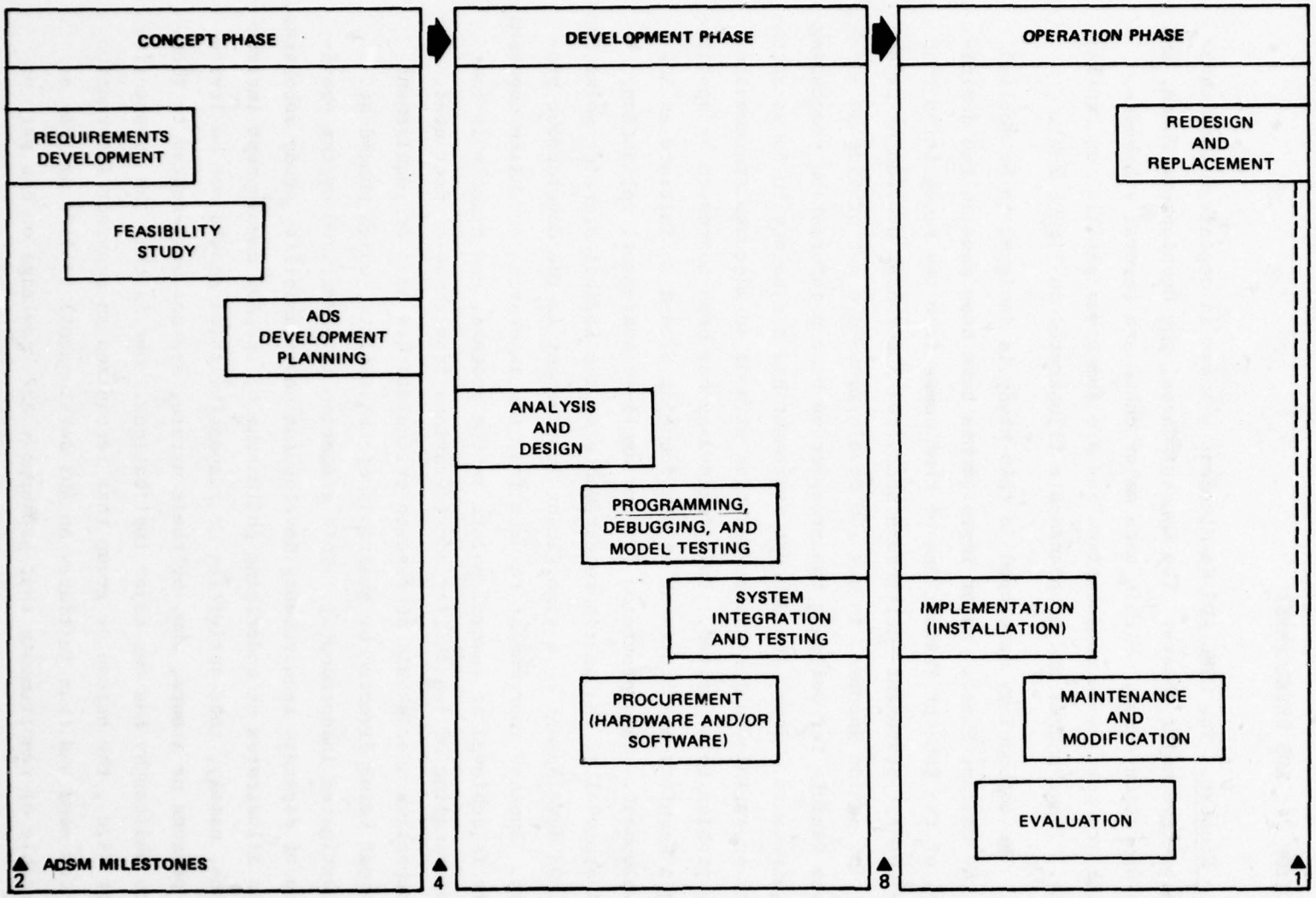

FIGURE 2-01 PHASES OF THE ADS DEVELOPMENT AND OPERATIONAL ACTIVATION PROCESS

that require him to be cognizant of management or resource considerations normally outside his purview. The instructions laid on the user are equally applicable whether the users be staff officers in an FMF command, supply officers at a SASSY Management Unit, functional area specialists at HQMC, or ADP specialists at a Field Automated Services Center. The second implication is that an ADS Development Team will not necessarily have a fixed composition throughout the successive phases of development. Although the Team must have continuity, the types of competence required to carry out one phase of development will be different from those required for carrying out another. Hence, different people will serve on the Development Team at different times.

Because the Concept Phase involves planning for the other phases, those phases were also analyzed. Some problems that have affected all phases of ADS development are discussed in the next paragraph. Beginning with Section 3, the discussion is limited to the nature and process of the Concept Phase.

2.2 General Problem Areas. Listed below are four broad problems that have occurred in ADS development. The first three should be alleviated by the ADS Management Methodology developed in this study, as indicated in the individual discussions. The fourth is institutional, and hence is not amenable to alleviation by the ADS Management Methodology.

2.2.1 Personnel Shortage/Inadequate Staffing. This problem involves a shortage of qualified personnel and inadequate staffing at the Headquarters level.

It is highly probable that the problem results from insufficient knowledge of what numbers and types of personnel are required in an ADS development. The methodology developed in this study should help alleviate the problem by requiring that personnel resource requirements be explicitly estimated at the earliest possible times. A basis for such estimates is given in SRI/NWRC-TN-72, "Automated Data Systems (ADS) Management Methodology, Task 2 Report: Resource Requirements Estimating Methodology," May 1977.

2.2.2 Insufficient Interest and Support. This problem involves insufficient interest in and support of ADS development by the users/sponsor.

It is likely that this problem results in part from insufficient involvement of the users or the sponsor in requirements development, and in part from the enormous amount of repetitive, boring, and meaningless paperwork, based on nebulous guidance, that has been required in connection with ADS development. The methodology developed in this study should help to alleviate the problem by assuring that user requirements are clearly and completely stated and validated, by streamlining the paperwork insofar as permitted within the constraints imposed by external directives, and by providing instructions that are as concrete as possible.

Another possible cause of this problem is that the overall workload of the users or the sponsor may be excessive, and that other projects may carry a higher priority than the ADS. The solution in this case, naturally, would be to reduce the workload or rearrange priorities.

2.2.3 Division of Responsibility. This problem involves division of responsibility between various stages of the ADS development process. One method of alleviating it is to specify identifiable milestones that must be attained before responsibility can be transferred. This will help prevent situations such as, for example, a processing center's being held responsible for the output quality of an ADS that has not been fully tested and debugged. Another alleviation method is to establish definite interfaces between areas of responsibility. These milestones and interface definitions are provided for in the methodology developed in this study, particularly in the ADS Development Plan.

2.2.4 Personnel Turnover. This problem involves turnover of key personnel during the ADS development period. The term "key personnel" is assumed to include managers and senior technical personnel.

One approach might be not to assign a Marine to an ADS development unless he has sufficient remaining time in his present tour of duty to follow the project through. There are some problems with this, however.

For one thing, a Marine might not have attained enough knowledge to be assigned a key job until he has been in his job a significant amount of time. In such a case he would have correspondingly less time remaining. Also, some ADS development may be planned to extend beyond normal tours of duty. If a Marine's tour in a specialized job such as ADS development were extended, it would very likely be detrimental to his career.

Another approach might be to assign only Civil Service personnel to key positions. An obvious drawback to this is that Marines should constitute the top management of the Marine Corps. Officers can be prepared for top management only by becoming knowledgeable and experienced in all aspects of Marine Corps operations, including data systems. Therefore, some of the key personnel in ADS developments must be Marines.

A compromise approach would be to assign Marines to the more functionally oriented, but still crucial, systems development positions. Civil Service personnel could be assigned to the more technically oriented ones, with a Marine in overall command. To be effective, this approach would require that a sufficient overlap period be provided for in movements of Marines into and out of key positions. This approach is somewhat inefficient when viewed solely in terms of ADS development, but taking such a view is suboptimizing. The objective is to optimize the operation of Marine Corps as a whole; this makes inefficiencies in some technical operations inevitable.

SECTION 3. THE CONCEPT PHASE OF ADS DEVELOPMENT

The Concept Phase of ADS development begins with the identification of an apparent information system requirement and ends with a decision on whether to develop a system to satisfy the requirement.

The Concept Phase is subdivided into three subphases: Requirements Development, Feasibility Study, and ADS Development Planning. Each subphase culminates in the submission of a self-contained "action document" for approval by the appropriate authority. The activities and action documents involved in each subphase are described in the paragraphs that follow.

3.1 Requirements Development Subphase. This subphase is initiated informally by interested functional managers and users. The initiators should identify all potential users and invite them to participate in the subphase. Interested organizations will assign participants as required. The activities in the subphase are listed below; detailed instructions for each activity are given as part of the Requirements Statement (RS) preparation instructions in paragraph 4.2 of Section 4, following.

a. Identify and document all user requirements

b. Validate the user requirements

c. Suggest some conceptual approaches to satisfying the user requirements

d. Estimate the resources required for developing the concepts, selecting the preferred approach(es), and preparing an FS and an ADSDP

e. Compile the information in (a) through (d) into a Requirements Statement (RS).

3.2 Feasibility Study Subphase. This subphase is initiated by approval of the RS, which implies the commitment of the resources required to develop alternative approaches to satisfying the user requirements. As part of the subphase initiation directive, a System Sponsor is appointed. A Feasibility Study (FS) Team is also appointed for the subphase. The team should include members with broad experience in various functional

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areas of the Marine Corps so that the USMC-wide impacts of proposed alternative approaches can be identified and analyzed in the FS. The activities in the subphase are listed below; detailed instructions for each activity are given as part of the FS preparation instructions in paragraph 4.3 of Section 4.

a. Formulate objectives for and develop alternative approaches to satisfying the user requirements.

b. Determine whether the alternative approaches are technically and operationally feasible.

c. Estimate the costs of the feasible alternative approaches.

d. Identify and evaluate any beneficial effects (beyond the satisfaction of user requirements) that the feasible alternative approaches would have on the mission effectiveness of the Marine Corps or any of its subdivisions.

e. Select the preferred approach(es).

f. Compile the information in (a) through (e) into a Feasibility Study (FS) according to the instructions in paragraph 4.3.

g. If necessary, revise the estimate of the resources required to prepare an ADSDP.

h. Submit the FS and the revised estimate for approval. It is the responsibility of C4 (Headquarters) to determine the appropriate approval authority. The approval process is the standard military staffing process.

3.3 ADS Development Planning Subphase. This subphase is initiated by approval of the FS, which implies the commitment of the resources required for preparing an ADSDP. As part of the subphase initiation directive, an ADSDP Team is appointed for the subphase. The activities are given as part of the action document preparation instructions in paragraphs 4.4 and 4.5 of Section 4.

a. Perform the analyses necessary for compiling the subsidiary action documents (see paragraph 4.4) that must be appended to the ADSDP. These analyses must include cost-performance tradeoffs.

b. Compile the subsidiary action documents.

c. Prepare the ADSDP.

d. Submit the ADSDP for approval.

SECTION 4. ACTION DOCUMENT PREPARATION INSTRUCTIONS

4.1 General Instructions. This section presents information for preparing each action document required in the Concept Phase, including the subsidiary action documents referred to in paragraph 3.3a of the preceding section.

Instructions for the individual documents are presented in the form of action document outlines. The outlines themselves contain unbracketed and bracketed material. The unbracketed material must be included verbatim; it establishes the document frameworks and provides the basis for mutual understanding of document contents by both the preparers and the intended audience.

The bracketed material comprises instructions to, and guidelines for, the document preparers. The instructions are of two general types: administrative and substantive. The administrative instructions deal with dates, references, organizational matters, and other administrative details; they are quite specific. The substantive instructions, on the other hand, deal with the particular information problem being addressed and the suggested solution approaches, and depend upon an understanding of ADS technology and the problem.

The substantive instructions, by their nature, cannot be made very specific. Thus, preparation of the action documents cannot be treated as a mechanical process. The process requires intelligence, creativity, and concentration. No set of instructions can provide the substantive knowledge and information that are required for high-quality action documents--only qualified people can do that.

4.2 Requirements Statement (RS). Figure 4-01* presents the outline of the RS, which is to be prepared in accordance with the general instructions in paragraph 4.1.

The completed RS is to be submitted under a cover letter to the appropriate approval authority identified by C4.

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*All figures are presented immediately following the text of this section.

4.3 Feasibility Study (FS). Figure 4-02 presents the outline of the FS, which is to be prepared in accordance with the general instructions in paragraph 4.1.

The FS is to be submitted under cover letter to the appropriate approval authority identified by C4. The cover letter shall contain any revisions that may be required to Section 7 of the RS; if none is required, the cover letter shall so state. To provide the decision maker with complete historical background, the RS, the cover letter under which it was submitted, and the RS approval document shall be appended to the submission.

4.4 Subsidiary Action Documents for the ADS Development Plan (ADSDP). As indicated in paragraph 3.3 of Section 3, the ADSDP is the action document that culminates the ADS Development Planning Subphase of the Concept Phase. Four subsidiary action documents must be prepared in connection with the ADSDP: the Functional Description (FD), the Data Requirements Document (RD), the ADP Equipment Specifications (ADPES), and the Economic Analysis (EA).

As will be indicated in subparagraph 4.5.1 below, the ADSDP is prepared in part by summarizing the contents of the subsidiary action documents. Hence, the subsidiary action documents must be prepared before the ADSDP can be prepared. The following subparagraphs present preparation instructions for those documents.

4.4.1 Functional Description (FD). The FD is prescribed in Department of Defense Manual (DODM) 4120.17-M, "Automated Data Systems Documentation Standards Manual." The DODM 4120.17-M Foreword states that the FD format prescribed in the manual is mandatory, and further states that the military departments and defense agencies may publish only information that supplements the provisions of the manual, and is necessary for their own specific requirements.

The FD instructions in DODM 4120.17-M describe a document that is far wider in scope than a functional description per se. The prescribed format will produce a document that is verbose, diffuse, redundant, and without clear purpose; and that will not fit well into the ADS Concept

Phase logic delineated in Section 3 of this report. Nevertheless, it must be used as prescribed. An attempt has been made, through the supplementary instructions in Figure 4-03, to facilitate preparation of the prescribed FD.

4.4.2 Data Requirements Document (RD). The RD is prescribed in DODM 4120.17-M, "Automated Data Systems Documentation Standards Manual." As in the case of the FD (paragraph 4.4.1, above), the RD format is mandatory.

The RD instructions in DODM 4120.17-M are fairly straightforward. Some supplementary instructions are given in Figure 4-04.

4.4.3 ADP Equipment Specifications (ADPES). Figure 4-05 presents the outline of the ADPES. The ADPES is to be prepared in accordance with the general instructions in paragraph 4.1.

4.4.4 Economic Analysis (EA). Figure 4-06 presents an outline of the EA. The EA is to be prepared in accordance with the general instructions in paragraph 4.1.

4.5 ADS Development Plan (ADSDP). The ADSDP comprises a summary of the problem to be solved and the requirements to be met, a description of the ADS selected to satisfy the requirements, a summary of the resources required to develop and implement the ADS, and a development and implementation schedule. Instructions for the body of the ADSDP are given in subparagraph 4.5.1.

The ADSDP shall contain two appendixes, as described in subparagraph 4.5.2. The completed ADSDP shall be submitted under a cover letter to the appropriate approval authority identified by C4.

4.5.1 Body of Plan. Figure 4-07 presents the outline of the body of the ADSDP. The ADSDP is to be prepared in accordance with the general instructions in paragraph 4.1.

4.5.2 Appendixes to Plan. The ADSDP shall contain at least two appendixes; additional appendixes may be added if necessary. The names and contents of the mandatory appendixes are as follows:

a. Appendix A, Subsidiary Action Documents. This appendix shall contain, in order, the FD, RD, ADPES, and EA.

b. Appendix B, Archival Material. This appendix shall contain, in order:

(1) RS approval document

(2) RS cover letter

(3) RS

(4) FS approval document

(5) FS cover letter

(6) FS.

REQUIREMENTS STATEMENT (RS) FOR
AN INFORMATION SYSTEM TO [state system purpose succinctly]

SECTION 1. GENERAL [Date.]

1.1 Purpose. The purpose of this Requirements Statement (RS) is to provide:

a. A definitive written statement of user requirements.

b. A basis for deciding whether to commit the resources required to prepare a Feasibility Study (FS) of alternative approaches to meeting those requirements.

1.2 Content. This RS includes the following information:

a. Description of the problem and its context that generate the apparent necessity for the information system.

b. Specification of the user requirements derived from the problem.

c. Substantiation of the validity of the user requirements.

d. Description of some preliminary and not necessarily exhaustive conceptual approaches to satisfying the validated user requirements.

e. Specification of the organization, resources, and schedule required to prepare a Feasibility Study (FS) of alternative approaches to satisfying the user requirements

f. An estimate of the organization, resources, and time required to prepare an Automated Data System Development Plan (ADSDP).

1.3 Point of Contact. [Identify the person or office that is the specific point of contact for matters regarding this RS.]

FIGURE 4-01. Requirements Statement Outline (Page 1 of 7)

SECTION 2. PROBLEM

2.1 Problem Summary. [Summarize the problem concisely.]

2.2 Organizational Context. [Specify the functional areas and command levels affected by the problem, and describe their interrelationships.]

2.3 Annotated References. [List in some logical order the documents that bear directly on the problem, together with succinct pertinent annotations.]

2.4 Problem Description. [Describe the problem comprehensively. Be sure to include a concise description of all the deficiencies in the present situation.]

2.5 Existing System. [Describe the existing method or system, if any, for attempting to deal with the problem. If there is none, so state.]

FIGURE 4-01. Requirements Statement Outline (Page 2 of 7)

SECTION 3. USER REQUIREMENTS

[User requirements are derived from the problem. They have the characteristic that, from the user's point of view, satisfying them would solve the problem. User requirements are discussed at some length in SRI/NWRC TN-73, Automated Data Systems (ADS) Management Methodology, Task 1 Report: Objective-Writing Methodology for USMC ADS Development, July 1977; particularly see paragraph 1.3.

Do not confuse user requirements and solution approaches. For example, a user does not have a requirement for a cathode ray tube (CRT) terminal and a telecommunications link to a central computer; his requirement is actually for a means of entering data and/or receiving information at a specified location. A CRT terminal is only one of several possible solution approaches.

User requirements must be specific. For example, a requirement to ensure continuity in logistics information systems support when making a transition from a garrison to an operational environment is not a specific user requirement; it is a statement of a problem. Specific user requirements must be derived from this problem.

User requirements should be reduced to a list of statements, each presented as simply and quantitatively as possible. The list should be complete, and the individual statements should be mutually exclusive insofar as practical.]

