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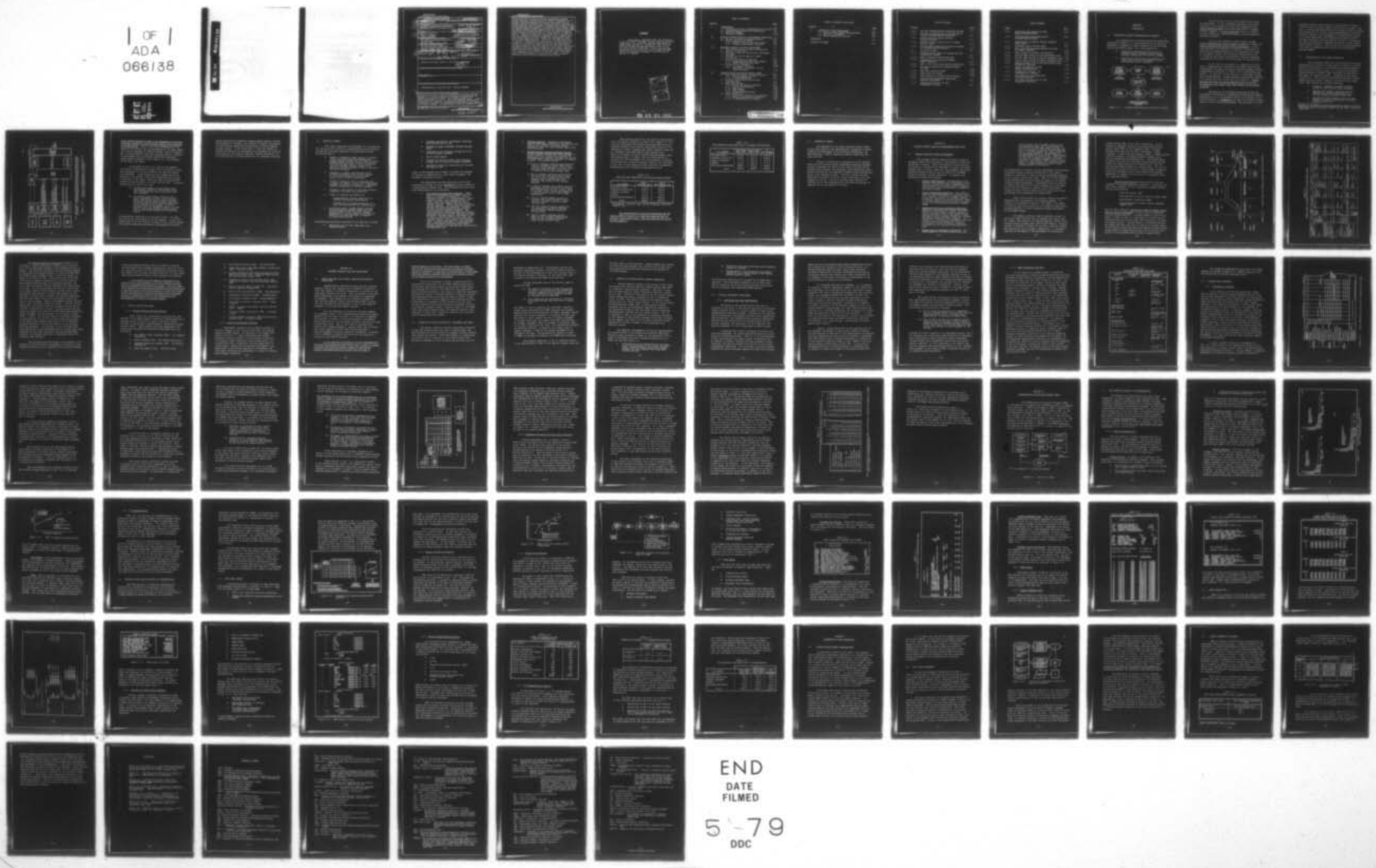

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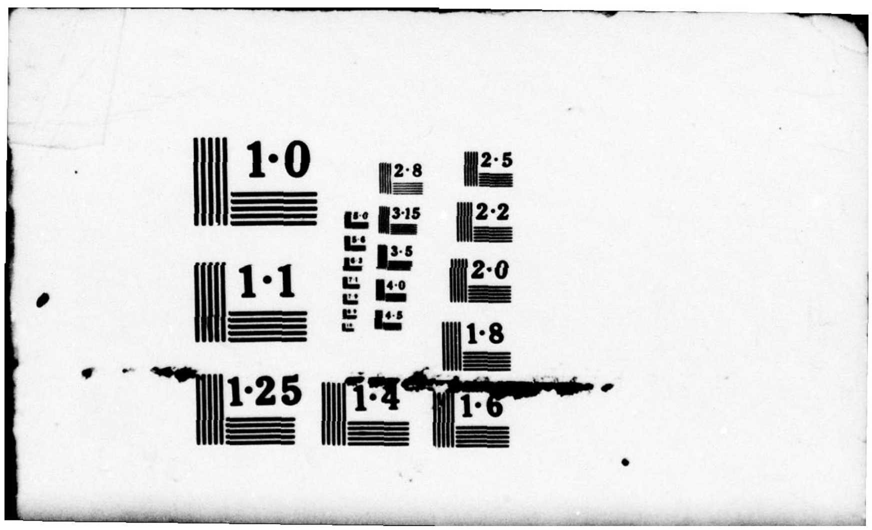
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The objective of the Avionics Standardization Potential Analysis program is to develop a general methodology for evaluating the benefits accruing from the use of standard equipment across future USAF avionics systems. The methodology has been developed using navigation avionics, as being representative of avionics in general, in a study of standardization potential across navigation systems (SPANS). The methodology covers the process of → next page

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establishing future avionics systems requirements through mission analysis, identification of available equipment for the design of mission-responsive avionics suites, evaluation of future quantitative demands for avionics equipment, synthesis of mission-capable avionics systems, collection of relevant cost and reliability data and evaluation of standardization options using a computer-based Standardization Evaluation Program (STEP). STEP has been delivered to AFAL complete with full documentation, is installed as a verified program on ASD's CDC Cyber 74 computer and is currently available for use through AFAL by the DOD community. STEP uses a life-cycle cost model that is sensitive to the cost benefits obtained by widespread use of standard equipment across several aircraft through cost learning and reliability improvement functions. The use of the STEP methodology to evaluate standardization options which are based both on procurement to a detailed design specification and procurement to a form, fit and function specification has been demonstrated. The major outputs of the STEP program are life-cycle cost/mission completion success probability maps for each aircraft type considered and the total (global) life-cycle cost value resulting from selection of the lowest life-cycle cost avionics suites for a complete force structure of aircraft types. With these outputs a System Analyst can explore the effects on global life-cycle cost of various standardization options.

FOREWORD

This report, AFAL-TR-78-168, was submitted on 31 July 1978 as TR-1059-3 by The Analytic Sciences Corporation, Six Jacob Way, Reading, Massachusetts 01867 under Contract No. F33615-77-C-1167 with the Avionics Systems Engineering Branch (AAA) of the Air Force Avionics Laboratory. This study was performed during the period May 1977 through May 1978. The Project Engineer throughout the study period was Mr. J. Garcher.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

SECTION I

INTRODUCTION

1.1 EVALUATING AVIONICS STANDARDIZATION POTENTIAL

The standardization potential evaluation methodology summarized in Figure 1.1-1 and described in this report was developed in response to a need, perceived by the Air Force Avionics Laboratory (AFAL), for a tool capable of:

- Identifying opportunities for the use of standard avionics equipment across future aircraft installation or retrofit programs
- Predicting the life-cycle cost benefits that would accrue from the procurement of such standardized avionics equipment.

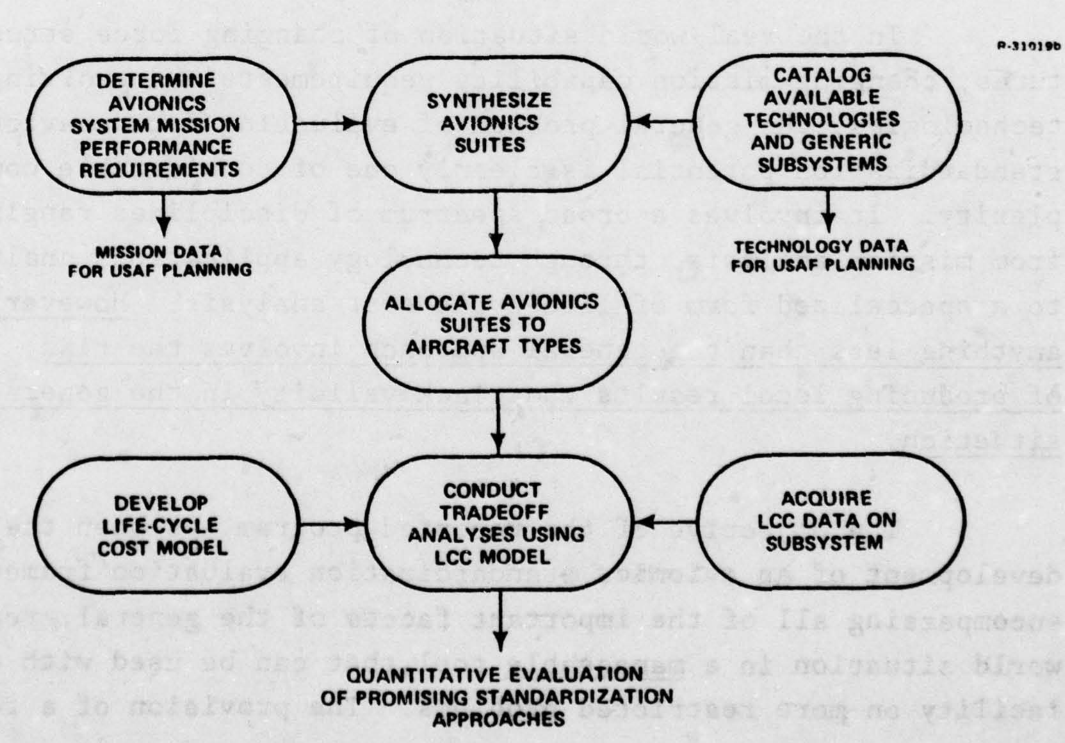

Figure 1.1-1 Top-Down Standardization Evaluation Concept

The use of the tool at various USAF decision levels was anticipated. It was, therefore, required to be equally applicable to the analysis of situations ranging from the global planning problem (force-wide application of standard avionics elements) to local evaluations (use of a standard avionics element on a specified program in lieu of specially developed equipment).

The tool was required to handle studies of subsystem standardization across avionics systems and studies of module standardization across avionics subsystems. It was also required to be adaptable to analyses of the effects of different procurement policies for the acquisition of standard equipment, notably that involving long production runs to a detailed fabrication specification, and that requiring conformance with a form, fit and function (F^3) specification.

In the real-world situation of changing force structures, changing mission capability requirements and evolving technologies, the general problem of evaluating future avionics standardization potential is clearly one of considerable complexity. It involves a broad spectrum of disciplines ranging from mission analysis, through technology applications analysis, to a specialized form of life-cycle cost analysis. However, anything less than the general approach involves the risk of producing local results that lack validity in the general situation.

The objective of the reported program has been the development of an avionics standardization evaluation framework encompassing all of the important facets of the general, real-world situation in a manageable tool that can be used with equal facility on more restricted problems. The provision of a technological avionics design guide for the synthesis of future avionics suites was not a primary objective of the study. However, to develop the evaluation tool, navigation avionics systems were singled out for study as being representative of avionics systems in general, and the process of defining future navigation system requirements and synthesizing navigation suites has been conducted in the most general context, to ensure that the resulting evaluation framework can handle the most comprehensive input situation. These activities have been conducted in a study of Standardization Potential Across Navigation Systems (SPANS).

1.2 STANDARDIZATION EVALUATION METHODOLOGY

The methodology adopted for the evaluation of avionics standardization potential is represented in Figure 1.2-1 which depicts its application to the problem of subsystem standardization within avionics suites. It is based on a Standardization Evaluation Program (STEP) developed and delivered to AFAL under the reported contract. Operating on data inputs (selected by a system analyst) specifying alternative mission-capable avionics suites in each of the aircraft types under study, STEP performs the following functions:

- Develops a sequence of optimal* avionics suites for each aircraft type considered
- Computes the avionics life-cycle cost for each aircraft avionics installation or retrofit program considered (Local LCC)
- Computes the total avionics life-cycle cost across all aircraft installation or retrofit programs (Global LCC).

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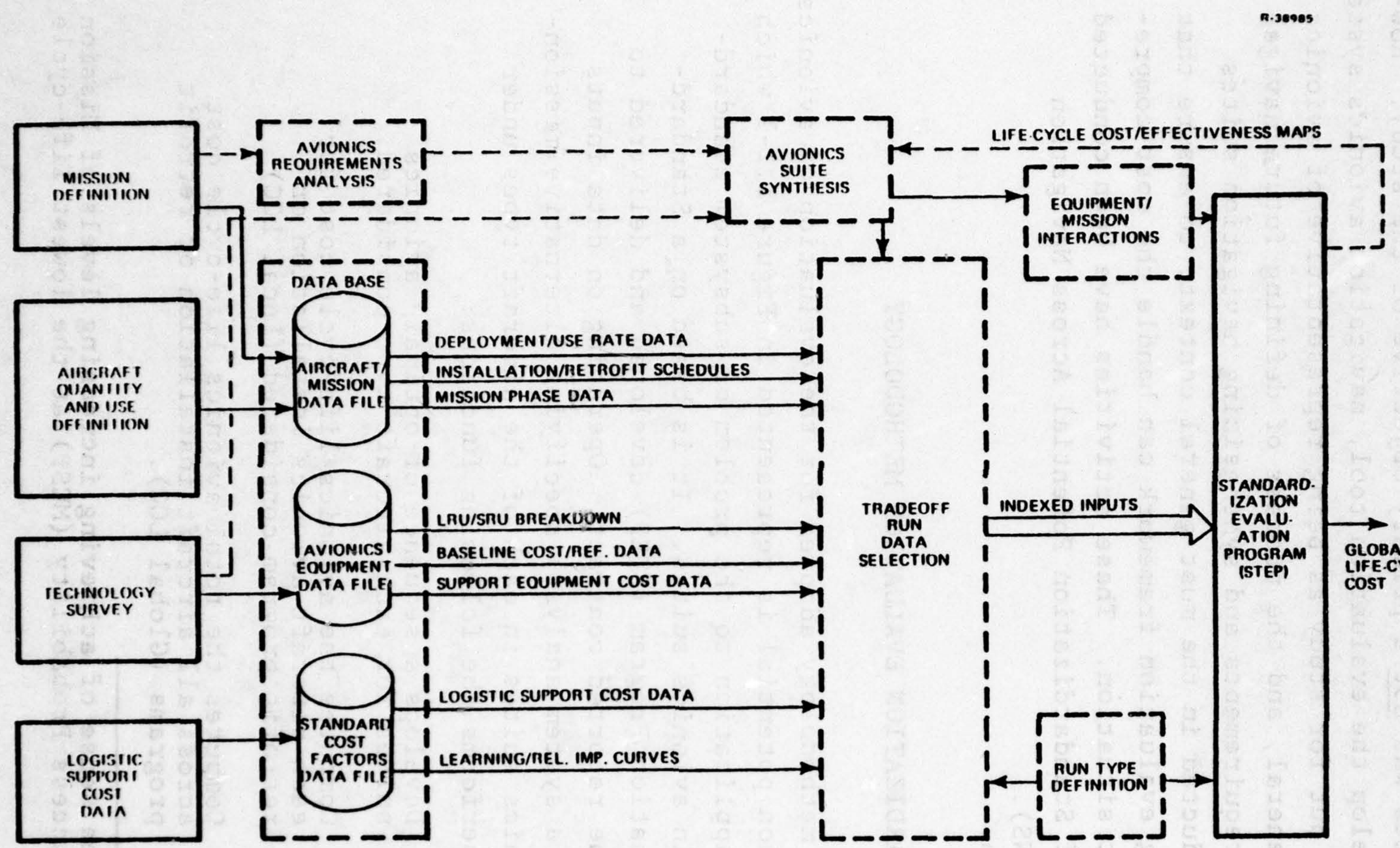
*Optimal in the sense of achieving increasing levels of Mission Completion Success Probability (MCSP) at the lowest life-cycle cost (LCC).



KEY; BROKEN LINES = TECHNOLOGICAL DESIGN ACTIVITIES (OFF-LINE SYSTEMS ANALYSIS)
SOLID LINES = DATA BASE FORMULATION AND STANDARDIZATION EVALUATIONS

Figure 1.2-1 Overview of Methodology for Evaluation of Avionics Standardization Potential

A key concept embodied in STEP is the recognition of avionics subsystem commonality across aircraft types in the life-cycle cost computations. Thus, if the suites nominated for evaluation by the analyst call for application of the same (standard) item of equipment on several aircraft, the cost benefits due to long production runs (cost learning curves), reliability improvement due to extensive operational experience, common support equipment, pooled spares, etc. are reflected in the Global LCC output.

