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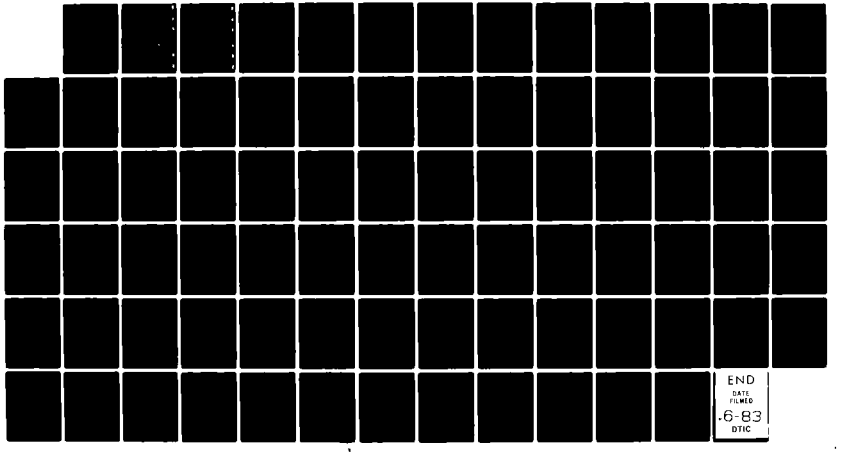

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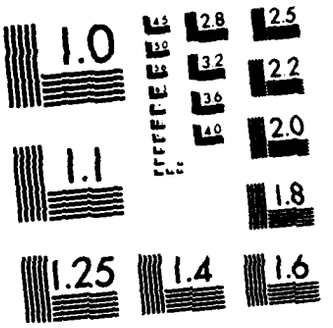

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The researchers developed a methodology for improving the accuracy of the Air Force Logistics Command (AFLC) forecasts of Aircraft Replenishment Spares (BP 1500) POM requirements. The research was divided into three phases:

a. Develop a program plan for accomplishing the study.

b. Examine the AFLC BP 1500 POM forecasting process and identify sources of errors and recommend changes.

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c. (3) Develop and demonstrate a methodology for improving the AFLC forecasting accuracy for BP 1500 POM requirement.

MANAGEMENT CONSULTING & RESEARCH, INC.

TR-8104-3

SUMMARY OF ANALYSIS OF SOURCES OF FORECASTING ERRORS IN BP 1500 REQUIREMENTS ESTIMATING PROCESS AND DESCRIPTION OF COMPENSATING METHODOLOGY

25 April 1982

By

Ms. Patricia A. Insley
Dr. William P. Hutzler
Dr. Gerald R. McNichols
Dr. George H. Worm

Prepared For:

Department of the Air Force
Business Research Management Center
Wright-Patterson AFB, Ohio 45433

Contract Number: F33615-81-C-5018

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PREFACE

Management Consulting & Research, Inc. (MCR) has been tasked by the Air Force Business Research Management Center (AFBRMC) to develop a methodology for improving the accuracy of the Air Force Logistics Command (AFLC) forecasts of Aircraft Replenishment Spares (BP 1500) POM requirements. This effort, performed under Contract Number F33615-81-C-5018, is divided into three phases:

- Phase I -- Develop a program plan for accomplishing the study.
- Phase II -- Research the AFLC BP 1500 POM forecasting process, identifying sources of errors and recommending changes.
- Phase III -- Develop and demonstrate a methodology for improving the AFLC forecasting accuracy for BP 1500 POM requirement.

This final report summarizes the findings of Phases II and III of this effort.

MCR wishes to express appreciation for the assistance provided by members of AFLC and the Air Staff in the completion of this research.

TABLE OF CONTENTS

LIST OF EXHIBITS

I. INTRODUCTION

This section presents discussions of the following topics:

- the background of the program,
- the purpose of the study,
- the approach taken in the study, and
- the structure of the report.

A. BACKGROUND

The Air Force annually presents its budget requirements to the Office of the Secretary of Defense (OSD) and the Office of Management and Budget (OMB). These requirements are developed and revised in the context of the Planning, Programming and Budget System (PPBS). Preliminary estimates are developed and presented in a Program Objective Memorandum (POM), presenting projections for the five year period following the Budget Year (BY). The POM is used to define a financial framework in which subsequent budgets will be developed.

Within the Air Force, the Air Force Logistics Command (AFLC) is responsible for determining and satisfying the logistics requirements of the Air Force. Part of the logistics requirements are aircraft replenishment spare parts, an individual budget program, BP 1500, in the aircraft procurement budget appropriation 3010.

Management Consulting & Research, Inc. (MCR) has been tasked by the Air Force Business Research Management Center (AFBRMC) to develop a methodology for improving the accuracy

of the AFLC POM forecasts of BP 1500 requirements. Emphasis has been placed on the POM since it is a critical analytical stage in the PPBS. It is in this stage that long-term requirements projections are first developed and reviewed in detail. This preliminary estimate, developed five years in advance, is refined in each subsequent year until the actual budget is developed for the given fiscal year. The budget, therefore, is intended to fit within the requirements constraints defined in the POM. For this reason accurately forecasting POM requirements is of vital importance.

B. PURPOSE

The purpose of this study is to develop a methodology for improving AFLC POM forecasting accuracy for BP 1500. This methodology is designed to be integrated into the overall requirements definition process, compensating for those characteristics of the current definition process which could introduce errors into the requirements estimates.

AFBRMC has tasked MCR to develop this methodology. The foundation of this methodology is a set of compensating factors, identified and developed by MCR, to be used in conjunction with output from the DO41 "Recoverable Consumption Item Requirements System." Working in cooperation with AFLC and various groups within the Air Staff (HQ USAF), MCR has:

- analyzed the current BP 1500 requirements forecasting process;
- identified the major contributors to errors in that forecasting process; and
- developed and demonstrated factors which can be used to compensate for the major deficiencies in the BP 1500 forecasting process.

This study focused on the impact that the characteristics of the BP 1500 requirements forecasting process has on the entire POM/Budget/Appropriation cycle rather than on just one aspect of it, such as the DO41 system. For this reason, the methodology is designed to compensate for, rather than correct some of these characteristics. By this it is meant that the methodology provides for a set of adjustments to be made to requirements forecasts as they are currently developed. It does not require alteration of the requirements determination process.

C. APPROACH

This study has been organized into a planning phase, a research phase, and a development and demonstration phase. These three phases include the following objectives:

- Phase I -- Develop a program plan for accomplishing the study;
- Phase II -- Research the AFLC BP 1500 POM forecasting process; and
- Phase III -- Develop and demonstrate factors which can be used in conjunction with the DO41 requirements computation to accurately forecast BP 1500 requirements in the POM.

This final report summarizes the Phase II and Phase III efforts of this study.

D. STRUCTURE OF THE REPORT

This report is composed of the following sections:

- Section I -- Introduction
- Section II -- Summary of Research into Sources of BP 1500 Requirements Forecasting Errors (Phase II)
- Section III -- Description of Cost Per Flying Hour (Phase III) Parametric Estimating Relationship
- Section IV -- Conclusions
- Appendix A -- Draft Factor Data Sheets
- Appendix B -- Glossary.

II. SUMMARY OF RESEARCH INTO SOURCES OF BP 1500 REQUIREMENTS FORECASTING ERRORS (PHASE II)

This section presents the following:

- a background discussion,
- an overview of the BP 1500 Requirements/POM/Budget/Appropriation Process, and
- a summary of the analysis of potential sources of error in this process.

A. BACKGROUND

In order to develop a compensating methodology which could be integrated into the current BP 1500 requirements estimating process, it was first necessary to perform some basic background research. The purpose of this research, which made up the Phase II portion of this study, was to familiarize the project team with the specific activities and organizations which comprise the BP 1500 requirements definition process. In researching the BP 1500 Requirements/POM/Budget/Appropriation Process, emphasis was placed on the data systems, internal management activities, regulations, policies, and procedures which have a major influence on the accuracy of the POM forecast. Having determined the major factors in the overall process, the significant sources of potential errors were identified. Finally, a proposed methodology was developed which focuses on the stage in the development of the POM requirements forecast which can affect the most immediate and efficient improvements in forecasting accuracy. This methodology is described in Section III of this report.

This section presents an overview of the activities and organizations which comprise the BP 1500 requirements definition process. After that a summary of the analysis of the potential sources of error in this process is provided. A more detailed description of the process and discussion of sources of errors is provided in the Phase II Technical Report.[1/]

B. OVERVIEW OF BP 1500 REQUIREMENTS/POM/BUDGET/APPROPRIATION PROCESS

The BP 1500 Requirements/POM/Budget/Appropriation Process is in this study defined in terms of the following elements:

- the materiel represented in the requirements calculations and estimates;
- the organizations and activities which comprise the process;
- the documents produced in the course of the process; and
- the schedule of events leading to the development of BP 1500 Requirements for inclusion in the Air Force POM.

Exhibit II-1 illustrates the major sequence of events in the development and presentation of BP 1500 requirements in the PPBS.

The material represented in the BP 1500 requirements calculations and estimates is categorized as follows:

1/ Description of the BP 1500 Requirements/POM/Budget/Appropriation Process and Analysis of Sources of Forecasting Errors, TR-8104-1. Patricia A. Insley, George H. Worm and Gerald R. McNichols, Mangement Consulting & Research, Inc., December 1981.

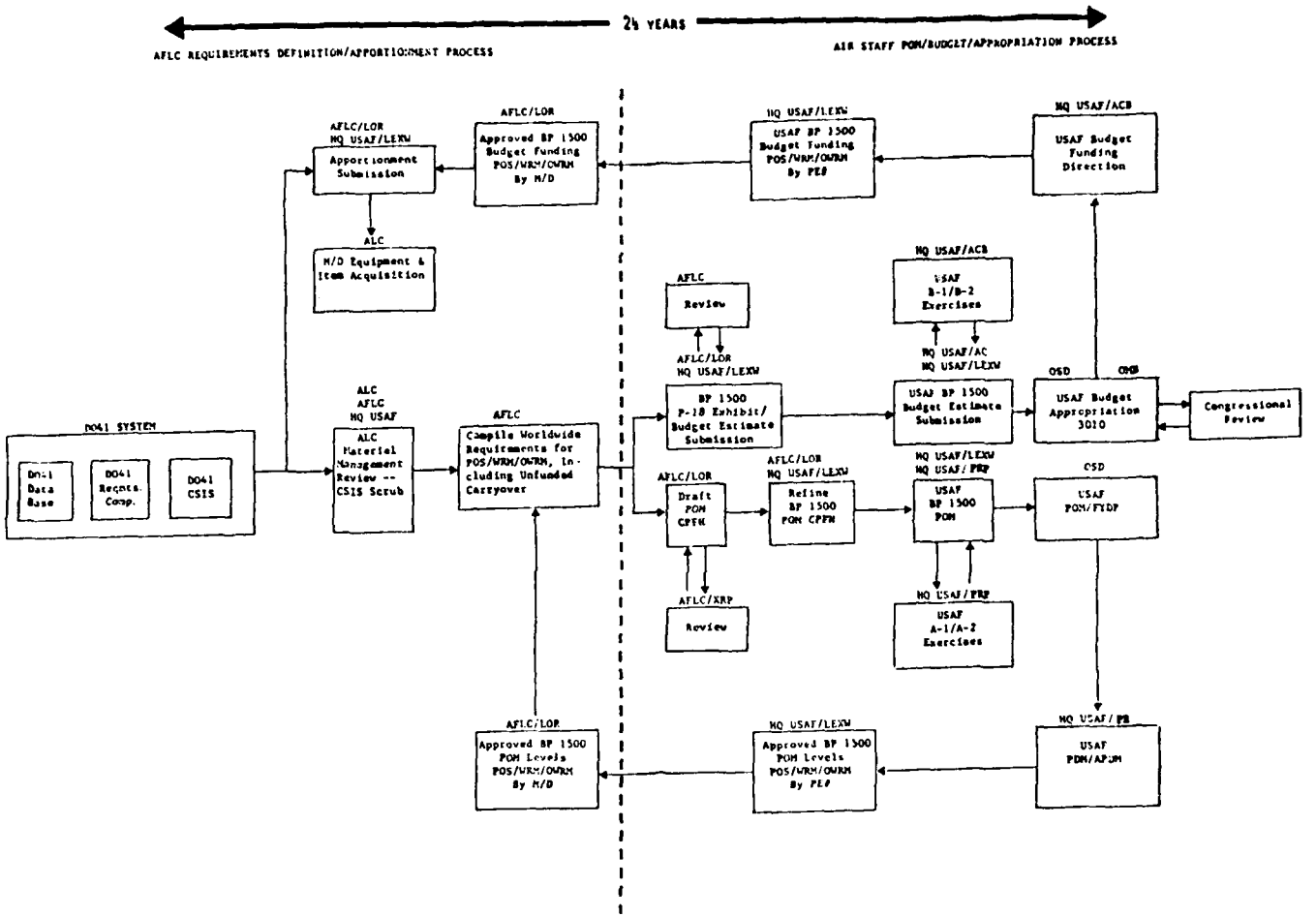


Exhibit II-1. BP 1500 REQUIREMENTS/POM/BUDGET/ APPROPRIATION PROCESS

- Peacetime Operating Stocks (POS), used in the day-to-day readiness operations, in support of the flying hour program;
- War Reserve Materiel (WRM) composed of two classes of spares:
  - War Readiness Spares Kits (WRSK), prepositioned materiel to support a 30-day deployment of a unit, and
  - Base Level Self-Sufficiency Spares (BLSS), prepositioned materiel at the home base to support the remaining units; and
- Other War Reserve Materiel (OWRM), planned to be used to sustain units beyond the 30-day period.