FIGURE 4-01. Requirements Statement Outline (Page 3 of 7)

SECTION 4. VALIDATION OF USER REQUIREMENTS

[The decision makers will want to satisfy themselves that the user requirements are valid. Therefore, justification must be provided in this section for each user requirement stipulated in Section 3. Justification statements depend on the situation, and may range from being objective (e.g., "unless a parts order can be delivered to a supply source within two hours, there is a high probability that an aircraft will have to be grounded") through subjective (e.g., "the DC/S Manpower believes morale will be adversely affected unless personnel records can be corrected in a specified way within one week") to being authoritative (e.g., "the Commander orders it"). The important thing is that there be an identified reason for all user requirements. Supporting data and analysis showing the extent to which the user requirements are not currently being met should also be provided.]

FIGURE 4-01. Requirements Statement Outline (Page 4 of 7)

SECTION 5. SOME PRELIMINARY CONCEPTUAL APPROACHES

[In this section, the person(s) preparing the RS may present conceptual approaches toward satisfying the user requirements. Presentation of conceptual approaches is desirable because it will give the decision makers some relatively concrete thoughts about possible end products, and it will provide a rough basis for the estimates in Sections 6 and 7. If the RS preparer(s) do not have any ideas for conceptual approaches, it should be so stated in this section.

Although it was noted in 1.2a that the problem generates an apparent need for an information system, there may be other solution approaches--reorganization, for example. These should be considered in this section. Further, even if there is a real requirement for an information system, the information system may not need to be automated.

Conceptual approaches that involve nonautomated or automated information systems may be presented at any level of detail from sketchy information flow descriptions to system designs that include generic software and/or hardware descriptions. Software and hardware should not be specified by brand.]

FIGURE 4-01. Requirements Statement Outline (Page 5 of 7)

SECTION 6. PLANNING FOR FEASIBILITY STUDY

6.1 Organization. [In this paragraph, specify the composition of the Feasibility Study (FS) team. The FS will be prepared by a team chaired by a representative of the system sponsor. The exact composition of the team will depend on the situation, but the following guidelines would usually apply. At least one representative of each user should be assigned to the team. One or more representatives would be required from the Information Systems Support and Management Branch (CCI) of the Command, Control, Communications and Computer Systems Division. Other representatives such as management engineers, operations analysts, and communications officers may be included, depending on the situation.]

6.2 Responsibilities. [This paragraph shall include a specification of the responsibilities of each FS team member. In general, the system sponsor would be responsible for the overall FS. The system sponsor representative, user representatives, and CCI representatives would be responsible for delineating alternative approaches. The CCI representative would be responsible for determining technical feasibility of ADS approaches. The sponsor/user representatives would be responsible for determining operational feasibility. The CCI representative would be responsible for developing life cycle cost estimates for feasible ADS approaches. Other responsibilities would depend on the particular situation.]

6.3 Resource Requirements. [This paragraph will present an estimate of the time required of each FS team member to perform his function. Any other resource requirements (e.g., travel funds) will also be identified and estimated.]

6.4 Schedule. [This paragraph will present an estimated schedule for preparing the FS, and will state the estimated completion date.]

FIGURE 4-01. Requirements Statement Outline (Page 6 of 7)

SECTION 7. PRELIMINARY PLANNING FOR ADS DEVELOPMENT PLAN

7.1 General. This section presents preliminary planning material relevant to preparation of the ADS Development Plan (ADSDP). Since the magnitude of the ADSDP effort cannot be predicted accurately until completion of the FS, however, this material is subject to substantial change. The purpose of presenting this preliminary material is to give the decision maker a broader basis for deciding whether to proceed with the FS.

7.2 Organization. [In this paragraph, specify the tentative composition of the ADSDP team. The ADSDP will be prepared by an ADSDP team which will be constituted upon approval of the FS. The team may contain many of the same members as the FS team; however, some may be dropped (e.g., management engineers) and some may be added (e.g., technical specialists).]

7.3 Responsibilities. [This paragraph will tentatively specify the responsibilities of each ADSDP team member with respect to the various sections of the ADSDP.]

7.4 Schedule. [This paragraph will present a tentative schedule, keyed to the FS approval date, for preparing and completing the ADSDP.]

FIGURE 4-01. Requirements Statement Outline (Page 7 of 7)

FEASIBILITY STUDY (FS)
OF APPROACHES TO [state system purpose as stated in title of RS]

SECTION 1. GENERAL [Date.]

1.1 Introduction. This Feasibility Study (FS) presents the results of an analysis of alternative approaches to satisfying the user requirements set forth in "Requirements Statement (RS) for an Information System to [State purpose as stated in title of RS.]" dated [State date of RS.]. The fact that this FS is being published means that an Automated Data System (ADS) was found to be a preferred alternative approach. It is emphasized, however, that automation was not presupposed when the analysis was undertaken--in fact, the designers of alternative approaches were specifically directed to consider nonautomated approaches as well as automated ones. The designers were further directed to design as many alternatives as practicable.

1.2 Purposes. The purposes of this Feasibility Study (FS) are:

a. To provide an analysis of broadly defined alternative approaches to satisfying the user requirements set forth in the RS referenced in 1.1.

b. To recommend an approach [If more than one is selected, state "To recommend approaches".] to be analyzed further in an Automated Data Systems Development Plan (ADSDP).

1.3 List of Alternative Approaches. This FS addresses the following broadly defined, relatively dissimilar alternative approaches to satisfying the user requirements: [Enumerate the alternatives in five words or less. The first alternative listed should be the existing system, if there is one. The existing system should be included even if it is patently deficient. If there is no existing system, insert the following sentence immediately following the title of this paragraph: "No system designed to satisfy the user requirements currently exists." As an example of the desired enumeration style, following is an enumeration of four hypothetical alternative approaches:

a. Existing system (manual)

b. Automated centralized processing

FIGURE 4-02. Feasibility Study Outline (Page 1 of 18)

c. Automated distributed processing

d. Reorganization.

Since a Functional Description (FD) will not yet have been produced at the time FS is written, the alternative approaches in the FS cannot be very finely defined; for example, the FS cannot be used to analyze detailed design tradeoffs within a broadly defined alternative approach.]

1.4 Content: This FS includes the following information:

a. Description of the alternative approach(es) recommended for further analysis in an ADSDP

b. Description of the existing approach, if any, and of the other alternative approaches listed in paragraph 1.3 above

c. Determination of the technical and operational feasibility of each alternative approach, including a discussion of the underlying rationale

d. Presentation of life cycle cost estimates for the technically and operationally feasible alternative approaches

e. Discussion of the benefits of the technically and operationally feasible alternative approaches

f. Discussion of the basis for selecting the recommended approach(es).

1.5 Functional Manager(s), System Sponsor, and User(s).

1.5.1 Functional Manager(s). [Specify the functional manager(s) involved. If there are more than one, specify which is the lead functional manager.]

1.5.2 System Sponsor. The system sponsor is the agent of the functional manager(s). [Specify organization and give specific point of contact for matters regarding this FS.]

1.5.3 System User(s). [Specify organization(s) and give specific point(s) of contact for matters regarding this FS.]

FIGURE 4-02. Feasibility Study Outline (Page 2 of 18)

1.6 Problem and User Requirements. The problem and the user requirements that underlie this FS are fully described in "Requirements Statement for an Information System to [state purpose as stated in title of RS]," dated [state date of RS]. References applicable to the problem are given in that document.

1.7 ADS Guidelines and Constraints. [Here set down a complete statement of all recognized pertinent guidelines and constraints beyond those already incorporated into the user requirements contained in the RS cited in paragraph 1.6 above. ADS guidelines and constraints are defined as requirements--either directive or restrictive--that reflect the influence of the larger environment in which the system development is taking place. They emanate from such factors as policy guidance, organizational arrangements, mission requirements, resource considerations, interoperability considerations, accepted technical practice, and other factors as well. For the Marine Corps, some of the primary sources of ADS guidelines and constraints are the DOD directives, SECNAV instructions, GSA regulations, and Marine Corps orders relating to ADS. Responsibilities for identifying the pertinent ADS guidelines and constraints rest as follows:

a. With the system sponsor for those governing functional area activities in the system sponsor's area

b. With the C^4 organization for those deriving from information system development policies, practices, standards, and so on.

Pertinent guidelines and constraints must be identified whether they originate with the Marine Corps or emanate from external authorities. Some guidelines and constraints may be pertinent to all the alternative approaches being considered, while others may pertain only to certain approaches. Such relationships should be made clear in the statement of guidelines and constraints. Responsibility for actually writing the statement of guidelines and constraints rests with the FS team in liaison with the system sponsor's organization and the C^4 organization. This team bears the further responsibility of contributing any additional guidelines and constraints known to it, and of conducting an analysis of the guidelines and constraints to ensure they are as complete as possible.]

1.8 Other References. [List in some logical order other documents that bear directly on feasibility determination, economic analysis, and other subjects

FIGURE 4-02. Feasibility Study Outline (Page 3 of 18)

covered in this FS. Do not repeat the problem references or other references previously cited. References should be annotated succinctly.]

FIGURE 4-02. Feasibility Study Outline (Page 4 of 18)

SECTION 2. RECOMMENDED APPROACH(ES)

It is recommended that the approach [if more than one approach is recommended, use plurals as required] described in this section be developed conceptually and analyzed as an approach to satisfying the user requirements specified in "Requirements Statement (RS) for an Information System to [state purpose as stated in title of RS.]," dated [state date of RS]. This approach was selected from among [state number] alternative approaches; the alternatives that were not selected are described functionally in Section 3.

Section 4 discusses the determination of technical and operational feasibility of all alternative approaches. First-cut cost (LCC) estimates for the recommended approach are recapitulated in 2.2; estimates for all technically and operationally feasible alternative approaches are presented in Section 5. The benefits associated with these approaches are analyzed in Section 6. A discussion of the selection process, including the basis for selection of the recommended approach, is presented in Section 7.

2.1 Description of Recommended Approach. [If there is more than one recommended approach, this title will be "Description of First Recommended Approach," and the subparagraphs under 2.1 will cover the first recommended approach only. The purpose of this description is for the determination of feasibility, as discussed in Section 4. Generally, for this purpose the approach need be conceived and expressed only in broad conceptual terms. Typically, the approach can be described only in such terms at this early stage of consideration. Extensive analysis of the approach in order to refine it into a system design is not called for as part of the feasibility determination process.]

2.1.1 Concept. [This paragraph will describe, to whatever extent is practicable without extensive analysis and design effort, the overall concept of how the recommended approach satisfies the user requirements stipulated in the RS. The description will include system objectives (see SRI/NWRC-TN-73, Automated Data Systems (ADS) Management Methodology, Task 1 Report: Objective-Writing Methodology for USMC ADS Development, July 1977; particularly see paragraph 9.1). It will also include an overview of system architecture, i.e., whether processing and data bases are distributed or centralized, whether the system is on-line or batch, etc. If it is necessary to make any assumptions about the system, they should be stated explicitly. The description will identify data inputs in general terms (they will be described in more detail in 2.1.2), data entry points, processing steps

FIGURE 4-02. Feasibility Study Outline (Page 5 of 18)

including intermediate actions by users, processing points, and output points. Entry and output points define system interfaces with the environment. If appropriate, interactions with the environment that are unique to this approach may be described briefly in general terms. The paragraph should include a System Organization Chart and a System Information Flowchart as defined in paragraphs 9.2.1 and 9.2.2, respectively, of SECNAVINST 5233.1A.]

2.1.2 Inputs. [This paragraph will describe the data elements, records, documents, files, parameters, etc., introduced by user action during system operation. Sources of inputs will be identified.]

2.1.3 Outputs. [The data elements, records, documents, files, displays, or other information will be generally identified and described, together with the destinations of the outputs.]

2.1.4 Software. [This paragraph will describe the types of operations that must be performed by software, e.g., file updating, search and retrieval, order entry, inventory analysis, etc. If specific computation approaches or algorithms can be identified at this stage, they should be described. To the extent applicable and possible, existing software (whether or not it is government property) that can probably be used or adapted for use will be identified.]

2.1.5 Equipment. [The kinds, capacities, and quantities of hardware required for communications, input, storage, processing, print, display, or other output will be identified and described in generic terms.]

[Note: If there is more than one recommended approach, the second should be described in 2.2, and so on. The paragraph that now follows will be the last major paragraph in the section, and will contain cost estimate recapitulations for all recommended approaches.]

2.2 Cost Estimate Recapitulation. Presented below is the summary cost estimate for the recommended approach. Cost details underlying this estimate are given in Section 5. [Summarize the costs of the recommended approach, using pertinent material from Section 5.]

FIGURE 4-02. Feasibility Study Outline (Page 6 of 18)

SECTION 3. OTHER APPROACHES

This section describes the approaches to satisfying the user requirements specified in the RS that were analyzed but not recommended for further conceptual development and analysis.

3.1 Existing Approach. [This paragraph should contain the same information as paragraph 2.5 of the RS. Insofar as possible, the format of this paragraph should follow the format of paragraph 2.1 above.]

3.2 Description of Second Nonrecommended Approach. [Each new alternative approach shall be described in a major paragraph. The descriptions shall be in accordance with the instructions for paragraph 2.1. Major paragraphs shall be headed 3.n Description of nth Nonrecommended Approach, with n representing the sequential designator number of the approach not recommended, starting with n=2. Subparagraphs shall be headed as they are in paragraph 2.1. In many cases, subparagraphs 3.n.2 and 3.n.3 will contain the same information as subparagraphs 2.1.2 and 2.1.3, respectively. In such cases, do not repeat the earlier information; instead, refer back to the appropriate subparagraph.]

FIGURE 4-02. Feasibility Study Outline (Page 7 of 18)

SECTION 4. FEASIBILITY DETERMINATION

4.1 Purpose of Section. The purpose of this section is to present the results of analyzing each alternative approach described in Sections 2 and 3 to determine whether it is feasible.

4.2 Meaning of Feasible. "Feasible" means capable of being realized. However, "possible" and "practicable" also mean capable of being realized. Feasible is distinguished from possible and practicable by connotation, as follows:

a. Possible implies that user requirements may certainly be satisfied given the proper circumstances

b. Practicable implies that user requirements may be easily or readily satisfied by available means or under current conditions

c. Feasible suggests what is likely to work or be useful in achieving satisfaction of user requirements.

4.3 Philosophy of Feasibility Analysis. It is apparent from 4.2 that feasibility determination is judgmental. It is, however, based on analysis. Feasibility analysis is a process of elimination. Each alternative is analyzed with a view toward discovering any characteristic or quality that would render it infeasible. If such a characteristic or quality is found, the feasibility analysis of that approach may be terminated. The rationale for adjudging the approach infeasible must be documented. If no such characteristic or quality is found, the approach is adjudged feasible.

4.4 Aspects of Feasibility. For analytical convenience, feasibility can be viewed from two aspects, technical and operational. Technical feasibility involves equipment, software, and communications technology and their integrability, together with human resources, into systems. Operational feasibility involves the integrability of these systems into the environment. It should be recognized that these aspects are not all independent.

Some feasibility analysis techniques treat "economic feasibility" as a third aspect of feasibility. This would not be correct at the FS level,

FIGURE 4-02. Feasibility Study Outline (Page 8 of 18)

however, since the analysts who prepare the FS cannot assess the importance of their project relative to others that may compete for the same economic resources. Since the FS analysts cannot make decisions about resource reallocations, they cannot determine economic feasibility. In the FS, therefore, the economic dimension is treated as a price tag; it is up to higher-level decision makers to determine whether and how the price can be paid.

4.5 General Feasibility Criteria. The general feasibility criteria given below apply to all Marine Corps information systems, and must be used as guidelines in the feasibility analysis.

4.5.1 General Technical Feasibility Criteria. Following are the general technical feasibility criteria applicable to all Marine Corps information systems:

a. Equipment must be standard production equipment. [The reason for this criterion is that the Marine Corps should not be in the information system equipment research and development business, and should not serve as a test bed for unproven equipment. If this criterion is modified, full justification must be provided.]

b. Software must be state-of-the-practice. [The reason for this criterion is analogous to that in (a) above.]

c. Communications technology must be state-of-the-practice. [The reason for this criterion is analogous to that in (a) above.]

d. The components listed in a, b, and c must be integrable using standard practice. [The reason for this criterion is analogous to that in (a) above.]

4.5.2 General Operational Feasibility Criterion. The general operational feasibility criterion applicable to all Marine Corps information systems is that the system not adversely affect the ability of the Marine Corps, or any subdivision thereof, to perform its mission effectively. [If this criterion is modified, full justification must be provided.]

4.6 Feasibility Analysis of Alternative Approaches.

4.6.1 Technical Feasibility.

FIGURE 4-02. Feasibility Study Outline (Page 9 of 18)

4.6.1.1 Issues. [In preparing material for this paragraph, the analyst must carefully analyze user requirements, guidelines and constraints, and the alternative approaches in order to determine technical feasibility issues. These are derived from critical functions and any ancillary functions that might have the potential of becoming choke points.

An example of a critical function may be a requirement to provide turnaround within a specified time. This may generate technical feasibility issues that involve system reliability and processing speed. These issues should be stated as quantitatively as possible.

An example of a choke point may be telecommunications capacity. The user requirements may not call for telecommunications capability, but some of the alternative approaches may incorporate the need for it.

This paragraph should list and discuss all technical feasibility issues. Presented below is a list of some potential sources of technical feasibility issues; the list is intended to be suggestive, not exhaustive, and the items on the list are not intended to be mutually exclusive.

a. Hardware

(1) Central processor

(a) Processing speed
(b) Primary storage capacity

(2) Storage (nonprimary)

(a) On-line auxiliary
(b) Off-line auxiliary

(3) Other peripherals

(a) Card/tape readers/punches
(b) Character readers
(c) Terminals
(d) Printers

FIGURE 4-02. Feasibility Study Outline (Page 10 of 18)

(4) Telecommunications equipment

(a) Communications processors
(b) Modems
(c) Multiplexors
(d) Data links

b. Software

(1) Operating system

(2) Functional packages

(3) Application software

c. Configuration

(1) Reliability

(2) Component mismatch

(3) Restart capability

(4) Backup capability.]

4.6.1.2 Analysis. [Each of the alternative approaches should be analyzed with respect to each technical feasibility issue in this paragraph. (If an alternative approach is patently infeasible with respect to any issue, or has been determined already to be operationally infeasible, the analysis of that approach need not be carried further.) If possible, summary charts listing technical feasibility issues horizontally and alternative approaches vertically should be included.]

4.6.2 Operational Feasibility.

4.6.2.1 Issues. [In preparing material for this paragraph, the analyst must carefully analyze user requirements, the guidelines and constraints, and the alternative approaches in order to determine operational feasibility issues, which are defined as operational factors that may possibly interact adversely with an alternative approach.

FIGURE 4-02. Feasibility Study Outline (Page 11 of 18)

As stated in paragraph 4.3, operational feasibility involves integrability into the environment. Environment has two aspects in this context; the "local" environment, restricted to information processing and handling; and the "global" environment, which includes the Marine Corps as a whole in all of its potential roles and missions. Both aspects may generate operational feasibility issues.

