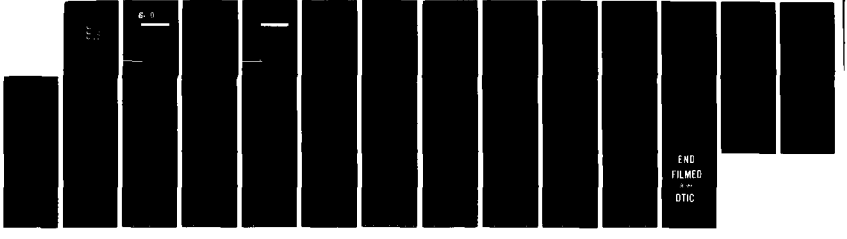
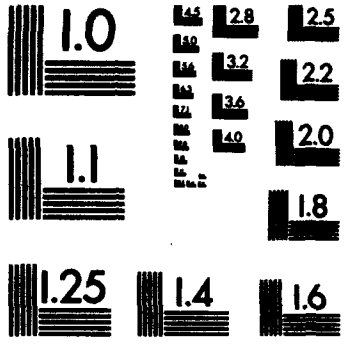
AD-A282 351 --DATA AND DATA PROCESSING ISSUES IN THE ESTIMATION OF 1/1
REQUIREMENTS FOR AIRCRAFT RECOVERABLE SPARES AND DEPOT
REPAIR(U) RAND CORP SANTA MONICA CA J B ABELL ET AL.
UNCLASSIFIED 1993 XC-USAF F49620-91-C-0003 NL



more incorrectly than we would otherwise have done, and in doing so, we buy a less effective mix of spares.

In this report, we describe the application file and discuss the construction of an indenture file, the kinds of errors that seem to pervade the requirements database, and the kinds of errors they induce. We use for instructive purposes a particular LRU family (an LRU and all of its SRUs), describe the conceptual and practical importance of



Chapter Two

THE ISSUE OF INDENTURE RELATIONSHIPS

RAND

Data and Data Processing Issues in the Estimation of Requirements for Aircraft Recoverable Spares and Depot Repair

John B. Abell,
Frederick W. Finnegan

Project AIR FORCE

Table 2.1

Formats for Application Data Element

	Format															
										1	1	1	1	1	1
Data Type	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5
Aircraft model/design/ series			B	0	5	2	E								

Directorate of Plans, HQ USAF.

Library of Congress Cataloging in Publication Data

Abell, John B.
Data and data processing issues in the estimation of requirements for aircraft recoverable spares and depot repair / John B. Abell, Frederick W. Finnegan, Jr.
p. cm.
"Prepared for the United States Air Force."
"MR-264-AF."
Includes bibliographical references.
ISBN 0-8330-1434-X
1. Airplanes, Military—United States—Parts—Costs—Data processing. 2. United States. Air Force—Procurement—Data processing. I. Finnegan, F. W. (Frederick W.), 1929- . II. United States. Air Force. III. Title.
UG1243.A24 1993
623.7'46'0288—dc20 93-28343
CIP

Published 1993 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
To obtain information about RAND studies or to order documents, call Distribution Services, (310) 393-0411, extension 6686

- Mission item essentiality code (MIEC),
- Source of MIEC, and
- Time-phased application data (up to three sets of entries may be made)
  - Program begin date,
  - Quantity per application, and

RAND

Data and Data Processing Issues in the Estimation of Requirements for Aircraft Recoverable Spares and Depot Repair

John B. Abell,
Frederick W. Finnegan

Prepared for the
United States Air Force

Project AIR FORCE

Table 2.2

A Notional Example of Application Records

Level	Stock Number	Application	PSC	PBG	QPA	FAP
L	5841-01-123-1234WF	F016C	1000	8409	1	100
L	5841-01-123-1234WF	F016D	1000	8409	1	100
L	5841-01-234-2345WF	B001B	1000	9006	1	100
2	5841-01-345-3456WF	B001B	1000	9006	1	100

PREFACE

This report discusses data and data processing issues that are important to the estimation of requirements for aircraft recoverable spares and, especially, depot-level repair. To the extent that the requirements database (the set of files used by the Recoverable Consumption Item Requirements System, D041) is used for other logistics management functions, these issues are also important to those purposes. For example, DRIVE (Distribution and Repair in Variable Environments) uses data from the requirements database to enable its prioritization of component repairs and allocation of assets emerging from repair to locations worldwide. Capability assessments also rely on knowledge of the indenture relationships among components of a weapon system.

The findings presented here are part of a larger body of research intended to enhance our understanding of the implications for requirements estimation of demand uncertainty and logistics management adaptations to cope with it. The several other reports that describe the larger body of work are listed here:

- John B. Abell, et al., *Estimating Requirements for Aircraft Recoverable Spares and Depot Repair*, RAND, R-4210-AF, 1993.
- John L. Adams, John B. Abell, and Karen E. Isaacson, *Modeling and Forecasting the Demand for Aircraft Recoverable Spare Parts*, RAND, R-4211-AF/OSD, 1993.
- Donald P. Gaver, Karen E. Isaacson, and John B. Abell, *Estimating Aircraft Recoverable Spares Requirements with Cannibalization of Designated Items*, RAND, R-4213-AF, 1993.

for informational purposes only. The 1234WF entry is the link to the F-16C/D, and 2345WF is the link to the B-1B aircraft. This SRU is at indenture level 2 in both applications. The 4567WF entry is an SRU that is peculiar to the F-16 LRU, 1234WF. Similarly, the 5678WF entry is for an SRU that is used only on the B-1B LRU. The final component, whose stock number ends in 6789WF, is also an SRU but one at indenture level 3 because its application is to an SRU at indenture level 2.

If the data processing program that builds the indenture file could not find the 2345WF record in the application file, it would promote

- Karen E. Isaacson, and Patricia M. Boren, *Dyna-METRIC Version 6: An Advanced Capability Assessment Model*, RAND, R-4214-AF, 1993.
- John B. Abell, *Estimating Requirements for Aircraft Recoverable Spares and Depot Repair: Executive Summary*, RAND, R-4215-AF, 1993.

The first of these reports describes the entire body of work in considerable detail and includes an elementary exposition of the current system. The second describes improved methods for forecasting the demand for aircraft recoverable spares and specifying the variance of the probability distribution describing the number of assets of a given type in resupply. The third presents a computational algorithm for estimating requirements for aircraft recoverable spares based on the assumption that items can be designated as cannibalizable or not. The fourth describes Dyna-METRIC (Dynamic Multi-Echelon Technique for Recoverable Item Control) Version 6, the capability assessment model used in the course of this research to evaluate the stockage postures that were anticipated to eventuate from purchases of particular mixes of recoverable spares. The fifth summarizes the entire body of work including this report and the four others.

This research has the joint sponsorship of Headquarters, United States Air Force (AF/LEX), and Headquarters, Air Force Materiel Command (AFMC/XP and AFMC/XR). It was carried out in the Resource Management and System Acquisition Program of Project AIR FORCE, RAND's federally funded research and development center supported by the U.S. Air Force. It should be of particular interest to those concerned with spares and repair requirements estimation, logistics system design and modeling, and logistics policy analysis. It should also interest logisticians throughout the Air Force, the other military services, and the Office of the Secretary of Defense.