Most of the data input into the requirements calculations relate to POS. WRM and OWRM requirements are based on the force structure and the cost of the materiel. They are not sensitive to the factors influencing POS requirements, i.e., the future flying hour program, demand rates, etc. At the heart of the BP 1500 requirements definition process is the D041 "Recoverable Consumption Item Requirements System," used to make the initial calculation of requirements. This is a complex computer model used for inventory tracking and requirements analysis. Calculations are based on item- and equipment-specific data.

There are three major organizations involved in the activities comprising the BP 1500 Requirements/POM/Budget/Appropriation Process:

- the Air Logistics Centers (ALC),
- the AFLC Logistics Operations Requirements Division, (AFLC/LOR) and the Directorate of Programs (AFLC/XRP), and

- the Directorate of Logistics Plans and Programs, Aircraft/Missiles Program Division of the Air Staff (HQ USAF/LEXW).

These groups are responsible for collecting the data and developing initial estimates; reviewing and refining the requirements estimates; and presenting and defending these requirements in the POM and Budget preparation process. Their specific responsibilities are summarized below.

The Air Logistics Centers (ALC) are responsible for the collection, review, and maintenance of the aircraft maintenance data. There are five ALCs, each responsible for specific systems:

- Ogden Air Logistics Center (OO-ALC), Hill Air Force Base, Utah;
- Oklahoma Air Logistics Center (OC-ALC), Tinker Air Force Base, Oklahoma;
- Sacramento Air Logistics Center (SM-ALC), McClellan Air Force Base, California;
- San Antonio Air Logistics Center (SA-ALC), Kelly Air Force Base, Texas; and
- Warner-Robins Air Logistics Center (WR-ALC), Warner-Robins Air Force Base, Georgia.

The ALC is the primary level at which logistics/maintenance data is collected and aggregated by item and equipment. Within the ALCs, the item and equipment data bases are the responsibility of the Equipment Specialist (ES) and Item Manager/ Inventory Management Specialist (IM or IMS - both terms are used). The ES and IMS have coordinated responsibility for collecting, validating and maintaining the usage and asset data,

and developing usage factors. The ALC has the overall responsibility for the following BP 1500 data related tasks:

- collect, maintain and validate actual data from bases and depot repair facilities;
- develop equipment repair and support requirements;
- develop forecasting factors;
- review and adjust data (through file maintenance procedures);
- maintain and track records of assets;
- participate in the review of the DO41 Requirements Computation and Central Secondary Item Stratification (CSIS);
- manually adjust estimated requirements and present these at the materiel management reviews;
- justify and defend materiel estimates to AFLC and HQ USAF; and
- acquire the BP 1500 items, based on guidance received from AFLC.

The next higher tier in the BP 1500 organization is the Air Force Logistics Command (AFLC). The ALCs report to and receive direction from AFLC. AFLC has the responsibility of projecting the worldwide BP 1500 requirements. Within AFLC, the Logistics Operations Requirements Division (AFLC/LOR) takes the lead in developing BP 1500 requirements.

The following are considered the primary responsibilities of AFLC/LOR in relation to projection of BP 1500 requirements:

- develop stock levels and cycles for DO41 computations;
- provide future and past program data for DO41 computations;

- evaluate requirements computation and CSIS for each ALC;
- allocate "common" equipment and develop justifications for allocation;
- array requirements by mission design (M/D) and engine;
- develop additive (one-time-only and recurring) requirements (in conjunction with ALCs and HQ USAF/LEXW);
- aggregate final ALC requirements and develop defined worldwide BP 1500 requirements;
- develop and document the BP 1500 requirements estimates for the POM submission, the USAF Budget input in the President's Budget, and the annual apportionment justification;
- make allocation decisions of POS funding for BP 1500 budget funds; and
- direct the IMS and ES at the ALCs on the requirements funding for each M/D.

The highest tier within the Air Force which deals directly with the BP 1500 process is HQ USAF-the Air Staff. The representative of the Air Staff in the BP 1500 requirements analysis process is USAF/LEXW. This group acts as the representative for BP 1500 interests in the Air Staff. The main responsibilities of USAF/LEXW in the BP 1500 requirements process are to:

- provide guidance and direction to AFLC in the areas of program requirements and constraints;
- transmit the specific WRM and OWRM funding direction and any relevant information related to POS requirements;
- monitor the execution of BP 1500 funds;
- present and defend BP 1500 requirements in the POM and Budget preparation process;

- represent the Air Staff at the materiel management reviews;
- maintain an advisory role in the AFLC/LOR computation of worldwide BP 1500 requirements;
- extract the POS, WRM and OWRM requirements, as well as any other salient information from the BP 1500 Budget Estimate Submission (BES), and present to the Comptroller of the Air Force, Directorate of the Budget (USAF/ACB);
- prepare and prioritize any Program Decision Packages (PDP) and Decision Package Sets (DPS) required to support the manual adjustments to the POS, the WRM and the OWRM requirements;
- transmit the final approved budget funding levels after review and revision of the PDP and DPS submissions by OSD, OMB, and finally Congress; and
- participate in the refinement of the draft cost per flying hour (CPFH) factors, developed by AFLC/LOR.

In addition to USAF/LEXW the other groups within the Air Staff with significant involvement in the presentation of BP 1500 requirements are USAF/PRP, USAF/ACB and USAF/ACM. USAF/PRP is responsible for coordinating the development of the Air Force POM. USAF/PRP is also the source of the future and past flying hour program data used in the D041 calculations. USAF/ACB is responsible for coordinating the Air Force budget estimate and transmitting direction concerning the final budget appropriation. USAF/ACM is involved in performing cost and management studies on a variety of topics including BP 1500 items. Exhibit II-2 illustrates the relationships of the various organizations within the BP 1500 requirements determination process.

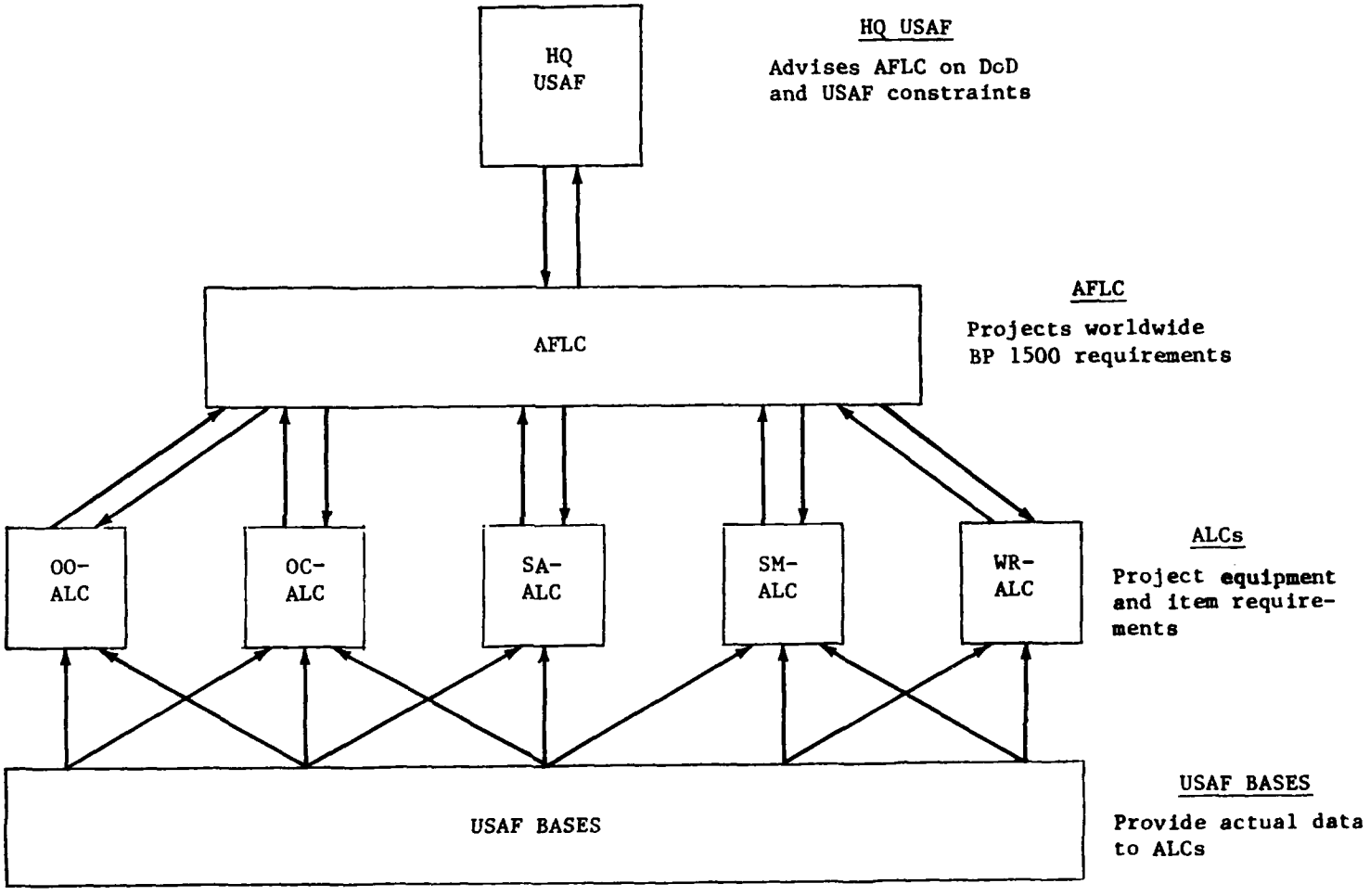


Exhibit II-2. BP 1500 INFORMATION HIERARCHY

Within the BP 1500 Requirements/POM/Budget/Appropriation Process, five significant documents are produced:

- The Requirements Computation calculates the net requirements by comparing the gross requirements to the net assets, and displays the projected requirements for the next 12 quarters, the buy period, the termination period, and the retention period. It is the first output of the DO41 system.

- The Central Secondary Item Stratification (CSIS), the ultimate product of the DO41, simulates the requirements in terms of an acquisition strategy for the Apportionment Year (AY), the Budget Year (BY) and the Extended Year (EY). Projected requirements are related to projected assets in a specific priority/time sequence.

- The Apportionment Submission, a report developed by AFLC/LOR for HQ USAF/LEXW, documents the apportionment decisions for the current fiscal year by Peacetime Operating Stock (POS), War Reserve Materiel (WRM), and Other War Reserve Materiel (OWRM).

- The P-18 Exhibit/Budget Estimate Submission (BES), a document developed by AFLC/LOR, is reviewed by AFLC/XRP, and is presented to HQ USAF/LEXW. This documents the total worldwide BP 1500 requirement, identifying the initial requirements developed in the DO41, CSIS, and the amount of manual adjustment, by type, made to the CSIS. Requirements are presented for the AY, BY and EY.2/

- The POM Cost Per Flying Hour (CPFH) Factors, Mission/Design (M/D)-specific cost factors developed from the DO41 CSIS for the EY with manual adjustments having been made to the initial estimate. These factors are used with the future flying hour program, provided by HQ USAF/PRP, to develop the POM POS requirements for each M/D. These requirements are combined with the WRM and OWRM requirements, calculated based on direction provided in the Consolidated Guidance (CG) to produce the total POM BP 1500 estimate.

2/ The FY83 Budget Estimate has been submitted in a new revised format which, in the future, may replace the P-18 Exhibit format.

The last element used to define the BP 1500 requirements determination process is the Schedule of Events. This schedule is designed to mesh with the federal PPBS schedule. Exhibit II-3 shows the BP 1500 Schedule of Events, the major milestones of which are the:

- 31 March cut off date for D041 data collection,
- mid-May production of the D041 Requirements Computation,
- mid-June production of the D041 CSIS report,
- mid-July Apportionment Submission,
- mid-September Budget Estimate Submission (BES), and
- late October to mid-November submission of draft POM CPFH factors.

As shown in the master illustration, the same D041 CSIS for 31 March of a given year is used to develop the Budget estimate and the POM estimate in each cycle. For example, the POM CPFH factors, developed from the 31 March 1980 data, are for the POM period of FY83-87. The same 31 March 1980 CSIS is also used to develop the BES for FY82. The following year, the 31 March 1981 CSIS will be used to develop the FY84-88 POM and the FY83 BES. Thus the budget estimate is always developed using data which are one year more recent than those used to develop the original fiscal framework in the preceding year's POM. The next part of this section presents a summary of the Phase II analysis of potential sources of errors in the development of the CPFH factors.