This paragraph should list and discuss all operational feasibility issues. Presented below is a list of some potential sources of operational feasibility issues; the list is intended to be suggestive, not exhaustive, and the items on the list are not intended to be mutually exclusive.

a. "Local" factors

(1) Data control procedures

(2) Backup procedures

(3) Restart procedures

(4) Security procedures

(5) Scheduling

(6) Maintenance and support requirements

b. "Global" factors

(1) Expansibility for mobilization

(2) Deployability

(3) Vulnerability

(4) Manning requirements (e.g., civilian vs. military)

(5) Backup capability

(6) Degraded mode operation (e.g., with electronic data links inoperative).]

FIGURE 4-02. Feasibility Study Outline (Page 12 of 18)

4.6.2.2 Analysis. [Each of the alternative approaches should be analyzed with respect to each operational feasibility issue in this paragraph. (If an alternative approach is patently infeasible with respect to any issue, or has been determined already to be technically infeasible, the analysis of that approach need not be carried further.) If possible, summary charts listing operational feasibility issues should be included horizontally and alternative approaches, vertically.]

4.7 Summary.

4.7.1 Feasible Approaches. [List the approaches determined to be technically and operationally feasible on the basis of the feasibility analyses in 4.6.]

4.7.2 Infeasible Approaches. [List the approaches determined to be infeasible on the basis of the feasibility analyses in 4.6 and briefly summarize the reasons(s).]

FIGURE 4-02. Feasibility Study Outline (Page 13 of 18)

SECTION 5. LIFE CYCLE COST ANALYSIS

[The contents of this section and the next section constitute an economic analysis as prescribed in DOD Instruction 7041.3. This economic analysis must not be confused with the EA (the ADSDP subsidiary action document discussed in paragraph 4.4.4 of the text), although the same technique is used for both.

The differences between this economic analysis and the EA are in the level of detail and in the degree of similarity among alternatives. The economic analysis in these sections addresses relatively dissimilar alternatives in relatively coarse detail, whereas the EA addresses relatively similar alternatives in relatively fine detail. The reason for this is that the economic analysis in these sections will help lead to a preferred alternative approach for further development; the EA will be chiefly concerned with cost performance tradeoffs within that approach.

This economic analysis is presented in two sections in order to separate cost estimation from the process of selecting the preferred alternative approach(es). This section contains the cost estimation portion of the economic analysis.

The economic analysis in these sections should be developed and presented in conformance with General Guidelines B and C in Enclosure 2 to DODI 7041.3 dated October 18, 1972. The guidelines that are particularly applicable to this section are B.1 through B.4 and B.7. Supplementary comments applicable to these guidelines are given below.

a. B.1 Objectives. These are given in Section 2 of the FS and need not be repeated here.

b. B.2 Assumptions. Technical assumptions are covered in paragraph 2.1 of the FS and need not be repeated. Any other assumptions should be stated explicitly in this section.

c. B.3 Alternatives. These are covered in section 2 of the FS and need not be repeated.

d. B.4 Cost Analysis. In addition to the material in the guidelines, SRI/NWRC-TN-72, Automated Data Systems (ADS) Management

FIGURE 4-02. Feasibility Study Outline (Page 14 of 18)

Methodology, Task 2 Report: Resource Requirements Estimating Methodology, May 1977, will be useful in developing cost estimates.

e. B.7. Risk/Uncertainty Analysis. The analysis portion of this guideline applies to Section 7 of the FS; however, the material on parametric cost estimation applies to this section. Parametric cost estimates and probability distributions of costs should be derived whenever possible.]

FIGURE 4-02. Feasibility Study Outline (Page 15 of 18)

SECTION 6. BENEFITS ANALYSIS

[As pointed out in General Guideline B.5 in Enclosure 2 to DODI 7041.3, benefits must be taken into account in an economic analysis. Negative benefits ("dysbenefits" or detrimental impacts) have already been addressed in Section 4, "Feasibility Determination".

"Benefits," for this purpose, are beneficial effects on the mission-effectiveness of the USMC or any of its subdivisions that were not included in the user requirements. Examples are the proposed system's expandability, potential adaptability to other uses, increased responsiveness, likelihood of successful implementation, commonality with other systems, potential for enhancement of combat readiness and of morale, potential cost savings in non-user agencies, and so on.

All benefits that can be identified should be listed and discussed for each technically and operationally feasible alternative.

Benefits should be quantified wherever possible. Care should be taken to describe and analyze non-quantifiable benefits in realistic terms; it is all too easy to indulge in wishful thinking in this area.]

FIGURE 4-02. Feasibility Study Outline (Page 16 of 18)

SECTION 7. THE SELECTION PROCESS

7.1 Purpose of Section. The purpose of this section is to present the basis for selecting the recommended approach(es) described in Section 2.

7.2 The Process. [Selection of a recommended approach from among the alternatives is a judgmental process. General Guidelines B.5 through B.9 in Enclosure 2 to DODI 7041.3 apply to the selection process. The material in the following paragraphs supplements the general guidelines.

In order to be considered for selection as a preferred alternative approach, a system must satisfy the user requirements and be technically and operationally feasible.

For the alternative approaches that qualify to be considered for selection, the following ranking rules shall apply:

a. Equal Costs - Unequal Benefits. When alternatives have the same discounted cost, the alternative with the greatest benefits is preferred.

b. Unequal Costs - Equal Benefits. When alternatives have the same level of benefits, the alternative with the lowest discounted cost is preferred.

c. Unequal Costs - Unequal Benefits. When alternatives have both unequal discounted costs and unequal levels of benefits, the following rules apply:

(1) If the alternative with the lowest discounted costs also provides the highest level of benefits, it is the preferred alternative.

(2) Alternatives whose costs and benefits exceed those of the lowest cost alternative may be selected as the preferred alternative only if their additional cost is clearly justified by the estimated value of their additional benefits and fully documented in this section.

If special considerations require the selection of an alternative by

FIGURE 4-02. Feasibility Study Outline (Page 17 of 18)

other than the above prescribed rules, the considerations must be compelling, defensible, and fully documented in this section.

In some cases--for example, when development involves considerable risk or uncertainty--it may be desirable to select more than one recommended approach. This procedure should be minimized because it will significantly increase the costs associated with preparation of the ADS Development Plan. If more than one approach is recommended, full justification must be provided for the decision to do so.]

FIGURE 4-02. Feasibility Study Outline (Page 18 of 18)

[These supplementary instructions refer to the correspondingly numbered FD paragraphs described in Figure 2-01 of DODM 4120-17-M. DODM 4120.17-M does not prescribe a title or date; they should be added as shown prior to Section 1.]

FUNCTIONAL DESCRIPTION (FD) FOR A SYSTEM TO
[State system purpose as stated in title of RS]

[Date.]

SECTION 1. GENERAL

1.1 Purpose of Functional Description. [Since DODM 4120.17-M states that the prescribed wording may be modified when appropriate, use the wording given subsequently.]

The purposes of this Functional Description for [state system purpose as state in titles of RS and FS] are:

a. To describe functionally the ADS designed to satisfy the user requirements set forth in the RS referenced in 1.2a, the design having been based on the preferred alternative approach selected in the FS referenced in 1.2b and refined in the EA referenced in 1.2c.

b. To provide the other information (or references to it) required to be included in an FD by DOD Manual 4120.17-M.

1.2 Project References. This FD is part of Appendix A to an ADS Development Plan (ADSDP). The general nature of the computer programs to be developed is indicated in references a and b below, which are part of Appendix B to the ADSDP. System functional manager(s), sponsor, and user(s) are specified in the body of the ADSDP. Specific references are:

a. [The RS]

b. [The FS]

c. [The EA]

FIGURE 4-03. Functional Description Supplementary Instructions (Page 1 of 4)

d. Significant correspondence related to the projects is given in Appendix B to ADSDP.

[The FD preparer must list any other relevant references, including those specified in 1.2d, e, and f.]

FIGURE 4-03. Functional Description Supplementary Instructions (Page 2 or 4)

SECTION 2. SYSTEM SUMMARY

2.1 Background. [Much of this material can be provided by reference to Section 2 of the RS.]

2.2 Objectives. [The DODM 4120.17-M instructions for this paragraph are not meaningful because they use the terms objectives, requirements and goals synonymously; because the relationship of the second sentence to objectives is not apparent; and because the third sentence has nothing to do with objectives. For instructions in writing operative objectives, see Section 5 of this report and SRI/NWRC-TN-73, Automated Data Systems (ADS) Management Methodology, Task 1 Report: Objective-Writing Methodology for USMC ADS Development, July 1977.]

2.3 Existing Methods and Procedures. [Much of this material can be provided by reference to paragraph 2.5 of the RS.]

2.4 Proposed Methods and Procedures. [No supplementary comments.]

2.4.1 Summary of Improvements. [Be concise; avoid verbosity and salesmanship.]

2.4.2 Summary of Impacts. [Be concise. (This guideline also applies to all the subparagraphs.)]

2.5 Expected Limitations. [No supplementary comments.]

SECTION 3. DETAILED CHARACTERISTICS

[No supplementary comments.]

SECTION 4. ENVIRONMENT

[No supplementary instructions.]

SECTION 5. COST FACTORS

[The instructions for this section call for presentation of material that is covered in the FS and EA. To avoid redundancy, they should be referenced rather than repeating the information.]

FIGURE 4-03. Functional Description Supplementary Instructions (Page 3 of 4)

SECTION 6. DEVELOPMENTAL PLAN

As previously stated in paragraph 1.2, this FD is part of an ADS Development Plan. In other words, the FD is--and logically should be--part of a developmental plan, rather than the other way around. For the developmental plan, refer to the ADSDP of which this FD is part of Appendix A.

FIGURE 4-03. Functional Description Supplementary Instructions (Page 4 of 4)

[These supplementary instructions refer to the correspondingly-numbered paragraphs described in Figure 2-02 of DODM 4120.17-M. DODM 4120.17-M does not prescribe a title or date; these should be added as shown prior to Section 1.]

DATA REQUIREMENTS DOCUMENT (RD) FOR A SYSTEM TO
[State system purpose as stated in title of RS.]

[Date.]

SECTION 1. GENERAL

1.1 Purpose of Data Requirements Document. [No supplementary instructions.]

1.2 Project References. [The requirement for this information is completely redundant since it is also required in the FD. To satisfy the requirement, copy paragraph 1.2 of the FD.]

1.3 Modification of Data Requirements. [No supplementary instructions.]

SECTION 2. DATA DESCRIPTION

[No supplementary instructions.]

SECTION 3. USER SUPPORT FOR DATA COLLECTION

[The "hardware device" in 3.1b should be specified only in generic terms, not by brand name.

The definition of "expansion factor" in 3.1h is incorrect. The expansion factor is not, as stated, "to be added to the maximum number of entries". Instead, it is the factor by which the maximum number of entries is to be multiplied. With this definition, the example given in 3.1h will be correct.]

FIGURE 4-04. Data Requirements Document Supplementary Instructions (Page 1 of 1)

ADP EQUIPMENT SPECIFICATIONS (ADPES) FOR A SYSTEM TO
[State system purpose as stated in title of RS.]

[Date.]

SECTION 1. GENERAL

1.1 Purpose. The purpose of this ADP Equipment Specification (ADPES) is to provide preliminary information to those concerned with procurement of ADP equipment so that they can initiate their activities.

1.2 Content. This ADPES contains a concise list, in generic terms, of the ADP equipment that is:

a. Required to operate the ADS described in the FD cited in 1.3 below; and

b. Not currently in service or programmed or planned to be put in service.

1.3 References. This ADPES is part of Appendix A to the ADS Development Plan with the same title. The entire plan should be referred to for complete information about the system. This ADPES relates most directly to paragraph 4.1 of the Functional Description (FD), which is also part of Appendix A to the plan.

SECTION 2. EQUIPMENT SPECIFICATIONS

[This section shall provide a generic description of the capabilities of the equipment that is required for the operation of the ADS and that is not currently in service or programmed or planned to be put in service. A suggestive but not exhaustive guideline for equipment to be described follows:

a. Processor(s), including number of each on/off-line and size of internal storage.

b. Storage media, including number and characteristics of disk units, tape units, etc.

FIGURE 4-05. ADP Equipment Specifications Outline (Page 1 of 2)

c. Output devices, including number and characteristics of each on/off line.

d. Input devices, including number and characteristics of each on/off line.

e. Telecommunications interfaces, including channel capacities.]

FIGURE 4-05. ADP Equipment Specifications Outline (Page 2 of 2)

ECONOMIC ANALYSIS (EA) OF AN ADS TO
[State system purpose as stated in title of RS]

[Date.]

SECTION 1. GENERAL

1.1 Purpose. The purpose of this Economic Analysis (EA) document is to present the results of a detailed economic analysis, performed in compliance with DOD Instruction 7041.3, of an ADS to [State system purpose as stated in title.].

1.2 Context. This EA is part of Appendix A to an ADS Development Plan (ADSDP) for an ADS to [state system purpose as stated in title of RS]. This ADS was designed to satisfy the validated user requirements stated in the Requirements Statement (RS) referred to in paragraph 1.3a below. The selection was made on the basis of the Feasibility Study (FS) referred to in paragraph 1.3b below. That FS contained an economic analysis of broadly defined, rather dissimilar alternatives, one of which was selected as the preferred alternative approach to satisfying the user requirements. The selected ADS, refined on the basis of the analysis herein, is described in the Functional Description (FD) referred to in paragraph 1.3c below. This FD is also a part of Appendix A to the ADSDP.

1.2.1 Objectives. The objectives of the ADS, required by DODI 7041.3 to be stated in an economic analysis, are given in paragraph 2.2 of the FD.

1.2.2 Assumptions. [State any assumptions made. If indicated, reference may be made to FD or to paragraph 2.1 of the FS for technical assumptions.]

1.2.3 Alternatives. As stated above, broadly defined, relatively dissimilar alternatives were addressed in the FS, and one was selected as the preferred approach.[Use plurals as necessary if there is more than one preferred alternative approach.] The alternatives considered in this EA are narrowly defined alternatives--for example, design tradeoffs-- within the broadly defined preferred alternative approach. They are all variations of the specific ADS approach described in Section 3 of the FD. The presently existing system was also addressed in the FS; its costs are recapitulated in this EA for easy reference. [If there is no existing system, replace the preceding sentence with a sentence that so states.] The alternatives considered in this EA are described below. [Add a subparagraph 1.2.3.1,

FIGURE 4-06. Economic Analysis Outline (Page 1 of 2)

1.2.3.2, etc., for each alternative. Describe the alternatives in terms of their unique features, being as concise as practicable. Note that "alternatives" should be broadly construed; for example, it may refer to alternative development schedules for the same technical system.]

1.3 References. The following references are directly relevant to this EA:

a. [The RS]

b. [The FS]

c. [The FD]

d. [The ADPES, if it is relevant].

SECTION 2. COST DEVELOPMENT

[The material in this section should be developed and presented according to General Guidelines B.4, B.7 (parametric cost estimation portion only), and C in Enclosure 2 to DODI 7041.3 dated October 18, 1972. In addition to the guidelines, SRI/NWRC-TN-72, Automated Dated Systems (ADS) Management Methodology, Task 2 Report: Resource Requirements Estimating Methodology, May 1977, and Section 6 of this report, will be very useful in developing cost estimates.]

SECTION 3. COST-VALUE ANALYSIS

[The material in this section should be developed and presented according to General Guidelines B.5 through B.9 and C in Enclosure 2 to DODI 7041.3 dated October 18, 1972. "Value," as used here, includes both quantifiable and non-quantifiable factors such as performance, work measures, benefits, and utility. Because of the inclusion of non-quantifiable factors, the cost-value analysis must be judgmental to a certain extent.]

SECTION 4. CONCLUSION

[State which of the alternatives in paragraph 1.2.3 was selected as the best system design for inclusion in the FD and ADPES, and state the reasons (which should be based on the analysis in Section 3.)]

FIGURE 4-06. Economic Analysis Outline (Page 2 of 2)

AUTOMATED DATA SYSTEM (ADS) DEVELOPMENT PLAN FOR A SYSTEM TO
[State system purpose as stated in title of RS]

[Date.]

SECTION 1. GENERAL

1.1 Purpose. The purpose of this ADS Development Plan (ADSDP) is to provide decision makers with a basis for deciding whether to approve for development and implementation and ADS to [state system purpose as stated in title].

1.2 Content. This ADSDP includes the following information:

a. A summary of the problem that generated the requirement for an ADS.

b. A summary of the specific user requirements that must be satisfied by the ADS.

c. A statement of the ADS objectives.

d. A summary of the characteristics of the ADS designed to satisfy the user requirements and the system objectives.

e. A resource-time schedule for developing and implementing the ADS.

f. A designation of responsibilities for achieving the ADS.

g. Two appendices [or more if required], as follows:

(1) Appendix A, Subsidiary Action Documents. This appendix contains the action documents that directly support this plan. In order of appearance, they are the FD, the RD, the ADPES, and the EA.

(2) Appendix B, Archival Material. This appendix contains, in order, the RS approval document, the RS cover letter, the RS, the FS approval document, the FS cover letter, and the FS.

FIGURE 4-07. ADS Development Plan Outline (Page 1 of 4)

1.3 Functional Manager(s), System Sponsor, and User(s).

1.3.1 Functional Manager(s). [Specify the functional managers involved. If there are more than one, specify which one is the lead functional manager.]

1.3.2 System Sponsor. The system sponsor is the agent of the functional manager(s). [Specify organization and give specific point of contact for matters regarding this ADSDP.]

1.3.3 System User(s). [Specify organization(s) and give specific point(s) of contact for matters regarding this ADSDP.]

1.4 References. Annotated references that bear directly on the problem are given in paragraph 2.3 of the RS (see Appendix B). ADS guidelines and constraints are covered in paragraph 1.7 of the FS (see Appendix B); references pertinent to feasibility determination and economic analysis are given in paragraph 1.8 of the FS. All the documents in Appendix A are directly pertinent to this ADSDP.

SECTION 2. PROBLEM SUMMARY

[In this section, summarize the problem concisely. It may be possible to repeat paragraph 2.1 of the RS and reference paragraph 2.4 of the RS for more detailed information; the preparer should use his judgment as to whether this is appropriate.]

SECTION 3. USER REQUIREMENTS SUMMARY

[Summarize succinctly the user requirements in Section 3 of the RS. Include a statement that these requirements were validated, and refer to Section 4 of the RS.]

SECTION 4. ADS OBJECTIVES

[Copy paragraph 2.2 of the FD.]

FIGURE 4-07. ADS Development Plan Outline (Page 2 of 4)

SECTION 5. ADS DESCRIPTION

[Summarize Section 3 of the FD succinctly. Consider all design features, but do not make the section any longer than absolutely necessary; refer the readers to Section 3 of the FD for complete details.]