Table 2.3

Work Breakdown Structure of the MLPRF

Level	WUC	Description[a]	Stock number[b]
1	74AN0	Modular LPRF	1270-01-233-0011WF
2	74ANA	Frequency multiplier	6615-01-124-0226WF
2	74ANB	Frequency synthesizer	6625-01-126-0097WF
3		Oscillator	5955-01-157-6444WF
2	74ANC	Reference oscillator	1270-01-208-8409WF
2	74AND	Transmit microwave	5841-01-291-6174WF

CONTENTS

The descriptions of components reflected in the work unit code manual are usually more sensible, although the description of the 74AND (5841-01-291-6174WF), "Transmit microwave," is from that source. All of the components in Table 2.3 that have work unit codes were extracted from the work unit code manual. The level-3 SRUs were extracted from the application file. Level-3 SRUs typically do not have work unit codes assigned in the aircraft work unit code manual, although they sometimes reflect the WUC of their parent SRUs in the application file. Work unit codes do not always appear in D041 files simply because many items apply to more than one weapon system; therefore, they may have different work unit codes

Table 2.4

D041 D50 Application Data for the MLPRF and Its Components

LRU/ SRU	Subgroup Master	Application		PSC	PBD	QPA	FAP	WUC
LRU	1270-01-233-0011WF	F016C		1000	8409	1	100	74AN0
LRU	1270-01-233-0011WF	F016D		1000	8409	1	100	
SRU	6625-01-124-0226WF	B001B		1000	8509	2	100	74ANA
SRU	6625-01-124-0226WF	F016C		1000	8409	1	100	
SRU	6625-01-124-0226WF	F016C	EG	1000	8409	1	100	
SRU	6625-01-124-0226WF	F016D		1000	8409	1	100	
SRU	6625-01-124-0226WF	F016D	EG	1000	8409	1	100	

The Air Force Materiel Command's data system that supports the estimation of requirements for aircraft recoverable spares and depot repair, the Recoverable Consumption Item Requirements System (D041), is fraught with errors, especially in application data. The result of these errors is that many components are promoted from their correct levels of indenture to higher levels of indenture by the computer software that constructs the indenture file used in spares requirements computations. The result of these promotions of items to higher levels of indenture is that the requirements computation overvalues the items. A shop-replaceable unit (SRU), for example, may be promoted to line-replaceable unit (LRU) status resulting in shortages of the SRU being viewed as holes in aircraft rather than holes in LRUs. Therefore, the system overinvests in these items. The effects of these errors on spares requirements estimation are probably not terribly serious in the grand scheme of spares requirements estimation; we simply buy too many of the promoted components.

In repair requirements estimation using DRIVE (Distribution and Repair in Variable Environments), however, and in the allocation of serviceable assets to locations worldwide using DRIVE, such errors are serious. If DRIVE does not see the correct relationship between SRUs and LRUs and LRUs and aircraft, it will probably not make the correct allocations. DRIVE derives substantial benefit from its rather surgical allocations of SRUs to LRUs that are awaiting parts (AWP), generating additional serviceable LRUs through SRU allocations. Thus, lack of correct indenture relationships in DRIVE results in poorer system performance.

Table 2.4—continued

LRU/ SRU	Subgroup Master	Application		PSC	PBD	QPA	FAP	WUC
SRU	1270-01-195-8634WF	F016C		1000	8409	1	100	74ANL
SRU	1270-01-195-8634WF	F016C	EG	1000	8409	1	100	
SRU	1270-01-195-8634WF	F016D		1000	8409	1	100	
SRU	1270-01-195-8634WF	F016D	EG	1000	8409	1	100	
SRU	5998-01-298-9139WF	F016C		1000	8409	1	100	74ANN
SRU	5998-01-298-9139WF	F016D		1000	8409	1	100	
SRU	5998-01-298-9139WF	0016C		1000	8409	1	100	
SRU	5998-01-298-9139WF	0016D		1000	8409	1	100	

D041 data and suggest an approach to cleaning up the database coupled with a system of audits of LRU families (LRUs and all of their indentured SRUs) and a related training program that could be expected to keep the database relatively error-free. We believe that the recommendations of this report are among the most important we have made in our research in spares and repair requirements estimation.

file in the requirements computation process; therefore, the requirements computation will tend to overestimate their requirements. The table also reflects several invalid aircraft entries.

An additional item, a cable assembly, was shown in the application file as a component of the MLPRF, although it did not appear in the work unit code manual. Its application data are shown in Table 2.5.

Table 2.6 reflects the indenture relationships inferred from the application records in the construction of the indenture file and compares them with the true relationships shown in Table 2.3. Note the discrepancies between the true relationships and those that are ulti-

ACKNOWLEDGMENTS

We are indebted to Maurice Carter of the Ogden Air Logistics Center and his associates for their assistance in familiarizing us with the problems of application data maintenance and related topics.

Table 2.6

Indenture Relationships Reflected in the Indenture File for the MLPRF

True Level	Inferred Level	WUC	Description	Stock Number
1	1	74AN0	Modular LPRF	1270-01-233-0011WF
2	2	74AN0	Cable assembly	6150-01-204-3695WF
2	1	74ANA	Frequency multiplier	6615-01-124-0226WF
2	1	74ANB	Frequency synthesizer	6625-01-126-0097WF
3	2		oscillator	5955-01-157-6444WF
2	1	74ANC	Reference oscillator	1270-01-208-8409WF
2	1	74AND	Transmit microwave	5841-01-291-6174WF

Chapter One

INTRODUCTION

In the course of extensive analyses and evaluations of the Air Force's system for estimating requirements for aircraft recoverable spares and depot repair, we observed several problems with the quality of data underlying the requirements computation. In the process of building the files needed to support the computation, an indenture file is constructed using data drawn from the application file that is part of the requirements database. In this report, we describe the construction of an indenture file. The indenture file is intended to reflect the indenture relationships among components of an aircraft. It is fundamentally important in the estimation of requirements for aircraft recoverable spares and, especially, depot repair. The logic that is built into the computer code that creates the indenture file compensates to some extent for errors in item application data. We explain this logic later in the text.

Although this logic makes the requirements estimation system (D041)[1] somewhat more robust in the face of errors in application data, indenture relationships are also needed by DRIVE (Distribution and Repair in Variable Environments),[2] AFMC's system for prioritizing the repair of recoverable components and allocating the serviceables emerging from depot repair to the item manager's account, depot supply, and bases worldwide. DRIVE is vulnerable to errors in indenture relationships and, if these relationships are incorrect, er-

[1]The system is known officially as the Recoverable Consumption Item Requirements System.

[2]See Abell et al. (1992) and Miller and Abell (1992).

Chapter Three

COMPLICATIONS FROM RELATIONSHIPS BETWEEN INTERCHANGEABLE AND SUBSTITUTABLE ITEMS

DRIVE uses indenture information to support its failed surgical allocation of shop-replaceable units (SRUs) to line-replaceable units (LRUs) that are awaiting parts (AWP), thus generating additional serviceable LRUs through SRU repair and distribution. DRIVE infers AWP conditions from requisitions that contain an advice code of 6L, the advice code used to designate requisitions for shortages of components of next higher assemblies that are being held down for lack of one or more parts. If a stock number, say an SRU stock number, is not known to apply to a particular LRU stock number, DRIVE will never allocate an SRU of that type to satisfy an AWP condition on that LRU.

Indenture relationships are also needed by AFMC's standard capability assessment model, the Sustainability Assessment Module of the Weapon System Management Information System (WSMIS/SAM) and in RAND's latest, most advanced capability assessment model, Dyna-METRIC Version 6.[3] To the extent that such capability assessment tools are used to model the real world using incorrect indenture relationships, they may lead to conclusions and recommendations that are also incorrect. A recent policy analysis of the concept of two levels of maintenance is a case in point. Conclusions about the savings associated with SRU stockage in the two-levels case could be flawed if the indenture file incorrectly promoted SRUs to LRU status because of errors in application data. As we explain later in this report, such promotions are frequent in the construction of the indenture file.[4]

We view the conclusions and recommendations in this report to be among the most important we have made in this body of research. Data errors should be taken very seriously. They have exactly the same effect as uncertainty does in degrading the performance of the mix of spares we buy. They cause us to project the future incorrectly,

[3]Dyna-METRIC is an acronym for Dynamic Multi-Echelon Technique for Recoverable Item Control, although it is a capability assessment tool, not a control tool. It has roots in an earlier RAND model called METRIC. See Sherbrooke (1968) and Isaacson and Boren (1993).

[4]The analysis referred to here actually used data files that were hand-built, thus avoiding the errors in application data that might have resulted from indenture relationships inferred from the application file.