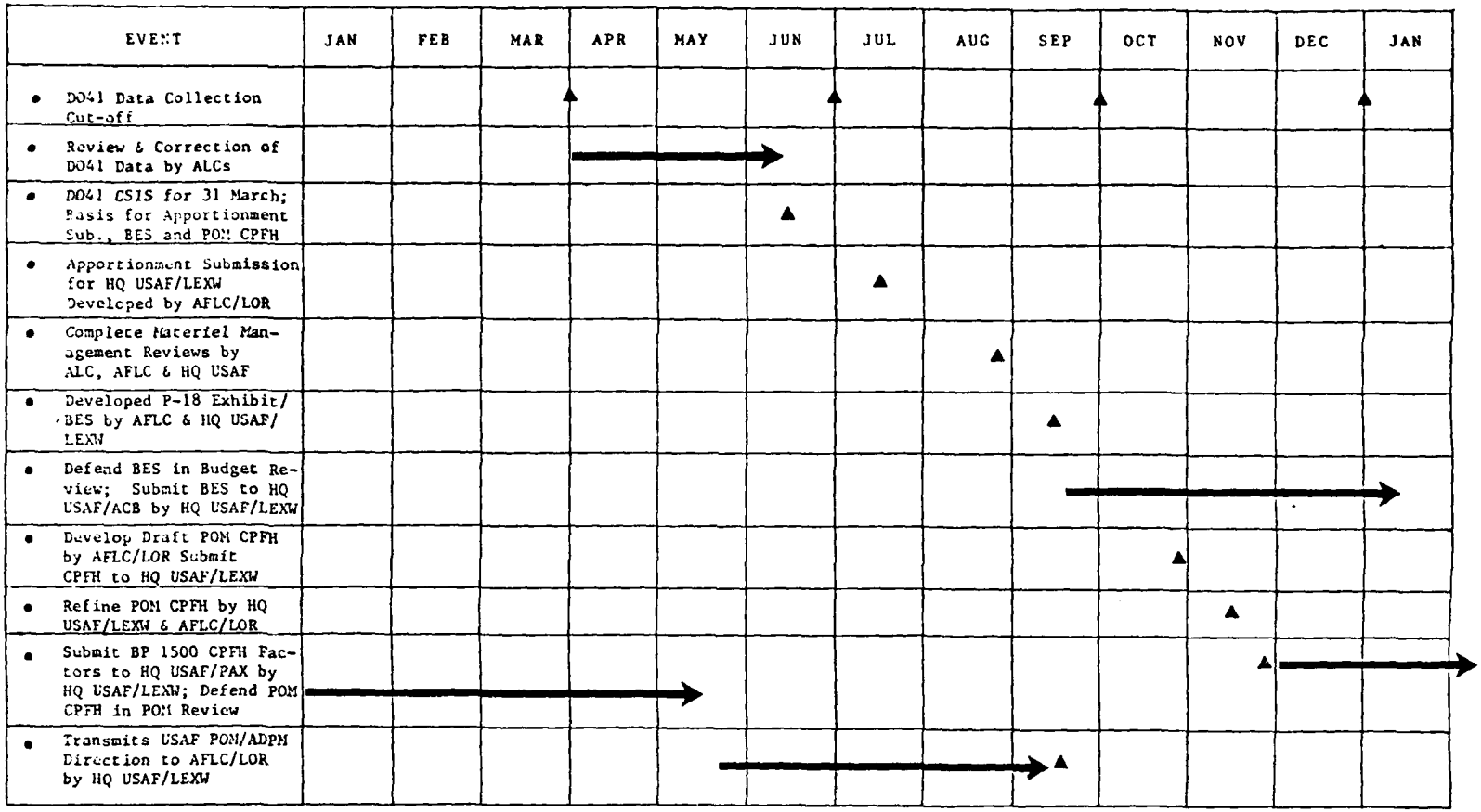


Exhibit II-3. BP 1500 SCHEDULE OF EVENTS

C. SUMMARY OF ANALYSIS OF SOURCES OF ERRORS

The research of the BP 1500 Requirements/POM/Budget/Appropriation process formed the basis of MCR's analysis of potential sources of error within the process. The potential for error can result from characteristics of the requirements analysis or from the method by which the Air Force implements the PPBS requirements. In considering the possible sources of errors, particular attention has been given to these aspects of the process:

- data systems,
- policies and regulations,
- management procedures,
- organizational and analytical interfaces, and
- documentation.

The internal workings of the DO41 system, while central to the analytical process, have not been examined. However, due to the integral role of the DO41 system in BP 1500 requirements analysis, characteristics of the system have been studied in order to understand how they affect the forecasting capability of AFLC.

It is recognized that some of these potential sources have been identified in other studies and are currently being addressed within the AFLC. These sources of errors in the current BP 1500 forecasting process have been categorized as:

- imbedded opportunities to make errors, which can affect the <u>accuracy</u> of the estimate;

- deficiencies and inconsistencies in the process, which can affect the credibility of the estimate, and

- uncompensated for factors, which can affect the realism of the estimate.

Seven of the most significant imbedded opportunities to make errors, identified in the current process, are related to the:

- accuracy, validity and currency of the data in the DO41 data bases, and the sufficiency of trend analyses applied to these data;

- imbedded limitations in the internal calculations and assumptions used to produce the DO41 Requirements Computation and CSIS;

- procedures for "scrubbing" the ALC requirements in the annual materiel management reviews, and documentation of the final negotiated requirements developed in these reviews;

- procedures for compiling the item- and equipment-specific negotiated requirements into worldwide BP 1500 requirements, and documenting this process;

- documentation of transitions from the original CSIS requirements to the projected Budget requirements as presented in the P-18 Exhibit/Budget Estimate Submission (BES). (This may not continue to be a source of potential errors if the P-18 format is replaced.);

- assumptions used to develop the draft POM CPFH factors, e.g., the method for allocating common items to each Mission/Design and the documentation of the conversion from the DO41 CSIS to the draft CPFH; and

- refinement for the POM submission of the draft CPFH, the linear application of these factors to the future flying hour program, the development of out-year POM CPFH factors, and the documentation of the refinement process.

Below is a brief review of specific aspects of these potential sources of accuracy errors.

- Errors in the data base are indicated by the magnitude of adjustments which have been made in the past. Exhibit II-4 compares the adjustments made to POS requirements as documented in the past two BESs.

- The DO41 assumptions which influence the accuracy of the estimates are the:

  - non-allocation of "common" parts on an item-by-item basis,

  - inclusion of only two years worth of historical data,

  - allowance of a maximum leadtime of three years, and

  - simulation of only a three year period in the CSIS.

- Potential problems associated with the Materiel Management Reviews are:

  - lack of specific direction for "scrubbing" the ALC CSIS,

  - corrections/adjustments are not reflected in the DO41 or in the data base, and

  - poorly-documented adjustments make it difficult to analyze utilization trends developed by the ALCs.

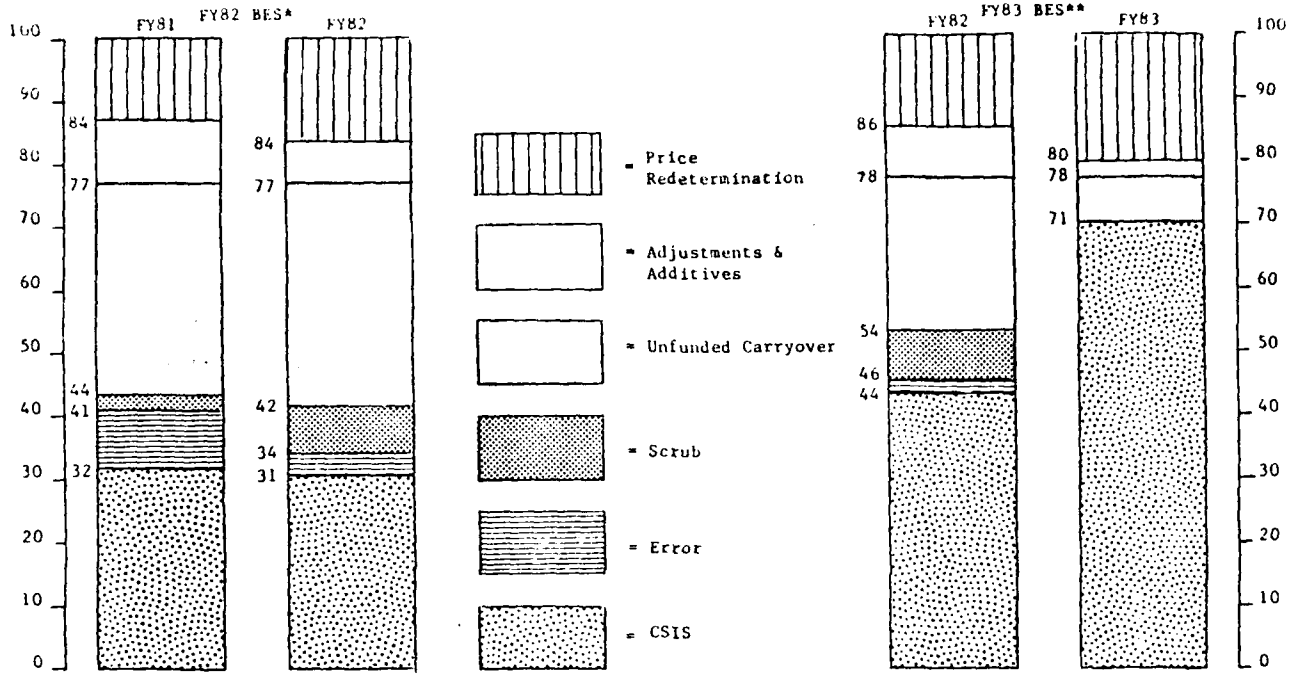
- The compilation of worldwide requirements has potential difficulties associated with it due to:

  - the past concern that computed CSIS requirements have constituted less than one-third of the total POS requirements submitted in the BES (the FY83 BES indicates a move toward correction of this disproportionate role.); and

  - the lack of formal documentation of procedures used to compile ALC requirements into total worldwide BP 1500 requirements.

- The P-18 Exhibit/BES had a variety of problems associated with it,3/ specifically:

3/ All of these problems will be eliminated if the revised format used in the FY83 BES is permanently adopted.



FY81	FY82 BES*	FY82	FY83 BES**	FY83
CSIS=32.0%	CSIS=31.0%	CSIS=44.1%	CSIS=71.1%	
Error=9.0%	Error=3.0%	Error=1.5%	Error=.4%	
Scrub=3.0%	Scrub=8.0%	Scrub=8.4%	Scrub=.1%	
Unfunded Carryover=33.0%	Unfunded Carryover=35.0%	Unfunded Carryover=24.4%	Unfunded Carryover=6.5%	
Other Demand & Level Adj.=6.0%	Other Demand & Level Adj.=4.0%	Other Demand & Level Adj.=2.5%	Other Demand & Level Adj.=-3.7%	
Additives=4.0%	Additives=3.0%	Additives=4.6%	Additives=5.0%	
Price Redetermination=13.0%	Price Redetermination=16.0%	Price Redetermination=14.6%	Price Redetermination=20.5%	

*USAF Budget Program: Aircraft Replenishment Spares P-81 Series Budget Exhibits--FY82 Budget. AFLC/LOR, 15 September 1980.

**United States Air Force Budget: Replenishment Spares (Revised) FY83 Budget Program is: Aircraft Replenishment Spares-3010 Aircraft Appropriation. AFLC/LOR, 26 October 1981.

Exhibit II-4. COMPARISON OF POS BUDGET ESTIMATE ADJUSTMENTS

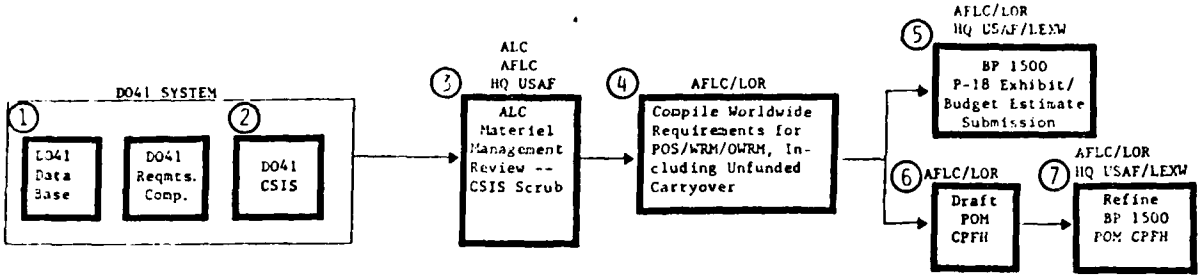
- the difficulty involved in tracking data through the document,
- the use of the phrase "Net Increase Based on Individual Item Review" to explain adjustments, and
- the fact that POS requirements are not explicitly identified.

- The questions associated with the development of the draft POM CPFH focus on:
  - the method used to allocate common items to M/Ds,
  - the question of using flying hours versus sorties to calculate requirements,
  - the inclusion of non-flying hour-sensitive costs, and
  - the question of whether there is a linear relationship between flying hours and requirements.
- The major concerns with the refinement of the POM CPFH are:
  - the use of OMB inflation indices, and
  - the additional adjustments made at the Air Staff level.

Exhibit II-5 illustrates where these accuracy problems occur in the process.

The major deficiencies and inconsistencies in the current process include the following generic types of potential problems:

- lack of formal documentation at various critical stages in the development of the BP 1500 POM and Budget requirements,
- lack of specific and consistent procedures for analyzing and adjusting estimates and developing a CPFH,



① Errors in Data Base (e.g., Accuracy, Validity and Currency of Data)

② DO41 Assumptions

③ Materiel Management Reviews

④ Compilation of Worldwide Requirements

⑤ P-18 Exhibit/Budget Estimate Submission

⑥ Draft POM CPFH

⑦ Refinements of POM CPFH

Exhibit II -5. IMBEDDED OPPORTUNITIES FOR ERROR(ACCURACY)

- sufficiency of trend analysis in the calculation of requirements,

- hardware and software limitations in the DO41 system, and

- inconsistencies in the coding of data, primarily attributable to the multiplicity of codes by which data are tracked in the system.