SECTION 6. RESOURCES AND SCHEDULE

This section presents a detailed time schedule for employing the resources enumerated in the EA (see Appendix A). Time is itself a resource; it is often possible to make tradeoffs between time and the other resources, which chiefly constitute manpower and equipment.

In planning for this ADS, it was [*or "was not", as appropriate*] possible to make tradeoffs between time and the other resources. [If it was possible, insert the following sentence: "Alternatives involving time tradeoffs are discussed in the EA." If it was not possible, explain why; for example, the time schedule may have been dictated by a deadline established and validated in the RS.

In the remainder of this section, present a schedule of tasks and subtasks, the resources consumed in performing the tasks and subtasks, and "milestone" dates that mark the completion of tasks and possibly of subtasks.

"Tasks" are logically related activities directed toward a single, tangible goal. For convenience, it is sometimes possible and desirable to subdivide tasks into "subtasks," each of which has a single tangible goal. Subtasks have the characteristic that, when the goals of all the subtasks within a task have been achieved, the goal of the task is thereby also achieved. The planner who subdivides a task must assure that this rule is adhered to.

An example of a task is the writing of program specifications for a major module of the ADS. If this module comprises several programs, the writing of program specifications for the individual programs may represent subtasks. In this case, an integration subtask would probably also be required. When all the program specification writing subtasks and the integration subtask are complete, the task is automatically complete.

FIGURE 4-07. ADS Development Plan Outline (Page 3 of 4)

Task and subtask definitions used in the ADSDP must be consistent with those in the EA. This will enable the basis for estimating the required resources to be traced.

"Milestones" are used to mark achievement points that are of particular significance to the planner or manager. In order to determine that a milestone has been reached, some measurable product must have been produced. This implies that a milestone can be established only at the end of a task or subtask. (In practice, milestones are usually established only at the end of selected tasks, not subtasks, but this is a matter of judgment for the planner.) Examples of the use of milestones are to mark points selected for management review or for transfer of responsibilities.

Times used in the schedule may be stated either absolutely (calendar dates) or relative to a reference time such as the initiation of the Analysis and Design Phase.

The schedule should be displayed on a horizontal bar chart with time on the horizontal axis. The chart may be supplemented with tables, explanatory text, and footnotes, as required. Critical path or PERT-type diagrams should be included if possible; however, if a full-blown PERT analysis is made, the fine details should be relegated to an appendix.

The schedule must include all tasks required to develop and implement the ADS. Partial schedules are not acceptable.]

SECTION 7. RESPONSIBILITIES

[In this section, specify the organization that is responsible for each task and subtask. Although more than one organization may participate in a task or subtask, only one will have the responsibility. Responsibility may be transferred only when milestones have been reached. Since reaching a milestone means that a measurable product has been produced, waiting until then to transfer responsibility assures a defined interface for the transfer.

If management review points are included in the schedule, this section should also designate the organizations responsible for the reviews.]

FIGURE 4-07. ADS Development Plan Outline (Page 4 of 4)

SECTION 5. OBJECTIVE-WRITING METHODOLOGY FOR USMC ADS DEVELOPMENT

5.1 ADS Objectives and Their Use. Objective-writing is an optional tool to assist developers to perform tasks and generate information required by the Concept Phase action document preparation procedures. It is not a mandatory requirement for ADS management. Specifically, objective-writing is a technique for defining the objectives of an ADS being developed to meet a user's perceived information processing requirements expressed in the user's own terms.

An ADS objective is any feature, property, characteristic, or ability specified in advance as being desired in an ADS proposed for development.

A set of ADS objective statements is a set of statements applying to the ADS as a whole, with each expressing one or more ADS objectives for the system. It constitutes the most general, or top-most, level of system specification.

ADS objectives serve three functions in the development process. First, they guide the design decisions made by the working system designers. As specifications, the ADS objectives define entities, relationships, and characteristics that must be created by the designers. The objectives direct and constrain design choices. Second, ADS objectives aid the decision-makers who must approve or disapprove the concept of the proposed system. Third, as specifications, the objectives provide a basis for evaluating the result produced by system development.

Experience with past ADS developments both outside and within the Marine Corps illustrates the inherent problems with specifying ADS objectives, as follows:

- Objectives are rarely stated explicitly
- Objectives, if stated, do not fully reflect user requirements
- Objectives are often contradictory
- Fulfillment of objectives cannot be adequately determined.

The Objective-Writing Methodology provides a systematic approach to producing a body of objective-statements that avoid these hazards.

Objective-writing is applied in the Concept Phase to the selected ADS approach or approaches that were recommended in the Feasibility Study. ADS objectives for each approach must be developed for inclusion in the FD portion of the ADSDP. Objective-writing can also be useful in the Feasibility Study, where frequently explicit objectives must be developed for the hypothetical alternative approaches whose feasibility is being investigated.

5.2 Objective-Writing Methodology

5.2.1 Conceptual Approach of the Method. This methodology represents a common-sense, manual approach to the problem of developing explicit ADS objectives. It is based on the concept of logically investigating and enhancing certain intrinsic serviceability properties of objective statements. Those properties are defined in Table 5-01.

This methodology consists of six distinct operational procedures:

a. Trial Objective Statements
b. Requirements Restatement
c. Requirements Mapping
d. Pairwise Checks for Consistency, Independence and Comparability
e. Check for Simplicity
f. Determinability Analysis.

They are essentially independent and can be employed in any convenient order and repeated as often as they are productive of refinements in the objectives.

5.2.2 Expected Results. The primary outcome of an application of the methodology is the production of a completed body of ADS objective statements. The objective statements will be such that:

a. All the requirements that are incumbent on the ADS from any source are reflected in (i.e., accommodated by, or mapped into) a set of ADS objectives, which itself is not unnecessarily extensive (see Figure 5-01).
b. The objective statements exhibit a high degree of each of the intrinsic serviceability properties desired for them.

TABLE 5-01. SERVICEABILITY PROPERTIES OF OBJECTIVE-CONSTRUCTS

Construct	Property	Definition
Individual Objective-Statements	Well-definedness	The property of having an unambiguous and understandable meaning.
	Simplicity	The property of addressing only one or a very small number of aspects of the ADS.
	Determinability	The degree to which the objective-statement lends itself to determination of the extent to which it is satisfied or unsatisfied.
Sets of Objective-Statements	Consistency	The property of objectives in the set being mutually non-contradictory.
	Independence	The property of objectives in the set being non-overlapping (non-redundant).
	Comparability	The property of objectives in the set being at a similar level of generality.
	Completeness	The characteristic of the set addressing all desired considerations but not addressing undesired or unnecessary considerations.
Structures of Objective-Statements	Relatability	The degree to which useful relationships exist between the objective-sets making the structure.
	Traceability	The extent to which any objective-set or objective-statement can be traced to antecedent objective-sets or objective-statements in the structure.
	. . .	

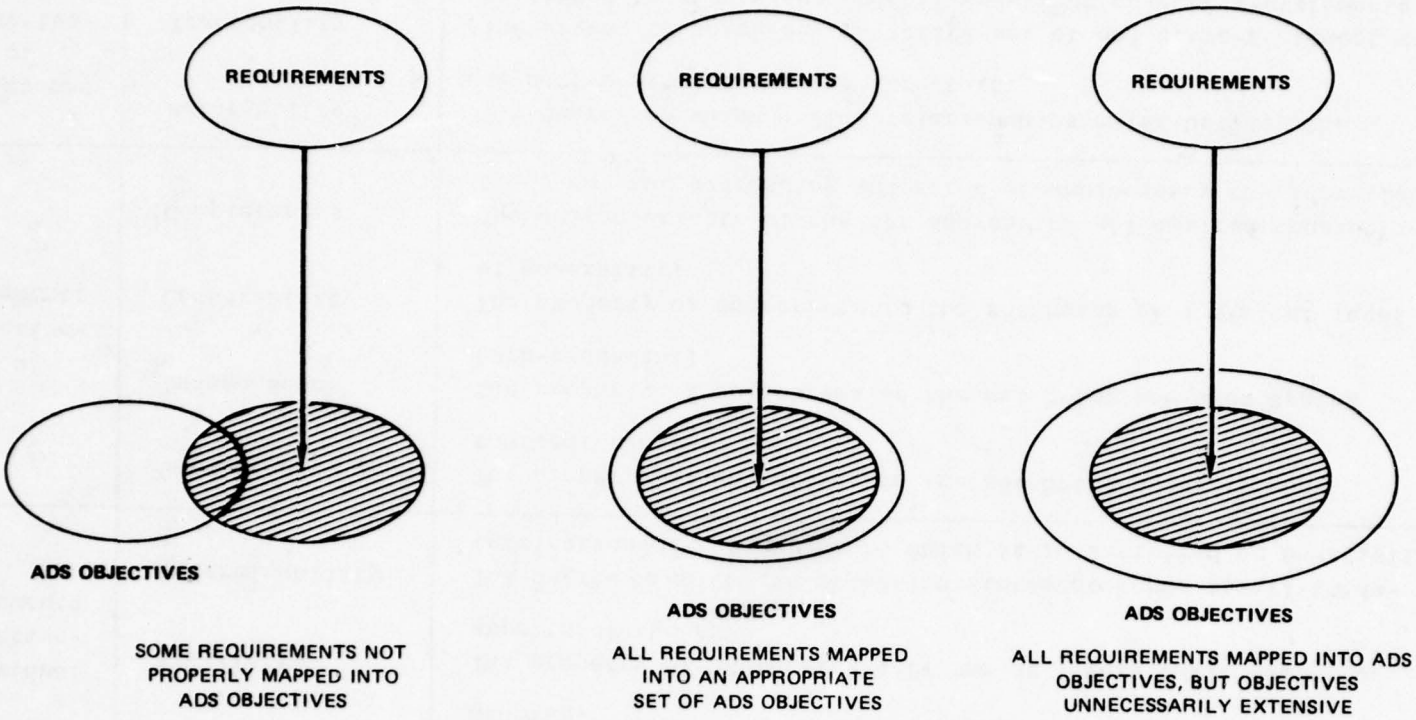

FIGURE 5-01 POSSIBLE RELATIONSHIPS BETWEEN REQUIREMENTS AND ADS OBJECTIVES

A second outcome is the production of certain aids to the USMC decision makers who must ultimately approve the ADS objectives as part of the ADS Development Plan. The records of some of the analyses performed during the application of certain of the procedures can be furnished to the decision makers as explanation and substantiation of the appropriateness and quality of the objectives. A third outcome is the revelation of contradictions or other inadequacies in the requirements in response to which the ADS objectives are generated. In such a case, objective development will generally be terminated, and the nature of the difficulty will be made known to those responsible for formulating and validating requirements.

5.2.3 Inputs

The requirements-related inputs to the procedures of the methodology are:

a. A body of stated and validated user requirements

b. A body of ADS guidelines and constraints

c. A body of results from a Concept Phase Feasibility Study (if it has already been performed), or else a hypothetical ADS solution approach (if objective-writing is being conducted as part of a Feasibility Study).

The user requirements are those requirements--stated from the user's viewpoint--that, if satisfied, would solve his information processing problem or need. The ADS guidelines and constraints represent requirements, both directive and restrictive, emanating from other sources (such as higher authority) in the systems development environment. The results from a concept phase feasibility study, or alternatively, the description of a hypothetical ADS solution approach being considered in a feasibility study, may imply requirements on the form or characteristics of the ADS.

The user requirements are contained in an approved Requirements Statement (RS), which is the result of the concept phase requirements development activity. The ADS guidelines and constraints as well as a description of a hypothetical ADS solution approach emanate from the

early phases of the feasibility study development activity. The final results are embodied in an approved Feasibility Study (FS) document. Figure 5-02 indicates the inputs and their sources for the two slightly different situations in which objective-writing can be applied.

5.3 Objective Writing Techniques.

5.3.1 Trial Objective Statements. Trial (or provisional) objective statements are a set of ADS objective statements, developed in any convenient manner and in any state of refinement, intended for use in the objective-writing procedures of the methodology. They are postulated at the start of objective-writing to initiate application of the procedures, and they are successively elaborated and refined through use of the procedures.

The trial objective statements are a body of well-defined, mutually independent, declarative statements. The initial set of trial objective statements is used in the first application of an objective-writing procedure. Successively improved versions are used in subsequent applications of the procedures.

5.3.2 The Requirements Restatement Procedure. The inputs to this procedure are those three bodies of statements identified as the requirements-related inputs to the procedures of the objective-writing methodology and defined in paragraph 5.2.3. The purpose of this procedure is the selective restatement of statements making up the inputs, without altering their substance and meaning, in order to produce one comprehensive list of all the requirements in a simple and uniform mode of expression.

5.3.2.1 Procedure. The user requirements are already explicitly stated as requirements. Simplicity of statement is a desired feature. If some of the statements are composite statements that incorporate multiple requirements into one expression, then these should be split into multiple, simple statements. If requirements are expressed in diverse styles or forms of expression, then they should be transformed into parallel modes of expression.

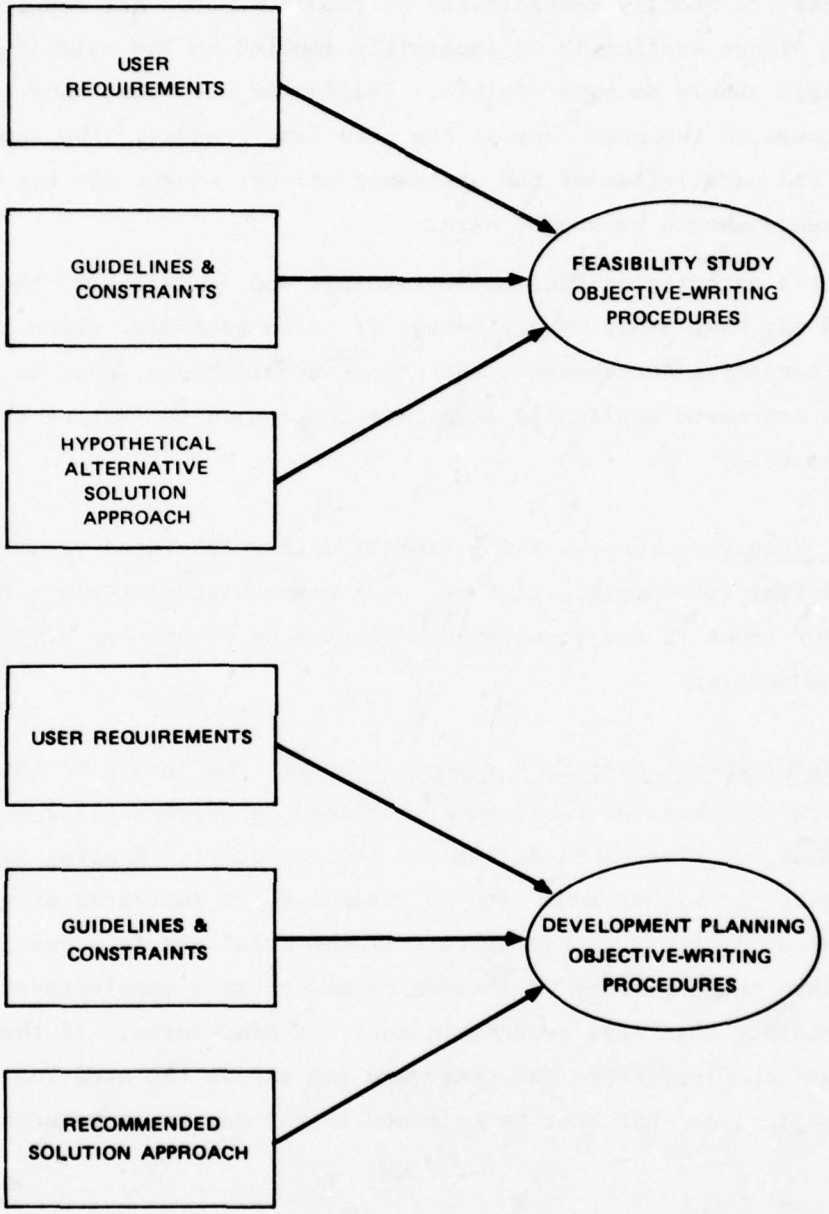

FIGURE 5-02 REQUIRED INPUTS FOR OBJECTIVE-WRITING

The ADS guidelines and constraints may or may not be expressed in forms that are readily recognizable as requirements. All requirements that are either explicitly or implicitly implied by the guidelines and constraints should be made visible. Insofar as possible, they should be expressed in the same form as the user requirements. The same simplicity and parallelism of the statement as that sought for the user requirements should be sought here.

To the extent possible, those findings and decisions of the Feasibility Study that imply requirements, or, alternatively, those aspects of an alternative ADS approach that imply requirements, must be identified and expressed explicitly in a form comparable to that of the other requirements.

5.3.2.1 Results. The resulting list of uniformly stated requirements is the definitive complete list of requirement statements in a form suited for input to the requirements mapping procedure described in the following section.

5.3.3 Requirements Mapping for Completeness. The inputs to this procedure are the restated requirements defined in Section 5.2.2 and the trial objective statements defined in Section 5.2.1. Mapping is a technique for either enhancing or verifying the intrinsic property of completeness of the ADS objectives. If the trial set is actually complete, then the procedure will serve to demonstrate completeness with more certainty than less systematic analysis procedures. If the trial set is not complete, then the procedure can expose the need for additional objectives that must be adjoined to the set to increase completeness.

5.3.3.1 Procedure. The mapping can be accomplished by the actual or figurative use of the matrix shown in Figure 5-03. Grouping the requirements according to source, in the manner shown along the top of the matrix, is merely a convenience.

		USER REQUIREMENTS				REQUIREMENTS FROM G & C	REQUIREMENTS FROM FS
		#1	#2	#3			
OBJECTIVE STATEMENTS	#1	+	0	0			
	#2	0	0	0			
	#3	+	0	0			
		0	0	-			
	• • •						
	#n	0	0	+			

FIGURE 5-03 FRAMEWORK FOR MAPPING REQUIREMENTS INTO OBJECTIVES

Proceeding in any convenient order, one works through all possible combinations of individual requirements with individual objectives. For each requirement-objective combination, there are three possibilities:

a. The objective contributes in some way to the satisfaction of the requirement.

b. The objective in some way conflicts with, or detracts from, the satisfaction of the requirement.

c. The objective does not affect the satisfaction of the requirement.

If the first case prevails, one enters a "+" in the corresponding matrix cell. If the second case prevails, then one enters a "-" in the cell. If the third case prevails, then one enters a "0" in the cell.

In many instances the determination of the cases will necessarily be done on an intuitive, rather than a rigorous, basis. This does not preclude useful analyses from being performed from the results.

After having traversed the entire matrix, one makes a variety of analytical checks. Several are column-by-column analyses. First, one looks for any columns consisting entirely of zeros. Such a column reveals a requirement that appears not to be addressed by any of the objectives in the trial set. This condition argues that one or more additional objectives must be added to the trial set to increase its completeness. Furthermore, a column that contains a very small number of pluses among zeros may (but need not necessarily) indicate a requirement that is only partially addressed by the objectives. This matter should be investigated.