As indicated in Fig. 1.2-1, much of the emphasis in avionics standardization studies lies in setting up a data base applicable to the use of STEP on the specific problem to be analyzed. A data acquisition and storage process applicable to the general (force-wide standardization) problem is depicted in the figure, which also shows the interaction between the system analyst, the data base and STEP. In general, acquired data is used in two ways:

(1) By the system analyst in analyzing mission requirements imposed on the avionics suites and in synthesizing those suites from available equipment

(2) In setting up data files tailored to the input requirements of STEP. As the problem under study becomes better defined through the acquisition of improved data, these files become the repository of verified knowledge on all aspects of the problem. As this available store of information grows, the time spent by the system analyst in data acquisition is reduced and problems are solved more quickly.

The methodology described is an efficient blend of the capabilities of the system analyst and the computer. It uses the system analyst for the solution of facets of the overall problem that require engineering experience and judgement and are not easily reducible for completely computer-based solution (notably the definition of missions, the analysis of mission requirements for the avionics systems and the synthesis of mission-capable avionics suites). On the other hand, it uses the computer to provide the analyst with the numerical consequences (in terms of life-cycle cost and mission completion success probability) of his decisions and to provide guidelines for subsequent decisions.

1.3 EXECUTIVE SUMMARY

This report describes the development of a methodology for evaluating the benefits of standardization across avionics systems and subsystems applicable to future USAF aircraft. The methodology is:

- Capable of handling a wide variety of standardization evaluation problems ranging from global planning studies (use of common avionics elements across the entire force structure for any planning time frame) to local evaluations (use of a standard avionics element on a specified aircraft program in lieu of specially developed equipment).
- Adaptable to studies involving the use of standard subsystems across avionics suites or to those involving the use of common modules across avionics subsystems.
- Schedule-oriented in that it recognizes and evaluates the impact of prior use of applicable equipment on decisions relating to a subsequent avionics installation or retrofit program.
- Designed to take account of projected avionics technology evolutions and transitions.
- Useable to evaluate the effects of:
  - Standardization through production to a detailed fabrication specification.
  - Standardization through conformance to a form, fit and function (F^3) specification.
- Structured around a computer-based Standardization Evaluation Program (STEP) which has been delivered to AFAL, with full program documentation, and is currently installed and operable on the ASD CDC Cyber 74 computer at Wright-Patterson AFB.

Cost-affecting mechanisms recognized by the STEP model include:

- Long production run cost reductions (cost learning curves)

- Equipment reliability improvements resulting from extended service use
- Sharing of support equipment between aircraft types
- Development cost avoidance through use of in-service standard equipment
- Use of pooled spares
- Training and Technical Order cost avoidance through use of in-service standard equipment
- Equipment reliability variations with aircraft and mission type.

Inputs to the program can be chosen to reflect the presence or absence of competition as a cost factor throughout the equipment acquisition process.

The methodology has been exercised on force-wide evaluations relating to future navigation avionics systems as a representative general case. *The following activities* have been accomplished in this evaluation:

- Data Acquisition/Data File Creation: Twenty three (23) representative missions have been detailed covering Air Superiority, Attack, Electronic Warfare, C^3, Reconnaissance, Cargo/Transport/Tanker, and Strategic Bomber aircraft; these have been extensively cross-checked with User Commands and USAF mission analysis agencies. Force structure projections through 1991 have been developed, including service introduction/phaseout and avionics installation and retrofit schedules. Aircraft-to-mission correlation data and aircraft deployment and use rate data have been acquired. Navigation equipment design, performance, cost, reliability and availablitity data have been acquired together with relevant information on requisite support equipment for each equipment type. Learning curve data by technology type has been developed from historical records. Logistic support cost data has also been acquired by technology type.

- <u>Off-Line Analyses</u>. Navigation requirements analyses have been conducted for all missions and used in the synthesis of mission-capable navigation suites for each aircraft type in the Force Structure.

- <u>Standardization Evaluation Tradeoff Studies</u>. Several tradeoff studies have been conducted to verify operation of STEP and to explore the magnitude of cost benefits accruing from the use of standardized navigation equipment in various contexts. The studies include:

  (1) Use of a standard (detailed specification) inertial navigation system (INS) across a force of air-superiority, attack, transport and tanker aircraft versus use of a different INS on each aircraft type.

  (2) Use of standard (detailed specification) INS across the same mixed force versus use of a mature, commercial INS on the transport and tanker aircraft and a different INS on each of the tactical aircraft.

  (3) A study to quantify the relative costs of procurement of INS systems to an F^3 standard specification for the tactical force of the early 1980's versus procurement to a detailed specification from a single manufacturer.

  (4) Use of a standard OMEGA receiver on transport and tanker aircraft versus use of a different receiver on each aircraft type.

  (5) Use of a standard digital computer on air superiority and attack aircraft versus separate computer selection for each type.

  (6) Use of a common strategic Doppler radar on the strategic bomber/tanker force versus a different Doppler radar on each aircraft type.

Some typical results (for the inertial system evaluations) are shown in Tables 1.3-1 and 1.3-2. Table 1.3-1 portrays the calculated cost benefits resulting from the use of standard (detailed specification) INS across a force of air-superiority, attack, transport and tanker aircraft versus use of a different (tailored) INS for each aircraft type. Table 1.3-2 relates to the F^3 standard INS procurement study and indicates that a "premium" cost of $104M invested in running an F^3 INS procurement will insure against a possible loss of $437M if a production award is made to one contractor at the start of the program and that contractor subsequently demonstrates a poor reliability improvement record.

TABLE 1.3-1

LIFE-CYCLE COST BENEFITS OF INS DESIGN STANDARDIZATION

LCC ELEMENT	CASE 1 STANDARD INS	CASE 2 NON-STANDARD INS
One-Time Costs*	$ 14 M	$ 99 M
Hardware Acquisition	$194 M	$256 M
Support Equipment	$ 91 M	$172 M
Spares	$ 42 M	$ 58 M
Recurring Maintenance	$241 M	$289 M
Total	$582 M	$874 M

*Development, Technical Data, Initial Training, Contractor Support, etc.

<u>The standardization evaluation methodology and the program (STEP) on which it is based have been verified as efficient quantitative tools. They are available for use by the DOD community.</u>

TABLE 1.3-2

RISK REDUCTION ASSOCIATED WITH F^3 STANDARD SPECIFICATION

LCC ELEMENT	SOLE-SOURCE BEST CASE	SOLE-SOURCE WORST CASE	F^3 PROCUREMENT
One-Time Costs	\$ 14 M	\$ 14 M	\$ 28 M
Hardware Acquisition	\$195 M	\$347 M	\$228 M
Support Equipment	\$ 74 M	\$113 M	\$ 82 M
Spares	\$ 33 M	\$103 M	\$ 47 M
Recurring Maintenance	\$169 M	\$345 M	\$204 M
Total	\$485 M	\$922 M	\$589 M

1.4 OVERVIEW OF REPORT

The remainder of this report provides further detail on the construction of the representative (navigation avionics) scenario for development of the evaluation methodology, the data acquired to conduct completed tradeoff studies and the nature of STEP.

Section 2 is devoted to a description of the mission definition and avionics system requirements analysis processes. Section 3 describes the nature of the force structure and deployment data acquired, the navigation system technology information collected for the completed tradeoff studies and the navigation suite synthesis process. Section 4 reviews the STEP model and the premises on which it was constructed, with some examples of its use. Section 5 presents some concepts for modification of the standardization evaluation methodology to simplify its use and extend its utility.

SECTION II

AVIONICS SYSTEM CAPABILITY REQUIREMENTS DEFINITION

2.1 FACTORS AFFECTING SYSTEM REQUIREMENTS

The strongest factors affecting avionics system requirements arise from the nature of the missions in which the system has to operate. Thus a description of those missions is necessary to establish the environment in which the system operates and to provide a basis for the equipment utilization schedules during the mission and the effects of equipment failure on mission success probability. In general, the following processes are required:

- Mission Identification: Determination of all missions that impose unique requirements on the avionics systems under study; amalgamation of these missions into representative or composite missions that exercise the avionics systems to the fullest extent.
- Mission Phase/Event Definition: This forms a basis for the determination of equipment selection, equipment utilization schedules during the mission and the effects of equipment failure on mission completion success probability (MCSP). It provides mission description data for direct use by the Standardization Evaluation Program (STEP).
- Definition of Mission Capability Objectives. Capability objectives for aircraft and weapon systems are established at various levels of detail in several forms of USAF documentation ranging from mission area requirements studies and weapon utility studies to approved, required operational capability (ROC) documents. In general, it is necessary to amalgamate data from a wide selection of documents to obtain a satisfactory overview of mission capability objectives for any extended future period of time.
- Mission Success Probability Objectives: The apportionment of the MCSP objective for the

entire aircraft into the MCSP objectives for its constituent parts (and in particular for the avionics system under study) provides, not only a criterion for avionics system effectiveness in the STEP program, but also a guideline to the system analyst in the synthesis of mission-capable avionics suites. Specifically, the MCSP objective gives an early indication of the need for redundant equipment in certain instances, particularly those in which the mission is of long duration and reliance on autonomous, on-board equipment is total during extended phases of the mission.

The determination of avionics system requirements from the above information usually requires redefinition of the mission capability objectives in terms of mission performance required of the avionics system under study. Here all of the representative missions must be scrutinized for impact on the subject avionics system requirements. Considerable off-line analysis is usually required in this process together with some familiarity with the synergistic aspects of the relationships between external avionics sensors and the system under study, and between those comprising the system itself.

Some of these aspects of avionics system requirements definition are illustrated by the following example. To preserve the unclassified nature of this report, the example is stated in qualitative terms but it is based on quantitative analyses conducted to define navigation system requirements for the SPANS program.

The example concerns a type of tactical aircraft in the current USAF inventory that is equipped for visual close air support (CAS) missions and limited night/all weather interdiction missions through radar offset blind bombing. Avionics retrofit is planned to extend the aircraft's night/all weather and counter-air (air-to-surface) capabilities. A concurrent objective of the update is the improvement of conventional weapon delivery CEPs in the visual attack mode. Current navigation equipment consists of an analog inertial navigation system (INS) of the 3-5nm/hour class, a forward-looking radar (FLR) of late 1960's technology, a radar altimeter, a central air data computer (CADC), a TACAN receiver, a VOR/ILS receiver, an analog navigation computer and a back-up heading/attitude reference set. The planned update is based on the use of a PAVE TACK forward-looking infrared (FLIR) for target detection and identification, with the existing FLR being retained as a cueing sensor. The size of the aircraft dictates the use of a single primary navigation system (no redundancy) with a mode hierarchy for graceful degradation of capability in the event of individual navigation subsystem failure.

Mission identification derives directly from the statement of required operational capability. Individual missions which represent the full spectrum of intended aircraft uses are identified as:

- Close Air Support (CAS)
- Quick Reaction Strike on Volatile Targets (QRS)
- Mass Movement Interdiction (MMI)
- Preplanned Attack on fixed, heavily defended targets (PPA)

Each of these missions is detailed in terms of phases, events and the tactical environment as these relate to navigation avionics system operation. A typical example of the level of detail is shown in Fig. 2.1-1 and Table 2.1-1 which are the mission profile and mission phase table relating to the Close Air Support Mission. Various aspects of the mission profile and phase table data will later be used by the system analyst in the process of synthesizing mission-capable avionics suites. Mission phase and phase duration data will be used as direct inputs to the Standardization Evaluation Program (STEP).

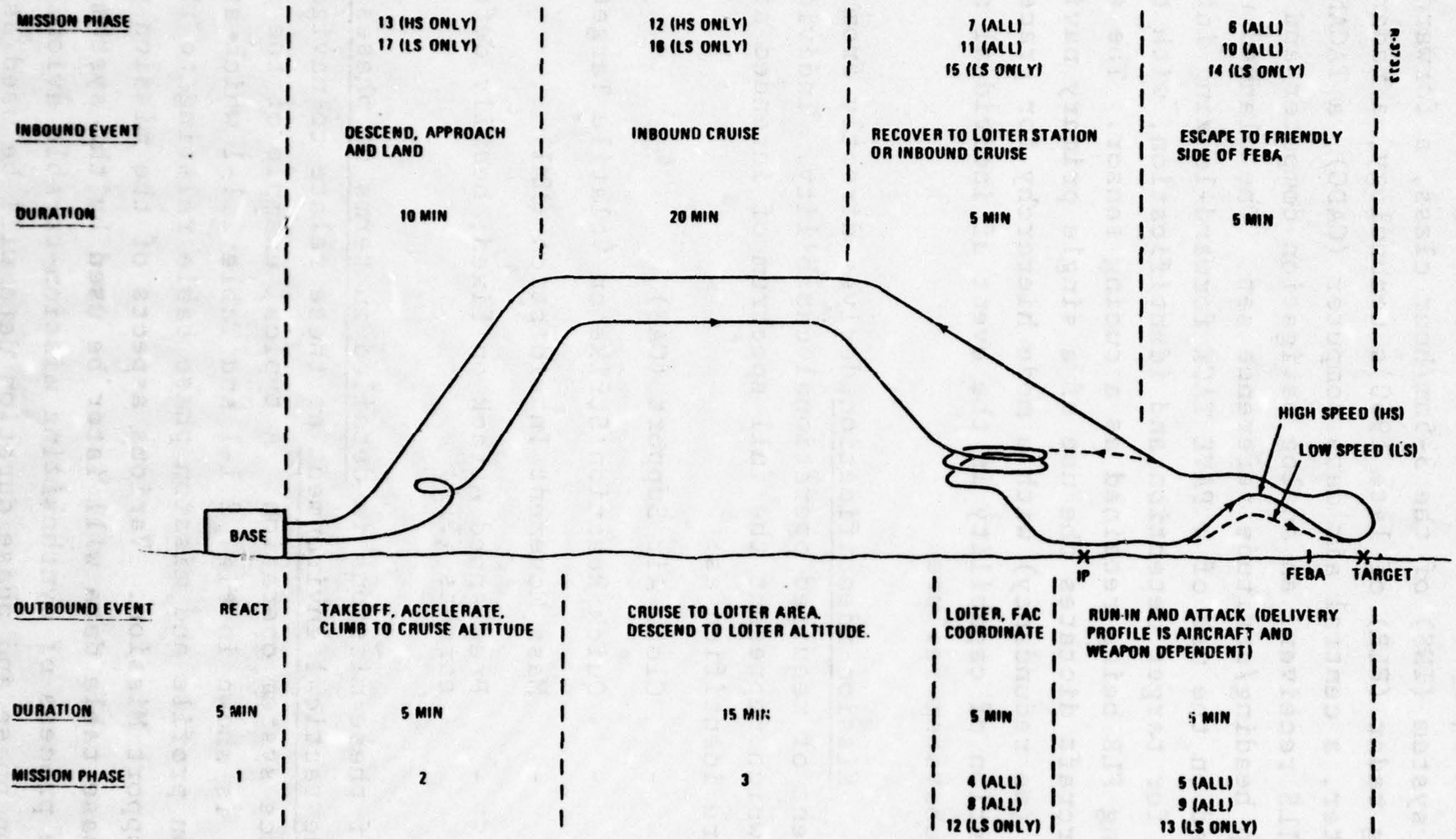


Figure 2.1-1 Attack-Close Air Support Mission (Mission Profile)

TABLE 2.1-1

ATTACK-CLOSE AIR SUPPORT MISSION (MISSION PHASE TABLE)

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MISSION PHASE / CHARACTERISTIC	1. PREFLIGHT	2. TAKEOFF, TURN, CLIMB	3. CRUISE TO LOITER AREA. DESCEND.	4. 8. 12.(LS) LOITER	5. 9. 13.(LS) RUN-IN AND ATTACK	6. 10. 14.(LS) ESCAPE	7. 11. 15.(LS) RECOVER	12.(HS) 16.(LS) INBOUND CRUISE	13.(HS) 17.(LS) DESCEND, APPROACH AND LAND.
Duration	5 min	5 min	15 min	5 min	5 min	5 min	5 min	20 min	10 min
Events	Startup, Power on, Funct. Checks, Nav System Align (BATH or Stored Hdg). Taxi.	Flight functional checks	Tactical Nav	Coordinate with FAC. (Exploit Nav. System update possibilities)	Low level (T.F. or T.A.) run in. (Formation on FAC leader). Pop up for target acquisition/ attack	Low level flight. Tactical Nav.	Tactical Nav. Regain Altitude	Tactical Nav. to Base Area	Possibility of letdown and landing without radiating ground aids. Diversion possibility
Aircraft Velocity High Speed CAS / Low Speed CAS	–	250-300 kt	500 kt 350 kt	350 kt 300 kt	450-550 kt 325 kt	450-550 kt 350 kt	350 kt 300 kt	500 kt 350 kt	450 kt → 150 kt 300 kt
Meterological Conditions									
Interim Capability (min.)	IMC	IMC	IMC/VMC	>3000 ft/3 nm	>3000 ft/3 nm	>3000 ft/3 nm	>3000 ft/3 nm	IMC/VMC	IMC
Capability Objectives	IMC	IMC	IMC	>250 ft/0.25 nm	>250 ft/0.25 nm	>250 ft/0.25 nm	IMC	IMC	IMC
Induced Environment:									
Altitude	Base at S.L. to 5000 ft	To 25,000-30,000 ft	30,000-3,000 ft	3,000 to 5000 ft	L.S. 200 to 3000 ft H.S. 200 to 5000 ft	100 to 300 ft	To loiter or inbound cruise altitude	25,000-30,000 ft	Base at S.L. to +5000 ft
Attitude	Level	±60° Roll. 0 to +30 Pitch	±40° Roll ±20° Pitch	±45° Roll ±20° Pitch	±90° Roll ±45° Pitch	±90° Roll ±30° Pitch	±45° Roll 0 to ±30° Pitch	±40° Roll ±20° Pitch	±60° Roll. 0 to -20° Pitch
RMS Vibration	Negligible	3g	2g	2g	5g	5g	2g	2g	3g
Normal Accel (Max)	1g	2g	1.5g	1.5g	5g	5g	2g	1.5g	2g
Geographic	Base Lat: 70°N to 70°S Base Long: Any	All Flight overland within 250 nm radius of base							Base Lat: 70°N to 70°S. Base Long: Any
Tactical Environment	Cooperative	Cooperative	Coop / Disputed (Fighter)	Disputed (Fighter)	Disputed (Fighter) / Hostile AAA/SAM	Hostile AAA/SAM	Disputed (Fighter)	Cooperative	Cooperative
Availability of External Navigation Aids:									
Invulnerable	–	GPS, JTIDS	GPS, JTIDS	GPS, JTIDS	JTIDS (Attack Sensors)	JTIDS	GPS, JTIDS	GPS, JTIDS	GPS, JTIDS
Limited or Vulnerable	–	VOR/TAC, Ground Control Comm., Loran	VOR/TAC, Loran	VOR/TAC, Loran	GPS, Loran	GPS, Loran	VOR/TAC, Loran	VOR/TAC, Loran Ground Control Comm.	Loran, VOR/TAC GCA, ILS, ADF

The mission capability objectives outlined in the statement of required operational capability are translated into a set of dominating demands on the navigation system, as follows. The horizontal navigation position accuracy demands are dictated by the required ability to direct the PAVE TACK FLIR from on-board navigation data, so that the target will appear in its field of view. This ability must be retained at the point of deepest penetration into hostile territory where adversary ECM may deny the penetrating aircraft the use of radio navigation aids and compromise the effectiveness of the FLR. Aircraft groundspeed and vertical velocity are also primary outputs of the navigation system; their accuracy requirements are dictated by delivery CEP demands for conventional, low-drag bombs, although the previously mentioned PAVE TACK FLIR target acquisition requirements effectively create a more stringent, implicit groundspeed accuracy requirement on most realizable navigation systems. Aircraft attitude information also emanates from the navigation system and its accuracy is dominated by the need to provide accurate stabilization on target of the beam of the PAVE TACK laser designator/ranger throughout evasive maneuvers of the aircraft during attack. Finally, the vertical position (altitude) requirement is established by the need for accurate height above target in the radar offset bombing mode which will be retained for missions conducted by the aircraft when it is not carrying PAVE TACK equipment. In conclusion, it must be noted that these navigation system requirements have to be met under strict preflight reaction time constraints and that degraded mode capability is valuable under many circumstances and must be optimized where possible.