Table 3.1

I&S Relationships of the MLPRF and Related Components

Actual Stock Number	Family Master	Order-of-Use Code
1270-01-153-8699	1270-01-153-8700	AAA
1270-01-153-8700	1270-01-153-8700	AAB
1270-01-132-6868	1270-01-194-5732	AAA
1270-01-194-5732	1270-01-194-5732	ABA
5998-01-132-7025	5998-01-196-3759	AAA
5998-01-194-5625	5998-01-196-3759	ABA
5998-01-196-3759	5998-01-196-3759	ACA
1270-01-132-6870	1270-01-208-8409	AAA
1270-01-208-8409	1270-01-208-8409	AAB

more incorrectly than we would otherwise have done, and in doing so, we buy a less effective mix of spares.

In this report, we describe the application file and discuss the construction of an indenture file, the kinds of errors that seem to pervade the requirements database, and the kinds of errors they induce. We use for instructive purposes a particular LRU family (an LRU and all of its SRUs), describe the conceptual and practical importance of the concept of an LRU family, and offer specific recommendations to AFMC that we hope will enable item managers, equipment management specialists, and others involved in data creation and maintenance processes to correct errors in the requirements database and militate against future errors.

Table 3.2

Application Data for Other Items Related to Items in Table 3.1

LRU/ SRU	Stock Number	Application	PSC	PBD	QPA	FAP
LRU	1270-01-132-2441WF	F016C	1000	8409	1	100
LRU	1270-01-132-2441WF	F016C EG	1000	8409	1	100
LRU	1270-01-132-2441WF	F016D	1000	8409	1	100

THE ISSUE OF INDENTURE RELATIONSHIPS

In this section, we first explore the structure and content of the D041 application file from which the indenture file is built. Then, for instructive purposes, we examine application and indenture data for a single LRU family, i.e., an LRU and all of its recoverable SRUs. This examination will help illustrate the kinds of problems that seem to pervade the application file and their implications for spares and repair requirements estimation and other logistics management functions.

D041 APPLICATION DATA

Component application data are contained in records called *50 records*, in a file called the *D50 file* or *application file*. All allowable formats of the application data element are illustrated in Table 2.1.

The application file contains application data for every component in the D041 database. Each valid record contains the following data:

- Record type,
- Air Logistics Center (ALC) code,
- Subgroup master stock number,
- Application (of the form shown in Table 2.1),
- Program select code,
- Deferred disposal code,

Table 3.2—continued

LRU/ SRU	Stock Number	Application		PSC	PBD	QPA	FAP
SRU	5998-01-196-3759WF	F016D		1000	8409	1	100
SRU	5998-01-196-3759WF	F016D	EG	1000	8409	1	100
SRU	1270-01-132-6870WF	B001B		1000	8509	2	100
SRU	1270-01-132-6870WF	F016C		1000	8409	1	100
				1000	8409	1	100

Table 2.1

Formats for Application Data Element

Data Type	Format														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Aircraft model/design/ series			B	0	5	2	E								
Aircraft model/design/ series		K	C	1	3	5	A								
Aircraft model/design/ series	N	K	C	1	3	5	A								
Aircraft model/design/ series		C	H	0	0	3	E								
Aircraft model/design/ series (Foreign military sales)	F	X	F	0	0	5	A							U	K
Aircraft model/design/ series			C	1	3	0	K								
Aircraft modification model/design/series			F	0	1	6	D	I	F	2	3	4	5	6	B
Aircraft modification model/design/series			F	0	1	6	D	R	F	2	3	4	5	6	B
Engine type/model			J	0	0	5	7	0	5	5	A				
Engine type/model		G	R	0	0	8	5	1	8	0					
Engine type/model	F	X	J	0	0	7	9	0	1	1	A				
Engine type/model	G	S	0	0	4	8	0	B	1	0	A	6			
Missile model/design/ series	A	I	M	0	2	6	B								
Drone model/design/ series		Q	F	1	0	2	A								
Trainer	1	A	D	0	0	0	A								
National stock number	1	6	5	0	0	0	1	2	3	4	5	6	7	L	H
Program element code	5	6	0	1											
Program element code	1	0	0	3	2										
System network	8	1	6	L											

Table 3.2—continued

LRU/ SRU	Stock Number	Application	PSC	PBD	QPA	FAP
SRU	5841-01-160-1690EK	B001B	1000	8506	4	100
SRU	5841-01-160-1690EK	5841-01-150-7527EK	0007	8506	2	100
SRU	5895-01-161-1142EK	B001B	1000	8506	2	100
SRU	5895-01-161-1142EK	5841-01-150-7527EK	0007	8506	1	100
SRU	6150-01-185-6465WT	F016C	0000	8400	1	100

- Mission item essentiality code (MIEC),
- Source of MIEC, and
- Time-phased application data (up to three sets of entries may be made)
  - Program begin date,
  - Quantity per application, and
  - Future application percentage.

Many records in the application file do not follow certain prescribed rules of format for one of two reasons: (a) the record is intended to act as a memorandum for the item manager or equipment management specialist rather than as a valid application record, and (b) an error has been made such that the record is not perceived as a valid record by data processing logic. Since the system allows for records that act as memoranda, the data processing logic must be able to distinguish valid application records from memoranda. The rules it uses to identify a valid application record are: (a) the application data element must follow one of the formats described in Table 2.1, (b) the program select code[1] must not be all zeroes, must begin with 0, 1, 2, 3, 5, 7, or 8, and must contain 0 or X in each of its last three positions, and (c) the program begin date must be equal to or earlier than some evaluation point, such as an inventory status point or an average lead time beyond the date of the application file. If any of these rules is violated, even in a record intended to be a valid application record, the record is excluded from consideration in the construction of the indenture file. Before any record in the application file is used in building the indenture file, it is screened for compliance with the rules and, if it fails to pass every test, it is ignored in further processing.

Table 2.2 is a contrived example of a set of application records. It reflects a set of valid applications for a group of related stock numbers.

[1]The program select code specifies what program(s) should be used to compute requirements for each particular stock number. They specify whether the requirements for the item are driven by, for example, flying hour programs, possessed aircraft, or rounds fired.

sumed to absorb 100 percent of the flying hours of the aircraft to which it is applicable, another error of the sort inflicted on the LRUs.

The next three SRUs suffer from the same errors. None of them has a valid application to an LRU, only to aircraft; therefore, they will be assumed to be LRUs and to absorb all of the flying hour programs on the aircraft to which they are applicable. The rest of the story on these three SRUs is somewhat more interesting. The reason they are in Table 3.2 is because the first of them, 5998-01-132-7025WF, shows an application (although invalid) to the least preferred MLPRF stock

Table 2.2

A Notional Example of Application Records

Level	Stock Number	Application	PSC	PBG	QPA	FAP
L	5841-01-123-1234WF	F016C	1000	8409	1	100
L	5841-01-123-1234WF	F016D	1000	8409	1	100
L	5841-01-234-2345WF	B001B	1000	9006	1	100
S	5841-01-345-3456WF	B001B	1000	9006	1	100
S	5841-01-345-3456WF	F016C	1000	8409	1	100
S	5841-01-345-3456WF	F016D	1000	8409	1	100
S	5841-01-345-3456WF	5841-01-123-1234WF	1000	8409	1	100
S	5841-01-345-3456WF	5841-01-234-2345WF	1000	8409	1	100
S	5841-01-456-4567WF	F016C	1000	8409	1	100
S	5841-01-456-4567WF	F016D	1000	8409	1	100
S	5841-01-456-4567WF	5841-01-123-1234WF	1000	8409	1	100
S	5841-01-567-5678WF	B001B	1000	9006	1	100
S	5841-01-567-5678WF	5841-01-234-2345WF	1000	9006	1	100
S	5841-01-678-6789WF	F016C	1000	8409	1	100
S	5841-01-678-6789WF	F016D	1000	8409	1	100
S	5841-01-678-6789WF	5841-01-456-4567WF	1000	8409	1	100

One can infer the indenture relationships among these items by examining the applications. If a stock number has only an MDS application, it is an LRU. If it has another stock number as an application, it is an SRU. LRUs are said to be at level 1; SRUs may be at any level from 2 through 5. The application of every stock number is its *next higher assembly* (NHA). In the example in Table 2.2, the stock numbers ending in 1234WF and 2345WF are LRUs; they have only aircraft as applications and they are at indenture level 1. The four rightmost columns in Table 2.2 are the program select code, the program begin date, the quantity per application, and the future application percentage.