The specific difficulties in each of these areas are reviewed below:

- the lack of formal documentation of activities and calculations was indicated by the:
  - difficulty in tracking the development of the requirements estimate through the process as experienced in this study,
  - Air Force Audit Agency reports criticising lack of documentation, and
  - questionable ability to reconstruct previous POM and Budget estimates.
- the lack of specific procedures which allow for the consistent evaluation, calculation and adjustment of estimates, specifically:
  - procedures for calculating and implementing scrub adjustments, and
  - procedures for tracking and regulating data file changes.
- the sufficiency of trend analysis was considered a potential source of errors4/ because:
  - it appears to be performed on an ad hoc basis, and

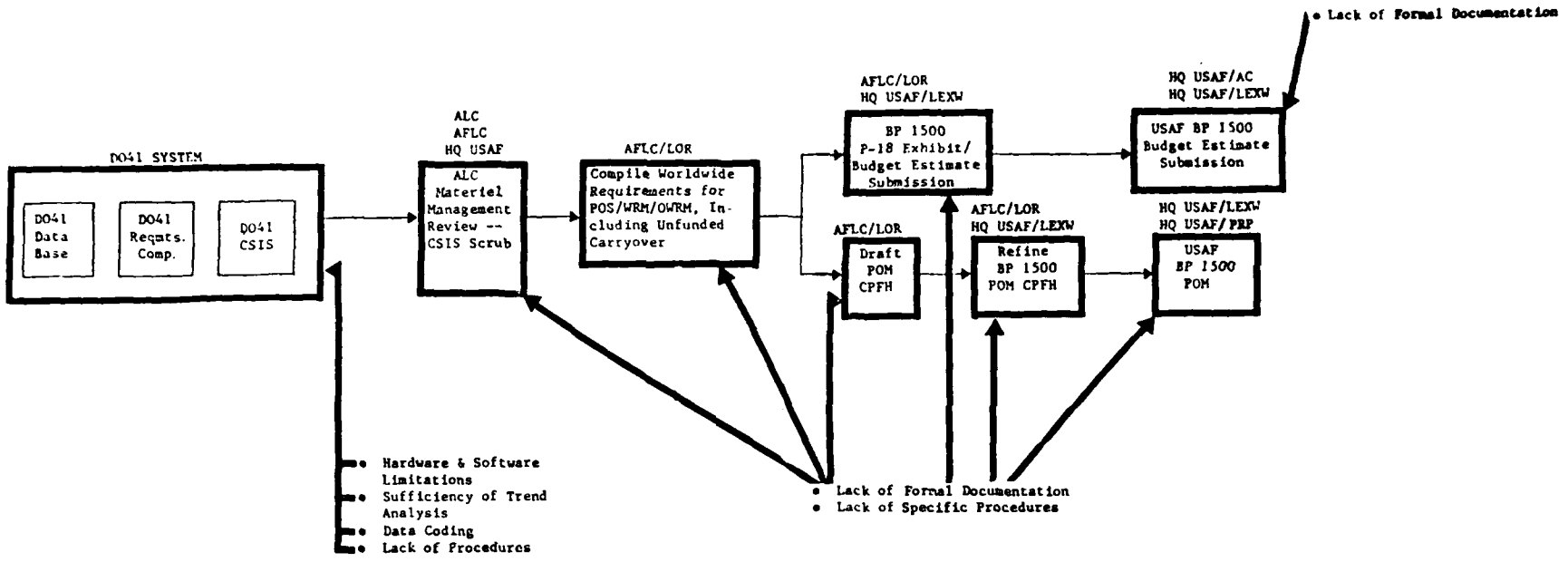
4/ However, a variety of studies are currently planned within AFLC/LOR which could remedy much of this.

- the lack of emphasis on studying major trends in BP 1500 requirements, e.g., acquisition data, item-specific usage rates, and location trends.

- the hardware and software limitations of particular concern are the:
  - time needed for the DO41 calculation (75 days),
  - responsiveness of the system to data corrections,
  - inaccessibility of the data,
  - lack of a real time retrieval and analysis capability, and
  - inability to perform "quick response" analyses.
- the potential problems with the data coding regard the:
  - complexity and variety of item and equipment identification codes (National Stock Numbers, Interchangeability and Support Codes, Selective Management Group Codes, etc.), and
  - translation of Stock Numbers to M/Ds and then conversion to Program Element (PE) numbers.

Exhibit II-6 illustrates where the potential sources of credibility problems occur in the process.

The third type of errors which can occur in the forecasting of POM requirements relates to those factors not compensated for in the current process. The first two categories relate to the sources of potential error in the internal activities associated with developing and documenting requirements and maintaining and using the history of these activities. The elements considered here related to the insufficient consideration of the impact of external factors on the validity, or realism of the forecast. The most significant of the uncompensated for factors are the:



- Lack of Formal Documentation
- Lack of Specific Procedures
- Sufficiency of Trend Analysis
- Hardware & Software Limitations
- Data Coding

Exhibit II-6. DEFICIENCIES AND INCONSISTENCIES (CREDIBILITY)

- PPBS environment, specifically, the differences between the intention of the POM to provide a baseline projection of requirements based on projected inventory demands and that of the Budget to provide a detailed analysis of near term requirements in the context of budget constraints and readiness objectives;

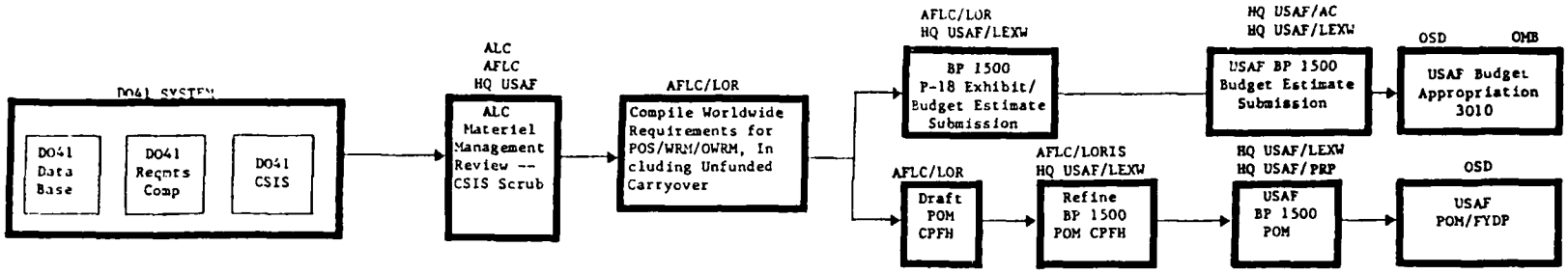
- consideration of exogenous data in the calculations, such as age of the equipment, production constraints, e.g., tooling availability, state of the art, technology type, etc., and financial considerations such as interest rates;

- changing basis for requirements analysis, particularly the imbedded inconsistencies between the data base and flying hour program used to develop the Budget estimate and the data base and flying hour program used to develop the POM CPFH for a given year;

- inadequate tailoring for outyear POM CPFH factors, which are modified from the first year factor, that is, the factor used to cost the first year of the POM, to reflect only mandated inflation; and

- impact of changing the near-term flying hour program during the period between the calculation of the POM and the calculation of the Budget for a given fiscal year.

The specifics of these potential sources will be discussed in greater detail in terms of how they relate to the realism factors in the compensation methodology. Exhibit II-7 illustrates the fact that these types of problems affect the whole BP 1500 requirements development process.



- PPBS Environment
- Exogenous Information
- Changing Basis For Requirements Analysis
- Forecasting POM CPFH
- Changing Future Flying Hour Program

Exhibit II -7. UNCOMPENSATED FOR FACTORS (REALISM)

III. DESCRIPTION OF COST PER FLYING HOUR PARAMETRIC ESTIMATING RELATIONSHIP (PHASE III)

This section presents the following topics:

- a background discussion,
- a summary of the factor identification process,
- a description of the factors, and
- a discussion of the factor development and application.

A. BACKGROUND

Potential sources of error in the current BP 1500 requirements analysis process were identified in Phase II of this study. These potential sources were grouped in terms of how they might impact the:

- accuracy,
- credibility, or
- realism

of the BP 1500 requirements estimate.

Phase III of this study has focused on translating the impacts of these potential sources of error into quantifiable factors. These factors will ultimately be applied to the raw Cost Per Flying Hour (CPFH) developed for each Mission/Design (M/D) to produced a refined CPFH. This refined CPFH will reflect the projected impact of a variety of factors which in the past have contributed to the lack of forecasting accuracy of the BP 1500 POM estimates. The factor refinement methodology is termed a Parametric Estimating Relationship (PER)

with factors for accuracy and realism as the parameters being estimated.

MCR's effort in the development of this Parametric Estimating Relationship has focused on:

- identifying compensating factors having the most significant influence on requirements growth,
- defining a structure in which to organize and apply the factors to develop a set of refined POM CPFHs; and
- describing potential sources of data and a method for applying each factor.

Several advantages were seen in taking the structured PER approach to addressing BP 1500 requirements forecasting problem:

- It provides the analyst with the ability to:
  - structure adjustments consistently from year to year;
  - isolate individual elements for which adjustments need to be made, on an M/D basis; and
  - document the adjustments easily and consistently.
- It allows for the deletion, replacement or addition of factors as improvements or changes occur in the process.

Finally, in developing this PER, emphasis has been placed on factors with the following characteristics:

- easy to explain and understand,
- defendable in OSD and Congressional reviews,
- compatible with DO41 output,
- flexible with the capability of being modified if necessary, and

- stand alone, to the degree possible.

The development of the factor refinement methodology will be described in the following sections.

B. SUMMARY OF FACTOR IDENTIFICATION PROCESS

The potential sources of error identified in Phase II of this study formed the basis for developing the PER factors. In first evaluating the potential sources of error, the initial criterion was whether the impact of the error was actually measurable. In considering the three main categories (accuracy, credibility, and realism) it was decided that the impact of potential credibility problems was *not translatable into a quantifiable* influence on the requirements estimates. Thus, initial emphasis was placed on the accuracy and realism problems. This requires factors for:

- accuracy errors related to imbedded opportunities for making errors within the process, namely the:
  - errors in the data base,
  - DO41 assumptions,
  - procedures for performing materiel management review adjustments,
  - historical lack of explanation associated with compilation of the worldwide requirements,
  - difficulties associated with identifying and tracking data in the P-18 submission,
  - requirements as represented in the Draft POM CPFH, and
  - refinement of the CPFH for the base and out-years of the POM; and

- realism errors related to factors not compensated for in the current process, namely the:
  - differences between the points of view of AFLC and the Air Staff as a function of the PPBS environment,
  - impact of exogenous information,
  - changing basis for requirements analysis, i.e., changes in data base and flying hour program,
  - lack of outyear forecasting in developing the POM CPFH factors, and
  - impact of changes in the future flying hour program.

Evaluation of these sources in light of their conversion into compensating factors revealed that many of them were not suitable. Several of the accuracy errors have been, or are in the process of being corrected through AFLC management initiations. For example, the P-18 Submission may be replaced by a revised format which resolves the previous confusion. In addition, although these are potential sources of errors, the impact of concerns such as explanations of the worldwide requirements compilation are not really quantifiable or realistically planned for. Thus, the only two sources of accuracy errors which were considered to be potentially quantifiable are:

- data base errors, and
- DO41 assumptions.

The impacts of both of these are usually corrected for through manual adjustments in the materiel management reviews.

A similar situation occurred in the evaluation of the sources of realism errors. Although all of these can potentially impact the forecasting accuracy of requirements estimates, not all of these are amenable to conversion to PER factors. Specifically, the differences due to the PPBS environment, that is the AFLC orientation toward minimizing stock shortages versus the Air Staff orientation of maximizing readiness, while capable of being analyzed, requires an indepth study. The approach taken in identifying the realism factors has been to focus on reasons for change in planned requirements. This allows for development of factors which reflect the impact of the realism errors on future requirements. The basic philosophy used in developing this methodology is that accuracy factors correct the raw CPFH up to the present, while the realism factors represent projections into the future of identifiable trends.

The first step after reviewing the specific accuracy and realism errors was to develop a list of <u>reasons for</u> which <u>requirements</u> estimates can <u>change</u>. These "reasons for change" were then grouped according to general category. The categories were:

- Data Base Errors,
- DO41 Assumptions,
- Program Changes,
- Funding/Financial,
- Design/Engineering,

- PPBS Schedule Changes,
- Procurement Data, and
- Price Redetermination.

There were two main problems that were found at this stage:

- a single generic type of reason could be assigned to multiple factor categories; and
- the complex interrelationships existing among the various reasons for change, and between the reasons for change and the different factor categories.

The accuracy factors were identified quite early as being restricted to errors in the data base and the DO41 assumptions. These will be discussed in later subsections. The focus of the remainder of this discussion of the factor identification process will be on development of the realism factors. Exhibit III-1 shows the first set of potential realism factors with the related initial set of "reasons for change." As can be seen, several "reasons for change" are identified with more than one factor category.

Exhibit III-2 illustrates the complex interrelationships between the initial set of reasons for change and the initial set of realism factor categories. Exhibit III-3 illustrates the intimate relationships among the "reasons for change." This analysis demonstrated the degree of potential complexity which must be considered in dealing with this problem. Subsequent reviews and evaluation eliminated some reasons for change as being inappropriate as contributors to the overall factor value, and reduced the duplications of reasons among the factor categories.

