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TSAR USER'S MANUAL: VOLUME II. DATA INPUT, PROGRAM OPERATION AN--ETC(U)

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A RAND NOTE

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Donald E. Emerson

February 1982

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Prepared For The United States Air Force

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This Note is one of five documents that collectively describe the TSAR and TSARINA computer models developed to assess the effect of air attacks on the sortie generation capabilities of air bases. The Theater Simulation of Airbase Resources (TSAR) model provides an analytic context within which a variety of airbase improvements may be tested. The present volume of the User's Manual is intended primarily for those responsible for preparing input materials and for operating the TSAR simulation model.

PREFACE

This Note is one of five documents that collectively describe the TSAR and TSARINA computer models developed at The Rand Corporation to assess the effect of air attacks on the sortie generation capabilities of air bases. This development was carried out under the Project AIR FORCE Resource Management Program project entitled, " Strategies To Improve Sortie Production in a Dynamic Wartime Environment."

The Theater Simulation of Airbase Resources (TSAR) model provides an analytic context within which a variety of airbase improvements may be tested. New passive defenses, new maintenance doctrine, modified manning levels, improved base repair and recovery capabilities, increased stock levels for parts and equipment, etc., as well as concepts for improved theater-wide resource management, all can be examined for their effect on aircraft sortie generation. These models have been briefed to several Air Force organizations during the development process.

This volume of the User's Manual is intended primarily for those responsible for preparing input materials and for operating the TSAR simulation model. The companion documents include:

R-2584-AF An Introduction to the TSAR Simulation Program: Model Features and Logic

N-1460-AF TSARINA--User's Guide to a Computer Model for Damage Assessment of Complex Airbase Target.

N-1820-AF TSAR User's Manual: Vol. I--Program Features, Logic, and Interactions

N-1822-AF TSAR User's Manual: Vol. III--Variable and Array Definitions, and Other Program Aids for the User

Other documents are planned that will discuss the problems associated with data acquisition for these models and will present the procedures currently under development at Rand to assist in solving those problems.

ACKNOWLEDGMENTS

The development of the TSAR computer model demanded uninterrupted concentration over an extended period. My debts to the Air Force and to Rand management are obvious. Not so obvious are the debts owed my most understanding family, who endured my total absorption in TSAR's development for over three years.

Among my colleagues at Rand, I would particularly like to acknowledge Lou Wegner and Michael Poindexter for their many helpful ideas and suggestions for dealing with a variety of programming problems, Major John Halliday and Milton Kamins for their ideas that have been incorporated into TSAR logic and for their careful work in creating the data bases that were used for TSAR development, and Mary Jo Parise for her patience and effective support in preparing the originals and innumerable revisions of the input formats and other graphic material for the TSAR documentation.

CONTENTS

GLOSSARY

AGE	Aerospace ground equipment and other equipment used for carrying out various tasks
AIS	Avionics Intermediate Shops; special test equipment used for repairing avionic LRUs and SRUs.
BLSS	Base-level self sufficiency stock of aircraft spare parts
CAP	Combat Air Patrol
CAS	Close Air Support
CILC	Centralized Intermediate Logistics Concept
CIRF	Centralized Intermediate Repair Facility
COB	Collocated Operating Base
COMO	Combat Oriented Maintenance Organization
CONUS	Continental United States
FRAG	Framentary order that specifies flight requirements
LCOM	Logistics Composite Model
LRU	Line replaceable unit; an aircraft spare part
MOB	Main Operating Base
NMCS	Not mission capable because of lack of spare parts
NORS	Not operationally ready because of lack of spare parts; same as NMCS
NRTS	Not reparable this station
OST	Order and ship time in days
PAA	Program Aircraft Authorized
POL	Petroleum, oils and lubricants; often used as an abbreviation for aircraft fuel
POS	Peacetime operating stock; an organization's stock of aircraft spare parts for aircraft maintenance in peacetime

RAM	Rapid area maintenance; special mobile teams used for repairing aircraft battle damage
RR	Flight line maintenance that removes and replaces malfunctioning aircraft parts with serviceable components
RRR	Flight line maintenace that removes, repairs, and replaces aircraft spare parts (actually, usually removes and replaces with a serviceable unit, and then repairs malfunctioning unit)
RRR	Rapid runway repair
SAMSOM	Support Availability Multi-System Operations Model
SCL	Standard combat load that designates the mission dependent munitions to be loaded
SRU	Shop replaceable unit; a component of an LRU
TRAP	Tanks, racks, adaptors and pylons
TSAR	Theater Simulation of Airbase Resources
TSARINA	TSAR Inputs using AIDA
WRM	War Reserve Material
WRSK	Wartime readiness spares kit

XVI. INTRODUCTION

Volume II of the User's Manual is intended primarily for those responsible for preparing input materials and for operating the TSAR computer simulation model. Volume III will prove useful for those interested in modifying and extending the program logic, or in trying to understand apparent errors.

TSAR is a Monte Carlo discrete-event simulation model designed for analyzing the interrelations among the resources associated with a set of airbases, and the capability of those airbases to generate aircraft sorties in a dynamic, rapidly evolving wartime environment. On-equipment maintenance tasks, parts and equipment repair jobs, munitions buildup jobs, and facilities repair tasks can be simulated for each of up to 63 airbases, as well as intra-theater transportation, communication, and resource management. Asset accounting for each of 11 classes of resources, and for each type within each class, permits assessment of a broad range of policy options that could improve the efficiency of resource utilization on a theater-wide basis.

An important objective in the original design formulation of TSAR was to achieve a sufficiently high speed of operation that the extensive (often trial and error) sequence of runs so frequently necessary in research and analysis would be economically practical. Adaptation of existing models (e.g., LCOM, SAMSOM) was rejected for several reasons, including the extent of the modifications that would have been required and the prohibitive costs that would be associated with their use for problems of the size that were contemplated. The initial phase of development was designed to test the hypothesis that speed would be improved if custom-tailored list processing techniques were created using the widely available FORTRAN language, rather than using standard simulation language packages, and if full advantage were taken of the large amounts of directly accessible computer memory that are now available. The resultant custom-designed program achieves a substantially higher speed than previously developed simulation models of equivalent and lesser complexity.

In its current formulation, TSAR makes no intermediate use of auxiliary high-speed storage units (e.g., disks, tapes) except for storing the initial conditions for multiple trials. To constrain the substantial computer storage requirements generated by this design feature, all but a handful of the program variables and array elements occupy only two bytes of core, and many of the array elements are packed with two and sometimes three, four, or even five pieces of information.

TSAR now consists of 120 subroutines and 12 functions (with 236 entry locations); the source code consists of over 34,000 card images, exclusive of that required for the common statements. Without the space required for the data storage arrays, approximately 520K bytes are required for the program, when only the input-related subroutines are overlaid. If certain features are not to be used (e.g., airbase attack, theater management of aircraft or other resources, and parts initialization) this requirement can be reduced by overlaying the subroutines associated with the unused features. For the substantial dimensions shown in the example in Fig. 17 in Section XXI, another 550K bytes are required for data storage. However, many useful applications of TSAR would require only an additional 50 to 100K bytes for storage. The auxiliary SIZE.TSAR.STORAGE program quickly estimates the user's requirements. All data that would be needed to resume operation in the event that processing was interrupted (as might be done, for example, if one wished to adapt the program for interactive operation) are in COMMON statements.

OUTLINE OF MATERIALS

The materials in this volume and the extensive comments included in the TSAR source code[1] are designed to help those responsible for preparing input materials and for operating TSAR. The next section outlines the classes of resources that TSAR can deal with, and discusses certain built-in numerical constraints that the user must observe.

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[1] The TSAR source code will be made available to qualified agencies on magnetic tape.

Section XVIII outlines the procedures that are to be used in restructuring TSAR storage space for each user's special requirements. Since essentially all data are retained in core during execution, core management discipline will dictate occasional program redimensioning, when the character of the situation to be simulated changes greatly.

Section XIX is the key source of information for the use of TSAR; it is the only location in which all of TSAR's features and controls are explained. Section XIX provides extensive discussions and explanations of the appropriate data entry procedures for the 50-plus data entry formats that are used with TSAR. Each discussion presents a copy of the data input format and sample entries to illustrate the use of each form. When options exist, each is illustrated.

A special sample problem has been developed to illustrate TSAR's many features, the data entry procedures, and the appearance of TSAR output. This sample is introduced in Section XX; the situation simulated (with a few exceptions and modifications) is defined by the same data that are introduced piecemeal in Section XIX to illustrate the input procedures. Section XXI presents portions of the computer output listing for this sample problem and illustrates the various kinds of information that can be obtained.

Appendixes A and B in Volume III present full alphabetical listings, with definitions, for all control variables and for all data storage arrays that are contained in any of TSAR's common statements. These will be helpful for better understanding the discussions in the User's Manual and for gaining a more detailed understanding of TSAR's data structure; they will be essential for anyone who works with the source code.

The other appendices in Volume III present a brief listing of the various subroutines currently incorporated into TSAR, a copy of the load module map that indicates in which subroutine each entry point can be found, a list of subroutine statements, entry statements, and call statements in the order in which they occur in the source code, a list of the labeled common statements used by each subroutine, and a summary of the Job Control Language required to execute TSAR, or TSAR and TSARINA.

DATA REQUIREMENTS

TSAR input data requirements naturally depend upon the level of detail at which the simulation is to be conducted and the features that are to be used. Many sources are available that can contribute to these requirements. Of the different types of data, probably the most complex and difficult to obtain are those that define the demands and resources for unscheduled maintenance and parts repair for different types of aircraft. Fortunately many of these data are collected on a regular basis for various purposes by the Air Force, including spare parts provisioning and manning studies. The data bases generated for LCOM (Logistics Composite Model) studies probably provide the best assimilations of these data that are currently available.

One such data base, obtained from Hq TAC, was manually converted into the form required by TSAR and was used extensively in the test calculations that were carried out in developing TSAR. Unscheduled aircraft maintenance was represented by some 300 different tasks that involved about the same number of parts. Work to develop a method by which the manual data reorganization that was required can be largely automated is now essentially complete, and input data have been generated for the F-4E, F-15, F-16, and A-10 aircraft.

XVII. RESOURCE LIMITATIONS

Eleven distinct classes of resources may be monitored using TSAR, but only aircraft are mandatory. The 11 classes of resources, the number used to identify each class, the arrays in which their status is stored, and the restrictions on the numbers of types and the numbers of each type are:

RESOURCE CLASS Name	RESOURCE CLASS Number	STORAGE ARRAY	MAXIMUM NUMBER OF TYPES	NUMBER PER TYPE PER BASE	MAXIMUM NUMBER SHIPPED PER LOT
Aircraft	#8	ACN	9	999	250
Aircrews		PILOT	1 per ac type	--	250
Shelters		BASES	1 per base	999	--
Ground Personnel	#1	PEOPLE	320	320	250
AGE and Equipment	#2	AGESTK	99	127	250
Parts (LRU,SRU)	#3	PARTS	3199	320	250
					250
Munitions	#4	MUNSTK	99	32000	6250
(Assembled and unassembled)					6250
TRAP	#5	TRAP	99	32000	6250
Building Materials	#6	MATERL	99	32000	250
POL	#7	POLSTK	1	32000	$250 \times (10^2)$
Other Facilities	#9	FACLTY	250	1	--

The status data maintained for each of the several classes of resources are listed in the corresponding storage array descriptions in Appendix B. Aircraft, aircrews, facilities, and reparable spare parts are monitored on an individual basis; all others are handled in more aggregated terms. The level of detail varies from that maintained for an aircraft--potentially several dozens of items of information--down to a simple tally of the numbers of shelters and the amount of POL available at each airbase.

Although not explicitly treated as a resource (except insofar as physical damage thereto may be reflected in the FACLTY array), the work-centers, or shops, on each base are the entities around which aircraft maintenance activities and the parts and equipment repair activities are organized. Except for civil engineering resources, all ongoing, interrupted, and waiting jobs are locatable using the pointers stored in the SHOPS array; as noted in Appendix B, that array stores 26 data elements for each shop on each base. TSAR storage arrays are sized for a maximum of 30 shops, the last five of which are reserved for preflight tasks and weapons assembly jobs.

The subroutines that prepare resources for intra-theater shipment (SHPRES) and that receive inter-theater and intra-theater shipments (DOSHIP), are written to accommodate ground personnel, AGE and equipment, parts, munitions, TRAP, building materials, and POL. However, the only theater resources that are actually transferred within the theater using the current theater management logic are ground personnel, AGE and equipment, and parts; all resources may be received from CONUS. Similarly, the program logic permits aircraft and spare aircrews to be ferried to the theater from CONUS, and allows aircraft to be ferried from base to base within the theater for maintenance and to be directed to land at a different base than the one from which they are scrambled on a combat sortie.

XVIII. DIMENSIONING AND REDIMENSIONING

For many study applications it will be appropriate and necessary to redimension various portions of TSAR's data storage arrays. All the arrays are listed below, and their dimensions are defined in terms of variables that are in COMMON (see Appendix A in Vol. III). When the user's data demands a different amount of space for storage, or if the problem can be projected to require a substantially different amount of space for queuing the internally generated event data (e.g., tasks in process, interrupted, and waiting), the dimension can be changed in all necessary locations with a single text editor command. Definitions of the variables used to dimension these arrays, and the arrays themselves, are listed alphabetically in Appendixes A and B respectively, in Volume III.

A special auxiliary program called SIZE.TSAR.STORAGE has been written to facilitate the necessary preparatory steps for redimensioning TSAR. All storage arrays are located in one of 25 different COMMON statements, and these statements are inserted into the appropriate subroutines by referring to their individual locations in storage; by this means, only one change is required to redimension any given array in all the locations in which it ultimately appears. This process is outlined in detail in the comments in the INIT subroutine, and in the SIZE.TSAR.STORAGE program that will be provided for any agency that acquires the TSAR simulation.

The dimensions of all arrays in all COMMON statements are shown in the list below using the variable that the program associates with each dimension. The appropriate value for many of the array dimensions will be uniquely identifiable by the nature and data of the user's problem. However, the dimensions needed for the data generated dynamically during the simulation are not knowable, a priori. Some experience with the particular application will be needed if space is to be conserved and data (tasks, jobs, shipments, etc.) are not to be lost; OVERFL permits the user some flexibility for dealing with this problem. The temporary queues in subroutine DELAYS may also overflow, but a warning to that effect is printed. Arrays with deterministic requirements are in the first of the following lists; the queues and heaps are listed second.

Many of the arrays are dimensioned by MAXM, MAXT, and MAXB--i.e., the maximum numbers of missions, aircraft types and bases.

These dimensions are abbreviated here as	M,	T,	and B.
The limits for these dimensions are	5,	9,	and 63.

DETERMINISTIC DIMENSION REQUIREMENTS

ACA(3,M,T,B)	ACDATA(30,T)
ACMDTA(20,M,T)	ACN(MAXACN,40)
ADELAY(24,2,B)	AGEREP(NOAGER,6)
AGERPT(NOAGE,8)	AGERQT(NOAGE,M,T)
AGESTK(NOAGE,3,B)	AIDALT(T)
AISDTA(NOSTAT,5)	AISUSE(NOSTAT,5,B)
ALERT(6,M,T,B)	ALTAGE(NOAGE,3)
ALTPEO(NOPEOP,3)	AQPEOP(NOPEOP,5)
ATTACK(LTHATT,5)	ATTDLY(2,B)
AVGP(3,30,B)	AVGREP(25,T)
AVGSHP(B)	AVGTSK(25,T)
BASES(50,B)	
BORROW(NOUSER,2)	BPARTS(15,T,B)
BSOR(B)	CANCEL(5,T,B)
CANFLY(3,M,T,B)	CANNTM(NOPART)
CARGO(NCARGO,2)	CEPRTY(NOFAC)
CERQTS(8,NOCE)	CHCKED(NOPART)
CIRFTM(24)	CKFILL(T)
CONFIG(NOCONF,8)	CONUS(NOCONS,2)
COSTS(NOPART)	CSTOCK(NOPART,2)
CTPEO(NOPEOP)	CTPEOP(NOPEOP,5)
DAMAGE(NOITEM,2)	DEPOT1(NOPEOP)
DEPOT2(NOAGE)	DEPOT3(NOPART)
DEPOT4(NOMUN)	DEPOT5(NOTRAP)
DEPOT6(NOMATL)	DEPOT8(T)
FACDAM(NOFAC,6)	FACLTY(7,NOFAC,B)
FILLER(T,2)	FRACBS(NOPART,B)
FRACJB(NOFAC)	FTAXI(2,B)
GTLMT(NOPART)	INPIPE(NOPART,B,2)
IPIPE(NOPART,2)	HURRY(B,5,2)
ITEMS(B)	JOBDTA(20,2)
JOBPR(2,T)	LANDNG(B)
LATERL(B)	LISTIN(LTHLST)
MATERL(NOMATL,B)	MAXOFF(2,T)
MUNRQD(NOMUN,M,T)	MUNRQT(4,NOBILD)
MUNSTK(NOMUN,4,B)	MXTASK(9)
NOR(B)	NORHRS(B)
NSTAT(NOSTAT,2,B)	OFFBSE(2,50,2,T)
OFFCOB(NOPART,T)	OFFMOB(NOPART,T)
OUTAGE(2,NOAGE,B)	OUTFAC(2,NOFAC,B)
OUTMAT(2,NOMATL,B)	OUTMUN(2,NOMUN,B)
OUTPER(2,NOPEOP,B)	OUTPOL(2,B)
OUTPRT(2,NOPART,B)	OUTSHP(6,30,B)
OUTTRP(2,NOTRAP,B)	OUTPT1(5,6,M,T,B)
OUTPT2(3,3,25,B)	OUTPT3(2,M,T,B)
OUTPT4(2,30,M,B)	OUTPT5(5,30,B)
PARTRQ(NOPART,T)	PARTS(NOPART,5,B)
PEOPLE(NOPEOP,7,B)	PEORPT(2,NOPEOP,B)
PEORQT(NOPEOP,M,T)	PERIOD(20,3)
PILOT(5,NOCREW)	PILOTS(5,T,B)
POLICY(NOPART,B,2)	POLSTK(B)
+PRTCRT(NOPRT,2)	+PRTLST(NOPRT)

PRTRPT(4,NOPART,B)	PRTRQ(NOPART,2,T)
PTZ(M,T,B)	RECORD(NSCROL,3,MAXREC)
REDUCE(B,5,2)	REFILL(2,9)
RELIMP(33,5)	REPALT(NOREPA,4)
REPORT(NOREPT,4)	REPRQT(NOREP,8)
RINDEX(4,9)	ROOTS(NOPART,T)
SAVE(B,5,2)	SCLP(5,M,T,2)
SCLRQT(NOSCL,9)	SEEDED(10)
SEEDS(10)	SHIP(NOSHIP,7)
SHIPSC(NOSHP,3)	SHIPTM(B,B,3)
SHIPTO(B,20,2)	SHOPAG(NOAGE)
SHOPEO(NOPEOP)	SHOPRQ(30,M,T)
SHOPS(26,30,B)	SHORT(NOPART)
SHPORD(50,T,B)	SHPT(B,B,4)
SHPTSK(3,NOTASK,25,T)	SICK(NOPEOP)
SORCAP(T,B)	SORDEF(16,3,M,T,B)
SORTHR(24,B)	SPARE(2,M,T,B)
SRFRAC(B,2)	STAFF(NOPEOP,2)
START(6)	STOP(6)
SVEFLT(12,5)	TCONF(M,M,T)
TEMPF(50,4)	THDATA(4,3)
TOCIRF(NOPART,2)	TOTALS(NOPART,B,3)
TPART(EXTPRT,3,B)	TRAP(NOTRAP,8)
TRAPRQ(2,3,T)	TRAY(NOPART)
TRAYS(NOTRAY)	TRAYST(NOTRAY,2,B)
TRYFLY(6,T,B)	TSKALT(NOTSKA,5)
TSKCRT(99,5)	TSKPR(25,T,3)
TSKRQT(NOTSK,15)	WXDATA(WXDAYS,2,B)
XMIT(4,B)	XSTAT(10,30,B)
XXSTAT(10,30)	ZPRTRQ(NOPART)
ZTASKS(5,T,B)	

+NOPRT must at least equal the highest part or LRU number.

