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HUMAN RESOURCES

WARTIME LOGISTICS DEMAND RATE FORECASTING

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This paper describes the methodology and results of a research and development ~~(R&D)~~ effort to develop Combat Experience Data Base and an automated Wartime Maintenance Information and Forecasting System with which t analyze the data. The data base is based on Vietnam-era Southeast Asia experience. The computerized analysi products are mathematical and simulation models which look at maintenance resource demands of typical Tactical Ai Command units under non-nuclear warfare conditions. The computerized analysis packages leading to these product are a combat data parameter regression and crossplot module, a stepwise multiple regression mathematical modelin module, and a simple dynamic simulation model module. The driving force for developing the data base an analysis/forecasting system is the thought that much can be learned about predicting wartime resource demand rate by examining actual historical combat data from the Southeast Asia conflict.

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SUMMARY

Historically, wartime demand rates are forecasted using peacetime data employing a simple "K" factor. This methodology generally uses flying hours as the primary utilization factor and ignores any resource demand causal relationships which may be present in the operational environment. Previous logistics analysis suggests that continued use of this procedure may provide misleading conclusions.

The present investigation consisted of six tasks: develop a Southeast Asia combat experience data base; conduct causal analysis of the operations and maintenance data; design/develop an automated parameter analysis package and a wartime maintenance demand rate mathematical model; conduct a dynamic interaction analysis; install and demonstrate the Wartime Maintenance Information and Forecasting System (WARMIFS) at Wright-Patterson AFB, Ohio; and document the results. The major "lesson learned" during this study is that wartime demands need to be forecasted using detailed and integrated combat data instead of generalized data.

The primary products of the present R&D effort are:

1. A generalized and fragmented maintenance experience data base which spans the Vietnam war years.
2. A computerized analysis system which, when combined with the data base, comprises the capability called WARMIFS.
3. An explanation of earlier-observed anomalies; i.e., inverse proportionality between flight hours and maintenance demands.

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PREFACE

This paper summarizes the results of an Air Force Human Resources Laboratory, Logistics and Human Factors Division (AFHRL/LR) contract to determine the feasibility of forecasting wartime resource demand rates using Southeast Asia (SEA) data and a simple computer simulation model. This effort was performed under Air Force Contract No. DAAK11-83-G-0079/0103 by Boeing Aerospace Company. This contract is a follow-on study related to the work that was accomplished under Contract No. F33615-77-C-0075. It is part of an overall AFHRL/LR approach to forecasting wartime demand rates using combat data instead of peacetime data. This effort developed an SEA data base and a prototype Wartime Maintenance Information and Forecasting System (WARMIFS) using the SEA data. The available SEA data were extremely generalized and fragmented. This resulted in moderate success in developing the forecasting model.

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I. INTRODUCTION

The ability to accurately predict logistics and maintenance resource requirements to support peacetime and combat operations is a well-recognized requirement. Beginning in 1971, an effort under Project 1124, "Human Resources in Aerospace System Development and Operations" (Reference 1), addressed predicting manpower required to support peacetime operations. Using the Logistics Composite Model (LCOM), a Maintenance Manpower Model (MMM) was developed to predict the manpower requirements necessary to support a developing weapon system. Also, another effort under Project 1124 was directed toward an expansion of the MMM to predict the Aerospace Ground Equipment (AGE) and spares resources requirements along with the manpower needs. A later contract, "Development of Maintenance Metrics to Forecast Resource Demands of Weapon Systems" (Reference 2), focused on improving the capability for determining maintenance demands of a new weapon system. The program explored the development of variables and weightings to be used in predicting the maintenance demands of an aircraft system. This contract is a follow-on effort related to the work that was accomplished above.

The present effort consisted of seven tasks:

TASK 1 - Develop Southeast Asia (SEA) Combat Experience Data Base. Historical SEA-era data tapes were screened for relevant data on selected study aircraft (A-7D, F-4C, RF-4C, and C-130). A literature search of scientific and technical information data bases and historical repositories was conducted to identify relevant SEA combat studies. Subsystems common to and representative of the four study aircraft were selected for stratifying the data. Parameters which were thought to significantly impact the study of aircraft resource demand rates were identified. A data base was established. Factors for adjusting the data to represent likely combat conditions were developed.

TASK 2 - Conduct Causal Analysis of Tactical Air Command (TAC) Operations and Maintenance. On-site data collection visits were made to a representative cross-section of TAC bases in the continental United States (CONUS) to gather information for use in analysis of a previously noted apparent anomaly; i.e., aircraft maintenance requirements decreased as flying hours increased. An analysis of the data produced an explanation for the anomaly.

TASK 3 - Design and Develop an Automated Parameter Analysis Package. An automated analysis package for correlating and statistically modeling maintenance parameters was developed.

TASK 4 - Design and Develop a Wartime Maintenance Demand Rate Mathematical Model. A model was provided to link an existing stepwise multiple regression routine to the data base. It was used to fit the parameters for avionics and engines prioritized in TASK 3 to their data in the data base of TASK 1, and to generate predictive wartime models.

TASK 5 - Conduct a Dynamic Interaction Analysis. After investigation and technical interchange, the preferred approach for a dynamic simulation capability was chosen. Dynamic simulation calls and management subroutines were designed and developed. These dynamic calls and subroutines call the Simulation Language for Alternative Modeling (SLAM II) simulation utility in the host Control Data Corporation (CDC) system. A dynamic simulation of a TAC base in combat was developed for the SLAM utility executable by the Wartime Maintenance Information and Forecasting System (WARMIFS).

TASK 6 - Install and Demonstrate WARMIFS at Wright-Patterson AFB. The developed system was installed at the Aeronautical Systems Division (ASD) Computer Center. The operability, accessibility and flexibility of the installed information and forecasting system were demonstrated using the initial data in the combat data base developed in Task 1. The demonstration results were analyzed and evaluated for possible enhancement. These enhancements are discussed in Section III, CONCLUSIONS AND RECOMMENDATIONS.

TASK 7 - Prepare Study Documentation. Study documentation includes: initial and amended study tasks; results and analyses of the system trade study; the data file; a user's guide; a guide to the maintenance, editing, updating, extending, and modification of the developed system; and this paper.

The primary products of this study are:

1. A maintenance experience data base which spans Vietnam war years (1965 - 1975).

2. A demonstration computerized analysis capability which, when combined with the data base, comprises the capability called WARMIFS.

3. An explanation of an earlier observed anomaly; i.e., inverse proportionality between flight hours and maintenance demands.

II. APPROACH AND METHODS

As previously described, this effort had seven interrelated tasks. Many of the tasks were actually performed partially in parallel in order to maximize study efficiency.

Develop Southeast Asia (SEA) Combat Experience Data Base

Data Sources. Three major data sources were used to develop the SEA combat experience data base:

Data on SEA-related historical records and research provided input for study planning, aircraft/equipment selection and relevant study parameter selection. This information came from the USAF Historical Research Center, Maxwell Air Force Base (AFB), AL; the Combat Data Information Center, Wright-Patterson AFB, OH (WPAFB); the Air Force Logistics Command History

Office, WPAFB, OH; and the National Archives, Washington, DC. Data on maintenance and operations results for aircraft equipment during the SEA conflict era (1965-1975) came from Boeing Aerospace Company's existing Experience Analysis Center (EAC) computerized Air Force data systems. This included maintenance data gathered under AFR 66-1, Maintenance Management Policy (D056E data tapes); Air Vehicle Performance Data gathered under AFR 65-110, Aerospace Vehicle and Equipment Inventory, Status and Utilization Reporting Systems; and data on possible causes for aircraft maintenance demands which came from historical information sources.

Data Collection. This combat experience data base was developed around four selected aircraft/area combinations, selected subsystem equipments, and selected study parameters. More than 1,900 AFR 66-1 (D056E) data tapes were screened; historical data repositories were visited; and relevant source data were obtained in machine readable and/or hard copy form.

A review was conducted of likely sources of historical experience data, related research, and/or descriptive studies of the SEA conflict (1965-1975) published about weapon system maintenance causes and resource use rates under combat conditions. This included a comprehensive set of technical reports, magazine articles, brochures, and other documentation dealing with the tactical air war in Vietnam published by the Air Force, industry, and other sources. A Scientific and Technical Information (STINFO) search of documentation pertaining to tactical aircraft maintenance causes and resource demands on all subsystems revealed the following agencies as sources of abundant Vietnam-era data and information: the USAF Historical Research Center (USAFHRC), Maxwell AFB, AL; the Combat Data Information Center (CDIC), Wright-Patterson AFB, OH; the USAF Logistics Command History Officer (AFLC/HO), Wright-Patterson AFB, OH; the USAF Inspection and Safety Center (AFISC), Norton AFB, CA; and the National Archives Machine Readable Branch (NAMRB), Washington, DC. Boeing has also accumulated a significant library of applicable documentation. Geographical data were gleaned from various detailed maps and geographies in the Boeing Technical Library. Climatic data were obtained from USAF Weather Service Climatic Briefs for the bases involved.

Review and Screen Historical Data Tapes

AFR 66-1 (D056E) Data. Boeing has maintained an extensive file of historical maintenance data tapes obtained through the Air Force data distribution channels. Only 1 or 2 current years worth of these data are kept in Air Force files in accordance with AFR 12-50, Disposition of Air Force Records - Records Disposition Policy (Reference 5). Boeing, however, retains a repository of over 5,000 historical AFR 66-1 (D056E) maintenance data tapes on most USAF aircraft from worldwide base locations; the tapes cover 1962 to present. Figure 1 indicates aircraft coverage by these tapes from 1965 through 1984. To use these data tapes, the first step required was to identify the approximately 1,900 tapes with creation dates between 1965 and 1975. The computer format of each of these tapes then had to be checked. During this check, tapes were screened for aircraft applicability (A-7D, F-4C, RF-4C, C-130) and data relevance (from Vietnam, Eastern Asia/Western Pacific region, CONUS) and to be sure that 1975 tapes were not post-Vietnam data (conflict ended during 1975). The final sort on the data tapes was to check

	YEAR																			
AIRCRAFT	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65
A-7D	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
A-10A	X	X	X	X	X	X	X	X	X	X										
B-52D	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
B-52G	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
B-52H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
C-5A	X	X	X	X	X	X	X	X	X	X			X	X						
C-7													X	X		X	X			
C-9	X	X	X	X	X	X	X	X												
C-123													X	X		X	X		X	X
C-130	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		X	X
C-135	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
C-141	X	X	X	X	X	X	X	X	X	X			X			X	X		X	X
E-3	X	X	X	X	X	X	X	X												
E-4	X	X	X	X	X	X	X	X	X	X										
F-4	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X
RF-4C										X	X	X	X	X		X	X		X	X
F-5	X	X	X	X	X	X													X	X
F-15	X	X	X	X	X	X	X	X	X											
F-16	X	X	X	X	X	X														
F-104																				X
F-105																			X	X
F-111	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X			
FB-111	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
T-38	X	X	X	X	X	X	X	X											X	
T-43	X	X	X	X	X	X	X	X	X	X	X									

Figure 1. Air Force Regulation 66-1 Aircraft Maintenance Data Received by Year.

the continuity of the data for aircraft, location, command, and collection time period. Incomplete and isolated event data were rejected at this screening. The data tapes remaining after this screening process form the maintenance demand portion of the source data for the combat experience data base. The unedited day-by-day transactional data on these tapes form a machine readable backup file to the normalized and summarized maintenance data contained in the completed combat data base. Figure 2 shows the processing steps which were necessary to screen the AFR 66-1 (D056E) data tapes and assemble the relevant data into the combat experience data base.

Record Types. The final form of the data gleaned from the AFR 66-1 tapes consists of aircraft maintenance records sorted by subsystem, by aircraft, by base, by month and by year. The format and variables of these data records were retained for the data base of this study and form the "B" and "C" record types of each data case. The Vietnam-era data cases found on the tapes form the basis for finding appropriate causal data for each maintenance data case. These causal data were obtained from operation reports and from historical sources previously identified.

Aircraft/Area/Subsystem Study Example

Selecting Aircraft and Geographical Area. Four TAC aircraft were selected which had extensive SEA combat experience, and which are or have been operational within the last 5 years: the A-7D, F-4C, RF-4C, and C-130E. Operational lives spanning from the Vietnam era into recent times allow data comparison between these aircraft and modern fighters such as the F-15 and F-16. This aids in updating the data base to present technological conditions. Active bases from a representative sample of operational areas (Vietnam, Pacific Theater, and CONUS) were included in the data base for each of the aircraft studied. Data cases were then selected for these aircraft/base combinations. Each case was selected based on a month's worth of maintenance data being available from the historic AFR 66-1 data tapes. Data cases were assembled for the data base for aircraft/base/months when both maintenance and causal factors (operational, combat, or geoclimatic) were available or could be estimated. Combat, noncombat overseas (Western Pacific), and CONUS data were included for comparison analyses. In addition, the selected sample includes a representative range of operational, geographical and seasonal environments.

Table 1 summarizes the contents of the source data base. Table 2 lists the aircraft/base data cases from which the combat experience data base was developed. The cases included in the data base are not a continuous monthly sample of each aircraft/base combination from January 1966 through June 1975, for the procedure of maintenance data recording and retention during the SEA conflict was not the routine continuous process that it is today. Also, not all of the data recorded have survived the intervening years. The data base represents the best coincidental sample of operations, maintenance, combat, and geoclimatic data from the Vietnam era available today. It is a broad representative sample of the tactical air operations, support, and environment of that time, with over 800 data cases spanning January 1966 through June 1975.

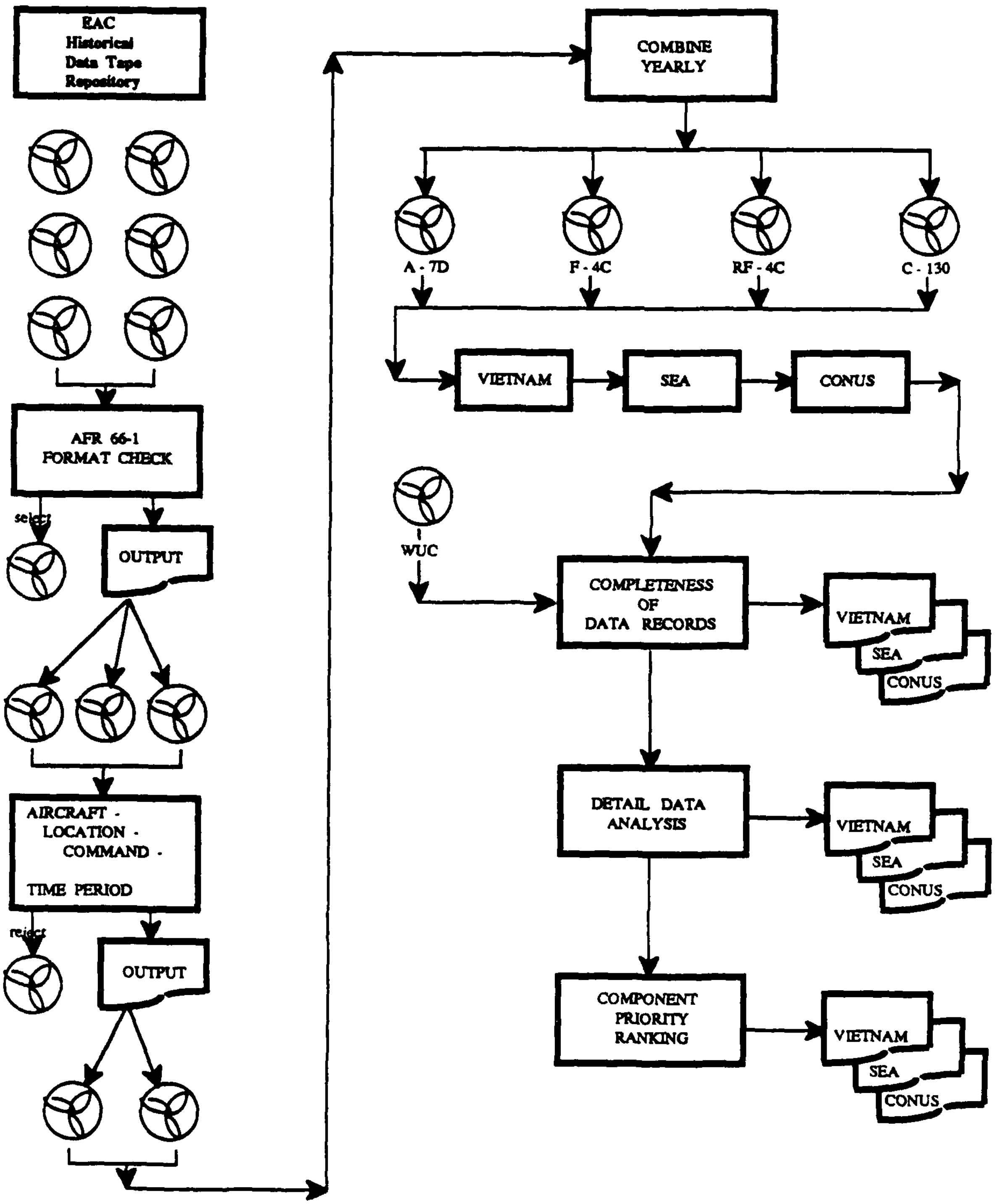

Figure 2. Combat Maintenance Demands Data Processing.

Table 1. Combat Data Base Contents

Aircraft
- F-4C
- RF-4C
- A-7D
- C-130E

Time Frame

- 1966-1975
- Monthly data samples (discontinuous due to data unavailability)
- 874 total data cases

SEA combat zone

Vietnam	(4 bases)
Thailand	(5 bases)

Western Pacific noncombat comparison

Taiwan	(1 base)
Philippines	(1 base)
Guam	(1 base)
Okinawa	(2 bases)
Japan	(3 bases)
Korea	(4 bases)

CONUS summary comparison

F-4C	(18-base summary)
RF-4C	(18-base summary)
A-7D	(18-base summary)
C-130E	(17-base summary)

Table 2. SEA Data Base Aircraft, Bases, Countries, and Cases

Aircraft	Base	Country	Case Numbers
	DATA BASE CONTENTS-F-4C 175 DATA CASES		
F-4C	Cam Ranh Bay	Vietnam	001-008
	Da Nang		009-012
	Tan Son Hnut		013-014
	Korat	Thailand	015-024
	Ubon		025-030
	C. C. Kang	Taiwan	031-060
	Clark	Philippines	061-103
	Fukuoka	Japan	104-108
	Misawa		109-114
	Naha	Okinawa	115-117
	Yokota	Japan	118-133
	Kunsan	Korea	134-146
	Osan		147-161
	Taegu		162-164
F-4C	CONUS Summary	CONUS	836-847
	DATA BASE CONTENTS-RF-4C 250 DATA CASES		
RF-4C	Tan Son Hnut	Vietnam	165-175
	Korat	Thailand	176
	Ubon		177-179
	Ubon		180-231
	C. C. Kang	Taiwan	232-238
	Clark	Philippines	239-266
	Kadena	Okinawa	267-318
	Misawa	Japan	319-321
	Yokota		322-327
	Kunsan	Korea	328-335
	Kwang Ju		336-337
	Osan		338-358
	Taegu		359-406
RF-4C	CONUS summary	CONUS	848-857

Table 2 (Concluded)

Aircraft	Base	Country	Case No's.
	DATA BASE CONTENTS-A-7D 52 DATA CASES		
A-7D	Korat	Thailand	407-436
	Nakhon Phanom		437-441
	Ta Khil		442-444
	Ubon		445-448
	Ubon		449-453
	Kunsan	Korea	454-455
A-7D	CONUS summary	CONUS	858-862
	DATA BASE CONTENTS-C-130E 389 DATA CASES		
C-130E	Cam Ranh Bay	Vietnam	456-469
	Da Nang		470-477
	Tan Son Hnut		478-500
	Pang Kang		501-508
	Korat	Thailand	509-538
	Nakhon Phanom		539-548
	Ta Khil		549-552
	U Tapao		553-570
	Ubon		571-581
	Ubon		582-600
	C. C. Kang	Taiwan	601-635
	Clark	Philippines	636-693
	Anderson	Guam	694-728
	Kadena	Okinawa	729-786
	Naha		787-794
	Yokota	Japan	795-827
	Osan	Korea	828-835
C-130E	CONUS summary	CONUS	863-873

Selecting Aircraft Subsystems. Aircraft subsystems common to the four selected aircraft were used to stratify the data. These subsystems (see Table 3) accounted for the major portion of aircraft maintenance demands.

Table 3. Study Subsystems

Work Unit Code	Subsystem
11	Airframe
12	Interior Fittings
13	Landing Gear
14	Flight Controls
23	Propulsion
41	Environmental Controls
42	Electric Power
44	Lighting
45	Hydraulics
46	Fuel
47	Oxygen
49	Miscellaneous
51	Instruments
52	Autopilot
63	UHF Communication System
65	IFF System
71	Radio Navigation
73	Bomb Navigation System
74	Radar Navigation System

Additional criteria used to select subsystems were:

1. Equipment must still be in use today or be equipment that has been upgraded to today's needs or replaced by functionally equivalent equipment so that comparability analysis can be performed.