Second, one looks for columns that have any minuses. The presence of a minus ostensibly indicates that an objective in some way contravenes the requirement in question. This argues that the objective must either be modified or removed from the set.

An additional column-by-column check may be valuable. A plus in a matrix cell only signifies that the objective satisfies the requirement <u>to some degree</u>. Hence, even the presence of several pluses in the same column does not ensure that the requirement will be fully met. Therefore, for each column (i.e., for each requirement) the question can be

asked: "Do the objectives indicated by the pluses ensure that the requirement will be fully met?" If the answer is "yes," some affirmative mark should be placed beneath the column. If the answer is "no," then additional objectives would seem to be called for.

The next analysis is a row-by-row analysis. Here one looks for any row that has no pluses. Such a row indicates an objective that appears to address none of the requirements and hence can ostensibly be eliminated from the set. Furthermore, a row that contains a very small number of pluses may (but need not necessarily) indicate an objective that is not particularly effective or relevant in addressing the requirements. Such an objective is a candidate for replacement. Conversely, a row with many pluses may tend to confirm the relevance of a particular objective.

5.3.3.2 Results. The result of an application of this procedure is a new set of trial objective statements with an improved degree of completeness. This set can be submitted to other procedures for other changes and refinements, and then, if it is useful, resubmitted to this procedure for further checking and refining of completeness.

5.3.4 Pairwise Checks for Consistency, Independence, and Comparability. The inputs are a set of trial objective statements. This pairwise checking addresses the intrinsic objective properties of consistency, independence, and comparability. The procedure provides a systematic and exhaustive means to avoid overlooking conflicts, overlaps, and discrepancies of generality in the objectives. It can also reveal tradeoffs between objectives.

5.3.4.1 Procedure. One successively pairs each objective with every other objective in the set. For each resulting pair of objectives, one poses the following questions:

a. Regarding consistency: Are the two objectives in any way mutually contradictory? If the answer is "no," then no action is taken. If "yes," then there are two possibilities to be considered. The first is that the

contradiction is clearly destructive, and it should be eliminated by modifying one or both of the objectives. The second possibility is that the contradiction points to the existence of a tradeoff between system characteristics implied by the two objectives in question. The nature and acceptability of any tradeoff recognized at this point should be analyzed before the objectives are either modified or provisionally accepted without modification. Records of each acceptable tradeoff identified by this means should be maintained for subsequent analysis.

b. Regarding independence: Do the two objectives redundantly address or imply the same system characteristic? If so, an attempt should be made to reformulate one or both of the objectives to reduce or eliminate the redundancy.

c. Regarding comparability: Are the two objective statements expressed in terms that are at a similar level of generality? If the answer is "no," there is not necessarily a clear cause for restatement. Discrepancies in generality may serve only to prompt a reanalysis of the statements to reveal possible, unintentional lapses in level of detail, point of view, or terms of expression.

5.3.4.2 Results. The result is a new set of trial objective statements with improved degrees of consistency, independence, and comparability. This set can be submitted to other procedures, and then, if it is useful, resubmitted to this procedure. A second result consists of records of tradeoffs identified in the consistency analysis.

5.3.5 Check for Simplicity. The inputs to this procedure are the individual objective statements of a set of trial objectives. The purpose of this procedure is to enhance the intrinsic property of simplicity by splitting objective statements that express composite or multiple objectives into separate statements that express simple objectives. Often it is one of the first checks applied.

5.3.5.1 Procedure. The initial check for simplicity consists of a systematic and complete reading of each trial objective to reveal any obvious opportunities to split composite objectives. Each such opportunity should be evaluated and acted upon accordingly.

The second step in the procedure entails a tabulation of the trial objectives in the manner indicated by Figure 5-04. Each objective is analyzed, and its implications tabulated in the following four categories.

a. Functional implications. These are strictly concerned with the types of operations, transformations, or computations a system is capable of executing.

b. Performance implications. These are concerned with the speeds, rates, or capacities of system functions or activities.

c. Physical design implications. These are concerned with the actual physical devices or physical structure of the system.

d. System quality implications. These refer to complex system aspects such as security, maintainability, and reliability, which cannot be easily expressed in terms of functions, performance, and structural features.

Each objective statement will have an entry in at least one column of the figure. However, an objective may have entries in more than one. Such objective statements may embody a composite objective and can be beneficially separated into two or more independent statements.

5.3.5.2 Results. The result of this procedure is a new set of trial objectives whose individual statements exhibit the desired degree of simplicity.

5.3.6 Determinability Analysis. The inputs to this procedure are the individual objective statements of a set of trial objectives. The purpose of this procedure is to discover if there are any objectives, which, because of the way they are stated, permit no satisfactory operational determination of objective fulfillment.

5.3.6.1 Procedure. Making use of Figure 5-04, one analyzes each of the implications of a given objective statement in turn, and asks the question: "Is the presence or absence of the implied system characteristic capable of being demonstrated by well-defined operational tests?" Objectives stated in relative terms may not pass. For example, the

OBJECTIVE STATEMENTS		FUNCTIONAL IMPLICATIONS	PERFORMANCE IMPLICATIONS	PHYSICAL DESIGN IMPLICATIONS	SYSTEM QUALITY IMPLICATIONS	OTHER IMPLICATIONS
	#1					
	#2					
	#3					
	• • •					
	#n					

FIGURE 5-04 AN ANALYSIS OF IMPLICATIONS OF OBJECTIVES

objective, "The ADS must provide adequate response times to user queries entered from a terminal," would not be determinable because the meaning of "adequate" is not well-defined. This objective could perhaps be recast in terms of allowable average and allowable extreme response times. Similarly, objectives employing the term "optimal" would be suspect unless well-defined criteria for optimality were to exist.

Satisfactory objectives must at some point in the development cycle have associated with them usable measures of objective fulfillment, together with operational procedures for evaluating these measures. For those objectives that are deemed determinable, any and all perceived measures of fulfillment should be listed together with their associated determinability tests. The points in the development cycle at which those tests can be performed should also be identified. The list forms the initial nucleus of a test plan for demonstrating fulfillment of the objective.

5.3.6.2 Results. The result of this analysis is a new set of trial objectives whose individual statements exhibit an enhanced degree of determinability. A second result is the production of the nucleus of a test plan for demonstrating objective fulfillment.

5.4 Objectives after the Concept Phase. The end result of Concept Phase objective-writing is a single set of top-level objectives for the ADS as a whole. The next phase of system development, i.e., the Development Phase, must necessarily be concerned with objectives for individual aspects and/or components of the ADS. This gives rise to the problem of deriving more detailed or lower-level objectives (often termed specifications) from the ADS objectives. This activity is referred to as developing a decomposition of objectives, and in the terminology of this report it consists of developing a structure of objectives. Typically, the basis for developing a decomposition is the separation of the ADS into component subsystems. Subobjectives are then sought for each subsystem. The techniques described in this section are considered to aid considerably in this decomposition process as well.

SECTION 6. ESTIMATING ADS LIFE CYCLE RESOURCES

6.1 Requirement for LCC. Discussions of cost estimating for DoD related systems can usually be taken as a requirement to provide Life Cycle Cost (LCC) estimates under DoD Inst 7041.3. There have been many attempts to extend the Life Cycle analysis with its terms and definitions to ADS as well. These terms, which are generally understood in hardware related systems, do not lend themselves well for use in describing the ADS life cycle. With almost every study of ADS Life Cycle Cost come new suggestions for a general ADS terminology; however, these efforts for a general terminology have not yet been successful. Without such a standard, it becomes necessary to define for this study the life cycle phases and their corresponding Life Cycle Cost elements. Table 6-01 shows how ADS terms used in this section relate to LCC requirements specified for military systems in general.

Table 6-01

LIFE CYCLE PHASES FOR ADS AND OTHER DOD SYSTEMS

ADS Life Cycle Phases	TRI-TAC*	ADSM Ch. 14
Concept phase	R&D	
Development phase	Nonrecurring investment	R&D
System implementation	Recurring investment	Investment
System operations	Annual operating	Recurring operations

*The TRI-TAC Life Cycle Cost Study has been accepted by the research community as a standard for LCC analysis.

Of the Life Cycle Costs that must be estimated, those required to develop the ADS software, i.e., the man-hour expenditure for analysis, programming, and testing are by far the most important and difficult to forecast. This, too, has been subject to considerable study over the past fifteen years, but, as with classifying LCC elements, generally

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accepted estimating standards have not been established. A cursory review of the literature indicates that there are two basic categories of ADS resource estimating. Micro, meaning that the estimate is the sum of individually described activities at a relatively fine grain level; and Macro, meaning that some overall or gross order of magnitude estimating methodology is used. Macro approaches are used usually when the system detail description, such as that used in the micro approach, is completely beyond reason.

The micro/macro classification is now generally acknowledged. DoD sponsored a joint study group that was formed in March 1975 to establish a DoD ADS resource estimating methodology.* The resulting recommendations have yet to be formalized and put into DoD instructions; however, interim findings are that DoD should adopt a method similar to what is termed the Fort Lee method for microestimating, and a model being developed by L. H. Putnam, Col., USA, as a macroestimating methodology. It is important, therefore, that any study of this subject for USMC use consider seriously the relative merits of these two methodologies.

Both micro- and macroestimating approaches, and several techniques within each, were studied and reported on in the May 1977 Technical Note on the topic. The approaches recommended as result of the study are:

a. Macro--Direct analogy and Delphi techniques in either of several variations.

b. Micro--The methodology developed by SRI for USMC use.

The recommendations contained in the present report reflect the result of further investigations into the subject brought on by the review process of the May Technical Note, as well as developments within the DoD ADS community since the TN's publication.

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*This group was sponsored by OASD(C) in a January 75 memo establishing New Automation Objectives for the Department of Defense. The specific study group referred to here was formed to satisfy Objective 3A, which was to develop a DOD Baseline Resource Estimating Model (DBREM).

6.2 ADS Life Cycle Cost (LCC) Elements. This section defines and discusses ADS Life Cycle Cost and Resource elements referred to in the proposed methodology. These elements are designed to highlight the ADS life cycle process, and present a procedure or methodology whereby Marine Corps analysts can make timely estimates of ADS Life Cycle Costs (particularly ADS development costs) to support the feasibility Study and Economic Analysis requirements.

6.2.1 LCC Cost Elements. Table 6-02 shows the ADS life cycle as consisting of four phases:

a. Concept Formulation Phase

b. Development Phase

c. System Implementation Phase

d. System Operation and Maintenance Phase.

Within each phase are distinct and separable activities, which can be grouped to form an ADS LCC element. Table 6.02 lists the major (cost breakdown) elements and associated activities for these elements. It is important to note that the elements refer to activities or events and not resources, such as manpower or items of expense. This separation serves several purposes. First, it clearly distinguishes between tasks to be performed and resources required. Second, it allows elements and resources to be cross-indexed to form a cost-resource matrix. Ready access to cost information by cost category and resource type is one of the primary benefits of presenting costs in matrix form.

Table 6-02

ADS LCC COST ELEMENTS AND RELATED ACTIVITIES

LCC Cost Element	
1	Concept Formulation[1]
1.1	User Requirements Development
	Statement of user requirements
	User requirement validation
	Preliminary suggestion of alternative concepts
1.2	Feasibility Study
	Formulation of objectives
	Development of alternative approaches
	Technical Feasibility analysis
	Operational Feasibility analysis
	Economic Feasibility analysis
	Select preferred approach(es)
	Feasibility Study (FS) document preparation
1.3	ADS Development Plan
	Functional Description (FD) document preparation
	DAta Requirements (RD) document preparation
	ADP Equipment Specifications (ADPES) document preparation
	Economic Analysis document preparation
	ADS Development Plan (ADSDP) document preparation
2	ADS Development[1]
2.1	Analysis and Design
	System configuration/architecture analysis
	System flow design
	Files design
	Program specifications writing
	System test plan development
	System implementation/training plan development
2.2	Programming (Coding)
	Module coding
	Module debugging[2]
	Module testing
2.3	Test and Evaluation
	Integration and system debugging
	Testing with test data
	Parallel operation and evaluation
	Completion of documentation

[1] Resources used are primarily manpower and computer processing costs.

[2] Debugging is the process of getting the module to function--i.e., to "run"; testing is the process of determining if the working module performs the desired function(s).

Table 6-02 (Concluded)

LCC Cost Element (Continued)	
2.4	ADS Project Management Plan Monitoring and evaluation of ADS development activity
3	System Implementation
3.1	ADS Hardware/Software Acquisition Source selection and contract negotiations Procurement, transportation, and shipping costs Receiving, checkout and inspection charges
3.2	Initial Training Instructor costs (MPA, transportation, per diem) Student costs (MPA, transportation, per diem) Training equipment and facility costs Computer processing Contracted services (for training)
3.3	User Manuals and System Documentation User manual preparation Printing and distribution costs
3.4	Site Activation Facility planning, modification and moving expenses Initial start-up costs, including assembly and installation Furnishings Rents, utilities, and communications
3.5	Initial Provisioning Spares and spare parts Supplies and materials Maintenance equipment, tools and instruments
3.6	ADS Project Management System implementation planning, scheduling, monitoring and evaluation
4	ADS System Operation
4.1	System Operations Operator personnel costs Computer processing costs Supplies and services Operator replacement and training
4.2	Equipment and Facility Maintenance Maintenance personnel costs Computer hardware and software service contracts Utilities, rents, and communications Facility maintenance costs
4.3	ADS System Charges and Modifications Personnel costs for system/program changes and modifications Computer processing costs for system maintenance
4.4	ADS Project Management Project office costs

6.2.2 ADS Resources. The resources discussed in the following two sections of this report concern personnel and development time only. Further, they treat only those resource costs that can be translated into dollars. Opportunity costs* are specifically addressed in Volume II of this report and are not added to the cost of a proposed ADS.

ADS resources described in Chapter 14, Appendix C of the ADSM as "Elements of Expense" may be useful for estimating the costs of ADS implementation (Section 4.5) and ADS operations and support (Section 4.6), but should not be used for estimating the cost of personnel. Personnel costs need to be based on total costs to the government for a given cause of action. Using budgetary or personnel salary costs understates their actual cost and thereby favors alternatives having higher personnel costs, other things being equal. A more appropriate cost for personnel is noted in Appendix B as "Billet Costs." These costs have been developed for use in Navy Life Cycle Cost studies by NAVPERS.

6.3 Estimating ADS Development Costs. Choosing which of the basic approaches to use for estimating ADS development costs is, of course, the initial step in the estimating process. However, selection of one approach over the other does not preclude the possibility that both may be used to some extent before the final estimate is made. Typically, however, this question is a moot point for the availability of data needed to form an estimate and the overall size of the project determines which approach is to be used. It is virtually impossible to employ microestimating techniques on very large and vaguely defined programming tasks; conversely, to use a Delphi estimate for a very definitive task requiring on the order of a couple of man-months to accomplish is unlikely to produce as accurate an estimate as could be developed by the right analyst using microestimating techniques. In general, projects

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*The costs of having to reassign personnel or equipment between projects, thereby delaying benefits which would accrue from alternative assignments.

ranging from two man-weeks to six man-years are likely candidates for microestimating techniques. Larger systems requiring two to twenty man-years of development effort are usually better suited for macro approaches, either Direct Analogy or Delphi approaches.

The following two sections present a recommended methodology for both macro- and microestimating techniques. However, the analyst is responsible for his estimate and will therefore use any means available to arrive at estimates he believes he can defend. These procedures are offered to provide a benchmark methodology for USMC use where estimating performance can be evaluated over time.

6.3.1 Macroestimating ADS Development Time. Two macroestimating techniques are recommended--the Direct Analogy and Delphi techniques.

6.3.1.1 Direct Analogy. In Direct Analogy approaches, the proposed ADS is compared with one or more previous ADS developments of similar characteristics. The procedure requires that the proposed project be subdivided into tasks that correspond to those for the project being used as a comparison base. That highlights areas where there is good comparability, and therefore a more certain basis for an estimate. It also minimizes the high risk that results from having little or no prior experience. This approach is predicated on having a historical data base upon which to draw. These data have not been well-maintained at HQMC in the past, with the corresponding consequence that Direct Analogy approaches to resource estimating are severely encumbered, although not precluded. Even such gross data as development time and project manning provide valuable aids for the macroestimator.

6.3.1.2 Delphi Approaches. Delphi techniques were developed by Dalkey and Helmer of the Rand Corporation in the early 1960s, as a systematic procedure to refine expert judgment. They are commonly employed for the very subjective problems about which there is uncertainty and often controversy. There are a number of variants, but basically the Delphi method consists of the following steps: (1) structuring objective questions, (2) soliciting independent responses from a panel of expert witnesses, (3) feeding back the distribution of responses to the participants (with rationale), (4) obtaining a second response, and (5) exploring

the basis for those responses farthest from the mean, and repeating steps (3) and (4) several times to reach a consensus.

The Delphi procedure works well in many situations, particularly those in which the experts are drawn from a number of independent perspectives. When it fails, the failure is usually caused by an incestuous opinion concentration, or because some unforeseen event or problem developed that was out of the realm of the experience base of the experts paneled.

The Delphi method is recommended subject to the following conditions. First, the Delphi method must be feasible from a cost and time point of view. It is an inherently expensive process, requiring considerable man-hour involvement over a relatively lengthy time. Second, the panel of experts must represent independent perspectives, but at the same time they should have some basis for making their estimates. In this context, experts should be drawn from staffs of the three CDPAs, Functional Managers staff, and--if possible--representatives from commercial software development firms and previous USMC programmers and/or consultants.

The procedure for setting up a Delphi approach should approximate the following:

Step 0. Identify a panel of experts who have agreed to participate.

Step 1. Prepare a description of project objectives, proposed approaches, etc.

Step 2. Determine the objective questions.

The requirement here is to develop at least one, but preferably several, questions that address the primary size problem in straightforward terms. For example, a series of questions might be:

Q.1. *What is your estimation of the development time (calendar time from project go-ahead to the first full production run?*

Q.2. *What is your estimate of the maximum programmer-analyst manning level?**

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*These questions are primary inputs to the DoD preferred "Putnam" macro-estimating model, and as such, may be used to develop an alternative estimate when the DoD instruction on ADS cost estimating is promulgated.

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Q.3. *Referring to Q.2, what is your estimate of time before that manning level is reached?**

Q.4. *What is your estimate of steady-state maintenance of the system once it has been debugged, documented, and fielded?*

Step 3. Solicit confidential responses from the panel of experts, giving them a brief description of the Delphi approach and informing them of what will be expected. The requests should also include the following instructions:

(a) *For your estimate to be valid, it must be made independently of other participants. You may consult other associates and any information sources normally available to you in forming your response.*

(b) *If you feel your judgment is without basis or understanding, you may reword the question, or refuse to answer it; however, indicate the rationale or problem you encountered when attempting to form your response. Your remarks should be helpful to other participants in later rounds, rather than a rationalization for not answering the question.*

(c) *Please indicate any answer that you believe should be more heavily weighted because of your high degree of confidence in that response (for example, you may find you hold knowledge that other participants lack and therefore your response has higher credibility).*

Step 4. Evaluate round-one responses and prepare the statistical distributions of responses for the participants to use in round two. This feedback should include graphic representation of range, clustering, and should note the rationale given for the responses that deviate significantly from the central cluster. The purpose of subsequent response solicitation is to inform the participants of the results of the previous round and allow them the opportunity to revise their responses in light of the new data.