The existing navigation system on the aircraft is not adequate for the new mission requirements and retrofit of the navigation avionics on this aircraft enters into the standardization evaluation problem as one of a number of avionics installation/retrofit programs projected for execution within the time frame covered by the standardization potential study. The example will be further pursued in Section 3 of this report where mission-capable avionics suite synthesis is discussed.

It is evident that the analyses discussed in this section do not lend themselves to on-line computer solution within a standardization evaluation program. For this reason the standardization evaluation methodology has been constructed to use the talents of the system analyst to their full extent in off-line analyses of system requirements while providing him with a computerized tool for the assessment of his deliberations in terms of cost-effectiveness.

2.2 MISSION ANALYSES FOR SPANS

2.2.1 Mission Profiles and Phase Tables

Twenty-three (23) representative missions have been detailed in the SPANS program, covering Air Defense/Superiority, Tactical Attack, Forward Air Control, Electronic Warfare, C^3/AWACS, Reconnaissance, Cargo/Transport, Tanker and Strategic Attack Aircraft. These missions have been amalgamated into sixteen (16) representative mission profile/phase table sets as follows:

- **Air Defense, Point Intercept (ADPI). Air Defense/ Superiority.**
- **Escort Intercept (EI). Air Defense/Superiority.**
- **Advanced Penetration Fighter (APF). Air Defense/ Superiority.**
- **Close Air Support (CAS). Tactical Attack.**

- Quick Reaction Strike (QRS). Tactical Attack.
- Preplanned Attack (PPA)/Mass Movement Interdiction (MMI). Tactical Attack.
- Defense Suppression (DS)/Target Designation (TD)/ Penetration Escort (PE). Tactical Attack (DS and TD) and Electronic Warfare (PE).
- Forward Air Control (FAC)/Shuttle Escort (SE). Forward Air Control (FAC) and Electronic Warfare (SE).
- Barrier Standoff (BS)/C^3-AWACS (C^3). Electronic Warfare (BS) and C^3-AWACS (C^3).
- Quick Strike Reconnaissance (QSR). Reconnaissance.
- Battlefield Surveillance (BSR). Reconnaissance.
- Intratheater Transport (IST). Cargo/Transport.
- Intertheater Logistics Transport (ILT). Cargo/ Transport.
- Tanker, Strategic (TS)/Tanker, Tactical-Airlift (TTA). Tanker.
- Strategic Bomber, Penetration (SBP). Strategic Attack.
- Strategic Bomber, Standoff (SBS)/Cruise Missile Carrier (CMC). Strategic Attack.

2.2.2 Avionics Requirements Analyses

Requirements imposed on the navigation systems of aircraft assigned to the listed missions have been derived during the SPANS program. As indicated in the example presented in Section 2.1, these requirements are strongly affected by factors external to the navigation system such as concurrent target acquisition sensor capabilities (e.g., the PAVE TACK FLIR), availability and ECM susceptiblity of cueing sensors, weapon type and delivery requirements, compliance with civil aviation regulations and emergency war order (EWO) conditions and requirements to operate in adverse meteorological conditions.

SECTION III
EQUIPMENT QUANTITY AND TYPE PROJECTIONS

3.1 FORCE STRUCTURE AND AVIONICS INSTALLATION/RETROFIT PROJECTIONS

Standardization evaluations across multiple aircraft programs require input figures for the quantity of each aircraft type subject to avionics installation or retrofit in the time frame covered by the study. This is necessary to provide proper weighting of the effects of decisions to standardize on equipment. The intended use of a standard equipment on 1500 tactical fighters clearly carriers more weight in potential cost savings than the decision to use the same piece of equipment on 50 electronic warfare aircraft.

Thus the definition of the force structure dynamics is a necessary input to the standardization evaluation program. Together with the force sturcture it is necessary to identify the occurence of avionics installation/retrofit requirements and/or opportunities for the various aircraft types and the times at which they occur. Data of this type is available from various USAF planning documents. However these tend to reflect only those programs in which a ROC has been approved, a Program Management Directive issued and, frequently, a specific type of equipment is already envisioned for installation or retrofit on the affected aircraft.

<u>It is a required characteristic of the standardization evaluation methodology described herein that it shall be useable to explore the cost-effectiveness impacts of alternative avionics installation/retrofit options that are open to</u>

decision-makers in the future. For this reason, a broader view of the future force structure and the avionics equipment options is necessary, a view that is not tied down to established near-term programs, although these may form important subsets of the overall situation to be evaluated.

With this requirement in mind, a generalized force structure was constructed for the SPANS program consisting of all aircraft types whose numbers in the projected USAF inventory exceeded 30 aircraft in the 1980-1991 time frame and in which a navigation avionics installation or update was considered desirable as a result of mission capability objective analyses. This generalized force structure was used as a guide to identify possibilites of future demand for new navigation avionics rather than as a statement of USAF intentions in that area. The USAF authorized and planned navigation equipment installation/retrofit programs became a reference subset for the SPANS study since these programs affect the baseline analysis conditions and, in some cases, themselves represent the initialization of standardization programs.

3.2 AIRCRAFT TO MISSION CORRELATION; DEPLOYMENT AND USAGE

The mission completion success computations conducted in the STEP program require the input of mission phase and duration data for the calculation of equipment failure probabilities during the mission. Since STEP conducts its evaluations by aircraft type, it requires not only mission phase data, but also a statement of which missions each aircraft type will experience in operational use. Multimission aircraft are becoming increasingly evident in the USAF inventory and projections of the percentage use of each such aircraft type in the missions defined in Section 2 of this report were also included in the generalized SPANS Force Structure

Aircraft deployment data of two distinct types is required by STEP:

(1) The number of aircraft of each type located in bases in the Continental USA (CONUS) and Overseas, together with the number of bases in each location and the number of aircraft of the given type at each base.

(2) Data indicating the occurrence of colocation of aircraft of more than one type at a given base.

The former is used in computing the (different) logistics support costs associated with CONUS operation and overseas operation and in the determination of support equipment requirements for the avionics equipment on the given aircraft type. The latter is used to modify the cost of support equipment at the given base when the program identifies the existence of a common (standard) piece of equipment on different types of aircraft colocated at that base. This modification reflects the economies effected by provision of a single type of support equipment to service the standard equipment on all aircraft at the base. The allocation of aircraft to bases in CONUS or overseas is covered in the SPANS Force Structure.

The aircraft usage rate is also an important factor in the determination by STEP of the logistics support costs for avionics suites in field service. Typical numbers for missions per month for each aircraft type in the Force Structure have been collected from historical records for the purposes of the SPANS program.

3.3 AIRCRAFT TO MISSION-SPECIFIC SENSOR CORRELATION

Mission-specific sensors in the context of this report are sensors that use data from the avionics system under study to accomplish a stated mission objective. They play a large part in determining the types of mission on which an aircraft will be used. Typical of these devices are the various tactical target acquisition sensors, presently in use or planned for use by the USAF, that require navigation and reported target location data for initial target contact. In the Strike Control and Reconnaissance (SCAR) area, mission-specific sensors frequently dictate the performance capabilities required of the navigation systems in both the target location reporting (reconnaissance) aircraft and the strike aircraft. Thus it is necessary to know of the existence (or projected existence) of such sensors on the aircraft included in the force structure and the demands they place on the on-board navigation system capabilities in order to embark on the navigation suite synthesis process.

The numerical preponderance of tactical reconnaissance and attack aircraft in the present and projected USAF Force Structure lends considerable weight to the importance of this aspect of the SPANS study and a sizeable proportion of the SPANS work has been devoted to:

- Determination of the characteristics and operational use procedures of the various reconnaissance, cueing and target acquisition sensors proposed for use in present and future USAF tactical aircraft.

- Allocation projections relating mission-specific sensors to aircraft.
- Determination of the navigation requirements imposed on the on-board system by the various mission-specific sensors.

The allocation projections are included in the SPANS Force Structure. The requirements imposed on the on-board navigation systems by the various mission-specific sensors must also be considered when performing SPANS analyses.

3.4 AVIONICS TECHNOLOGY PROJECTIONS

3.4.1 Technology Data Base Requirements

The nature of the building blocks that will be available at any point in time for the construction of mission-capable avionics suites is a central subject of study in any standardization evluation program. Starting with the identification of applicable technologies and their basic capabilities (and limitations), the standardization evaluation methodology requires further definition of the characteristics of the avionics equipment that represents (or will represent) the physical embodiment of those technologies in USAF aircraft.

In problems that involve the design of avionics systems from subsystems, the system synthesis process can be conducted at the functional level. That is, it is only necessary to know the functions that generic types of subsystems can be expected to perform, together with any synergistic system advantages that may be available from the use of two or more complementary subsystems. With the advent of airborne digital computers of vastly increased capacity and speed over previous models and with the growing trend towards standardized avionics data transmission systems for future military aircraft (e.g., MIL-STD-1553A Multiplex Data Bus), many issues concerning interface compatibility of future subsystems and availability of adequate computational capacity for system integration can be relegated to the status of secondary considerations in the initial process of avionics suite synthesis.

To illustrate with GPS as an example: it is possible to construct a "Generic Technology" summary of GPS capabilities which describes (to a sufficient level for 'functional' system synthesis) the service introduction schedules for the satellite system, the coverage provided over the Earth's surface, the levels of position and velocity accuracy obtainable with different classes of receiver, probable accuracy degradations resulting from aircraft maneuvers, vulnerability to jamming (in terms of distance from an adversary jamming facility), desirable symbiotic relationships with other airborne navigation functions (e.g., GPS-INS integration) and estimated size, weight, power and availability dates for the user equipment. At this point of application of the methodology, avionics suite synthesis is conducted using (where applicable) generically described GPS receivers (e.g., high accuracy, jam-resistant for highly maneuverable aircraft).

However, further definition of the characteristics of the component subsystems of each avionics system is required for the operation of STEP and for the identification of potential areas of standardization across avionics systems or subsystems. Thus STEP requires input statements describing the composition of the selected subsystems (number of LRUs, number of SRUs per LRU and number of piece parts in each LRU). In the case of navigation avionics a further descriptor of technology type is required to enable the program to distinguish between the different cost learning curve characteristics historically associated with electronics, radar and inertial equipment. STEP also requires baseline acquisition cost and reliability (failure rate) figures for the equipment selected for use in the synthesized avionics suites together with data on current production quantities (if any) and accumulated operating hours in service use. Development cost estimates will be required for equipment not currently in production. Finally, cost, quantity and usage rate data is needed for the support equipment required by the selected subsystems at both 'I' Level and at the depot.

The system analyst also requires access to some of this higher-definition data on available equipment in order to be able to accurately identify opportunities for the use of standard elements across several avionics systems. This need arises in two particular situations:

(1) That in which the possibility of widespread use of a standard module across several avionics subsystems exists (e.g., a standard power supply module, IF amplifier or memory card)

(2) That in which retrofit of an advanced avionics subsystem into an existing aircraft creates a demand for special interface equipment because of the older nature of the power and data transmission and retained avionics equipment on the aircraft.

Although the latter situation is of diminishing concern, due to the increased use of functional specifications for subsystems, local (distributed) digital processors within subsystems, standard digital data transmission systems and centralized avionics computers, it still represents a cost penalty that must be recognized when postulating retrofit of new, standardized equipment on some older aircraft undergoing conversion for improved mission capability.

3.4.2 SPANS Technology Data Base

In the course of the SPANS program, a technology data base was developed covering navigation subsystems currently installed in USAF aircraft or projected to become available for installation within the time frame covered by the study. The data base was developed in two phases, the first phase being aimed at establishing generic classes of equipment and their capabilities (accuracies, reaction times, coverage, jamming/maneuver susceptibility, etc.) for initial navigation system synthesis, and the second at defining specific user equipment in sufficient detail for the identification of standardization options and the use of STEP (number of LRUs, SRUs, piece parts, costs, failure rates, etc.). Since the major objective of the reported phase of the SPANS program was the verification of the STEP methodology through its use to evaluate standardization benefits for high-cost alternative equipment in future navigation systems, only that high-cost equipment was described at the detailed level. Nominal cost and reliability data was used for the elements of the synthesized navigation suites that were not subject to standardization evaluation. This approach does not place any constraints on the system analyst in the navigation suite selection process. For example, he is at liberty to select a navigation suite for a particular aircraft employing an inertial navigation system, a doppler radar set and an attitude and heading reference set as a primary navigation equipment alternative to two inertial navigation systems, as long as mission requirements are satisfied. If the subsequent standardization analyses are concentrated on evaluating the benefits of using a standard inertial navigation system on the subject aircraft and several other aircraft in the USAF inventory, the doppler radar set and the attitude reference equipment need only be represented by nominal cost and reliability data.

TABLE 3.4-1
NAVIGATION SUBSYSTEM DATA BASE

SUBSYSTEM	USER EQUIPMENT DETAIL	USER EQUIPMENT NOMINAL DATA	REPRESENTATIVE EQUIPMENT
RADIO NAVIGATION			
TACAN		✓	AN/ARN-84, AN/ARN-118 (STANDARD)
LORAN	✓		AN/ARN-92; AN/ARN-101
OMEGA	✓		AN/ARN-131
GPS	Functional Only	✓	Class A, B and C receivers.
JTIDS	Functional Only		AN/URQ-28, AN/ARC-181, AN/USQ-72
VOR/ILS		✓	AN/ARN-108
UHF/DF		✓	AN/ARA-50, DF-301E, DFA-70
RADAR NAVIGATION			
RADAR (GROUND MAP)		✓	AN/APN-59, AN/ASQ-120
DOPPLER RADAR	✓		AN/APN-194, AN/APN-190, Common Strategic Doppler (2)
RADAR ALTIMETER		✓	AN/APN-133, AN/APN-155
SELF-CONTAINED NAV.			
INS (High Precision)	✓		AN/ASN-131, N-73
INS (Moderate Accuracy)	✓		SKN-2400, LN-30 (Series), LINS, Carousel IV, V, N-16
INS (Low Accuracy)	✓		H-700, LN-12, AN/ASN-90(v)
Att/Hdg. Ref. Systems		✓	AHARS, Standby AHRS
Air Data Systems		✓	Generic CADC, DADC, Fighter ADS
Compass Systems		✓	N-1
Airborne Computers:			
• Fire Control	✓		Delco MAGIC 362 (F-16)
• NWDC (Integration)	✓		IBM 4π (TC-2)Series

The navigation subsystem data base used in the SPANS program is outlined in Table 3.4-1. Generic capability data was obtained for all of the subsystems listed.