DYNAMIC DIMENSION REQUIREMENTS

Queues and Heaps

BACKLG(5,LLQ)	BUILDQ(LBQ,10)
CEJOBQ(LTHCEQ,9)	CHANGE(NOCHG,5)
DEFTSK(LDT,4)	FLTRQT(LFQ,10)
INTTSK(LIQ,10)	LIMBO(NLIMBO,6)
NORQ(NNOR,3)	PRDFLT(MAXPER,5)
REJOIN(NJOINT,2)	
REPQ(LRQ,11)	RESUPP(LGQ,5)
RQDTSK(LNT,2)	SHIPQ(NOPKG,3)
TASKQ(LTQ,16)	WAITSK(LWQ,13)

XIX. DATA ENTRY

The data requirements for TSAR are substantial, and it is mandatory that the user observe the specifications outlined here. Even though TSAR checks input data for a considerable number of possible errors, possibilities for error remain and great care should be exercised with data entry. Careful adherence to the data-entry-form specifications is advised.

Data entry is accomplished using the (approximately) 50 distinct card formats illustrated in this section. With few exceptions (to be outlined) all cards are read with the same format (I2,I3,15I5) and all data must be right-adjusted. The number of the Card Type appears in the first two-column field. The second field (Cols 3-5) is occasionally referred to as the "J" field. Although there are only a few constraints on the actual order in which the cards are arranged, data organization will generally be simplified and fewer errors incurred if the various card types are entered in numerical order.

The proper organization of a card deck of TSAR input data is illustrated in Fig. 1. As will be noted, several special control cards are needed, in addition to the formatted input data cards. The first input card controls which of the numbered input cards are to be listed as a part of the printed record of the job. That card is followed by Card Types #1 through #4, including whatever comment cards the user has added after Card Type #1; these cards define the user's selection of the primary control data, as will be described shortly. Descriptions of the various kinds of jobs, the quantities of resources available at each of the airbases, specifications for the transportation and communications systems, etc. are entered next using Card Types #5 through #49. The end of this large set of input cards is designated with a Type #99 Card; and following that is another special card that controls which, if any, of the initialized contents of the data storage arrays are to be listed in the printed record of the job.

The sortie demand data (Type #50 Cards) and any transportation schedule changes (Type #60 Cards) conclude the input data deck. These cards may be arranged in several groups that are to be read at different

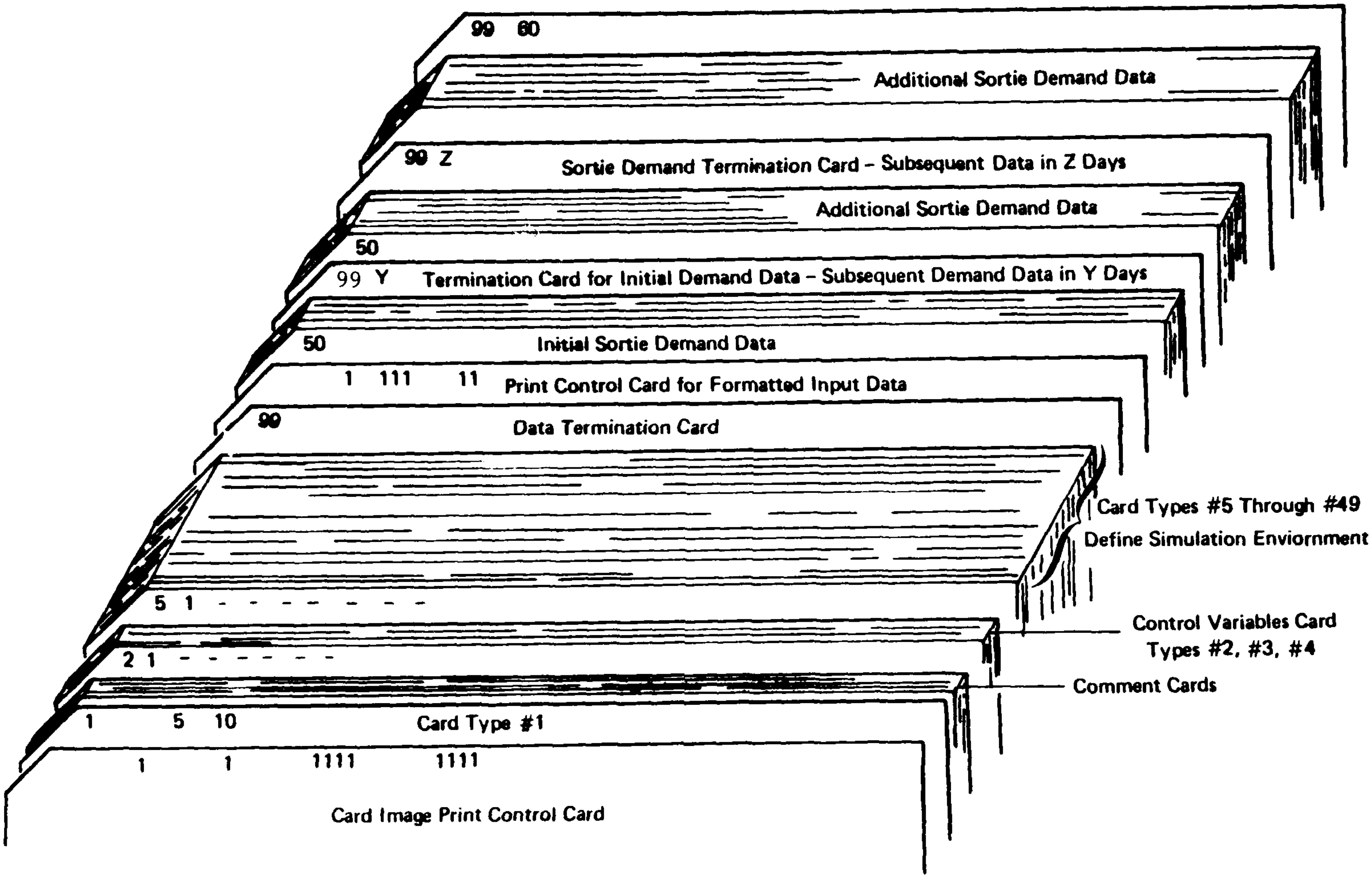

Fig. 1 — Organization of TSAR input data card images

times during the simulation; the last of the first group of such cards is denoted by another Type #99 Card that specifies (in the "J" field) the day of the simulation when the next group of sortie demand data are to be read. As noted in Fig. 1, each subsequent group of sortie demand data cards is also terminated with a Type #99 Card and each of these cards must specify how many simulated days are to elapse before additional sortie demand data should be input.

Most data for TSAR are stored as half-words (two-byte integers), and many of the half-words are packed with 2, 3, 4, or 5 pieces of data. Since TSAR was designed to be compatible with a 32-bit-word machine (e.g., IBM), the largest integer that may be stored in a half word is 2^{15} -1. The number 32750 is occasionally used in the code to denote "infinity" and the user must exercise care that no larger number is entered in any of the five-column fields. (When 50,000 units of fuel were inadvertently provided an airbase in an early test run, the quantity was recorded as negative, and all sorties were grounded.)

One consequence of these data storage features is that time is subdivided into three-minute increments referred to as TTU--TSAR time units--and the maximum length of time that should be simulated per trial is 65 days; to generate a single history of greater length, it is necessary to use the EXTEND feature (see Card Type #1).

The Card Type descriptions that follow each include (a) the entry form formats,[1] (b) a description of the nature of the data requirements and (c) comments on the occasional nonstandard formats. As will be noted in many places on the card formats, the data are sometimes packed automatically on input--i.e., when two or more data items are read in the same five-column field.

Although TSAR will be compatible with machines that use more than 32 bits for a word, it will not function properly on a machine that uses a shorter word. For those installations at which half-words (*2 integers) are not available, data storage requirements will be nearly doubled, but no difficulties should be encountered with the "packed" data.

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[1] Master copies of these entry forms will be made available to those who obtain a tape copy of the TSAR program.

Each of the shops and each of the sets of resource requirements (e.g., tasks, repairs, combat loadings and their alternatives), as well as each of the various types of the various resources, are identified within the model by a number. That number also designates the column of an array in which the data regarding that entity are stored. The user must:

- Name each such element that is involved in his problem with a number,
- Assure that that number is no greater than the size of the storage array for that class of information and that only one number of that class has that number,
- Maintain lists (dictionaries) of such definitions, external to the program, to avoid confusion,
- Assure the accuracy of all cross-references within the input data that involve these user-specified entity names.

TSAR PRIMARY CONTROL DATA

Card Types #1 through #4, shown in Fig. 2, provide for entry of key TSAR control variables. These cards should be at the beginning of the user's card deck and should be entered in numerical order. All data must be right-adjusted. The many control variables that the user sets with Card Types #1 through #4 either define operating conditions for the simulation, activate (or deactivate) TSAR's optional features, or delineate the user's choice among optional operating modes.

Two special convenience features may be invoked with Card Types #1 and #2/1. If the user desires to have his output headed by N lines of descriptive material, the number N is entered in columns 3-5 on Card Type #1, and N card images are then mandatory before card Type #2/1 is read; there are no restrictions as to the format for these descriptive materials.

The first control variable on Card Type #2/1 is TEST. A null entry is appropriate for normal operation, but a variety of intermediate

Card Type																
CONTROL VARIABLES																
1		SIMLTH Days	INTRIAL	EXTEND	SEED	NBASE	NTYPE	CREWS	BUILD	TSAR	CMODE	CONSIG				AIDA
OUTPUT CONTROL VARIABLES																
2	1	TEST	VERIFY	PRINT	SCROLL Days	SCROLL 1st AC	OVERFL	STATFQ	CUMSTA	NONUNI	YT'S	CEWORK	ATRISK	CEPEO	CEAGE	CRBLDG
REPETITIVE RANDOM NUMBER STREAMS																
2	2	Sortie Demand	Intra-Theater Transport	Resource Status Reports	Zero-Time Shop Activity	Task Uncertainty						ADAPTR Percent	SEEKSH	SHPREP	NRTPDL	TUDOLY
		Enter "-1" if stream should not repeat trial-to-trial														
OPERATIONS CONTROL VARIABLES																
3	1	OPSBSE	POSTPN	IGNORE	CONCUR	LTHOEF	CANMOD	MXHOLF	DOCANN	CANMUL	CANSRU	CRASH	ORDIT(R)	ORDER1	ORDER2	INDEX
AIRCRAFT MANAGEMENT CONTROL VARIABLES																
3	2	JOBCDN	FILLAC	FLEVEL	MNTLMT Hr / Min	MNTF Percent	MNTR Percent	QUIK	RPARTS Percent	MAXMNT Hr / Min	EMERG	NOFUEL	UNCEP Distri No.	VBREAK	OLDATA	NEWDTA
AIRCRAFT PARTS GENERATION																
3	3	OUTFIT	PHODE	PPRINT	RANDM	FULL	SHORT	HIATUS Days	TOOFEW	K1LOW	K2LOW	ZNORS	NEWPRT	NPART	CHNRTS	FSALVG Percent
MISCELLANEOUS TIME FACTORS																
4	1	SLEEP Hr	REST Min	ENDAY Hr	EXPED	LOADTM Hr / Min	LSTTOD Hr / Min	OVERTH Min	DOWNTM Hr	COFLAY Min	PRGTM Min	CEDELY Min	SHPDLY Min	PROTME Min	Q4TH Hr	CHINT Hr
												PLANNING TIME HORIZON*				
4	2	STATE	SELECT	MULTI1	MULTI2			NOSAVE		NOPOMO Min			HR / TH	HR / TH	HR / TH	HR / TH

* Planning horizon extends TH hours when time of day less than HR hours, but greater than prior HR

Fig. 2 -- Primary Control Variables

debugging data may be obtained by initializing this variable. For positive entries between 1 and 15, an ever increasing amount of such data will be printed for all trials. If the entry is -1, the volume of such output can be reduced by limiting debugging output to one, or up to six, specific periods of simulated time during a specific trial: When this is done, a single card image must immediately follow Card Type #2/1, which specifies the trial, the time intervals, and the value for TEST during those time intervals. This card is read as I3, I2, 12I5; the order of data entry is TTRIAL, TEST, START(1), STOP(1), . . . , START(6), STOP(6). If the trial number (TTRIAL) is not specified, the output will occur during the first trial. The times are to be entered in TSAR time units (i.e., 3 minute time intervals); one to six time intervals may be specified and the intervals must be entered in the order of their occurrence.

Card Type #1

If J is not zero, J comment cards must follow this card

SIMLTH	Length in days of the period to be simulated.
NTRIAL	Number of repetitions of the simulation.
EXTEND	If unity, an NTRIAL simulation produces a single history NTRIAL × SIMLTH days in duration.
SEED	If set equal to a nonnegative integer, the operating system selects a reproducible value for the SEED of the random-number generator; if set to zero the SEED is selected by a random process.
NBASE	Number of bases that will launch or recover aircraft (may be less than or as great as MAXB).
NTYPE	Number of aircraft types to be used in the simulation (may be less than or as great as MAXT).
CREWS	Air crews are accounted for when = 1; neglected if 0.
BUILD	Switch; when unity, the munitions assembly features are activated.
TSAR	If unity, resources are managed centrally; if set to "2" the highest numbered base will act as a centralized intermediate repair facility that does not operate aircraft--i.e., no aircraft "belong" to this base.
CMODE	When not zero defines the mode of operation for theater resource management (see Section XI).
CONSIG	If zero, any parts that are shipped to the theater to replace condemned parts, and LRUs that were NRTSed to CONUS, are consigned to the base of origin on return; if unity, all parts are consigned to the theater manager for distribution.
AIDA	Controls the interpretation of base damage data; normally not to be specified by the user, but to be entered with the airbase damage data.

Card Type #2/1

TEST — Controls internal debugging features. If >0 diagnostic messages are printed for the entire simulation; if - 1, a special card must follow defining the time intervals for the debug output.

VERIFY — Controls input data testing features. If = 1 or 2, limited tests are made on input; if = 3, each input card is checked by subroutine TESTER; if ≥2, operation is terminated after initialization.

PRINT — Value controls content of simulation output (see Section XV).

SCROLL — Provides aircraft activity reports for the specified number of days for up to 24 aircraft, starting with the aircraft number specified.

OVERFL — Value controls simulation behavior if the dimensions of the arrays used to store internally generated data are exceeded:

When OVERFL = 0, simulation stops;
= 1, overflow noted and tallied;
= 2, overflow noted for first entry and tallied;
= 3, overflow tallied.

This feature must be used with caution because program behavior can become extremely erratic when certain types of records are discarded. In any event execution is terminated automatically at the end of any day if the cumulative number of discarded records is 20 or more.

STATFQ — The frequency, in days, with which the summary data regarding the average length of time for tasks and jobs, and the causes and lengths of the aircraft delays, are printed. If STATFQ = 0, these data are not collected or printed.

CUMSTA — Controls the cumulation of task and delay time data; when 0, data are cumulated separately for each trial; when 1, data are cumulated across all trials.

NONUNI — When unity, resource losses are determined by a sample from the binomial distribution; if zero, losses are determined on a straight percentage, or expected value basis.

XTEST — If initialized when VERIFY = 2, TEST is set to XTEST for the last portion of the initialization process carried out by subroutine TRIALS.

CEWORK Switch; when unity, civil engineering resources are allocated to repair damage from airbase attacks in accord with the priorities defined by the CEPRTY array.

ATRISK When a shop facility, or all elements of a distributed shop, are damaged at the time of a subsequent attack, the resources assigned to that shop are assumed to have been relocated and to be invulnerable if ATRISK is zero; if ATRISK is unity, the damage is assessed as though operations were normal.

CEPEO The number of types of personnel associated (exclusively) with civil engineering tasks.

CEAGE The number of types of equipment associated exclusively with civil engineering tasks.

CRBLDG Unless civil engineering resources are sufficient to initiate repairs to all damaged facilities up to and including this priority, reconstruction tasks are pursued with secondary procedures using lesser resources.

Card Type #2/2

TSAR provides ten distinct random number streams that are repeated from trial to trial. These streams can be disengaged only if the user enters a "-1" in the Nth field on Card Type #2/2 to disengage the Nth stream.

At this time, only five of the random number streams are used. The first random number stream (col 6-10) is used in the generation of TSAR's aircraft sortie demands; the second is used for selecting the intra-theater transportation schedules; the third is for generating resource status reports; the fourth is for selecting the zero-time shop activity controlled by Card Type #42; and the fifth is used in generating "actual" task probabilities for unscheduled maintenance when UNCER is not zero. Random streams six (col 31-35) through ten (col 51-55) currently are available for additional applications.

AUXILIARY CONTROL VARIABLES

ADAPTR	NRTS policy for RR parts is changed when there are fewer LRUs than ADAPTR percent of the initial LRU stocks; they are shipped to a lateral resupply base rather than nominal NRTS destination if the NRTS rate at that base is lower than at the base where the reparable was generated.
SEEKSH	When unity, another in-theater shop is sought for parts repair, when the nominal shop is closed by damage.
SHPREP	When not zero, all parts repaired at an operating base are shipped to the base that is selected with the SEND logic in the CONTROL subroutine, when (On-base NORS Aircraft - Required Parts) is greater than, or equal to, SHPREP.
NRTPOL	If unity, an LRU that requires an SRU that is unavailable and is not normally stocked, is NRTSed.
TODOCK	If unity, parts that are normally NRTSed to another base, but can't be because no shipment schedule exists, are held for later lateral repair rather than being sent to CONUS.

Card Type #2/3

This special Card Type is only used during debugging operations; it permits the user to repeat a specific trial of a prior run by entering the value of the seed for the random number generator that was printed at the beginning of that trial. The value should be right adjusted in columns 6-20.

Card Type #2/4

This card, in conjunction with the variable PRINT, can be used to obtain periodic data that define how deferred aircraft tasks are distributed among the aircraft at each airbase. The day and hour for the first report should be entered in the first data field (col 6-10) and the period between subsequent reports should be entered in the second data field (also in days and hours). If the user wishes to distinguish between all deferred tasks, and those that "belong" to some subset of the shops, the shop numbers for that special set of shops should be entered in fields three through twelve (i.e., a maximum of 10 "critical" shops).

Card Type #3/1

OPSBSE	Number of airbases that may launch combat sorties; excludes rear maintenance bases, the emergency recovery base (EMERG), and a centralized intermediate repair facility, if any.
POSTPN	If zero, all unscheduled maintenance tasks must be accomplished before next flight; if = 1, tasks will be deferred (postponed) that are not critical for next mission.
IGNORE	If initialized to unity, all jobs that may be deferred for all missions, are ignored.
CONCUR	If unity, battle damage repair jobs may be initiated concurrently with the first of the other unscheduled maintenance tasks; otherwise, the battle damage tasks are scheduled to be accomplished first.
LTHDEF	Unscheduled maintenance tasks whose criticality is greater than 66 may be deferred ("back-pocketed") for a maximum of LTHDEF sorties.
CANMOD	Cannibalization mode (see Section V).
MXHOLE	The maximum number of "holes" that may be created on a single aircraft by cannibalization (default = 10000).
DOCANN	When DOCANN is greater than zero, parts for which the CANNTM is less than -1 may be cannibalized if the number of aircraft that require the part at the base is greater than DOCANN.
CANMUL	Nominal task time when a part is cannibalized; expressed as a percentage of the nominal time for the task segment that specifies the part (default = 150 percent).
CANSRU	If not zero, the SRUs are stripped from one of two or more LRUs that are waiting for repair, when aircraft are NORS because of that LRU. At a CIRF, an LRU will be be similarly salvaged, if the total NORS count in the theater is greater than or equal to the value of CANSRU.
CRASH	When runways are closed at all operating bases (and at any emergency base) recovering aircraft will be lost if this variable is initialized to unity; if not initialized, the sortie length is artifically extended such that the aircraft will land after the runway at the planned recovery base has been opened.