2. Equipment must be mature enough for data samples to be taken beyond the learning curve period, yet include a mix of both new and old equipment.

3. The equipment must have sufficient historical data available for valid analysis.

Maintenance data are recorded in the data base at the subsystem level. Combat and accident damage data are recorded against specific equipment items but are referenced to the appropriate subsystem so that statistical analyses may be performed at the subsystem level.

Maintenance Resource Impact Parameter Identification

Sources for Parameter Selection Identification of parameters associated with the wartime operational, support, threat, and natural environments relied heavily upon the literature search and review. Relevant studies and documents were screened for combat incident and damage repair parameters. Basic operational parameters and data such as flying hours, sorties, and landings were obtained through operational records. Climatic parameters and data were selected from the Air Weather Service "Weather Climatic Briefs" (AWSP 105-4, Ref 6). Geographic atlases and maps furnished geographic parameters and data. The AFISC furnished noncombat aircraft accident data.

Parameter Selection Process. The selection process was based on selecting only those parameters that met the following criteria:

1. Usefulness - the parameter must be sensitive to the maintenance resource demand requirements of the subsystem(s)/equipment(s) that are being studied; and

2. Availability - the information necessary for use of the parameter must be identifiable and available from a known source.

Considering the above selection criteria and using a previous study (e.g., Reference 2), individual parameters were selected within six major categories: operations, combat incident, combat damage repair, accidents, geographic, and climatic. Figure 3 portrays the data case record setup in computer input card image form.

Assemble SEA Combat Experience Source Data Base

Geographic A data base was assembled for the parameters selected for the aircraft/base combinations shown in Table 2. The study data base was further subdivided into three separate geographical data bases: Southeast Asia combat theater, the rest of the Far East, and CONUS. This breakdown helped ensure that sufficient data had been collected to achieve a statistically valid data sample. This sample was then used to derive average operations and

Each Of The 874 Data Cases In The Vietnam Era Has The Following 80 Space Card Images

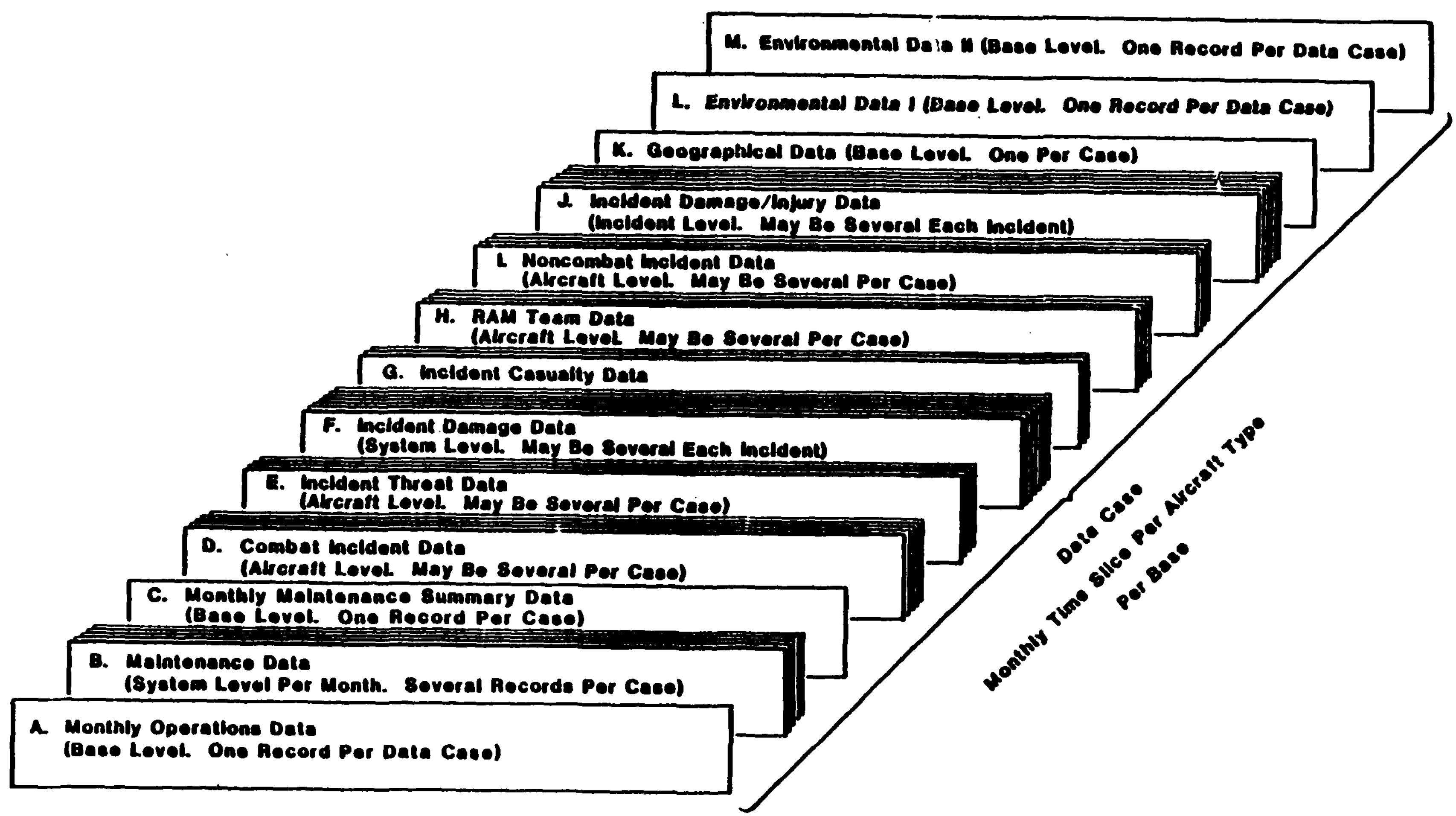

Figure 3. Data Base Record Layout.

maintenance comparability "multipliers." These multipliers were then used to update the combat data base to estimate values under present technological, operational and maintenance considerations. Data base theater codes allowed the data to be sorted into the three geographic regions.

Data Base Construction. Data base assembly consisted of three distinct efforts: identification of data sources, along with the quantity and quality of data contained in each source; data acquisition, including the physical acquisition, preprocessing (by computer or manually), and collation of the raw source data; and finally, processing and integration of the source data into the Combat Experience Source Data Base. The first two efforts have been previously discussed.

Final Data Processing. The third and final data base construction step was to prepare the acquired data and assemble them into a data base suitable for future analyses. The AFR 66-1 maintenance record tapes (DO56E) were screened for relevant data. During this task, the raw unsorted transactions recorded on the DO56E tapes were combined, computer-analyzed using Experience Analyses Center (EAC) analysis programs, and processed into integrated and ranked record files for each of the study aircraft for each of the comparative study areas (SEA, Western Pacific, CONUS). (See Figure 2.)

Data Discontinuities. During the process of screening the DO56E data tapes, the historical maintenance records for the four studied aircraft were found to be incomplete. That is, base maintenance records as recorded on the AFLC DO56E tapes from the Vietnam-era have either had large blocks of data fade away due to "tape aging" or were never recorded on tape in the first place.

Data Sufficiency. Appendix B contains a "Data Case Map" which indicates those years and months for which valid maintenance data were found for each study aircraft/base combination. It was determined that there was enough information to provide a good statistical sample of maintenance demands during the Vietnam war years (847 individual data cases). Data cases (specific aircraft-theater-country-base-month-year) were selected for inclusion in the data file based on availability of valid maintenance demands records which appear to reflect steady-state levels of base aircraft and activity. For example, the data case map for F-4C aircraft at Cam Ranh Bay Air Base indicated valid steady-state maintenance records from May through September of 1968. The validity of these records had been previously determined by the tape screening process; so, this string of data cases was included in the data base.

Identifier Codes. Each data case selected was given a unique identifier code which reflects the aircraft type, theater, country within theater, base within country, month, and year. The code is designed such that the data base can be computer-sorted by any or all of the six code elements or group of elements.

Table 4 presents the layout, key and explanation for the assigned case codes. Appendix B maps the selected data case sample on month/year matrices by aircraft type and base.

Table 4. Data Case Code Layout and Key

Aircraft	Theater	Country	Base	Month No.	Year No.
A - F-4C	A - SEA	A - VIETNAM	A - BIEN HOA	01 - JAN	19 - 66
			B - CAM RANH BAY	02 - FEB	68
B - RF-4C	B - Western Pacific		C - DA NANG	03 - MAR	71
			D - PHU CAT	04 - APR	72
C - A-7D	C - CONUS		E - PLEI KU	05 - MAY	73
			F - TAN SON HNUT	06 - JUN	74
D - C-130E			G - HHA TRANG	07 - JUL	75
			H - TUY HOA	08 - AUG	
E - F-4C			I - PANG KANG	09 - SEP	
update				10 - OCT	
		B - THAILAND	A - KORAT	11 - NOV	
F - RF-4C			B - NAKHON PHANOM	12 - DEC	
			C - TA KHIL		
			D - U TAPAO		
G - A-7D			E - UBON (XMPA)		
update			F - UBON (XMTG)		
		C - CONUS			
H - C-130E		D - TAIWAN	A - CC KANG		
update			B - TAIPEI		
		E - PHILIPPINES	A - CLARK		
			B - MACTAN		
		F - OKINAWA	A - KADENA		
		G - JAPAN	A - FUKUOKA		
			B - MISAWA		
			C - NAHA		
			D - TACHIKAWA		
			E - YOKOTA		
		H - KOREA	A - KUNSAN		
			B - KWANG JU		
			C - OSAN		
			D - TAEGU		
		I - GUAM	A - ANDERSON		

The combat maintenance and resource impact data gathered from the historical records and documentation were rationalized, integrated and assembled into files for each of the aircraft subsystems of the study according to the scheme discussed above. The files were then put on computer tapes. The assembled data files form the integrated SEA Combat Experience Source Data Base.

Normalize and Update the SEA Combat Data Base

Filling in the Blanks. Although many of the data cases in the SEA Combat Experience Source Data Base were incomplete in one or more operations parameters, these missing parameter values did not make the data case unusable for analysis. In order to make these cases more valuable, however, missing operations parameter values were estimated by "cross-case comparability analysis." When data were available in adjacent or similar data cases, several estimation techniques were used. These were:

1. Cross-Case Regression. When data were available over an appropriate range of data cases for the parameter in question, but with missing data within this range, a regression line was struck through the data using a suitably stable independent parameter such as time series. The missing data within the range were then estimated from the regression line. This technique worked well when the value string to which a missing parameter value was compared had sufficient range or scope. When comparative values were stable about some average value, however, the simple average worked better than the regression line as an estimating tool.

2. Cross-Case Averaging. When the values that a parameter takes were seen to fall around some average value dependent upon some other independent condition such as time of year or flying hours, missing data were assumed to approximate the average. This method worked well for cylical variations. (See Appendix D for a typical example of the methodology.)

3. Cross-Case Factor Comparison. When there was a good reason to expect the data for one parameter to vary in the same manner as the data for another related parameter (for instance sortie rate and landings), then a factor was calculated for the rate of variance and applied to the parameter of interest to estimate missing data cases.

Transformed Data. Portions of the SEA Combat Experience Source Data Base were normalized, updated, and entered into a generalized Baseline Combat Experience Data Base for modern TAC aircraft. All cases from the original data base which listed combat incidents, damage repair, or accidents were included. Processes and techniques discussed in Appendix E were applied to the SEA data base to transform its records into the basic analytic data for this study effort. These transformed cases are in the same file along with the original source data (as E, F, G, and H aircraft type records). Appendix C is a listing of the transformed data cases in the Baseline Combat Experience Data Base.

Resulting Transforms. Appendix F lists the derived factors to be applied to the operations and maintenance parameters for each of the four aircraft. Derivation of the factors was based on a combination of empirical and deductive approaches. For this reason, the factors should not be used for planning purposes. They only demonstrate the concept of applying such factors to actual data to build a normalized data base.

Conduct Causal Analysis of Tactical Air Command Operations/Maintenance Experience

Anomaly from Maintenance Metrics Study. During the course of analysis of the Phase III data base from a previous Maintenance Metrics study (Reference 2), a major anomaly became apparent in the correlations between fighter equipment Maintenance Action Demand (MAD) and usage variables such as Flying Hours per Year.

Initial Investigation. When the correlation tests of fighter equipment MAD against operational parameters were being screened, fighter equipment MAD was found to be negatively correlated with the usage variables Sortie Rate, Total Landings, and Flying Hours. Out of the 30 fighter equipment items tested, 22 indicated inverse correlations between MAD and these variables. The data were apparently indicating that the more the equipment was used, the less it failed. This seemed contrary to "common sense." A detailed cross-checking of the records, both the AFR 66-1 Maintenance Data Collection (MDC) System values for MAD and the AFR 65-110 Status and Utilization Reporting System, found the values for usage variables accurate and complete. The anomaly was obviously due to other causes. Investigation of this anomaly was assigned to the WARMIFS study.

On-Site Investigation of TAC Fighter Usage

Bases Visited. The study team visited a representative sample of TAC bases to gather information on the actual relationship between maintenance demand and aircraft usage, and on the underlying causes for the relationship. The following bases were visited based on their intensive combat training flight schedules:

1. Eglin Air Force Base, Florida (F-15A)
2. George Air Force Base, California (F-4E)
3. Hill Air Force Base, Utah (F-16A)
4. Luke Air Force Base, Arizona (F-15A)
5. Myrtle Beach Air Force Base, South Carolina (A-10A)
6. Nellis Air Force Base, Nevada (Various)

All of the bases except Nellis were covered in the previous Maintenance Metrics data base contracts in which the anomaly was first discovered. Nellis AFB served as a verification check for the information gathered at the other bases.

Type of Information Gathered. The type of information/data which were gathered included:

1. Operational flying hours and sorties scheduled versus sorties achieved
2. Typical operational schedule slack (if any)
3. Reasons for meeting/not meeting flying hour and sortie schedule
4. History of unusual flying loads (such as exercises) and unusual slack periods (such as severe weather)
5. History of unusual maintenance loads such as Time Compliance Technical Order (TCTO) retrofit periods, groundings, etc.
6. Typical maintenance scheduled versus maintenance achieved

Data Sources. This information/data were acquired through a combination of informal interviews with base personnel and examination of unclassified historical operations and maintenance documentation/records such as "Monthly Maintenance Summaries" and "Daedalian Reports."

Functional Areas Visited. At each base visited, the following functional areas were visited in order to obtain a complete picture of the base Operations and Maintenance (O&M) processes.

1. Deputy Chief of Operations (DCO)
2. Operations Scheduling
3. Deputy Chief of Maintenance (DCM)
4. Maintenance Control
5. Maintenance Analysis
6. Other Sources of information as suggested by the DCO and/or DCM

Data Analysis. The most revealing task in the causal analysis was the regression analysis of the field experience data. Using raw data only (non-transformed data), correlations were established between flight hours and maintenance manhours for each of seven subsystems. The first seven subsystems were arbitrarily selected. The results are shown in Figure 4. The following conclusions can be drawn:

1. The correlation coefficients are extremely low, indicating that maintenance performed on these subsystems during the month has very little to do with their flying hours during the month.

2. Low correlations for all seven subsystems suggest that coincidence can be ruled out.

3. The low correlations are negative, indicating that an increased number of flying hours during the month may result in a decreased amount of maintenance during the same month.

Hypothesis: Aggregation Problem. For such low correlations between flight hours and maintenance manhours, one possible explanation is that the cause and effect are separated from each other by the "narrow" time slice of data; i.e., 1 month per data case. If this hypothesis holds up, then it should be possible to get a better correlation (both in magnitude and sign) by aggregation of data by broader time slices, say 1 year in duration.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	-.03
12	INTERIOR FURNISHINGS	-.01
13	LANDING GEAR	.02
14	FLIGHT CONTROLS	-.01
23	PROPULSION	-.02
41	ENVIRONMENTAL CONTROLS	-.07
42	ELECTRICAL POWER	-.01

NOTE: Flying hours occurred in the same month as maintenance.

Figure 4. Correlation of Maintenance Manhours with Flying Hours.

Aggregation. Figure 5 shows the regression lines for the propulsion subsystem that resulted from aggregating the data by year, rather than by month. The correlation was weak; however, the aggregation shows that the anomaly that was observed is caused by narrow (monthly) time slices. This says that maintenance occurring in a given month is the result of wear-and-tear stresses (e.g., flight hours) that occurred in previous months.

H pothesis: Deferred Maintenance. If maintenance is deferred, it is deferred for a reason. The most likely reason is opportunity for maintenance. If the plane is "down" for one type of maintenance, it would be available for other types of maintenance, without compromising readiness further. If this hypothesis holds, then maintenance on one subsystem would correlate positively with maintenance on other subsystems, in the same month.

Mathematical Construct. In order to determine the correlation between maintenance actions on subsystems, a series of regression analyses were performed. The coefficient of determination (r^2) represents the linear association between the two variables. In this case, it represents the correlation between maintenance on two specific subsystems. The range of values on the coefficient of determination is $0 \le r^2 \le 1$, where "0" shows no linear relation between the two variables and "1" shows a perfect linear correlation between them. The square root of r^2 (where $r = \mp \sqrt{r^2}$) is called the coefficient of correlation.

Maintenance Correlation with Other Maintenance. Figures 6 through 12 show how maintenance for each of the subsystems selected above correlates with maintenance of the other subsystems.

Maintenance in one subsystem performed concurrently with maintenance in another subsystem, but separated in time from the normal stresses that cause the maintenance, falls into one of the following cases:

- Case 1: Maintenance that is deferred on a case-by-case basis
- Case 2: Correction of faults that were discovered during the maintenance but were undetected before that time
- Case 3: Maintenance requirements induced by other maintenance (maintenance "damage")

The first two cases are deferred maintenance, one by practice and the other by design and policy. Case 3, faults induced by maintenance, is unlikely in subsystems that are not collocated.

Conclusion. The great majority of maintenance is deferred, to be performed concurrently with other maintenance. Observations of inverse proportionality between wear-and-tear stresses and resulting maintenance are errors resulting from month-long time slices. Longer time slices show direct proportionality.

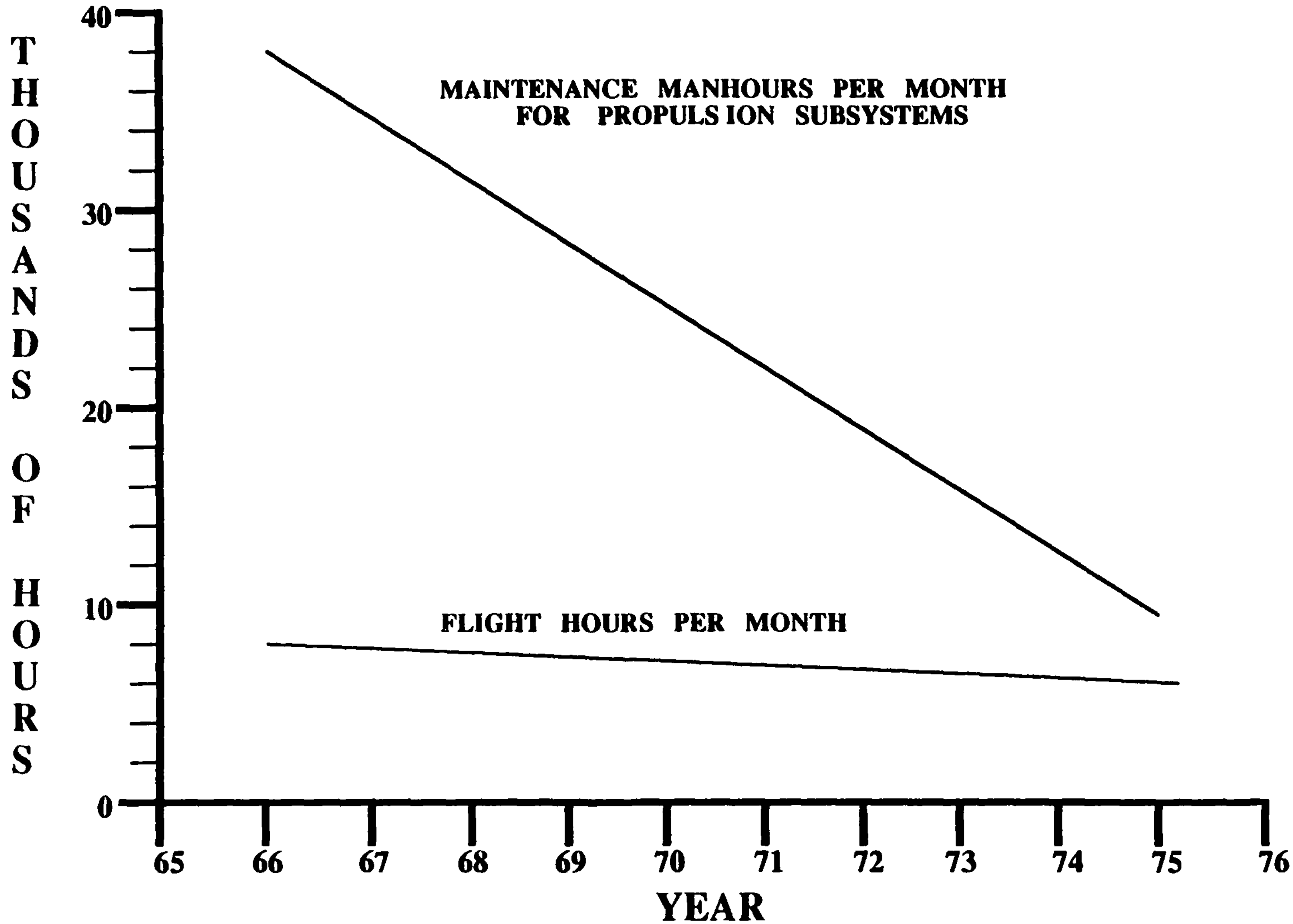

Figure 5. Data Aggregated by Year.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	- - -
12	INTERIOR FURNISHINGS	.65
13	LANDING GEAR	.82
14	FLIGHT CONTROLS	.60
23	PROPULSION	.23
41	ENVIRONMENTAL CONTROLS	.75
42	ELECTRICAL POWER	.52

Figure 6. Airframe Maintenance Manhours Correlation with Maintenance in Other Subsystems.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	.65
12	INTERIOR FURNISHINGS	- - -
13	LANDING GEAR	.82
14	FLIGHT CONTROLS	.64
23	PROPULSION	.14
41	ENVIRONMENTAL CONTROLS	.66
42	ELECTRICAL POWER	.42

Figure 7. Interior Furnishings Maintenance Manhours Correlation with Maintenance in Other Subsystems.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	.82
12	INTERIOR FURNISHINGS	.81
13	LANDING GEAR	- - -
14	FLIGHT CONTROLS	.69
23	PROPULSION	.23
41	ENVIRONMENTAL CONTROLS	.76
42	ELECTRICAL POWER	.45

Figure 8. Landing Gear Maintenance Manhours Correlation with Maintenance in Other Subsystems.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	.60
12	INTERIOR FURNISHINGS	.64
13	LANDING GEAR	.69
14	'LIGHT CONTROLS	- - -
23	PROPULSION	.22
41	ENVIRONMENTAL CONTROLS	.65
42	ELECTRICAL POWER	.46

Figure 9. Flight Controls Maintenance Manhours Correlation with Maintenance in Other Subsystems.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	.23
12	INTERIOR FURNISHINGS	.14
13	LANDING GEAR	.23
14	FLIGHT CONTROLS	.22
23	PROPULSION	- - -
41	ENVIRONMENTAL CONTROLS	.18
42	ELECTRICAL POWER	.34

Figure 10. Propulsion Maintenance Manhours Correlation with Maintenance in Other Subsystems.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	.75
12	INTERIOR FURNISHINGS	.66
13	LANDING GEAR	.76
14	FLIGHT CONTROLS	.65
23	PROPULSION	.18
41	ENVIRONMENTAL CONTROLS	- - -
42	ELECTRICAL POWER	.43

Figure 11. Environmental Controls Maintenance Manhours Correlation with Maintenance in Other Subsystems.