3.5 AVIONICS SUITE SYNTHESIS

3.5.1 The General Situation

In its "Design to System Performance/Cost" (DSPC) mode of operation, the STEP program evaluates avionics suite alternatives nominated by the system analyst for a particular aircraft type to produce Mission Completion Success Probability (MCSP) and life-cycle cost figures for the "best" (upper boundary) of the nominated alternatives. This process places few constraints on the system analyst in his selection of alternative avionics suites. In practice, however, the alternative suite synthesis process is constrained by the need for mission responsiveness and by the available technology at the projected time of installation or retrofit of new equipment. A number of less evident but equally important constraints is usually operating to reduce the suite alternative selections even further, such as the desire to retain existing subsystems (where possible) to minimize costs of conversion, mandates on the use of existing standard subsystems of proven reliability and utility, retention of growth potential for further system enhancements at a later date and the final constraint imposed by airframe obsolescence.

A typical, general situation is represented in Fig. 3.5-1, which relates to the navigation avionics retrofit requirements for a tactical aircraft type in the USAF inventory previously discussed in Section 2. In this example, an immediate upgrading of the aircraft navigation system is required to

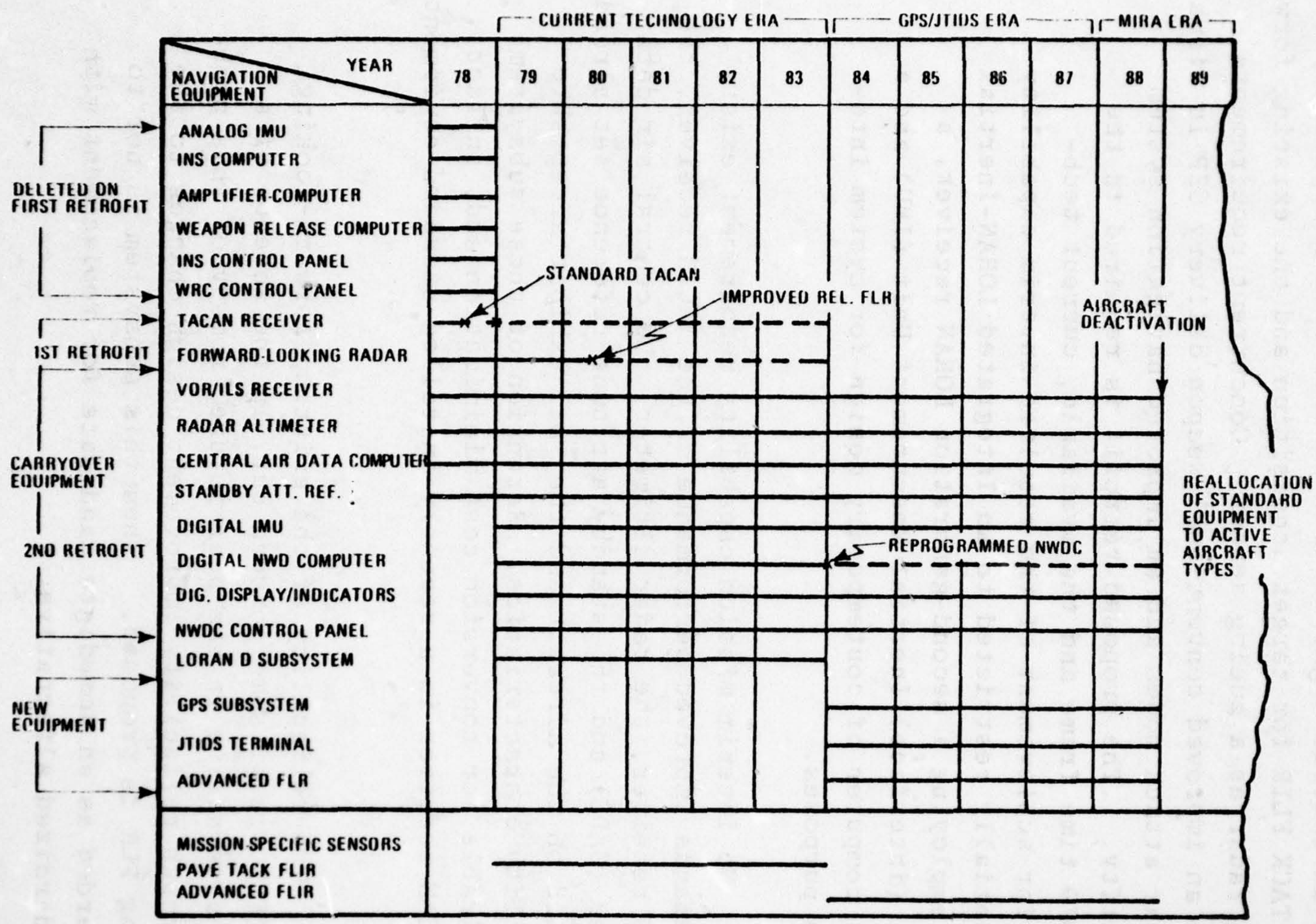

Figure 3.5-1 General Retrofit Situation for a Single Aircraft Type

provide an interim night/adverse weather attack capability using a PAVE TACK FLIR for target acquisition and the existing forward-looking radar as a cueing sensor. Concurrent requirements include an improved conventional weapon delivery CEP in visual and radar attack modes and an improved navigation system reliability. The proposed retrofit is required in the 1978-1979 time frame and the available, current technology for achievement of the required interim capability is essentially restricted to an Integrated LORAN-Inertial System employing a second-generation LORAN receiver, a digital (interface) Inertial Measurement Unit (IMU) and a digital computer of contemporary design for system integration purposes.

No interim mission capability requirement exists that demands improved performance of the TACAN receiver, the VOR/ILS receiver, the radar altimeter, the central air data computer (CADC) and the standby attitude reference set already installed on the aircraft and they all exhibit acceptable reliability characteristics. Retention of these subsystems is desirable for conversion cost minimization and, in fact, the TACAN receiver is a recently installed standard equipment type.

The reliability of the existing forward-looking radar (FLR) is of some concern but, in the absence of a proven alternative in the near future, remedy of this problem through reliability improvement design changes to the existing FLR is proposed. Thus this subsystem is not to be regarded as an immediate candidate for replacement with a standardized alternative.

Thus the navigation suite synthesis process for the first retrofit program depicted in Fig. 3.5-1 is conducted under constraints that result in only one viable system configuration. Of course, several different candidate equipments exist that could fill the roles of the various subsystems (LORAN, IMU and Navigation Computer), and the STEP program operating in the DSPC mode can be used by the system analyst at this juncture to obtain quantitative values for the life-cycle cost and mission completion success probability of navigation suites synthesized from various combinations of candidate equipment. STEP will provide this data on the "best" combinations of equipment, that is, those combinations whose MCSP-LCC characteristics define the upper bounding curve of the complete MCSP-LCC map. As will be described in Section 4 of this report, the use of retrofit equipment that is effectively standard in nature (i.e., it has a prior use history in the USAF) in the synthesized navigation suite must be recognized in the equipment description inputs to the STEP program when it is used in this manner.

A second retrofit of navigation equipment for this aircraft type is indicated in the 1984-85 time period when a further upgrading of mission capability is made possible by the projected availability of new technology navigation and target acquisition equipment, notably GPS receivers, JTIDS Class II terminals, advanced (doppler beam-sharpened) forward-looking radars and advanced FLIRs. A considerable payoff in successful target acquisition and attack probabilities is predicted to result from the provision of a very high precision navigation system on the aircraft at this retrofit.

The second retrofit possibility creates the kind of general situation that must be manageable using the standardization evaluation methodology, in that it impacts decisions made in the avionics suite synthesis process associated with the first retrofit. In particular, it creates the additional consideration that equipment selected for the first retrofit must be chosen with growth potential in mind so that a navigation system responsive to future capability requirements can be synthesized at minimum overall cost during the second retrofit.

Usually, the minimum overall cost path equates with maximum retention of existing equipment in the second retrofit, but the system analyst must be sensitive to situations in which this is not the case. For example, in the case under discussion, a relatively small forward shift of the development and production schedule of the Standard Precision Navigator (GEANS) would have made it a candidate for incorporation in the first retrofit, thereby creating the situation in which two alternative retrofit paths were open:

(1) Provision of a moderate accuracy digital IMU with a LORAN receiver at the first retrofit, followed by replacement of the LORAN subsystem with a high-accuracy, jam-resistant GPS receiver in the second retrofit

(2) Installation of a Standard Precision Navigator in the Integrated LORAN-Inertial System at the first retrofit and abolition of the need for the second retrofit.

It is not automatically evident that the second option (which would imply a full retention of the on-board equipment at the time of the second retrofit) would be a better overall cost deal than the first, because of the different costs of the IMUs involved and the different mission capabilities represented by the alternative systems.

It is clear from this discussion that the timing of events relating to avionics retrofits is a critical factor in real-world decisions relating to the synthesis of mission-responsive avionics suites, the overall cost of successive retrofits and the feasibility of creating and using standardization equipment in airframes of extensive longevity.

The importance of the timing element has led to the organization of STEP to evaluate avionics installation and retrofit programs in chronological order for the purposes of standardization benefit analyses across a force structure of aircraft types, as indicated in Fig. 3.5-2. The adoption of this pragmatic approach was influenced by three considerations:

(1) It is just as necessary (sometimes more necessary) to obtain a required interim mission capability in the near future as it is to plan for an ultimate mission capability further downstream in a new technological era.

(2) The degree of confidence associated with decisions based on current technology is higher than that associated with those based on future technology projections.

(3) The number of technological and mission-related variables associated with the determination of the content of evolving avionics suites for future mission capability is too large to allow a formal, a posteriori optimization program to be embedded within the standardization evaluation program.

Suite optimization is therefore regarded as the province of the system analyst and is conducted through offline studies associated with the avionics suite synthesis activity.

Referring back to Fig. 3.5-1, the second retrofit of the avionics system, shown in the 1984-85 time period, occurs after a technology transition that places several new types of equipment at the designer's disposal, notably elements of an advanced Communications, Navigation and Positioning Integration

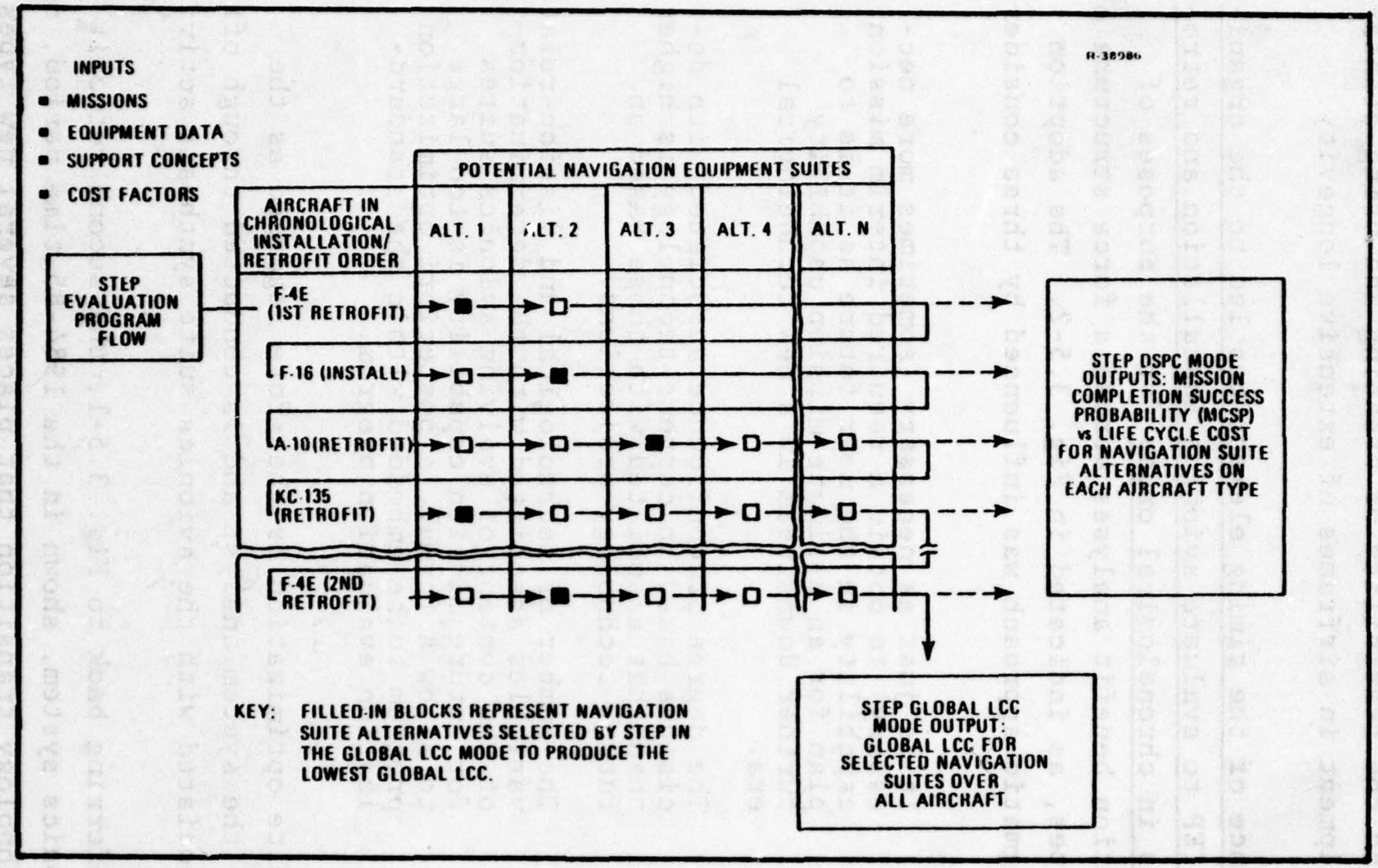

Figure 3.5-2 Chronological Ordering of Aircraft Programs for Standardization Analysis

(CNPI) System (a GPS subsystem, JTIDS user terminal and inertial navigation subsystem) and an advanced forward-looking radar (probably of the Doppler beam-sharpened type). Several alternative mission-capable navigation suites can be synthesized from combinations of the existing and the new equipment at this juncture (only one of which is shown in Fig. 3.5-1). As indicated in Fig. 3.5-2, the STEP program will evaluate the life-cycle cost and MCSP characteristics of those alternatives as a separate program from the first retrofit and in correct chronological order with all of the other aircraft avionics installation/retrofit programs that are considered in the study. The present version of STEP requires the system analyst to indicate what equipment is carried over from the previous avionics complement of the aircraft type (after the first retrofit) through zeroing of inputs affecting acquisition cost, technical orders, etc. Automatic recognition of carryover can be included as an extended capability.

3.5.2 Redundancy and Mission Failure Impact Matrices

Mission requirements are, in general, stated in terms of both performance and Mission Completion Success Probability (MCSP), the latter being a measure of the survivability of the aircraft and its component systems during a defined mission in the absence of hostile action (i.e., mission reliability). Thus the design of any avionics system must be conducted with both performance and mission reliability objectives in view. In the case of tactical aircraft of limited size, and limited mission duration, the space constraints on on-board equipment usually force avionics system design into the use of a set of single, complementary subsystems that are interconnected in such a way as to provide a primary mode of operation (when all subsystems are operating correctly) and a hierarchy of secondary modes, ordered to provide a graceful degradation of mission capability when individual systems fail. The final mode is usually configured around the use of simple, backup (or standby) equipment that is functionally separate from the main avionics system and provides only for safe return to base.

In the case of larger aircraft with longer missions, equipment redundancy is frequently used as a means of achieving MCSP objectives. Such redundancy clearly has an effect on equipment standardization evaluations since it affects the numbers of equipments of a given type that have to be procured to meet future requirements (for example, use of a standard INS on 70 C-5As in a triply-redundant INS system carries the same weight in standardization evaluations as the use of a single standard INS on 210 tactical fighters). As a result, equipment redundancy options and requirements must be recognized in the avionics suite synthesis process of the standardization evaluation methodology and also incorporated in the MCSP computations of STEP where it occurs. The "Design to System Performance/Cost" (DSPC) methodology on which STEP was based allows evaluation of both the MCSP and the LCC of systems utilizing redundant equipment. This facility has been retained in the DSPC mode of STEP and can, in fact, be used to provide the system analyst with a determination of the need for equipment redundancy to meet MCSP objectives when that situation arises.

The final requirement of the evaluation methodology in the avionics suite synthesis area lies in providing inputs to STEP that describe the impact of equipment failure during any phase of the mission on mission failure probability. These inputs are best represented as a matrix of equipment operating times during each mission phase and mission failure probabilities that result from the failure of any piece of equipment during any mission phase. A typical example (for the tactical fighter used for illustration throughout this report) is shown in Table 3.5-1. The mission used for demonstration is the Close Air Support Mission (High Speed Aircraft) detailed by the mission profile and phase table presented in Section 2.2 of this report. A visual attack with unguided weapons is postulated, in which the forward-looking radar is used to provide slant range to target during weapon delivery. It should be noted in passing that all thirteen mission phases are included in the failure impact matrix although only events occurring in those preceding the second attack (9 phases) affect MCSP. This is because equipment failures occurring during escape and return to base do impact LCC for the system. Also, the failure probabilities are computed on the basis that only the subsystem under consideration experiences a failure and all of the other subsystems constituting the avionics suite operate within specification throughout the mission.