ORDIT — Interrupted tasks and repairs are prioritized when ORDIT = 1; FIFO if 0. See Sections V, VII, and XI for discussions of priority schemes.

ORDWT — Waiting tasks and repairs are prioritized when ORDWT = 1; FIFO if 0. See Sections V, VII, and XI for discussions of priority schemes.

ORDER1 — Threshold controlling theater response to parts shortages; responds only if (Enroute Parts + On-base Reparables - Required Parts) is less than or equal to ORDER1. Response is increasingly restricted for ever lower values of ORDER1.

ORDER2 — Threshold controlling an operating base's recourse to lateral resupply; seeks lateral resupply only if (On-base Reparables - Required Parts) is less than or equal to ORDER2. (Reparables are assessed only if the shop is open and functioning)

INDEX — A threshold used when checking repair jobs waiting at a CIRF; if exceeded as jobs are checked, the job is processed without checking for a higher priority job. The appropriate value to set will depend upon which of the two logics (SHOPRY = 1 or 2) is in use.

Card Type #3/2

These entries jointly control TSAR's mechanisms for replacing lost and heavily damaged aircraft and for transferring and/or augmenting aircraft with extended maintenance requirements.

JOBCON — Defines which jobs are to be accomplished when an aircraft is sent to a rear maintenance base:

If = 1, the maintenance scheduled for the rear-base includes all mandatory rear-base tasks, all other required tasks, and all mission dependent deferred tasks that must be done in rear;
If = 2, above plus all mission dependent deferred tasks;
If = 3, above plus all deferred tasks;
If = 4, aircraft is returned to operating base with all non-rear-base tasks remaining.

FILLAC — Value controls use of filler aircraft:

If = 1, only aircraft losses are replaced from the filler force;
If = 2, aircraft transferred to the rear for battle damage repair are also replaced;
If = 3, any aircraft transferred to the rear is replaced;
If = 4, base aircraft are augmented as for FILLAC = 2, and when an aircraft's on-base battle damage repair time is expected to exceed MAXMNT hours;
If = 5, base aircraft are augmented for any of previous conditions and when an aircraft's unscheduled maintenance is expected to exceed MAXMNT hours.

FLEVEL — The value of FLEVEL affects the decision to augment on-base aircraft and controls the disposition of aircraft repaired at a rear base and aircraft that are transferred from CONUS to the filler pool. To requisition an augmentee aircraft, or to return aircraft from the rear, the on-base aircraft must satisfy the condition noted below:

If = 0, number of aircraft less than the number of assigned aircraft;
If = 1, number of non-battle-damaged aircraft less than the number of assigned aircraft;
If = 2, number of aircraft less than the base's shelter capacity;
If = 3, number of non-battle-damaged aircraft less than the base's shelter capacity.

When these conditions are not met, newly repaired and aircraft newly arrived from CONUS are consigned to the filler pool.

MNTLMT — Aircraft whose projected ready-to-fly time exceeds MNTLMT hours are transferred to a rear-area base for maintenance, if the time projected to ready the aircraft for a one-way ferry flight is less than the time for the remaining maintenance, and if the constraints imposed by MNTF and MNTR (below) are also satisfied.

MNTF
MNTR — Candidates for transfer to a rear-area base that are projected to require as much as MNTF percent of the time that would be needed at the rear-area base to be readied for the ferry flight will be transferred only if the estimated maintenance time at the rear-area base exceeds MNTR percent of MNTLMT hours.

QUIK — Filler aircraft used to replace combat aircraft that are transferred to the rear for maintenance are launched at the same time the combat aircraft initiates the ferry flight if QUIK is zero; if QUIK is unity, the filler is launched as soon as the combat aircraft has landed and it is decided that it will be ferried to the rear. The time for the ferry flight is entered on Card Type #20/77.

RPARTS — When the automatic parts generation feature is used, RPARTS percent of the parts procured for the forward operating bases will be placed at the rear-area maintenance base(s); these are in addition to those that are transferred to the rear because of tasks that must be handled in the rear.

MAXMNT — If maintenance of on-base aircraft is projected to extend beyond MAXMNT hours, the base will be augmented with a filler aircraft if FILLAC is 4 or 5, and an aircraft is available.

EMERG — Number of the emergency recovery base; when specified will be used for aircraft recovery when the runways at all other bases have been closed; this base may not be used for a CIRF. The task sequence cards have a unique requirement at this base (see p. 80).

NOFUEL — If unity, other preflight tasks are prohibited when refueling is being conducted.

UNCER — When initialized with the number of a distribution from the TTIME Subroutine, the "actual" unscheduled maintenance task probabilities used in the simulation are determined by selecting a value from that distribution, assuming the mean is the value entered by Card Type #7.

VBREAK A switch. If zero or -1, unscheduled maintenance task probabilities are modified in proportion to the Card Type #44 entries. If unity the basic probabilities are varied by shop and aircraft type as a function of achieved sortie rate. If set to -1 or +1, the basic values are used for estimating average shop task times, average resource requirements (in BSECAP) and initial parts stocks.

OLDATA Base resource reports are generated when zero, and deferred initially while equal to unity.

NEWDTA The time at which theater resource reports are to be initiated; only applicable if OLDATA is initialized as zero.

Card Type #3/3

The following control variables control the automatic generation of base parts stocks, when that option is elected. (See Section VII-1 and Subroutine IPARTS in Vol. III.)

OUTFIT	Activates the automatic parts stock initialization.
PMODE	When unity, parts initialization of WRSKs approximates DO-29; otherwise the Chapter 11 procedures from AFM 67-1 are used.
PPRINT	Controls output summaries of the initial stock levels and the parts pipelines (see subroutine IPARTS). When increased by 10, residual parts levels are listed after the delay statistics controlled by STATFQ. When increased by 20, the initial listing includes parts generated by IPARTS and those entered manually.
RANDM	When unity, parts shortages and the location of parts in the pipelines are determined with samples from the Poisson approximation of a binomial distribution.
FULL	If unity, all parts are on base, none enroute, at zero time (identified as NOPIPE in Common).
SHORT	Parts shortfalls from "authorized" levels (percent) that result from system-wide shortages.
HIATUS	Delivery of parts in pipeline at the beginning of the simulation are to be delayed HIATUS days.
TOOFEW	The parts supply system is critically short of a percentage of the parts (equal to TOOFEW/10) because of insufficient numbers system-wide; part numbers are selected at random.
K1LOW K2LOW	For parts that are "critically short" the actual stock level, as a percentage of the nominal requirement, is selected at random in the range K1LOW to (K1LOW + K2LOW).
ZNORS	When initialized to unity, parts that were not available to be placed in the pipeline during parts initialization because of shortages, are obtained by removing them from an aircraft--i.e., by creating a NORS condition. If ZNORS is zero, a message noting the shortage is printed.
NEWPRT	If NEWPRT is unity, the parts initialization computations are repeated for each trial.

NPART	The number of the highest numbered LRU or SRU. (default = NOPART)
CHNRTS	When spare parts generated by the automatic parts initialization logic are augmented using basic Type #23 Cards, the NRTS rates during the simulation will be the values in the POLICY array if CHNRTS is zero; if CHNRTS is unity the NRTS value on the basic Type #23 Card will be used.
FSALVG	If an aircraft is damaged by air attack and is not reparable, FSALVG percent of the aircraft's spare parts not destroyed during the attack are salvaged and added to the serviceables.

Card Type #4/1

SLEEP	Minimum number of off-duty hours between shifts for the aircrews.
REST	Minimum number of minutes between flights for an aircrew.
ENDAY	End of the nominal flying day (used to control accomplishment of deferred maintenance) (hours).
EXPED	When initialized, the parts repair administrative delays are reduced to 1/EXPED of the nominal time, if there are no serviceables.
LOADTM	Nominal time to commence preflight preparation for the day (hour-minute).
LSTTOD	Last time for commencing morning preflight (used to limit expected time for deferred tasks) (hour-minute).
OVERTM	Number of minutes of overtime permitted.
DOWNTM	Parts may not be cannibalized from an aircraft with a ready-to-fly time within "DOWNTM" hours.
CDELAY	The default time for cannibalization is one-half the related on-equipment task time, plus CDELAY minutes.
PKGTM	Number of minutes required to package resources for an intra-theater shipment.
CEDELY	Initiation of all reconstruction tasks is delayed by this number of minutes after an airbase attack, to account for the preliminary delays involved in overcoming the disruptive effects of fires, roadway damage, etc.
SHPDLY	This delay is introduced to all on- and off-equipment aircraft-related tasks, to account for the disruption following an airbase attack.
PROTME	When insufficient aircraft are ready for a scheduled flight, and none can be found in the spare queue or a lower priority alert, an aircraft can be taken from another scheduled flight of the same or lower priority if the flight time is at least PROTME minutes later (default = 30 minutes).
C4TM	Time for initial theater resource review-hours.
C4INT	Time interval in hours between periodic theater resource reviews, subsequent to the initial review.

Card Type #4/2

STATE	If not zero, the state of each base's capability to generate sorties is computed daily (see Section XI-1).
≥ 1	Base-state-data used to select base for diversion
≥ 2	Base-state-data used to decide when aircraft recover at their parent base (see MULTI1)
≥ 3	Aircraft base assignment reorganized nightly when work-loads are disproportionate (see MULTI2)
SELECT	When not zero, a daily summary of the assigned sorties is prepared to facilitate selection of bases for sorties.
≥ 1	Summary data used when base not specified
≥ 2	Summary data used for reallocating demands on airbases with closed runways
MULTI1	When a base's projected sortie generation capability per assigned aircraft is greater by MULTI1 percent than that of the parent base of an aircraft, that aircraft is retained and not returned to the parent.
MULTI2	Aircraft reassignment (STATE = 3) activated among bases whose projected sorties per available aircraft differ by more than MULTI2 percent.
NOSAVE	When NOSAVE = 1 records are not saved for parts that break after an air attack has closed the shop that would normally process the repaire; if the projected shop reconstitution time is not earlier than the end of the simulation.
NOPOMO	The average additional on-equipment task time that is required at a base operating under 66-1, when the data apply to 66-5 activities. (REDUCE is set to - NOPOMO)
HR-TH	The time horizon used with the sortie supply and demand projections may be changed from the default values with these entries; for example, if the entries are 8-12, 24-16 the time horizon would be 12 hours from 0 to 0800 and 16 hours from 0801 until midnight.

Card Type #4/3

SPARE1 ... SPARE9	Provides nine unassigned variables that are available in the BASIC labeled common statement for temporary use with user contrived logic.

SPECIFICATION OF TASK CRITICALITY AND AIRCRAFT STATUS

The importance of each aircraft maintenance task for each of the missions that that type of aircraft may be scheduled to fly is specified with a two-digit number between 1 and 99. The capability of each particular aircraft to fly a particular type of mission at any given time is also expressed with a number generated in the same way.

The interpretation of these numbers is specified in Table 1. When the task criticality or the aircraft flying status is specified by one of the numbers along the top, its status for a particular type of mission is recorded in the row corresponding to that mission. If the entry is 1, the task is critical for that mission, or the aircraft has a task that has been deferred that prevents that mission from being flown. If task criticality is 32, the aircraft may be ferried; if it is 33, the aircraft is grounded until the task has been accomplished.

If a task may be deferred only until the end of the day, task criticality is increased by 33; if a task may be deferred only for LTHDEF sorties, task criticality is increased by 66.

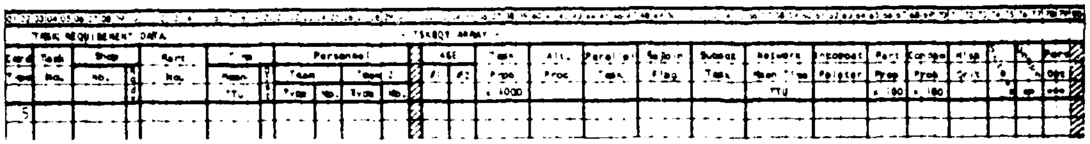
Table 1

CRITICALITY CHART

MISSION	TASK CRITICALITY or AIRCRAFT STATUS																																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1
2	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	1
3	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1
4	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

RESOURCE REQUIREMENTS DATA

Card Type #5



On-equipment aircraft maintenance tasks are entered here: These can include scheduled maintenance, unscheduled maintenance and battle damage tasks. As explained in Section V, the organization and sequencing of all aircraft maintenance tasks, other than battle damage repair work, are controlled independently for each aircraft type at each airbase using Card Type #29. Tasks may be handled either individually or as collections of unscheduled tasks associated with the various work centers or shops. The first 24 shops should be used for such task collections; Shop #25 (the "flight line" shop) and the preflight Shops #27, #28 and #29, are handled somewhat differently (see Section V and VI) and have a "flexible overtime" policy. (Periodic scheduled maintenance tasks could also be included if TSAR were to be modified to keep a record of total flight time, and to conduct those tasks as required.)

Resource requirements (time, personnel, equipment, and parts) are entered following the cognizant shop number and the number of the part, if any, that is associated with the task. If the shop facility itself is required for the task, or if the task must be accomplished at a rear base, those constraints are specified by the entry in column 10 (see note to Fig. 3).

If the base is structured in a 66-5 organization (COMO), and specialists of the type required are assigned at squadron level, the numerical designation of personnel assigned to the first squadron shall be specified for the task. Equipment specifications are handled in a comparable manner. All resource data are "packed." If only one set of specialists or one piece of equipment is required, it should be entered in the left position. If one of the two sets of personnel is a "load team" (see Card Type #15/1) it must be placed in the left position. As will be noted, the number of the first of any alternative procedures should be entered in columns 40-43.

Task networks are specified by the entries in the columns provided for subsequent and parallel task numbers, and for the rejoin flags. All segments of a task network are to be associated with the same shop, even though personnel and equipment must be borrowed from another shop for some of the task segments. Task networks will be "chained" if the last entry of a network limb is the root segment for another network. Care must be taken that no two networks can both point to the other.

In a task network, any segment that specifies a part may be followed immediately by a task that can be made to be contingent on whether a part is required; if a part is not required, the task so designated will be skipped and subsequent tasks will be considered immediately. This option is activated by placing a -1 in the part column of a single task, or of members of a set of parallel tasks. (See illustration in Section V of Volume I.)

The task probability entered with Card Type #7 determines usage for the root segment of tasks entered with the shop collections. The task probabilities entered in columns 36-39 with Card Type #5 only apply to the segments of a task network that follow the root segment and to most tasks that are handled individually (the only exceptions are the tasks for loading basic munitions, which are controlled by the probabilities that such munitions are retained from the previous missions, which are entered with the mission data on Card Type #16).

When a network splits into two or more parallel paths, some of the several paths may be mutually exclusive, others not mutually exclusive; the sign of the task probability for the task segments that begin each parallel path defines how that path is to be treated. All paths for which the task probability is negative are treated as mutually exclusive; tasks with positive probabilities are not mutually exclusive.

If any parallel paths later rejoin, the number of the task segment that immediately follows that junction shall be entered in the "rejoin flag" column of the initial task in each parallel path that rejoins. It is also mandatory that any parallel paths that split and rejoin must all split and rejoin at the same junctions. Furthermore, once begun, any parallel paths that can later rejoin must rejoin; that is the likelihood that activity continues along the path until the junction is reached must be unity.

"The network mean time" normally is estimated internally, and need only be entered for task networks that are not included in the shop collections; for such networks it should be the mean time through the entire task network. The "incompatibility pointer" defines the position in the LISTIN array (Card Type #19) that contains the first item incompatible with the current simple task or tasks.

The criticality of each task for any of five missions is specified with a two-digit integer whose binary equivalent defines task essentiality (1) or deferability (0); if the task may be deferred only until the end of day, the criticality indices (defined in Table 1) should be increased by 33; if the task may be deferred only for LTHDEF sorties, the criticality indices should be increased by 66. This datum need only be entered for simple tasks and for the root segment of a network; if no value is entered, the default value is 32. Space has also been provided so that each unscheduled maintenance task may be categorized by what will be called the "task stress"; this provision is intended to facilitate future code extensions that could, for example, let task efficiency vary with task stress under specified conditions.

All tasks that are not to be categorized as unscheduled maintenance are identified by entering a 1 in column 77. An entry in column 79 designates whether cross-trained or task-assist-qualified personnel are able to handle this task. When records are maintained on disk, an alphanumeric description of the task may be entered in columns 81-100.

Sample Data: The first task listed in Fig. 3, Task #1, is assigned to Shop #2 and is carried out by one Type #2 maintenance personnel, using a piece of #2 equipment (AGE). The mean task time is 30 minutes (i.e., 10 TTU) with the variance specified by distribution #2. No part is associated with this task. If the resources for this task are unavailable, no alternative procedure is available. The task must be accomplished before any mission is flown (default criticality).

TASK REQUIREMENT DATA — TSKROT ARRAY

Card Type	Task No.	Shop No.	Shop Rqd*	Part No.	Time Mean TTU	Time Dis	Personnel Team 1 Type	Personnel Team 1 No.	Personnel Team 2 Type	Personnel Team 2 No.	AGE #1	AGE #2	Task Prob x 1000	Alt. Proc	Parallel Task	Rejoin Flag	Subsqt Task	Network Mean Time TTU	Incompat Pointer	Part Prob x 100	Condem Prob x 100	Miss Crit	Strs	Unsch	Pers Opt**
5	1	2			10	2	2	1			2														
5	2	2		1	25		2	1	3	2	2	3					3		4			7			
5	3	2			15		3	2					-40	1	4										
5	4	2			40		1	2			2		-35		5										
5	5	2			30		2	1					-25		0										
5	6	3	1	2	20		3	3			3								1	60	1.0				
5	7	3		3	15		3	2			2			2			8			50					1
5	8	3		-1	40		3	1					40				9								
5	9	3			10		3	2			2		30				0								1
5	18	10		9	14		8	1									19			45	5				
5	19	10			15		8	2					-33		23	21	20								
5	20	10		10	25		8	1					100				21			77	14				
5	21	10			16		8	1	7	1			70				22								
5	22	10		15	24		8	2					80							75					
5	23	10		12	19		8	1			7		-15		24	21	21			100					
5	24	10		14	32		8	2					60		25	21	21			60					
5	25	10		-1	12		8	1			7		-52				26								
5	26	10		11	32		8	1					80				27			100					
5	27	10			14		8	2			6	7	-60		28										
5	28	10		13	24		7	1					-40							100					
5	41	2			10		1	2										0				33		1	
5	42	25		16205	15		63	2					60					5						1	1
5	43	25		13012	8		62	4					100					8						1	2
5	44	25		12911	5		63	2					100					5						1	1
5	101	1		201	1000	1	31	1					25					1.00		1.00	1.00	33		1	
5	102	1	2	202	800	1	31	2					25					4.0		1.00	1.00	32		1	
5	103	1	2	203	600	1	31	1					25					6.0		1.00	1.00	32		1	
5	104	1		204	400	1	31	2					25					18.0		1.00	1.00	33		1	

*Maintenance requirement
- = 1 Shop not required; rearward maintenance req'd for COB
- = 2 Shop not required; rearward maintenance req'd for all bases
- = 3 Shop required
- = 4 Shop required; rearward maintenance req'd for COB
- = 5 Shop required; rearward maintenance req'd for all bases

Enter a "1" for all tasks that are not unscheduled maintenance

**Personnel Substitutability: 1 if cross-trained personnel may be used; 2 for task-assist-qualified personnel; 3 if either may be used.