SUBSYSTEM WUC	SUBSYSTEM NAME	
11	AIRFRAME	.52
12	INTERIOR FURNISHINGS	.42
13	LANDING GEAR	.45
14	FLIGHT CONTROLS	.46
23	PROPULSION	.34
41	ENVIRONMENTAL CONTROLS	.43
42	ELECTRICAL POWER	- - -

Figure 12. Electrical Power Maintenance Manhours Correlation with Maintenance in Other Subsystems.

Wartime Maintenance Information and Forecasting System (WARMIFS)

The WARMIFS developed for this study is a demonstration interactive, user-friendly data base management and analysis system. In developing WARMIFS, maximum use was made of existing high-level software languages, routines, and utilities currently available and supported at the Area B Computer Center on WPAFB. The system is designed for a remote access, interactive user environment and a user-friendly data and analysis management system. The WARMIFS master management executive program is set up as a formal procedures file (PROC) within the operating environment. It controls the "Menu" program which is coded in FORTRAN 77 and consists of menu-driven data and analysis control programs, the Combat Experience Data Base, a status program, a Regression and Crossplot Parameter Analysis module, and a call program for the simulation utilities. Figure 13 provides an overview of the WARMIFS program packages as configured for the computing environment at WPAFB. Figure 14 depicts access to these packages using the WARMIFS menu sequence.

WARMIFS Parametric Analysis

Requirement. WARMIFS provides Air Force users the capability to run cross-correlations of the parametric data residing in the Combat Experience Data Base. The capability to detect nonrandom relationships among the parameters and to prioritize these relationships is also provided.

General Description. This capability is the initial package in the overall WARMIFS. The data base has been described in an earlier section. This section describes the parametric analysis capability.

To manage, edit, and interface the data base, the input and output files, and the analysis modules in a user-friendly environment, an interactive executive program was developed for WARMIFS. This executive, coded in FORTRAN 77, provides an easily used, menu-guided interactive environment for working with the Combat Experience Data Base, the parametric analysis module, the mathematical modeling/statistical module, and the simulation module. Status information can also be called with this program.

Design and Develop an Automated Parameter Analysis Package (Crossplot Package)

Approach. An automated package was designed and developed to analyze the data in the Automated Combat Data Base. The approach to the development of the Automated Parameter Analysis Package was to use the "PKING" data analysis program imbedded in an interactive, menu-driven operating system written in FORTRAN 77 language. It is designed to be user-friendly, with hierarchical menus that lead the user naturally through the analysis task. A discussion of the PKING program and its use appears below. Features which were added to the original mainframe computer batch version of the program are as follows:

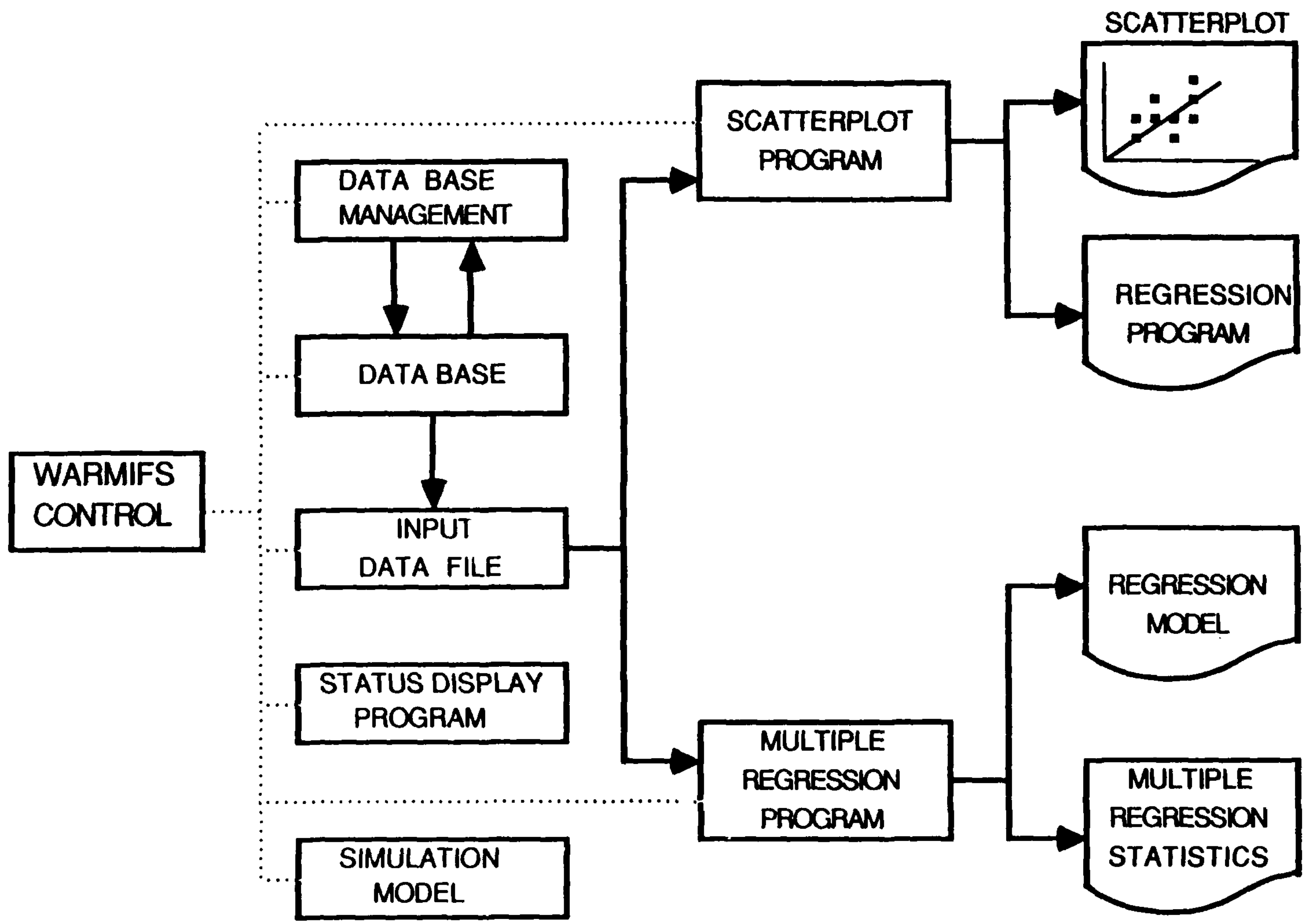

Figure 13. WARMIFS Overview.

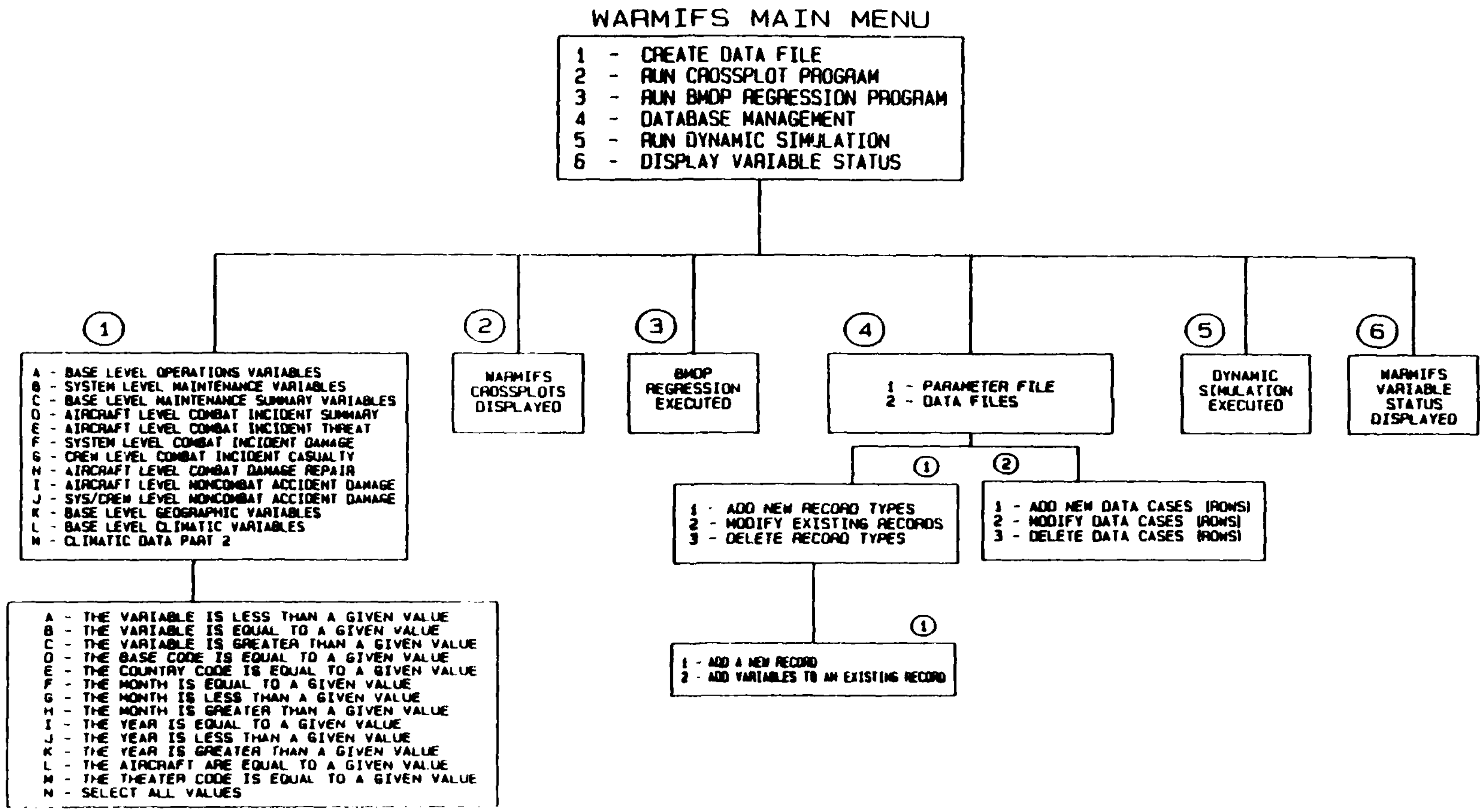

Figure 14. WARMIFS Menu Roadmap.

1. Expanded data point capability (as many as are required to accommodate the record entries in the Automated Combat Data Base)

2. Regression line identified on scatterplots

3. Capability to route scatterplots one-by-one onto a user's terminal screen as well as normal batch printout

4. Automatic testing and suppression of scatterplots with correlation coefficients below a threshold value set by the user

The "PKING" program, as used in the WARMIFS application, is a data manipulation program written in FORTRAN 77. The program can handle moderately large input data sets (8 variables, 1,000 data points variable in the WARMIFS version) such as are encountered in cost and support system analysis. Program input is flexible and straightforward in the form of data tables. Output is in the form of easy-to-read crossplots derived from the input variables.

Significant Characteristics. The significant characteristics of the "PKING" module as programmed for WARMIFS are as follows:

1. The program records and manipulates up to 8 variables.

2. As many as 1,000 entries can be made for each variable.

3. All 8 variables may be input variables.

4. A minimum of 2 variables may be input variables (to assure 1 dependent and 1 independent variable).

5. A total of 8 output variables may be specified.

6. The output of the program consists of scattergrams which plot specified combinations of input variables.

7. The plots may be constrained somewhat by specifying that certain input variables be used only as "independent" variables.

8. All variables are treated in turn as independent variables and dependent variables against all other variables except themselves. Maximum output per run is 56 scatterplots per input data set.

9. The form of the output scattergrams has been carefully designed to permit rapid visual scanning for two variable correlations.

10. Input data are stored in a single 8- by 1,000-cell addressable matrix.

11. A simple least square regression routine is used to compute the regression statistics of each crossplot.

12. The module contains a subroutine that will suppress crossplots with correlation coefficients below a user-specified threshold.

Screening and Filling Gaps The program can be used to quickly screen large numbers of variables for possible primary correlations and to identify subtle higher-order correlations by visual inspection of the data point relationships on the crossplots of likely combinations of variables. The program is also useful in filling holes in data sets when there is reason to believe that the missing data are continuous with the data in hand. In this use, the program is run with the missing data variable input, along with several related variables which are complete. If the missing data variable is correlated with any of the other complete variables, this can be seen from the output plots and a linking function derived and used to compute the expected values of the missing data points.

Economical to Use. The basic simplicity of the program makes it economical to use. Data input encoding is simple and need be done only once for any given data set. A typical data run with an output of several hundred crossplots may be made at a very small cost.

Perform Analyses of the Baseline Combat Data Base (Using Crossplot Package).

The Automated Parameter Analysis Package was applied to the Baseline Combat Data Base to detect, screen, test, define, and prioritize causal relationships and resource interactions among the identified operations, combat, accident, geographic, and climatic parameters and the maintenance rate and resource demand parameters. Aircraft avionics and engine resource demands were investigated.

Analysis Process The steps involved in the analysis process are as follows:

1. Create Input File. Input the appropriate data files contained in the Automated Baseline Combat Data Base to the input file creation subroutine imbedded in the Automated Parameter Analysis Package.

2. Execute Crossplots. The "PKING" program is then called to execute the data files one at a time with up to 8 input variables (data base parameters per file). The program generates and stores crossplots of every variable against every other variable, first as the dependent (Y) variable and then as the independent (X) variable. When the total data base has been run with all combinations, the crossplots are ready to be screened for nonrandom relationships.

3. Screen Out Low Correlations. Input the crossplot statistics (e.g., correlation coefficient, r) into the screening subroutine with a controllable "accept-reject" threshold. This routine will automatically reject crossplots with statistics which indicate basically random relationships between the plotted variables. The parameters involved in the crossplots of high-priority rank can be considered as good candidates for inclusion and testing in the

multivariate mathematical modeling system. The regression equation generated with each crossplot (printed on the scattergram of the crossplot) can be used as a predictive mathematical model in its own right for relationships with high linearity and high correlation coefficients.

4. Visual Screening. As a backup to the automatic screening routine, a visual check and screening of the crossplots can be made. This can be done by printing each crossplot either to hard copy scattergram or to the terminal display screen (hard copy in this instance to provide a permanent record). A visual check of the "PKING" output scattergrams should always be done. This check will pick up any strong but nonlinear relationships that will be missed by the linearity checks in the automatic screening routine. Regression equations and statistics can be computed for nonlinear relationships by applying a suitable nonlinear-to-linear data fitting transform to the input variable and rerunning the data involved.

5. List of Prioritized Parameters. The final step in this analysis process is to generate a list of prioritized parameters from the Automated Combat Data Base which is included and tested in the automated mathematical modeling system that will be discussed in a later section.

Wartime Maintenance Demand Forecasting Model

The following sections discuss the approach to the initial employment of the developed modeling system on the Baseline Combat Data Base to generate predictive expressions for avionics and engine subsystems.

Design and Develop an Automated, Interactive Combinatorial Mathematical Modeling System

Regression Package. A mathematical modeling system was designed with the capability to use the data base and the analysis package to "fit" the best combination of causal parameters to the data and create a predictive equation model for dependent parameters. The developed modeling system is compatible and interactive with the automated data base. The approach was to use a proven statistical analysis and combinatorial modeling package, Bio Medical Data Processing (BMDP), in conjunction with the interactive, menu-driven operating system programmed in FORTRAN 77. When the BMDP Regression is called, the interactive operating system transfers to the BMDP library in the mainframe computer system environment. The stepwise multiple regression analysis routine available in BMDP is then used to operate on input files generated from the combat data base. Several different methods are available in BMDP for generating mathematical models. The WARMIFS method for generating the required model involves a stepwise, multiple regression routine (BMDP2R). With this routine, parameters are included or rejected in the model equation until model test statistics are peaked and consequently provide the best "fit" to the data.

"Hardwired" to BMDP2R. Although BMDP is a multicapability statistical analysis package, WARMIFS calls only one of these subprograms: specifically, BMDP2R, the multiple regression subprogram. BMDP2R was chosen because of its versatility and power as a statistical subroutine.

Generate Initial Wartime Prediction Models for Avionics and Engine Subsystems

Checkout. As a checkout of the developed Interactive Combinatorial Mathematical Modeling System, and to provide an initial capability to statistically predict wartime maintenance demands, the system was employed to generate initial wartime maintenance rate, resource demand, and resources interaction prediction models for avionics and engine subsystems.

Analysis Steps. Using the stepwise multiple regression modeling approach, the steps in the analysis were as follows:

1. Input File. Generate the appropriate data files on avionics subsystems and engines from the Baseline Combat Data Base (user function).

2. Select Regression. Call the BMDP Library and accomplish the stepwise multiple regression routine (WARMIFS function).

3. Select Dependent and Independent Variables. Input the appropriate dependent and independent variable data file (e.g., maintenance demand rate, operations, threat, and environmental parameter data).

4. Execute. Execute the stepwise multiple regression to operate on the input data variables. The program will test all of the independent variables and will enter the one step which best explains the variation of the dependent variable. The program will then print out the test statistics for the fit and nonrandomness of the regression equation and will then test and enter the next best variable. This process will be repeated for each of the other independent variables in order of their strengths of correlation. The program routine, BMDP2R, "peaks" the statistics of the model and keeps only those independent (explanatory) variables which together provide the equation best fitted to the data (BMDP2R function).

5. Repeat. Repeat the above process until a predictive model equation has been generated for each of the avionic and engine subsystems analyzed for each of the dependent demand parameters (combined function).

Results. The results, findings, and conclusions of the initial wartime maintenance demand forecasting model development were transmitted to AFHRL under separate cover.

Dynamic Interaction Analysis

Simulation Capability. A sample dynamic simulation analysis package was designed for inclusion in WARMIFS. This very simple model was used to demonstrate that a Simulation Language for Alternative Modeling (SLAM) model, developed by the user, could be incorporated easily into the WARMIFS structure. The model considered the interactive effects of wartime maintenance rates and resource demands on tactical unit readiness time profiles. The converse effects of wartime operational requirements, threat constraints, and operating environment constraints on maintenance rates and resource demand time profiles were also considered.

The dimensions considered in the model were:

1. Input variables (data).

2. Output variables (answers sought).

3. Situation represented (base, missions, etc.).

The resulting model should not be used in simulations having any other purposes than the above.