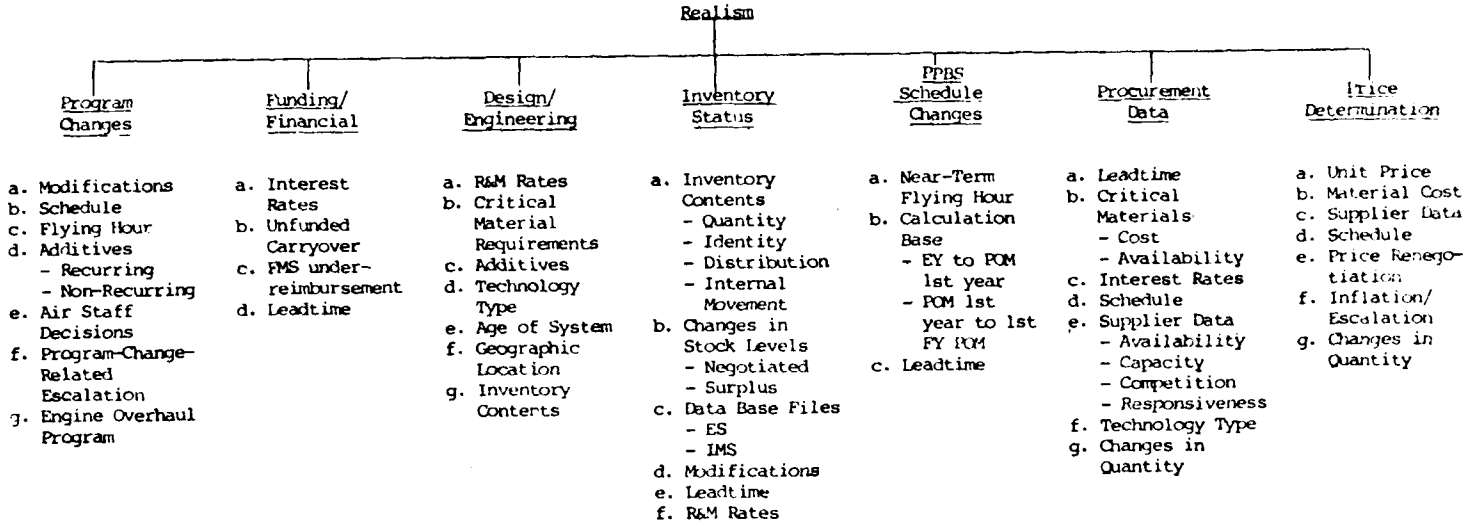


Exhibit III-1. BP 1500 CPFH PER STRUCTURE: REALISM FACTORS

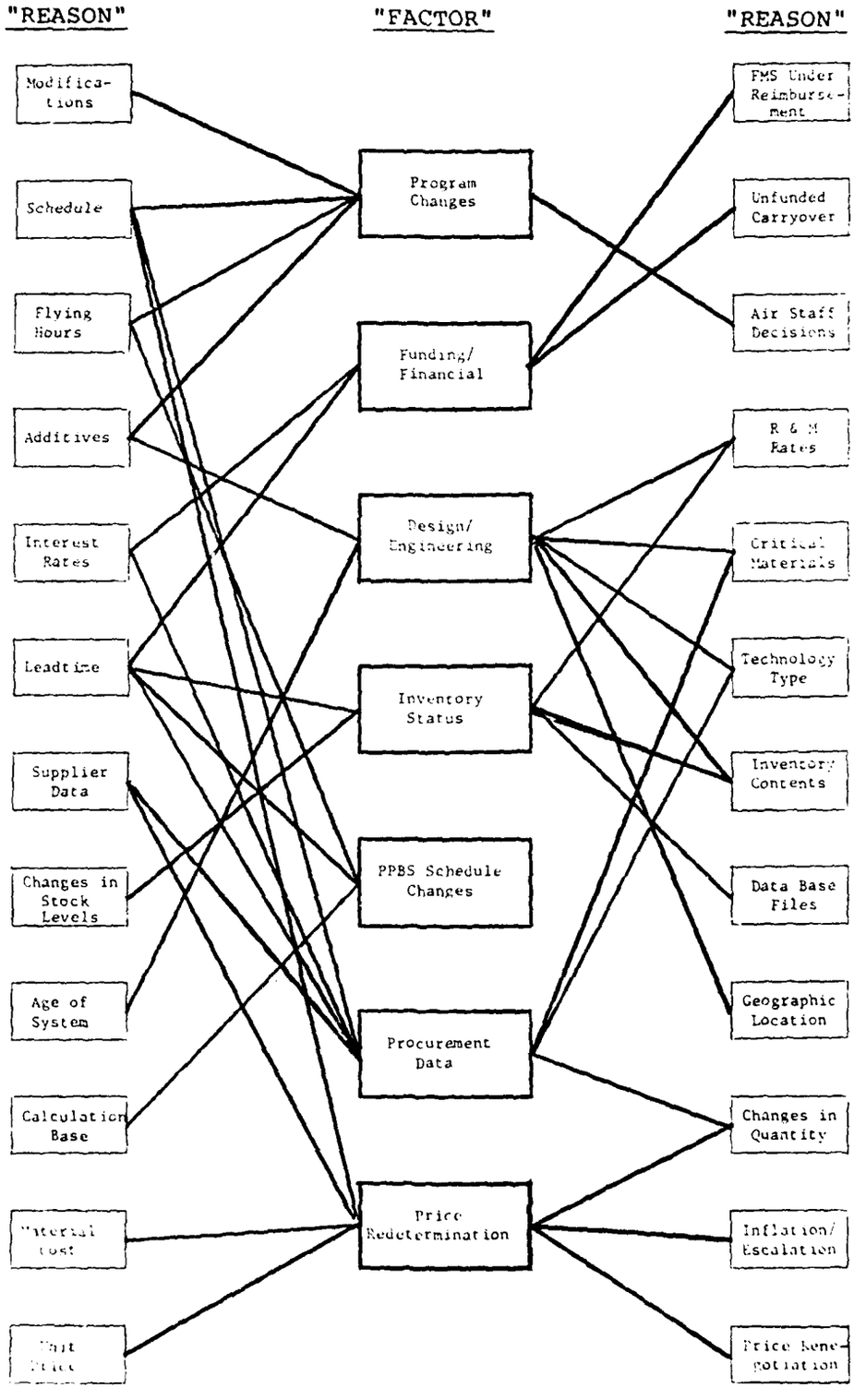


Exhibit III-2. RELATIONSHIP BETWEEN REALSIM FACTORS AND "REASONS FOR CHANGE"

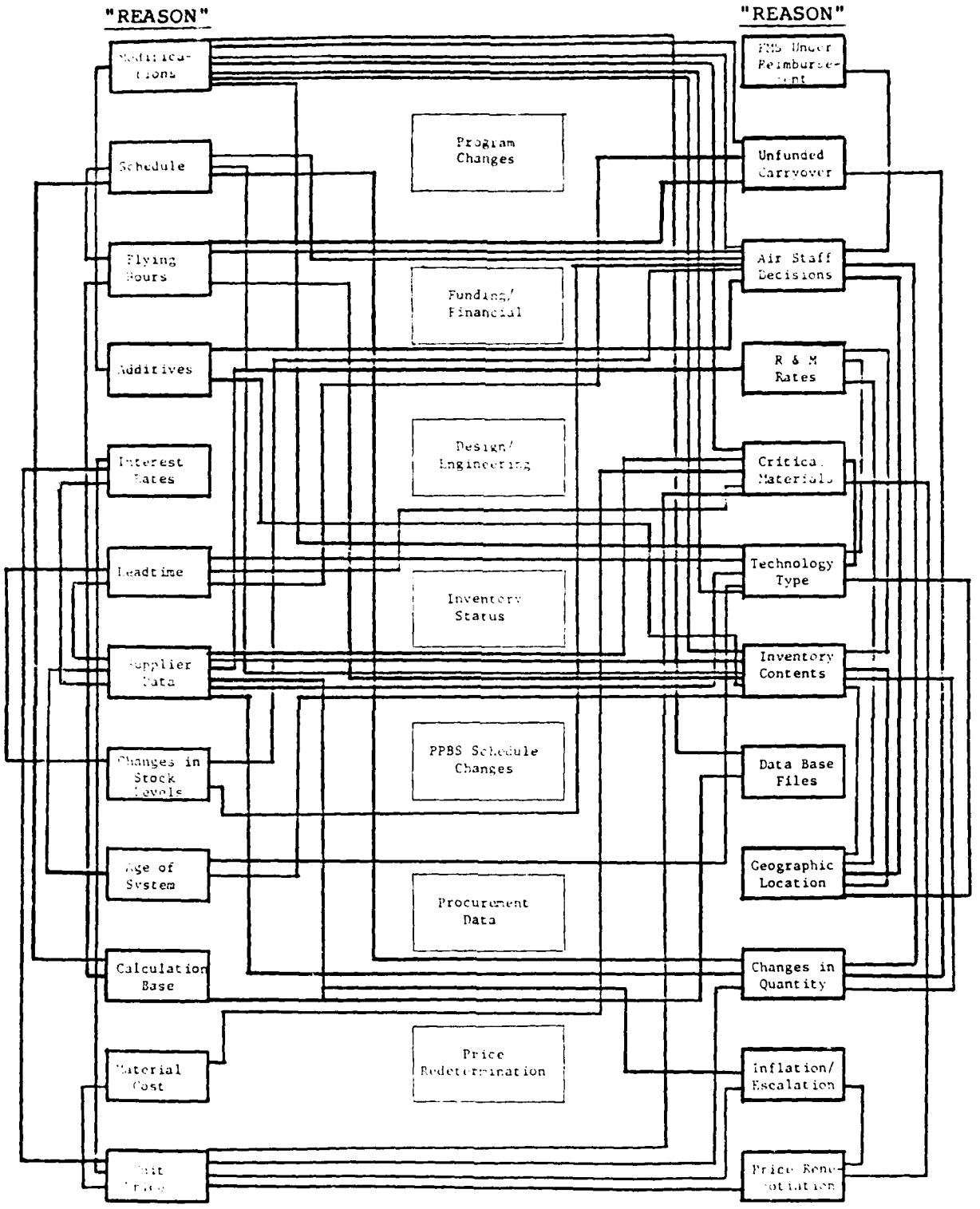


Exhibit III-3. RELATIONSHIP BETWEEN REALISM "REASONS FOR CHANGE"

The next major question to be resolved was the following. "Should emphasis be placed on developing data for many small, very specific factors, i.e., the reasons for requirements changes, or on a few large, aggregate factors?" There are pros and cons to each approach:

- Specific, non-aggregate factors could apparently allow for more precise refinement and tailoring of the CPFH factor. However, as noted earlier, these factors have complex interrelationships requiring a much more extensive analytical effort to develop values.

- Aggregate factors may be easier to defend. However, they must be developed very carefully or they could make the requested funding more vulnerable. Exceptions to a given factor could relate to a much higher percentage of the projected requirement than any of the more specific factors.

After careful analysis and discusions between MCR and AFLC, it was ultimately decided that emphasis should be placed on the latter approach.

In addition to further eliminating some potential "reasons for change," the on-going review of the factor structure resulted in some rearranging of the "reasons for change." Perhaps the most significant "reason for change" to be eliminated was unfunded carryover. This factor points out the distinctions which must be made between reasons why requirements change over time and compensating factors. Unfunded carryover reflects the shortfall between estimated and funded requirements. It can also relate to differences between an initial requirements estimate and a subsequent estimate. For example, changes in future flying hour programs can change quarterly, resulting in changes

in projections for requirements and, therefore, potential unfunded carryover. In either case, unfunded carryover is generated by changing plans usually related to specific requirements drivers. Therefore, if other requirements drivers are calculated correctly, unfunded carryover will be diminished. For that reason, explicit identification of unfunded carryover is not needed.

Exhibit III-4 shows the relationship between the draft set of reasons for change and the aggregate factors. Two factors previously considered, Procurement Data and Price Renegotiation, have been eliminated, with most of the related effects being captured by the Financial factor. Additionally, all of the reasons for change associated with the PPBS Schedule and Leadtime factors were also either duplicated in other factors or ultimately not practically quantifiable. This resulted in the development of the matrix currently in use, shown in Exhibit III-5.

The elimination of Leadtime as a factor again raises the question of the alternate objectives of the factors:

- to project ultimate requirements, or
- to account for reasons for requirements changes.

As has been previously discussed, the evolution of the factor development has been:

- identification of sources of error in the process,
- conversion of sources of error into reasons for requirements changes, and

Reasons for Changes in Requirements / Realism Factors	Program Changes	Financial	Inventory Status	Design/ Engineering	PPBS Schedule	Leadtime	Economic Escalation
Modifications	X		X				
Schedule	X						
Flying Hours	X				X		
Air Staff Decisions	X					X	
Additives	X			X			
Supplier Data		X				X	
Unit Price		X				X	
Price Renegotiation		X				X	
Quantity Changes		X					
Program Change-Related Escalation	X	X			X		
Interest Rates		X					X
R&M/Failure Rates			X	X			
Condemnation Rates			X	X			
Inventory Contents			X	X			
Changes in Stock Levels			X			X	
Technology Type				X		X	
Age of System				X			
Geographic Location				X			
Critical Material Requirements				X		X	
Data Base Files		X				X	
Calculation Base			X		X		

Exhibit III-4. REASONS FOR CHANGES IN REQUIREMENTS VERSUS REALISM FACTORS

Reasons for Requirements Changes / Realism Factors	Program Changes R-1	Financial R-2	Inventory Status R-3	Design Engineering R-4	Economic Escalation R-5
Modifications	X				
Schedule	X				
Flying Hour Program	X				
Management Decisions	X				
Additives	X				
Supplier Data		X			
Unit Price		X			
Quantity Changes		X			
Program-Change Related Escalation		X			
R&M/Failure Rates			X		
Condemnation Rates			X		
Inventory Contents			X		
Changes in Stock Levels			X		
Technology Type				X	
System Age				X	
Geographic Location				X	
Critical Material Requirements				X	
Inflation Rates					X

Exhibit III-5. CURRENT REALISM FACTOR RELATIONSHIPS

- relation of reasons for requirements changes to aggregrate projection factors.

Changes in Leadtime have accounted for substantial increases in requirements. However, it is questionable as to whether future Leadtime changes need to be projected explicitly or whether it is sufficient to capture the many effects of changes in Leadtime in other factors. The approach decided upon was to select a given factor and, to the degree possible, represent all of the specific effects of a given reason for change within the aggregate factor. In those cases, such as Leadtime, where multiple effects occur, the approach is to identify the individual effects related to a specific factor. Therefore, while there is no reason or factor specifically identified with Leadtime changes, realism reasons such as Supplier Data, Unit Price, and Program-Change-Related Escalation, and the accuracy factor related to DO41 Assumptions capture the multiple effects.

The following are brief descriptions of the selected factors and the related reasons requirements change.

C. DESCRIPTION OF FACTORS

Having identified a preliminary set of aggregate factors and related reasons for requirements changes, it was then necessary to define what was specifically meant by each of these. Philosophically, the accuracy factors were thought of as correcting the raw CPFH to reflect many of the adjustments made to the CSIS output in the materiel management reviews, to

bring them "up to the present." The realism factors were envisioned as representing the adjustments needed to project the requirements "out into the future."