The mission failure impact matrix can be used as a mechanism for introducing more comprehensive mission effectiveness measures than MCSP (mission reliability) into the evaluation, but this requires extensive, off-line equipment failure effects analyses that did not appear to be justifiable in the context of the initial standardization evaluation studies. Thus the matrix of Table 3.5-1 has been constructed so that a mission completion success probability (MCSP) of 1.0 results if all subsystems survive the mission, and subsystem failure is regarded as an event which takes the affected subsystem completely out of operation. In the real-world, the probability of target kill (which is a much more satisfactory measure of mission effectiveness) is certainly less than 1.0 even if all subsystems survive the mission; it depends, in the first instance, on subsystem design performance capabilities and is

TABLE 3.5-1

DUTY CYCLE/FAILURE IMPACT MATRIX FOR CLOSE AIR SUPPORT MISSION

		MISSION PHASE											
		1		2		3		11		12		13	
1	TACAN RECEIVER	5	0	5	0	15	0	5	0	20	0	10	0
2	FORWARD-LOOKING RADAR	0	1.0	3	1.0	15	1.0	0	0	0	0	10	0
3	VOR/ILS RECEIVER	0	0	3	0	15	0	0	0	20	0	10	0
4	RADAR ALTIMETER	0	1.0	3	1.0	0	1.0	0	0	0	0	0	0
5	CADC	5	1.0	5	1.0	15	1.0	5	0	20	0	10	0
6	STANDBY ATT. REF.	5	1.0	5	1.0	5	1.0	5	0	20	0	10	0
7	DIGITAL IMU	5	1.0	5	1.0	15	1.0	5	0	20	0	10	0
8	DIGITAL COMPUTER	5	1.0	5	1.0	5	1.0	5	0	20	0	10	0
9	DISPLAY/INDICATORS	5	1.0	5	1.0	5	1.0	5	0	20	0	10	0
10	COMPUTER CONTROL	5	1.0	5	1.0	5	1.0	5	0	20	0	10	0
11	LORAN D SUBSYSTEM	5	1.0	5	1.0	5	1.0	5	0	20	0	10	0

NOTE: FIRST TABULAR ENTRY IS OPERATING TIME OF EQUIPMENT i IN MISSION PHASE k, SECOND ENTRY IS PROBABILITY OF MISSION ABORT IF EQUIPMENT i IS LOST IN MISSION PHASE k.

affected by the graceful degradations of performance that characterize the "failure" patterns of some of the subystems (e.g. increased gyro drift in the INS, heightened sensitivity to ground clutter in the FLR or higher-than-normal temporal errors in the LORAN time difference grid).

The mission failure probabilities shown in Table 3.5-1 are simply statements of the probability that mission abort will ensue from catastrophic subsystem failure at any phase of the mission. Given the objectives of the standardization evaluation program, the methodology chosen and the current state of development of the tool, they are regarded as being satisfactory first-order approximations to the ultimately desirable mission effectiveness measures.

SECTION IV

STANDARDIZATION EVALUATION PROGRAM (STEP)

The Standardization Evaluation Program (STEP) is the analytic tool supporting the SPANS approach to standardization analysis. STEP was developed by TASC to perform the required studies for the initial SPANS contract (Ref. 1), and was subsequently documented and delivered to the Air Force. An overview of the inputs to STEP, its outputs, and the interface of STEP with the system analyst is shown in Fig. 4-1. The remainder of this chapter is devoted to a discussion of the rationale underlying STEP, a summary of the STEP methodology, and examples of STEP application to a variety of questions concerning avionics planning.

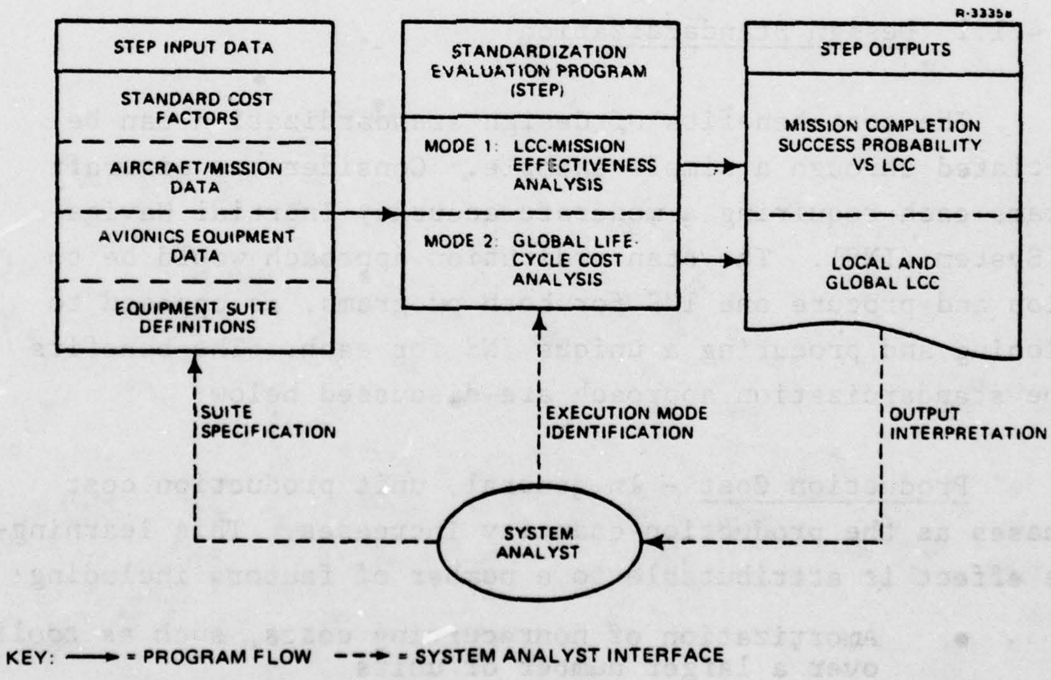

Figure 4-1 Overview of STEP

4.1 COST REDUCTION ASPECTS OF STANDARDIZATION

The benefits of standardization have been touted frequently, but almost always in purely qualitative terms. STEP represents a means of quantifying these benefits and hence comparing standardization alternatives or lending credibility to specific equipment standardization programs. By definition, standardization implies the consideration of more than one aircraft program and, in the same sense, the associated cost benefits are identifiable only over multiple aircraft programs. While STEP is oriented toward quantifying these benefits for the case of design standardization, i.e. utilization of the identical equipment designs on multiple programs, it may also be used to analyze several Form, Fit, and Function (F^3) standardization issues concerning cost.

4.1.1 Design Standardization

The cost-benefits of design standardization can be appreciated through a simple example. Consider two aircraft programs each requiring a moderate accuracy Inertial Navigation System (INS). The standardization approach would be to develop and procure one INS for both programs, as opposed to developing and procuring a unique INS for each. The benefits of the standardization approach are discussed below:

Production Cost - In general, unit production cost decreases as the production quantity increases. This learning-curve effect is attributable to a number of factors including:

- Amortization of nonrecurring costs, such as tooling, over a larger number of units
- Price discounts from piece-part vendors associated with larger orders

- Increased efficiency of manufacturing labor and procedures as production continues

Fig. 4.1-1 illustrates conceptually the cost benefits of standardization associated with these considerations. Simply stated, standardization permits realization of the lower production costs further down the learning curve.

Reliability Growth - Equipment reliability, as measured by Mean Time Between Failure (MTBF), is a primary driver of spares requirements and maintenance costs for a system. Empirical data (Refs. 2, 3, 4) exist demonstrating that if an equipment reliability improvement program is sustained during operational usage, then MTBF grows with cumulative operating time in the manner displayed in Fig. 4.1-2. This behavior is often referred to as following a Duane model of reliability growth. The implication of this consideration relative to the example is that the standard INS would accumulate operating time at a higher rate than would either of the nonstandard systems. Reliability improves more rapidly as a result and spares requirements and maintenance costs over the operational life of each aircraft decrease.

Initial Logistics - There are a number of cost savings in the area of initial logistics associated with standardization. For instance, suppose that the two aircraft in the example are colocated at some base locations. In the unique INS scenario, two distinct sets of intermediate level support equipment would be required at each of these bases, one for each system. However, in the standard INS scenario, a single set could support both aircraft types at these locations. At these bases there are also potential savings in spares requirements, this being a result of the fact that greater logistics efficiency is achieved with large spares

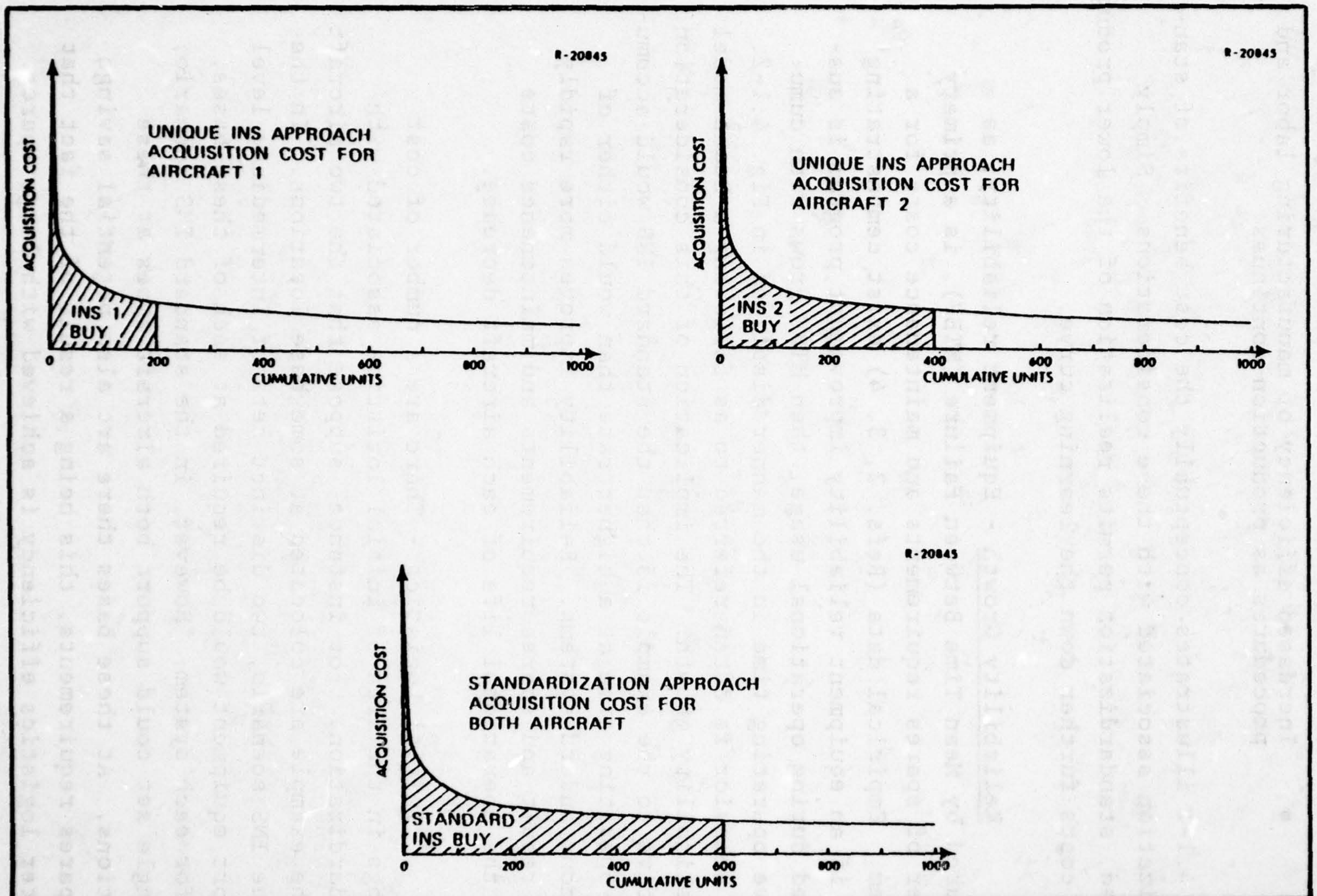

Figure 4.1-1 Standardization Impact on Acquisition Cost - Illustrative Example

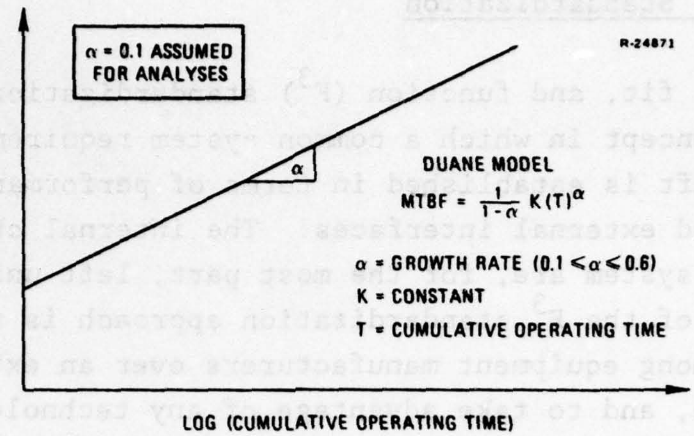

Figure 4.1-2 MTBF vs Cumulative Operating Time

pools of common items than with several smaller pools of unique items. For analogous reasons, overall SE and spares requirements at D-Level are lower under a standardization approach.

Development - System development costs are obviously higher in the absence of standardization. Rather than paying for the development of multiple equipments, the standardization approach requires development of only one. This development cost savings is associated with the system software and support equipment as well as the prime mission equipment.

Other - When an equipment is introduced into the government inventory for the first time, costs are incurred for items such as technical data, manuals, training materials, and contractor support. In general, these costs will not be incurred again, or will be incurred at a much lower rate, if the same equipment is reprocured for a subsequent aircraft program. Thus, these costs, when considered across multiple aircraft, will be lower under a standardization approach.

4.1.2 F^3 Standardization

Form, fit, and function (F^3) standardization is an acquisition concept in which a common system requirement among several aircraft is established in terms of performance, configuration, and external interfaces. The internal characteristics of the system are, for the most part, left unspecified. The objective of the F^3 standardization approach is to promote competition among equipment manufacturers over an extended period of time, and to take advantage of any technological advances that occur in that time span.

The benefits of F^3 standardization lie in the competitive incentive placed on the contractors to achieve as good a cost and reliability for their equipment as is possible, and in the long-range procurement flexibility provided to the Government. Whereas, under the conventional procurement approach, the Government runs the risk of locking itself into the wrong contractor by virtue of its initial decision, the F^3 approach allows the Government to buy initially from multiple contractors, measure the cost and reliability performance of each, and then direct subsequent buys to the best performing contractor. From this perspective, F^3 standardization is a means of risk minimization, or an insurance policy against the potential high costs associated with sole-source procurement.

4.2 AVIONICS SUITE MISSION RELIABILITY CONSIDERATIONS

The SPANS approach to evaluating standardization opportunities is based on the formulation of acceptable avionics suites for aircraft in the USAF force structure, Mission reliability is an important criterion of acceptability. A common measure of mission reliability is the Mission

Completion Success Probability (MCSP), the probability that successful accomplishment of the defined aircraft mission is not precluded by a failure, or combination of failures, in the avionics suite.

If a baseline avionics suite does not satisfy MCSP requirements, there are alternative approaches to improving it. These include switching to higher reliability equipment options for subsystems within the suite, or incorporating redundancy for some of these subsystems. The overall number of such improvement options can be quite large, and consequently the least-cost means of satisfying the MCSP objectives is unlikely to be obvious.

The problem becomes more complicated when standard items for one or more of the subsystems are candidate options. In these cases, the prior production and usage histories of the standard on preceding aircraft programs influence the MCSP and LCC of suites utilizing the standard. Conceivably, a low cost suite alternative could be unacceptable in the event that this was the first application of the standard, but acceptable if the standard had been applied on a preceding program and matured in reliability as a result of this application.