Building the Modeling Capability. The process of designing and developing this modeling capability was as follows:

1. Management System. A simulation management system was programmed in FORTRAN 77. The structure of this management system allows the user to select the simulation mode, call up the system model module, launch the simulation run, and after execution, call up the output reports either to terminal screen or remote printer.

2. Build SLAM Model. FORTRAN-based SLAM was used to model the structure of a selected wartime tactical fighter unit. Instructions for building SLAM models are found in Reference 7.

3. Build Input Data/Statement File. The input data/statement file and initial conditions subroutine (INTLC) were programmed per the requirements of the SLAM language. Dynamic simulations require certain input data such as system operating point constants, table values, initial values for system rates, and initial values for system state variables.

4. Execute. The simulation then runs the time interactions within the system rates and states, and produces reports and time profiles of the specified rate-and-state variables. From these reports the analyst can track the interactions of the various system variables.

Debug Model After the model was programmed and set up, it was experimentally exercised to debug the programming. Figure 15 portrays typical output variable time profiles to be expected from simulation runs.

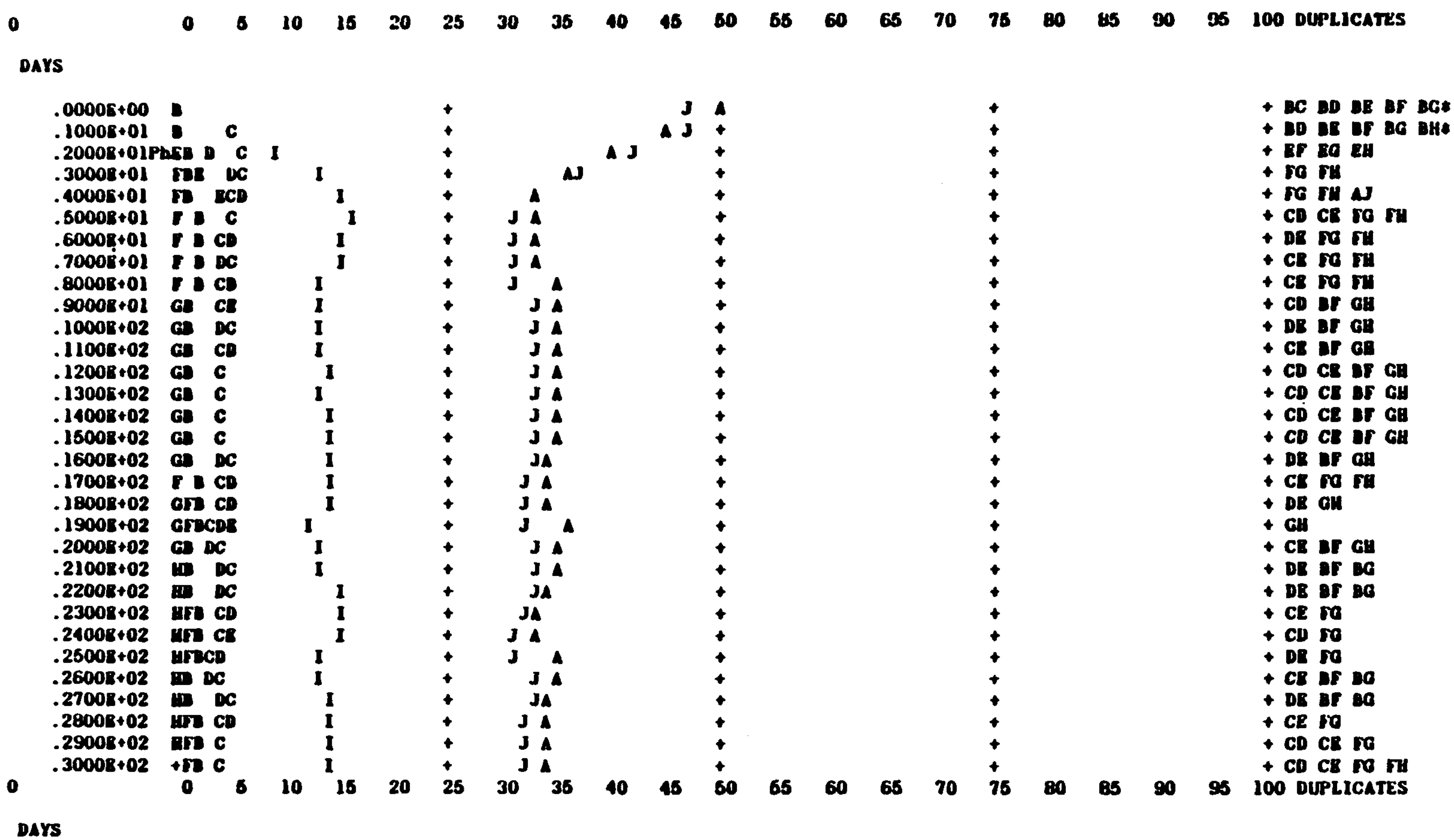

Figure 15. Typical Output from SLAM WARBASE Module.

III. CONCLUSIONS AND RECOMMENDATIONS

Eight specific objectives were set for the present research and development (R&D) effort:

1. Assemble a historical SEA combat data base for tactical aircraft.

2. Update portions of this data base to project near-term wartime conditions.

3. Determine causes and effects underlying tactical aircraft O&M experiences.

4. Automate the combat data base to facilitate computer analysis.

5. Develop an automated analysis package for detecting correlations among causative and dependent resource demand parameters from the data base.

6. Develop an automated multivariate mathematical modeling system for "fitting" resource demand forecasting models to the data base.

7. Develop a computerized dynamic simulation analysis system to explore the concept of a data-base-driven simulation.

8. Integrate the data base and the analysis packages into a compatible, interactive information and forecasting system.

The Wartime Logistics Demand Rate Forecasting study effort has accomplished all of the eight specific objectives to varying degrees. Conclusions and recommendations concerning each of the objectives are discussed in the following subsections.

Combat Data Base

Conclusions. A large, coherent tactical airpower data base was assembled. The data base contains monthly time slices of maintenance-related parameters from the SEA conflict era. It thus forms an information source for the analysis of the tactical air war. Over 800 data cases of aircraft/bases/months were assembled from SEA, Western Pacific, and CONUS sources for the 1966 to 1975 timeframe. These data form an adequate baseline information source for first-approximation forecasts of the wartime logistics resource needs of tactical airpower.

Recommendations. In order to enhance this data base for future R&D and forecasts, it is recommended that the data base be expanded by adding Strategic Air Command (SAC) and Military Airlift Command (MAC) experience data for 1966 to 1975. These data could include the B-52 combat experience, along with "normal" CONUS B-52 experience for comparison. C-141 and C-5A airlift experience, both in and out of the combat theater, could be included. United States Air Forces in Europe (USAFE) data from this era would also enhance the data base and make it useful for a broad range of operations, maintenance, and logistics research.

The Updated Combat Data Base

Conclusions. The combat data cases in the SEA Combat Experience Source Data Base were hypothetically updated to approximate present-day conditions and technology. Over 170 data cases were updated in this manner to form the Baseline Combat Experience Data Base. This data base was used to generate baseline forecasting models for maintenance: removals, failures, maintenance manhours, troubleshooting manhours, and abort rates by aircraft system. These models form first-approximation tools for forecasting present-day wartime logistics demand rates. The weakest point in this transformed data base is the set of transforms for updating the data to present conditions.

Recommendations. In order to enhance the utility of this updated data base, it is recommended that additional recent and present-day data be added. It is recommended that the operations, maintenance, combat incident (simulated and/or real), accident, and corresponding environmental data be added from recent and ongoing simulated combat exercises by Pacific Air Forces (PACAF), USAFE, TAC, and NATO. Also, if possible, actual combat data and corresponding operations, maintenance, and environmental data from recent allied forces experiences should be added.

A more conservative, and perhaps more "controllable" approach to forecasting wartime maintenance loads is to use raw data; i.e., non-transformed, non-normalized data. By making adjustments to the outputs, not the raw data, it would be clear and evident to all what is being done or what bias is being introduced.

Transformation factors were developed during this study. In retrospect, these factors (for adjusting various data to present-day wartime conditions) were appropriate to the scope of this study. However, they are not good enough to produce better data than the raw data. If transforming raw data is to be pursued by AFHRL, we strongly recommend that the building of these transforms be a concerted, focused, undiluted effort.

O&M Causal Analysis

Conclusions. The classical wear-and-tear variables (flight hours, landings, and sorties) should correlate closely with maintenance demands, and maintenance demands should be directly proportional to wear-and-tear. Intuitively, this should be the case. However, earlier investigations indicated weak correlations and inverse proportionality for some subsystems. This observation, cursory as it was, threatened to undermine some long-standing algorithms used in life-cycle costing, repair level analyses, and other resource planning. Investigation of this apparent anomaly was made a part of the WARMIFS study.

There is ample evidence that the anomaly is due to deferred maintenance. Most maintenance is deferred to coincide with other maintenance downtime. The wear-and-tear stresses occur in a given month, but most of the maintenance is actually performed in a subsequent month. Maintenance demands are (as is reasonable) generated by flight hours, landings, and sorties. Planners must be aware, however, that emplacement of maintenance resources must consider that most of the resulting maintenance may not be done when and where the demands are created.

Recommendation. Cause and effect become separated in a data base that is made up of time slices of 1 month's duration. A coarser aggregation of time collateral data would probably preserve more of the coupling between cause and effect. Future efforts at data collection of this type might benefit from knowledge of this phenomenon. Aside from coarser aggregation of time slices, a type of lead time analysis algorithm might be worth investigating for operation on data with known separations of causes and effects.

Data Base Automation

Conclusion. The SEA Combat Experience Source Data Base and the Baseline Combat Experience Data Base were input as a single "flat" file. That is, all records of all data cases for both data bases are simply listed serially within the file and each record of each case is controlled by an individual data case code. This arrangement best accomplished the objective of data base automation which facilitates analysis by WARMIFS. With the complex case code, record type, and sequence identifiers, WARMIFS can access any element of the data base by aircraft type, theater of operation, basing country, specific base, month, year, parameter category, specific record and/or specific parameter. This allows a wide range of "record sorts" and facilitates computer analysis of many different aspects and characteristics of the data base. The programs handling the automated data base and WARMIFS data base also allow the analyst to use as many or as few of the data base data cases as desired for a particular analytical procedure. The data base file has a layout which is easily edited. This can be done by adding, modifying, or deleting cases, records, parameters, or parameter values.

Recommendation. Accessing the data file requires the same menu selections for all users, from novices to experts. A facility to make selections without viewing all menus should be provided for the more experienced user.

Automated Parameter Analysis Package

Conclusion. The Crossplot module programmed into the interactive WARMIFS "MENU" program satisfies the parameter analysis objective. This module with its menu-driven input, analysis processing, and output is easy for analysts to use. Input files may be created from any or all of the parameters in the data base utilizing any or all of the 1,000-plus data cases. The output scatterplots and annotated statistics are clear and easy to interpret. The crossplot analysis program runs quickly on large data sets so that an analyst can accomplish a moderate amount of two-variable analysis at one terminal session.

Recommendation. The most significant limitation of the crossplot module is the limit of eight variables per input files. It is recommended that the memory matrix defined for the input data file creation routine be expanded so that the crossplot program can process at least 25 variables simultaneously.

Mathematical Modeling Package

Conclusion. This objective was accomplished by programming WARMIFS to interface with the powerful "BMDP" statistical analysis library already supported on the CDC interactive network. Subroutines have been programmed by which the user can extract selected data from the main data base for input to BMDP. The BMDP input file is automatically constructed and passed to the BMDP utility. The output file from the mathematical modeling process is passed back to WARMIFS and stored in a reserved WARMIFS file while a short form output report is transmitted to the screen for immediate viewing by the user.

Recommendation. The limitation here is the same as that for the crossplot module; i.e., the input file is limited to 8 variables. It should be expanded to 25 variables.

Dynamic Simulation Package

Conclusion. A simulation capability was included in WARMIFS to explore the concept of a model driven by a large experience data base. The findings are:

1. SLAM is not a workable simulation language for this type of application.

2. Continuous (rate, flow) models are not sensitive enough to reflect the type of changes being examined.

3. The input variables, output variables, and situations represented are not bounded (stable) enough to permit a predetermined interface to exist between the data base and the model. Dynamic interaction models offer more problems in this regard than do steady-state, deterministic mathematical models.

4. The model provided here should not be used in simulations having any purpose other than exploring modeling concepts.

Recommendations. Dynamic interaction models (where time is advanced to cause things to happen in the model) are the most difficult models to feed (i.e., input data). Such models can be driven by a data base; however, the data base must be developed specifically for that purpose. Otherwise, the model and the data base are likely to be incompatible. For dynamic, discrete, stochastic simulation, the General Purpose Simulation System (GPSS) is recommended.

Integrated Information and Forecasting System

Conclusion. The WARMIFS interactive program is completely menu-driven so that the user will have little trouble in conducting analyses. The user is introduced to the system through a top menu which lists all of the modules available. Each analysis module has a submenu or menus which guide the user through the various steps of the analysis. As each procedure progresses, instructions are printed on-screen at each user decision point. The user-friendly nature of WARMIFS should make it a popular tool.

Recommendation. It is recommended that, as changes are made to WARMIFS, its current configuration and format be retained. One possible improvement would be to allow the more experienced user greater flexibility in moving through the menus.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ADP	Automated Data Processing
AFB	Air Force Base
AFHRL	Air Force Human Resources Laboratory
AFHRL/LRL	Logistics Systems Branch, Logistics and Human Factors Division, Air Force Human Resources Laboratory
AFR	Air Force Regulation
AFR 66-1	Air Force Regulation for Aircraft Maintenance Data Collection System
ALR	Aircraft Loss Replacement
ARR	Aircraft Restoration Rate
ASD	Aeronautical Systems Division
BDL	Battle Damage Repair Delay Level
BDR	Battle Damage Repair
BMDP	BioMedical Data Processing - A Statistical Program Utility
BMDP2R	BMDP Stepwise Multiple Regression Routine
BMDPL1B	A WARMIFS File Name
BMDPRPT	A WARMIFS File Name Containing Regression Analysis Results
BMPDAY	The Dayfile Produced When Running the BMDP Procedure
CDC	Control Data Corporation
CDRL	Contract Data Requirements List
CFS	Central File System
CIRS	Combat Information Retrieval System
CONUS	Continental United States
CROSSP	Crossplot. A WARMIFS File Name
DATABASI	The WARMIFS Database
DRL	Delayed Repair Level
DRR	Delayed Repair Rate
DRT	Damage Repair Time
EAC	Experience Analysis Center
EQLIST	A WARMIFS File Name Containing the Last Generated Model Equation
EVR	Evacuation Rate
FAF	Flight Activity Fraction
FAR	Flight Activity Rate
FMCA	Fully Mission Capable Aircraft
FMCR	Fully Mission Capable Rate
FORTRAN 77	A General Purpose Computer Language
FRES	Flight Reserve Aircraft
FSE	Full Screen Editor
G.P. Language	General Purpose Language
GAA	Ground Attack Attrition
GAM	Ground Attack Multiplier
GPSS	General Purpose Systems Simulator. A High Level Simulation Language
GTABL(FAT)	Get Table Function (Flight Activity Table)
HELPW	A WARMIFS File Name Containing the Text of the HELP Information

GLOSSARY OF ACRONYMS AND ABBREVIATIONS (CONT'D)

IAM	Inflight Attrition Multiplier
IAR	Inflight Attrition RAte
IAS	Indicated Airspeed
IBM	International Business Machines
INTLC	The Subroutine in Which the Input Data Statements in Warbase File are Contained
JCL	Job Control Language
LIB	Library
LRF	Loss Replacement Fraction Multiplier
LRL	Logistics Systems Branch, Logistics and Human Factors Division, AFHRL
MAD	Maintenance Action Demand
MAX	Maximum
MDX Channel	A Networking System to Connect the NAS and CDC Computing Systems at ASD Computer Center
MENU	The Object Code from WARM
MIMIC	A High Level Simulation Language
MIN	Minimum
N/Y	No/Yes
NAS	Major IBM Compatible Computing System at ASD Computer Center, WPAFB
NMCA	Not Mission Capable Aircraft
NMCR	Not Mission Capable Rate
NOS	Network Operating System
O&M	Operations and Maintenance
PACAF	Pacific Air Forces
PARAMI	A WARMIFS File Name Containing the Information on the Database Structure
PC	Personal Computer
PDATA2	WARMIFS File Name
PFAA	Post Flight Activity Aircraft
PKING	A Fortran Analysis Program Developed by Boeing
PROC	Procedure
RDT	Repair Delay Time
REPORT	A WARMIFS File Name Containing the Output from the SLAM Model
RFP	Request for Proposal
RJE	Remote Job Entry
RNORM	Random Draw From Normal Distribution
SAC	Strategic Air Command
SAS	Statistical Analysis Software Package
SAINT	A High Level Simulation Model Language
SEA	Southeast Asia
SEVNT	SLAM Subroutine
SIML	Simulation
SIMSCRIPT	A Computer Simulation Language
SLAM	Simulation Language for Alternative Modeling
SLAM II	High Level Simulation Language
SLAMINI	A WARMIFS File Name

GLOSSARY OF ACRONYMS AND ABBREVIATIONS (CONCLUDED)

SOW	Statement of Work
STAT.PKG.	Statistical Package
STATE	WARBASE Subroutine
STINFO	Scientific and Technical Information
SYSTEM 2000	A High Level Management-Oriented Computer Language
TAC	Tactical Air Command
TCTO	Time Compliance Technical Order
TSAR	Theater Simulation of Airbase Resources (A High Level Logistics Simulation Model)
TTY	Teletypewriter
USAF	United States Air Force
USAFE	United States Air Forces in Europe
USERCON	The Control File for the BMDP Procedure
USERDAT	The Output File From the Crossplot Screening Program
UT	Utilities
VAR	Variable
WARBASE	The Program Used to Generate the SLAM Model
WARM	The Source Code for the Data Selection, Crossplot, Screening, and Model Equation Programs
WARMIFS	Wartime Maintenance Information and Forecasting System
WBMDP	The BMDP Procedure
WMIFS	Same as WARMIFS
WPAFB	Wright-Patterson Air Force Base
WPRODAY	The Day File for the Procedure WARMIFS
WSLAM	The Procedure Which Calls SLAM
WUC	Work Unit Code
Y/N	Yes/No
YR-MO-DA	Year-Month-Day

APPENDIX A: DETAILED RECORD FIELD LAYOUTS AND SAMPLE DATA CASE

RECORD TYPE A: MONTHLY OPERATIONS DATA (BASE LEVEL, ONE RECORD PER DATA CASE)

CASE CODE[1]	BLANK	RECORD TYPE	RECORD SEQ. NO.	ACFT. TYPE	001 002 TIME PERIOD (M M Y Y)	003 FLIGHT HOURS	004 LANDINGS	005 SORTIES	006 NO. OF A/C			007 AVG SORTIE LENGTH		008 COMBAT INCIDENTS		009 CLASS-A&B ACCIDENTS		CASE SEQ NO.
	X	A	0 1		X001 X002	X003	X004	X005	X006		X	X007	X	X008	X	X009		

RECORD TYPE B: MAINTENANCE DATA (SYSTEM LEVEL PER MO. SEVERAL RECORDS/CASE)

CASE CODE[1]	BLANK	RECORD TYPE	RECORD SEQ. NO.	ACFT SYSTEM WUC	WORK UNIT CODE NOMENCLATURE	010 REMOVALS	011 FAILURES	012 MAINT. MANHOURS	013 TROUBLE SHOOTING MANHOURS	014 ABORTS	
	X	B				YM01	YM02	YM03	YM04	YM05	

RECORD TYPE C: MONTHLY MAINTENANCE DATA (BASE LEVEL, ONE RECORD PER CASE)

CASE CODE[1]	BLANK	RECORD TYPE	RECORD SEQ. NO.	ACFT SUMMARY WUC		015 REMOVALS	016 FAILURES	017 MAINT. MANHOURS	018 TROUBLE SHOOTING MANHOURS	019 ABORTS	
	X	C	0 1	9 9	T O T A L	YM06	YM07	YM08	YM09	YM10	

NOTE: ALL MAINTENANCE VALUES PER 1000 FLIGHT HOURS AND IN HUNDREDTHS.