The stock number ending in 3456WF has applications to the B-1B, F-16C, and F-16D aircraft, but also to the two LRUs already described. Thus 3456WF has application to both of the LRUs; in fact, it is said to be *common* to the two LRUs. Its aircraft applications are

for informational purposes only. The 1234WF entry is the link to the F-16C/D, and 2345WF is the link to the B-1B aircraft. This SRU is at indenture level 2 in both applications. The 4567WF entry is an SRU that is peculiar to the F-16 LRU, 1234WF. Similarly, the 5678WF entry is for an SRU that is used only on the B-1B LRU. The final component, whose stock number ends in 6789WF, is also an SRU but one at indenture level 3 because its application is to an SRU at indenture level 2.

If the data processing program that builds the indenture file could not find the 2345WF record in the application file, it would promote the 5678WF SRU to an LRU. In this case, the requirements system would tend to overinvest in this SRU because it would view shortages of the SRU as holes in aircraft rather than holes in LRUs. Holes in aircraft, obviously, affect aircraft availability more directly than holes in LRUs, and the logic of the aircraft availability model, the requirements system's computational algorithm that computes safety stock requirements, accounts for this difference.

EXAMPLES OF APPLICATION DATA FOR A SINGLE LRU FAMILY

The LRU we use for instructive purposes is the modular low power radio frequency unit (MLPRF) used on the F-16C, F-16D, and B-1B aircraft. Although not pertinent to the discussion that follows, the function of the MLPRF, as we understand it, is to enable the aircraft's radar system to discriminate between its own reflected radar energy and that of other aircraft, thus helping to reduce or eliminate the problem of false targets. The responsibility for managing the LRU and most of its SRUs rests with the Ogden Air Logistics Center. The LRU procurement cost in the March 1991 D041 database that supported the analysis discussed here was $236,008, placing the MLPRF in the most costly one percent of all the items in the database.

Table 2.3 reflects the level of indenture, work unit code (WUC), description, and master stock number of the MLPRF used in the F-16C/D aircraft and its principal SRUs. The work unit codes and

SRU-to-LRU relationship between the stock number in the requisition and its correct parent LRU, it will not attribute the correct worth of the SRU to that backorder release; thus, its effectiveness in generating additional serviceable LRUs through sensible SRU allocations is also seriously inhibited.

Although the major effect of errors in application and indenture data is on repair requirements, repair prioritization, and asset allocations, such errors also affect spares requirements. Although we point out that SRU promotions *tend* to offset the effects of not buying SRU safety stock to cover the depot job-routed repair pipeline, it is an ac-

Table 2.3

Work Breakdown Structure of the MLPRF

Level	WUC	Description[a]	Stock number[b]
1	74AN0	Modular LPRF	1270-01-233-0011WF
2	74ANA	Frequency multiplier	6615-01-124-0226WF
2	74ANB	Frequency synthesizer	6625-01-126-0097WF
3		Oscillator	5955-01-157-6444WF
2	74ANC	Reference oscillator	1270-01-208-8409WF
2	74AND	Transmit microwave	5841-01-291-6174WF
2	74ANE	Receiver assembly	1270-01-194-5732WF
2	74ANF	Hi res mod adapter	1270-01-153-0515
2	74ANH	Sampled data PWA	5999-01-278-5983WF
2	74ANK	PWA interface controller	5999-01-232-5232WF
2	74ANL	PWA analog controller	1270-01-195-8634WF
2	74ANN	PWA CPU controller	5998-01-298-9139WF
2	74ANP	Low noise amplifier	1270-01-132-6867WF
3		FET amplifier assembly	1270-01-153-8700WF
3		IF assembly	1270-01-223-5840WF
3		Rec protect	1270-01-283-0952WF
2	74ANQ	Low voltage power supply	1280-01-126-0079WF

[a]The descriptions of level-3 SRUs were extracted from the D041 database.

[b]The stock number of the 74ANF "hi res mod adapter" was extracted from the Integrated Logistics Data File.

descriptions of the components that have work unit codes shown in the table were extracted from Technical Order 1F-16CJ-06, 1 July 1991, changed 27 April 1992, the *Work Unit Code Manual* for the F-16C/D aircraft, Blocks 50 and 52. The Ogden Air Logistics Center kindly provided most of the stock numbers shown. We inferred the levels of indenture from application data and other sources.

Table 2.3 clarifies the indenture relationships among the various components of the MLPRF. The integer shown under "Level" for each component indicates whether the component is the LRU (level 1) or an SRU (levels 2 and 3). Components at level 3 are subassemblies of the level-2 SRUs. For example, the oscillator, (5955-01-157-6444WF) is a subassembly of the frequency synthesizer, while the low noise amplifier has three subassemblies, the FET amplifier assembly, the IF assembly, and the component called "rec protect." It is common to encounter such unintelligible nomenclature in D041 records.

Chapter Five

AN APPROACH TO BUILDING CORRECT INDENTURE FILES

The descriptions of components reflected in the work unit code manual are usually more sensible, although the description of the 74AND (5841-01-291-6174WF), "Transmit microwave," is from that source. All of the components in Table 2.3 that have work unit codes were extracted from the work unit code manual. The level-3 SRUs were extracted from the application file. Level-3 SRUs typically do not have work unit codes assigned in the aircraft work unit code manual, although they sometimes reflect the WUC of their parent SRUs in the application file. Work unit codes do not always appear in D041 files simply because many items apply to more than one weapon system; therefore, they may have different work unit codes in each application.

The 74ANF "hi res mod adapter" was not in the D041 database. It may be a consumable item. We will not discuss it further. We believe that the data in Table 2.3 reflect the true indenture relationships among all of the components of the MLPRF that are recoverable or that appear in the work unit code manual.

Table 2.4 reflects the application records for the MLPRF and all of its recoverable SRUs. This is followed by the subgroup master stock number of the component and an application. The application might be an aircraft or another stock number, or, in some cases, the record might just be a memorandum. Application records are treated as memoranda if the program select code (PSC) in the record is 0000. Inspection reveals that some of the records with program select codes equal to 0000 were not *intended* to be memoranda as they reflect valid applications. The remaining data elements are the program select code, program begin date, quantity per application, and future application percentage. The "EG" entries in the table reflect applications to F-16 aircraft of the Egyptian Air Force. The data in Table 2.4 have been changed since this report was written. They do not reflect adversely on the MLPRF's current item manager or equipment specialist.

Note the large number of SRUs in Table 2.4 without a valid application to an LRU; this is because either no such application record exists or the program select code is 0000. Each of these SRUs will be promoted to LRU status in the construction of the indenture

lated stock numbers the I&S set. This file should look about like the last five lines of Table 3.1.

2. Extract all application records of the stock numbers in the I&S set from the application file. Call this the application set. This file should look similar to the first 17 lines of Table 3.2 and the first 2 lines of Table 2.4.
3. Extract all application records that reflect applications to the application set and add them to the application set. This step adds items to the application set from one lower indenture level.