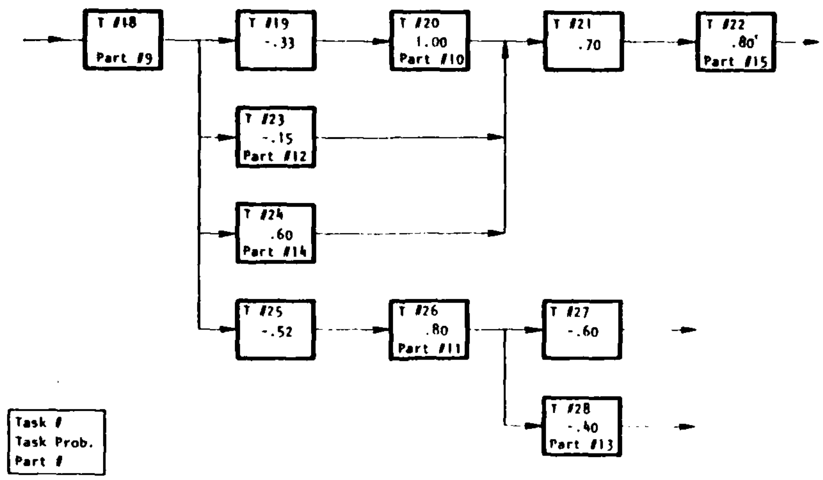
Fig. 3 -- Aircraft Maintenance Task Requirements

The #2 Task, carried out by two Type #1 and three Type #2 personnel, using both #2 and #3 AGE, is the root segment of a simple network; this initial task requires 1 hour and 15 minutes (25 TTU). The task is only critical when the second or third mission type is to be flown (criticality is 7; see Table 1). If any of the incompatible tasks (beginning in the 61st field of the INCOMP array) are in process, the task may not be started. Three mutually exclusive Tasks, #3, #4, and #5 (denoted by the minus probabilities), follow Task #2: Task #3 is required 40 percent of the time; #4, 35 percent, and #5, 25 percent. An alternative procedure (#1) can be used for task segment #3, but for no other.

Task #6 requires three type #3 personnel an average of 1 hour (20 TTU) using a type #3 AGE; furthermore, if the aircraft is at a COB it is necessary that it be ferried to a rear maintenance base to carry out this task (specified by the "1" in column 10). Sixty percent of the occasions when this task arises, a Type #2 part is required; in 10 percent of the cases that a part is removed, it must be condemned. If any of the tasks or shops listed in the incompatible task list (beginning in the 67th field) are in process, this task must wait.

Task #7 is the root segment for a simple task network that is assigned to Shop #3; Task #7 takes two type #3 personnel 45 minutes to complete. Part #3 is required for Task #7 on 50 percent of the occasions. If a part is required there is a 40 percent chance that Task #8 is required; if a part was not required, or if it was and Task #8 also was required, then there is a 30 percent chance that Task #9 must be performed to complete the task. If two type #3 personnel are not available for Task #7 or Task #9, personnel that have been cross-trained to replace these specialists could be used; at least one type #3 person is required when Task #8 must be handled, however, since no personnel substitutability is indicated for this element of the network.

Task #18 is the root segment for the complex task network sketched on the next page; this network involves 11 task segments and seven parts:



Following completion of the root segment task, one of the three mutually exclusive Tasks #19, #23, or #25 (denoted by the minus probabilities) is selected, and there is a 60 percent chance that Task #24 also must be done. If Task #24 and either #19 or #23 are required, both paths must be completed before a check is made to see if Task #21 is required. Also, if part #9 had not been required with Task #18, and Task #25 was selected from the mutually exclusive set, that task is bypassed (as dictated by the -1 in the parts column for Task #25) and a check is made to see if Task #26 is required.

Other tasks shown include the refueling Task #41 (see Card Type #15), and the scheduled maintenance tasks for uploading auxiliary fuel Tanks (#42) and for loading the basic munitions (#43 and #44). The coded part numbers for the last three of these tasks specify two type #5 TRAP, two #12 and one #11 munition (3200 × Class + 100 × Number + Type). The fuel tanks are required after 60 percent of the sorties; the expenditure rate for the basic munitions is controlled by mission with Card Type #16. Task-assist-qualified personnel may be used for the fuel tank and #11 munitions tasks; either cross-trained or task-assist-qualified personnel may help with the #12 munition task.

The last four tasks comprise the set of the battle-damage repair tasks as specified on Card Type #15/2; each has a 25 percent chance of needing attention when an aircraft is damaged and all require that the aircraft be grounded (criticality = 33). All parts are condemned.

Card Type #6

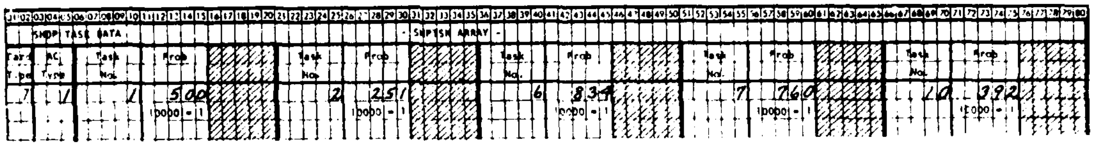
TASK ALTERNATIVES DATA - TSKALT ARRAY -

Card Type		Alternate Task No.	Time Mean TTU	Dist	Personnel Team 1 Type	Personnel Team 1 No.	Personnel Team 2 Type	Personnel Team 2 No.		AGE #1	AGE #2	Alt Procedure	Shpd	Alternate Task No.	Time Mean TTU	Dist	Personnel Team 1 Type	Personnel Team 1 No.	Personnel Team 2 Type	Personnel Team 2 No.		AGE #1	AGE #2	Alt Procedure	Spnd
6		1	25		2	2	1	1						2	35		3	2							

Alternative procedures and resource requirements for on-equipment maintenance tasks are specified here. The task numbers for alternative procedures specify the location of the data in the TSKALT array and are distinct from the numbers that define the nominal procedures and resources. As noted, additional alternative procedures may also be specified.

Sample Data: Two alternative sets of resource requirements are shown; the first provides an alternative procedure for task #3; two type #2 and one type #1 specialist can do the job instead of two type #3 personnel, but they require an additional half-hour. Alternative procedure #2 indicates that the same personnel, working without the #2 AGE, could do Task #7 in an extra hour (35 rather than 15 TTU).

Card Type #7



These cards control the incidence per sortie of the on-equipment maintenance tasks associated with the shop task collections. The probability per sortie (multiplied by 10,000) is entered for each task number. These data are entered separately from the task data entered with Card Type #5, so that the same tasks may arise on different types of aircraft with different probabilities.

Sample Data: This sample indicates that Tasks #1, #2, #6, #7 and #10 are required after 5.0, 2.51, 8.34, 7.6, and 3.92 percent, respectively, of the sorties flown by aircraft type #1.

Card Type #8

The resource requirements for a parts repair job are structured somewhat like those for an on-equipment task. The parts removed from an aircraft may be of two types: parts that may be repaired and reused, or LRUs that have a defective SRU that must be diagnosed and replaced. Only one SRU may fail at a time. The repair of a part may involve either a specific procedure or one of two or more different procedures. One procedure is assumed to apply when shop action is required before a part is NRTSed, rather than being NRTSed immediately after removal from the aircraft. If the same shop procedure (personnel, equipment, and time) is used, whether the part is repaired on base or is determined to require a NRTS action, only one procedure need be listed. The format used with the Type #8 Cards (Fig. 4) depends upon which type of part is being treated. The #8/1 format is used with simple parts, the #8/2 format is used when more than one procedure or SRU is involved and the #8/3 format is used to specify multiple procedures, SRU replacement procedures, and SRU repair procedures. The part number or LRU number specified in the TSKRQT array (on Card Type #5) denotes where the REPRQT array should be entered for data regarding its repair; therefore, the parts associated with various aircraft types must each be assigned a unique number, except for parts that are common to two or more types of aircraft.

Parts that involve two or more repair procedures but no SRUs are entered with the #8/2 format and are denoted by a minus two in columns 24-25 (59-60). An LRU is denoted by a minus one in the same field. The location of the first repair procedure, or the first of the SRUs in an LRU, is specified in columns 26-30 (61-65). The requirements for the various procedures and the requirements for diagnosing and replacing

REPAIR REQUIREMENTS DATA - REPRQT ARRAY - DATA DEPENDENT FORMAT

SIMPLE PART - ONE REPAIR PROCEDURE

Card Type		Part No.	Shop	Time Mean TTU	Dist	People Type	People No.	AGE F1	AGE F2	Alternate Procedure	Part No.	Shop	Time Mean TTU	Dist	People Type	People No.	AGE F1	AGE F2	Alternate Procedure
8	1	1	2	66		72	1	22		1									

SIMPLE PART WITH MULTIPLE REPAIR PROCEDURES or LRU WITH SEVERAL SRUs

Card Type		Part or LRU No.	Shop	Multi-Item Flag	First Item Location	Part or LRU No.	Shop	Multi-Item Flag	First Item Location
8	2	2	3	Enter -1 for SRUs -1	101			Enter -1 for SRUs	
9	2	9	10	-2	109				
				Enter -2 for Non-RRs				Enter -2 for Non-RRs	

OPTIONAL REPAIR PROCEDURES and SRU DIAGNOSTIC AND REPLACEMENT PROCEDURES

Card Type		Repair Procedure or SRU	Next Item Location	Time Mean TTU	Dist	People Type	People No.	AGE F1	AGE F2	First SRU Repair Procedure	Item Prob	Alternate Procedure	Repair Procedure or SRU	Next Item Location	Time Mean TTU	Dist	People Type	People No.	AGE F1	AGE F2	First SRU Repair Procedure	Item Prob	Alternate Procedure
8	3	101	102	68		73	1	3		131	30	30	102	103	96		73	1			134	10	4
9	3	103	401	44		73	1	3			20												
9	3	131	132	48		77	1	16			40		132	133	66		77	1	16			20	
9	3	133	0	20		77	1	16			40												

Fig. 4 -- Aircraft Parts Repair Requirements

each of the SRUs in an LRU are entered using the #8/3 format and are also stored in the REPRQT array. The first repair procedure is always used for a part that is checked in the shop before being NRTSed, rather than being NRTSed immediately after removal from the aircraft. If the probability of the first procedure is greater than zero, the same procedure may be selected when the part is to be repaired on base; otherwise the first procedure would be used only when the part is checked in the shop and NRTSed.

A repair procedure that is numbered less than NOPART and does not require an SRU must be distinguished from one that does by a -1 entry in columns 33-34 (68-69). If the repair procedures that do not involve an SRU are numbered between NOPART and NOREP, the size of arrays that use NOPART as a dimension can be minimized. (Furthermore, the requirement for a negative entry will be avoided, since that entry is made automatically except for those LRUs that have procedures that do not require an SRU, and are numbered less than NOPART.)

Each alternative procedure, or SRU entry, also specifies (1) the likelihood that that procedure is required or that the SRU is faulty, and (2) the number of the next procedure or SRU, if any. The probabilities associated with the alternate procedures, or with the SRUs in an LRU, must sum to 100.

When an SRU may itself be repaired, the location of the first of the one or more procedures that may be specified for that repair is listed in columns 31-34 (66-69) of the SRU replacement data. If two or more procedures are given for the repair of an SRU, the particular one required in a given instance is selected on the basis of the individual procedure probabilities entered in columns 35-37 (70-72). As with any LRU, the first of the SRU procedures specifies the resources required when the SRU must be checked when it is NRTSed, rather than NRTSed immediately after removal from the LRU. If the probability of the first procedure is not zero it may also be selected when the SRU is repaired on base.

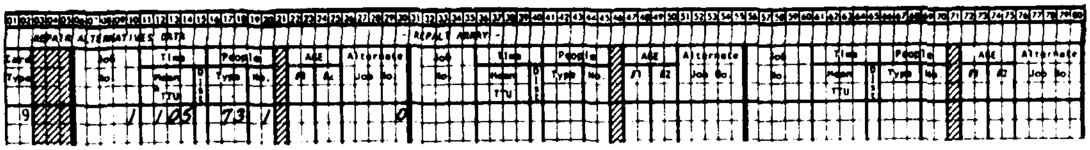
Sample Data: Repair procedures are illustrated for a simple part (#1), an LRU (#2), a simple part with several possible repair procedures (#9), and for an SRU (#101). Part #1 requires one Type #72 specialist for 3 hours and 18 minutes to repair or to check for a NRTS action, using a piece of #22 equipment. An alternative procedure is listed.

The LRU #2 has 3 SRUs (#101, #102, and #103) that fail 30, 10, and 20 percent of the time, respectively; in the other 40 percent of the repairs no SRU is required and repair procedure #601 or #602 is used. As will be noted, the times and resources for each of the repair procedures differ, and in one instance, #102, an alternative procedure is listed. Also SRU #101 may itself be repaired. When LRU #2 must be checked before it is NRTSed, the resources associated with procedure #101 are committed.

Part #9 is repaired in Shop #10 using one of the three procedures, #109, #110, or #111; the 4-hour procedure (#110) is done most commonly (55 percent), but the job often takes five or six hours; the six hour job is required to determihe that the part must be NRTSed.

The #101 SRU is repaired by one of two procedures--#132 or #133; procedure #131 is only used when the SRU is checked and NRTSed. The personnel and equipment are the same for all these procedures, but the work can require as little as one hour (#133) or as much as 3 hours (#132).

Card Type #9



Data entries for alternative parts repair procedures are structured analogously to those for alternative on-equipment tasks and are stored in the REPALT array.

Sample Data: Indicates that one Type #73 person can repair Part #1 in 5-1/4 hours without any specialized AGE; see comments on Card Type #8.

Card Type #10

EQUIPMENT REPAIR REQUIREMENTS DATA - AGEREP ARRAY -

Card Type		Equipment Type	Shop	Break Rate	Time Man-TTU	D	People Type	People No.	AGE #1	AGE #2	Alternate Procedure	Equipment Type	Shop	Break Rate	Time Man-TTU	D	People Type	People No.	AGE #1	AGE #2	Alternate Procedure
10			Or next procedure	Or procedure probability	Or enter minus station type if AIS		Enter for alternate procedures	-1	Enter first alternate procedure												
10		2	2	626				-1		51		3	3	78	50		3	2			
10		51	52	25	40		2	1				52	53	70	80		2	1			
10		53	0	5	2400		0	0	0	0											
10		18	10		-3																

For repair purposes, support equipment are divided into two categories; those that are either serviceable or must be repaired, and those that also have an intermediate, partially mission-capable state. The former are treated with the procedures that are outlined with Card Type #10 and are stored in the AGEREP array. The latter category, consisting primarily of the AIS used for testing and repairing avionics on late model aircraft, are described with Card Types #22/66 and #22/77.

For the first of these categories one or more procedures may be specified for repairing each of these types of equipment; when more than one procedure is listed, they are assumed to be mutually exclusive and the one that is required for any particular repair is selected by a random process. The data appropriate for each type of equipment is found in that column of the AGEREP array that corresponds to the number that designates the type of equipment.

The shop to which the equipment repair is assigned and the likelihood that the equipment is broken following each use are entered in columns 11-15 and 16-20; when a single procedure is always appropriate, the time, personnel, and equipment are entered next. If the repair requirements vary depending upon circumstances, a -1 is entered in columns 29-30 of the basic entry, and the entry in column 31-35 specifies the location in the AGEREP array of the first of the multiple repair procedures. For those procedures columns 16-20 contain the probability that each of the multiple procedures will be required, and columns 11-15 specify the location of the next procedure.

In all cases an alternative set of resources may be specified for accomplishing the nominal repair.

Sample Data: Repair requirements are shown for two types of equipment, #2 and #3. Their repair is assigned to Shop #2 and #3. The likelihood that a piece of #2 equipment is found faulty following each use is 6.26 percent; for the #3 equipment, it is 0.78 percent. Two type #3 personnel are always used to repair the #3 equipment, and the nominal task time is 2.5 hours. One of three different procedures may be required to repair a type #2 equipment; 25 percent of the time one type #2 personnel can repair it in 2 hours; 70 percent of the same specialist takes 4 hours, and 5 percent of the time five days (2400 TTU) must elapse before the repair is accomplished (this type of procedure, one that consumes time but no personnel or equipment, can be used to approximate the effect of waiting for a critical piece-part from another location).

The last entry illustrates how the AIS equivalent of an AGE type is identified. In this instance, a #3 type AIS station is identified as a piece of type #18 equipment; the minus sign denotes the special nature of this entry.

Card Type #11

MUNITIONS ASSEMBLY REQUIREMENTS DATA - MUNRQT ARRAY -

Card Type	Type Ammo	Time Reqd TTU	People Type	People No.	AGE #1	AGE #2	Quan*	Alt*	PS*	Type Ammo	Time Reqd TTU	People Type	People No.	AGE #1	AGE #2	Quan*	Alt*	PS*	Type Ammo	Time Reqd TTU	People Type	People No.	AGE #1	AGE #2	Quan*	Alt*	PS*
11	1	40	65	3	21		6		1	2	120	64	4	25					3	70	65	3	21	23			
11	4	30	65	3	21		4		2	5	105	64	4	25			21		6	95	64	2	25				2

* Quan - Number of weapons assembled in mean time
Alt - Alternate assembly procedure
PS - Personnel substitutability

Resource requirements for assembling munitions are specified and stored in the MUNRQT array; the number of the munitions type determines the column in that array in which the data are filed. The quantity of munitions to be assembled for each task should be selected such that the buildup time is no greater than two to three hours, so that the simulated assembly activities will be responsive to sudden shifts in munitions requirements. The default value for the number of munitions assembled is 12. The requirements for alternative procedures, when specified, are also filed with these cards in the MUNRQT array; these data should not be filed in columns defined by any of the munition types considered.

Sample Data: Assembly requirements are shown for six types of munitions. The assembly of six Type #1 munitions takes three Type #65 personnel two hours (40 TTU) using a unit of Type #21 equipment. If available, cross-trained personnel may replace the Type #65 personnel in assembling the Type #1 munitions. For assembling #4 and #6 munitions, task-assist-qualified personnel may assist, but not replace, the normal personnel. In one instance (the #5 munitions) an alternative procedure permits assembly without special equipment, but requires an additional 1-3/4 hours (35 TTU).

Card Type #12

STANDARD COMBAT LOAD PREFERENCES - SCLP ARRAY -

Card Type	Aircraft Type	Mission	Priority #1 SCL #	Priority #1 Value	Priority #2 SCL #	Priority #2 Value	Priority #3 SCL #	Priority #3 Value	Priority #4 SCL #	Priority #4 Value	Priority #5 SCL #	Priority #5 Value
12	1	1	1	110	2	90						
12	1	2	3	100	4	60						

These cards permit the user to specify up to five standard combat loads for each combination of aircraft type and mission. The preferred loading is listed first; the least acceptable load is listed last. An effectiveness proxy may be entered for each SCL; these values are summed during the simulation for each sortie that is launched and does not abort, and provide an overall measure of effectiveness. The user must be careful to ensure consistency between the effectiveness proxies for the different types of aircraft and missions.

When the program is executed, resources are sought first for the preferred munitions, and then for the secondary (less effective) options. Resource requirements for the various SCLs are listed in the SCLRQT array.

Sample Data: Combat loading preferences are shown for two missions for aircraft Type #1; primary and secondary choices have been defined in both cases. The first card image indicates that when an aircraft Type #1 is launched on a Type #1 mission, loaded with SCL #1, 110 effectiveness units are tallied; if the required munitions or TRAP are not available, mission effectiveness would drop to 90 when SCL #2 is used.

Card Type #13

STANDARD, COMBAT LOAD RESOURCE REQUIREMENTS													SERRQT ARRAY								
Card Type	SCL	Config No.	Snd	Time Mean TTU	Dist	PS	Ammo Type	Ammo No.	Equip #1	Equip #2	People Type	People No.	Time Mean TTU	Dist	PS	Ammo Type	Ammo No.	Equip #1	Equip #2	People Type	People No.
13	1	1		75		3	1	12	31		62	4	10			5	2	32		63	3

The munitions loading requirements for the various SCLs are entered here. Since the SCL number denotes the column in the SCLRQT array in which the data are stored, distinct SCLs are required for each aircraft type, unless the time requirements are the same. Resources needed to set up the aircraft configuation specified in columns 6-9 are handled with the next card type. Either one or two sets of munitions may be specified. If the personnel and equipment requirements for the two tasks are the same, the tasks may be done in series if there are insufficient resources available for both. Otherwise, both must wait until all resources are available, unless a subordinate SCL may be loaded.