4.3 STEP MODEL REVIEW

A mathematical model is embodied in STEP reflecting the considerations discussed in Sections 4.1 and 4.2. There are two primary aspects to the STEP model:

- MCSP vs LCC evaluation of suite alternatives
- Global LCC evaluation taking standardization into account

These two aspects are summarized in Fig. 4.3-1. The aircraft for which suites are defined are arranged in chronological order of proposed retrofit or installation. Starting with the earliest aircraft, the program evaluates mission effectiveness and life-cycle cost of each avionics suite specified for that aircraft. The appropriate data are extracted from the various data sets to perform these computations. The lowest LCC suite satisfying the mission effectiveness requirement(s) for the aircraft is in effect "selected" for the aircraft. The program steps to the second aircraft in the chronological list and repeats the LCC-mission effectiveness evaluation for its specified suites. However, this evaluation is characterized by one important difference in the nature of the equipment cost and reliability

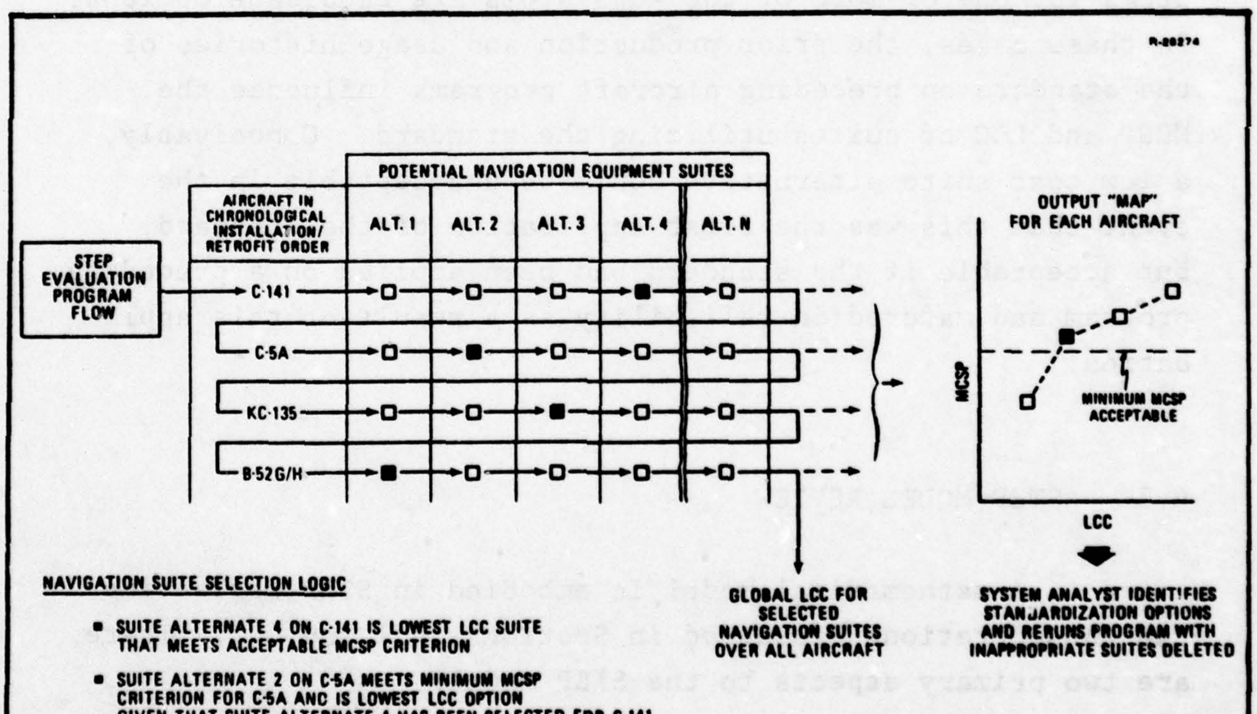

Figure 4.3-1 Standardization Evaluation Program (STEP) Operation

data used. If an equipment item proposed for use on the second aircraft is included in the selected suite of the first aircraft, the program adjusts the cost and reliability figures associated with that item for the second aircraft to reflect the fact that it already has a development and production history.

Suite alternatives for subsequent aircraft are evaluated in a similar manner. In each case the cost and reliability characteristics of selected equipments are updated to reflect the new production and usage projections associated with their selection. The updated values are used in all subsequent LCC calculations. In this manner, the global LCC as computed by STEP reflects the cost benefits resulting from the selection of common equipment items for different aircraft.

4.3.1 Mission Reliability Analysis

Mission reliability analysis over navigation suite alternatives for each aircraft are conducted at the option of the analyst. An existing USAF computer program, the Design to System Performance/Cost (DSPC) model developed by the Directorate of Aerospace Studies at Kirtland AFB (Ref. 5), has been incorporated into STEP for this purpose.

The nature of the DSPC output generated by STEP for each aircraft is illustrated in Fig. 4.3-2. From among the alternatives specified, a sequence of improved suites is identified which are optimal in the sense of achieving different levels of MCSP for the lowest LCC. The lowest LCC suite meeting the MCSP objective is identified and "selected" for the aircraft. If the aircraft flies multiple missions, then the lowest LCC suite meeting all MCSP objectives is selected. The standardization factors associated with each equipment in the selected suite are updated prior to consideration in subsequent aircraft programs.

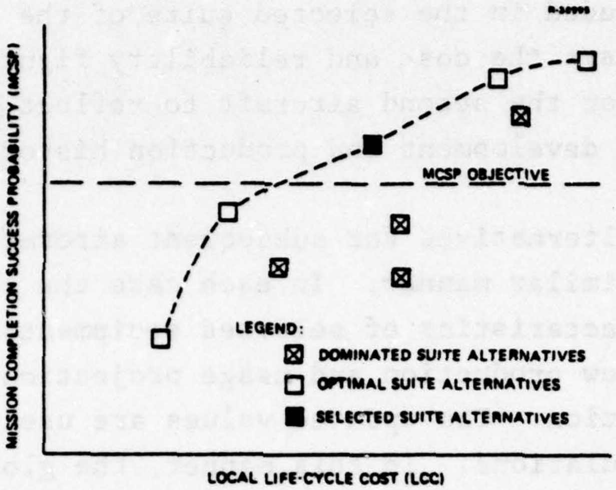

Figure 4.3-2 MCSP vs LCC for Avionics Suite Alternatives

4.3.2 Global LCC Evaluation

A life-cycle cost model is incorporated in STEP for the purposes of comparing alternative standardization concepts. This model is unique in that system life-cycle costs are computed on a global basis, that is over multiple aircraft programs as opposed to just one, with equipment commonality between different aircraft factored into the LCC computation.

The manner in which Global LCC considerations are addressed in STEP is illustrated in Fig. 4.3-3. Crucial to the concept is that aircraft are analyzed in chronological order of their scheduled activation/retrofit programs. A table of "standardization factors" is maintained for each equipment that, in effect, reflect the degree to which that equipment has been applied on aircraft analyzed to date in the evaluation. These factors are parameters of the LCC computation for the aircraft under current evaluation. When this evaluation is

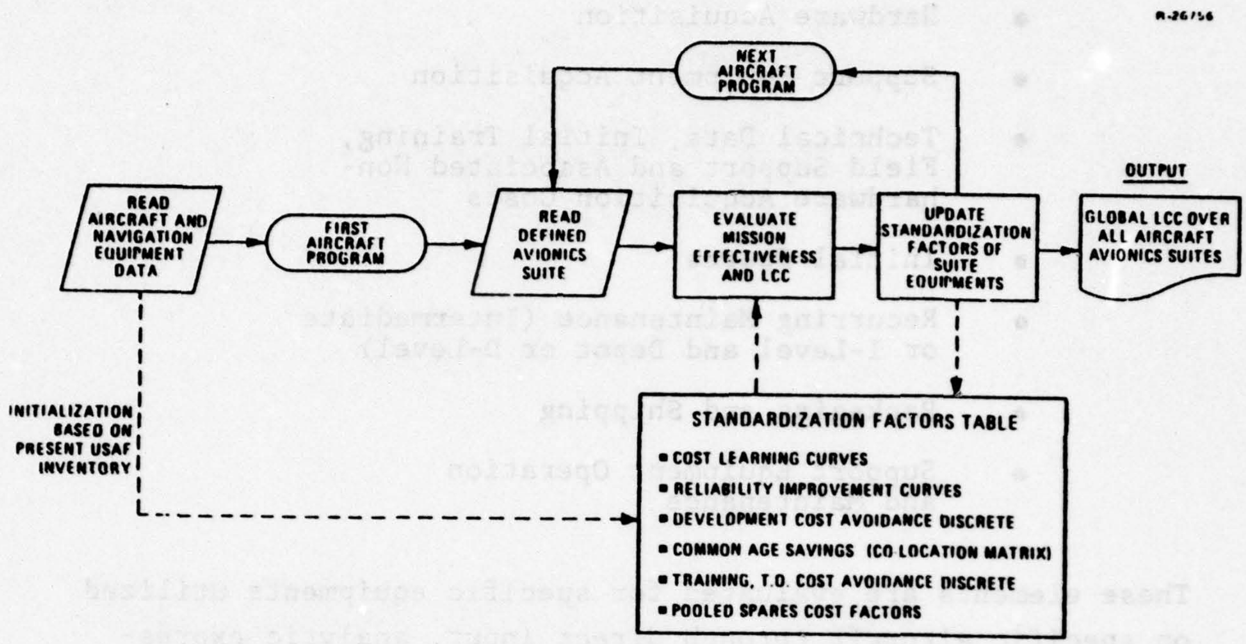

Figure 4.3-3 Overview of Global LCC Evaluation Model for STEP

complete, the standardization factors associated with each equipment are updated, reflecting their application on the aircraft. The updated factors are then utilized in any LCC computations for subsequent aircraft programs that utilize this equipment.

STEP does not attempt to estimate system life-cycle costs on an absolute basis. It does, however, consider all major elements of LCC which are potentially influenced by standardization considerations and for which sufficient data exists to evaluate the relative differences between navigation technologies. The following LCC elements are included:

- Hardware Development
- Support Equipment Development

- Hardware Acquisition
- Support Equipment Acquisition
- Technical Data, Initial Training, Field Support and Associated Non-hardware Acquisition Costs
- Initial Spares
- Recurring Maintenance (Intermediate or I-Level and Depot or D-Level)
- Packaging and Shipping
- Support Equipment Operation and Maintenance

These elements are evaluated for specific equipments utilized on specific aircraft through direct input, analytic expressions, or Cost Estimating Relationships (CERs). All are impacted in one way or another by standardization. The detailed equations are presented in Ref. 6.

4.3.3 Data Inputs

There are four basic sets of input data which are set up by the analyst to perform a STEP evaluation. These are:

- Standard Cost Factors
- Aircraft/Mission Data
- Avionics Equipment Data
- Equipment Suite Definitions

In general, the first three of these contain data inputs that are established initially for a study and will be infrequently modified thereafter; that is, they represent the data base for the study. The Equipment Suite Definitions, on the other hand, are modified from run to run as the analyst identifies additional suite options to be evaluated.

Standard Cost Factors - These data include program constants and LCC parameters that are relatively independent of aircraft type and avionics technology. They are listed in Table 4.3.1.

TABLE 4.3.1

STEP LISTING OF STANDARD COST FACTORS

STEP INPUT DATA

STANDARD FACTORS

LYF:	ANALYSIS TIME SPAN (YEARS)	40
ALLN:	AVAILABILITY ALLOCATION FACTOR	0.10
BDSC:	CONUS RESUPPLY TIME (HOURS)	240.
BDSC:	OVERSEAS RESUPPLY TIME (HOURS)	360.
BDSC:	CONUS SHIPPING TIME TO DEPOT (HOURS)	240.
BDSO:	OVERSEAS SHIPPING TIME TO DEPOT (HOURS)	360.
TAT:	BASE REPAIR TURNAROUND TIME (HOURS)	48.
DRC:	DEPOT REPAIR TURNAROUND TIME (HOURS)	720.
DLY:	DEPOT STOCK SAFETY FACTOR (STANDARD DEVIATIONS)	1.65
SBR:	BASE LABOR RATE (DOLLARS/MANHOUR)	11.70
SBMC:	BASE MATERIALS CONSUMPTION RATE (DOLLARS/MANHOUR)	2.28
SDR:	DEPOT LABOR RATE (DOLLARS/MANHOUR)	20.00
SDMC:	DEPOT MATERIALS CONSUMPTION RATE (DOLLARS/MANHOUR)	6.75
CSEM:	SUPPORT EQUIPMENT MAINTENANCE FACTOR	0.01
SPSC:	CONUS SHIPPING COST (DOLLARS/POUND)	0.53
SPSO:	OVERSEAS SHIPPING COST (DOLLARS/POUND)	0.99
NBF:	TOTAL-NUMBER OF BASE LOCATIONS	125
NBC:	NUMBER OF CONUS BASE LOCATIONS	99
LC(1):	PRODUCTION LEARNING CURVE (RADIO EQUIPMENT)	0.90
LC(2):	PRODUCTION LEARNING CURVE (RADAR EQUIPMENT)	0.90
LC(3):	PRODUCTION LEARNING CURVE (INERTIAL EQUIPMENT)	0.90
LCSE:	PRODUCTION LEARNING CURVE (SUPPORT EQUIPMENT)	0.80
HMS:	DEPOT OPERATION FACTOR (HOURS/MONTH/SHIFT)	140.
NDS:	NUMBER OF SHIFTS AT DEPOT	1
UTIL:	SUPPORT EQUIPMENT UTILIZATION FACTOR	0.70
SNHAF:	NONHARDWARE ACQUISITION FACTOR	35.

Aircraft/Mission Data - This data set consists of a sequenced list of aircraft to be considered in the study and parameters associated with these aircraft. Data are included on inventory entry or retrofit schedule, quantities, and deployment. Missions to be flown by the aircraft are also detailed in terms of mission phases pertinent to avionics system events and phase duration. A listing of this data for one aircraft is provided in Table 4.3-2.

TABLE 4.3-2

PARTIAL STEP LISTING OF AIRCRAFT/MISSION DATA

AIRCRAFT FILE

F-16

AIRCRAFT INPUT DATA

IBY:	INITIAL YEAR OF PRODUCTION/RETROFIT	4
IFY:	FINAL YEAR OF PRODUCTION/RETROFIT	11
RP:	PRODUCTION/RETROFIT RATE (AIRCRAFT/MONTH)	17.
NA:	TOTAL NUMBER OF AIRCRAFT	1380
LIFE:	OPERATIONAL LIFE (YEARS)	20.
XK:	RELIABILITY K-FACTOR (BASELINE MTBF/OPERATIONAL MTBF)	3.0
AO:	AVAILABILITY OBJECTIVE	0.990
NM:	NUMBER OF MISSIONS	3

		MISSION 1	MISSION 2	MISSION 3
NPHASE:	NUMBER OF PHASES	8	10	8
NMPM:	MISSIONS PER MONTH	5	5	5
SPO:	SUCCESS PROBABILITY OBJECTIVE	0.950	0.950	0.950

NB:	NUMBER OF BASE LOCATIONS	18

IB:	BASE LOCATION INDEX	2	8	15	21	27	28	29	37	45	48
NBA:	AIRCRAFT AT BASE	90	90	90	90	90	90	90	90	90	30
IB:	BASE LOCATION INDEX	60	104	105	108	112	115	120	124		
NBA:	AIRCRAFT AT BASE	90	90	30	30	90	90	90	30		

Avionics Equipment Data - This data set consists of a sequenced list of avionics equipments and parameters associated with the cost and reliability of these equipments. Required support equipment items and associated cost factors are also included in this data set. Depending on the nature of the STEP application, these parameters may either be representative of generic avionics equipments, or pertain to specific equipments in the USAF inventory or under development. A listing of this data for one equipment is provided in Table 4.3-3 and the associated support equipment data in Table 4.3-4.

Equipment Suite Definitions - The equipment suites are comprised of items in the Avionics Equipment Data set and are specified for all or some of the aircraft identified in the Aircraft/Mission Data set. For each defined suite, the duty cycles and the impact of equipment failures on the likelihood of successful mission completion are specified in matrix form. Examples of these matrices are displayed in Table 4.3-5.

4.3.4 STEP Outputs

The primary outputs of STEP are the results of the DSPC analysis (if requested) and of the global LCC analysis. Examples of these two outputs are shown in Figs. 4.3-4 and 4.3-5 respectively. The local LCC associated with each aircraft is also provided and the user may also request a formatted listing of the input data.

4.3.5 Program Implementation

STEP is written in Fortran for operation on the Aeronautical System Division's CDC Cyber 74 at Wright-Patterson AFB. It was developed on TASC's IBM System 370/158.

TABLE 4.3-3

PARTIAL STEP LISTING OF AVIONICS EQUIPMENT DATA

EQUIPMENT FILE

INS

EQUIPMENT INPUT DATA

IYA:	INITIAL YEAR AVAILABLE	1
ITYPE:	EQUIPMENT TECHNOLOGY INDEX	3
PC:	PRESENT COST (DOLLARS)	120000.
NQ:	PRESENT PRODUCTION QUANTITY	1
DC:	DEVELOPMENT COST (DOLLARS)	3000000.
ISS:	INVENTORY INTRODUCTION SWITCH	1
ALPHA:	RELIABILITY IMPROVEMENT FACTOR	0.10
NLRU:	NUMBER OF LINE REPLACEABLE UNITS	2

		LRU 1	LRU 2
NSRU:	NUMBER OF SRUS	5	0
NPP:	NUMBER OF PARTS	500	1
FC:	FRACTIONAL COST	0.990	0.010
FM:	FRACTIONAL FAILURE RATE	0.990	0.010
RTS:	FRACTION BASE REPARABLE	0.80	1.00
BRT:	BASE REPAIR TIME (HOURS)	5.0	2.0
DRT:	DEPOT REPAIR TIME (HOURS)	20.0	0.0
W:	WEIGHT (POUNDS)	30.0	5.0
DDP:	DEPOT DEMANDS/HOUR	0.0	0.0
NSPDP:	CURRENT DEPOT SPARES	0	0

INTERMEDIATE SUPPORT EQUIPMENT: IMU I-LEVEL S.E.

DEPOT SUPPORT EQUIPMENT: IMU D-LEVEL S.E.