LRU/ SRU	Subgroup Master	Application	PSC	PBD	QPA	FAP	WUC
LRU	1270-01-233-0011WF	F016C	1000	8409	1	100	74AN0
LRU	1270-01-233-0011WF	F016D	1000	8409	1	100	
SRU	6625-01-124-0226WF	B001B	1000	8509	2	100	74ANA
SRU	6625-01-124-0226WF	F016C	1000	8409	1	100	
SRU	6625-01-124-0226WF	F016C EG	1000	8409	1	100	
SRU	6625-01-124-0226WF	F016D	1000	8409	1	100	
SRU	6625-01-124-0226WF	F016D EG	1000	8409	1	100	
SRU	6625-01-126-0097WF	B001B	1000	8509	1	100	74ANB
SRU	6625-01-126-0097WF	F016C	1000	8409	1	100	
SRU	6625-01-126-0097WF	F016C EG	1000	8409	1	100	
SRU	6625-01-126-0097WF	F016D	1000	8409	1	100	
SRU	6625-01-126-0097WF	F016D EG	1000	8409	1	100	
SRU	6625-01-126-0097WF	1270-01-132-2441WF	0000	8409	1	100	
SRU	5955-01-157-6444WF	B001B	0000	8509	2	100	
SRU	5955-01-157-6444WF	F016C	0000	8409	1	100	
SRU	5955-01-157-6444WF	F016C EG	0000	8409	1	100	
SRU	5955-01-157-6444WF	F016D	0000	8409	1	100	
SRU	5955-01-157-6444WF	F016D EG	0000	8409	1	100	
SRU	5955-01-157-6444WF	1270-01-194-8163EK	0007	8509	1	100	
SRU	5955-01-157-6444WF	6625-01-126-0097WF	0007	8409	1	100	
SRU	1270-01-208-8409WF	B001B	1000	8509	2	100	74ANC
SRU	1270-01-208-8409WF	F016C	1000	8409	1	100	
SRU	1270-01-208-8409WF	F016C EG	1000	8409	1	100	
SRU	1270-01-208-8409WF	F016D	1000	8409	1	100	
SRU	1270-01-208-8409WF	F016D EG	1000	8409	1	100	
SRU	5895-01-291-6174WF	F016C	1000	8409	1	100	74AND
SRU	5895-01-291-6174WF	F016D	1000	8409	1	100	
SRU	5895-01-291-6174WF	0016C	1000	8409	1	100	
SRU	5895-01-291-6174WF	0016D	1000	8409	1	100	
SRU	1270-01-194-5732WF	F016C	1000	8409	1	100	74ANE
SRU	1270-01-194-5732WF	F016C EG	1000	8409	1	100	
SRU	1270-01-194-5732WF	F016D	1000	8409	1	100	
SRU	1270-01-194-5732WF	F016D EG	1000	8409	1	100	
SRU	5999-01-278-5983WF	F016C	1000	8409	1	100	74ANH
SRU	5999-01-278-5983WF	F016D	1000	8409	1	100	
SRU	5999-01-278-5983WF	0016C	1000	8409	1	100	
SRU	5999-01-278-5983WF	0016D	1000	8409	1	100	
SRU	5999-01-232-5232WF	F016C	1000	8409	1	100	74ANK
SRU	5999-01-232-5232WF	F016C EG	1000	8409	1	100	
SRU	5999-01-232-5232WF	F016D	1000	8409	1	100	

breakdown, i.e., the applicable "dash-4" technical order for the LRU. Care should be taken here to ensure that the indenture structure reflected in the work unit code manual is the same as that shown in the illustrated parts breakdown. It may also be necessary in some cases to draw upon the expertise of a maintenance technician who is familiar with the physical pathology of the LRU. When all else fails, it may be necessary to take the cover off an LRU and determine the true indenture relationships by physical inspection.

The result of the process thus far is a set of I&S data and application data describing what the system thinks this LRU family comprises, along with its true indenture structure. The true indenture structure

LRU/ SRU	Subgroup Master	Application	PSC	PBD	QPA	FAP	WUC
SRU	1270-01-195-8634WF	F016C	1000	8409	1	100	74ANL
SRU	1270-01-195-8634WF	F016C EG	1000	8409	1	100	
SRU	1270-01-195-8634WF	F016D	1000	8409	1	100	
SRU	1270-01-195-8634WF	F016D EG	1000	8409	1	100	
SRU	5998-01-298-9139WF	F016C	1000	8409	1	100	74ANN
SRU	5998-01-298-9139WF	F016D	1000	8409	1	100	
SRU	5998-01-298-9139WF	0016C	1000	8409	1	100	
SRU	5998-01-298-9139WF	0016D	1000	8409	1	100	
SRU	1270-01-132-6867WF	F016C	1000	8409	1	100	74ANP
SRU	1270-01-132-6867WF	F016C EG	1000	8409	1	100	
SRU	1270-01-132-6867WF	F016D	1000	8409	1	100	
SRU	1270-01-132-6867WF	F016D EG	1000	8409	1	100	
SRU	1270-01-132-6867WF	0691R748G01 ANP	0000	0000	0	0	
SRU	1270-01-132-6867WF	1270-01-132-2441WF	0000	8409	1	100	
SRU	1270-01-153-8700WF	B001B	0000	8509	2	100	
SRU	1270-01-153-8700WF	F016C	0000	8409	1	100	
SRU	1270-01-153-8700WF	F016C EG	0000	8409	1	100	
SRU	1270-01-153-8700WF	F016D	0000	8409	1	100	
SRU	1270-01-153-8700WF	F016D EG	0000	8409	1	100	
SRU	1270-01-153-8700WF	1270-01-132-6867WF	0007	8409	1	100	
SRU	1270-01-153-8700WF	5895-01-161-1142EK	0007	8509	2	100	
SRU	1270-01-223-5840WF	F016C	0000	8409	1	100	
SRU	1270-01-223-5840WF	F016C EG	0000	8409	1	100	
SRU	1270-01-223-5840WF	F016D	0000	8409	1	100	
SRU	1270-01-223-5840WF	F016D EG	0000	8409	1	100	
SRU	1270-01-223-5840WF	1270-01-132-6867WF	0007	8409	1	100	
SRU	1270-01-283-0952WF	B001B	0000	8509	1	100	
SRU	1270-01-283-0952WF	F016C	0007	8409	1	100	
SRU	1270-01-283-0952WF	F016D	0000	8409	1	100	
SRU	1270-01-283-0952WF	0001B	0000	8509	1	100	
SRU	1270-01-283-0952WF	0016C	0000	8509	1	100	
SRU	1270-01-283-0952WF	0016D	0000	8409	1	100	
SRU	1270-01-283-0952WF	1270-01-132-6867WF	0007	8409	1	100	
SRU	1270-01-283-0952WF	5895-01-161-1142EK	0007	8409	1	100	
SRU	1280-01-126-0079WF	B001B	1000	8509	2	100	74ANQ
SRU	1280-01-126-0079WF	F016C	1000	8409	1	100	
SRU	1280-01-126-0079WF	F016C EG	1000	8409	1	100	
SRU	1280-01-126-0079WF	F016D	1000	8409	1	100	
SRU	1280-01-126-0079WF	F016D EG	1000	8409	1	100	

There are other such examples. We have observed item managers manually reduce an item's demand rate to zero to suppress any procurement actions on the item. Although this action has the desired effect in the spares requirements computation, it has an equally obvious effect on DRIVE. DRIVE won't repair any of that item simply because it estimates no demand for the item during the planning horizon. D041 has a compute code whose valid values are Y or N. The use of a compute code of N suppresses any requirement for the item without falsifying data elements that are needed for purposes other than spares requirements computation.

The current condition of application data largely derives from the

ments computation will tend to overestimate their requirements. The table also reflects several invalid aircraft entries.

An additional item, a cable assembly, was shown in the application file as a component of the MLPRF, although it did not appear in the work unit code manual. Its application data are shown in Table 2.5.