The following are brief descriptions of the factors and related reasons for changes in requirements. Additional information is provided on the draft factor data sheets contained in Appendix A.

1. Accuracy Factors

There are two accuracy factors representing:

- Data Base Errors, and
- D041 Assumptions.

a. Data Base Errors (A_1)

This factor incorporates the impact of adjustments which must be made to the CSIS outputs to correct for:

- input or keypunch errors, and
- existing misinformation in the data base not corrected in the data file review process.

b. D041 Assumptions (A_2)

There were four major assumptions forming the basis of the D041 system calculations:

- the non-allocation of common requirements on an item-by-item basis,
- the inclusion of only two years worth of historical data,
- the allowance of a maximum leadtime of only three years, and
- the simulation of only a three year period (AY, BY and EY) in the CSIS.

The first three of these are potentially quantifiable in terms of their impact on the requirements estimates, while the fourth assumption is not considered measurable. Adjustments made in the materiel management reviews frequently try to compensate for these kinds of D041 calculation limitations. However, the impact of the limited simulation period is difficult to measure due to its very pervasiveness. It appears that, barring some other approach, the only way to measure the impact would be to actually extend the simulation period and analyze the differences. This currently does not seem possible.

2. Realism Factors

Realism is made up of five factors, each incorporating specific components or reasons for changes in requirements. These factors are:

- Program Changes,
- Financial,
- Inventory Status,
- Design/Engineering, and
- Economic Escalation

a. Program Changes (R_1)

This factor accounts for the projected impact of changes in program planning and operational planning. The components or "reasons for change" in projected requirements are:

- Modifications to existing systems, i.e., aircraft structure, major subsystems such as avionics or

electronic warfare, or engines, which are either already represented in the original configuration in the DO41 system, or are not represented in the DO41 system. Examples of modifications which must be adjusted for in the final calculation, and considered in the future are the retrofitting of older gyro systems or engine fan blades, due to redesign upgrades. Although modifications will impact a variety of areas, e.g., Financial, Inventory Status, etc., the effect will be represented in this factor.

- Schedule changes relating to the phasing in, or out of a system or equipment, as well as decisions to defer procurement from one year to the next. Changes in phasing frequently relate to the gradual replacement of one Mission/Design/Series (M/D/S) with a newer, related M/D/S. The original schedule for the phased replacement is changed after initial incorporation in the long term planning documents producing changes in planned requirements. Another type of schedule change relates to changes in overhaul schedules, such as the engine overhaul program. These schedule changes, can be related to modifications, and like them, influence other factors, e.g., Inventory Status, Financial, etc. However, the impact of this reason will be, to the degree possible, contained and represented in this factor.

- Flying Hour Program changes are necessary to consider since this program is one of the basic elements used in the calculation of the POM requirements. The flying hour program is updated quarterly to reflect changes in the future operational plans, i.e., the distribution and quantity of planned flying operations. Also involved in this quarterly updating process are the past flying hour records, documenting the actual flying hour program flown. Both of these reports are used as inputs to the DO41 system. The future flying hour program is also used, in conjunction with the CPFH, to develop the basic POS requirements for the POM.

  POM Requirements for BP 1500 items may change due to changes in the flying hour program. There are two basic ways in which this may occur:

  - the flying hour program planned for a particular M/D in a specific time period may fluctuate from quarter to quarter in the period before the program is actually flown, or

- changes may occur between the flying hour program planned for a given period and the one actually flown.

In both cases, failure to project accurately will result in differences between projected and actual requirements. This, in turn, can produce a bow wave effect, showing up ultimately as an unforeseen increase in projected or actual unfunded carryover, or an "equipment rich" inventory, containing unnecessary spares to support a reduced flying hour program. Flying Hour Program changes, in addition to their relationship to Program Changes, also influence the Inventory Status as indicated above. This is primarily due to changes in base demand and utilization rates. It is also possible that substantial changes in the flying hour program could influence the CPFH for a given M/D.

- Management Decisions is a more general reason for changes in requirements, relating to the collective group of decisions which change the standard or planned operating procedure for accomplishing or requiring replenishment. Examples of such decisions are changes in inspection frequency; transfer of maintenance responsibility from base to depot; changes in operating procedures which could increase or decrease failure rates, etc. These decisions frequently relate to specific items or equipment as well as a specific M/D/S.

  Another type of management decision relates to overall replenishment spares planning. Examples are criteria for assets being identified as POS versus WRM; the leadtime planning cycle, e.g., change from one year leadtime to two year, etc. These types of decisions may apply to a much broader variety of systems than the more restrictive, item/equipment-specific decisions. The distinction between the two types may also be that the former may be made by the ALC or AFLC, while the latter may be made at the Air Staff level.

- Additives are those requirements which reflect unforeseen or understated special demands for spares. There are two major categories of additives:

  - recurring additives which represent a single requirement, i.e., C-5 wing replacements, retooling etc, which will need to be funded over a period of several years and are not in

the D041 system.. These may be identified for common or unique equipments and are incorporated into the calculation of the CPFH.

- non-recurring additives, are generally very large, one-time-only additives which are not planned to be distributed over multiple years. Some of these may occur in more than one year but they will be in response to additional requirements projected for that year, e.g., additives for understated programmed Foreign Military Sales (FMS) requirements. Other examples are additives for spares to support new systems resulting from modifications. These are <u>not</u> incorporated into the calculation of the CPFH.

b. <u>Financial (R_2)</u>

This factor accounts for the projected impact of changes in the purchasing power of the planned programmed funds. It represents the following set of reasons for requirements changes:

- <u>Supplier Data</u> relates to the ability to procure equipment, when required, under reasonable terms. Factors to be considered are availability of suppliers, industrial capacity given potential competition with other Services and private industry, competition among potential suppliers, and responsiveness of suppliers to providing necessary equipment/materiel to the Air Force. Supplier data is indirectly influenced by other considerations such as interest rates, the type of technology involved, age of the system, and the need and availability of critical materials. It, in turn, influences other reasons such as Unit Price.

- <u>Unit Prices</u> may experience substantial differences between the historical "last price paid," used in the D041 calculation, and the actual price subsequently paid. These prices will almost exclusively be calculated on an equipment-specific basis, and may apply to several M/Ds. Specific examples would be projected price growth in engine components, wings, and electronic assemblies. The unit price value includes "out of production," or line restart costs in "base-year" or constant dollars.

- Quantity Changes. The impact of "learning curve" effects, multi-year procurement and planned obsolesence (such as the new initiative of Pre-Planned Product Improvement) should be considered for their financial implications. The "buy size" can influence the total price paid. This is related to other "reasons for change," such as Unit Prices and Program-Change-Related Escalation.

- Program-Change-Related Escalation. Other "reasons for change" measure the financial effects of Supplier Data, Unit Prices and Quantity Changes. Any program change, however, has both a constant dollar effect and an inflated or then-year dollar effect. The effect of escalation (inflation) due to these other program changes is picked up in this reason for change. One example is the added escalation due to deferring a buy decision for one year.

c. Inventory Status (R_3)

This factor represents the projected impact of changes in inventory status related to changes in projected system performance, and administrative decisions relating to inventory management. It incorporates the impacts of the following reasons for changes in requirements.

- R&M/Failure Rates can change for a variety of reasons including failure of a system to meet required performance standards, increasing age of the system and changes in operating procedures. Changes in these rates translate into changes in item demand and usage patterns in the inventory. These rates are related to other reasons for change including the Age of the System, where newer systems may have rates subject to substantial future change due to relative inexperience with actual operations; and Geographic Location, the impact of which may show up as changes in these rates.

- Condemnation Rates, can change over time in response to operational, management, or inventory administration decisions. Some examples are changes in flying procedures which can increase wear on specific parts, thus increasing failure rates, decreasing R&M rates and potentially increasing condemnations. Management decisions such as transferring repair responsibility

from depot to base, where repair facilities may be more limited, can also impact these rates. Administrative decisions concerning repair versus replacement of parts and criteria for condemnation can also impact these factors. Equipment condemnation rates can also be related to other considerations such as Inventory Contents where decisions may be made based on quantity in the inventory; System Age, where older components have higher condemnation rates; and Critical Materials Requirements, where special efforts are made to reduce condemnation rates on components with critical materials.

- Inventory Contents are of interest since they reflect the nature and characteristics of the replenishment spares world. In considering the inventory contents, the following characteristics are important:

  - the quantity of items in the inventory, in terms of cost,
  - the identity of those items,
  - the distribution of those items (how many of what kind), and
  - the internal movement of items within and through the inventory, i.e. of the total inventory, how frequently are what items/equipments removed, replaced, etc; what systems account for the greatest percentage of movement, percentage of dollars.

  The contents of the inventory are related to other factors such as Program Changes, Financial reasons such as Supplier Data and Quantity Changes; and R&M, Failure and Condemnation Rates.

- Changes in Stock Levels relate to changes in negotiated base stock level requirements due to redistribution of operational units or responsibilities, safety stock levels, i.e., increasing or decreasing required safety levels which are the basis for determining that the inventory needs to be restocked, and surplus stocks, by redistributing assets among bases or categories.

  A second type of change can occur which relates to the underestimation of future requirements for the POM due to the limited projection capability of the DO41. Assets may be adequate for the budget year

(EY) but not for the POM base year (EY-1). This, however, as discussed in the section on accuracy factors while contributing to requirements growth is not considered feasible to explicitly measure.

d. Design/Engineering (R_4)

This factor represents the projected impact of changes in technology. This is distinct from changes in performance expectations/estimates, which are represented in the Inventory Status factor. It reflects the following reasons for requirements changes.

- Technology Type, that is the type of technology represented in a system or equipment. This can greatly influence the replenishment spares requirements for the system. Older technologies may be more difficult to replace, having fewer suppliers and higher unit prices. Newer technologies, while perhaps having more potential suppliers, run the risk of demanding critical materials, elaborate manufacturing processes, etc. In either case, the technology can impact the leadtime. As with Supplier Data, a related element, competition for advanced technology sources is a possible problem.

- System Age, can be a significant factor to consider in projecting future aircraft replenishment spares requirements. The operational or flying age of the system is different from the chronological age, which relates more to technology type. The flying age of a system, or the total amount of time the system has been operated can affect the maintenance requirements. Thus it may not be sufficient to know only the mean time between failures (MTBF), the mean time to next maintenance action (MTNMA), or the mean time to repair (MTTR) but also where the system is in it's projected life span, since any of these factors can change due to an aging system. The notional "bathtub curve" in Exhibit III-6 illustrates this pattern.

- Geographic Location can influence requirements in addition to technology type and system age. Usage patterns and requirements can also change due to the environment in which a system operates. Some environments are more demanding of systems, particularly

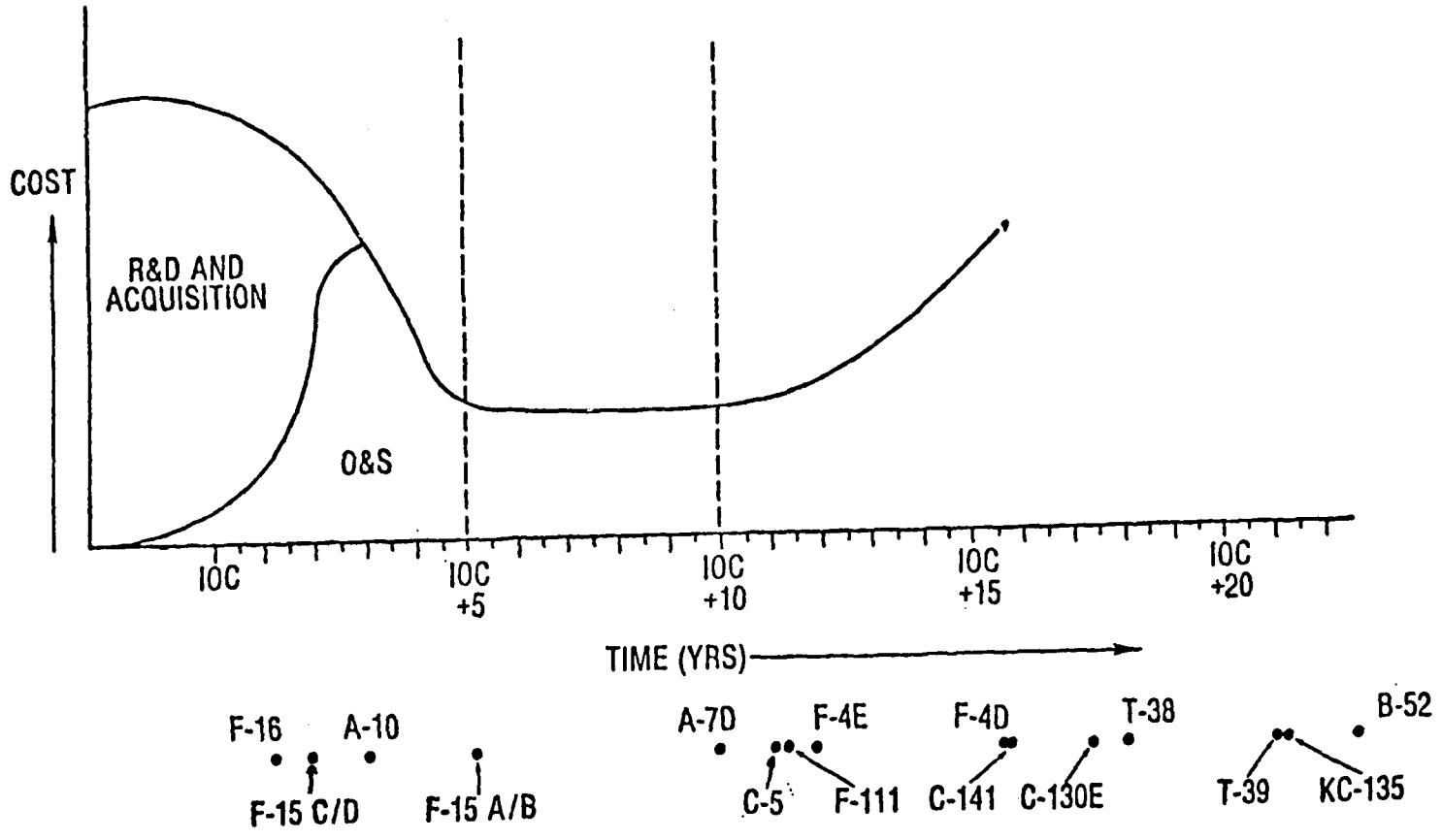


Exhibit III-6. NOTIONAL BATHTUB CURVE

electronics, than others. Studies have shown that maintenance requirements can be substantially different, depending on different operational locations, even for the same system. This effect is lost when system data are averaged without regard to location. The ability to project potentially higher, or lower requirements for key systems, depending on the environment/climate in which they will operate is, therefore, of great use.