Sample Data: These data specify that SCL #1 involves configuration #1 and that 12 Type #1 and two Type #5 munitions are to be loaded. Four Type #62 personnel require a #31 equipment for 45 minutes to load the #1 munitions, and three Type #63 personnel take 30 minutes with a #32 equipment to load the #5 munitions. Cross-trained or task-assist-qualified personnel may be used for the first task (the 3 in column 15), but no substitutions are permitted for the second.

Card Type #14

AIRCRAFT CONFIGURATION RESOURCE REQUIREMENTS											CONFIG ARRAY								
Card Type	Config No.	Time TTU	D/B/R	P/S	TRAP Type	NUM	Eqpt #1	Eqpt #2	People Type	People No	Time TTU	D/B/R	P/S	TRAP Type	NUM	Eqpt #1	Eqpt #2	People Type	People No
14	1	10		1	2	1	54		62	2	8		1	4	1	28	8	62	2

The resource requirements and task times for all aircraft configurations are entered using Card Type #14. Either one or two tasks may be specified. The configuration number denotes the position of the data in the CONFIG array. TRAP are considered to be returned when the aircraft returns from a mission and are returned to stock if inappropriate for the next mission. When the TRAP that is to be represented are auxiliary aircraft fuel tanks that are consumed --i.e., dropped in combat--they cannot be handled here, but must be treated as a special task assigned to Shop #25 (see the Card Type #5 discussion for these special tasks).

When an aircraft must be reconfigured to meet the requirements of a different mission (or because the required ammunition stocks are depleted), the time required to remove the TRAP is assumed to be equal to the time specified here for equipping the aircraft. If either of the two sets of TRAP is common to the two configurations, only the dissimilar TRAP are "changed" during a reconfiguration. Also, as with such descriptors in the other kinds of tasks, the personnel, equipment, and time requirements may be satisfied with a null entry; if, for example, the same crew using the same equipment loads two sets of TRAP in sequence, the descriptors for the second reconfiguration task could be limited to the TRAP, with null entries for personnel, equipment, and time; the total time would be listed for the first task.

Sample Data: Two tasks are required for configuration #1. In the first case two Type #62 personnel are to mount one #2 TRAP and will require 30 minutes using a piece of #34 equipment. The second task mounts one #4 TRAP in 24 minutes; again two #62 personnel are required. Cross-trained personnel may be used for either task, as designated by the 1 in columns 10 and 30.

Card Type #15

Card Type	Card No.	AC Type	Delay Post-flight Min	D/H	Delay Pre-flight Min	D/H	Fuel Quantity	Fueling Task No.	Number Missions	Nominal Unsch Time Min	Nominal Cycle Time Min	Inspection First Part	Load Team Type	Load Team No.	Special AGE Type Numbers #1	Special AGE Type Numbers #2	Basic Munitions Type	No.	Type	No.	Type	No.
15	1	1		6			5	41	3	60	150	1	62	4	2	4	11	1	12	2		

Card Type	Card No.	AC Type	Transfer Delay Min	Battle-Damage Tasks First	Battle-Damage Tasks Last	Parts Recovery* %	Air Base Damage Alternate Tasks First	Air Base Damage Alternate Tasks Last	Battle Damage Spares Sorties/AC	Alert Aircraft Personnel Type	Alert Aircraft Personnel No.	Alert Aircraft Equipment #1	Alert Aircraft Equipment #2	Rear Maintenance Base	Eligible for CRA	Munitions Omission Penalty Percent		
15	2	1	60	101	104	40	0	0	14	2	2	1		5				

* Probability that a part is recoverable from a salvaged aircraft

Miscellaneous aircraft data are entered using Card Types #15/1, #15/2, and #16. The first entries on #15/1 permit the user to specify two delays in which no specific tasks are accomplished; one immediately after the aircraft lands and one before the preflight maintenance tasks are begun. The values specified might be chosen to reflect taxi time, inspections, or various scheduling inefficiencies. The quantity of fuel (in thousands of pounds) and the appropriate task number are specified next. The approximate expected values that are entered for unscheduled maintenance time and for total sortie cycle time are only used for projecting the future supply of ready aircraft, and only for aircraft that have not yet been recovered; the user should derive these values from the various data entered with Card Types #5, #7, and #29.

If the specifications for a munitions load team are entered, only one load team will be permitted to work on any given aircraft at a time; that constraint will be observed even when substitute or alternative personnel are employed to make up the required load team. For equipment types entered into the Special AGE fields, it is assumed that only one piece of such equipment need be present at an aircraft to satisfy all concurrent task demands. When an aircraft is always to be equipped with some minimal kinds of munitions, those types should be entered in the last fields on Card Type #15/1 and not included in the mission-dependent munitions requirements. These munitions are referred to as basic munitions. These entries and the retention data on Card Type #16 are used in assessing the demands for munitions assembly; the resource requirements for uploading these basic munitions must be entered with Type #5 Cards (e.g., see Tasks #43 and #44).

The first entry on Card Type #15/2 is an administrative delay that will be imposed when an aircraft is newly arrived on base. When aircraft battle-damage repair tasks are specified, the root segments of those tasks should be arranged in a numerically ordered set; the first and last task numbers of that set are entered next on this card. The next entry is the probability that each part will be recoverable from aircraft that are too badly damaged for repair and must be salvaged. A separate set of tasks may be specified for the aircraft damage inflicted by enemy airbase attacks; the root-segments of these tasks should also form a numerically ordered set. If a number of sorties is entered in the battle damage spares column, quantities of the spare parts that would be required for battle damage repairs are automatically stocked at each base. The numbers of parts stocked are the numbers that would be expected to be required if a number of aircraft were each flown the specified number of sorties; the number of aircraft is either the number of each type initially at each base or, if OUTFIT is not zero, the number specified on the #23/70 Type Cards.

The next two entries on Card Type 15/2 are used to specify any personnel or equipment that must be maintained with each aircraft that is to be placed on alert. The next entry specifies the base number of that rear base where aircraft of the specified type are flown for rear-base maintenance. Initializing the next entry declares that this aircraft may be designated for assignment to "special alert" (e.g., QRA) and will be given priority when aircraft shelters allocated to this role are assigned (see Card Type #19/1). When a "1" is entered in this field, an aircraft alert requiirement for the highest numbered mission that this aircraft type may be assigned to (col. 35 on Card Type #15/1) is interpreted as "special" alert.

The last three entries on the #15/2 Type Card provide the user with options for launching aircraft despite the unavailability of certain basic munitions. If any of these three fields is not zero (or null), the aircraft will be permitted to fly a combat mission without the corresponding munitions on Card Type #15/1, and the entry is interpreted as the percentage degradation to be applied to the overall sortie effectiveness recorded in the effectiveness proxy when the aircraft is launched.

Sample Data: For aircraft type #1, there is a six-minute postflight delay. Fueling requires five units of POL; the time and personnel required are specified with Task #41. The aircraft can be assigned to three different missions. Approximate time for unscheduled maintenance and for a complete sortie cycle are 60 and 150 minutes. A munitions load crew consists of four Type #62 specialists; one piece of Type #2 or Type #4 equipment will satisfy all concurrent demands for either of those types of equipment. The basic munitions that are to be loaded for all missions consist of one Type #11 munitions and two Type #12 munitions.

When a Type #1 aircraft recovers at a different base or is transferred to a different base an hour is required for various administrative procedures. For aircraft that receive battle damage in combat, tasks are selected from the Task set #101 through #104, inclusive. For aircraft too damaged to be repaired, 40 percent of the parts are salvaged; those recovered are selected at random from the aircraft parts list.

No repair tasks are specified for aircraft damaged by air attack. Spare parts are stocked at each base for repairing battle damage sustained in flight operations, on the assumption each aircraft will fly an average of 14 combat sorties.

If an aircraft is to be placed on an alert, two #2 personnel and a #1 equipment must be assigned. When it is necessary for Type #1 aircraft to have maintenance done in the rear, the aircraft are to be ferried to base #5.

Card Type #16

AIRCRAFT MISSION DATA – ACMDTA ARRAY –																						
Card Type	AC Type	Mission No.	Flight Time Mean Min	Dist	Fraction Aircraft Not Repairable	Aircraft Damage/Kill Ratio x 10	Late Takeoff Allowance Min	Percent Abort	Percent Crews Lost per AC Lost	Percent Armament Retained: Mission Dependent (Shop 26)	Percent Armament Retained: Basic (Shop 25)	Time Dependent Attrition Rate: <Day	Rate	<Day	Rate	<Day	Rate	<Day	Rate	<Day	Rate	Unit Landing (if Unity)
16	1	1	90	6	8	50	10	1	85	10	20	1	60	3	45	7	32	15	20	40	8	

The only flight data used in TSAR are entered here. For each aircraft type and each of the missions that that aircraft can fly, estimates are entered for the duration of the flight, the expected attrition and battle damage, abort rate and munitions expenditures; different attrition levels may be specified for each of five blocks of time. If aircraft of this type and mission are permitted to take off late, that allowance is also entered. If the members of a flight are to recover together, rather than independently, a "1" is entered in the final field.

Sample Data: This card image indicates that the nominal flight time for mission Type #1 with aircraft Type #1 is 1-1/2 hours, and that takeoff up to 10 minutes after the scheduled flight time is acceptable. One percent of the aircraft abort on takeoff, 10 percent, on the average, return with their mission dependent munitions, and 20 percent retain their basic (typically defensive) munitions. For the first day, 6 percent of the aircraft are lost for each combat sortie; 4.5 percent are lost on the second through third days, 3.2 percent on the fourth through seventh day, 2 percent from the eighth to the 15th day, and 0.8 percent thereafter. Five times as many aircraft are damaged as are lost, and 8 percent of the damaged aircraft must be salvaged. As noted on Card Type #15/2, 40 percent of the parts, selected at random, are recovered. When an aircraft is lost in combat the crew is recovered only 15 percent of the time.

Card Type #17/1

MISCELLANEOUS BASE DATA														
Card Type		Base No.	Base Size [MOB = 1, COB = 2]	Enter 1 if based on 66-1 data are COMO	Cross-trained Personnel	Task-assist-qualified Personnel	Weapon Assembly Tasks*	Number Shelters	Aircraft per Shelter (x10)	Alert Shelters	POL Capacity	Taxiway Access Algorithm: Damage Limit	Taxiway Access Algorithm: Summary	
17	1	1	1		1		4	48	12		32,000	150	200	

* Required if BUILD = 1

Miscellaneous base data are entered with Card Types #17/1 and #17/2. The kind of base is entered in the first field following the base number; 1 denotes a MOB, and 2 a COB. A "1" should be entered in the next field if maintenance personnel at the base are in a 66-1 maintenance organization, and the data have been prepared for a COMO (66-5) organization. The latter entry signals the program to ignore back-shop personnel requirements and to use the equivalent flight-line specialist for the basic parts repair procedures. The same entry also signals the program to extend the mean on-equipment task times by NOPOMO time units, to account for the increased dispatch and travel time in a "66-1" type of organization.

If the maintenance personnel at the base have been cross-trained for certain tasks, or have been qualified to assist on various tasks (as outlined for the 66-5 organization), a "1" should be entered as appropriate in the next two fields. The entry in columns 31-35 is used to control the assignment of weapons assembly personnel in Shop #30 after all immediate demands have been satisfied; additional assembly tasks are defined and initiated until the total number of ongoing tasks is equal to the value entered.

The number of aircraft shelters is specified in columns 31-35. The average number of aircraft that may be housed in each shelter (times 10) is entered in columns 36-40. The number of these shelters that are to be allocated preferentially to "special" alert aircraft is entered in columns 41-45; damage to these shelters and their contents will be distinguished from that for the other shelters.

The next entry is the base's POL storage capacity; that capacity should be expressed in the same units used for specifying POL supplies on Card Type #27 and the aircraft's per-sortie consumption--normally thousands of pounds. Since this value cannot exceed 32750 it may be necessary to select a different unit of measure--tons, for example.

The last two entries permit the user to control the relationship between the "probability that an aircraft is unable to access the runway" and the "percentage damage" to the base's taxiways (i.e., facility #35). The "damage limit" identifies that percentage damage beyond which access is impossible, and the exponent controls the manner in which the probability varies between no damage and the "limit," as discussed in Section IX.

Sample Data: The sample data indicate that Base #1 is a MOB and has cross-trained personnel. At least four munitions assembly tasks are to be ongoing at all times. The base has 48 shelters, and an average of 1.2 aircraft may be housed in each shelter; none of the shelters are set aside for alert aircraft. POL storage capacity is 32000 units.

Card Type #17/2

Card Type		Base No.	HURRY (percent) On Equip	Pre-Flight	Off Equipment	Munitions Assembly	Civil Engineering	REDUCE (min) On Equipment	Pre-Flight	Off Equipment	Munitions Assembly	Civil Engineering	SAVE (min) On Equipment	Pre-Flight	Off Equipment	Munitions Assembly	Civil Engineering
17	2	1	100	10	100	100	100	0	0	0	0	0	0	0	0	0	0
17	2	2	100	100	130	100	100	0	0	0	0	0	0	0	0	0	0

The actual times for various tasks that are drawn from the specified distributions may be modified to reflect various schemes of work speedup. The HURRY, REDUCE, and SAVE arrays control these arrays according to the relationship:

$$\text{Task Time} = \text{HURRY(i)} \times D_j\ [\text{Mean Time} - \text{REDUC(i)}] - \text{SAVE(i)}$$

where D_j represents the value selected from the distribution j, and

i = 1 for on-equipment tasks
= 2 for preflight tasks
= 3 for parts and equipment repair jobs
= 4 for munitions assembly jobs
= 5 for civil engineering tasks

HURRY	Percentage of nominal task time
REDUCE	Mean time reduction in minutes
SAVE	Overall task time reduction in minutes

These procedures may be used to modify the many input values on Card Types #5, #6, #8, #9, #10, #11, #13, #14, and #38, by entering values for HURRY, REDUCE, and SAVE with Card Type #17/2. Different values may be specified for each of the five groups of tasks at each base. If no base number is entered, the values will be the same at all bases. When these values differ from the default values of 100, 0, and 0, task times are computed as shown above.

Sample Data: Card Type #17/2 indicates that preflight tasks are to be accomplished in 80 percent of the nominal times at base #1, and equipment repairs are to consume 30 percent more than the normal time at base #2.

Card Type #18

SHIFT DATA — BEGINNING OF DAY SHIFT AND PERCENTAGE OF AIRCRAFT EXPOSED																															
Card Type	Card No.	Shop 1&16		Shop 2&17		Shop 3&18		Shop 4&19		Shop 5&20		Shop 6&21		Shop 7&22		Shop 8&23		Shop 9&24		Shop 10&25		Shop 11&26		Shop 12&27		Shop 13&28		Shop 14&29		Shop 15&30	
		Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct	Hr	Pct
18	1	8	30	8		8		8	20	8		8		8	20	8		8		8		8		8		8		8		8	
18	2	8		8		8		8		8		8		8		8		8		6				4		4		6	60	8	

These cards are used to specify the beginning of the "day" shift for each of the 30 shops and the fraction of the tasks for each of the shops that require a sheltered aircraft to be exposed to a higher likelihood of damage. The permissible entries for shift changes are limited to even-valued hours between zero (midnight) and 10 (1000 hours); the two 12-hour shifts are presumed to be the same for the same-numbered shops at all bases. When an airbase is attacked, each sheltered aircraft is checked as to which shops are engaged in tasks on the aircraft; exposure to the higher damage level is determined on a random basis.

Tasks associated with shop #25, or the flight line shop, and with the preflight shops (shops #27, #28 and #29), are treated differently at the time of their shift change. These shops have a flexible overtime policy such that no ongoing tasks are interrupted as a result of the shift change, but are completed before the crew is released.

Sample Data: The day shift commences at 0400 for Shops #27 and #28 and at 0600 for shops #25 and #29; all others change shift at 0800. Aircraft must be left partially exposed in their shelters a percentage of the time that Shops #1, #4, #7, and #29 work on the aircraft; this occurs 30 percent of the time for Shop #1, 20 percent for Shops #4 and #7, and 60 percent for Shop #29.

Card Type #19

TASK INCOMPATIBILITY LIST — LISTIN ARRAY — 15 ENTRIES PER CARD

Card Type	First Element No.															
19	61	6	7	-1	5	9	0	66	-1	7	7	-2	76	96	0	

All incompatible on-equipment task data are stored in the one-dimensional LISTIN array. For each task that may not be initiated while other tasks are underway or until specific tasks have been completed, the entry on Card Type #5 (i.e., TSKRQT (-,11)) specifies the first position in the LISTIN array for the relevant incompatibility data. Whenever an attempt is made to initiate a task, all tasks being conducted on that aircraft are checked to see if they are incompatible. To ease the specification of incompatibilities, entire groups of shops and tasks and task segments may be specified as well as individual tasks.

The task numbers of the individual tasks that are incompatible are entered first and the TASKQ is searched to see if any of those tasks are in progress. If the task may not be processed when other shops are working on the aircraft, the number "-1" is entered, followed by the first and last shop number; one or more shop number pairs may be listed in sequence. If the task is incompatible with an entire block of task numbers, the number "-2" should be entered and followed by the first and last task number in that block (several task number pairs may be entered for several incompatible blocks of tasks). If the task must not be started until after a set or sets of task segments are completed, the number "-3" should be entered and followed by the first and last task segment numbers of each such set (several task segment pairs may be entered). A zero entry in the LISTIN array denotes the end of that particular sub-list of incompatibilities.

Sample Data: These data are filed in the 61st thru 75th elements of the linear LISTIN array. Data in columns 6-30 specify those activities that may not be ongoing when Task #2 is to be initiated; the first two numbers refer to Tasks #6 and #7. The number "-1" signals that the following two numbers are the first and last of the ranges of shops that may not be active; thus Task #2 may not be started if Shop #5, #6, #7, #8, or #9 is performing a task on the aircraft.

Data in columns 36-75 similarly specify that Task #6 may be initiated if Task #66 or any job by Shop #7 is in progress; furthermore it may not be started if any task number in the range #76 to #96, inclusive, is in process.

The first entry of an incompatibility list is specified on a Card Type #5 by naming the appropriate element in the linear LISTIN array; in this case, Task #6 specified element #67, since Task #66 is the 67th element. If some other task was incompatible only with tasks #76 through #96, the incompatibility pointer should specify #71, reusing a part of the Task #6 list, thereby saving storage space.

INITIAL STOCKS OF AIRBASE RESOURCES

The next eight types of cards (#20 thru #27) define resource availability at zero time for each of the airbases. These data are required for each type of each of the eight resource classes that the user has distinguished in his descriptors of task requirements. These data may be entered separately for each base; or, if no base is specified (except for aircraft, crews, and POL), the same quantity of each class and type of resource is provided at each base. (When all but one base or only a few bases have the same quantity of a resource, the resource can first be entered for all bases with a zero base number, and then corrected for that base(s) with a different quantity.)

Other aids are available for Card Types #21 through #25. When an "88" is encountered in the "J" field for any of these card types, two more entries are expected: #B1 and #B2. These entries designate that the entire stockage array for that class of resource is to be copied from Base #B1 into the storage space for Base #B2. If this card is placed at an intermediate point in the entries for Base #B1, only the data entered to that point are copied for Base #B2. A more sophisticated aid is available for parts data; it automatically generates parts stocks and initializes the parts pipelines.

The quantities of all types of these various resources that are available in depots to replace losses may also be specified with the #20 through #27 Type Cards. When a "99" is entered in the "J" field for any of these card types, the total numbers of resources of types I through I + 9 that are available at time zero, are listed in the ten 5-column fields in columns 11-60, where I is the resource type listed in columns 6-10 (see Card Type #23/99).