Table 2.6 reflects the indenture relationships inferred from the application records in the construction of the indenture file and compares them with the true relationships shown in Table 2.3. Note the discrepancies between the true relationships and those that are ultimately reflected in the indenture file. With the single exception of the cable assembly in Table 2.5, every component of the MLPRF gets promoted from its correct level of indenture to the next higher level in the construction of the indenture file. We caution the reader that this is not a unique, exceptional, or pathological case in any sense. Errors such as one sees in this example pervade the application file. The natural question in the face of such data is why we don't see any evidence in system performance that we are computing our requirements for recoverable spares incorrectly. The answer is that the promotions of components to higher levels simply tend to induce overinvestments in their requirements. The only way in which these errors affect spares requirements estimation is that we spend more on these promoted components than we need to spend to achieve specified levels of system performance. (This assumes that we model

Table 2.5

Additional D041 D50 Records for an MLPRF Component

LRU/ SRU	Subgroup Master	Application	PSC	PBD	QPA	FAP	WUC[a]
SRU	6150-01-204-3695WF	F016C	0000	8409	1	100	74AN0
SRU	6150-01-204-3695WF	F016C EG	0000	8409	1	100	
SRU	6150-01-204-3695WF	F016D	0000	8409	1	100	
SRU	6150-01-204-3695WF	F016D EG	0000	8409	1	100	
SRU	6150-01-204-3695WF	1270-01-194-8163WF	0007	8409	1	100	
SRU	6150-01-204-3695WF	1270-01-233-0011WF	0007	8409	1	100	

[a]The work unit code shown for this component was reflected in a list obtained from the F-16 System Program Manager at the Ogden Air Logistics Center.

BIBLIOGRAPHY

Indenture Relationships Reflected in the Indenture File for the MLPRF

True Level	Inferred Level	WUC	Description	Stock Number
1	1	74AN0	Modular LPRF	1270-01-233-0011WF
2	2	74AN0	Cable assembly	6150-01-204-3695WF
2	1	74ANA	Frequency multiplier	6615-01-124-0226WF
2	1	74ANB	Frequency synthesizer	6625-01-126-0097WF
3	2		oscillator	5955-01-157-6444WF
2	1	74ANC	Reference oscillator	1270-01-208-8409WF
2	1	74AND	Transmit microwave	5841-01-291-6174WF
2	1	74ANE	Receiver assembly	1270-01-194-5732WF
2		74ANF	Hi res mod adapter	1270-01-153-0515
2	1	74ANH	Sampled data PWA	5999-01-278-5983WF
2	1	74ANK	PWA interface controller	5999-01-232-5232WF
2	1	74ANL	PWA analog controller	1270-01-195-8634WF
2	1	74ANN	PWA CPU controller	5998-01-298-9139WF
2	1	74ANP	Low noise amplifier	1270-01-132-6867WF
3	2		FET amplifier assembly	1270-01-153-8700WF
3	2		IF assembly	1270-01-223-5840WF
3	2		Rec protect	1270-01-283-0952WF
2	1	74ANQ	Low voltage power supply	1280-01-126-0079WF

the effects of SRU shortages correctly.) On the other hand, in attempting to apply DRIVE to the estimation of component repair requirements and the prioritization and allocation of assets to the depot and bases worldwide, errors in indenture relationships defeat us. We discuss this problem at greater length in Chapter Four.

Chapter Three

COMPLICATIONS FROM RELATIONSHIPS BETWEEN INTERCHANGEABLE AND SUBSTITUTABLE ITEMS

A complete description of the indenture relationships for the items in Table 2.4 depends not only on all of their applications, but also on the applications of all items that apply to them, and on all items that are interchangeable with or substitutable for any of them and all of their applications and the applications of items applicable to them, and so on. Conscientious maintenance of application data is sometimes made rather tedious because of such interchangeability and substitutability (I&S) relationships. One must ensure that the application file reflects all of the applications of every item, not only to preferred items (group masters) but to any subgroup master items as well. In the case of the MLPRF we examined in Chapter Two, the preferred stock number, 1270-01-233-0011WF, has four one-way interchangeables or subgroup masters. Table 3.1 reflects the I&S relationships of the MLPRF and its recoverable components. The MLPRF, 1270-01-233-0011, is one of five subgroup masters and is the head of family. In the data presented in the remainder of this chapter, note how much more frequently the least-preferred item, 1270-01-132-2441, appears as an application than does the preferred item. The least-preferred item is shown first within each grouping in Table 3.1, and the most-preferred item is shown last.

By definition, the less-preferred items in the group cannot be used to satisfy requirements for any more-preferred item in the group; the most-preferred item in the group, the 1270-01-233-0011WF, can be used to satisfy a requirement for any less-preferred item in the group. On the other end of the scale, the least-preferred item in the group can be used only to satisfy its own requirements.

Actual Stock Number	Family Master	Order-of-Use Code
1270-01-153-8699	1270-01-153-8700	AAA
1270-01-153-8700	1270-01-153-8700	AAB
1270-01-132-6868	1270-01-194-5732	AAA
1270-01-194-5732	1270-01-194-5732	ABA
5998-01-132-7025	5998-01-196-3759	AAA
5998-01-194-5625	5998-01-196-3759	ABA
5998-01-196-3759	5998-01-196-3759	ACA
1270-01-132-6870	1270-01-208-8409	AAA
1270-01-208-8409	1270-01-208-8409	AAB
1270-01-132-2441	1270-01-233-0011	AAA
1270-01-196-3788	1270-01-233-0011	ABA
1270-01-196-3789	1270-01-233-0011	ACA
1270-01-194-8163	1270-01-233-0011	ADA
1270-01-233-0011	1270-01-233-0011	AEA

A search of the application file, using the I&S relationships in Table 3.1, revealed the additional relationships shown in Table 3.2.

The first four sets of application data in Table 3.2 apply to LRUs, each one a subgroup master according to the I&S data in Table 3.1. The serious flaw in these application data is that each of the four LRUs has an application percentage of 100. What this implies is that each one is used on every F-16C and F-16D of the U.S. and Egyptian Air Forces; therefore, all of the flying programs of these aircraft would be absorbed by all five MLPRFs, these four and the family master as well. There is room on an F-16 for only one MLPRF. What needs to be done here is to change the FAPs to reflect the percentage of the total aircraft flying hours by MDS that will be absorbed by each of these subgroup master stock numbers (and also by the master). Before the advent of DRIVE, there was no motivation to correct this problem simply because the requirements system computes requirements only for master stock numbers. With DRIVE on the scene, however, the application data need to be correct for every subgroup master LRU family.

The first SRU in Table 3.2, 1270-01-132-6868WF, is a subgroup master item whose head of family is 1270-01-194-5732WF. According to

Table 3.2

Application Data for Other Items Related to Items in Table 3.1

LRU/ SRU	Stock Number	Application	PSC	PBD	QPA	FAP
LRU	1270-01-132-2441WF	F016C	1000	8409	1	100
LRU	1270-01-132-2441WF	F016C EG	1000	8409	1	100
LRU	1270-01-132-2441WF	F016D	1000	8409	1	100
LRU	1270-01-132-2441WF	F016D EG	1000	8409	1	100
LRU	1270-01-132-2441WF	0758R006G01 ANO	0000	0000	0	0
LRU	1270-01-196-3788WF	F016C	1000	8409	1	100
LRU	1270-01-196-3788WF	F016C EG	1000	8409	1	100
LRU	1270-01-196-3788WF	F016D	1000	8409	1	100
LRU	1270-01-196-3788WF	F016D EG	1000	8409	1	100
LRU	1270-01-196-3789WF	F016C	1000	8409	1	100
LRU	1270-01-196-3789WF	F016C EG	1000	8409	1	100
LRU	1270-01-196-3789WF	F016D	1000	8409	1	100
LRU	1270-01-196-3789WF	F016D EG	1000	8409	1	100
LRU	1270-01-194-8163WF	F016C	1000	8409	1	100
LRU	1270-01-194-8163WF	F016C EG	1000	8409	1	100
LRU	1270-01-194-8163WF	F016D	1000	8409	1	100
LRU	1270-01-194-8163WF	F016D EG	1000	8409	1	100
SRU	1270-01-132-6868WF	F016C	1000	8409	1	100
SRU	1270-01-132-6868WF	F016C EG	1000	8409	1	100
SRU	1270-01-132-6868WF	F016D	1000	8409	1	100
SRU	1270-01-132-6868WF	F016D EG	1000	8409	1	100
SRU	1270-01-132-6868WF	0691R744G01 ANE	0000	0000	0	0
SRU	1270-01-132-6868WF	1270-01-132-2441WF	0000	8409	1	100
SRU	5998-01-132-7025WF	F016C	1000	8409	1	100
SRU	5998-01-132-7025WF	F016C EG	1000	8409	1	100
SRU	5998-01-132-7025WF	F016D	1000	8409	1	100
SRU	5998-01-132-7025WF	F016D EG	1000	8409	1	100
SRU	5998-01-132-7025WF	1270-01-132-2441WF	0000	8409	1	100
SRU	5998-01-194-5625WF	F016C	1000	8409	1	100
SRU	5998-01-194-5625WF	F016C EG	1000	8409	1	100
SRU	5998-01-194-5625WF	F016D	1000	8409	1	100
SRU	5998-01-194-5625WF	F016D EG	1000	8409	1	100
SRU	5998-01-196-3759WF	F016C	1000	8409	1	100
SRU	5998-01-196-3759WF	F016C EG	1000	8409	1	100