Step 5-8. These essentially repeat Steps 3 and 4 for those questions for which a consensus has not been established. It is normally not necessary to repeat questions on which there is agreement.

Upon completion of the Delphi process, estimates will have been generated, based on the intuition or "opinion" of an expert panel. It is important to remember that these estimates are simply the collective

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*These questions are primary inputs to the DoD preferred "Putnam" macro-estimating model, and as such, may be used to develop an alternative estimate when the DoD instruction on ADS cost estimating is promulgated.

opinion, and, while they presumably benefit from the body of all available knowledge, they are just as prone to error as those produced by other means.

6.3.2 Microestimating ADS Development Time. There are two microestimating techniques that may be appropriate for USMC use. One is called the "Fort Lee Method." Developed for the U.S. Army, it is described in detail in USACSCSGL Memo 18-1 of 16 December 1976, entitled, "SCR Estimating Procedures." The other, proposed by SRI International, is presented in detail in the succeeding section. The two methods have a slightly different orientation. The Fort Lee Method appears to be designed to estimate resources required for modification efforts or developmental efforts that are well into the design phase. The SRI method requires less specific inputs and may, therefore, be used more effectively in the Concept phase. In this sense, the two models are complementary. Under sample conditions, both produce similar estimates. If the DoD adopts the Fort Lee Method as its standard microestimating procedure, the USMC should consider using the SRI-proposed method during concept development and the Fort Lee Method later in the process (i.e., after the design detail is available).

The SRI methodology presented here is a bottom-up technique, based primarily upon parametric estimating relationships. For purposes of resource estimation, the ADS development phase has been divided into the following phases:

a. Analysis and Design
b. Programing
c. Test and Evaluation
d. Documentation*

An estimating relationship is formulated for each phase; as a whole, they produce a general model for estimating total ADS development time (in man-days):

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*While documentation is actually a task within the other phases, it is treated as a phase for purposes of estimation.

$$\text{DEVELOPMENT TIME} = \text{A\&D} + \sum\text{PROGRAMMING} + \text{T\&E} + \text{DOCUMENTATION} \quad (6\text{-}1)$$

Note that all phases have single-value estimates, except the programming phase, which is a summation over estimates of the individual programs. Factors influencing development time that affect all phases are then applied.

This methodology was designed to produce estimates for efforts that require from approximately two man-weeks to six man-years--the size range for which bottom-up techniques have been applied with some confidence. The Methodology is easily adapted to either full-scale development efforts or system modification, and maintenance tasks.

6.3.2.1 Analysis and Design. A&D man-days are estimated for the entire project. Estimating factors are system complexity, general A&D experience, and functional knowledge of the specific job to be automated or modified. While system complexity is directly proportional to the amount of manpower expended, the other two factors are inversely proportional. They may be expressed mathematically as follows:

$$\frac{\text{A\&D MAN-DAYS}}{\text{FOR PROJECT}} = \left[\frac{\text{SYSTEM COMPLEXITY}}{\text{A\&D EXPERIENCE + JOB KNOWLEDGE}}\right] \quad (6\text{-}2)$$

The weighting scales for this relationship are found in Appendix B, Table B-01. Supporting rationale and a description of how these scales were derived and how they may be modified are found in Appendix B, Section 1.0. The weighting scales are designed for a full range of estimates--i.e., from minor modification to complete development of a major system.

6.3.2.2 Programming. The estimating relationship for the programming effort is logically identical to that for A&D. The fundamental difference is that programming estimates must be produced individually for each programming module to account for the varying module complexities and varying programmer skill levels. In addition, a shop's productivity is greatly influenced during the programming and T&E phases by system turnaround for submitted work. The extremes for turnaround range from

having interactive access via a terminal in the programmer's office, to courier pickup and delivery of low-priority card decks when the programmer and computer are in separate locations. Because the situation may be different for the programming and T&E phases, the factors should be applied separately to those two phases. The turnaround categories are defined for the Methodology with the appropriate quantitative values in Appendix B, Table B-02.

Summing over the modules, the total programming effort may be expressed thus:

$$\text{PROGRAMMING MAN-DAYS FOR PROJECT} = \left[\sum_{i=1}^{n}\left(\frac{(\text{PROGRAM COMPLEXITY})_i}{\text{PROGRAMMER}_j\ (\text{EXPERIENCE} + \text{JOB KNOWLEDGE})}\right) \times \left(\begin{matrix}\text{TURNAROUND}\\ \text{FACTOR}\end{matrix}\right)\right] \quad (6\text{-}3)$$

6.3.2.3 Test and Evaluation. The T&E phase is the most difficult of the three development phases to estimate. While the A&D phase produces a specific plan for T&E, T&E is nonetheless the phase in which the unanticipated appears. Problems overlooked during A&D, and which remain hidden during the coding, may appear for the first time during testing. It is the resource impact of those unknowns that must be accounted for.

Intuitively, one would imagine that the better the A&D work, the less time the T&E will require. However, looking over ADS histories available in the literature, one finds that the ratio of effort spent on the T&E phase is roughly proportional to that spent on the A&D portion (one to one). This leads to the conclusion that both efforts--over the long run--are based largely on system complexity. As a result, the proposed T&E estimating relationship is similar to that for A&D. This helps the estimator know what "ballpark" his estimate should be in, and is useful during actual development for estimate modification if the A&D effort is proceeding faster or slower than expected.

The basis of the T&E estimating relationship is identical to that for A&D, with the exception that programmer and analyst talent is averaged since both types participate in the T&E effort. The A&D weighting scales should be used. The uncertainties mentioned earlier can be

treated with an equalizing factor that takes into account lower- or higher-than-average T&E activities. By computing the mean of these discrepancies, we have such an equalizing factor. It is called the Mean T&E Requirement (MTER) and is computed by summing the T&E requirements/component, as determined in Appendix B, Table B-03, and dividing by five.

The T&E relationship is thus expressed as follows:

$$\text{T\&E MAN-DAYS FOR PROJECT} = \left[\left(\frac{\text{SYSTEM COMPLEXITY}}{\text{ANALYST-PROGRAMMER (EXPERIENCE + JOB KNOWLEDGE)}}\right) \times (\text{MTER}) \times \left(\begin{matrix}\text{TURNAROUND}\\ \text{FACTOR}\end{matrix}\right)\right] \quad (6\text{-}4)$$

6.3.2.4 Documentation. The cost of documentation is often estimated as a last phase (after T&E) in the development effort. While a portion of this activity must be handled after the system is fully tested--e.g., final writing and reproduction--the effort continues through all stages of development. It is, in fact, highly integrated into other activities. For example, the system designer will produce program specifications for the programmer's use; these working documents form the substance of the Functional Description. Because of such integration, it may be deduced that the documentation effort is proportional to the complexity of the system, and therefore requires a proportional level of effort across the entire development. For the same reason, this task will tend to be fairly constant over the majority of developments, and it is recommended that this overall effort be assessed at 5% of the net total development time. For atypical documentation requirements, this number may be modified up or down as appropriate. The documentation effort may therefore be estimated by the following relationship:

$$\text{DOCUMENTATION MAN-HOURS FOR PROJECT} = (\text{TOTAL PROJECT MAN-HOURS}) \times .05 \quad (6\text{-}5)$$

The methodology presented thus far has been explained in terms of full-scale development. It is easily applied to software modification efforts by the same principles. For example, suppose one program in a large system has to be changed. For the A&D activities, most of the

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AUTOMATED DATA SYSTEMS (ADS) MANAGEMENT METHODOLOGY. VOLUME I. --ETC(U)
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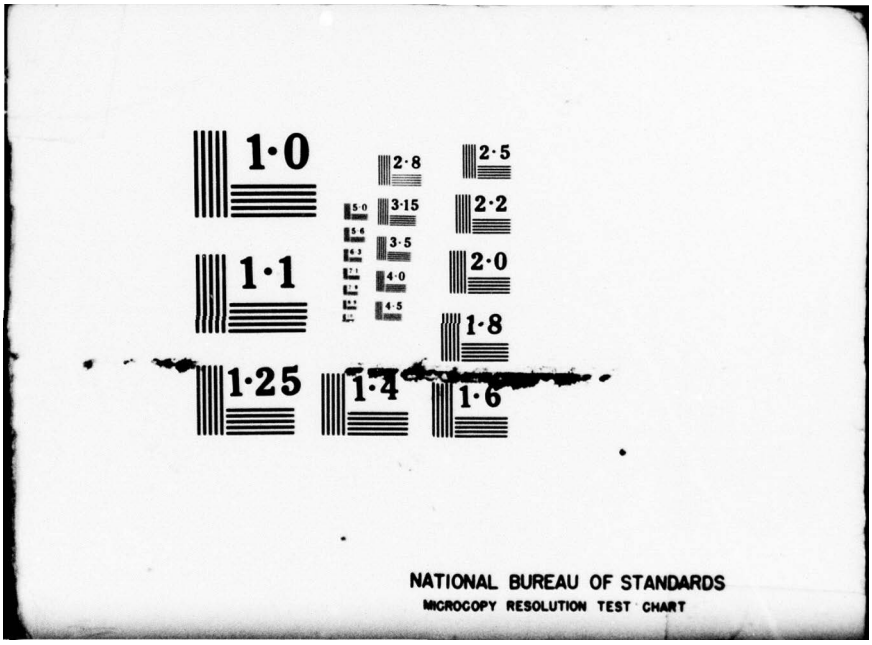
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applicable weighting factors would be in the 0-3 range. The programming weighting factors are also reduced, depending on how much code is still usable. The T&E phase is reduced corresponding to the reduction in the A&D effort and can be modified further. Modification is no harder to estimate than development when one can adjust the complexity to reflect the effort affected by previous programming. In other words, original complexity, minus the reduction in complexity brought about by earlier programming, yields the remaining complexity.

6.3.2.5 Productivity Degradation Factor. The sum of the estimates for the A&D, Programming, and T&E phases yields a nominal (productive) development time. That is, this estimate is exclusive of normal and unexpected downtime and assumes a constant, optimum level of productivity throughout development. Real world obstacles to optimum productivity are abundant and must be taken into consideration. Collectively, these are referred to as the Productivity Degradation Factor. Although the components of this factor are common to all data processing installations, the actual value of the Production Degradation Factor may vary from site to site. As a baseline figure, it is recommended that a value of 1.6 be multiplied by the nominal development time to yield actual manpower requirements.

It should be noted that productivity is also degraded according to the manning level of a project. This results from problems of coordination that develop among larger groups of people and the increasing need to devote time to strictly managerial or administrative activities. In the microestimating realm, this problem is relatively negligible because the manning levels of projects of several man-years or less never truly increase beyond the "surgical team" dimensions. For this reason, it is probable that the Productivity Degradation Factor can remain constant at any given site. This factor is the appropriate place for correcting a bias in estimates that may appear after many estimates have been made and compared to actual development time.

6.3.3 Proposed Estimating Equation. The component estimating relationships have now been defined. In combining them, the total manpower estimating equation may be specified as follows:

$$\left\{\left[\frac{\text{SYSTEM COMPLEXITY}}{\text{A \& D EXPERIENCE + JOB KNOWLEDGE}}\right] + \left[\sum_{i=1}^{n}\left(\frac{(\text{PROGRAM COMPLEXITY})_i}{\text{PROGRAMMER}_j\ (\text{EXPERIENCE + JOB KNOWLEDGE})}\right)\right.\right.$$
$$\left.\times\left(\begin{matrix}\text{TURNAROUND}\\ \text{FACTOR}\end{matrix}\right)\right] + \left[\left(\frac{\text{SYSTEM COMPLEXITY}}{\text{ANALYST-PROGRAMMER (EXPERIENCE + JOB KNOWLEDGE)}}\right)\right.$$
$$\left.\left.\times\ (\text{MTER})\times\left(\begin{matrix}\text{TURNAROUND}\\ \text{FACTOR}\end{matrix}\right)\right]\right\} \times \left(\begin{matrix}\text{DOCUMENTATION}\\ \text{FACTOR 1.05}\end{matrix}\right) \times \left(\begin{matrix}\text{PRODUCTIVITY}\\ \text{DEGRADATION}\\ \text{FACTOR 1.6}\end{matrix}\right) \qquad (6\text{-}6)$$

Table B-04 in Appendix B is a sample estimating worksheet provided to assist the user in preparing estimates of ADS development using this methodology. Again the weighting scales to be used in quantifying the estimating factors are itemized in Appendix B.

6.3.4 Costs. The primary development cost is the cost of personnel assigned to the development process. For this reason, the previous sections have dealt totally with estimating project man-year expenditures. The use of computer processing time during development is not usually a significant factor, but it may become one. This cost has been treated in the methodology as an overhead cost applied to the cost of a programmer-analyst. This assumption should be examined when making an estimate to be sure the cost is adequately covered. Appendix B Tables B-05 and B-06 show the cost/man-year in 1977 dollars for different rank and skill levels. The factors include payroll burden and overhead charges in addition to base pay and allowances. Section 6 discusses the applications of escalation factors to be used as multipliers for the man-year expenditure for the year in which it is incurred.

6.4 Estimating ADS Implementation Costs. Analysis of historical data supports using a 1:3 ratio of ADS implementation to ADS development. However, one must use this relationship with caution for any ADS system implementation costs may vary over an extremely wide range. Because an

ADS may or may not involve hardware acquisition or require off-site processing, there is virtually no direct correlation between development and implementation. Except for those ADS that involve extensive hardware costs, the major implementation cost is that for the personnel required to transport the software to the required sites, train operators and users, and monitor an initial period of operation. Since ADS development personnel often assume responsibility for system implementation, it may be useful to estimate implementation cost as a function of development costs. The macroestimating approach described and summarized in Section 3 of the SRI Technical Note NWRCTN-72 of May 1977 allows the following relationship:

System implementation = (.285) (ADS development costs)
= (.105) (Total ADS life cycle costs)*

If the ADS involves hardware and site activation (i.e., more than simply a software package), and, for those larger ADS developments, system implementation, estimating its cost is an entirely different matter.

The Resource Estimating Methodology is understandably different for the above two situations. The topics discussed below address the more involved system implementation case. When applying this Methodology the user may find that some of the items below can be skipped as "not applicable."

System implementation is broken down into the following categories:†

a. ADS Hardware/Software Acquisition
b. Initial Training
c. User Manuals and System Documentation
d. Site Activation
e. Initial Provisioning
f. ADS Project Management.

6.4.1 ADS Hardware/Software Acquisition. Estimating hardware costs can prove a paradoxical task. Although current prices are easily obtained

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*For further explanation, see DOA Pamphlet No. 18-8, "A Software-Resource Macroestimating Procedure."

†See Table 6-02.

from eager vendors, a rapidly changing state of the art and, hence, constantly changing marketing schemes cause the validity of such information to be short-lived. This condition can be particularly deleterious when estimating hardware costs for long-range planning. Long-range estimation must, therefore, involve trend prediction.

The most difficult step in determining hardware costs, whether they be for leasing or purchase, is the prerequisite task of determining which configuration will best do the job. It is then a matter of contacting system vendors with these requirements and choosing among alternatives. Tradeoffs will be involved, and the person(s) authorized to make the actual decision must have predetermined ranges of system specifications which they consider acceptable.

Specific items to be costed are:

a. CPU (with X amount of memory)
b. Mass storage (with Y amount of memory)
c. Type and number of I/O devices
d. Other peripherals (e.g., COM, plotter)
e. Communications gear
f. Removable data medium.

6.4.1.1 Other Acquisition Costs. When hardware or software packages are procured, the contracted amount represents only a portion of the acquisition costs. The cost of USMC/government personnel tasked to conduct source selection and contract negotiations is a marginal cost and properly charged to the ADS. These costs are strongly dependent on the particular circumstances of the development. Often they can be estimated by budgeting a certain number of man-days or months for the process and estimating the cost of these man-days. A general estimating relationship of 5% of the contracted price is not a reliable estimator, but may serve as a benchmark if the man-day estimate is not possible.

Delivery costs attending hardware acquisition must also be estimated. These are noted generally as shipping, delivery, checkout, and inspection charges, but may include other costs of bringing the hardware to the point of installation. Since the contracted price for larger

acquisitions often includes delivery and installation, they may be buried in the vendor quotation. Whatever the case, the user should check to see that his estimate provides for delivery and associated costs.

6.4.2 Initial Training. This cost element is estimated by forecasting the training requirement (i.e., in the number of trained operators and maintenance personnel needed), and the time required to qualify operators. Costs include both the "billet costs" of the instructor and student, travel and per diem, special training equipment and facilities, and computer processing costs. Additionally contracted services may be involved if the training is to be performed by a vendor.

6.4.3 User Manuals and System Documentation. System documentation is part of the ADS development cost. The cost element addressed here is intended to cover those costs incurred for drafting and printing the system operation and user manuals, provided that such materials are not supplied by the vendor. Although subject to wide-ranging variability, a convenient starting place for estimating these costs is to equate them to the development documentation task. Hence the relationship:

User Training Manuals* Costs = (.05) (ADS Development Costs)

6.4.4 Site Activation. These costs generally apply only to the large ADS development projects. Covered in the cost element are the costs of preparing a facility to receive and operate some form of ADS equipment. Specifically, the following items need to be estimated:

a. Facility planning, modification, and moving expenses
b. Assembly, installation, and checkout
c. Initial rents, utilities, and communications charges
d. Furnishings.

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*User-oriented; not DoD specifications; assumes that A&D and T&E phases are well-documented, if that is not the case this factor should be increased up to as much as 20%, depending on the specific situation.

Because each application is unique to its specific situation, the analyst must base his estimates on input from vendors and plant or facility engineers.

6.4.5 Initial Provisioning. Although this category is common for most military equipment, its application to ADS is often not appropriate. Equipment maintenance is generally provided under some form of a service agreement, thereby obviating the need for spares and spare parts. Occasionally ADS equipment is situated such that USMC personnel have specific maintenance responsibilities, in which case an estimate of initial spares provisioning would be required.

Supplies, materials, and certain special-purpose maintenance equipment are commonly required to support an ADS. These items do not usually represent a major cost. Estimates for the maintenance equipment can usually be provided by the vendor. Supplies are generally based on a resupply period plus a backup for emergency use.