<u>Card Type #20</u>

AIRCRAFT ASSIGNMENT BY BASE																					
Card	Base	Aircraft																			
Type	No.	Type	Sq	Number	Crews	Type	Sq	Number	Crews	Type	Sq	Number	Crews	Type	Sq	Number	Crews	Type	Sq	Number	Crews
20	1	1	2	48	64																
20	2	1	2	48	66																
20	3	1		24	30																
20	4	1		18	24																
20	77	1		24	120																
20	99	1		72																	

Initial aircraft inventories may include up to five different types of aircraft at each airbase. This Card Type is used to specify the initial inventory of each type of aircraft and the initial number of air crews qualified for that type of aircraft at each base. The total number of aircraft in the simulation at any time is limited to the size of the ACN array (i.e., MAXACN), and the total number of air crews is limited to the size of the PILOT array (i.e., NOCREW).

The Type #41 and Type #42 Cards are used in conjunction with Card Type #20 for initializing aircraft configurations for various missions and for initializing the status of aircraft maintenance; those cards must be entered after to the entry of the Type #20 Cards.

The aircraft of a given type at any particular base may be separated into two or three squadrons by entering a "2" or "3" in the "Sq" column. When this is done, personnel and equipment may be assigned separately to each squadron, as in a "66-5," or COMO-type organization, rather than all aircraft drawing upon a common group of such resources. Organization of those resources is controlled by the ALTPEO and ALTAGE arrays that are entered with Card Types #45/1 and #46.

The #22/77 Type Cards are used to initialize the pool of "filler" aircraft, if any, and to specify the time required to ferry the aircraft to the operating base when it has been assigned. The #22/99 Type Cards impose constraints on the number of aircraft of each type that are available to replace losses incurred during flight operations or from air base attacks. The availability and delivery delays for these replacement aircraft are controlled by the Type #43 Cards; these aircraft are in addition to those that may be designated for the filler force. Each filler aircraft and each replacement aircraft is ferried by an aircrew that is presumed to be reassigned to the operating unit on arrival.

Sample Data: Bases #1 and #2 each have 48 Type #1 aircraft organized into two squadrons; Base #1 has 54 aircrews and Base #2 has 60. Bases #3 and #4 also have Type #1 aircraft; the PAA is 24 aircraft at Base #3 and 18 at Base #4. Twenty-four #1 Type aircraft are available in the theater as fillers and can reach their assigned base in two hours. In addition, 72 #1 Type aircraft are available for replacing lost aircraft and can reach their assigned base in 3.5 days (see Card Type #43).

Card Type #21

BASE PERSONNEL									PEOPLE ARRAY													
		Personnel																				
Card Type	Base No.	Type	Total		Day Shift		Base Shop	Min Size	Type	Total		Day Shift		Base Shop	Min Size	Type	Total		Day Shift		Base Shop	Min Size
			Act.	Tgt	Act.	Tgt				Act.	Tgt	Act.	Tgt				Act.	Tgt	Act.	Tgt		
21	1	1	44	44	30	30	1	2	2	16	16	8	8	2	2	3	8	8	4	4	3	3
21		30	6	6	4	4	5	2														
21	88	3		4																		

Airbase personnel resource descriptors include the number on the day shift and the total number on base at zero time; the difference is assumed to be on the night shift. In addition to "actual" values, the user must also enter the "target level" for each of these two factors. The target levels may be the same as the actual levels or different, except that the target level may not exceed 99, whereas the actual values may be as large as 320. The target levels permit dynamic estimates of resource depletion and provide a basis for theater resource management. Whenever the total number of people of a given type on a base changes, the day/total ratio of the target levels is used to apportion the new force among the two 12-hour shifts, subject to the minimum shift size constraint, when entered.

If personnel of a given type are organized into several separate groups, the personnel in each group will be identified by different personnel type numbers. When personnel of a particular type are assigned several different designations, it is assumed that the lowest numbered personnel type is associated with the first group, or squadron, and that the next be with the second, etc.; the highest numbered type is assumed to be assigned to wing level. Equivalent personnel types are identified as such with the Type #45/1 Cards. When personnel are designated for on-equipment tasks on the Type #5 Cards, it is mandatory that the lowest type number for the specialty be specified.

Civil engineering personnel are treated in a distinct manner; their designations must be greater than (NOPEOP - CEPEO), and both shifts must have the same number of each type of personnel.

<u>Sample</u> <u>Data</u>: The first card image indicates that Base #1 has 48 Type #1 personnel, 16 Type #2 personnel and eight Type #3 personnel; of these, 30, 8, and 4 are on the day shift, respectively. The minimum shift size is two for Types #1 and #2, and three for personnel Type #3.

The second card image assigns six Type #30 personnel to each of all the bases, since no base number is mentioned. The third card image specifies that base #4 should be staffed with the same numbers of personnel as base #3. Since no limits on replacement personnel are specified with a #21/99 Type Card, all personnel losses will be replaced if so specified with the #43 Type Cards.

Card Type #22

Card Type	Base No.	Type AGE	Total Act.	Total Tgt	Avl	Shop	Type AGE	Total Act.	Total Tgt	Avl	Shop	Type AGE	Total Act.	Total Tgt	Avl	Shop	Type AGE	Total Act.	Total Tgt	Avl	Shop
22	1	7	1	1	1	10															
22	2	1		2																	
22		2	4	4	4	2	3	1	1	1	3										
22	1	2	3	3	3	2															

BASE AGE AND EQUIPMENT — AGESTK ARRAY —

For each type of support equipment (AGE) to be distinguished in the simulation, initial entries include the total number on base, a target level for the total number, and the number that are not assigned at zero time. All three numbers would be the same if the base were fully stocked and all shop tasks were assumed to have been worked off at zero time (except that the target level may not exceed 99).

If equipments are assigned to different organizations, they will be numbered differently, as with the personnel data described above, and the stocks for each of the organizations will be identified; the equivalent types will be identified with the Type #46 Cards.

Equipment employed by civil engineers must have designations greater than (NOAGE - CEAGE).

Sample Data: The first card image equips base #1 with one piece of Type #7 AGE and assigns it to Shop #10. The second card equips base #2 with the same AGE and equipment that have been designated for base #1, up to this point. The third card image equips all bases with four Type #2 AGE and one Type #3 AGE. All are available at the beginning of the simulation. The fourth card image changes the initial stocks of AGE Types #2 and #3 to three and two, respectively, at base #1.

Card Types #22/66 and #22/77

AIS DESCRIPTIVE DATA							AIS QTA Array		
Card Type		Type of Station	Number of First Tray	Prob NRTS per Repair x 10000	Parts Replacement Time Days	D*	AIS Maintenance Time (percent) 1 Station	>1 Station	AGE Equivalent
22	66	3	7	131	6		33	26	18

CONDITIONAL PROBABILITY TRAY IS AFFECTED BY AWP x 10000			TRAYS Array									
Card Type		Number in Tray	I	I+1	I+2	I+3	I+4	I+5	I+6	I+7	I+8	I+9
22	77	1	1200	700	560	140	975	1680	1320	912	415	1265

* Distribution

The specialized support equipment used for testing and repairing avionics on late model aircraft--the AIS or Avionics Intermediate Shops--may also be simulated in TSAR. The manner in which the special characteristics of AIS are modeled in TSAR is discussed in Section VII. Whenever an LRU repair is completed using an AIS station, additional station time is allocated for maintenance of the station. This is handled by increasing the LRU repair time by a user-specified percentage. When that time is over a check is made to see if any piece part needed for station maintenance was not in stock. If so, the station's residual capability to repair LRUs is estimated on the basis of statistics that indicate how frequently each particular LRU repair capability is lost, on the average, when an AIS part is back-ordered. To do this we imagine that each station is divided into a number of sections, or "trays," one tray for each type of LRU, and when a part is back-ordered the mission capability of each tray is determined on the basis of the statistical experience.

To organize the necessary input data, the user must number each type of station, and each "tray" associated with each station. The station type numbers should be in sequence beginning with type #1 and the trays should be numbered consecutively from the first tray in station #1 to the last tray in the last type of station. The user then identifies the correspondence between the AGE type and the station type on Card Type #22/66, and between the part number and the tray number with entries in the AISDTA array (see col. 11-15 on Card Type #22/66) and in the TRAY array (see Card Type #23/78). The #22/66 and #22/74 Card Types provide the rest of the required data.

The entries for each type of station on Card Type #22/66 include the station-type number, the location in the TRAYS array of the first tray associated with the station, the probability that a part will be unavailable for AIS maintenance following each use of that AIS station, the order and ship time to replace a needed part, the increase (a percentage) in LRU repair time to be used to represent AIS maintenance, and the number of the equivalent AGE. The probabilities that an individual tray is affected by a missing part are entered with Card Type #22/77.

Sample Data: The #22/66 Type Card provides characteristics for the #3 type of AIS station. The first "tray" associated with this station is located in the ninth position in TRAYS array. After 1.31 percent of the times this type of station is used, a piece part required for maintenance of the AIS is unavailable and must be ordered; six days, on the average, are required to obtain the needed component. The actual repair time for each LRU processed on station #3 must be increased by 33 percent, to account for necessary AIS maintenance (if two or more stations of the same type are available for cross-checks, "hot mock-ups," etc., only 26 percent additional time is required). The equipment, or AGE, identification number for the #3 AIS station is #18.

When a piece part is required to service the AIS and it is not available, the subsequent mission capability of the station is affected as specified by the #22/77 Type Card. In this instance there is a 12.0 percent chance that the LRUs associated with Tray #1 will not be reparable if a piece part is unavailable for AIS maintenance; the likelihood for the other trays varies from 1.40 percent for Tray #4 to 16.80 percent for Tray #6.

Card Type #23

BASE PARTS STOCKAGE								- PARTSK ARRAY -						(Place SRUs at end of array)					
Card Type	Base No.	Part Number	Tot Serv	Bent	Tot in Shop	Nominal Stock Level	Percent NRTS	Part Number	Tot Serv	Bent	Tot in Shop	Nominal Stock Level	Percent NRTS	Part Number	Tot Serv	Bent	Tot in Shop	Nominal Stock Level	Percent NRTS
23		5	10	0	0	12	20												
23		104	6	0	0	8	100	105	3	0	0	4	100	106	10	0	0	12	100

Ten distinct formats are used in connection with Card Type #23 to permit the user to either specify spare part stock levels explicitly, or to direct TSAR to generate exemplar stock levels consistent with user-specified parts procurement policies.

Entry of Specific Stock Levels

When the user chooses to enter the stock levels himself, the first of these formats is used; entries include the number of serviceables (i.e., available spares), the number of reparables or "bent" parts,[2] and the "normal" or authorized stock levels. The percentage of reparables that can not be repaired on base--the NRTS rate--is also entered. The reparable ("bent") parts include both those awaiting repair and those undergoing repair (if any); all bent parts are presumed to be stored in the appropriate shop and are at risk to destruction if that shop is damaged by air attack. When an on-equipment task is initiated, tests are made to see if a part is broken; if it is, it begins an administrative delay, after which it is repaired in the local shop or, if it is to be NRTSed, it is prepared for shipment. The "nominal stock level" at an operating base is taken to be the level that is authorized for the aircraft initially assigned to that base, and it is used with certain of the decision algorithms for reaching judgments during the simulation as to which bases have the greatest need for parts. When a base has been designated as a CIRF, or as the location of

[2] This entry normally is zero, with the reparable status at zero time being generated by the ZSHOPS subroutine; see Card Type #42.

the theater manager, the "nominal stock level" at that base defines the minimum stock level to be maintained at that location; serviceables above this level are "pushed" to the "most needy" base, if that resource management mode has been selected. The number of serviceable parts of any given type may not exceed 320, and the nominal stock level may not exceed 250.

Several other Type #23 Card formats are illustrated in Figs. 5 and 6. One is used to supply data as to which bases may be checked for a part when the simpler of two lateral supply doctrines is used. A Type #23 Card enters these data when a 74 is entered in the "J" field. The calling base is entered in columns 6-10 and the bases that may be called are entered in the next five 5-column fields; these five bases are called in order. As indicated on page 63, an "88" or "99" in the "J" field can be used to have the parts at one base duplicated at another, or to enter the quantities of spare parts available at depots for replacing losses. Card Type #23/78 is used to identify the corresponding tray number (see Card Type #22/77 and Section VII) for those LRUs and SRUs that are repaired with AIS equipment.

Parts Stockage Algorithms

TSAR provides special subroutines that permit the user to generate the parts stock levels for any base; these are activated when OUTFIT is initialized on Card Type #3/3. The parts provisioned are for those unscheduled maintenance tasks included in the shop collections whose occurrence is controlled by Type #7 Card entries. The numbers generated are either appropriate for a WRSK kit or are the total of POS and BLSS, depending upon the user's specifications. They do not, however, make any provision for the additional parts that may be needed for repairing aircraft damage sustained in air battle or in airbase attacks.

Card Types #23/70 and #23/72 are used with the parts generation option to describe those factors that define stockage policy; they include the base number and kind, as well as the type and number of aircraft and the nominal sortie rates, base repair cycle times, and order-and-ship times in peace and war, and safety factors. Base kind determines whether the aircraft are in place and the base is to be

FORMS FOR SPECIAL PARTS OPTIONS INCLUDING AUTOMATIC INITIATION OF BASE STOCKS AND PIPELINE

POLICY DATA — POLICY ARRAY

Card Type	Base	Element No. of Ith Item	T NRTS	T BUY	T+1 NRTS	T+1 BUY	T+2 NRTS	T+2 BUY	T+3 NRTS	T+3 BUY	T+4 NRTS	T+4 BUY	T+5 NRTS	T+5 BUY	T+6 NRTS	T+6 BUY	T+7 NRTS	T+7 BUY	T+8 NRTS	T+8 BUY	T+9 NRTS	T+9 BUY
2 3	2	without CIRF*																				
		11			20		40	1			50											
2 3	3	with CIRF*																				
		11			80		100		80		100											

PARTS COST DATA ($100s)

Card Type		Number Ith Part	T	T+1	T+2	T+3	T+4	T+5	T+6	T+7	T+8	T+9
2 3	6 6	11	3.00	275	6							

BASE DATA

Card Type		Base No.	Base Kind	Type Aircraft	Number Aircraft	Sortie Rate Peace	Sortie Rate War	[illegible] Peace	[illegible] War	Order/Ship Time Days Peace	Order/Ship Time Days War	Travel Time Hours	No on-base SRU Stocks
2 3	7 0	1	1	1	45	3	2.0	72	48	1.0	2.0		
2 3	7 0	2	1										
2 3	7 0	3	2		24	8.0	12.0	72	48	1.0	2.5		
2 3	7 0	4	2	1	8	8.0	12.0	72	48	1.0	2.5		

* ... for CIRF eligible LRUs if = 1; all LRUs if = 2.

Fig. 5 -- Automatic Spare Parts Initialization Data

SPARES ARRAY (Cont'd.)							
Card Type		Base No.	Type Aircraft	ALPHA1	ALPHA2	BETA1	BETA2
23	72	1	1	150	75	120	75
23	72	3	1	120	75	120	75
23	72	4	1	120	75	120	75

SPECIAL PARTS DATA CONTROLS: - LATERL ARRAY -							
Card Type		Base No.	Lateral Resupply Bases				
			First	Second	Third	Fourth	Fifth
23	74						

POLICY DATA DUPLICATIONS			
Card Type		Copy Base	To Base
23	76		

AIS TRAY USED FOR REPAIR - TRAY Array -												
Card Type		[illegible] Part	I	I+1	I+2	I+3	I+4	I+5	I+6	I+7	I+8	I+9
23	78	7	1	10	5							

PARTS STORAGE DUPLICATION			
Card Type		Copy Base	To Base
23	88		

DEPOT STOCKS OF AIRCRAFT SPARE PARTS												
Card Type		[illegible] Part	I	I+1	I+2	I+3	I+4	I+5	I+6	I+7	I+8	I+9
23	99											

stocked with POS and BLSS, or the unit has been deployed into the theater with a WRSK kit; kind is 1 for the former and 2 for the latter. If a CIRF is simulated, it must be assigned its own base as well as its own NRTS rates and other policy factors, except that no aircraft are to be assigned at that location.

NRTS data for the parts stockage algorithms are entered using Card Types 23/20x and #23/30x for each part type. The 23/20x Cards define that fraction that would be NRTSed at base x if there is no CIRF in the theater, and the #23/30x Cards define the same data for the case in which there is a CIRF. If a part, LRU, or SRU is NRTSed 100 percent of the time but first undergoes a normal administrative delay and then a shop check, the NRTS value is entered as 100; if the part is NRTSed immediately upon removal, the NRTS rate should be entered as 101. The "buy" column on the #23/30x card is currently not used; on the 23/20x card a "1" entered in the "buy" column prohibits procurement of that part type for a WRSK. The stockage calculations are explained at greater length in Section V-1 in Volume I. If the POLICY array data entered with Card Types 23/20x and #23/30x are the same at two bases, a #23/76 Type Card can be used to duplicate the data for one base at another. (Since a #23/76 Card duplicates only that data already entered, this Card can be used to copy some, but not all, POLICY entries from one base to another, by appropriate placement of the card among the entries for the first base.)

When a CIRF is not simulated, the #23/30x cards may be used to provide the user an option to modify the NRTS rates at a specific time during the simulation. This might be desirable, for example, when intermediate repair facilities become available, as at a COB. To use this option, see the instructions for Card Type #31.

Card Type #23/66 provides unit cost data that are used to calculate WRSK stock levels with an algorithm that approximates the DO-29 WRSK calculation (when PMODE=1); these data are also used to compute the total costs for all the parts procured and "authorized" for each base.

If the control variable FULL that is defined on Card Type #3/3 is zero rather than one, a nominal number of each type of part that is NRTSed to other locations will be entered into the [illegible] delivery at random times after the simulation begins. If the user wishes to specify that the stocks that have been procured are short of the computed allowances, two procedures are provided. The first procedure for shorting stocks reduces the estimated stock level for each type of part by SHORT percent; the second reduces the stock level for a portion of the part types to a value chosen at random between K1LOW and (K1LOW + K2LOW) percent. If TOOFEW is greater than zero, the number of part types chosen at random to be shorted is [TOOFEW/10] percent of the part types; if TOOFEW is "-1", the probability that any part type is shorted is equal to that part's unit cost divided by the unit cost of the most expensive type of part. These procedures may be used separately or together. If RANDM is one, the availability of each part is determined by a random draw; otherwise the shortage is the expected value of the shortage.

Parts for battle damage repair can be specified separately, using the basic Type #23 cards, or can be provisioned by initializing columns 41-45 on Card Type #15/2. In addition, shortages (overstockage), relative to the numbers computed with these algorithms may also be represented by separately specifying negative (positive) numbers of parts with the basic #23 cards. The user is restricted, however, to entering at most 500 specific stock levels for each base, in addition to those generated by the stockage algorithms; the part types so entered may be the same as or different from those dealt with automatically.

Sample Data: The first card (p. 71) stocks all bases (with ten serviceable Type #5 parts. There are no reparables on base at the beginning of the simulation. Twenty percent of these parts cannot be repaired on base. The target level is 12 parts of that kind. The second card image provides spare SRUs for Part #5, which is an LRU (see Card Types #8).

Card Types #23/20x and #23/30x present the NRTS rates that are used when TSAR generates spare parts stocks. These data indicate that in the absence of a CIRF 20 percent of Type #12 reparables would be NRTSed at Base x, as well as 40 percent of Type #13 and 50 percent of Type #15.

Furthermore, Type #13 parts would not be procured for WRSKs. The data also indicate that all #13 and #15 parts would be NRTSed if there were a CIRF, and 80 percent of part Types #12 and #14 would be NRTSed. Without a CIRF no #14 parts would be NRTSed, since the null entry is taken to signify a zero NRTS rate.

The policy options that will be used in automatically generating parts levels are illustrated with the #23/70 and #23/72 cards. Bases #1 and #2 are both to be treated as in-place units (KIND = 1) that operate 48 Type #1 aircraft. The nominal peacetime and wartime sortie rates are assumed to be 0.8 and 1.2 sorties per aircraft per day; base repair times are 72 and 48 hours in peace and war respectively; and the order and ship times are 10 and 20 days in peace and war. No base-CIRF travel time is entered since there is no CIRF. The safety factors (Card Type #23/72) that are to be considered in computing stockage levels are 1.5 for LRUs associated with mission-essential tasks, and 0.75 for those that are not. For SRUs the factors in these same circumstances are 1.20 and 0.75.