RECORD TYPE D: COMBAT INCIDENT (ACFT LEVEL, MAY BE SEVERAL PER CASE CODE)

CASE CODE	BLANK	RECORD TYPE	RECORD SEQ. NO.		ACFT SERIAL NUMBER		PRI UNIT	SEC UNIT		020 MISSION COUNTRY	021 KNOTS TAS		022 ALTITUDE FEET	023 SPECIFIC IMPACT CODE		024 MISSION STAGE CODE		025 TARGET TYPE CODE		026 OPS IMPACT CODE	027 NUMERICAL DATE Y Y M M D D		028 MILITARY TIME	029 ULTIMATE DISPOSITION CODE	030 REPAIR HH
	X	D		X		X			X	XC01	XC02	X	XC03	XC04	X	XC05	X	XC06	X	XC07	XC08	X	XC09	XC10	XC11

RECORD TYPE E: INCIDENT THREAT (ACFT LEVEL, MAY BE SEVERAL PER CASE CODE)

CASE CODE	BLANK	RECORD TYPE	RECORD SEQ. NO.	INCIDENT RECORD SEQ. NO.		031 FIRE LEVEL NUMERIC CODE	BLANK	032 DIRECT HITS		033 INDIRECT HITS		034 FRAGMENT HITS		THREAT CLASS DESCRIPTOR	035 NUMERIC CODE		THREAT TYPE DESCRIPTOR	036 NUMERIC CODE		FUSE TYPE DESCRIPTOR	037 NUMERIC CODE		ROUND TYPE DESCRIPTOR	038 NUMERIC CODE		039 AZIMUTH EST. DEGREES		ELEVATION DESCRIPTOR		040 NUMERIC CODE		RANGE DESCRIPTOR		041 ESTIMATED NUMERIC RANGE
	X	E		D	X	XC12	X	XC13	X	XC14	X	XC15	X		XC16	X		XC17	X		XC18	X		XC19	X	XC20	X		X	XC21	X		X	XC22

RECORD TYPE F: INCIDENT DAMAGE (SYSTEM LEVEL, MAY BE SEVERAL PER INCIDENT)

CASE CODE	BLANK	RECORD TYPE	RECORD SEQ. NO.	INCIDENT RECORD SEQ. NO.	042 SYSTEM WUC		WORK UNIT CODE NUMENCLATURE		HIT LOCATION	043 NUMERIC CODE		THREAT EFFECT	044 NUMERIC SEVERITY CD.		DAMAGE BRIEF	045 DAMAGE CODE
	X	F		D	XC23	X		X		XC24	X		XC25	X		XC26

RECORD TYPE G: INCIDENT CASUALTY (CREW LEVEL, MAY BE SEVERAL PER INCIDENT)

CASE CODE	BLANK	RECORD TYPE	RECORD SEQ. NO.	INCIDENT RECORD SEQ. NO.		046 NUMBER CASUALTIES		CREW FUNCT.	047 NUMERIC CODE		STATUS	048 NUMERIC CODE		SEVERITY	049 NUMERIC CODE		CAUSE	050 NUMERIC CODE		WOUND LOCATION	051 NUMERIC CODE		PROT. DEV.	052 NUMERIC CODE		FINAL DISPOSITION	053 NUMERIC CODE
	X	G		D	X	XC27	X		XC28	X		XC29	X		XC30	X		XC31	X		XC32	X		XC33	X		XC34

RECORD TYPE H: RAM TEAM DATA (ACFT LEVEL, MAY BE SEVERAL PER CASE CODE)

CASE CODE¹	BLANK	RECORD TYPE	RECORD SEQ. NO.		RAM ID		TAIL NUMBER		DAMAGE DATE (MMDDYY)		RAM DATE (MMDDYY)		WORK START (MMDDYY)		ACTUAL WORK COMPL. (MMDDYY)		054 ACTUAL HOURS		055 REPAIR STATUS		056 DAMAGE CAUSE
	X	H		X		X		X		X		X		X		X	XR01	X	XR02	X	XR03

RECORD TYPE I: NONCOMBAT INCIDENT (ACFT LEVEL, MAYBE SEVERAL PER CASE CODE)

CASE CODE¹	BLANK	RECORD TYPE	RECORD SEQ. NO.	COMMAND		ACCIDENT CLASS	057 NUMERIC CODE		058 PHASE OF OPERN NUMERIC CODES (1)	059 (2)		060 ACCIDENT TYPE NUMERIC CODES (1)	061 (2)		062 CONDITIONS AFFECTING ACCIDENT ALPH NUM CODES (1)	063 (2)		064 BASIC CAUSES NUMERIC CODES (1)	065 (2)		066 ACCIDENT IDENTIFYING DESCRIPTORS	067 ACCIDENT ID CODE
	X	I			X			X	XA 02	XA 03	X	XA 04	XA 05	X	XA 06	XA 07	X	XA 08	XA 09	X	XA10	XA11

RECORD TYPE J: INCIDENT DAMAGE/INJURY (MAY BE SEVERAL PER ACCIDENT/INCIDENT)

CASE CODE¹	BLANK	RECORD TYPE	RECORD SEQ. NO.	I-RECORD SEQUENCE NUMBER	068 DAMAGE CLASS	069 SYSTEM WUC		DAMAGE LOCATION	070 NUMERIC CODE		071 DAMAGE BRIEF	072 NUMBER OF INJURIES	073 INJURY CLASS	NUMERIC CODE	CREW FUNCTION	074 NUMERIC CODE	INJURY SEVERITY	075 NUMERIC CODE
	X	J		I	XA 12	XA 13	X		XA 14	X	XA15	XA 16	XA17			XA 18		XA 19

RECORD TYPE K: GEOGRAPHIC DATA (BASE LEVEL, ONE RECORD PER DATA CASE)

Field	Heading	Entry
	CASE CODE[1]	
	BLANK	X
	RECORD TYPE	K
	RECORD SEQ. NO.	0 1
076	BASE ALTITUDE	XG01
		X
077	LATITUDE (0-180° S-N)	XG02
		X
078	LONGITUDE (0-360° E)	XG03
	TERRAIN TYPE DESCRIPTOR	
079	NUMERIC CODE	XG 04
	SOIL TYPE DESCRIPTOR	
080	NUMERIC CODE	XG 05
	VEGITATION TYPE DESCRIPTOR	
081	NUMERIC CODE	XG 06
082	PROXIMITY TO SALT WATER	XG07
083	PROXIMITY TO FRESH WATER	XG08
084	NEAREST TOWN	XG09
085	NEAREST CITY	XG10
086	DISTANCE TO COMBAT ZONE	XG11

RECORD TYPE L: CLIMATIC DATA (BASE LEVEL, ONE RECORD PER DATA CASE)

Field	Heading	Entry
	CASE CODE[1]	
	BLANK	X
	RECORD TYPE	L
	RECORD SEQ. NO.	0 1
087	MAX. TEMP RECORDED FOR MONTH	XE01
088	MEAN DAILY MAX. TEMP	XE02
089	MEAN DAILY MIN. TEMP	XE03
090	MIN. TEMP RECORDED FOR MONTH	XE04
091	MONTHLY MEAN TEMP	XE05
092	DAYS PER MONTH MAX. TEMP ≥90°F	XE06
093	DAYS PER MONTH MAX. TEMP ≥80°F	XE07
094	DAYS PER MONTH MIN. TEMP ≤32°F	XE08
095	DAYS PER MONTH MIN. TEMP ≤0°F	XE09
096	MEAN CLOUD COVER (TENTHS)	XE 10
097	FOG EVENT DAYS (VISIBILTY <7 MILES)	XE11
098	% FREQ CEILING <5000 FT VISIBILITY <3 MI	XE12
099	% FREQ CEILING <1500 FT VISIBILTY <3 MI	XE13
100	% FREQ CEILING <1000 FT VISIBILTY <2 MI	XE14
101	% FREQ CEILING <200 FT VISIBILTY <1/2 MI	XE15
102	DAYS PER MONTH THUNDERSTORMS OCCURRED	XE16
103	PREVAILING WIND DIRECTION	XE17
104	MEAN MONTH WIND SPEED	XE18
105	PEAK GUST RECORDED FOR MONTH	XE19

RECORD TYPE M: CLIMATIC DATA (BASE LEVEL, ONE RECORD PER DATA CASE)

Field	Heading	Entry
	CASE CODE[1]	
	BLANK	X
	RECORD TYPE	M
	RECORD SEQ. NO.	0 1
106	MEAN TOTAL MONTHLY PRECIPITATION	XE20
107	MAXIMUM PRECIP. IN 24-HOUR PERIOD	XE21
108	MEAN MONTHLY SNOWFALL	XE22
109	MAXIMUM SNOWFALL IN 24 HOUR PERIOD	XE23
110	DAYS PER MO. PRECIPITATION ≥0.01 IN.	XE24
111	DAYS PER MO. PRECIPITATION ≥0.50 IN.	XE25
112	DAYS PER MO. SNOWFALL ≥0.10 IN.	XE26
113	DAYS PER MO. SNOWFALL ≥1.50 IN.	XE27
114	MO. MEAN REL. HUMIDITY AT 0400 HR	XE28
115	MO. MEAN REL. HUMIDITY AT 1300 HR	XE29
116	MO. MEAN DEWPOINT (° F)	XE30
117	MO. MEAN VAPOR PRESSURE (IN. HG)	XE31
118	MO. MEAN PRESSURE ALTITUDE (FT.)	XE32

F4C AIRCRAFT
SEA COMBAT THEATER
VIETNAM
CAM RANH BAY AIR BASE
JUNE
1966
RECORD TYPE
RECORD TYPE SEQUENCE NUMBER

SAMPLE DATA CASE

```
AAAB0666 A01          666   4266   2474   2474  73        1.8                        3
AAAB0666 B0101GROUND HANDLING          .0        .0      38.9         .0       .0
AAAB0666 B0202AIRCRAFT CLEANING        .0        .0       4.2         .0       .0
AAAB0666 B0303"LOOK" PHASE OF INS      .0        .0    3090.4         .0       .0
AAAB0666 B0404SPECIAL INSPECTION       .0        .0     626.7         .0       .0
AAAB0666 B0506GROUND SAFETY            .0        .0      18.0         .0       .0
AAAB0666 B0607PREP. MAINT. RECORD      .0        .0        .7         .0       .0
AAAB0666 B0708SPECIAL WEAPON HAND      .0        .0        .4         .0       .0
AAAB0666 B0809SHOP SUPPORT GEN         .0        .0        .2         .0       .0
AAAB0666 B0911AIRFRAME              220.4     258.7    1335.8         .0      1.1
AAAB0666 B1012FSLG COMPARTMENTS     121.0      36.5     419.6         .4       .9
AAAB0666 B1113LANDING GEAR           44.2      72.8     438.2        1.8      3.1
AAAB0666 B1214FLIGHT CONTROLS        31.7      81.4     716.7       80.1      2.0
AAAB0666 B1323TURBO FAN PWR PLTB     22.0      91.9     768.4       10.0      3.3
AAAB0666 B1441AIR COND. ANTI-ICE     14.7      18.5     127.7        1.9       .9
AAAB0666 B1542ELECT POWER SUPPLY      8.8      10.3     106.0        3.0       .2
AAAB0666 B1644LIGHTING SYSTEMS        7.3      17.2      39.7        1.4       .0
AAAB0666 B1745HYD/PNEU PWR SUP       40.9      35.2     216.5        1.8      1.8
AAAB0666 B1846FUEL SYSTEM             8.6      24.2     241.1       32.5      1.8
AAAB0666 B1947OXYGEN SYSTEM           2.8       9.0      21.3        1.2       .2
AAAB0666 B2049MISC UTILITIES          1.8       1.1      14.3         .2       .4
AAAB0666 B2151INSTRUMENTS, GEN        2.4      37.6      76.9         .6       .0
AAAB0666 B2252AUTOPILOT              11.6       9.9     153.7       38.7       .4
AAAB0666 B2361HF COMM SYSTEMS          .0        .2        .2         .0       .0
AAAB0666 B2471RADIO NAVIGATION       15.8      33.7     221.2         .0       .4
AAAB0666 B2572RADAR NAVIGATION         .0       1.1       9.5         .0       .0
AAAB0666 B2673BOMBING NAVIGATION      5.3       5.7      61.9         .0       .0
AAAB0666 B2774FIRE CONTROL           23.8     112.6     484.9        3.1       .0
AAAB0666 B2875WEAPONS DELIVERY       15.0      14.7     150.8       21.4       .2
AAAB0666 B2976ELECT COUNTER MEAS       .0        .6      11.7         .0       .0
AAAB0666 B3077PHOTO/RECON              .6       1.5       2.7         .0       .0
AAAB0666 B3191EMERGENCY EQUIP         5.7       2.2       7.0         .0       .0
AAAB0666 B3293DRAG CHUTE EQUIP        2.0      10.3      14.0         .2       .0
AAAB0666 B3396PERSONNEL EQUIP         1.5        .6       2.6         .0       .0
AAAB0666 B3497EXPLOSIVE DEVICES       1.5        .0      17.0         .0       .0
AAAB0666 C0199TOTAL ALL SYSTEMS     609.5     887.8    9435.4      199.2     16.7
AAAB0666 D01 64-0571   8TFW  433TFS   3430  1500 10  13  03   6660601 2155  5
AAAB0666 E01D01 HE3              AAA 5 57MMSH 5
AAAB0666 F0100111 AIRFRAME WGETC              EXPLOS 4
AAAB0666 G01D01  2 PILOT 09 INJURY 3 NOTSER1 4 PARLN03 ANKLE 04            POWR   5
AAAB0666 G02D01  2 COPILO08 INJURY 3 NOTSER1 4 PARLN03 BACK  14            POWR   5
AAAB0666 H01 00349 64-0658 061466 061566 070266 071166 00260 SHIP      CRASH
AAAB0666 I01PAF MINOR1 5052 04   L12          EMERGENCY LANDING HARD LOG 00000000
AAAB0666 J0110181111 AIRFRM13 HARD LOG TOTAL AIRCRAFT    00NONE 0       00       00
AAAB0666 K01 0006  012N 109  SANDCOAST08FINMSAND28COPSE   11 001 038 007 008 100
AAAB0666 L01 102  92  78  74        27  30           7   0   6  1   0   0  5 SSW  6  26
AAAB0666 M01  2.1  2.0   0   0   6   1   0   0  82  57  74  .85   400
```

APPENDIX B: DATA CASE MAP

AIRCRAFT	YEAR	CAM RANH BAY, VIETNAM (CXNA) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
F-4C	1966				●	●	●						
	1967												
	1968					●	●	●	●				
	1969												
	1970												
	1971												
	1972												
	1973												
	1974												
	1975												

AIRCRAFT	YEAR	DA NANG, VIETNAM (EZEH) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
F-4C	1966				●	●	●						
	1967												
	1968					●							
	1969												
	1970												
	1971												
	1972												
	1973												
	1974												
	1975												

AIRCRAFT	YEAR	TAN SON NHUT, VIETNAM (WRMC) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
F-4C	1966				●		●						
	1967												
	1968												
	1969												
	1970												
	1971												
	1972												
	1973												
	1974												
	1975												

AIRCRAFT	YEAR	KORAT, THAILAND (MLEH) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
F-4C	1966					●	●						
	1967												
	1968												
	1969												
	1970												
	1971												
	1972									●	●	●	●
	1973	●	●	●									
	1974												
	1975				●								

AIRCRAFT	YEAR	UBON, THAILAND (XMTG) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
F-4C	1966				●	●	●						
	1967												
	1968												
	1969												
	1970												
	1971												
	1972												●
	1973								●	●			
	1974												
	1975												

AIRCRAFT	YEAR	CC KANG, TAIWAN (MLTX) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
F-4C	1966												
	1967												
	1968												
	1969												
	1970												
	1971												
	1972											●	●
	1973	●	●	●	●	●	●	●	●	●	●	●	●
	1974	●	●	●	●	●	●	●	●	●	●	●	●
	1975	●	●	●	●								

SEA DATA BASE CASE MAP SHEET 1 OF 10

AIRCRAFT	BASE -->	CLARK, PHILIPPINES (BVLK)												FUKUOKA, JAPAN (LQZN)												MISAWA, JAPAN (QKKA)											
	YEAR	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																																				
F-4C	1966				●	●	●																														
	1967																																				
	1968					●	●	●	●	●								●	●	●	●	●								●	●	●	●	●			
	1969																																				
	1970																																				
	1971	●	●	●	●	●	●	●	●	●	●	●	●															●									
	1972	●	●	●																																	
	1973							●	●	●	●	●																									
	1974		●	●	●	●	●	●	●	●	●	●																									
	1975	●	●	●	●																																

AIRCRAFT	BASE -->	NAHA, OKINAWA (JAPAN) (REPD)												YOKOTA, JAPAN (ZNRE)												KUNSAN, KOREA (NLWR)											
	YEAR	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																																				
F-4C	1966				●	●	●																														
	1967																																				
	1968																	●	●	●	●	●															
	1969																																				
	1970																																				
	1971													●	●	●	●	●	●	●	●				●				●	●	●	●		●			
	1972													●		●													●	●	●	●	●	●	●		
	1973																																				
	1974																																		●		
	1975																																				

SEA DATA BASE CASE MAP SHEET 2 OF 10

AIRCRAFT: F-4C

BASE --> OSAN, KOREA (SMYU)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968					●	●	●	●				
1969												
1970												
1971	●	●	●	●								●
1972				●	●				●			
1973												
1974		●		●								
1975		●										

BASE --> TAEGU, KOREA (WPZQ)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968												
1969												
1970												
1971							●	●		●		
1972												
1973												
1974												
1975												

BASE --> CONUS SUMMARY

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966	▬	▬	▬	▬	▬	▬						
1967												
1968	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
1969												
1970												
1971	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
1972	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
1973	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
1974	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
1975	▬	▬	▬	▬	▬	▬						

AIRCRAFT: RF-4C

BASE --> TAN SON NHUT, VIETNAM (WRMC)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966			●	●	●	●	●					
1967												
1968												
1969												
1970												
1971	●	●	●	●	●							
1972												
1973												
1974												
1975												

BASE --> KORAT, THAILAND (MLER)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968												
1969												
1970												
1971												
1972												
1973												
1974								●				
1975												

BASE --> UBON, THAILAND (XMPA)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968												
1969												
1970												
1971												
1972	●											
1973						●	●					
1974												
1975												

SEA DATA BASE CASE MAP   SHEET 3 OF 10

AIRCRAFT	YEAR	BASE --> UBON, THAILAND (XMTG)											
		J	F	M	A	M	J	J	A	S	O	N	D
	1965												
RF-4C	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●	●	●	●	●	●	●	●	●
	1972	●	●	●	●	●	●	●	●	●	●	●	●
	1973	●	●	●	●	●	●	●	●	●	●	●	●
	1974	●	●	●	●	●	●	●	●	●	●	●	●
	1975	●	●	●	●								

AIRCRAFT	YEAR	CC KANG, TAIWAN (MLTX)											
		J	F	M	A	M	J	J	A	S	O	N	D
	1965												
RF-4C	1966												
	1967												
	1968												
	1969												
	1970												
	1971												
	1972												
	1973						●	●					
	1974	●	●		●	●							
	1975		●										

AIRCRAFT	YEAR	CLARK, PHILIPPINES (DVLK)											
		J	F	M	A	M	J	J	A	S	O	N	D
	1965												
RF-4C	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●	●	●	●	●		●	●	
	1972		●	●	●		●					●	
	1973	●		●	●	●	●						
	1974	●	●	●		●						●	
	1975	●	●		●								

AIRCRAFT	YEAR	BASE --> KADINA, OKINAWA (JAPAN) (LXKZ)											
		J	F	M	A	M	J	J	A	S	O	N	D
	1965												
RF-4C	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●	●	●	●	●	●	●	●	●
	1972	●	●	●	●	●	●	●	●	●	●	●	●
	1973	●	●	●	●	●	●	●	●	●	●	●	●
	1974	●	●	●	●	●	●	●	●	●	●	●	●
	1975	●	●	●	●								

AIRCRAFT	YEAR	MISAWA, JAPAN (QKKA)											
		J	F	M	A	M	J	J	A	S	O	N	D
	1965												
RF-4C	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●									
	1972												
	1973												
	1974												
	1975												

AIRCRAFT	YEAR	YOKOTA, JAPAN (ZNRE)											
		J	F	M	A	M	J	J	A	S	O	N	D
	1965												
RF-4C	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●		●						
	1972												
	1973	●											
	1974												
	1975												

SEA DATA BASE CASE MAP SHEET 4 OF 10

KUNSAN, KOREA (MLWR)

AIRCRAFT	YEAR	J	F	M	A	M	J	J	A	S	O	N	D
RF-4C	1965												
	1966												
	1967												
	1968												
	1969												
	1970												
	1971					●							
	1972	●				●	●	●	●	●			
	1973	●											
	1974												
	1975												

KWANG JU, KOREA (MMFZ)

AIRCRAFT	YEAR	J	F	M	A	M	J	J	A	S	O	N	D
RF-4C	1965												
	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●										
	1972												
	1973												
	1974												
	1975												

OSAN, KOREA (SMYU)

AIRCRAFT	YEAR	J	F	M	A	M	J	J	A	S	O	N	D
RF-4C	1965												
	1966												
	1967												
	1968												
	1969												
	1970												
	1971												
	1972							●	●	●			
	1973					●			●			●	
	1974		●	●	●	●	●	●	●	●	●	●	●
	1975	●	●	●	●								

TAEGU, KOREA (WPZQ)

AIRCRAFT	YEAR	J	F	M	A	M	J	J	A	S	O	N	D
RF-4C	1965												
	1966												
	1967												
	1968												
	1969												
	1970												
	1971			●	●			●	●	●	●	●	●
	1972	●	●	●	●	●	●	●	●	●	●	●	●
	1973	●	●	●	●	●	●	●	●	●	●	●	●
	1974	●	●	●	●	●	●	●	●	●	●	●	●
	1975	●	●	●	●								