6.4.6 ADS Project Management. This cost element extends over the entire ADS life cycle, typically running approximately 10% of the Life Cycle Costs. The cost element is treated as an implementation cost because it generally reaches a peak activity level during this phase. As with ADS development, the analyst may select either a macro or micro approach for estimating this cost. The macro estimate is the above-mentioned 10% factor of development and other implementation costs. For smaller projects, the management staff can usually be identified, and man-day (month) time for this function can be costed accordingly. It is often accounted as overhead.

6.5 Estimating ADS Operation and Support (O&S) Costs. The basis for estimating ADS (US costs is the system conceptual plan or scheme. Unlike ADS development costs where lack of design detail is a serious problem for the analyst, the conceptual plan specifies the requirement for operators, equipment (or processing time), and facilities. Since these requirements are typically part of the design specifications, changes in the system plan are more or less bounded within tolerable limits.

Given these specifications, a microestimating methodology is generally possible for O&S costs.

Operating and Support activities fall into one of two groups, both of which must be estimated. The first is that associated with the planned system operation; system operators, keypunch, computer processing, and maintenance cost and supplies. The second concerns the system software maintenance and modification. A discussion of each category follows.

6.5.1 Breakdown of System (O&S) Costs. This category includes the cost of all operating personnel, exclusive of those programmer-analysts who are assigned to maintain the currency of the system software. It also includes all processing costs, equipment leaseholds, and hardware maintenance, as well as all facility maintenance, utilities, communications, and contract services.

There are several difficult divisions of costs, which must be consistent and unbiased. More specifically, personnel assigned to the functional area may be required to provide input data to the ADS. Although they may devote all of their time to this function, this time may not be part of the system cost. The criterion for determining ADS associated and unassociated cost is whether or not the ADS requirement is added to the existing job duties had there been no ADS. Another test would be to draw an analogy with an item of unit equipment, e.g., a truck. In the truck example, a warehouseman may be assigned to load and unload the truck all of the time, but he is obviously not part of the LCC of the truck. The truck is a tool to perform a function, and similarly, so is an ADS.

The issue is less a problem of correct allocation of cost than it is of unbiased treatment of costs among alternative approaches, ADS or otherwise. Particular care must be exercised when comparing the LCC of the manual and automated systems.

6.5.1.1 System Operations. Table 6-02 listed the LCC elements treated under ADS System Operations as the following:

a. Operator Personnel Costs. To determine all normal personnel costs, the recommended approach is to use the "billet costs"

shown in Appendix B. These costs account for the many hidden, but real costs of maintaining a requirement for staff. It will be necessary to forecast the number and rank of operators, data processors, and programmer analysts before the proper costs can be determined.

b. Computer Processing Costs. Unless the computational equipment is completely dedicated to the ADS, these costs are based on estimates of computer processing times and the cost per unit time as fixed by the host activity or as quoted by a vendor of the service. The pricing algorithm used should include all peripheral, keypunch, and associated charges.

c. Supplies and Services. These costs are generally self-explanatory. They cover the cost of paper, tapes, cards, special forms, and other such materials as are required to operate the ADS.

d. Replacement and Training Operators. The "billet cost" used to estimate the personnel cost of the operator covers the normal replacement training for the rating specified. This cost element is intended to cover special training required to support the ADS. For example, new operators may be sent TDY to alternate locations for on-the-job training prior to assuming their new duties. In such a case the replacement training would include the following:

(1) Additional "billet cost" for training period

(2) Travel and per diem

(3) Instructor and processing costs

(4) Supplies and materials consumed.

6.5.1.2 Equipment and Facility Maintenance. The categories listed are:

a. Maintenance Personnel Cost. These are "billet costs" for those personnel assigned to equipment maintenance functions.

b. Computer Hardware Maintenance. This cost may be incurred as a service contract or as maintenance material and replacement parts, or both. Some form of maintenance agreement is typical for the large central processing activities (i.e., CDPA). User-level maintenance may be part of the remote terminal or minicomputer equipment, particularly those that need to be deployable. Whatever the case, the vendor-supplied maintenance cost estimate is a valuable source for determining this cost, whether contracted separately or performed internally.

c. Utilities, Rents, and Communications. This element covers the general facility costs that are incurred as a result of the ADS operation. Generally speaking,

ADP systems are operated out of government owned facilities where costs are not separable. For this condition a general rent figure may be applied if the ADS space requirement displaces other government uses for the facility.* For ADS that require special facilities or communication systems, all costs of these special facilities are charged to the ADS. Care must be taken to avoid double accounting. The pricing of computational services usually covers equipment, facility, and maintenance costs. This element is intended to cover only those costs that are incrementally added to the unit or host activity as a result of operating the subject ADS.

d. Facility Maintenance Costs. The points discussed in the previous paragraph apply here as well. The facility maintenance of the personnel work station is included in the "billet cost" factor and should not be added again unless the requirement causes additional facilities over and above a normal working situation (e.g., if a field office were to be set up to conduct some function, the cost of operating and maintaining it would be considered "incremental"). A similar situation exists for facilities set up to house ADS equipment, i.e., it is not incremental to add a terminal to an existing work station, but it would be incremental to maintain rent space in a field office to house that same equipment.

6.5.2 System Software Maintenance and Modification Costs. This category of cost is often the most speculative of the ADS resource estimates. Certain classes of ADS (e.g., fiscal, manpower, or logistics) require considerably more modification than others. There is also a noticeable difference in size and type of modifications between ADS classes. More than any other, these costs are "managed" costs, meaning that, to a considerable extent, they are incurred at management's discretion. To attempt a parametric estimating procedure would be ill-advised. The most reliable approach would be to relate historical data on ADS maintenance and modification to the initial ADS development cost, categorized by ADS type and supporting installation.

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*A typical rent of $3-5/sq. ft. would be adequate to cover facility costs that cannot be separably identified.

6.5.2.1 Macroestimating Approach to Estimating Software Maintenance. The macroestimating methodologies presented in Section 4 of the Resource Requirements Estimating Technical Note for ADS development costs showed the relationship of life cycle manning as a Rayleigh distribution for time as a dependent variable. It was also noted that, at the end of development, maintenance and modification activities begin when the system manning during development falls to roughly 22% of the maximum project manning.*

This manning level offers a starting point in a procedure for estimating the ADS project staff of analyst-programmers assigned to maintenance and modification duties. The next step is to reconstruct ADS development historical data to determine the site-peculiar management response to ADS maintenance and modification requirements. Finally, a ratio of maintenance to development staff should be determined for each functional area (i.e., class of ADS) and CDPA. Such a ratio will become a primary determinant of the cost of this LCC element.

6.6 Time Related LCC Estimating. The life cycle of an ADS is often considered to be development plus eight years of operation. However, there are no DoD instructions specifying an exact figure to be used for life cycle costing, and rightly so. This factor is a variable that differs from system to system and, hence, must be appraised on a case-by-case basis. Costs for an ADS are incurred over the entire life cycle. A decision to develop an ADS, therefore, commits the USMC to a flow of funds over time, which can be discounted. Since funds are spent in future years, allowance must be made for inflation as well. The rationale and method of application of discounting and inflating funding flows are discussed in the following paragraphs.

6.6.1 Discounting. Present DoD policy specifies that discounted cash flow be used whenever the system being considered requires funding for a period of more than three years. This policy is stated again in

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*There is, of course, considerable overlap of development and program maintenance. The line between continued development and system modification is not clear. This cutoff point is arbitrary but not unreasonable.

Chapter 14 of the ADSM. The rationale for discounting future expenditures is that to postpone the payment of any funds permits current funds to be invested to yield, presumably, some return (i.e., benefits). Another way of viewing it is to assume all the funds are made available at the start of a project, and those held in reserve for future expenditures draw interest at 10% per annum. The point being made is the same, since alternatives being evaluated have different cash flows. These flows must relate to a present value for some specified rate of return so that the alternative cost flows can be evaluated equitably. DoD instruction 7041.3 specifies an annual discount rate of 10%. Table B-07, Appendix B, lists 10% discount factors to use for expenditures beyond the base year.

6.6.2 Inflation. The treatment of inflation and/or cost escalation for expenditures has become a common part of cost and economic analyses. DoD policy states that all LCC analyses reflect the total expected cost to the government for acquiring the system in both constant, current year, and inflated dollars. Inflation rates are regularly forecast by cognizant government agencies. The rates can be guides to estimating the effects of inflation as it relates to alternative approaches. Inflated costs should be used in economic analyses whenever costs are part of the decision process.

DoD instruction 7041.3 calls for presenting LCC estimates in both constant dollars and inflated (then year) dollars. The instruction further cautions:

a. That, to avoid double accounting, one should investigate the applicability of contract escalation provisions or the impact of ongoing fixed price contracts for goods and services

b. Estimates of inflation are very uncertain for longer periods (beyond four years), and particular care should be taken.

A good procedure to follow would be to investigate the effect of using different inflation rates on the decision reached. Table B-08, Appendix B shows predicted price level indices recommended for use in DoD studies.

6.6.3 Sunk Costs and Residual Value. Sunk costs are those resources that have been incurred or irrevocably committed before a decision on alternatives is to be made. The correct treatment of sunk costs in the Feasibility Study or Economic Analysis is to exclude them from the project cost summary. If there is to be a salvage value to the sunk cost items, the net return to the government may be legitimately subtracted from the cost of the competing alternatives in the form of cash resulting from a supposed sale or in some other less tangible form, e.g., initial training, facility modification, etc.

At the end of the system's life, there may be a projected residual value, either in the form of cash resulting from a supposed sale or some other less tangible (but transferable) asset such as special training. If the asset can be redistributed to some other government activity, valid benefits accrue, and they should be credited to the affected system at fair market value.

Note, however, that since the residual value occurs at the end of the system life, and since the residual value must be net of removal, checkout, and disposal costs, the resulting benefit may be so small as to be ignored in the analysis.

APPENDIX A

ILLUSTRATIVE EXAMPLE OF OBJECTIVE-WRITING METHODOLOGY

A1.0 This section is devoted to an example that illustrates the Concept Phase Objective-Writing Methodology defined in Section 5. The example is intended to be generally realistic and to provide a reasonable exercise of the features of the objective-writing methodology. Understandably, any example chosen to illustrate the basic ideas within the scope of a few pages must be somewhat simple compared with many actual cases encountered in USMC ADS development.

A1.1 The User Need. The user need that is envisioned in this example is for an improved administrative and management tool for garrison-based staff and action officers to use in the conduct of their daily work. It is intended to address the writing, composition, and document production and control required in their work, together with certain closely associated activities. It is intended to increase productivity and improve the comprehensiveness and quality of the work in comparison to the conventional manual clerical modes of handling such tasks.

The intent is not to impose on the user a large encompassing system, but rather to give him an aid that appears to him as his own personal dedicated tool for performing and managing his work. He should be able to regard it in much the same way as he regards his own assigned typewriter or dictating machine. While it may eventually alter his style of working significantly, it should not force him to abandon any customary activities he prefers to continue, nor to learn any new formal languages, write computer programs, or engage in other activities outside the scope and interests of his assigned work. It also should not degrade his ability to accomplish any aspect of his job--for example, to maintain the privacy of sensitive records.

A2.0 The Inputs to the Objective-Writing Example. In general, inputs to objective-writing consist of a body of stated user requirements, applicable guidelines and constraints, and--if a Feasibility Study has previously been performed--certain results from the Feasibility Study. For the case of this example, the inputs are described below.

A2.1 User Requirements. The user requirements for the example are the following:

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a. (R1) The solution must provide an accessible, responsive, easily usable personal tool for a staff or action officer.

b. (R2) The solution must provide capabilities for creating, manipulating, and producing administrative information and documents encountered in the user's work.

c. (R3) It must provide calculating capabilities of a typical desk calculator with some extended features.

d. (R4) The solution must improve upon conventional manual/clerical methods.

e. (R5) It must be highly available and fully operational in the normal garrison environment.

f. (R6) It must be easily maintainable.

g. (R7) It must be economical.

h. (R8) The solution must provide capabilities at least as effective as the current manual capabilities for protecting the security of recorded material.

i. (R9) It must provide capabilities for protecting the privacy of recorded material.

A2.2 Guidelines and Constraints. For the example, the following guidelines and constraints apply:

a. (GC1) No additional nonvoice usage will be imposed on the in-house telephone system by any newly developed administrative information system or aid.

b. (GC2) Any computer software to be programmed or maintained in-house will be written in one of the approved higher-level languages listed in Document XX. Software to be furnished and maintained exclusively by a vendor/contractor is not subject to this restriction.

c. (GC3) All new in-house automated equipment and systems must be strictly justifiable on the basis of tangible, demonstrable cost savings (i.e., no intangible cost savings or intangible improvements in work quality will be considered).

A2.3 Results of Feasibility Study. For the example assume that a Feasibility Study has been conducted, and that the following results have implications for requirements:

a. (FS1) The system to be developed will be a self-contained stand-alone system rather than a clustered, netted, or remote access system.

b. (FS2) No computer programming of the system by users will be necessary or possible.

A2.4 Restatement of the Inputs. At this point, the inputs are restated for uniformity and convenience. Since restatement is open to individual

interpretation, the results can vary from person to person. The results of the restatement for this example are tabulated in Figure A-01. Through its identifying number, each item listed in the figure can be traced back to an antecedent user requirement, guidelines and constraint, or Feasibility Study result. Thus, for example, one can see that R1-1. R1-2, R1-3, and R1-4 all relate back to user requirement R1; or, conversely, that user requirement R1 has been split into the four statements R1-1, R1-2, R1-3, and R1-4. Similarly, guideline and constraint GC1 has been restated in simple and direct requirement form as GC1-1. Certain inputs (e.g., R3 and GC2) carry over directly without restatement. Occasionally, more than one input will be subsumed under one restated requirement--as in the case of R7 and GC3 being combined into GC3-1.

The complete tabulation of restated requirements (Figure A-01) becomes the list of requirements used in the operational procedures for the objective-writing example. The brief parenthesized word or phrase associated with each requirement will be used in the subsequent procedures as an abbreviation for the requirement.

A2.5 Initial Trial Objective Statements. An initial trial set of objective statements for the example is tabulated in A-02. The set was produced by inspecting the restated requirements and attempting to state a list of technologically attainable and attractive ADS objectives that together address all of the requirements. While basically sound, the set contains some defects that were overlooked initially, and that were subsequently revealed by application of the various objective-writing procedures.

A-2.6 Application of the Objective-Writing Procedures. For the illustrative example, each of the objective-writing procedures is illustrated using the trial set of objective statements exhibited in Figure A-02. In an actual system development case, the trial set would be modified after the application of each procedure to reflect the improvements induced by that procedure. The improved set would then be submitted to the next procedure. For purposes of illustration, only a small number of results typical of each procedure are noted. The reader who pursues the procedures further will discover other results and conclusions.

R1-1	(Personal tool) The solution must be a personal tool for the staff or action officer.
R1-2	(Accessibility) The solution must be accessible to the user.
R1-3	(Responsiveness) It must be responsive to the user.
R1-4	(Utility) It must be usable to the user.
R2-1	(Creation capabilities) It must provide creation capabilities for user's information and documents.
R2-2	(Manipulation capabilities) It must provide manipulation capabilities for user's information and documents.
R2-3	(Production capabilities) It must provide production capabilities for user's information and documents.
R3	(Calculating capabilities) It must provide the calculating capabilities of a typical desk calculator with some extended features.
R4	(Improved methods) It must improve upon conventional manual/clerical methods.
R5-1	(Availability) It must be highly available in the normal garrison environment.
R5-2	(Operation) It must be fully operational in the normal garrison environment.
R6	(Maintainability) It must be easily maintainable.
R8	(Security) The solution must provide capabilities at least as effective as the current manual capabilities for protecting the security of recorded material.
R9	(Privacy) The solution must provide capabilities for protecting the privacy of recorded material.
GC1-1	(Telephone usage) The solution will not connect to the in-house telephone network.
GC2	(Programming language) Any computer software to be either programmed or maintained in-house will be written in one of the approved higher-level languages listed in Document XX. Software to be furnished and maintained exclusively by a vendor/contractor is not subject to this restriction.

FIGURE A-01 RESTATED EXAMPLE REQUIREMENTS (PAGE 1 OF 2)

GC3-1	(Cost justification) The solution must result in demonstrable equipment savings, supply savings, clerical labor savings, and user labor savings that will offset its cost.
FS1	(Stand-alone system) The solution will take the form of a self-contained stand-alone system.
FS2	(User programming) No computer programming of the system will be necessary or possible.

FIGURE A-01 RESTATED EXAMPLE REQUIREMENTS (PAGE 2 OF 2)

OB1	(Text editing) The system shall provide the following text editing functions: - inserting strings of text (one or more characters) into existing text - deleting strings of text from existing text - copying existing text to a new location - moving existing text to a new location - locating occurrences of text strings in existing text for identification or modification.
OB2	(Text formatting) The system shall provide the following text formatting functions for displayed and output text; - variable control of page length - variable control of line length - variable control of line spacing
OB3	(Arithmetic) The system shall perform the following arithmetic functions; - addition, subtraction, multiplication, division - repeated multiplication with accumulation - square root - exponentiation - computation of logarithms
OB4	(Data entry) The system shall provide on-line keyboard data entry capabilities for textual narrative, tabular information, and alphanumeric data.
OB5	(Storage and retrieval) The system shall be capable of referencing, storing, retrieving, and manipulating as single files information in amounts up to 400,000 characters.

FIGURE A-02 TRIAL OBJECTIVE STATEMENTS (PAGE 1 OF 3)

OB6	(Template manipulation) The system shall have the capability to input, store, retrieve, and fill out templates for administrative forms and documents.
OB7	(Calendar/clock) The system shall provide a calendar and clock for scheduling, prompting, and time stamping of chronological events.
OB8	(File utilities) The system shall provide the following file utility functions: - copying files - deleting files - printing files - compiling a directory of files
OB9	(Removable storage) The system shall be capable of storing files on, and retrieving files from, a removable storage medium.
OB10	(Interoperability) The removable output media of the system shall be readable by other similar systems and by standard computer-based systems.
OB11	*(File limit) The maximum size of* files accommodated by the system shall be 400,000 characters.
OB12	(Hardcopy output) The system shall be capable of outputting hardcopy at a rate of 30 characters per second.
OB13	(Calculating speed) Response times for arithmetic calculations shall be at least as good as those of a typical pocket calculator.
OB14	(Up-time) The system shall be operable each month an average of 98% of the time for two work shifts per day.
OB15	(Physical security) The system shall be physically closable and lockable with a degree of security equivalent to that of a SECRET document container.
OB16	(Password protection) The system shall provide for file protection permitting unique passwords for each file.
OB17	(Packaging and size) The system shall be completely contained in either one or two cabinets whose total cube shall not exceed that of a standard office desk.