Table 3.2—continued

LRU/ SRU	Stock Number	Application	PSC	PBD	QPA	FAP
SRU	5998-01-196-3759WF	F016D	1000	8409	1	100
SRU	5998-01-196-3759WF	F016D EG	1000	8409	1	100
SRU	1270-01-132-6870WF	B001B	1000	8509	2	100
SRU	1270-01-132-6870WF	F016C	1000	8409	1	100
SRU	1270-01-132-6870WF	F016C EG	1000	8409	1	100
SRU	1270-01-132-6870WF	F016D	1000	8409	1	100
SRU	1270-01-132-6870WF	F016D EG	1000	8409	1	100
SRU	1270-01-132-6870WF	0691R746G01 ANC	0000	0000	0	0
SRU	1270-01-132-6870WF	1270-01-132-2441WF	0000	8409	1	100
SRU	5998-01-132-5759WF	F016C	1000	8409	1	100
SRU	5998-01-132-5759WF	F016C EG	1000	8409	1	100
SRU	5998-01-132-5759WF	F016D	1000	8409	1	100
SRU	5998-01-132-5759WF	F016D EG	1000	8409	1	100
SRU	5998-01-132-5759WF	0691R739G01 ANN	0000	0000	0	0
SRU	5998-01-132-5759WF	1270-01-132-2441WF	0000	8409	1	100
SRU	5998-01-132-7026WF	F016C	1000	8409	1	100
SRU	5998-01-132-7026WF	F016C EG	1000	8409	1	100
SRU	5998-01-132-7026WF	F016D	1000	8409	1	100
SRU	5998-01-132-7026WF	F016D EG	1000	8409	1	100
SRU	5998-01-132-7026WF	0691R736G01 ANK	0000	0000	0	0
SRU	5998-01-132-7026WF	1270-01-132-2441WF	0000	8409	1	100
SRU	1270-01-133-2423WF	B001B	1000	8509	2	100
SRU	1270-01-133-2423WF	F016C	1000	8409	1	100
SRU	1270-01-133-2423WF	F016C EG	1000	8409	1	100
SRU	1270-01-133-2423WF	F016D	1000	8409	1	100
SRU	1270-01-133-2423WF	F016D EG	1000	8409	1	100
SRU	1270-01-133-2423WF	0586R212H01 AND	0000	0000	0	0
SRU	1270-01-133-2423WF	1270-01-132-2441WF	0000	8409	1	100
SRU	5841-01-150-7527EK	B001	0007	8709	1	100
SRU	5841-01-150-7527EK	B001B	1X00	8506	2	100
SRU	1270-01-153-9814WF	B001B	0000	8509	1	100
SRU	1270-01-153-9814WF	F016C	0000	8409	1	100
SRU	1270-01-153-9814WF	F016C EG	0000	8409	1	100
SRU	1270-01-153-9814WF	F016D	0000	8409	1	100
SRU	1270-01-153-9814WF	F016D EG	0000	8409	1	100
SRU	1270-01-153-9814WF	1270-01-132-6867WF	0007	8409	1	100
SRU	1270-01-153-9814WF	5895-01-161-1142EK	0007	8509	1	100

Table 3.2—continued

LRU/ SRU	Stock Number	Application	PSC	PBD	QPA	FAP
SRU	5841-01-160-1690EK	B001B	1000	8506	4	100
SRU	5841-01-160-1690EK	5841-01-150-7527EK	0007	8506	2	100
SRU	5895-01-161-1142EK	B001B	1000	8506	2	100
SRU	5895-01-161-1142EK	5841-01-150-7527EK	0007	8506	1	100
SRU	6150-01-185-6465WF	F016C	0000	8409	1	100
SRU	6150-01-185-6465WF	F016C EG	0000	8409	1	100
SRU	6150-01-185-6465WF	F016D	0000	8409	1	100
SRU	6150-01-185-6465WF	F016D EG	0000	8409	1	100
SRU	6150-01-185-6465WF	1270-01-194-8163WF	0007	8409	1	100
SRU	5895-01-193-7344WF	F016C	0000	8409	1	100
SRU	5895-01-193-7344WF	F016C EG	0000	8409	1	100
SRU	5895-01-193-7344WF	F016D	0000	8409	1	100
SRU	5895-01-193-7344WF	F016D EG	0000	8409	1	100
SRU	5895-01-193-7344WF	1270-01-132-6867WF	0007	8409	1	100
SRU	1270-01-200-2325EK	B001B	0000	8503	1	100
SRU	1270-01-200-2325EK	F016C	0000	8503	1	100
SRU	1270-01-200-2325EK	F016D	0000	8503	1	100
SRU	1270-01-200-2325EK	5841-01-160-1690EK	0007	8503	1	100
SRU	5998-01-202-6572EK	B001B	1000	8503	1	100
SRU	5998-01-202-6572EK	F016D	1000	8503	1	100
SRU	5998-01-202-6572EK	F016D EG	1000	8503	1	100
SRU	5998-01-202-6572EK	1270-01-208-8409EK	0007	8503	1	100
SRU	5841-01-230-1309EK	B001B	0000	8503	1	100
SRU	5841-01-230-1309EK	F016C	0000	8503	1	100
SRU	5841-01-230-1309EK	F016D	0000	8503	1	100
SRU	5841-01-230-1309EK	5841-01-160-1690EK	0007	8503	1	100

the application data, it applies only to the least preferred LRU, 1270-01-132-2441. This may or may not be true. In any event, it will end up looking like an LRU in the indenture file because it has no valid application to any LRU (the program select code is 0000 for its only LRU application); its only valid applications are to aircraft, so it will be assigned to level 1 by the indenture file software. It will also be as-

sumed to absorb 100 percent of the flying hours of the aircraft to which it is applicable, another error of the sort inflicted on the LRUs.

The next three SRUs suffer from the same errors. None of them has a valid application to an LRU, only to aircraft; therefore, they will be assumed to be LRUs and to absorb all of the flying hour programs on the aircraft to which they are applicable. The rest of the story on these three SRUs is somewhat more interesting. The reason they are in Table 3.2 is because the first of them, 5998-01-132-7025WF, shows an application (although invalid) to the least preferred MLPRF stock number. It is related to the other two by one-way interchangeability, i.e., they are all subgroup masters. The two more-preferred items have no LRU applications, but they probably apply in some way to the more-preferred LRUs. The other interesting fact about them is that there is no entry in the work unit code manual to suggest that anything is missing from Table 2.3, which shows all of the indentured components of the family master LRU that are indicated in the work unit code manual. These application data are so poor that we are at a loss to determine the truth about these three items.

The next SRU, 1270-01-132-6870WF, is interchangeable with the 1270-01-208-8409WF reference oscillator, the preferred item and a component SRU of the master LRU. Interestingly, inexplicably, it shows an application (although invalid) only to the least-preferred LRU stock number.

The remaining items in Table 3.2 are there because they have applications to other items, or other items have application to them. They suffer from most of the same problems of invalid application records, etc.