CONUS SUMMARY

AIRCRAFT	YEAR	J	F	M	A	M	J	J	A	S	O	N	D
RF-4C	1965												
	1966	■	■	■	■	■	■	■	■	■	■	■	■
	1967												
	1968												
	1969												
	1970												
	1971	■	■	■	■	■	■	■	■	■	■	■	■
	1972	■	■	■	■	■	■	■	■	■	■	■	■
	1973	■	■	■	■	■	■	■	■	■	■	■	■
	1974	■	■	■	■	■	■	■	■	■	■	■	■
	1975	■	■	■	■	■							

SEA DATA BASE CASE MAP SHEET 5 OF 10

AIRCRAFT	BASE --> YEAR	KORAT, THAILAND (MLER)												NAKHON PHANOM, THAILAND (RFCV)												TA KHLI, THAILAND (WQYC)											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																																				
A-7D	1966																																				
	1967																																				
	1968																																				
	1969																																				
	1970																																				
	1971																																				
	1972																																				
	1973	●	●	●	●	●	●	●	●	●	●	●	●														●	●									
	1974	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●				●	●							●								
	1975	●	●	●	●	●	●																														

AIRCRAFT	BASE --> YEAR	UBON, THAILAND (XMPA)												UBON, THAILAND (XMTG)												KUNSAN, KOREA (MLWR)											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																																				
A-7D	1966																																				
	1967																																				
	1968																																				
	1969																																				
	1970																																				
	1971																																				
	1972																																				
	1973	●			●			●								●										●											
	1974	●													●	●	●	●										●									
	1975																																				

SEA DATA BASE CASE MAP SHEET 6 OF 10

Aircraft: A-7D — Base: CONUS SUMMARY

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968												
1969												
1970												
1971												
1972												
1973	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
1974	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
1975	▬	▬	▬	▬	▬	▬						

Aircraft: C-130E — Base: CAM RANH BAY, VIETNAM (CXNA)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968												
1969												
1970												
1971	●	●	●	●	●	●	●	●	●	●	●	●
1972	●	●										
1973												
1974												
1975												

Aircraft: C-130E — Base: DA NANG, VIETNAM (EZEM)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968												
1969												
1970												
1971	●	●							●	●	●	
1972				●	●	●						
1973												
1974												
1975												

Aircraft: C-130E — Base: TAN SON NHUT, VIETNAM (WRMC)

YEAR	J	F	M	A	M	J	J	A	S	O	N	D
1965												
1966												
1967												
1968												
1969												
1970												
1971	●	●	●	●	●	●	●	●	●	●	●	●
1972	●	●	●	●	●	●	●	●	●	●	●	
1973												
1974												
1975												

SEA DATA BASE CASE MAP   SHEET 7 OF 10

AIRCRAFT	BASE --> YEAR	PANG KANG, VIETNAM (TDTK)												KORAT, THAILAND (MLER)												NAK HON PHANOM, THAILAND (RFCV)											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																																				
C-130E	1966																																				
	1967																																				
	1968																																				
	1969																																				
	1970																																				
	1971	●	●	●	●	●	●	●	●																										●		
	1972																●	●	●	●	●	●	●	●	●												
	1973													●	●	●	●	●	●	●	●	●	●	●	●						●	●	●	●	●	●	●
	1974													●	●	●	●	●								●	●										
	1975														●		●	●	●																		

AIRCRAFT	BASE --> YEAR	TA KHLI,, THAILAND (WOYC)												U TAPAO, THAILAND (XMPX)												UBON, THAILAND (XMPA)											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																																				
C-130E	1966																																				
	1967																																				
	1968																																				
	1969																																				
	1970																																				
	1971																												●								
	1972																												●	●	●			●			●
	1973		●	●	●	●																		●	●									●	●	●	
	1974													●	●	●	●	●	●	●	●	●	●	●	●	●			●								
	1975													●	●	●	●																				

SEA DATA BASE CASE MAP SHEET 8 OF 10

AIRCRAFT	BASE --> YEAR	UBON, THAILAND (XMTG) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
C-130E	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●	●	●	●	●	●	●	●	●
	1972	●	●	●	●	●	●	●					
	1973												
	1974												
	1975												

AIRCRAFT	BASE --> YEAR	CC KANG, TAIWAN (MLTX) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
C-130E	1966												
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●	●	●	●	●	●	●	●	●
	1972	●	●	●	●	●	●	●	●	●	●	●	●
	1973	●	●	●	●	●	●	●	●	●	●	●	
	1974												
	1975												

AIRCRAFT	BASE --> YEAR	CLARK, PHILIPPINES (DVLX) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
C-130E	1966			●	●	●	●	●					
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●	●	●	●	●	●	●	●	●
	1972	●	●	●	●	●	●	●	●	●	●	●	●
	1973	●	●	●	●	●	●	●	●	●	●	●	●
	1974	●	●	●	●	●	●	●	●	●	●	●	●
	1975	●	●	●	●	●	●						

AIRCRAFT	BASE --> YEAR	ANDERSON, GUAM (AJJY) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
C-130E	1966			●	●	●							
	1967												
	1968												
	1969												
	1970												
	1971			●	●	●	●	●	●	●			
	1972	●	●	●	●					●			
	1973									●		●	
	1974	●	●	●	●	●	●	●	●	●	●	●	
	1975	●	●	●	●	●	●						

AIRCRAFT	BASE --> YEAR	KADENA, OKINAWA (JAPAN) (LXEZ) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
C-130E	1966				●	●	●	●					
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●	●	●	●	●	●	●	●	●
	1972	●	●	●	●	●	●	●	●	●	●	●	●
	1973	●	●	●	●	●	●	●	●	●	●	●	●
	1974	●	●	●	●	●	●	●	●	●	●	●	●
	1975	●	●	●	●	●	●						

AIRCRAFT	BASE --> YEAR	NAHA, OKINAWA (JAPAN) (REPD) J	F	M	A	M	J	J	A	S	O	N	D
	1965												
C-130E	1966				●	●	●	●					
	1967												
	1968												
	1969												
	1970												
	1971	●	●	●	●								
	1972												
	1973												
	1974												
	1975												

SEA DATA BASE CASE MAP SHEET 9 OF 10

AIRCRAFT	BASE --> / YEAR	YOKOTA, JAPAN (ZNRE)												OSAN, KOREA (SMYU)												CONUS SUMMARY											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																									■	■	■	■	■	■	■	■	■	■	■	■
C-130E	1966																																				
	1967																																				
	1968																																				
	1969																																				
	1970																																				
	1971	●	●	●	●	●	●	●	●	●						●										■	■	■	■	■	■	■	■	■	■	■	■
	1972	●	●	●	●	●	●	●	●	●	●										●					■	■	■	■	■	■	■	■	■	■	■	■
	1973							●																		■	■	■	■	■	■	■	■	■	■	■	■
	1974						●	●	●	●	●	●	●						●	●					●	■	■	■	■	■	■	■	■	■	■	■	■
	1975	●	●	●	●	●	●							●	●			●								■	■	■	■	■	■						

AIRCRAFT	BASE --> / YEAR																																				
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	1965																																				
	1966																																				
	1967																																				
	1968																																				
	1969																																				
	1970																																				
	1971																																				
	1972																																				
	1973																																				
	1974																																				
	1975																																				

SEA DATA BASE CASE MAP   SHEET 10 OF 10

APPENDIX C: UPDATE CASE LIST, F, G, AND H CASES BASELINE COMBAT DATA BASE

APPENDIX C: BASELINE COMBAT DATA BASE UPDATE CASE LIST

UPDATED CASE CODE	SOURCE CASE CODE	UPDATED CASE CODE	SOURCE CASE CODE
EAAB 0501	AAAB 0566	GABA 0505	CABA 0573
EAAB 0601	AAAB 0666	GABA 0507	CABA 0575
EAAB 0502	AAAB 0568	GCCS 0605	CCCS 0673
EAAB 0602	AAAB 0668	GCCS 0606	CCCS 0674
EAAB 0702	AAAB 0768	GCCS 0607	CCCS 0675
EAAB 0802	AAAB 0868		
EAAB 0902	AAAB 0968	HAAF 0603	DAAF 0671
EAAC 0401	AAAC 0466	HAAF 0404	DAAF 0472
EAAC 0601	AAAC 0666	HAAF 0504	DAAF 0572
EAAC 0502	AAAC 0568	HAAF 0604	DAAF 0672
EAAF 0601	AAAF 0666	HAAF 0804	DAAF 0872
EABA 0501	AABA 0566	HAAF 1004	DAAF 1072
EABE 0401	AABE 0466	HABA 0604	DABA 0672
EABE 0501	AABE 0566	HABE 1204	DABE 1272
EABE 0601	AABE 0666	HABE 0406	DABE 0474
EBDA 0207	ABDA 0275	HABF 0103	DABF 0171
EBEA 0702	ABEA 0768	HABF 0303	DABF 0371
EBGB 0502	ABGB 0568		
ECCS 0601	ACCS 0666	HABF 0803	DABF 0871
ECCS 0602	ACCS 0668	HABF 0903	DABF 0971
ECCS 0603	ACCS 0671	HABF 1103	DABF 1171
ECCS 1203	ACCS 1271	HABF 0104	DABF 0172
ECCS 0605	ACCS 0673	HABF 0204	DABF 0272
		HABF 0304	DABF 0372
FAAF 0401	BAAF 0466	HABF 0404	DABF 0472
FAAF 0501	BAAF 0566	HABF 0504	DABF 0572
FAAF 0701	BAAF 0766	HABF 0604	DABF 0672
FAAF 0103	BAAF 0171	HBDA 0603	DBDA 0671
FABF 0603	BABF 0671	HBDA 0404	DBDA 0472
FABF 1003	BABF 1071	HBDA 0504	DBDA 0572
FABF 0104	BABF 0172	HBDA 0604	DBDA 0672
FABF 0404	BABF 0472	HBDA 0904	DBDA 0972
FABF 0704	BABF 0772	HBDA 1204	DBDA 1272
FABF 0804	BABF 0872	HBDA 0405	DBDA 0473
FABF 0904	BABF 0972	HBDA 0905	DBDA 0973
FABF 1204	BABF 1272	HBEA 0404	DBEA 0472
FBFA 0703	BBFA 0771	HBFA 0701	DBFA 0766
FBFA 0504	BBFA 0572	HBGC 0501	DBGC 0566
FCCS 0601	BCCS 0666	HBGC 0601	DBGC 0666
FCCS 1201	BCCS 1266	HBIA 0603	DBIA 0671
FCCS 0604	BCCS 0672	HCCS 0601	HCCS 0666
FCCS 0606	BCCS 0674	HCCS 1201	HCCS 1266
FCCS 0607	BCCS 0675	HCCS 0604	HCCS 0672
		HCCS 0605	HCCS 0673
GABA 0105	CABA 0173	HCCS 0606	HCCS 0674
GABA 0205	CABA 0273	HCCS 1206	HCCS 1274

APPENDIX D: EXAMPLE OF CROSS-CASE AVERAGING TO ESTIMATE MISSING OPERATIONS DATA

The following example shows the step-by-step process to estimate missing operations parameter values in the SEA Combat Experience Source Data Base. The example shown includes estimates for the F-4C aircraft operating out of Korat Air Base, Thailand. The values for flight hours, landings, sorties and number of possessed aircraft were missing for the data cases covering June 1966, March 1973, and April 1974. To estimate these values, a comparison sample of several consecutive cases with complete data from the same base and aircraft were selected. A parameter with complete data in both the missing data sample and the comparison sample was chosen as the estimate control. This parameter was Maintenance Manhours Expended for the month. The following step-by-step process was then followed to derive estimates for the missing data values.

1. Total each of the desired operational parameters (flight hour, landings, sorties, number of aircraft) and the maintenance manhours control parameter across the comparison sample data cases.

2. Divide each of the totals for the operational parameters by the total maintenance manhour (MMH) value. These calculations yield average factors for flight hours/MMH, landings/MMH, sorties/MMH, and possessed aircraft/MMH across the comparison sample.

3. To estimate the missing values for flight hours, landings, sorties and possessed aircraft, multiply the maintenance manhours for the cases in question by the corresponding factor calculated in Step 2 above.

The data values and calculations for the selected example are tabulated in Table D-1.

Table D-1. Example of Missing Operational Values Estimating

DATA CASE	FLIGHT HOURS .003	LANDINGS .004	SORTIES .005	NO. OF AIRCRAFT .006	TOTAL MMH .017
AABA0972	49	22	22	2	609
AABA1072	455	147	147	6	7188
AABA1172	260	83	84	6	5233
AABA1272	515	100	100	6	4646
AABA0173	286	117	117	6	5721
AABA0273	100	56	56	4	2474
TOTALS FOR SAMPLE	1665	525	526	30	25862
AVG. VALUES PER MMH	0.0644	0.0203	0.0203	0.00116	1
TO BE ESTIMATED	ESTIMATE	ESTIMATE	ESTIMATE	ESTIMATE	KNOWN
AABA0566	INDETERMINATE				0
AABA0666	85	27	27	2	1319
AABA0373	584	184	184	11	9069
AABA0475	2651	836	836	48	41169

APPENDIX E: TRANSFORMATION PROCESS

After missing operations data in the SEA Combat Data Base were filled in as completely as possible, the second part of the problem was to try to "normalize" the special case of SEA air combat to a more general case and to update these data from the technology and conditions of the 1965 to 1975 timeframe to present technology and likely combat conditions. The general methodology for updating is schematically depicted in Figure E-1. The general process was as follows:

1. Compute compatibility factors from data differences in key parameters; e.g., added attrition rate due to combat (compare SEA Combat to Western Pacific to CONUS).

2. Next compute update factors on the key parameters from Vietnam era to present utilizing the present AFR 66-1 and G033B data bases (CONUS, Western Pacific to present Western Pacific).

3. Compute technology factors by comparing Vietnam-era technology aircraft's key parameter rates (such as maintenance rate) with "now" technology aircraft's key parameter rates. Allowances must be made for the "then age" and the "now age" of the old technology aircraft.

The foregoing methodologies were applied to the SEA Combat Data Base to produce the "Baseline Combat Data Base" as represented by aircraft types "E" (F-4 updates), "F" (RF-4 updates), "G" (A-7 updates) and "H" (C-130 updates).

Assumptions and Methods. The specific process used to update this data base used the following assumptions and methods. A level of combat equal to that of SEA from 1965 to 1975 was assumed for the updated combat situation. The general combat environment was also assumed to be the same as SEA. The objective was to bring the SEA "then" data (using "then operational" aircraft) up to present operational, logistical, and technological conditions; hat is, to estimate a data base that would result if modern aircraft such as the F-15 and F-16 were in combat in SEA using today's operational and logistical doctrines.

This was done by developing translation factors from recent operational and maintenance data and applying them across the various available comparison data files until a final translation factor for "SEA Then" data was obtained. Figure E-2 shows the process. This factor was achieved by first calculating "CONUS Now Technology Multipliers" by ratioing "Now Aircraft," "Now Data" (F-15/F-16) to "Then Aircraft," "Now Data" (F-4C, RF-4C, A-7D). These "Then Aircraft" data were adjusted for time passage and aircraft aging by a "CONUS Then/CONUS Now" ratio multiplier which adjusts the data as if the "Then Aircraft" were new and were using new technology.

Geographic differences were compensated for with a "PACAF Then/CONUS Then" multiplier. Finally, the data were translated into combat conditions with a "SEA Then/PACAF Then" multiplier.

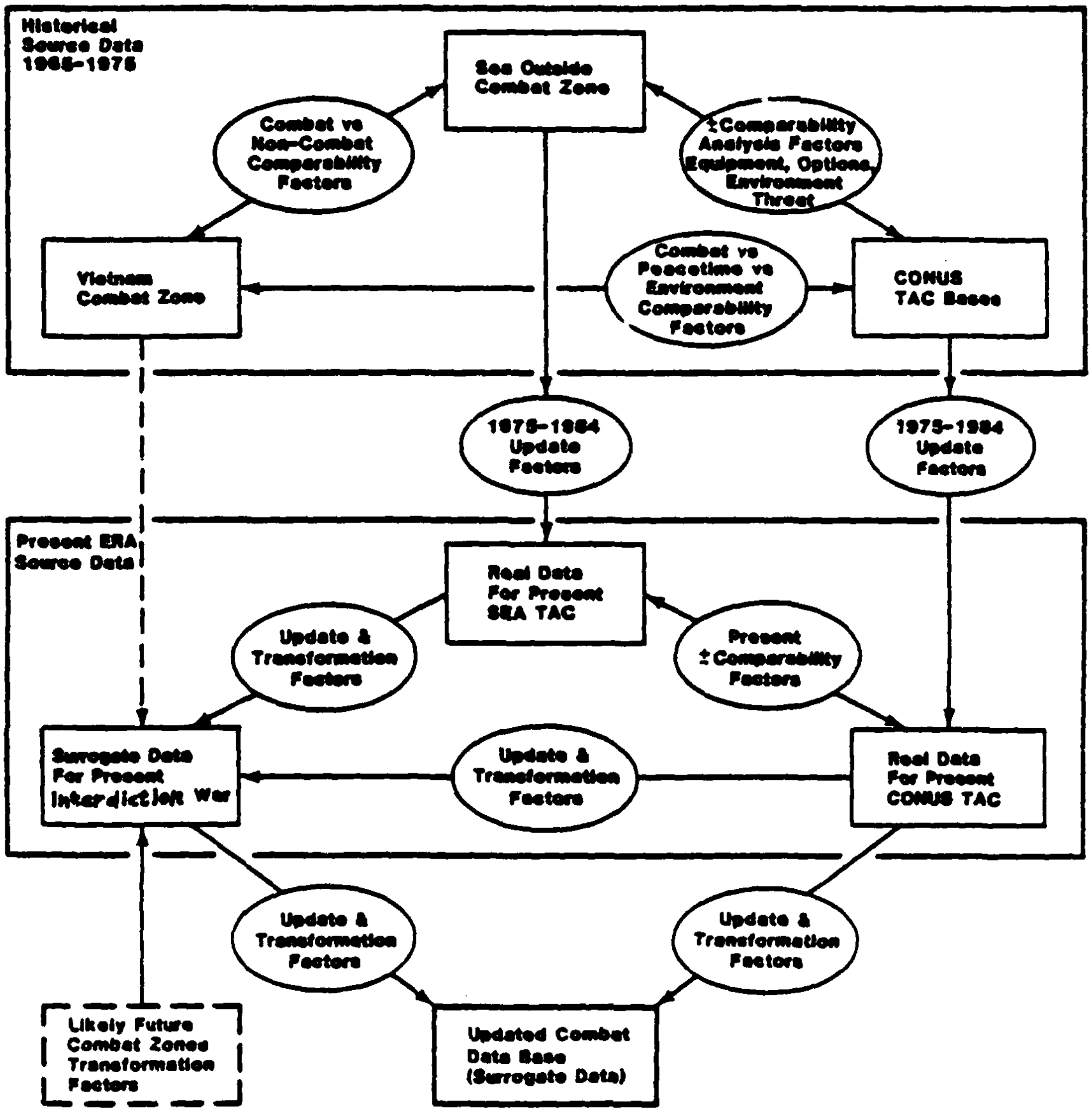

Figure E-1. Data Base Updating Process.

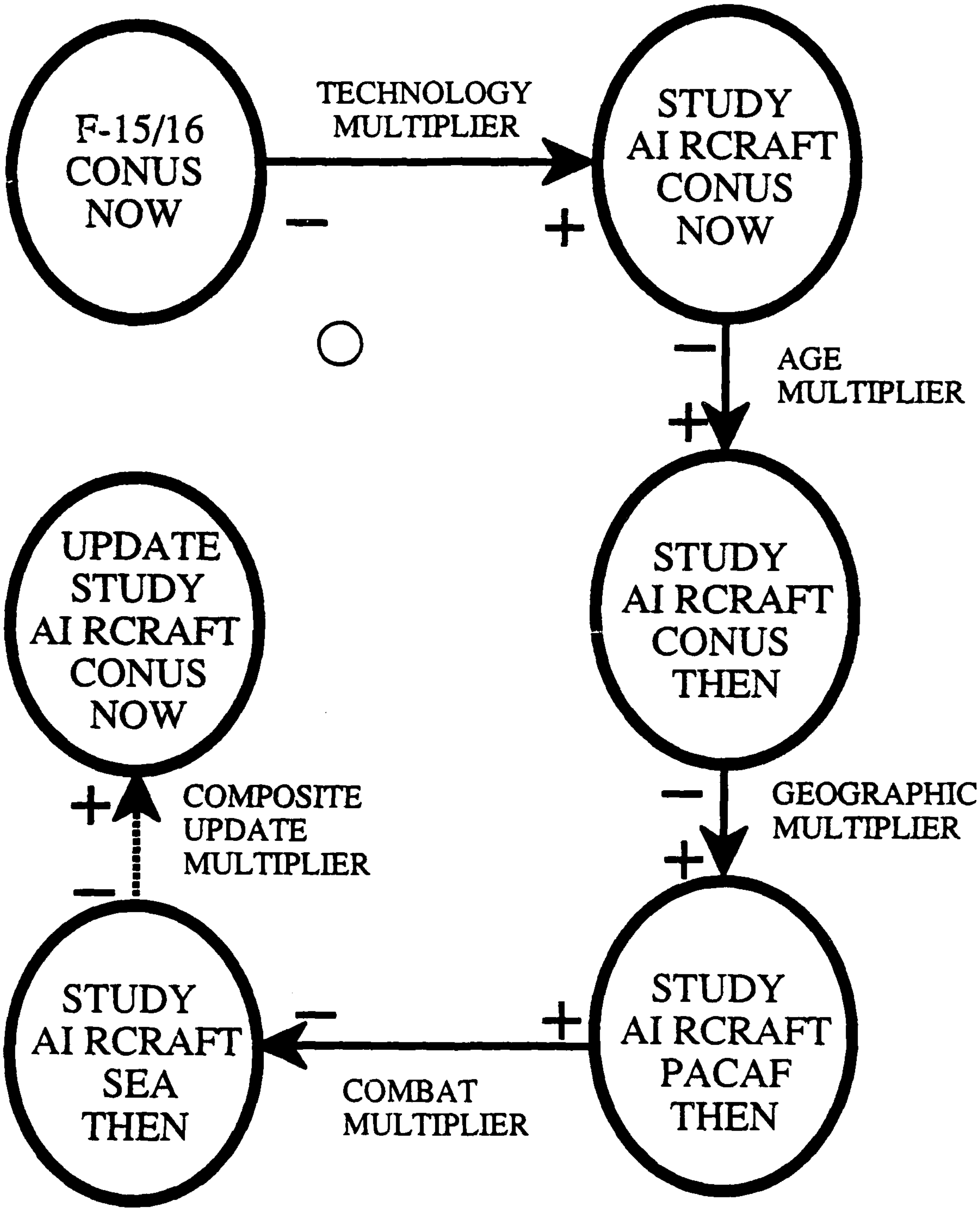

Figure E-2. Translation of Data from SEA THEN to SEA NOW.