FIGURE A-02 TRIAL OBJECTIVE STATEMENTS (PAGE 2 OF 3)

OB18	(Air conditioning) The system shall operate without external air conditioning or humidity control.
OB19	(Power sources) The system shall operate on standard 110 volt, 60 Hz, 15 amp (max) power.
OB20	(Physical modularity) The system shall be modularly constructed and interconnected such that all major devices and components of those devices can be replaced as modules.
OB21	(Typewriter equivalence) The system shall be capable of being used as the strict equivalent of a standard office typewriter.
OB22	(Stand-alone capability) The system shall operate as a completely self-contained stand-alone functional unit.
OB23	(User interface) The system shall be suited for use by anyone who can operate an electric typewriter or portable electronic calculator.
OB24	(Functional completeness) The system shall come to the user with a complete repertoire of functions and not require any programming by the user.
OB25	(Diagnostics) The system shall include intrinsic error detection and diagnostic capabilities for each major component device.
OB26	(Output quality) Hardcopy output of the system shall be of sufficient quality to reproduce well under standard office copying methods.

FIGURE A-02 TRIAL OBJECTIVE STATEMENTS (PAGE 3 OF 3)

A2.7 Requirements Mapping. An illustrative mapping of the restated requirements (Figure A-01) into the trial objectives (Figure A-02) is shown in Figure A-03. In the figure, any box that has no entry should be interpreted as containing a zero. The zeros have been omitted merely to improve the legibility of the matrix. The entries in the table are intended to be realistic and meaningful entries for this example case. Some of the entries are, nevertheless, open to interpretation and would merit discussion in a more extended treatment than can be given here.

Applying the types of column-by-column and row-by-row analyses called for by the methodology reveals several inadequacies or possible improvements in the objective set. For example, the column under GC2 (Programming language) consists entirely of zeros. This reveals that there is no objective in the trial set that addresses requirement GC2. One or perhaps more objectives should be added to the trial set to accommodate requirement GC2. The columns under GC1 (Telephone usage) and FS2 (User programming) each have only one plus. Analysis shows that the two objectives accounting for the pluses do not strongly guarantee the fulfillment of the two requirements in question. Additional reinforcing objectives should be added.

Columns 1, 2, and 4 are heavily filled with pluses. On investigation, the requirements represented by these columns appear to be fully met by (mapped into) the objectives of the trial set. This is indicated by the checkmarks at the bottoms of the columns. Other columns may fall into this category as well.

Each of the instances of minus signs in the matrix should be investigated. For example, in the row for OB16 (Password protection) the minus sign indicates the fact that password protection of files interferes somewhat with accessibility for even the system's authorized user. Nevertheless, the offsetting benefits regarding security (R8), privacy (R9), utility (R1-4), and improved methods (R4) appear to more than compensate in this case.

	R1-1 PERSONAL TOOL	R1-2 ACCESSIBILITY	R1-3 RESPONSIVENESS	R1-4 UTILITY	R2-1 CREATION CAPABILITIES	R2-2 MANIPULATION CAPABILITIES	R2-3 PRODUCTION CAPABILITIES	R3 CALCULATING CAPABILITIES	R4 IMPROVED METHODS	R5-1 AVAILABILITY	R5-2 OPERATION	R6 MAINTAINABILITY	R8 SECURITY	R9 PRIVACY	GC1-1 TELEPHONE USAGE	GC2 PROGRAMMING LANGUAGE	GC3-1 COST JUSTIFICATION	FS1 STANDALONE SYSTEM	FS2 USER PROGRAMMING
OB1 TEXT EDITING	+			+		+			+										
OB2 TEXT FORMATTING	+			+		+	+		+										
OB3 ARITHMETIC	+			+	+	+	+	+									+		
OB4 DATA ENTRY	+			+	+				+								+		
OB5 STORAGE AND RETRIEVAL	+			+		+	+		+								+		
OB6 TEMPLATE MANIPULATION	+			+	+	+											+		
OB7 CALENDAR/CLOCK	+			+		+			+										
OB8 FILE UTILITIES	+			+	+	+	+												
OB9 REMOVABLE STORAGE				+			+			+			+	+			+	+	
OB10 INTEROPERABILITY		+		+			+		+	+	+			-				+	
OB11 FILE LIMIT			+	+	-	-													
OB12 HARDCOPY OUTPUT				+			+		+								+		
OB13 CALCULATING SPEED			+					+											
OB14 UP-TIME		+	+	+						+	+								
OB15 PHYSICAL SECURITY		+		+									+	+				+	
OB16 PASSWORD PROTECTION		-		+					+				+	+					
OB17 PACKAGING AND SIZE		+								+	+	+						+	
OB18 AIR CONDITIONING		+								+	+								
OB19 POWER SOURCE		+		+						+	+								
OB20 PHYSICAL MODULARITY										+	+	+							
OB21 TYPEWRITER EQUIVALENCE	+			+			+										+	+	
OB22 STANDALONE CAPABILITY		+								+	+		+		+			+	
OB23 USER INTERFACE	+	+	+	+				+											
OB24 FUNCTIONAL COMPLETENESS				+	+			+					+						+
OB25 DIAGNOSTICS										+	+	+							
OB26 OUTPUT QUALITY				+			+		+								+		
	✓	✓		✓															

FIGURE A-03 ILLUSTRATIVE REQUIREMENTS MAPPING

A2.8 Simplicity Check. A critical reading of each objective with respect to its simplicity reveals some opportunities to split composite objectives. For example, OB17 (Packaging and size) is really a dual statement that would be better separated into:

a. OB17-1 (Packaging). The system shall be contained in either one or two cabinets.

b. OB17-2 (Size). The total cube of the system shall not exceed that of a standard office desk.

Analyzing each of the objectives into its functional, performance, physical design, and system quality, implications also reveals some opportunities to produce simplified objectives. For example, OB12 (Hardcopy output) has both a functional implication and a performance implication. These can be separated and written respectively as:

a. OB12-1 (Hardcopy output). The system shall be capable of printing hardcopy output.

b. OB12-2 (Printing rate). The system shall print at least 30 characters per second.

A2.9 Pairwise Checks. Pairwise checks for consistency, independence, and comparability have considerable potential for improving the trial set. For example, when OB12 (Output rate) is paired with OB13 (Calculating speed), an ostensible inconsistency comes to light. If the output rate called for by OB12 is the maximum rate at which the system can display (print) arithmetic operands (numbers), then the printing times alone will far exceed the response times seemingly called for by OB13. However, if OB13 is interpreted to mean that calculations, exclusive of operand printing, will be performed as fast as those of a typical electronic pocket calculator, then the inconsistency is resolved.

An example of nonindependence (overlap) is revealed when OB11 (File limit) and OB5 (Storage and retrieval) are paired and analyzed together. Both specify the same maximum file size of 400,000 characters for the system. The set of objectives would be improved and the simplicity of OB5 would be enhanced by eliminating the reference to file size from OB5.

A2.10 Determinability Analysis. Analysis of OB10 (Interoperability) pinpoints a determinability problem. The reference to "standard computer-

based systems" must be better defined to make objective fulfillment determinable. It could, for example, be changed to: "Computers having the appropriate type of input/output device and employing the American Standard Code for Information Interchange (ASCII)."

Determinability analysis of OB18 (Air conditioning) suggests the need to restate the objective to include specification of desired environmental temperature and humidity limits. It further indicates the need to provide for eventual operational tests of the system under appropriate environmental extremes to determine whether it fulfills the stated objective.

APPENDIX B

DEFINITION, DERIVATION, AND MODIFICATION OF MICROESTIMATING WEIGHTING AND SCORING FACTORS

B-1.0 The following definitions describe the microestimating factors in the context of the proposed methodology:

a. System Complexity--This refers to the combined level of difficulty in programming the various components of the system. Care must be taken not to confuse amount with difficulty. As an example, three fixed-length record input files may be easier to program than a single variable-length record input file. Program complexity is analogous.

b. Experience--Analyst A&D experience and programmer programming experience refer to the amount of general background and use of those skills by the analyst and programmer, respectively. In many cases this is directly proportional to military rank or GS grade.

c. Job Knowledge--This refers to functional knowledge of the specific application which is to be automated, or if currently automated, knowledge of the existing automated system as well.

Derivation of weighting scales for application against the above factors was relatively straightforward. The crucial task was to identify all of the parameters involved and their interrelationships in each developmental subphase. Each subphase was then further divided into the specific activities of which it is comprised. "Expert judgment" is sufficiently accurate at this level for estimation purposes. Any experienced analyst who currently has the authority to produce estimates is qualified to use this system. The use of bottom-up techniques is obvious. Activity estimates are combined to produce subphase estimates, which are in turn combined to produce a single overall estimate for the development phase.

Several constraints had to be observed when developing the scales presented. First, the relative complexities of the activities to each other determined the variation in ranges. Second, it is important for the estimator to remember that, with respect to programming effort, complexity is not linear. To impress the importance of this on the estimator, the complexity scales are subdivided into logarithmic categories (the terms "Simple," "Average," "Complex," and "Very Complex" have only conceptual meaning). Third, the relative level-of-effort among the subphases--i.e., A&D, programming, and T&E--was determined

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from the literature to be approximately 40, 20, and 40% respectively. Given these constraints, it was a straightforward procedure to derive numbers that would produce estimates in the desired range of two man-weeks to six man-years.

Modification of the weighting factors may be necessary if the methodology yields a biased distribution estimate.* The success of using the microestimating equation is dependent upon feedback from prior usage. In this way actual versus estimated man-hours may be monitored to determine the source of error. This feedback should also be used to improve the analyst's ability to determine the appropriate weighting factor.

When a considerable amount of historical data is collected, sophisticated mathematical techniques--e.g., multiple regression analysis--may be employed to determine the weighting factors. A discussion of such techniques is not within the scope of the material presented here. The point to be made, however, is that the analyst has a variety of mathematical tools at his disposal, which, with a sufficient amount of historical data, will enable him to refine the equation parameters produced in this report. The refinement process is considered an essential part of this proposed methodology.

B-2.0 Tables B-01 through B-03 are sample scoring sheets for applying the microestimating methodology. Table B-04 is a sample worksheet for microestimating.

Tables B-05 and B-06 show the 1976-1977 total cost per man-year of military and civilian personnel as it applies to Life Cycle Cost studies. These constitute the fully loaded (marginal) cost to the government for maintaining a billet requirement.

Tables B-07 and B-08 list two cost indicies needed in conducting Life Cycle Cost estimates. Table B-07 shows the 10% discount factor for future expenditures. Table B-08 shows a projected inflation index for future development and procurement expenditures.

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*If the bias applies to all components uniformly, the Productivity Degradation Factor is the appropriate term to modify.

TABLE B-01

ANALYSIS AND DESIGN (A&D) WEIGHTING SCALES*

Activity	A&D Complexity			
	Simple	Average	Complex	Very Complex
Design system flow	0-3	4-11	12-35	36-100
Design input forms/report formats	0-3	4-7	8-20	21-50
Design master files	0-3	4-12	13-40	41-150
Design input files	0-3	4-11	12-35	36-100
Design output files	0-3	4-11	12-35	36-100
Design intermediate files	0-3	4-11	12-35	36-100
Design programming logic	0-4	5-15	16-60	61-200
Write program specs	0-3	4-7	8-20	21-50
Develop T&E plan	0-3	4-12	13-40	41-150
Develop training/ implementation plan	0-3	4-12	13-40	41-150

Analyst's Capability	A&D Experience	Job Knowledge
Considerable	2.0	2.0
Average	1.5	1.5
Little	1.0	1.0
None	0.5	0.5

*These scales also apply to the T&E equation.

TABLE B-02

PROGRAMMING WEIGHTING SCALES

Activity	Program Complexity			
	Simple	Average	Complex	Very Complex
I/O	0-1	2	3-5	6-12
Edit/validation	0-1	2	3-5	6-12
Sort/merge*	0-1	2	3-5	6-12
Lookup/search	0-1	2	3-4	5-10
Calculations	0-1	2	3-5	6-12
Update	0-1	2	3-4	5-10
Utilities or subroutines	0-1	2	3-4	5-8
JCL	0-1	2	3-4	5-8

Programmer's Capability	Programming Experience	Job Knowledge
Considerable	2.0	2.0
Average	1.5	1.5
Little	1.0	1.0
None	0.5	0.5

Turnaround Factor	Value
Interactive	.7
More than once per day	1.0
Once per day or less	1.5

*If not done by a utility.

TABLE B-03

TEST AND EVALUATION

Activity	T&E Requirement/Component		
	Low	Average	High
Operational tests	0	1	2
Technical reviews	0	1	2
Hardware/software verification tests	0	1	2
Data base control tests	0	1	2
Program/file security tests	0	1	2

TABLE B-04
MICROESTIMATING SAMPLE FORM
ESTIMATING ADS DEVELOPMENT TIME

(Sample Worksheet)

Activity	A&D Complexity: Simple	Average	Complex	Very Complex	SCORE
Design System Flow	0-3	4-11	12-35	36-100	____
Design Input Forms/Report Formats	0-3	4-7	8-20	21-50	____
Design Master Files	0-3	4-12	13-40	41-150	____
Design Input Files	0-3	4-11	12-35	36-100	____
Design Output Files	0-3	4-11	12-35	36-100	____
Design Intermediate Files	0-3	4-11	12-35	36-100	____
Design Programming Logic	0-4	5-15	16-60	61-200	____
Write Program Specs	0-3	4-7	8-20	21-50	____
Develop T&E Plan	0-3	4-12	13-40	41-150	____
Develop Training/Implementation Plan	0-3	4-12	13-40	41-150	____

ANALYST EXPERIENCE ____ ANALYST JOB KNOWLEDGE ____ A&D SUBTOTAL = $\frac{\text{SYSTEM COMPLEXITY}}{\text{EXPERIENCE + JOB KNOWLEDGE}}$

A&D SUBTOTAL ____

Activity	Program Complexity: Simple	Average	Complex	Very Complex	PROGRAM 1 SCORE	PROGRAM 2 SCORE	PROGRAM 3 SCORE	PROGRAM 4 SCORE	PROGRAM 5 SCORE	...
I/O	0-1	2	3-5	6-12	____	____	____	____	____	
Edit/Validation	0-1	2	3-5	6-12	____	____	____	____	____	
Sort/Merge	0-1	2	3-5	6-12	____	____	____	____	____	
Lookup/Search	0-1	2	3-4	5-10	____	____	____	____	____	
Calculations	0-1	2	3-5	6-10	____	____	____	____	____	
Update	0-1	2	3-4	5-10	____	____	____	____	____	
Utilities/Subroutines	0-1	2	3-4	5-8	____	____	____	____	____	
JCL	0-1	2	3-4	5-8	____	____	____	____	____	
SCORE TOTALS-					____	____	____	____	____	
PROGRAMMER EXPERIENCE + JOB KNOWLEDGE-					____	____	____	____	____	

TURNAROUND = ____

PROGRAMMING SUBTOTAL = $\left(\sum \frac{\text{SCORE TOTAL}}{\text{PROGRAMMER EXPERIENCE + JOB KNOWLEDGE}}\right)$

PROGRAMMING SUBTOTAL = ____

Activity	T&E Requirement/Component: Low	Average	High	SCORE
Operational Tests	0	1	2	____
Technical Reviews	0	1	2	____
Hardware/Software Verification Tests	0	1	2	____
Data Base Control Tests	0	1	2	____
Program/File Security Tests	0	1	2	____

T&E SUBTOTAL = $\left(\frac{\text{SYSTEM COMPLEXITY}}{\text{AVG EXPERIENCE + AVG JOB KNOWLEDGE}}\right)$ x MTER

TOTAL SCORE /5 = ____ = MTER

AVERAGE EXPERIENCE = ____

AVERAGE JOB KNOWLEDGE = ____

TURNAROUND = ____

T&E SUBTOTAL = ____

TURNAROUND FACTOR (Circle)	Interactive	> Once/Day	≤ Once/Day
	.7	1.0	1.5

DOCUMENTATION (1.05) x PRODUCTIVITY DEGRADATION (1.6) = 1.68

TOTAL DEVELOPMENT MAN-DAYS

(A&D + (PROGRAMMING + T&E) x TURNAROUND) x 1.68

(____ + (____ + ____) x ____) x 1.68 = ____

TABLE B-05

MILITARY BILLET COST[1] FOR LCC STUDIES

Cost in 1977 Dollars/Man-year

Enlisted Officers	E3/01	E4/02	E5/03	E6/04	E7/05	E8/06	E9
DP*	17,500	20,700	25,100	31,000	33,300	37,500	43,100
DS**	20,100	22,900	28,300	34,400	36,000	40,700	51,000
Officers	30,000	38,400	44,000	54,800	64,200	86,400	

Cost in 1977 Dollars/Man-day[2]

DP*	80	94	114	141	151	170	196
DS**	91	104	129	156	164	185	232
Officers	136	174	200	249	292	393	

Source: Navy Military Manpower Billet Cost Data for Life Cycle Planning Purposes, NAVPERS 15163, July 1973.

*DP--Data Processing Technician (MOS 4016, 4034)

**DS--Data System Technician (MOC 4038, 4044, 4063, 4065, 4069)

[1]Billet Cost includes: MPA proficiency pay, retirement, payroll charges, training, transportation, reenlistment. Cost estimates are based on scaling 1973 dollars to 1977 dollars according to the ratio of MPA for 1976/1973.

[2]Based on 220 man-days per man-year.

TABLE B-06

CIVILIAN PERSONNEL "BILLET" COST FOR LCC STUDIES

Annual Cost (1977 Dollars/Man-Year)

GS-2	GS-3	GS-4	GS-5	GS-6	GS-7
17,200	19,300	24,200	26,800	29,700	33,000

GS-8	GS-9	GS-11	GS-12	GS-13	GS-14
36,500	40,100	48,200	57,000	67,700	79,700

Man-Day Cost (1977 Dollars/Man-Day)*

GS-2	GS-3	GS-4	GS-5	GS-6	GS-7
76	86	108	119	132	147

GS-8	GS-9	GS-11	GS-12	GS-13	GS-14
162	178	214	253	301	354

Source: SRI International

*Based on 225 man-days per man-year.

TABLE B-07

TEN PERCENT ANNUAL DISCOUNT FACTORS

Base Year +	1.000
1	0.954
2	0.867
3	0.788
4	0.717
5	0.651
6	0.592
7	0.538
8	0.489
9	0.445
10	0.405
11	0.368
12	0.334
13	0.304
14	0.276
15	0.251
16	0.228
17	0.208
18	0.189
19	0.172
20	0.156

Note: These factors are equivalent to an arithmetic average of beginning and end of the year compound amount factors found in standard present value tables.

TABLE B-08

PRICE LEVEL INDICES (BASE YEAR 1977)

Year	Development	Procurement
1977	1.000	1.000
1978	1.058	1.056
1979	1.096	1.100
1980	1.142	1.144
1981	1.184	1.190
1982	1.230	1.237
1983	1.277	1.287
1984	1.324	1.338
1985	1.375	1.392
1986	1.427	1.447
1987	1.481	1.505
1988	1.538	1.566
1989	1.596	1.628
1990	1.657	1.693

Source: ASD (PA&E) Memorandum, 13 March 1975. Reported in Ref. Bellance, USAR Cost Effectiveness Program Plan.