YEAR	CUMULATIVE OPERATING HOURS		FAILURE RATE (FAILURES/HOURS)	
1	T(1,13)	5000.	FR(1,13)	0.010000
2	T(2,13)	5000.	FR(2,13)	0.010000
3	T(3,13)	5000.	FR(3,13)	0.010000
4	T(4,13)	5000.	FR(4,13)	0.010000
5	T(5,13)	5000.	FR(5,13)	0.010000
6	T(6,13)	5000.	FR(6,13)	0.010000
7	T(7,13)	5000.	FR(7,13)	0.010000
8	T(8,13)	5000.	FR(8,13)	0.010000
9	T(9,13)	5000.	FR(9,13)	0.010000
10	T(10,13)	5000.	FR(10,13)	0.010000
11	T(11,13)	5000.	FR(11,13)	0.010000
12	T(12,13)	5000.	FR(12,13)	0.010000
13	T(13,13)	5000.	FR(13,13)	0.010000
14	T(14,13)	5000.	FR(14,13)	0.010000
15	T(15,13)	5000.	FR(15,13)	0.010000
16	T(16,13)	5000.	FR(16,13)	0.010000
17	T(17,13)	5000.	FR(17,13)	0.010000
18	T(18,13)	5000.	FR(18,13)	0.010000
19	T(19,13)	5000.	FR(19,13)	0.010000
20	T(20,13)	5000.	FR(20,13)	0.010000
21	T(21,13)	5000.	FR(21,13)	0.010000
22	T(22,13)	5000.	FR(22,13)	0.010000
23	T(23,13)	5000.	FR(23,13)	0.010000
24	T(24,13)	5000.	FR(24,13)	0.010000
25	T(25,13)	5000.	FR(25,13)	0.010000
26	T(26,13)	5000.	FR(26,13)	0.010000
27	T(27,13)	5000.	FR(27,13)	0.010000
28	T(28,13)	5000.	FR(28,13)	0.010000
29	T(29,13)	5000.	FR(29,13)	0.010000
30	T(30,13)	5000.	FR(30,13)	0.010000
31	T(31,13)	5000.	FR(31,13)	0.010000
32	T(32,13)	5000.	FR(32,13)	0.010000
33	T(33,13)	5000.	FR(33,13)	0.010000
34	T(34,13)	5000.	FR(34,13)	0.010000
35	T(35,13)	5000.	FR(35,13)	0.010000
36	T(36,13)	5000.	FR(36,13)	0.010000
37	T(37,13)	5000.	FR(37,13)	0.010000
38	T(38,13)	5000.	FR(38,13)	0.010000
39	T(39,13)	5000.	FR(39,13)	0.010000
40	T(40,13)	5000.	FR(40,13)	0.010000

TABLE 4.3-4

PARTIAL STEP LISTING OF SUPPORT EQUIPMENT DATA

```
        IMU I-LEVEL S.E.

        SUPPORT EQUIPMENT INPUT DATA


SED:    DEVELOPMENT COST (DOLLARS)                 3000000.
ISE:    INVENTORY INTRODUCTION SWITCH                    1
PSE:    PRESENT COST (DOLLARS)                      300000.
NQSE:   PRESENT PRODUCTION QUANTITY                      1
USET:   CURRENT USAGE RATE (HOURS/MONTH)                0.
NDEP:   CURRENT DEPOT QUANTITY                           0
NBSE:   CURRENT BASE QUANTITY                            0



        IMU D-LEVEL S.E.

        SUPPORT EQUIPMENT INPUT DATA


SED:    DEVELOPMENT COST (DOLLARS)                 4000000.
ISE:    INVENTORY INTRODUCTION SWITCH                    1
PSE:    PRESENT COST (DOLLARS)                     1000000.
NQSE:   PRESENT PRODUCTION QUANTITY                      1
USET:   CURRENT USAGE RATE (HOURS/MONTH)                0.
NDEP:   CURRENT DEPOT QUANTITY                           0
NBSE:   CURRENT BASE QUANTITY                            0
```

The program has been delivered and an executable load module is stored on disk under the INTERCOM system. The program requires approximately 150,000 bytes of memory and 10 seconds of CPU time. Formal program documentation is provided in Ref. 6 and Ref. 7 is a user guide for the program.

4.4 STEP CAPABILITIES

STEP is not designed to solve any one specific problem, but rather is a general purpose tool for gaining insights into

TABLE 4.3-5

SAMPLE EQUIPMENT DUTY CYCLE AND FAILURE IMPACT PROBABILITY MATRICES

MISSION

EQUIPMENT DUTY CYCLE MATRIX

MISSION PHASE

SUBSYSTEM	1	2	3	4	5	6	7	8	9
1	0.050	0.330	1.000	0.0	0.0	0.0	0.0	1.000	0.330
2	0.050	0.330	1.000	1.500	0.500	0.330	1.500	1.000	0.330
3	0.0	0.330	1.000	0.0	0.500	0.0	0.0	1.000	0.330
4	0.0	0.330	1.000	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.330	0.0	0.0	0.0	0.0	0.0	0.0	0.330
6	0.050	0.330	1.000	1.500	0.500	0.330	1.500	1.000	0.330
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.050	0.330	1.000	1.500	0.500	0.330	1.500	1.000	0.330

FAILURE IMPACT PROBABILITY MATRIX

MISSION PHASE

SUBSYSTEM	1	2	3	4	5	6	7	8	9
1	0.10	0.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.20	0.20	0.20	0.20	0.10	0.0	0.0	0.0	0.0
3	0.90	0.70	0.60	0.50	0.50	0.0	0.0	0.0	0.0
4	0.50	0.30	0.30	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.50	0.30	0.30	0.30	0.10	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	1.00	1.00	1.00	1.00	0.70	0.0	0.0	0.0	0.0

MISSION 2

EQUIPMENT DUTY CYCLE MATRIX

MISSION PHASE

SUBSYSTEM	1	2	3	4	5	6	7	8	9
1	0.500	0.330	0.170	0.0	0.0	0.0	0.0	0.500	0.330
2	0.500	0.330	0.170	2.000	2.000	0.500	3.000	0.500	0.330
3	0.0	0.330	0.170	0.0	0.500	0.0	0.0	0.500	0.330
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.330	0.0	0.0	0.0	0.0	0.0	0.0	0.330
6	0.500	0.330	0.170	2.000	2.000	0.500	3.000	0.500	0.330
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.500	0.330	0.170	2.000	2.000	0.500	3.000	0.500	0.330

FAILURE IMPACT PROBABILITY MATRIX

MISSION PHASE

SUBSYSTEM	1	2	3	4	5	6	7	8	9
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.20	0.20	0.20	0.20	0.20	0.0	0.0	0.0	0.0
3	0.50	0.50	0.50	0.50	0.50	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.50	0.30	0.30	0.30	0.10	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	1.00	1.00	1.00	1.00	0.70	0.0	0.0	0.0	0.0

various aspects of avionics reliability, life-cycle costs, and procurement strategy. The manner of its utilization is highly dependent on the specific problem at hand and the quantity and quality of the available data. As such it is quite flexible, but also requires the participation of a system

```
                         BASELINE CONFIGURATION
AIRCRAFT SUBSYSTEM            EQUIPMENT

        1             TACAN                          (NONREDUNDANT)
        2             RADAR                          (NONREDUNDANT)
        3             INS                            (NONREDUNDANT)
        4             ADS                            (NONREDUNDANT)
        5             COMPUTER                       (NONREDUNDANT)

                         MISSION SUCCESS PROBABILITIES
      MISSION          BASELINE MCSP
         1                 0.93231

      BASELINE LIFE CYCLE COST = $    442777344.

                         IMPROVED CONFIGURATIONS
CONFIGURATION  SUBSYSTEM                  NEW                   MCSP
    NUMBER     IMPROVED                   OPTION              MISSION 1           LCC
      1           4       ADS        (REDUNDANT UNIT  1)      0.93720        449652480.
                          ADS        (REDUNDANT UNIT  2)
      2           5       COMPUTER   (REDUNDANT UNIT  1)      0.94769        468587264.
                          COMPUTER   (REDUNDANT UNIT  2)
      3           3       INS        (REDUNDANT UNIT  1)      0.97343        561264128.
                          INS        (REDUNDANT UNIT  2)
      4           2       RADAR      (REDUNDANT UNIT  1)      0.99845        729058816.
                          RADAR      (REDUNDANT UNIT  2)

                         SELECTED CONFIGURATION
AIRCRAFT SUBSYSTEM            EQUIPMENT

        1             TACAN                          (NONREDUNDANT)
        2             RADAR                          (NONREDUNDANT)
        3             INS                            (REDUNDANT UNIT  1)
                      INS                            (REDUNDANT UNIT  2)
        4             ADS                            (REDUNDANT UNIT  1)
                      ADS                            (REDUNDANT UNIT  2)
        5             COMPUTER                       (REDUNDANT UNIT  1)
                      COMPUTER                       (REDUNDANT UNIT  2)

                         MISSION SUCCESS PROBABILITIES
      MISSION          SELECTED MCSP
         1                 0.97343

      SELECTED LIFE CYCLE COST = $    561264128.
```

Figure 4.3-4   STEP DSPC Analysis Output

GLOBAL LIFE-CYCLE COSTS		
ALL SUBSYSTEMS CUMULATIVE THROUGH CURRENT AIRCRAFT		
HARDWARE DEVELOPMENT COST	=	3000000.
S.E. DEVELOPMENT COST	=	7000000.
SOFTWARE DEVELOPMENT COST	=	0.
HARDWARE ACQUISITION COST	=	185734944.
S.E. ACQUISITION COST	=	87426224.
NONHARDWARE ACQUISITION COST	=	4200000.
INITIAL SPARES COST	=	40291024.
I-LEVEL MAINTENANCE COST	=	19628848.
O-LEVEL MAINTENANCE COST	=	187060176.
S.E. MAINTENANCE COST	=	17485248.
SHIPPING COST	=	2641717.
SOFTWARE MAINTENANCE COST	=	0.
TOTAL GLOBAL CYCLE COST	=	554467584.

Figure 4.3-5 STEP Global LCC Output

analyst intimate with the program to properly establish the inputs and interpret the outputs for a given problem. A number of sample analyses are presented in this section in order to indicate the range of potential uses and the nature of the STEP-system analyst interface. The actual mechanics of STEP operation for each of these analyses are provided in the STEP User Manual (Ref. 7).

4.4.1 Analysis of Avionics Suite Options

The first example illustrates utilization of STEP to perform a DSPC analysis of equipment alternatives for an aircraft avionics suite. For this example, it is assumed that a tanker type aircraft is to undergo a retrofit of its avionics suite. An analysis of the navigation requirements of the tanker mission has determined that a suite comprised of the following items will provide sufficient capabilities and accuracies:

- Tactical Navigation (TACAN) Set
- OMEGA Radio Navigation Set
- Search Radar
- Doppler Radar
- Radar Altimeter
- Inertial Navigation Set
- Air Data System
- Navigation Management Computer

The objective of the analysis is to evaluate equipment alternatives from the standpoint of mission reliability and LCC. The alternatives may take the form of higher reliability, higher cost equipment options for an item or equipment redundancy implementations.

The STEP input data base must contain the Aircraft/ Mission Data (see Table 4.3-2) for the aircraft and the Avionics Equipment Data (see Table 4.3-3) for each equipment option. Through specification of the Equipment Suite Definitions the analyst defines the actual alternatives to be considered. The nature of the STEP output presented to the analyst is displayed in Fig. 4.4-1. This includes:

- **The lowest LCC configuration (baseline configuration)**
- **The optimal sequence of improved MCSP configurations**
- **The lowest LCC configuration satisfying MCSP requirements (selected configuration)**

In this example, objectives were satisfied by making the computer redundant.

BASELINE CONFIGURATION

AIRCRAFT SUBSYSTEM	EQUIPMENT	
1	TACAN	(NONREDUNDANT)
2	OMEGA	(NONREDUNDANT)
3	RADAR	(NONREDUNDANT)
4	DOPPLER	(NONREDUNDANT)
5	ALTIMETER	(NONREDUNDANT)
6	C-IV INS	(NONREDUNDANT)
7	ADS	(NONREDUNDANT)
8	COMPUTER	(NONREDUNDANT)

MISSION SUCCESS PROBABILITIES

MISSION	BASELINE MCSP
1	0.93528
2	0.94715

BASELINE LIFE CYCLE COST = $ 364063440.

IMPROVED CONFIGURATIONS

CONFIGURATION NUMBER	SUBSYSTEM IMPROVED	NEW OPTION		MCSP MISSION 1	MCSP MISSION 2
1	8	COMPUTER COMPUTER	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.95766	0.97789
2	2	OMEGA OMEGA	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.96035	0.98228
3	4	DOPPLER DOPPLER	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.96608	0.98228
4	3	RADAR HI-REL	(NONREDUNDANT)	0.98188	0.98968
5	6	C-IV INS C-IV INS	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.98324	0.99146
6	8	COMPUTER HI-REL COMPUTER HI-REL	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.98366	0.99224
7	1	TACAN TACAN	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.98373	0.99224
8	5	ALTIMETER ALTIMETER	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.98373	0.99224
9	7	ADS ADS	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)	0.98373	0.99224

SELECTED CONFIGURATION

AIRCRAFT SUBSYSTEM	EQUIPMENT	
1	TACAN	(NONREDUNDANT)
2	OMEGA	(NONREDUNDANT)
3	RADAR	(NONREDUNDANT)
4	DOPPLER	(NONREDUNDANT)
5	ALTIMETER	(NONREDUNDANT)
6	C-IV INS	(NONREDUNDANT)
7	ADS	(NONREDUNDANT)
8	COMPUTER COMPUTER	(REDUNDANT UNIT 1) (REDUNDANT UNIT 2)

MISSION SUCCESS PROBABILITIES

MISSION	SELECTED MCSP
1	0.95766
2	0.97789

SELECTED LIFE CYCLE COST = $ 378155264.

Figure 4.4-1 STEP Analysis of Avionics Suite Options

4.4.2 Design Standardization Analysis

The strictest form of standardization, namely application of equipment items identical in design and piece-part composition in multiple aircraft programs, is considered in the second example. It is assumed that a requirement for a moderate accuracy INS has been established for the following aircraft:

- A-10A
- KC-135
- Advanced Tanker/Cargo Aircraft (ATCA)
- F-16
- Follow-On Interceptor (FOI)
- Advanced Medium Short Takeoff and Landing Aircraft (AMST)
- A-10B

STEP provides the analyst with the capability to estimate the global LCC benefits of utilizing a standard INS on each of the above aircraft versus developing and procuring a unique INS for each. Equipment Suite Definitions are set up corresponding to these two cases and two STEP runs in the Global LCC analysis mode are performed.

STEP will provide the Local LCC on each aircraft program and the cumulative Global LCC across all aircraft under both utilization scenarios. These results can then be tabulated as shown in Table 4.4-1 for comparison purposes. Such comparisons indicate not only the magnitude of the potential LCC benefits of standardization, but also the areas in which the payoff is highest.

TABLE 4.4-1
GLOBAL LCC BENEFITS OF INS
DESIGN STANDARDIZATION

LCC ELEMENT	GLOBAL LIFE-CYCLE COST	
	STANDARD INS	UNIQUE INS
Hardware Development	3M	21M
Support Equipment Development	7M	49M
Hardware Acquisition	195M	256M
Support Equipment Acquisition	91M	172M
Nonhardware Acquisition	4M	29M
Initial Spares	42M	58M
I-Level Maintenance	21M	24M
D-Level Maintenance	200M	228M
Support Equipment Maintenance	18M	34M
Packing and Shipping	3M	3M
Total	$584M	$874M

4.4.3 F^3 Standardization Analysis

As discussed in Section 4.1.2, F^3 standardization is a form of an insurance policy against the risks associated with sole-source procurement. While STEP was originally developed to address the design standardization approach, it can also be utilized to assess the value of F^3 standardization in terms of risk reduction.

To illustrate this application, the INS and the seven aircraft programs listed in Section 4.4.2 are again considered. It is assumed that there are two qualified contractors for the INS and that the actual production learning curves and reliability growth rates that these two contractors are capable of achieving are as listed in Table 4.4-2.

TABLE 4.4-2

ASSUMED COST FACTORS: F^3 STANDARDIZATION EXAMPLE

	LEARNING CURVE	RELIABILITY GROWTH FACTOR
Contractor A	0.95	0.05
Contractor B	0.9	0.15

The conventional standardization approach corresponds to selection of either Contractor A or Contractor B to provide the INS for all seven aircraft programs. This selection is generally based on a proposal evaluation since actual cost and reliability measurement data is not available at the time of selection. A representative F^3 standardization acquisition strategy would be to award the initial aircraft contract to Contractor A, the second aircraft contract to Contractor B, and subsequent contracts to the contractor demonstrating the best cost and reliability performance (in this case Contractor B).

The STEP input data can be set up to reflect each of the following acquisition scenarios (see Ref. 7):

- Application of INS 1 on all seven aircraft
- Application of INS 2 on all seven aircraft
- Application of INS 1 on the first aircraft, INS 2 on the second aircraft, and INS 2 again on the subsequent five aircraft.

The Global LCC outputs from the three STEP runs corresponding to these scenarios are then the basis for assessment of the risk reduction. These outputs are displayed in Table 4.4-3. While the Global LCC corresponding to the F^3 procurement scenario is approximately $100 million greater than the best case sole-source scenario, it is more than $300 million less than the worst case sole-source scenario. From this perspective, the F^3 approach is an insurance policy against the enormous cost associated with the worst-case scenario.

TABLE 4.4-3

RISK REDUCTION ASSOCIATED WITH F^3 STANDARDIZATION

LCC ELEMENT	GLOBAL LCC SOLE-SOURCE BEST CASE	GLOBAL LCC SOLE-SOURCE WORST CASE	GLOBAL LCC F^3 PROCUREMENT
One-Time Costs	$ 14 M	$ 14 M	$ 28 M
Hardware Acquisition	195 M	347 M	228 M
Support Equipment	74 M	113 M	82 M
Spares	33 M	103 M	47 M
Recurring Maintenance	169 M	345 M	204 M
Total	$485 M	$922 M	$589 M

SECTION V

EXTENSIONS TO STEP METHODOLOGY

5.1 MISSION EFFECTIVENESS CONSIDERATIONS

As previously stated in this report, the standardization evaluation methodology described is not intended for use as a technological guide to the selection of avionics equipment for future aircraft. For this reason, a very simple index of mission capability (MCSP) has been used in STEP. However, it is likely that the need for efficient use of USAF funds in the future will require budgetary considerations, including standardization potential evaluation, to be included in the process of technological design. In this situation STEP will be available to the system technologist as a design evaluation tool and it is highly probable that he will require a more refined measure of mission effectiveness to be incorporated in the methodology to do justice to many of the gradations of system performance capability that occur in practice.