- Critical Material Requirements, is a consideration of increasing concern to materiel groups (users as well as producers). The demand for materials which are critical to construction of key systems is increasing. Critical materials can be thought of as both rare raw materials such as titaniam, as well as materials which are very difficult to produce such as cadmium coatings. The type and quantity of critical materials a system requires can substantially influence the cost, supplier availability, lead-time and, ultimately, the operational availability of that system. Studies also show that this problem is not expected to decrease, but rather, increase as more exotic materials are developed and limited raw resources are depleted. The situation is also aggravated by increasing competition for these resources.

e. Economic Escalation (R_5)

This factor represents the effect of applying the OMB inflation indices to a given requirement.

D. FACTOR DEVELOPMENT AND APPLICATION

Having made the transition from potential sources of error to a Parametric Estimating Relationship (PER) (in the form of a set of correction and projection parameters or factors), and having described these factors, the final step in the methodology development is to describe how to develop factor values and apply them.

1. Development of Factor Values

In developing factor values it is necessary to determine several characteristics:

- the nature of the value, i.e., a percentage or fraction value to be multiplied or a dollar value to be added,
- the sources of data used to develop the values, and
- a method for using the sources of data.

These are discussed below.

a. The Nature of the Value

The nature of the factor value is determined by how that factor is planned to be applied: multiplicatively or additively. With a multiplicative value, in the form of a fraction or percentage, a relationship is explicitly stated between the base CPFH and the derived value of the factor. Values of less than one would indicate that the factor is projected to have an overall decreasing effect on requirements, while values greater than one would have an increasing effect. Additive factors, in the form of total dollar values, represent an implicit relationship between the factor and the basic dollar value of the CPFH. Positive values would indicate an increasing effect while negative values would indicate a decreasing effect.

In addition to the actual value calculated for each of the factors, the impact of the factor can be modified using a weighting scheme. Thus, for some M/Ds it may be appropriate to place more emphasis on the impact of Design/ Engineering changes than on Program Changes. In both cases,

factor value and factor weight, the potential validity of the assigned factor is largely dependent on the sources of data used to develop the value and weight and the method used to apply the data.

After considering the specific requirements of the BP 1500 POM forecasting process, as well as data availability, MCR still believes that the originally suggested approach of developing multiplicative values is more appropriate.

b. Data Sources

There are three major categories of sources of data which can be used to develop the factor values:

- data within the DO41 system, e.g., condemnation rates, inventory contents,
- data developed within the Air Force planning process, e.g., flying hour programs, modifications, additives, and
- data developed by the industrial sector or based on industry studies or data developed in studies by other Government Agencies, e.g., technology type, critical materials data, and applied to BP 1500 requirements analysis.

Each of the factor values should be derived from data sources in one or more of these categories. The particular characteristics of each of these categories is briefly considered below.

- The DO41 System is extremely complex, based on the input and analysis of a variety of specific data. Most of these data are item- or equipment-specific. The responsibility for analyzing these data and maintaining the data files rests with the Equipment Specialists and Item Managers at each of the ALCs. In some senses these analysts can also be thought of as

data resources, providing additional interpretation and applications of the specific DO41 data. As conceived now, the DO41 System, either extracts from the data base or the expertise of the item and equipment analysts, or more likely some combination of these two sources, would provide the basis for developing the Financial, Inventory Status and Design/Engineering Factors. Initial studies examining Price Growth in DO41 items can form the basis for developing the Financial factor value.

- A variety of Air Force Planning Documents are developed by different groups within AFLC and the Air Staff. Among these documents are the reports identified with developing the BP 1500 Requirements/POM/Budget/Appropriation estimates, as well as more specialized documents such as modification and overhaul schedules, the flying hour program and the phase-in/phase-out plans. Each of these planning documents plays a role in defining requirements, and documents some aspect of this overall process. As such they are potentially important sources of information on particular requirements drivers. As with the DO41 System, the analysts responsible for developing, reviewing and applying these documents are an integral part of this information base since they frequently provide needed background and interpretation of the documents. As envisioned now, data in this category will provide the base for developing the Program Change factor in the Realism category and the Data Base Error and DO41 Assumption factors in the Accuracy category. These latter factors would be based on the materiel management review analysis and would be developed by AFLC. The OMB inflation indices will form the basis for the Economic Escalation factor.

- There are a wide variety of Industry and Government Studies which are potential sources for factor values. The trade associations frequently function as a clearinghouse for industry information, as well as sponsor special industry studies such as a recent one on castings and forgings leadtimes, and analyses of the impacts of new manufacturing techniques. In addition, major periodicals have studied significant problems including the Aviation Week and Space Technology, Metals Week and Business Week studies on critical material availability in the aerospace industry. Data are also available from several Department of Commerce Publications such as the Annual Index of Manufacturers. Finally, in recent years the Services, working with industry, have investigated the development of technology

indices by which systems can be categorized. This field of material, while needing further investigation, could provide information used in the development of the Design/Engineering factor value.

c. Use of the Data Sources

A major consideration in using any of the data sources discussed above is the actual availability and accessibility of data. Ideally all of the factor values should be developed through collection of a large representative set of data for an extended period of time. Such a body of data could then be rigorously statistically analyzed, with precise relationships among factors and basic requirements being developed. A significant drawback to this approach is the availability of consistent, relevant data in all of the needed areas.

Initial research has indicated that accessing data from the DO41 system and aggregating to an M/D level is very difficult. In addition, while efforts have been initiated in the last several years to accumulate more detailed records of development activities, these records are not extensive enough to form a sufficient analytical data base by themselves Planning documents, while usually providing more extensive histories, may also not be sufficient by themselves to analyze and develop factor values. The same holds true for industry studies which must also be considered in light of the special impacts on BP 1500 requirements.

Although all of these limitations can be overcome in the long term, they restrict the statistical analysis of

data in the short term. Given the current need, the alternative is to develop factor values using a combination of statistical analysis, to the degree that reliable data are available, augmented by the use of analytical expertise of individuals familiar with specific facets of the process. Such individual expertise is available at the ALCs, AFLC and the Air Staff. A combination of statistical and subjective analyses will allow for development of useful factor values within a constrained time frame while also allowing for more detailed planning of more explicit data collection for developing subsequent factor values. This approach allows for the imbedding of a factor weight in the factor value or explicitly stating them, as required.

Exhibit III-7 shows a sample factor data sheet, designed to document what the factor represents, how it was developed, data sources, and limitations. Such a sheet would be developed for each factor, for each CPFH, to document specific refinements. Appendix A shows the Draft Factor Data Sheets developed as part of Phase III research.

2. Factor Application

As discussed earlier, the PER includes factor values which are multiplicative in nature. Thus a basic CPFH factor is converted to a refined CPFH. The PER has two sets of factors to be applied: two accuracy factors and five Realism factors. Application of the accuracy factors corrects the basic or raw CPFH

BP 1500 POM CPFH FACTOR REFINEMENT DRAFT DATA SHEET

① FACTOR IDENTIFICATION INFORMATION POM _____

- FACTOR NAME_____ • FACTOR ID _____
- TYPE_____ • FACTOR VALUE_____
- PURPOSE_____ • M/D_____
- DEVELOPING ORGANIZATION_____ • VERSION #_____
- POM YEAR_____
- FREQUENCY OF UPDATE_____ • FACTOR DEVELOPER_____

② FACTOR DESCRIPTION

③ APPLICATION

④ DATA SOURCE

⑤ DEVELOPMENT METHODOLOGY

⑥ COMMENTS/LIMITATIONS

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Exhibit III-7. SAMPLE DATA SHEET

to account for errors and limitations in the initial requirements calculation. Application of the realism factors accounts for the projected impact of changes in each of the five areas. Due to the commutative nature of the factors it does not matter in what order they are applied.

Exhibit III-8 shows the basic structure of the PER. An AFLC CPFH ($CPFH_{AFLC}$) is developed by applying the seven factors to the raw or CSIS CPFH ($CPFH_{CSIS}$). This $CPFH_{CSIS}$ represents the initial calculation combining the unadjusted or "scrubbed" peculiar and common requirements generated from the CSIS. Corrections for data base errors and DO41 calculation limitations are made to this raw CPFH by the accuracy factors (A_1 and A_2). Adjustments to this partially refined CPFH for projected trends in the major factor categories are made with the realism factors (R_1, R_2, R_3, R_4, and R_5). Thus the $CPFH_{AFLC}$ is gradually adjusted through the application of this set of seven factors.

Exhibit III-9 gives an example of the development of the $CPFH_{ALFC}$ using nominal factor values. The raw CPFH or $CPFH_{CSIS}$ is used as the base. As shown in this example the A_1 and A_2 factors are applied first, although the actual order in which the factors are applied is of no consequence. The factors can be applied in two ways;

- they can be multiplied individually with the $CPFH_{CSIS}$ as shown in the draft data sheets, or
- they can be multiplied together and then multiplied with the $CPFH_{CSIS}$, as shown in Exhibit III-9.

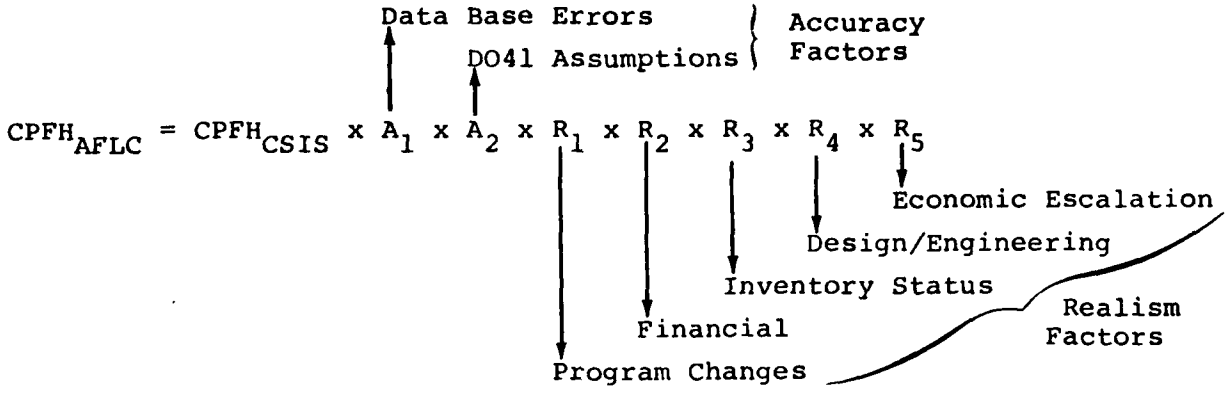

Exhibit III-8. PARAMETRIC ESTIMATING RELATIONSHIP

Mission Design	Raw CPFH (CSIS) ($)	Accuracy Factors			Realism Factors						Total CPFH With PER Refinement ($)	Total Effect of PER Refinement ($)
		A_1	A_2	Composite	R_1	R_2	R_3	R_4	R_5	Composite		
A-10	326	1.01	1.07	1.08	1.14	1.23	1.15	1.19	1.06	2.03	715	715 - 326 = 389
B-52	1079	1.00	1.4									
C-130	184	1.04										
C-5	2004	1.01										
		A_1 = Data Base Errors A_2 = DO41 Assumptions			R_1 = Program Changes R_2 = Financial R_3 = Inventory Status R_4 = Design/Engineering R_5 = Economic Escalation							

Exhibit III-9. SAMPLE CALCULATION FOR "PER"

Either approach is acceptable since the ultimate value of the $CPFH_{AFLC}$ will be the same.

Although all of the PER factors shown in the example result in increasing the CPFH, it is possible that a factor value could result in a decrease or in no change. Such a case is shown for the A_1 factor for the B-52, which has a value of 1.00. Also indicated in the A_1 column is the potential variety of values for a given factor. Since each factor is calculated individually for each M/D, each factor value may be different. Or, as shown in the cases of the A-10 and the C-5, the factor value may be the same, however, the dollar value represented by the factor is substantially different. As discussed earlier, imbedded in these factor values would be the relative weight given each of the factors for each M/D.

The following section summarizes MCR's conclusions concerning forecasting errors in the BP 1500 Requirements/POM/Budget/Appropriation Process, and the PER.

IV. CONCLUSIONS

Based on this research and analysis, and in conjunction with other groups also involved in BP 1500 analysis, MCR has arrived at the following conclusions:

- As designed now, there appears to be a substantial incompatability between the analysis used to develop the POM, specifically CPFH factors, and the analysis used to develop the Budget, i.e., item-by-item evaluation.

- AFLC has had a long-standing interest in improving the process by which BP 1500 requirements are tracked, calculated and projected. This interest, and the increasing demand for more quantified and documented approaches, has resulted in primarily the dual effort of:

  - modifying the D041 system to provide additional capability beyond its original inventory tracking role, and

  - developing new analytical and computing methods to improve the calculations developed using D041.