WRSK kits are specified for the units at bases #3 and #4 (i.e., KIND = 2 specifies a unit that is deployed into the theater during an emergency). Since PMODE equals 1 (see CARD Type #3/3) the approximate DO-29 logic is to be used in computing the stock for these WRSK kits. The other policy factors governing parts procurement for these units are the same as for bases #1 and #2, except that fewer aircraft are to be covered, and the safety factor for mission-essential LRUs is only 1.20.

The sample cost data on the #23/66 card indicate that #11, #12, and #13 type parts have unit costs of $30,000, $27,500 and $600 respectively.

When parts are required at Base #1, the #23/74 Type Card indicates that Base #2 is first asked if they can fill the requirement; if not, Base #3 is asked. The #23/76 Card indicates that the various NRTS data entered with the #23/201 and #23/301 Cards for Base #1 also should be applied to Base #2. The #23/78 Cards specify which tray in the AIS string is associated with a particular LRU or SRU; this sample specifies that trays #1, #10, and #5 are used wit LRUs #1, #2, and #3, respectively.

Card Types #24, #25, #26 and #27

These cards specify the initial stocks of munitions, TRAP, building materials, and POL. The "J = 99" version of each Card Type permits the user to indicate the stock levels available for resupply for whichever resources have resupply limitations. Use of the normal munitions type number designates assembled munitions; for unassembled munitions, add 100 to the nominal type number.

Sample Data: The first cards stock all operating bases with 200 Type #1 and 160 Type #2 munitions that are assembled, and 4000 and 2500 of the same types that are unassembled.

BASE MUNITIONS STOCKS — MUNSTK ARRAY —

Card Type	Base No.	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level
24		1	200	2	160										
		101	4000	102	2500										

BASE TRAP STOCKS — TRAP ARRAY —

Card Type	Base No.	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level
25	1	1	20	2	20	3	10	4	20	5	780				

CIVIL ENGINEERING BUILDING MATERIALS — MATERL ARRAY —

Card Type	Base No.	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level
26	1	1	6000	2	8000	4	2000	6	1000						

BASE POL STOCKS (Thousands of Pounds) — POLSTK ARRAY —

Card Type		Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL
27		1	30000	2	30000	3	20000	4	16000						

Card Type #28

Card Type	First Element No.	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC	Part No.	#/AC
28	1	1		2		3		4		5		6		7		8		9		0									

These cards define the one-dimensional parts-list (PRTLST) array. These data are used when parts are to be salvaged from an aircraft too badly damaged for repair. The numbers of all parts and all LRUs on each aircraft type that are to be considered eligible for salvage are entered, as well as the quantity of each of these items that are used on the aircraft. If the quantity is left blank, it is assumed that the aircraft only uses one part of that type. A zero is used to denote the end of the parts list for each aircraft type. The position in the array of the first part for each aircraft type is specified on Card Type #15. The position within the PRTLST array of the first of the entries on each card is defined by the value in the col. 3-5 field.

Card Type #29

SHOP AND TASK SEQUENCE CARDS (Up to 5 Cards for Each Base and Type Aircraft)*

Card Type	Base No.	Aircraft Type	Card No.	Contiguous Shops and Tasks May Work Together - Subsequent Sets Follow									
29	1	1	1	45	0	62	49	1	17	19	2	4	9
29	1	1	2	24	0	8	51	3	21	12	0	26	52
29	1	1	3	29	0	0							

* For emergency receiving base, EMERG, do not enter Shop #26, and conclude sequence with Shop #30, by itself

These cards define the order in which on-equipment aircraft maintenance tasks are to be scheduled. Tasks may be entered individually or as collections of work center (shop) activities. When a shop number is entered, all tasks associated with that shop number in the SHPTSK array (Card Type #7) are implied. To be distinguishable, all numbers less than 31 are interpreted as shops and all others as tasks.

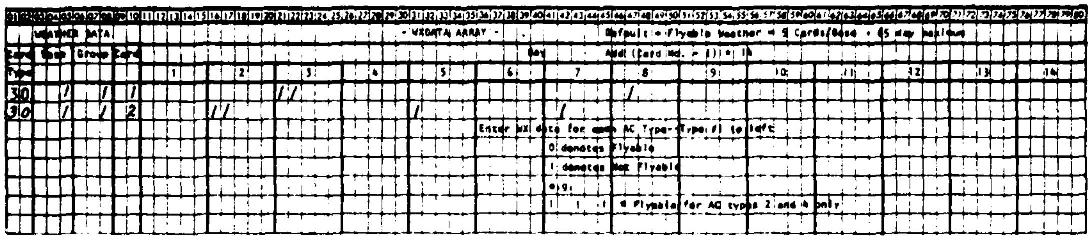
The order in which tasks are carried out is controlled by the position of the task and shop numbers on these cards. The numbers may be entered in any order; when two or more tasks or shops may be worked at the same time, the numbers are entered in successive fields; if two groups of tasks or shops may not work on an aircraft simultaneously, and one must follow the other, they will be separated by a null entry in a field. The last item is denoted by two following null entries. Task organization may be further modified and controlled by the LISTIN array of incompatability data (see Card Type #19).

Up to five cards may be used to enter the task and shop sequence for each base-aircraft-type combination. A distinct set of cards is required for each combination, unless the base number is not entered, in which case all bases will function in a common manner.

When an emergency recovery base (EMERG) is specified, the sequence for that base must be concluded with a '0' followed by '30' and two null entries, and Shop #26 should not be specified. Resources must be provided at this base for whatever activities are specified by the task sequence cards and for battle damage the recovered aircraft have sustained.

Sample Data: These three cards illustrate how the on-equipment aircraft maintenance task schedule illustrated in Fig. 6 of Volume I would be entered for the Type #1 aircraft at base #1.

Card Type #30



On-equipment maintenance tasks that are not mission-essential may be deferred, and may be worked off at night or, if bad weather exists and the aircraft cannot fly, during the day as well. The weather status can be entered by base and by aircraft type for a 65-day period with these cards. Two groups of five cards with 14 entries each may be submitted for each base; the first group is used for the first five aircraft types; the second group is used with the last four aircraft types. Each field is filled with ones or zeros (blanks) to indicate the weather on the nth day. The left-most column of the first group pertains to aircraft type number one and the right-most column to aircraft type number five; the left-most column of the second group applies to the sixth type of aircraft and the next to the right-most to the ninth. A one signifies non-flying weather for a particular day-base-aircraft, while a zero denotes no weather restriction. If no data are entered, clear weather is presumed throughout the 65-day period.

Sample Data: Flying is interrupted by weather on only five days at Base #1. Neither the first nor second type of aircraft may fly on the 3rd and 17th days; the first type of aircraft is also grounded on day 20 and the second type on days 8 and 22.

COMMUNICATIONS SYSTEMS INPUT DATA

Card Type #31

RESOURCE, SHIPMENTS FROM CONUS				CONUS and CARGO ARRAYS											
Card Type	Arrival Time		Base	Commodity			Commodity			Commodity			Commodity		
	Day	Hour	No.	Class	Number	Type	Class	Number	Type	Class	Number	Type	Class	Number	Type
31	5	17	1	1	5	7									
31				3	4	3	4	10	104	5	2	11	7	12	
31	7	21	2	3	4	1									

These cards permit the user to define resource deliveries from the United States (i.e., outside the theater). The format permits the user to specify the destination and time of arrival of each shipment from CONUS, and the nature of the cargo. The destination and time need be specified only on the first of the cards defining the contents of a shipment, since the cargos specified on all subsequent Type #31 Cards are delivered at the same time and place until a new destination is encountered.

The maximum number of items that may be defined with a single entry is 99, but any number of identical entries are permissible with the same shipment. For convenience, the actual quantities that are delivered are multiples of the number entered for certain classes of resources: for munitions and TRAP, the number delivered is 25 times the number entered. For POL, 100 units are delivered for each unit entered on this Card Type; if the unit of measure on base is thousands of pounds, an entry of 50 on this card would direct the delivery of 5 million pounds--i.e., 50 × 100 × 1000. (For POL, "type" is normally zero; if Type = 100, shipment is additional storage capacity.)

For personnel only, this card type may also be used to withdraw a specified quantity of specialists of a given type. To do this, the personnel type is entered as a negative value as a signal that the quantity is to be interpreted as a withdrawal.

This card type is also used to change the NRTS policies of a base, but can only be used when no CIRF is simulated. Such a change might be desirable, for example, when intermediate repair facilities become available for a unit deployed to the theater (e.g., at a COB). The time to effect the change is signaled by delivery of a Type #3250 part (Class #3) to the appropriate base. At that time, the NRTS data that had been entered with Type #23/20x Cards are replaced with the data submitted on the #23/30x Card Types and stored in the POLICY array.

Sample Data: These two cards specify that base #1 is to receive a shipment from CONUS at 1700 on day 5. Included are five Type #7 personnel, four Type #3 spare parts, 250 unassembled Type #4 munitions, 50 Type #11 TRAP, and 1.2 million pounds of POL. Note that the arrival time and destination appear on only the first card. The third card indicates that four Type #1 aircraft are to be ferried to base #2 at 2100 on day 7.

Card Type #32

INTRA - THEATER SHIPMENT SCHEDULE - SHIPSC ARRAY -

Card Type		From Base	To Base	Departure Freq	Departure Hr	From Base	To Base	Departure Freq	Departure Hr	From Base	To Base	Departure Freq	Departure Hr	From Base	To Base	Departure Freq	Departure Hr	From Base	To Base	Departure Freq	Departure Hr
32		1	2	1	17	1	3	2	14												

These cards define the daily intra-theater transportation schedule. The nominal departure times for all links in the transportation network may be specified.

Sample Data: This card image indicates a daily shipment at 1700 from Base #1 to Base #2 and a shipment every other day at 1400 from Base #1 to Base #3. When shipments are not daily, the day for the first shipment is picked at random.

Card Type #33

BASE TO BASE SHIPMENT TIMES — SHIPTH ARRAY

Card Type		From Base	To Base	Departure Delay: Mean (hr)	Departure Delay: Dist	Transit Time*: Mean (hr)	Transit Time*: Dist	Arrival Prob	From Base	To Base	Departure Delay: Mean (hr)	Departure Delay: Dist	Transit Time: Mean (hr)	Transit Time: Dist	Arrival Prob	
33		1	2	2	1	36	2	98								
33		1	3	1	1	48	2	(100%)							(100%)	

*Maximum mean transit time is 100 hours

These cards, in conjunction with the Type #32 cards, describe the intra-theater transportation system. For each base combination the user may specify the expected departure delays and their distributions, and the transit times and their distributions. The chance that a shipment is lost (to enemy action?) is also entered with these cards.

Sample Data: These data indicate that all intra-theater shipments from Base #1 to Base #2 leave an average of two hours late and take 36 hours on the average to reach their destination. The actual departure delay and transit time are determined by random selections from distributions #1 and #2 respectively. There is a 2 percent probability that each shipment is lost enroute.

Note that for shipments from Base #1 to Base #3 the arrival probability was not entered, since the default value is 100 percent, and no losses are expected along that route.

Card Type #34

SHIPPING INSTRUCTIONS FOR PARTS - SHIPTO ARRAY - NRTS Instructions													
Card Type	Base	Card No.*	Last Part No.	Receiving Base	Last Part No.	Receiving Base	Last Part No.	Receiving Base	Last Part No.	Receiving Base	Last Part No.	Receiving Base	
34	1	1	600	9									
34	3	1	13	1	600	9							

* 1 to 4 cards per base

These cards provide the instructions for each base for the disposition of NRTS parts. The entries delimit those parts numbers that are to be NRTSed to other bases. For example, all parts numbered from #1 to the first part number are NRTSed to the first base listed all subsequent part numbers up to and including the next part number are NRTSed to the next base, etc. If all NRTSed parts are to go to a common base (i.e., a CIRF) only one entry would be necessary--i.e., the highest relevant part number and the repair base number. If parts are to be NRTSed to different bases, the part numbers should be organized into contiguous groups to avoid exceeding the SHIPTO array capacity of 20 groups. Parts to be NRTSed to CONUS are indicated by a base number that exceeds the maximum number of bases by one (i.e., MAXB + 1).

Sample Data: This card indicates that whenever Parts #1 thru #600 are NRTSed at Base #1 they are all to be shipped to CONUS (i.e., MAXB + 1). At Base #3, Parts #1 thru #13 are NRTSed to Base #1 and Parts #14 thru #600 are NRTSed to CONUS.

AD-A114 236 RAND CORP SANTA MONICA CA F/G 15/3
TSAR USER'S MANUAL: VOLUME II. DATA INPUT, PROGRAM OPERATION AN--ETC(U)
FEB 82 D E EMERSON F49620-82-C-0018
UNCLASSIFIED RAND/N-1821-AF NL

2 OF 2
AD A
114236

END
DATE
FILMED
05-82
DTIC

Card Type #35

CANNIBALIZATION TIME FOR PARTS - CANNTM ARRAY																	
Card Type		Part No.	Time ¢14	Part No.	Time ¢14	Part No.	Time ¢14	Part No.	Time ¢14	Part No.	Time ¢14	Part No.	Time ¢14	Part No.	Time ¢14	Part No.	Time ¢14
35		1	20	2	15	3	-30										

These cards provide the user an opportunity to specify a time different from the default value that is required to cannibalize a part. For those parts that have had a cannibalization time entered, the nominal task time for handling the relevant task will be increased by this time, when the required part must be acquired by cannibalization. If the entry is -1, the part may not be cannibalized. If the entry is negative but not -1, the part may not be cannibalized except when the number of aircraft on base that require the part exceeds DOCANN; in that case the nominal task time is increased by the absolute value of CANNTM to account for cannibalization.

If a value is entered for an SRU, the time required to diagnose and replace that SRU is increased by the entry if an LRU is disassembled to obtain the required SRU. If no value is entered, the default is one-half the nominal time for that SRU.

Sample Data: These data indicate that only 20 additional minutes are required to obtain a #1 Type part by cannibalization, rather than the 36 minute default (i.e., the 25 TTU task time for task #2; see Card Type #5). For Type #2 parts a time of 15 rather than 30 minutes is indicated. Part Type #3 cannot be cannibalized unless the number of aircraft that have this part missing exceeds five.

Card Type #36

REPORT SCHEDULES, DELAYS, LOSSES							- XMIT ARRAY AND REPORT ARRAY -																			
Card Type	Base	Transit Time			Loss Rate		Daily Report Times																			
		Hours	Minutes	Dist	Item	Report	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min
36	1	4	30	1		3	2	30	14	30																

Management of theater resources may be based upon imperfect information. These cards permit the user to define periodic base-by-base resource status reports that may be late, imperfect, canceled, or lost. Each base reports its current resource status each day at times specified by the user. The arrival time at "Theater Headquarters" is controlled by the submittal time and the uncertain transit time. The likelihood that any element of the transmitted data is received is governed by the "Item Loss Rate," and the likelihood that the entire report is lost in transit is governed by the "Report Loss Rate." The transit times must be such that reports are received before the next one is transmitted, if this rule is violated, the transit time will be shortened appropriately, and the change will be noted in the output listing.

Sample Data: These data specify that Base #1 reports to the control authority at 0230 and 1430 and that the reports arrive an average of 4 hours and 30 minutes later (the variance is controlled by distribution #1). There is a 3 percent chance that the report is lost in transit.

AIRBASE FACILITIES DATA AND ATTACK DATA

Card Type #37

Card Type	Base	Building	Task Type		Size	Alternate Bldg	Alternate Cap	Subsequent	Building	Task Type		Size	Alternate Bldg	Alternate Cap	Subsequent	Building	Task Type		Size	Alternate Bldg	Alternate Cap	Subsequent
BASE FACILITY DESCRIPTORS									- FACLTY ARRAY -													
37	1	1	5		120	41	4	51	3	3		80				7	5		95			
37	1	41	7		80	42	2		42	7		60	4	1								

Card Types #37, #38, and #39 jointly describe the size of the critical facilities on each base, the procedures and resources needed to restore the facilities to an operational condition when they have sustained damage, and the relative priorities for repair. The sizes and designations of the repair procedures for the various facilities are stored in the FACLTY array, and the resource requirements for each type of repair procedure are stored in the CERQTS array. The repair priority for each facility is stored in the CEPRTY array and it is mandatory that all facilities be represented in that array, even though some of them are not to be considered for repair. A facility may be restored to an operational condition using one repair procedure, or it may require a sequence of repair procedures. The time and resources required for each of these procedures is determined by the extent of the damage that was sustained.

The Type #37 Cards describe the size of the critical facilities on each base other than aircraft shelters and specify the types of procedures that are to be used for repairs to each facility. Facilities (e.g., buildings) of like function on the several bases should all be identified with the same building number. For the work centers (shops) that deal with aircraft maintenance, the buildings housing the functions must be given a "building" number identical to the "shop" number. The runway(s) should be designated #36 and the taxiways as #35. If the repair of any of these facilities can require an additional repair procedure subsequent to that listed for the facility, the data describing those procedures are also stored in (otherwise unused) columns of the FACLTY array; each such listing defines the type of procedure and the effective "size" of the facility.

The "size" of the facility is meaningful in the context of the repair requirements specified with Card Types #38; the time to repair a facility sufficiently such that it is functional is defined in terms of the required reconstruction (percent damage × size).

The work consigned to some shops may in fact be carried out at more than one on-base location, and thus a base's capacity for the activities assigned to those shops would not be entirely dependent upon a specific facility not being damaged. When this situation exists, the alternative locations for the activities of any particular type of shop are designated with the Type #37 Cards, along with an indication of the task capacity at each location. When this is done the repair capacity for parts and equipment in such a shop is equal to the sum of the capacities specified for each of the separate locations that remain undamaged following an attack. Personnel and other resources engaged in such activity at the time of an attack are assumed to be distributed among the several locations in proportion to their pre-attack repair capacities.

Sample Data: The first card specifies the nature of the reconstruction that would be required and the size of the facility for each of three facilities on Base #1; two involve #5 Type construction and one involves #3. In addition, when the work required using the #5 Type restoration procedure has been completed on Shop #1 (building #1), subsequent work may be required, as defined by the data filed for building #51 in the FACLTY array; that work would use the #7 Type of work procedure.

The sample also illustrates the specification of a distributed shop capacity. In this instance the parts and equipment repairs consigned to Shop #1 are distributed among buildings #1, #41, and #42; their respective repair capacities are 4, 2, and 1.

Card Type #38

CIVIL ENGINEERING TASK REQUIREMENTS - CERQTS ARRAY -

Card Type	Task Type	Time: Per Unit (Min)	Time: Fact	Personnel #1: Type	Personnel #1: No.	Personnel #2: Type	Personnel #2: No.	Equipment #1: Type	Equipment #1: No.	Equipment #2: Type	Equipment #2: No.	Material #1: Quan	Material #1: Type	Material #2: Quan	Material #2: Type	Alternate Procedure
38	5	200	45	30	10	20	8	42	4	44	6	30	5	60	10	22
38	22	280	56	30	6	20	8	42	2	44	4	30	5	60	10	0

The resources required for civil engineering reconstruction are summarized on these cards. Each task type defines the resource requirements for a particular reconstitution procedure. Each procedure is expressed in terms of a level of effort for manpower and equipment; building material requirements are assumed to be proportional to the level of damage that was sustained, and the time required to execute a repair procedure is related to the damage in a more complex fashion as noted below. The basic procedures specified with the Type #37 Cards should be followed whenever sufficient resources exist; the first alternative should be used to specify a procedure that requires fewer personnel and equipment. (Since a base may have no more than 320 units of personnel of a particular type, the personnel requirements for these tasks may have to define a unit of personnel as several persons.)