There were differences in the update source data for the four studied aircraft so the application of the above factors was different for each aircraft case. For the F-4, which is still in active service in CONUS in large numbers, a recent data base is available as well as the 1965 to 1975 data.

1. The factor calculation for the F-4 was as follows:

Update Multiplier = Tech Factor * Time Factor * Geo Factor * Combat Factor

2. No recent comparison data were available for the RF-4; so, the technological multiplier was applied to the "Then" data base so that:

Update Multiplier = Tech Factor * Geo Factor * Combat Factor

3. Recent PACAF comparison data were available for the A-7; so, geographic compensation did not have to be calculated. Hence:

Update Multiplier = Tech Factor * Time Factor * Combat Factor

4. The C-130 is still in service throughout the world and will be the likely tactical transport in any near-term combat situation. Its multiplier requires no technological update factor; so:

Update Multiplier = Time Factor * Geo Factor * Combat Factor

APPENDIX F: TRANSFORMATION FACTORS TO UPDATE "SEA THEN" DATA TO "SEA NOW" DATA

The general procedure for transforming the operations and maintenance parameters of the combat theater portion (Vietnam and Thailand primarily) of the SEA Combat Experience Data Base to an updated baseline data base is as follows:

'. Derive a technological transform factor from recent F-15/F-16 CONUS experience.

2. Derive "CONUS NOW" transform factors for the study aircraft.

3. Derive "CONUS THEN" transform factors for the study aircraft.

4. Derive "PACAF THEN" transform factors for the study aircraft.

5. Derive "SEA THEN" transform factors for the study aircraft.

6. Use the derived factors in combination to calculate Technological Multipliers, Time Multipliers, Geographic Multipliers, and Combat Multipliers to use in the Update Transform Multiplier calculations for each aircraft according to the following expressions:

F-4UM = Technology Mult * Time Mult * Geographic Mult * Combat Mult
RF-4UM = (F15/F16 CONUS NOW)*(RF4 SEA THEN)/(RF4 CONUS THEN)^2
A-7UM = *(F15/F16 CONUS NOW)*(A7 SEA THEN)/(A7CONUS NOW)^2
C-130UM = (C130 SEA THEN)/(C130 WORLD NOW)

Where: Technology Multiplier = (F15/F16 CONUS NOW)/(F4 CONUS NOW)
Time Multiplier = (F4 CONUS THEN)/(F4 CONUS NOW)
Geographic Multiplier = (F4 PACAF THEN)/(F4 CONUS THEN)
Combat Multiplier = (F4 SEA THEN)/(F4 PACAF THEN)

C130 WORLD NOW is the transform factor representing the recent experience data of the worldwide C-130 fleet.

7. Apply the Update Transform Multipliers to the operations and maintenance parameters of the combat data cases for each study aircraft.

The F-4UM expression represents the long form of the update multiplier calculation method. The F-4 update multipliers were calculated by this long form to illustrate the process. The calculated expressions for the other aircraft take advantage of algebraic cancellation opportunities for the various factors. This was done to increase calculation efficiency.

Update multipliers were derived for the following SEA Combat Experience Source Data Base O&M parameters:

NUMBER	NAME
003	Flight Hours This Month
004	Landings This Month
005	Sorties this Month
007	Average Sortie Length
010	Removals by System
011	Failures by System
012	Maintenance Manhours by System
013	Troubleshooting Manhours by System
014	Aborts by System
015	Removals This Month
016	Failures This Month
017	Maintenance Manhours This Month
018	Troubleshooting Manhours This Month
019	Aborts This Month

Tables F-1 through F-4 present the Update Transform Multipliers for the listed variables for each of the four studied aircraft. The data and calculations of the factors underlying the above multipliers are listed in Tables F-5 through F-31.

Table F-1. F-4 Update Transform Multiplier ("E" Aircraft Data Cases)

The following tactors are to be multiplied times each data case value of the respective listed variables.

Variable No.	Name	Multiplier
03	Flight Hours	3.10
04	Landings	1.96
05	Sorties	2.29
07	Average Sortie Length	1.34
10	Removals by System	1.02
11	Failures by System	1.18
12	Maintenance Manhours by System	2.30
13	Troubleshooting Manhours by System	0.68
14	Aborts by System	1.56
15	All Removals	1.02
16	All Failures	1.18
17	Total Maintenance Manhours	2.30
18	Total Troubleshooting Manhours	0 68
19	Total Aborts	1 56

Table F-2. RF-4 Update Transform Multipliers ("F" Aircraft Data Cases)

The following factors are to be multiplied times each data case value of the respective listed variables.

Variable No.	Name	Multiplier
03	Flight Hours	2.18
04	Landings	1.18
05	Sorties	2.68
07	Average Sortie Length	0.82
10	Removals by System	8.70
11	Failures by System	10.43
12	Maintenance Manhours by System	10.40
13	Troubleshooting Manhours by System	6.30
14	Aborts by System	21.07
15	All Removals	8.70
16	All Failures	10.43
17	Total Maintenance Manhours	10.40
18	Total Troubleshooting Manhours	6.30
19	Total Aborts	21.07

Table F-3. A-7 Update Transform Multipliers ("G" Aircraft Data Cases)

The following factors are to be multiplied times each data case value of the respective listed variables.

Variable No.	Name	Multiplier
03	Flight Hours	2.68
04	Landings	2.15
05	Sorties	2.05
07	Average Sortie Length	1.33
10	Removals by System	2.53
11	Failures by System	0.73
12	Maintenance Manhours by System	10.71
13	Troubleshooting Manhours by System	3.63
14	Aborts by System	1.82
15	All Removals	2.53
16	All Failures	0.73
17	Total Maintenance Manhours	10.71
18	Total Troubleshooting Manhours	3.63
19	Total Aborts	1.82

Table F-4. C-130 Update Transform Multiplier ("H" Aircraft Data Cases)

The following factors are to be multiplied times each data case value of the respective listed variables.

Variable No.	Name	Multiplier
03	Flight Hours	2.19
04	Landings	0.90
05	Sorties	2.07
07	Average Sortie Length	1.05
10	Removals by System	2.10
11	Failures by System	2.42
12	Maintenance Manhours by System	2.69
13	Troubleshooting Manhours by System	1.78
14	Aborts by System	3.20
15	All Removals	2.10
16	All Failures	2.42
17	Total Maintenance Manhours	2.69
18	Total Troubleshooting Manhours	1.78
19	Total Aborts	3.20

Table F-5. F-15 and F-16 CONUS NOW Transformation Factors

F-15 Factors

003	Flight hr/mo/acft	-	67178/12/213	-	26.28
004	Landings/mo/acft	-	52606/12/213	-	21.
005	Sorties/mo/acft	-	52319/12/213	-	20.
007	Avg. Sortie Length hr.	-	given	-	1.284
015	Removals/mo/acft	-	0.984 * 26.28	-	25.86
016	Failures/mo/acft	-	1.6 * 26.28	-	42.05
017	Maint MH/mo/acft	-	40.013 * 26.28	-	1052.
018	Troubleshooting MH/mo/acft	-	1.188 * 26.28	-	31.22
019	Aborts/mo/acft	-	0.017 * 26.28	-	0.45

SOURCE DATA SUMMARY

F-15 TAC CONUS Oct. 83 - Sep. 84 - 12 Months

213 Average Possessed Aircraft

67,178 Total Flight Hours

1.277 Flight Hours per Landing

67,178/1.277 - 52,606 Total Landings

1.284 Flight Hours per Sortie

67,178/1.284 - 52,319 Total Sorties

0.984 Removals per Flight Hour

1.600 Failures per Flight Hour

40.013 Maint Manhours per Flight Hour

1.188 Troubleshooting Manhours per Flight Hour

0.017 Aborts per Flight Hour

Table F-5 (Concluded)

F-16 Factors

003	Flight hr/mo/acft	=	102683/12/301	=	28.43
004	Landings/mo/acft	=	81754/12/301	=	23.
005	Sorties/mo/acft	=	80,347/12/301	=	22.
007	Avg. Sortie Length hr.	=	given	=	1.278
015	Removals/mo/acft	=	0.496 * 28.43	=	14.10
016	Failures/mo/acft	=	0.925 * 28.43	=	26.30
017	Maint MH/mo/acft	=	20.307 * 28.43	=	557.33
018	Troubleshooting MH/mo/acft	=	0.879 * 28.43	=	24.99
019	Aborts/mo/acft	=	0.03 * 28.43	=	0.85

SOURCE DATA SUMMARY

F-16 TAC CONUS Nov. 83 - Oct. 84 = 12 Months

301 Average Possessed Aircraft

102,683 Total Flight Hours

1.256 Landings per Flight Hour

102,683/1.256 = 81,754 Total Landings

1.278 Sorties per Flight Hour

102,683/1.278 = 80,347 Total Sorties

0.496 Removals per Flight Hour

0.925 Failures per Flight Hour

20.307 Maint Manhours per Flight Hour

0.879 Troubleshooting Manhours per Flight Hour

0.03 Aborts per Flight Hour

Note. Use same factors for variables 10-14 as for 15-19.

Table F-6. Combined "F-15/F-16 CONUS NOW" Factors

F-15/F-16 CONUS average parameter values per month per aircraft. Table F-1 calculated values per month per aircraft for each type separately. Average values form a combined CONUS Technology operator.

003 Flight Hours/mo/acft = (28.43 + 26.28)/2 = 27.36 fh/mo/acft

004 Landings/mo/acft = (23 + 21)/2 = 22 lndgs/mo/acft

005 Sorties/mo/acft = (22 + 20)/2 = 21 sorties/mo/acft

007 Sortie Length = (1.278 + 1.284)/2 = 1.281 hr.

015 Removals/mo/acft = (14.10 + 25.86)/2 = 19.98 remvls/mo/acft

016 Failures/mo/acft = (26.30 + 42.05)/2 - 34.18 failures/mo/acft

017 Maint Manhour/mo/acft = (557 + 1052)/2 = 805 mmh/mo/acft

018 Troubleshooting Manhour/mo/acft = (24.99 + 31.22)/2 = 28.11 trbl/mo/acft

019 Aborts/mo/acft = (0.85 + 0.45)/2 = 0.65 aborts/mo/acft

Notes. Multipliers for variables 10-14 same as for variables 15-19. To calculate Technology Multiplier, ratio the above new technology aircraft parameter values against "NOW" CONUS values for each of the study aircraft (for RF-4, it will have to be ratioed against "THEN" values).

Table F-7. F-4 CONUS NOW Transformation Factors

003	Flight hr/mo/acft	-	212022/42/241	-	20.95
004	Landings/mo/acft	-	185984/42/241	-	18.
005	Sorties/mo/acft	-	164385/42/241	-	16.
007	Avg. Sortie Length hr.	-	given	-	1.29
015	Removals/mo/acft	-	1.274 * 20.95	-	26.69
016	Failures/mo/acft	-	1.933 * 20.95	-	40.50
017	Maint MH/mo/acft	-	22.884 * 20.95	-	479.42
018	Troubleshoot MH/mo/acft	-	1.89 * 20.95	-	39.60
019	Aborts/mo/acft	-	0.023 * 20.95	-	0.48

SOURCE DATA SUMMARY

F-4 TAC CONUS Oct. 79 - Mar. 83 - 42 Months

241 Average Possessed Aircraft

212,022 Total Flight Hours

1.14 Flight Hours per Landing

212022/1.14 - 185,984 Total Landings

1.29 Flight Hours per Sortie

212022/1.29 - 164,358 Total Sorties

1.274 Removals per Flight Hour

1.933 Failures per Flight Hour

22.884 Maint Manhours per Flight Hour

1.89 Troubleshooting Manhours per Flight Hour

0.023 Aborts per Flight Hour

Note. Use same factors for variables 10-14 as for 15-19.

Table F-8. F-4 Technology Multipliers = (F-15/F-16 CONUS NOW)/(F-4 CONUS NOW)

003	Flight Hours Multiplier	=	27.36/20.95	=	1.31
004	Landings Multiplier	=	22/18	=	1.22
005	Sorties Multiplier	=	21/16	=	1.31
007	Sorties Length Multiplier	=	1.281/1.29	=	0.99
015	Removals Multiplier	=	19.93/26.69	=	0.75
016	Failures Multiplier	=	34.18/40.50	=	0.84
017	Maint. Manhours Multiplier	=	805/479	=	1.68
018	Troubleshooting Manhour Multiplier	=	28.11/39.60	=	0.71
019	Aborts Multiplier	=	0.65/0.48	=	1.35

Note. Multipliers for variables 10-14 same as for variables 15-19.

Table F-9. F-4 CONUS THEN Source Data Sample

VARIABLE NUMBER	003	004	005	006	007	015	016	017	018	019
DATA CASES	FLIGHT HOURS	LANDINGS	SORTIES	AVERAGE POSSESSED AIRCRAFT	AVERAGE SORTIE LENGTH	REMOVALS PER FH	FAILURES PER FH	MAINT.MH PER FH	TROUBLESHT. MH PER FH	ABORTS PER FH
JAN 66 - JUN 66	43478	32857	24812	254	1.75	0.327	0.638	7.342	0.303	0.008
JAN 68 - 0.002 JUN 68		23690	21904	14501	99	1.63	0.144	0.186	1.809	0.085
JAN 71 - JUN 71	23792	22442	16389	142	1.45	2.218	2.739	30.571	1.460	0.032
JUL 71 - DEC 71	20704	21941	14753	163	1.40	2.116	3.035	34.444	2.024	0.027
JAN 73 - JUN 73	18206	21088	13201	128	1.38	2.022	3.035	34.866	1.679	0.033
30 TOTAL MONTHS	129870 TOTAL FH	120232 TOTAL LNDGS	83656 TOTAL SORTIES	786 TOTAL ACFT	7.61 TOTAL HR.	6.827 SAMPLE TOTAL	9.633 TOTAL	109.032 TOTAL	5.551 TOTAL	0.1011 TOTAL
AVER-AGES	4329 FH/MO	4008 LNDG/ MO.	2789 SORTIE/ MO.	157 AVG ACFT/ MO	1.52 AVG HR	1.365 AVG/ FH	1.927 AVG/ FH	21.806 AVG/ FH	1.110 AVG/ FH	0.020 AVG/ FH

Table F-10. F-4 CONUS THEN Transformation Factors

003	Flight hr/mo/acft	=	4329/157		=	27.57
004	Landings/mo/acft	=	4008/157		=	26.
005	Sorties/mo/acft	=	2789/157		=	18.
007	Avg. Sortie Length				=	1.52
015	Removals/mo/acft	=	1.365	* 27.57	=	37.63
016	Failures/mo/acft	=	1.927	* 27.57	=	53.13
017	Maint MH/mo/acft	=	21.806	* 27.57	=	601.19
018	Troubleshoot MH/mo/acft	=	1.110	* 27.57	=	30.60
019	Aborts/mo/acft	=	0.02	* 27.57	=	0.55

Note. Use same factors for variables 10-14 as for 15-19.

Table F-11. F-4 Time Multipliers = (F-4 CONUS THEN)/(F-4 CONUS NOW)

003	Flight Hours Multiplier	=	27.57/20.95	=	1.32
004	Landings Multiplier	=	26/18	=	1.44
005	Sorties Multiplier	=	18/16	=	1.13
007	Sortie Length Multiplier	=	1.52/1.29	=	1.18
015	Removals Multiplier	=	37.63/26.69	=	1.41
016	Failures Multiplier	=	53.13/40.50	=	1.31
017	Maint. Manhours Multiplier	=	601/479	=	1.25
018	Troubleshooting Manhour Multiplier	=	30.6/39.6	=	0.77
019	Aborts Multiplier	=	0.55/0.48	=	1.15

Note. Multipliers for variables 10-14 same as for variables 15-19.

Table F-12. F-4 PACAF THEN Source Data Sample

VARIABLE NUMBER	003	004	005	006	015	016	017	018	019
DATA CASES	FLIGHT HOURS	LANDINGS	SORTIES	POSSESSED AIRCRAFT	REMOVALS PER FH	FAILURES PER FH	MAINT MH PER FH	TROUBLESHT MH PER FH	ABORTS PER FH
ABEA0668	146	90	90	8	1.795	1.199	25.751	2.402	0.021
ABEA0768	59	37	37	5	2.593	2.542	43.868	3.993	0.034
ABEA0868	55	35	35	4	3.709	2.855	51.635	4.040	0.055
ABEA0968	46	29	29	3	2.739	2.565	55.409	5.874	0.022
ABGB0568	815	500	428	29	1.269	2.215	24.370	1.494	0.021
ABGB0668	654	446	391	25	1.448	3.131	35.398	3.000	0.023
ABGB0768	1976	748	736	19	0.686	1.201	14.767	1.021	0.013
ABGB0968	692	444	380	19	1.464	1.806	20.073	2.151	0.026
ABGE0568	1508	1050	896	43	0.245	0.769	6.449	0.575	0.003
ABGE0668	1201	768	715	32	1.066	1.075	17.372	0.832	0.009
ABGE0768	2662	1596	1554	26	0.658	0.851	12.337	0.988	0.014
ABGE0968	708	413	388	17	3.133	3.442	54.916	4.490	0.047
ABHC0668	154	2	2	11	2.409	1.578	20.153	1.325	0.026
ABHC0768	477	281	280	21	0.476	0.191	2.921	0.211	0.000
14 TOTAL MO	11153 TOTAL FH	6439 TOTAL LNDGS	5691 TOTAL SORTIES	262 TOTAL ACFT	23.690 SAMPLE TOTAL	25.420 TOTAL	385.419 TOTAL	32.396 TOTAL	0.314 TOTAL
AVER-AGES AVG/ FH	797 FH/MO	460 LNDG/ MO	426 SORTIE/ MO	19 AVG ACFT/	1.692 AVG HR	1.816 AVG/ FH	27.530 AVG/ FH	2.314 AVG/ FH	0.022 AVG/ FH

Table F-13. F-4 PACAF THEN Transformation Factors

003	Flight Hours/mo/acft	=	797/19		=	41.95 fh/mo/acft
004	Landings/mo/acft	=	460/19		=	24 lndgs/mo/acft
005	Sorties/mo/acft	=	426/19		=	22 sorties/mo/acft
007	Sortie Length	=	797/426		=	1.87 hr
015	Removals/mo/acft	=	1.692	* 41.95	=	70.979
016	Failures/mo/acft	=	1.816	* 41.95	=	76.176
017	Maint Manhour/mo/acft	=	27.530	* 41.95	=	1154.88
018	Troubleshooting MH/mo/acft	=	2.314	* 41.95	=	97.07
019	Aborts/mo/acft	=	0.022	* 41.95	=	0.923

Note. Use same factors for variables 10-14 as for 15-19.

Table F-14. F-4 Geographic Multipliers = (F-4 PACAF THEN)/(F-4 CONUS THEN)

003	Flight Hours Multiplier	=	41.95/27.57	=	1.52
004	Landings Multiplier	=	24/26	=	0.92
005	Sorties Multiplier	=	22/18	=	1.22
007	Sortie Length Multiplier	=	1.87/1.52	=	1.23
015	Removals Multiplier	=	70.97/37.63	=	1.89
016	Failures Multiplier	=	76.18/53.13	=	1.43
017	Maint. Manhours Multiplier	=	1155/601	=	1.92
018	Troubleshooting Manhour Multiplier	=	97.07/30.6	=	3.17
019	Aborts Multiplier	=	0.92/0.55	=	1.67

Note. Multipliers for variables 10-14 same as for variables 15-19.