- Many of the sources of potential error are correctable by instituting administrative measures. Specific problems requiring attention include:

  - the lack of formal documentation of adjustments,

  - the lack of specific and consistent procedures for evaluating data, adjusting requirements, communicating information and results, and

  - the inconsistency in coding and maintaining the data.

- Formal procedures for evaluating and refining requirements estimates and for documenting these evaluations and adjustments are needed to institutionalize the current process.

- The inconsistent and possibly insufficient use of trend analysis reduces the long term applicability of the BP 1500 requirements projections.

- Inherent limitations in the DO41 system will be felt throughout the process. The most important limitations are the:
  - out-of-date hardware, and
  - cumbersome software.
- Many factors which could influence requirements are currently not compensated for or considered in the BP 1500 Requirements/POM/Budget/Appropriation Process.
- A methodology for compensating for the impact of the errors inherent in the existing process should concentrate on determining the total effects of these errors and counteracting them. As an interim measure such an approach allows for the identification of the "bottom-line" impacts, produced through the accumulation of the various types of errors in the total process.
- MCR's methodology is designed to represent the more specific reasons why future requirements change in a few aggregate factors.
- MCR concluded that the aggregate factors should have the following characteristics of being:
  - measurable or quantifiable,
  - easy to explain and understand,
  - defensible in OSD and Congressional reviews,
  - compatible with DO41 output,
  - flexible with the capability of being modified if necessary, and
  - stand alone, to the degree possible.
- This factor refinement methodology is based on the multiplicative application of two types of factors, accuracy and realism factors.
- The two accuracy factors represent corrections made in the materiel management reviews for input errors or errors in the data base, and to compensate for the limiting impact of some of the DO41 assumptions.

- The five realism factors represent the projected impact on requirements of future changes in plans related to the Program, Financial, Inventory Status, Design/Engineering and Economic Escalation.

- Initially the values for these factors will be developed using a combination of statistical and subjective analysis. This is necessary due to the limited availability of some of the needed data.

- As data becomes more accessible, more statistically precise values can be developed using more rigorous mathematical methods.

- These PER factors should be applied to the Cost Per Flying Hour (CPFH) factors developed from the D041 Central Secondary Item Stratification (CSIS). They are designed to replace the external adjustments which have previously been made to these factors. These factors reflect projected changes in recurring POS requirements only, and do not relate to WRM, OWRM, and non-recurring additives.

APPENDIX A

DRAFT FACTOR DATA SHEETS

BP 1500 POM CPFH FACTOR REFINEMENT DRAFT DATA SHEET

(1) Factor Identification Information

POM _____

- Factor Name: Data Base Errors
- Factor ID: A_1
- Type: Accuracy
- Factor Value: _____
- Purpose: Incorporate Corrections to Data Base Not Reflected in Calculation
- M/D: M/D Specific
- Developing Organization: AFLC & ALCs
- Version #: _____
- POM Year: _____
- Frequency of Update: Semi-Annual
- Factor Developer: _____

(2) Factor Description

This factor represents the corrections made to DO41 CSIS for errors in the data base due to:

- input or key punch errors, and
- existing misinformation in the data base not correctd in the data base file review process.

(3) Application

This factor, representing a percentage of the raw CPFH developed for each M/D, is applied as a multiplier of the CPFH developed from the raw CSIS output:

$$CPFH_1 = CPFH_{CSIS} \times A_1$$

(4) Data Source

Histories of materiel management reviews; additional data received from IMS and ES at ALC; analytical judgement.

(5) Development Methodology

Determine from data if the following exist:

- A tendency toward some consistent type of error,
- A predictable magnitude of errors, and
- A stable relationship across M/Ds.

The factor values should be initially calculated based on the 31 March CSIS run, and re-evaluated during the September update.

(6) Comments/Limitations

If historical data base errors have averaged some value (say 10%), it is not necessarily true that the current CSIS output has the same value (10%) of errors in it. Thus judgement and caution should be applied in using this factor.

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BP 1500 POM CPFH FACTOR REFINEMENT DRAFT DATA SHEET

(1) Factor Identification Information

POM _____

- Factor Name: D041 Assumptions
- Factor ID: A_2
- Type: Accuracy
- Factor Value: _____
- Purpose: Account for Impact of Imbedded Assumptions and Calculation Limitations Of D041.
- M/D: M/D Specific
- Developing Organization: AFLC & ALC
- Version #: _____
- POM Year: _____
- Frequency of Update: Semi-Annual
- Factor Developer: _____

(2) Factor Description

This factor represents the corrections made to the D041 CSIS to compensate for restrictions and biases of the D041 assumptions, specifically:

- the non-allocation of common parts on an item-by-item basis;
- the inclusion of only two years worth of historical data; and
- the allowance of a maximum of only a three year procurement leadtime in calculating requirements.

(3) Application

This factor, representing the percentage relationship between D041 calculation limitations and requirements developed for each M/D, is applied as a multiplier of of the raw CPFH:

$$CPFH_2 = CPFH_1 \times A_2$$

(Imbedded in this value are weights reflecting the perceived impact of the D041 assumptions on specific systems and/or M/Ds.)

(4) Data Source

Records of materiel management review analyses and adjustments; additional background and historical data from IM and ES at ALC and AFLC analysts.

(5) Development Methodology

Based on available data determine the relative importance of the three major limiting assumptions; determine if these assumptions individually have more impact on some types of equipments and/or M/Ds; and determine the relative merits, if possible, of different common parts allocation schemes. The factor value should be initially calculated based on the 31 March CSIS run and re-evaluated during the September update.

(6) Comments/Limitations

This factor's value can be initally assessed by judgement from analysts familiar with the D041 system and inventory theory in general. Actual analytical calculation would require extensive study and time.

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BP 1500 POM CPFH FACTOR REFINEMENT DRAFT DATA SHEET

(1) Factor Identification Information

POM _____

- Factor Name: Financial
- Factor ID: R_2
- Type: Realism
- Factor Value: _____
- Purpose: Account for Changes in the Purchasing Power of Programmed Funds
- M/D: M/D Specific
- Developing Organization: AFLC
- Version #: _____
- POM Year: _____
- Frequency of Update: Annual
- Factor Developer: _____

(2) Factor Description

This factor incorporates the impact of changes due to the following reasons:

- Supplier data, relating to the ability of USAF to procure necessary materiel when required, under reasonable terms; contingent upon considerations such as supplier availability, industrial capacity, competition among suppliers and supplier responsiveness;
- Unit price changes between the last purchase and the next projected purchase, (exclusive of Program-Change-Related Escalation);
- Program-Change-Related Escalation, relates to the impact of program change decisions, such as scheduled phase-in, on the projected unit price.
- Quantity changes (buy size)

(3) Application

This factor, representing the composite financial effect, may initially be based on the LORAA Price Growth Study, i.e., consistent value applied to all M/D CPFHs. Ultimately, however, the financial impact of deferred decisions (e.g., program changes) should be explicitly separated out. It is applied as a multiplier of the CPFH after adjustments for accuracy:

$$CPFH_4 = CPFH_3 \times R_2$$

(4) Data Source

The initial data source will be the LORAA Price Growth Study. When feasible additional data should be collected concerning industry studies of suppliers and DoD studies of the effects of Program-Change-Related Escalation to provide additional interpretation of the Price Gtowth Study Result. All major systems report escalation impact during acquisition in the Selected Acquisition Reports (SARs).

(5) Development Methodology

Taking the results of the LORAA Price Growth Study, determine if conclusions can be reached about specific M/Ds; separate the effect of economic escalation using the historical OMB inflation indices. (Economic Escalation is separately handled).

(6) Comments/Limitations

AFLC should have separate insight into constant dollar effects of learning curves, production line reopening, schedule impacts.

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A-3

BP 1500 POM CPFH FACTOR REFINEMENT DRAFT DATA SHEET

(1) Factor Identification Information

POM _____

- Factor Name: Inventory Status
- Factor ID: R_3
- Type: Realism
- Factor Value: _____
- Purpose: Account for the Impact of Changes in the Drivers of the Inventory Status
- M/D: M/D Specific
- Developing Organization: AFLC & ALCs
- Version #: _____
- POM Year: _____
- Frequency of Update: Annual
- Factor Developer: _____

(2) Factor Description

This factor represents the impact of changes in requirements for the following reasons:

- R & M/Failure Rates influence the projected level of spares required to support a given system; changes in these rates from those projected will mean changes in the planned inventory stock levels; also influenced by changes in operating procedures;
- Condemnation Rate changes can have a similar effect on R & M/Failure Rates changes producing different demand and usage rates than those planned; also influenced by changes in maintenance philosophy and operating procedures;
- Inventory contents and the dynamics of movement of items/equipment within the inventory can influence the uncertainty of a requirements estimate; and
- Changes in stock levels, particularly negotiated depot and base stock levels can produce unexpected demands on existing stock levels.

(3) Application

This factor is multiplicative and is tailored to each M/D based on analysis of the subsystem drivers of M/D CPFH. It is closely related to the Design/Engineering Factor. It is applied as a multiplier of the CPFH after adjustment for accuracy:

$$CPFH_5 = CPFH_4 \times R_3$$

(4) Data Source

Selected information from DO41/ALC files interpreted with assistance of ALC ES and IMS and AFLC analysts.

(5) Development Methodology

Using the expertise of the ALC and AFLC analysts, determine the relative stability of R & M/Failure Rates and Condemnation Rates; identify perceived sources of rate changes, i.e., technology type, system age, geographic location. Develop specific values taking into account analysis of Design/Engineering factor.

(6) Comments/Limitations

This factor is more of an indirect indicator, tied to changes related to other factors, however, it reflects the need to consider these changes in light of the peculiar dynamics of the inventory the requirements estimates must support.

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BP 1500 POM CPFH FACTOR REFINEMENT DRAFT DATA SHEET

(1) Factor Identification Information

POM _____

- Factor Name: Design/Engineering
- Factor ID: R_4
- Type: Realism
- Factor Value: _____
- Purpose: Account for Impact on Requirements of Changing Technology
- M/D: M/D Specific
- Version #: _____
- Developing Organization: AFLC & ALC
- POM Year: _____
- Frequency of Update: Annual
- Factor Developer: _____

(2) Factor Description

This factor represents the changes in requirements due to the following reasons:

- Technology Type of the systems, relating to the representation of a variety of technology levels, from microcircuits to vacuum tubes, in the inventory, the changing distribution and amount of which may occur faster in the future than it has in the past; represents the systems chronological or technological age;
- System age, particularly the operational age of the system is believed to have a significant impact on maintenance requirements
- Geographic Location and the prevailing climates the system operates in can place different demands on different parts, producing different demand and usage rates; and
- Critical Material Requirements, specifically rare or exotic materials can influence parts availability; the availability of such materials is expected to continue to decrease.

(3) Application

This factor is multiplicative and is tailored to specific M/Ds. It is related to the Inventory Status factor in that much of the information identified in analyzing the inventory status provides understanding of the relative importance of each of these reasons for change. It is applied as a multiplier of the CPFH after adjustment for accuracy:

$$CPFH_6 = CPFH \times R_4$$

(4) Data Source

Inventory information from DO41 interpreted by ALC analysts and used in conjuction with specialized industry studies on various aspects of technological impacts.

(5) Development Methodology

Analyzing the inventory contents with the assistance of ALC and AFLC analysts determine the potential impact on specific subsystems and the related M/Ds of advanced technology, perceived system age impacts, geographic location and critical materials requirements. The technology type and critical materials requirements will be largely based on analysis of industry and other DoD studies.

(6) Comments/Limitations

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BP 1500 POM CPFH FACTOR REFINEMENT DRAFT DATA SHEET

(1) Factor Identification Information

POM _____

- Factor Name: Economic Escalation
- Factor ID: R_5
- Type: Realism
- Factor Value: _____
- Purpose: The Impact of Projected Inflation on Programmed Funds
- M/D: Non-M/D Specific
- Developing Organization: AFLC & LEXW
- Version #: _____
- POM Year: _____
- Frequency of Update: Annual
- Factor Developer: _____

(2) Factor Description

This factor represents the outyear escalation adjustment to the base year CPFH. A separate factor is developed for each POM year by OMB and promulgated by OSD. Outyear escalation is a projected value of what future inflation is likely to occur.

(3) Application

Escalation factors are applied to the adjusted CPFH as a multiplier.

$$CPFH_{AFLC} = CPFH_6 \times R_5$$

(4) Data Source

OMB produces the required index annually, which is transmitted to the Services by OASD (Comptroller). Alternate aircraft indices are provided by Air Force Systems Command/ Comptroller each July, as well as by DRI and other econometric firms.

(5) Development Methodology

Existing memoranda/reports describe and document current indices. The current OSD/OMB index must be used for the POM submission.

(6) Comments/Limitations

Currently the Air Staff must use the OSD/OMB indices for all POM years unless sufficient justification can be given for alternative escalation rates (different).

APPENDIX B

GLOSSARY

GLOSSARY

AY	- Apportionment Year
BES	- Budget Estimate Submission
BLSS	- Base Level Self-Sufficiency
BY	- Budget Year
CPFH	- Cost Per Flying Hour
CSIS	- Central Secondary Item Stratification
DPS	- Decision Package Set
ES	- Equipment Specialist
EY	- Extended Year
IMS	- Inventory Management Specialist
FMS	- Foreign Military Sales
M/D/S	- Mission/Design/Series
MTBF	- Mean Time Between Failure
MTNMA	- Mean Time to Next Maintenance Action
MTTR	- Mean Time to Repair
OWRM	- Other War Reserve Materiel
PDP	- Program Decision Package
PER	- Parametric Estimating Relationship
POM	- Program Objective Memorandum
POS	- Peacetime Operating Stock
PPBS	- Planning, Programming and Budgeting System
WRM	- War Reserve Materiel
WRSK	- War Readiness Spares Kit


MED
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