The present STEP format requires input statements describing the impact of equipment failure during any mission phase on mission continuation. (See Table 3.5-1, Duty Cycle/ Failure Impact Matrix for Close Air Support Mission). At present the failure impacts are simply stated in terms of the probability of mission abort. However, this input to STEP could be used to introduce more comprehensive mission effectiveness measures into the evaluation by computing, off-line, mission success probabilities (such as probability of target kill or probability of successful weapon release) and including them in place of the simpler mission abort figures.

It is evident that the off-line computations involved can be very complex. In fact there is no general agreement as to what constitutes an adequate mission effectiveness measure in many instances. Any attempt to incorporate these computations into STEP would have produced an unwieldy standardization evaluation tool and the alternative option of providing a useable interface between STEP and mission effectiveness analyses was adopted as the best compromise during development of the standardization evaluation methodology.

5.2 DATA ENTRY MANAGEMENT

As has been emphasized throughout this report, effective utilization of STEP requires the active participation of a system analyst who is intimate with the program and its operation. This is largely due to limitations in the current data base and the lack of an effective data management and user interface system. Potential enhancements exist in these areas which would greatly facilitate STEP operation and broaden the field of potential users to system planners and program offices.

The major components of an improved data management system and executive interface for STEP are shown in Fig. 5.2-1. Some minor restructuring of the data base would be in order under this scheme. The Aircraft/Mission Data would be split into two distinct sets, aircraft and missions. This would provide an additional degree of flexibility to the analyst, namely the capability to allocate missions to aircraft. The equipment duty cycle and failure impact probability data, currently in the Equipment Suite Definitions, would be included in the Mission Data. Finally, the Equipment Suite Definitions

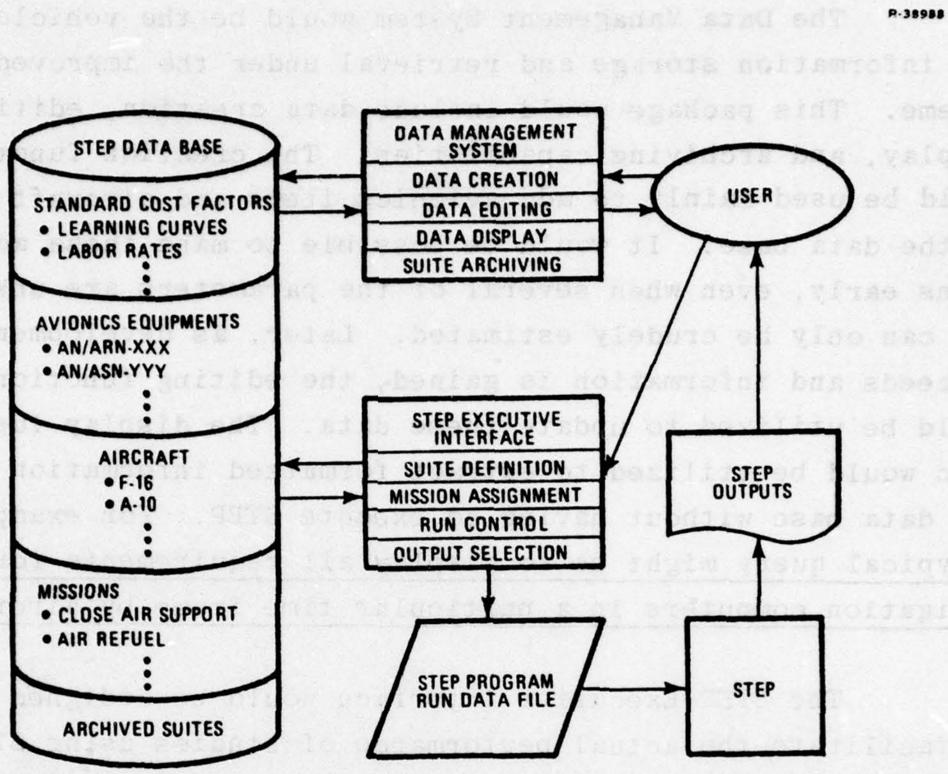

Figure 5.2-1 Improved Data Management System and Executive Interface

would not be part of the data base per se, but rather would be created through the executive interface at the time of a program run. However, a capability to archive and retrieve previously created suites to and from the data base would be included.

While the formats of the Standard Cost Factors and Avionics Equipment Data sets would be largely unchanged under the improved scheme, an extensive data collection effort would be required to upgrade the latter. While the current data base contains records corresponding to generic equipment items, it would be feasible to incorporate data representing actual equipments in the USAF inventory and under development.

The Data Management System would be the vehicle for information storage and retrieval under the improved scheme. This package would include data creation, editing, display, and archiving capabilities. The creation function would be used mainly to add avionics items and aircraft to the data base. It would be possible to make these additions early, even when several of the parameters are unknown and can only be crudely estimated. Later, as development proceeds and information is gained, the editing function could be utilized to update these data. The display function would be utilized to extract formatted information from the data base without having to execute STEP. For example, a typical query might be to display all requirements for navigation computers in a particular time frame by aircraft.

The STEP Executive Interface would be designed to facilitate the actual performance of studies using STEP. Its major function would be the creation of the Equipment Suite Definitions for a given program run. The requirements placed on the user would be reduced to listing the aircraft to be considered, assigning missions to each aircraft, and identifying the equipment items comprising the avionics suite, or suite alternatives, for each aircraft. The executive package would then perform the function of extracting the relevant data from different sections of the data base, merging it, and reformatting it into a program run data file for input to STEP. Besides greatly reducing the burden on the user, this approach has the added advantage of greater program efficiency by limiting the data utilized in a run to only that which is required.

5.3 MODULE COMMONALITY ANALYSES

STEP is currently directed toward standardization of subsystems within avionics suites. A logical extension of the methodology is towards standardization alternatives at lower levels of system definition, e.g. at the Shop Replaceable Unit (SRU) level. There are several future avionics programs* which will entail application of different versions of the same basic avionics item on different aircraft. There will certainly be substantial room for commonality at the module level between the different versions, and alternative design approaches which impact the degree of commonality that is achievable. In such cases, it is important that aircraft mission requirements and LCC analyses of alternative standardization approaches influence the design decisions.

While this class of problems may appear to be quite different from those associated with subsystem standardization, they are still conducive to evaluation under the basic STEP methodology. This is accomplished by making certain equivalences as summarized in Table 5.3-1 below.

TABLE 5.3-1

STEP INPUT EQUIVALENCES FOR SRU COMMONALITY ANALYSIS

CONVENTIONAL STEP INPUT	SRU COMMONALITY EQUIVALENT INPUT
AVIONICS SUITE	LINE REPLACEABLE UNIT
SUBSYSTEM 1	SRU 1
SUBSYSTEM 2	SRU 2
⋮	⋮

*These include GPS, JTIDS and MFBARS

A Line Replaceable Unit is thus input as an avionics suite is in a conventional STEP analysis, and a Shop Replaceable Unit is input as a subsystem is. The resulting "suite" input is then as illustrated in Fig. 5.3-1.

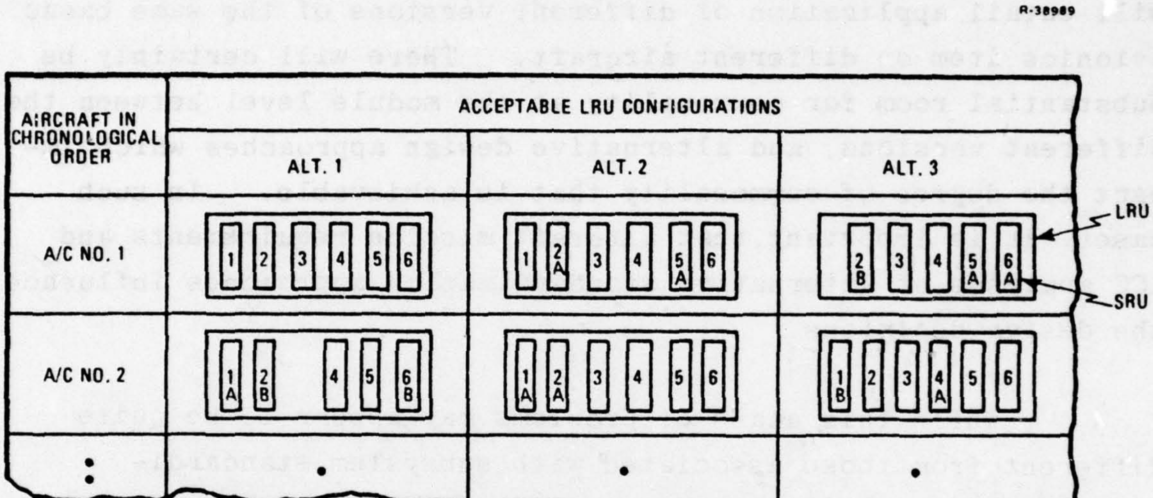

Figure 5.3-1 Representative Input for SRU Commonality Analysis

In this situation, the alternative suites for an aircraft now take the form of alternative LRU configurations, a configuration being defined by its composition of SRUs. A standardization concept is then defined by the utilization of specific common SRUs in the LRU configurations of different aircraft.

With respect to the two modes of STEP operation, the Global LCC analysis mode is more relevant to the typical issues associated with SRU standardization. While it is feasible to set up the data to perform DSPC analyses, the concepts of

Mission Completion Success Probability and redundancy are not as meaningful at the SRU level as they are at the subsystem level. A more germane problem would be quantification of the LCC benefits associated with alternative LRU configurations incorporating varying degrees of SRU standardization. The Global LCC mode of STEP operation is directly suited to this problem. Other than the required modifications to the input data, the only significant change to STEP that would be necessary is in the area of spares computation. Specifically, this computation would have to be augmented to determine SRU spares requirements as well as LRU spares requirements. However, the remaining LCC computations and standardization factors incorporated in STEP are applicable to SRU standardization analysis.

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GLOSSARY OF TERMS

A/C - Aircraft

ADF - Automatic Direction Finding Equipment

ADPI - Air Defense Point Intercept (Mission)

ADS - Air Data System (used to describe a rudimentary air data sensing/computing subsystem which is less comprehensive in function than a CADC)

AFAL - Air Force Avionics Laboratory (AFSC)

AFLC - Air Force Logistics Command

AFSC - Air Force Systems Command

AGE - Aerospace Ground Equipment

AHARS - Advanced Heading-Attitude Reference System (A specific type of AHRS)

AHRS - Attitude-Heading Reference System

APF - Advanced Penetration Fighter (Mission)

ASD - Aeronautical Systems Division (AFSC)

AWACS - Airborne Warning and Control System

Baseline Mission Profile - Representative flight profile for a specific mission

BATH - Best Available True Heading

BIT(E) - Built In Test (Equipment)

BS - Barrier Standoff (Mission). Electronic Warfare Aircraft

BSR - Battlefield Surveillance (Reconnaissance Mission)

CADC - Central Air Data Computer

CAS - Close Air Support (Mission)

CAT I - Category I landing conditions (>200 ft cloud base, > 0.5 mile visibility)

CAT II - Category II landing conditions (100-200 ft cloud base/ 0.25-0.5 mile visibility)

CEP - Circular Error Probable

CER - Cost Estimating Relationships

CIV - Carousel IV Inertial Navigation System (Commercial INS)

CMC - Cruise Missile Carrier (Mission)

CNPI - Communications, Navigation and Positioning Integration (System)

Colocation - Location of more than one type of aircraft at a single base

CONUS - Continental U.S.A.

CSD - Common Strategic Doppler

Cueing Sensor - Aircraft mounted equipment which contributes to target acquisition through means other than direct target detection (e.g. forward-looking radar used on a radar identification point at a known location)

C^3 - Command, Control and Communication

C^3-AWACS - Command, Control and Communication and Airborne Warning and Control (Composite Mission)

Design Standardization - Utilization of identical equipment designs on multiple programs

D-Level - Depot Level (of equipment maintenance)

DS - Defense Suppression (Mission)

DSPC - Design to System Performance/Cost (Model developed by Directorate of Aerospace Studies, Kirtland AFB)

ECM - Electronic Counter Measures

EI - Escort Intercept (Mission)

EMP - Electromagnetic Pulse (Associated with nuclear explosion)

EWO - Emergency War Order

FAA - Federal Aviation Agency

(FAA)AC - (Federal Aviation Agency) Advisory Circular

FAC - Forward Air Control (Mission)

FAC-X(A-10B) - Forward Air Control Aircraft (Projected)

FAR - Federal Aviation Regulation

FEBA - Forward Edge Battle Area

FLIR - Forward-looking Infrared (Target detection/identification system)

FLR - Forward-looking Radar

FOI - Follow-on Interceptor

Force Structure - The entire complement of aircraft in the USAF operational inventory at any specified point in time

F^3 - Form, Fit and Function (specification)

F^3 INS - Form, Fit and Function Standard Inertial Navigation System

GCA - Ground Controlled Approach

Generic (class of equipment) - Airborne Equipment described by characteristics representative of its class, rather than by characteristics of one specific member of the class

Global LCC (G-LCC) - Total life-cycle cost for developing, acquiring, installing and supporting the avionics equipment selected for <u>all</u> aircraft in the USAF force structure

GPS - Global Positioning System

ICAO - International Carrier Airlines Organization

IF - Intermediate frequency

'I' Level - Intermediate Level (of equipment maintenance)

ILT - Intertheater Logistics Transport (Mission)

IMC - Instrument Meteorological Conditions

INS - Inertial Navigation System

I.P. - Identification Point

IST - Intratheater Transport (Mission)

JTIDS - Joint Tactical Information Distribution System

K-Factor - Reliability degradation factor for equipment operating in severe environments. (In this report K=1 for the Cargo/Transport cruise flight environment and K>1 for Strategic Bomber, Attack and Air Superiority Aircraft)

LCC - Life-Cycle Cost

Local LCC (L-LCC) - Life-cycle cost for developing, acquiring, installing and supporting the avionics equipment selected for a single aircraft type

LRU - Line Replaceable Unit

MCSP - Mission Completion Success Probability (Probability of Aircraft arriving in mission objective area with sufficient equipment operative to complete mission)

MFBARS - Multi-Function, Multiband Airborne Radio System is an Air Force Avionics Laboratory technology effort to develop cost effective, integrated communication-radio navigation - cooperative identification (CNI) user equipment required by tactical aircraft in the 1990 time frame.

MILS - Milliradians (in weapon delivery, the angle subtended by weapon miss distance at the aircraft's position at the instant of weapon release)

MIRA - Multifunction Inertial Reference Assembly

Mission Area - Generalized mission role

Mission Phase - Segment of the mission profile requiring specific avionics system/subsystem utilization and performance

Mission-Specific Sensors - Aircraft-mounted Sensors which rely on outputs of the avionics system under study and which determine the mission capabilities of the carrying aircraft. (Example: A FLIR target detection sensor, which uses navigation avionics outputs for placement over the predicted target area and allows night-time target detection and attack)

MMI - Mass Movement Interdiction (Mission)

MMR - Multi-Mode Radar

MTBF - Mean Time Between Failures

Navigation Subsystem (User Equipment) - A generic, functional element of the navigation suite, e.g., Inertial Navigation Subsystem, Doppler radar subsystem, navigation computer

Navigation Suite - The entire complement of navigation avionics equipment on an aircraft

NWDC - Navigation and Weapon Delivery Computer

OMEGA - Long range radio navigation system

PAVE TACK - Contemporary, pod-mounted FLIR

PE - Penetration Escort (Mission). Electronic Warfare Aircraft

PPA - Preplanned Attack (on fixed, defended target)

QRS - Quick Reaction Strike (on volatile target)

QSR - Quick Strike Reconnaissance (Mission)

Redundancy - Provision of two identical pieces of equipment performing parallel functions to provide a single-fail-operative mission capability

ROC - Required Operational Capability (document)

SBP - Strategic Bomber, Penetration (Mission)

SBS - Strategic Bomber, Standoff (Mission)

SE - Shuttle Escort (Mission). Electronic Warfare Aircraft

SE - Support Equipment

S.L. - Sea Level

SPANS - Standardization Potential Across Navigation Systems (Program)

SRU - Shop Replaceable Unit. (Usually a removable module within an LRU)

Standard Cost Factors - Cost parameters associated with equipment entry into USAF inventory and equipment support which are independent of the aircraft program considered, e.g., maintenance labor rates, data management costs, packaging and shipping costs.

Standardization - Use of a standard subsystem on more than one aircraft type

STEP - Standardization Evaluation Program

TA - Terrain Aviodance

TD - Target Designation (Mission)

TDS - Tactical Data System

TF - Terrain Following

TS - Tanker, Strategic (Mission)

TTA - Tanker, Tactical/Airlift (Mission)

UHF/DF - Ultra-High Frequency Direction-Finding Equipment

User - Aircraft operating element of the USAF

User equipment - The elements of cooperative navigation systems that are installed on aircraft under study

VLF - Very Low Frequency

VMC - Visual Meteorological Conditions

VOR/ILS - Vertical Omni-Range/Instrument Landing System Equipment

VOR/TAC - Composite Civil/Military VOR/TACAN Facility

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