Table F-15. F-4 SEA THEN Source Data Sample

VARIABLE NUMBER	003	004	005	006	015	016	017	018	019
DATA CASES	FLIGHT HOURS	LANDINGS	SORTIES	POSSESSED AIRCRAFT	REMOVALS PER FH	FAILURES PER FH	MAINT MH PER FH	TROUBLESHT MH PER FH	ABORTS PER FH
AAAB0566	2895	1807	1807	73	0.263	0.324	4.218	0.100	0.006
AAAB0666	4546	2474	2474	73	0.610	0.888	9.435	0.199	0.017
AAAB0568	3179	1933	1915	54	0.618	1.058	14.005	0.937	0.0006
AAAB0668	2783	1671	1665	49	0.848	1.280	14.912	0.990	0.008
AAAB0768	3769	1921	1858	54	1.067	1.671	18.849	1.372	0.009
AAAB0868	2050	1969	1878	54	1.590	1.954	27.572	1.951	0.015
AAAB0968	2525	1665	1658	52	1.115	1.795	24.776	1.735	0.010
AAAC0466	2619	797	797	74	0.519	0.608	6.641	0.192	0.011
AAAC0666	1367	522	522	24	0.813	1.136	11.116	0.414	0.018
AABE0466	2554	1506	1506	56	0.360	0.752	7.784	0.378	0.009
AABE0566	2445	1337	1337	55	0.453	1.167	10.397	0.475	0.013
AABE0666	2536	1666	1666	57	0.451	1.303	9.761	0.448	0.013
12 TOTAL MO	33268 TOTAL FH	19268 TOTAL LNDGS	19083 TOTAL SORTIES	675 TOTAL ACFT	8.707 SAMPLE TOTAL	13.936 TOTAL	159.466 TOTAL	9.191 TOTAL	0.135 TOTAL
AVER-AGES	2772 FH/MO	1606 LNDG/MO	1590 SORTIE/MO	56 AVG ACFT	0.726 AVG/FH	1.161 AVG/FH	13.289 AVG/FH	0.766 AVG/FH	0.011 AVG/FH

Table F-16. F-4 SEA THEN Transformation Factors

003	Flight Hours/mo/acft	-	2772/56	-	49.50
004	Landings/mo/acft	-	1606/56	-	29.
005	Sorties/mo/acft	-	1590/56	-	28.
007	Sortie Length	-	2772/1590	-	1.74
015	Removals/mo/acft	-	0.726 * 49.50	-	35.94
016	Failures/mo/acft	-	1.161 * 49.50	-	57.47
017	Maint Manhour/mo/acft	-	13.289 * 49.50	-	658.
018	Troubleshooting MH/mo/acft	-	0.766 * 49.50	-	37.92
019	Aborts/mo/acft	-	0.011 * 49.50	-	0.55

Note. Use same factors for variables 10-14 as for 15-19

Table F-17. F-4 Combat Multipliers - (F-4 SEA THEN)/(F-4 PACAF THEN)

003	Flight Hours Multiplier	-	49.50/41.95	-	1.18
004	Landings Multiplier	-	29/24	-	1.21
005	Sorties Multiplier	-	28/22	-	1.27
007	Sortie Length Multiplier	-	1.74/1.87	-	0.93
015	Removals Multiplier	-	35.94/70.97	-	0.51
016	Failures Multiplier	-	57.47/76.18	-	0.75
017	Maint. Manhours Multiplier	-	658/1155	-	0.57
018	Troubleshooting Manhour Multiplier	-	37.92/97.07	-	0.39
019	Aborts Multiplier	-	0.55/0.92	-	0.60

Note. Multipliers for variables 10-14 same as for variables 15-19.

Table F-18. F-4 UPDATE Transform Multipliers

F4UM = Technology * Time * Geographic * Combat

003	Flight Hours Multiplier	= 1.31 * 1.32 * 1.52 * 1.18	= 3.10
004	Landings Multiplier	= 1.22 * 1.44 * 0.92 * 1.21	= 1.96
005	Sorties Multiplier	= 1.31 * 1.13 * 1.22 * 1.27	= 2.29
007	Sortie Length Multiplier	= 0.99 * 1.18 * 1.23 * 0.93	= 1.34
015	Removals Multiplier	= 0.75 * 1.41 * 1.89 * 0.51	= 1.02
016	Failures Multiplier	= 0.84 * 1.31 * 1.43 * 0.75	= 1.18
017	Maint Manhour Multiplier	= 1.68 * 1.25 * 1.92 * 0.57	= 2.30
018	Troubleshoot Manhour Multiplier	= 0.71 * 0.77 * 3.17 * 0.39	= 0.68
019	Aborts Multiplier	= 1.35 * 1.15 * 1.67 * 0.60	= 1.56

Note. Multipliers for variables 10-14 same as for variables 15-19.

Table F-19. F-4 CONUS THEN Source Data Sample

VARIABLE NUMBER	003	004	005	006	07	015	016	017	018	019
DATA CASES	FLIGHT HOURS	LANDINGS	SORTIES	AVG POSSESSED AIRCRAFT	SORTIE LENGTH	REMOVALS PER FH	FAILURES PER FH	MAINT MH PER FH	TROUBLESHT MH PER FH	ABORTS PER FH
BCCS0166 1 BCCS0666	7563	7263	3931	39	1.92	0.180	0.502	9.219	0.486	0.0067
BCCS0766 1 BCCS1266	10575	10356	5596	69	1.89	0.014	0.030	0.571	0.038	0.0005
BCCS0172 1 BCCS0672	22248	15519	12201	148	1.82	1.030	1.698	23.516	0.916	0.0111
18 TOTAL MO.	40386 TOTAL FH	33138 TOTAL LNDGS	21728 TOTAL SORTIES	256 TOTAL ACFT	5.63 TOTAL HR	1.225 SAMPLE TOTAL	2.230 TOTAL	33.306 TOTAL	1.440 TOTAL	0.0183 TOTAL
AVER-AGES	2244 FH/MO	1841 LNDG/MO	1207 SORTIE/MO	85 AVG ACFT/MO	1.88 AVG HR	0.408 AVG/FH	0.743 AVG/FH	11.102 AVG/FH	0.480 AVG/FH	0.0061 AVG/FH

Table F-20. RF-4 CONUS THEN Transformation Factors

003	Flight Hours/mo/acft	=	2244/85		= 26.40
004	Landings/mo/acft	=	1841/85		= 22
005	Sorties/mo/acft	=	1207/85		= 14
007	Sortie Length	=	given		= 1.88
015	Removals/mo/acft	=	0.408	* 26.4	= 10.77
016	Failures/mo/acft	=	0.743	* 26.4	= 19.62
017	Maint Manhour/mo/acft	=	11.102	* 26.4	= 293
018	Troubleshooting MH/mo/acft	=	0.48	* 26.4	= 13
019	Aborts/mo/acft	=	0.0061	* 26.4	= 0.16

Table F-21. RF-4 SEA THEN Source Data Sample

VARIABLE NUMBER	003	004	005	006	007	015	016	017	018	019
DATA CASES	FLIGHT HOURS	LANDINGS	AVG SORTIES	POSSESSED AIRCRAFT	SORTIE LENGTH	REMOVALS PER 1000 FH	FAILURES PER 1000 FH	MAINT MH PER 1000 FH	TROUBLSHT MH PER 1000 FH	ABORTS PER 1000 FH
BAAF0466	1121	531	531	18	2.11	198.03	875.11	9593.13	208.65	2.67
BAAF0566	1022	552	537	17	1.90	395.30	1471.62	12901.76	294.22	6.84
BAAF0766	1323	637	632	18	2.09	201.05	303.85	4032.19	110.95	3.77
BAAF0171	878	465	392	18	2.24	1492.02	1925.96	30540.66	1439.97	25.05
BABF0671	923	441	443	22	2.08	1152.76	2157.09	32495.77	855.90	14.08
BABF1071	1140	453	449	19	2.54	1079.82	1786.84	26199.47	756.4C	21.92
BABF0172	957	469	470	19	2.04	1167.18	1809.82	23900.73	1024.24	18.80
BABF0472	1151	492	392	18	2.94	806.25	1609.90	16070.37	480.53	8.68
BABF0772	1151	493	484	19	2.38	1299.73	2042.57	23249.43	820.76	17.37
BABF0872	1102	462	457	20	2.41	963.70	1949.18	18959.98	708.07	15.42
BABF0972	998	463	461	17	2.16	1128.25	1673.34	20868.03	713.82	23.04
BABF1272	916	403	403	19	2.27	1001.09	1858.07	20441.37	857.86	20.74
12 TOTAL MO	12682 TOTAL FH	5861 TOTAL LNDGS	5653 TOTAL SORTIES	224 TOTAL ACFT	27.16 TOTAL HR	10885.18 SAMPLE TOTAL	25326.76 TOTAL	239252 TOTAL	8272 TOTAL	178.48 TOTAL
AVER-AGES	1057 FH/MO	488 LNDG/MO	471 SORTIE/MO	19 AVG ACFT/MO	2.26 AVG HR	0.907 AVG/FH	2.111 AVG/FH	19.938 AVG/FH	0.689 AVG/FH	0.015 AVG/FH

Table F-22. RF-4 SEA THEN Transformation Factors

003	Flight Hours/mo/acft	=	1057/19	=	55.63
004	Landings/mo/acft	=	488/19	=	26
005	Sorties/mo/acft	=	471/19	=	25
007	Sortie Length	=	given	=	2.26
015	Removals/mo/acft	=	0.907 * 55.63	=	50.46
016	Failures/mo/acft	=	2.111 * 55.63	=	117.44
017	Maint Manhour/mo/acft	=	19.938 * 55.63	=	1109
018	Tblesht MH/mo/acft	=	0.689 * 55.63	=	38
019	Aborts/mo/acft	=	0.015 * 55.63	=	0.83

Note. Use same factors for variables 10-14 as for 15-19.

Table F-23. RF-4 UPDATE Transform Multiplier Calculations

RF-4 UM = (F-15/F-16 CONUS NOW)*(RF-4 SEA THEN)/(RF-4 CONUS THEN)^2

003	Flight Hours UM	=	(27.36) * (55.63)/(26.40)^2	=	2.18
004	Landings UM	=	(22) * (26)/(22)^2	=	1.18
005	Sorties UM	=	(21) * (25)/(14)^2	=	2.68
007	Avg Sortie Length UM	=	(1.28) * (2.26)/(1.88)^2	=	0.82
010	Removals by System UM	=	(19.93) * (50.63)/(10.77)^2	=	8.70
011	Failures by system UM	=	(34.18) * (117.44)/(19.62)^2	=	10.43
012	MMH by System UM	=	(805) * (1109)/(293)^2	=	10.40
013	Trblesht MH by System UM	=	(28) * (38)/(13)^2	=	6.30
014	Aborts by System UM	=	(0.65) * (0.83)/(0.16)^2	=	21.07
015	All Removals UM	=	Same as 10		
016	All Failures UM	=	Same as 11		
017	Total MMH UM	=	Same as 12		
018	Total Trblesht MH UM	=	Same as 13		
019	Total Aborts UM	=	Same as 14		

Table F-24. A-7 CONUS NOW Transformation Factors

003	Flight hr/mo/acft	=	54222/36/63	=	23.92
004	Landings/mo/acft	=	34758/36/63	=	15
005	Sorties/mo/acft	=	34536/36/63	=	15
007	Avg. Sortie Length hr.	=	given	=	1.57
015	Removals/mo/acft	=	0.668 * 23.91	=	15.97
016	Failures/mo/acft	=	1.158 * 23.91	=	27.69
017	Maint MH/mo/acft	=	10.515 * 23.91	=	251.41
018	Troubleshoot MH/mo/acft	=	0.739 * 23.91	=	17.67
019	Aborts/mo/acft	=	0.017 * 23.91	=	0.41

SOURCE DATA SUMMARY

A-7D TAC CONUS Jan 79 - Dec 81 = 36 Months

63 Average Possessed Aircraft

54,222 total Flight Hours

1.57 Flight Hours per sortie

54,222/1.57 = 34.536 Total Sorties

1.56 Flight Hours per Landing

54,222/1.56 = 34,758 Total Landings

0.668 Removals per Flight Hour

1.158 Failures per flight Hour

10.515 Maintenance Manhours per Flight Hour

0.739 Trouble-shooting Manhours per Flight Hour

0.017 Aborts per Flight Hour

Note. Use same factors for variables 10-14 as for 15-19.

TABLE F-25. A-7D SEA THEN Source Data Sample

VARIABLE NUMBER	003	004	005	006	007	015	016	017	018	019
DATA CASES	FLIGHT HOURS	LANDINGS	SORTIES	AVG POSSESSED AIRCRAFT	SORTIE LENGTH	REMOVALS PER FH	FAILURES PER FH	MAINT MH PER FH	TROUBLESHT MH PER FH	ABORTS PER FH
CABA0173	3663	1536	1536	66	2.38	0.613	1.566	15.591	0.729	0.0082
CABA0273	3820	1556	1517	67	2.52	0.571	0.967	13.831	0.503	0.0055
CABA0573	12975	1297	1297	66	2.83	0.548	1.077	15.422	1.017	0.0114
3 TOTAL MO	11154 TOTAL FH	4389 TOTAL LNDGS	4350 TOTAL SORTIES	199 TOTAL ACFT	7.73 TOTAL HR	1.732 SAMPLE TOTAL	3.610 TOTAL	44.844 TOTAL	2.249 TOTAL	0.0251 TOTAL
AVER-AGES	3718 FH/MO	1463 LNDG/ MO	1450 SORTIE/ MO	66 AVG ACFT/ MO	2.58 AVG HR	0.577 AVG/ FH	1.203 AVG/ FH	14.948 AVG/ FH	0.750 AVG/ FH	0.0084 AVG/ FH

Table F-26. A-7 SEA THEN Transformation Factors

003	Flight Hours/mo/acft	= 371/66		= 5.62
004	Landings/mo/acft	= 1463/66		= 22
005	Sorties/mo/acft	= 1450/66		= 22
006	Avg. Possessed Acft	= given		= 66
007	Avg. Sortie Length	= 3718/1450		= 2.56
015	Removals/mo/acft	= 0.577	* 56.05	= 32.34
016	Failures/mo/acft	= 1.203	* 56.05	= 67.43
017	Maint Manhour/mo/acft	= 14.948	* 56.05	= 837.84
018	Trblesht MH/mo/acft	= 0.750	* 56.05	= 42.04
019	Aborts/mo/acft	= 0.0084	* 56.05	= 0.47

Note. Use same factors for variables 10-14 as for 15-19.

Table F-27. A-7 UPDATE Transform Multiplier Calculations

A-7 UM=(F-15/F-16 CONUS NOW) *(A-7 SEA THEN)/(A-7 CONUS NOW)^2

003	Flight Hours UM	= (27.36) * (56.05)/(23.91)^2	= 2.68
004	Landings UM	= (22) * (22)/(15)^2	= 2.15
005	Sorties UM	= (21) * (22)/(15)^2	= 2.05
007	Avg Sortie Length UM	= (1.28) * (2.56)/(1.57)^2	= 1.33
010	Removals by System UM	= (19.93) * (32.34)/(15.97)^2	= 2.53
011	Failures by System UM	= (34.18) * (16.47)/(27.69)^2	= 0.73
012	MMH by System UM	= (805) * (838)/(251)^2	= 10.71
013	Trblesht MH by System UM	= (28) * (42)/(18)^2	= 3.63
014	Aborts by System UM	= (0.65) * (0.47)/(0.41)^2	= 1.82
015	All Removals UM	= Same as 10	
016	All Failures UM	= Same as 11	
017	Total MMH UM	= Same as 12	
018	Total Trblesht MH UM	= Same as 13	
019	Total Aborts UM	= Same as 14	

TABLE F-28. C-130 SEA THEN Source Data Sample

VARIABLE NUMBER	003	004	005	006	015	016	017	018	019
DATA CASES	FLIGHT HOURS	LANDINGS	SORTIES	AVG POSSESSED AIRCRAFT	REMOVALS PER FH	FAILURES PER FH	MAINT. MH PER FH	TROUBLE SHT MH PER FH	ABORTS. PER FH
DAAF0671	1889	1082	1091	25	1.283	2.392	24.326	1.364	0.0185
DAAF0572	5680	3717	3913	43	0.357	0.631	5.931	0.459	0.0055
DAAF0672	4998	3531	3631	47	0.550	0.892	8.454	0.649	0.0096
DAAF0872	3744	2222	2191	24	0.469	0.692	7.072	0.540	0.0072
DAAF1072	3299	1364	1351	19	0.235	0.350	3.311	0.259	0.0064
DABA0672	1581	317	138	8	0.639	1.890	17.222	0.871	0.0082
DABF0171	1603	344	158	6	0.726	1.007	15.786	0.786	0.0019
DABF0371	1624	148	109	6	0.579	1.156	13.954	0.689	0.0025
DABF0971	1599	383	142	7	0.731	1.900	17.594	1.009	0.0038
DABF1171	1837	473	156	8	0.468	1.290	14.907	0.986	0.0060
DABF0172	1713	349	148	8	0.649	1.847	16.516	0.912	0.0064
DABF0272	1563	288	133	8	0.905	1.991	17.755	0.973	0.0102
DABF0372	985	131	85	9	1.523	4.717	31.204	1.693	0.0223
DABF0472	302	38	27	2	0.752	4.467	16.335	0.987	0.0132
14 TOTAL MO.	32417 TOTAL FH	14387 TOTAL LNDGS	13273 TOTAL SORTIES	220 TOTAL ACFT	9.866 SAMPLE TOTAL	25.222 TOTAL	210.367 TOTAL	12.159 TOTAL	0.0217 TOTAL
AVER-AGES	2316 FH/MO	1028 LNDG/MO	948 SORTIE/MO	16 AVG/ACFT/	0.705 AVG/FH	1.802 AVG/FH	15.026 AVG/FH	0.869 AVG/FH	0.0087 AVG/FH

Table F-29. C-130 SEA THEN Tranformation Factors

003	Flight Hours/mo/acft	= 2316/6	= 386
004	Landings/mo/acft	= 1028/16	= 65.
005	Sorties/mo/acft	= 948/16	= 60.
007	Avg. Sortie Length hr.	= 2316/948	= 2.44
015	Removals/mo/acft	= 0.705 * 147.35	= 103.88
016	Failures/mo/acft	= 1.802 * 147.35	= 265.525
017	Maint Manhour/mo/acft	= 15.026 * 147.35	= 2214.
018	Trblesht MH/mo/acft	= 0.869 * 147.35	= 128.
019	Aborts/mo/acft	= 0.0087 * 147.35	= 1.281

Note. Use same factors for variables 10-14 as for 15-19.

Table F-30. C-130 CONUS WORLD NOW Transformatiom Factors

003	Flight hr/mo/acft	=	461570/42/163	=	67.42
004	Landings/mo/acft	=	491607/423/163	=	72.
005	Sorties/mo/acft	=	199237/42/163	=	29.
007	Avg. Sortie Length hr.	=	given	=	2.32
015	Removals/mo/acft	=	0.734 * 67.42	=	49.49
016	Failures/mo/acft	=	1.625 * 67.42	=	109.56
017	Maint MH/mo/acft	=	12.205 * 67.42	=	822.86
018	Troubleshoot MH/mo/acft	=	1.062 * 67.42	=	71.60
019	Aborts/mo/acft	=	0.006 * 67.42	=	0.40

SOURCE DATA SUMMARY

C-130 MAC WORLD Oct 79 - Mar 83 = 42 Months

163 Average Possessed Aircraft

461,570 Total flight Hours

0.94 Flight Hours per Landing

461,570/0.94 = 491,607 Total Landings

2.32 Flight Hours per Sortie

461570/2.32 = 199,237 Total Sorties

0.734 Removals per Flight Hour

1.625 Failures per Flight Hour

12.205 Maintenance Manhours per Flight Hour

1.062 Trouble-shooting Manhours per Flight Hour

0.006 Abort per Flight Hour

Note. Use same factors for variables 10-14 as for 15-19.

Table F-31. C-130 UPDATE Tranform Multiplier Calculations

C-130 UM = (C-130 SEA THEN)/(C-130 WORLD NOW)

003	Flight Hours UM	=	(147.35)/(67.42)	=	2.19
004	Landings UM	=	(65)/(72)	=	0.90
005	Sorties UM	=	(60)/(29)	=	2.07
007	Avg Sortie Length	=	(2.44)/(2.32)	=	1.05
010	Removals by System	=	(103.84)/(49.49)	=	2.10
011	Failures by System	=	(265.46)/(109.56)	=	2.42
012	MMH by System	=	(2214)/(823)	=	2.69
013	Trblesht MH by System	=	(128)/(72)	=	1.78
014	Aborts by System	=	(1.281)/(0.4)	=	3.20
015	All Removals	=	Same as 10		
016	All Failures	=	Same as 11		
017	Total MMH	=	Same as 12		
018	Total Trblesht MH	=	Same as 13		
019	Total Aborts	=	Same as 14		