Chapter Four

IMPLICATIONS OF ERRORS IN INDENTURE RELATIONSHIPS

Implicit in the computations of the spares requirements system is the policy that the Air Force does not buy safety stock to cover the SRU job-routed depot repair pipeline. Thus, it may be that the overinvestment in SRUs that is induced by their promotion to higher levels of indenture helps protect the system against additional delays in depot-level repair of LRUs. Why, then, are errors in application and indenture data important?

The principal answer lies in another important use of the indenture file, that of supporting the decisionmaking functions of DRIVE: (a) estimating depot-level component repair requirements, (b) prioritizing component repairs, and (c) allocating the serviceable assets emerging from repair to the depot and bases worldwide. The decisionmaking logic underlying each of these functions depends on accurate indenture relationships. An important use of such relationships lies in identifying opportunities to generate additional serviceable LRUs by allocating SRUs where they will alleviate AWP shortages. In repair requirements estimation and component repair prioritization, DRIVE prioritizes rather heavily those SRU repairs that will generate additional serviceable LRUs, a policy it cannot implement without the correct indenture relationships in its database. Thus, DRIVE will underestimate requirements for and underprioritize SRU repairs if it does not see the SRU-LRU relationship.

DRIVE infers AWP shortages at bases from the advice codes in requisitions for SRUs in the depot backorder file. An advice code of 6L indicates an AWP shortage. If DRIVE's database does not reflect an

SRU-to-LRU relationship between the stock number in the requisition and its correct parent LRU, it will not attribute the correct worth of the SRU to that backorder release; thus, its effectiveness in generating additional serviceable LRUs through sensible SRU allocations is also seriously inhibited.

Although the major effect of errors in application and indenture data is on repair requirements, repair prioritization, and asset allocations, such errors also affect spares requirements. Although we point out that SRU promotions *tend* to offset the effects of not buying SRU safety stock to cover the depot job-routed repair pipeline, it is an accident, and not defensible as an approach to determining SRU requirements sensibly.

For any specified investment level, errors in indenture data, as we pointed out earlier, act to degrade system performance. In this sense, they have the same effect as uncertainty: They cause us to buy a less-effective mix of spares.

Chapter Five

AN APPROACH TO BUILDING CORRECT INDENTURE FILES

Achieving the ability to produce accurate, complete indenture files requires a conscientious effort to correct the deficiencies in the current application file, coupled with some method for auditing and routinely correcting or updating it. Viewing the inventory system as a collection of LRU families is a necessary ingredient of any effective approach to cleaning up the file. Related stock numbers cannot be treated in isolation.

CLEANING UP THE APPLICATION DATA

The information required to support this task has already been discussed in this report. One needs to bring together data from the appropriate aircraft work unit code manual and illustrated parts breakdown (the "dash-4" technical order), the I&S file, the application file, and the file in the D041 database that contains item nomenclature and other item-level data elements called the D041 *01 file.* Data from the application file must always be extracted using I&S relationships. One should build two files, one comprising a set of stock numbers (and related data) called the *application set,* the second comprising a set of stock numbers (and related data) called the *I&S set.* The purpose of these files is simply to gather together all of the application and I&S data related to an LRU family. One might proceed in the following sequence:

1. Find the LRU stock number in the I&S file and extract all of its I&S relationships with other stock numbers. *Call this collection of re-*

the last five lines of Table 3.1.

2. Extract all application records of the stock numbers in the I&S set from the application file. Call this the application set. This file should look similar to the first 17 lines of Table 3.2 and the first 2 lines of Table 2.4.
3. Extract all application records that reflect applications to the application set and add them to the application set. This step adds items to the application set from one lower indenture level.
4. Extract from the I&S file the I&S relationships of the stock numbers in the application set and add them to the I&S set if they are not already there. This step adds stock numbers related to those most recently added to the application set.
5. Add all stock numbers in the I&S set to the application set that are not already there. This step adds to the application set the stock numbers just added to the I&S set in step 4.
6. Repeat steps 3 through 5 three more times, each time adding to the application set applications from the next lower indenture level, and picking up any related stock numbers from the I&S file and adding them to the I&S set and the application set.
7. Extract from the D041 01 file the records for all of the stock numbers in the application set so that nomenclature and other information can be correlated with information from other sources.

In analyzing the data for the MLPRF, we sorted the application records by stock number within work unit code. This helped us determine the *true indenture structure* of the LRU family for the preferred LRU, i.e., the master stock number. Unfortunately, the work unit code is not always available in D041 records. We added them manually by sorting through the application data and matching the nomenclature in D041 01 records with that in the work unit code manual. Such a procedure might not always work, however, because sometimes the nomenclature in the D041 01 record and that in the work unit code manual are so different that the match may not be decipherable. In any event, it is necessary to understand the master LRU family's true indenture structure before one has the basis for corrective action. It may be helpful to refer to the illustrated parts

Care should be taken here to ensure that the indenture structure reflected in the work unit code manual is the same as that shown in the illustrated parts breakdown. It may also be necessary in some cases to draw upon the expertise of a maintenance technician who is familiar with the physical pathology of the LRU. When all else fails, it may be necessary to take the cover off an LRU and determine the true indenture relationships by physical inspection.

The result of the process thus far is a set of I&S data and application data describing what the system thinks this LRU family comprises, along with its true indenture structure. The true indenture structure resembles the data in Table 2.3. There we can see what components are parts of other components, at least for the family master LRU. The remainder of the task of cleaning up the application file is relatively straightforward, albeit in many cases tedious. Specific guidance to persons involved in cleaning up application and I&S data is needed so that they know what to look for once the true indenture structure is known and the required data have been assembled.

DATA FOR SPARES REQUIREMENTS VS. DATA FOR REPAIR REQUIREMENTS

Some of the pervasive problems we have seen in data are not problems for the spares requirements computation, but are serious problems for repair prioritization and asset allocation. For example, consider again the LRU family used as an example in this report. There is one family master stock number and four subgroup master stock numbers. Each is shown to have 100 percent application. This is not a problem for the spares requirements computation simply because only the family master item will be procured and the demand data for the subgroup master items will be pooled with those of the family master. In estimating quarterly repair requirements or prioritizing repairs and allocating assets, DRIVE needs to know what proportion of the flying hours flown at each base will be absorbed by each subgroup master stock number. Therefore, it needs to have the actual application percentage of each subgroup master accurately reflected in its data source.

manually reduce an item's demand rate to zero to suppress any procurement actions on the item. Although this action has the desired effect in the spares requirements computation, it has an equally obvious effect on DRIVE. DRIVE won't repair any of that item simply because it estimates no demand for the item during the planning horizon. D041 has a compute code whose valid values are Y or N. The use of a compute code of N suppresses any requirement for the item without falsifying data elements that are needed for purposes other than spares requirements computation.

The current condition of application data largely derives from the fact that data for items that are no longer preferred items (family or subgroup masters) are not maintained because the Air Force is no longer procuring such items. Unfortunately, DRIVE needs correct data on these items because we still repair them and allocate them to locations worldwide. Therefore, the application file must be maintained for all subgroup master stock numbers at all indenture levels.

Those charged with the responsibility for cleaning up the data files must understand that the data will be put to uses other than spares requirements computations. These uses should be explained in detail before the cleanup task is undertaken.

BIBLIOGRAPHY

Abell, John B., et al., *DRIVE (Distribution and Repair in Variable Environments): Enhancing the Responsiveness of Depot Repair*, RAND, R-3888-AF, 1992.

Isaacson, Karen E., and Patricia Boren, *Dyna-METRIC Version 6: An Advanced Capability Assessment Model*, RAND, R-4214-AF, 1993.

Miller, Louis W., and John B. Abell, *DRIVE (Distribution and Repair in Variable Environments): Design and Operation of the Ogden Prototype*, RAND, R-4158-AF, 1992.

Sherbrooke, Craig C., *METRIC: A Multi-Echelon Technique for Recoverable Item Control*, RAND, RM-5078-AF, 1968.