When a facility may require a sequence of two or more reconstitution procedures for it to be restored to an operational status, the time and resource requirements for each procedure are determined on the basis of the damage reported in the DAMAGE array data for each procedure or building and the size of that building as defined by the #37 Type Cards. Only when all required procedures have been executed in sequence is the facility returned to operations.

The repair time and material requirements entered on the Type #38 Cards should be the requirement for one size-unit of reconstruction. The largest quantity of material that may be entered for a unit-task is 320. The time function relates the total task time to the unit-task time (as outlined in the FTIME subroutine). It permits the total task time to be expressed as the sum of a startup time and a damage dependent time. This function is defined as:

$$C = 12 \times P + (B - 1)$$

and the total task time is:

$$T = \text{Delay (B)} + \frac{\text{(Repair Time)}}{\text{(Unit Damage)}} \times \text{(Units of Damage)}^{g}$$

where

Delay (B) = 0,1,2,3,4,6,8,12,18,24,36,48 hours for B = 1 to 12

and

g(P) = 0.5, 0.75, 0.9, 1.0, 1.1, 1.25, and 1.5 for P = 1 to 7

Alternate procedures are also filed in the CERQTS array.

Sample Data: These two cards indicate the primary and alternative procedures for #5 reconstruction jobs. The primary procedure uses ten Type #30 and eight Type #20 personnel and four Type #42 and six Type #44 pieces of equipment. Thirty units of building material Type #5 and 60 units of Type #10 are required per unit of damage. The time per unit of construction is 200 minutes and varies as a function of the amount of reconstruction as specified by function FTIME #43; i.e., if 40 percent damage were sustained by a facility that is 60 units in size, the total time for reconstruction would be

$$240 + (200/3) \times (.40 \times 60)^{0.9} = 1404 \text{ TTU}$$

or about 70 hours.

If the alternative procedure were used, fewer personnel and equipment are required but the time would be increased (function #56) to

$$360 + (280/3) \times (.40 \times 60) = 2600 \text{ TTU}$$

or 130 hours.

Card Type #39

RECONSTRUCTION PRIORITIES BY FACILITY (BLDG) NUMBER - CEPSTY ARRAY - Same All Bases														
Card Type	Building	Priority	Building	Priority	Building	Priority	Building	Priority	Building	Priority	Building	Priority	Building	Priority
39	100	1	36	2	2	3	4	4	7	5				

The order of importance of the facilities and functions on a main base is specified with these cards; the priority is the same for all bases. For each facility (or building) number that has been specified on a base (including alternative facilities but exclusive of facility numbers used to define a sequence of necessary tasks), the priority of that facility must be entered in this priority list, even though repairs are not contemplated.

Since facility #36 has been set aside (by program logic) as the runway, the entry-pair '36 1' would specify runway reconstruction as the first priority civil engineering task; '2 3' would specify that reconstruction or reconstitution of shop #2 was the third priority task.

When a base has been attacked and the total damage established (in subroutine BOMB), TSAR first tests whether the civil engineering resources are adequate to initiate reconstruction or reconstitution of all damaged facilities of higher than or equal priority to that of facility CRBLDG. If the resources are available, all work is started; if they are insufficient, resources for the first alternative repair procedure (when specified), or alternatives thereto, are allocated to each damaged facility until the civil engineering personnel are all assigned. By specifying fewer resources and longer times for the alternative repair procedures, this use of CRBLDG results in the available work force being assigned to a larger proportion of the more critical tasks.

Card Type #40

AIRBASE DAMAGE DATA — DAMAGE ARRAY

Card Type	Base	Attack Time: Day	Hour	Minutes	Class	Type	Percent Type Lost	Percent [illegible] Lost	Percent AGE Lost	Percent Parts Lost	Class	Type	Percent Type Lost	Percent [illegible] Lost	Percent AGE Lost	Percent Parts Lost
4(0)	Enter only on first card of each attack					Entire Class if Type=0 for Classes 1,3,4,5,7										
40	3	2	5	35	1		20				4		34			
40					5	3	15				5	8	49			
40					10	1	10	40	70		10	2	100			
40					8	1	15	10	70	92						
40					9	5	40	40	20	50	9	7	30	40	30	20
40					9	3	15	16	30	72	9	100	10			

These cards prescribe the damage inflicted by airbase attacks. They permit the user to define the time of the attack and the level of damage sustained by each of the many types and several classes of resources. Such data will need to be developed from a distinct set of calculations. The companion TSARINA computer model (derived from the AIDA airbase damage model) permits the user to generate the appropriate data for direct input into TSAR. The procedure for introducing damage data for multiple trials, either directly from TSARINA or with separate sets of card images for each trial, are explained in the comments in subroutine INPUTC.

The order in which these data must be entered is significant. An attack is denoted by entering the time and location of the attack in the "J" field and in the next three fields. All subsequent Type #40 Cards are associated with the same attack until an entry is encountered in the "J" field.

The percent losses experienced by each class and type of resource may be specified using these cards; however, if the user wishes to assume that all members of a given class sustain the same level of attrition, a type number should not be entered; when that is done, all members of that class suffer a common loss percentage. For the first seven classes of resources, only the class, type, and percent loss may be entered. For aircraft and facilities, additional loss rates may be entered that express the percentages of the personnel, equipment, and parts in the facility that are destroyed by the attack. Entries for these categories will depend upon the user's assessment of the available warning of airbase attack and passive defenses.

The specification of damage and destruction to aircraft and of the damage to shelters requires at least three sets of entries. The first two are entered as Class #10 data. The "percent type lost" for "Type #1" is interpreted as the percentage of the aircraft shelters that are not designated for "special" alert that are destroyed in the attack. The entries under personnel and equipment are interpreted as "the percentage of the aircraft in those shelters that are damaged when the shelter doors are open," and "the percentage of the unsheltered aircraft that are damaged," respectively. The entry for "percent type lost" for "Type #2" is interpreted as "the percentage of the aircraft that are damaged in the attack that are not reparable." The entries under personnel and equipment are interpreted as "the percentage of the "special" alert shelters that are destroyed" and "the percentage of the aircraft in the special alert shelters that are damaged when the doors are open."

The final entries are the Class #8 data. The "percent type lost" for "Type #1" is interpreted as "the percentage of the aircraft that are damaged in regular shelters when the doors are closed" and as percentage of the personnel, equipment, and parts associated with damaged aircraft that are lost. The "percent type lost" entry for "Type #2" is interpreted as "the percentage of aircraft damaged in the special shelters when their doors are closed."

Sample Data: These several cards specify the damage inflicted on Base #3 by an attack at 0538 on Day 2. The first card specifies that 20 percent of all types of ground personnel (class #1) and 34 percent of all types of munitions (class #4) are destroyed; all types are affected since no type is specified. The second card indicates that 15 percent of TRAP #3 and 43 percent of TRAP #8 were lost.

The fifth and sixth cards indicate that 40 percent, 30 percent, and 15 percent of facilities #5, #7 and #3, respectively, were damaged and must be repaired to restore the functions associated with those shop facilities. The percentages of personnel, equipment, and parts that were destroyed in each facility by the attack are also noted. The fourth card also indicates that the runway[3] is closed and that 10 holes must be repaired to reopen it for flight operations.

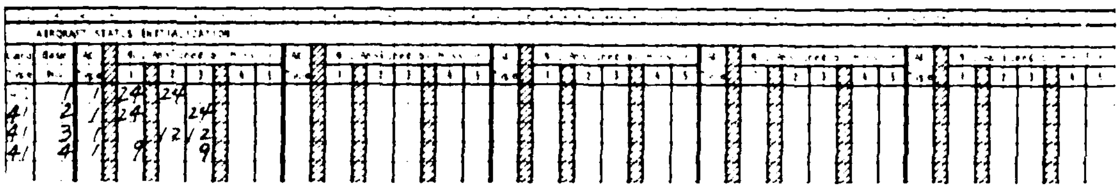
The third and fourth cards specify the damage sustained by the shelters and the aircraft on base at the time of the attack. Note that the special data (Class #10) precede data for the aircraft (Class #8). The entries for the Type #1 special data specify that 10 percent of the shelters are destroyed, that 40 percent of any aircraft that are only partially sheltered are damaged, and that 70 percent of the aircraft outside of shelters are damaged. The entry for the Type #2 special data specifies that 100 percent of the aircraft that are damaged are not reparable; since no "special" shelters have been defined for this illustration, there are no other entries on this card. The fourth card specifies that 15 percent of the aircraft that are sheltered are damaged, and that 10 percent of the personnel and 70 percent of the AGE associated with the damaged aircraft at the time of the attack are lost; and, for those aircraft that are not reparable, 92 percent of the parts can not be recovered by salvage operations.

These various damage data may be entered in any order except that the special damage data (Class #10) must precede the aircraft damage data (Class #8).

[3] The facility designated #36 is interpreted as the runway.

INITIALIZATION OF AIRCRAFT AND SHOP STATUS

Card Type #41



These cards permit the user to initiate the simulation with the aircraft and shops in the conditions that might be expected if war were to break out following a period of warning and alert. All aircraft are ready to be launched on specified missions, fully loaded with the preferred standard combat load and configuration for those missions. No aircraft maintenance tasks, parts repair, weapons assembly or civil engineering tasks are in process, waiting, or interrupted. These latter conditions may be modified by Card Type #42.

These cards specify the numbers of each type of aircraft that are ready for each of the several missions for each base. They must be entered after Card Type #20, and the bases and the aircraft types must be entered in the identical order in which they are specified on Card Type #20.

Sample Data: This card specifies that at the beginning of the simulation half of the aircraft on each base are assigned to one of two missions; aircraft are configured for missions #1 and #2 at Base #1, and for mission #1 and #3 at Base #2, etc. These data must be input in the identical base-aircraft order used with the #20 Card Types.

Card Type #42

SHOP ACTIVITY AT ZERO TIME				(BASIC ARRAY)							
Card Type		Base #	Aircraft Type	Distribution of On-Equipment Maintenance						On-Base Repairs	
				Group 1		Group 2		Group 3		Admin. Delay	In Process
				% AC	# Tasks	% AC	# Tasks	% AC	# Tasks		
42		1	1	10	1	20	2	5	4	15	6

These cards can be used in conjunction with Card Type #41 to initialize aircraft maintenance activity at the beginning of the simulation. After Card Type #41 has been used to specify that all aircraft are ready to be launched and that there is no activity ongoing in the shops, these cards will modify those conditions. To simulate the existence of ongoing unscheduled on-equipment tasks, the user may specify a three-part distribution. Each part is defined as a fraction of a given type of aircraft at a particular base, and a number of tasks; thus one might specify that 10 percent of the aircraft have one unscheduled task to be completed, 20 percent have two tasks, and 5 percent have four tasks. At initialization, a random number is drawn for each aircraft to see if work remains, and how much. If so, tasks are selected at random, in proportion to their nominal probability of occurrence; when initiated, the time remaining to completion is taken as a random portion of the total task time.

The user may also specify a level of parts repair activity. Two numbers can be input for each aircraft type and base; the first is the number of repair tasks to be placed in the administrative delay, and the second is the number that are placed in-process or waiting. These activities are selected in proportion to their nominal probability of occurrence, and the portion of the time remaining is selected with a random number.

<u>Sample</u> <u>Data</u>: This card image indicates that Type #1 aircraft at Base #1 should be assigned ongoing maintenance activity at zero-time according to the distribution discussed above. This card also directs that 21 on-base parts repair jobs are to exist at zero-time--15 in the administrative delay queue and six in process or waiting for resources to be started.

Card Type #43

RESOURCE RESUPPLY DATA — REFILL ARRAY

Card Type	Class	Mean Resupply Time Days	Mean Resupply Time Hrs	Time Dist	Class	Mean Resupply Time Days	Mean Resupply Time Hrs	Time Dist	Class	Mean Resupply Time Days	Mean Resupply Time Hrs	Time Dist	Class	Mean Resupply Time Days	Mean Resupply Time Hrs	Time Dist	Class	Mean Resupply Time Days	Mean Resupply Time Hrs	Time Dist
43	1	3	12	6	3	20		6	8	1	12	6								

These cards permit the user to simulate the requisitioning and resupply of resources that are lost in combat or during an airbase attack, and parts that are not reparable in the theater. For those classes of resources that are specified with these cards, such losses are replenished from CONUS after a delay that is controlled by the mean resupply time and the time distribution. The numbers that designate the various resource classes are:

1 - Ground personnel	5 - TRAP
2 - AGE and equipment	6 - Building materials
3 - Parts	8 - Aircraft
4 - Munitions	9 - Aircrews

Note that the number "9" is not used to designate facilities; this is the only exception to that usage in TSAR. Also, POL is not included at this time.

Whenever losses are suffered by any type of resource of the classes that are entered, a resupply shipment of the same quantity and type is scheduled to arrive at the location that suffered the loss after an appropriate delay. If the stocks available for resupply are limited, the limits for each type of resource are specified with the "J = 99" version of each of the resource stockage cards (i.e., Card Types #20 through #27).

Sample Data: With these illustrative entries, ground personnel that are lost to air attack would be replaced in about 3-1/2 days; parts that are lost or are not reparable in the theater could be requisitioned from CONUS with replacement expected in about 20 days. Aircraft lost in combat or from air base attack would be replaced in approximately 36 hours. In each case the actual resupply time is established with a sample from the #6 distribution (i.e., about plus-or-minus 40 percent, relative to the mean).

Card Type #44

BREAK RATE MODIFIERS (Input rates modified by indicated percentage or reduced by indicated percentage for each sortie day [illegible] if VBREAK = 1)															
Card Type	A/C Type	Card No.	SHOP												
			1 or 13	2 or 14	3 or 15	4 or 16	5 or 17	6 or 18	7 or 19	8 or 20	9 or 21	10 or 22	11 or 23	12 or 24	[illegible]
44		1													
44		2													

The probability that the various unscheduled on-equipment maintenance tasks are required after a given sortie are entered using Card Type #7. The normal data available for estimating these probabilities, or breakrates, are usually derived from peacetime experiences at low sortie rates. Limited evidence suggests, however, that the perceived breakrates in wartime, at higher activity levels, may not be as high on a per sortie basis. These cards permit the user to reflect his perceptions of such experiences in the simulation on a shop by shop basis. The breakrates may be reduced (or increased) from the nominal values for whichever aircraft types and shops are designated. Two options are available; if the control variable VBREAK (Card Type #3/2) is zero, the entry is interpreted as the percentage of the nominal breakrate (as entered with Card Type #7) that should be applied. If VBREAK is unity the entry is interpreted as the percentage reduction in the breakrate that is experienced for each sortie/day/UE that the achieved sortie rate exceeds one. If no value is entered (100 percent of) the nominal values will apply.

Card Type #45/1

When personnel and equipment of the same kind are assigned to different on-base organizations, it is necessary to designate each subset by a different number in TSAR, as illustrated in Fig. 7. The Type #45/1 Cards provide TSAR the necessary data with which personnel of common skills can be identified. Identical personnel types may be assigned to up to three flight-line organizations and a wing organization. The personnel type numbers that are identified with the on-equipment maintenance task requirements on Card Types #5 and #6 should be entered under "Personnel Type"; these personnel designations are assumed to be available to support the first squadron. The TSAR personnel type numbers for the same type of personnel assigned to the second and third squadrons should be entered in the next two fields; those assigned at wing level are entered in the fourth field. These numbers, when entered on this card type, must appear in an ascending sequence.

If some personnel types are not assigned at squadron level and all demands are met from a common base pool, the user need enter the personnel type number only in the first field; the same number will be entered automatically into the other fields. Contrarily, any personnel type that is identified in the second, third, or fourth fields as an equivalent type should not be entered elsewhere in the first field.

These data are used not only to identify within TSAR which personnel types are to be called on when a particular on-equipment task arises in the second or third squadron, they are also used when personnel of a given type are lost or gained; the program automatically adjusts staffs in the several organizations so that their relative sizes are stable.

Sample Data: The entries on the first card indicate that Types #1 and #2 specialists are assigned to squadron #1 and that their counterparts in squadron #2 are Types #21 and #22. There are also some of the second type of specialist assigned at wing level; they are designated Type #72. The second card indicates that there are no equivalents for Type #62 personnel; all such personnel can be called upon for work at any location.

PERSONNEL EQUIVALENCE DATA — ALTPEQ ARRAY —

Card Type		Personnel Type	2nd Squadron	3rd Squadron	Wing Personnel	Personnel Type	2nd Squadron	3rd Squadron	Wing Personnel	Personnel Type	2nd Squadron	3rd Squadron	Wing Personnel
45	1	1	21			2	22		72				
45	1	62											

CROSS-TRAINED PERSONNEL DATA — CTPEOP ARRAY —

Card Type		Normal Type	Cross-trained Types					Normal Type	Cross-trained Types				
45	2	5	6	7									

TASK-ASSIST-QUALIFIED PERSONNEL — AQPEOP ARRAY —

Card Type		Normal Type	Task-assist-qualified Types					Normal Type	Task-assist-qualified Types				
45	3	6	5	7				3	2	4			

Fig. 7--Personnel Equivalence and Substitutability Data

Card Types #45/2 and #45/3

Personnel may be cross-trained to handle some or all of the tasks normally assigned to other specialists; others may be trained sufficiently to assist the nominal specialists. Card Types #45/2 and #45/3 provide the means by which the user can designate the personnel types that have been trained to replace or assist various specialists. Up to five types of specialists may be specified in each category; when personnel are organized into squadrons, only the designators for those in the first squadron should be entered.

Sample Data: #45/2. This card indicates that Type #6 and Type #7 personnel can replace #5 personnel and that Type #3 personnel can replace the #2 Types.

Sample Data: #45/3. Types #5 and #7 personnel are trained to assist Type #6 personnel on designated tasks, and Types #2 and #4 can assist #3 Type people.

Card Type #46

AGE EQUIVALENCE DATA						ALTAGE ARRAY							
Card Type		AGE	2nd Squadron	3rd Squadron	Wing AGE	AGE	2nd Squadron	3rd Squadron	Wing AGE	AGE	2nd Squadron	3rd Squadron	Wing AGE
45		2	12		22								

These cards provide the same kinds of information on AGE and equipment as are provided for personnel with Card Type #45/1. The same constraints and objectives apply for AGE as for personnel.

Sample Data: These data indicate that a particular type of AGE is assigned to both of two squadrons, and at wing level; they are designated Types #2, #12, and #22 at these locations, respectively.

Card Type #47

PARTS REPAIR ADMINISTRATIVE DELAY TIMES

Card Type	Base	Card No.	Shop 1&13 Hrs	Dist	Shop 2&14 Hrs	Dist	Shop 3&15 Hrs	Dist	Shop 4&16 Hrs	Dist	Shop 5&17 Hrs	Dist	Shop 6&18 Hrs	Dist	Shop 7&19 Hrs	Dist	Shop 8&20 Hrs	Dist	Shop 9&21 Hrs	Dist	Shop 10&22 Hrs	Dist	Shop 11&23 Hrs	Dist	Shop 12&24 Hrs	Dist
47		1, 2	[illegible] parts cards																							
		3, 4	[illegible] and equipment																							
47	1	1	48	6	48	6	48	6	60	6	60	6														
47	1	2					60	6																		
47		3	72	6	72	6	72	6	72	6	72	6	36	6	72	6	72	6	72	6	36	6				
47		4	72	6	72	6	72	6																		

These cards permit the user to specify the length of the administrative delay for each shop at each base for both parts and equipment. These delays should be used to reflect the times required to process the necessary paperwork and for intra-base transportation as well as the delays imposed by the need to await the arrival of necessary component parts (that are not tracked in TSAR). When a delay is specified for parts or equipment, repair initiation is deferred until the delay has concluded, unless the control variable EXPED has been set to a value greater than unity. In that case, the delay will be reduced to 1/EXPED times the nominal value when the base has no serviceables.

Sample Data: The sample indicates a 48-hour parts repair delay at the first three shops, and 60 hours at Shops #4, #5, and #15; the actual delays are all selected from a Type #6 distribution. For equipment the nominal delays are 72 hours at all shops except #6 and #10, where they are only 36 hours.

Card Type #48

CIRF REPAIR TIMES (as a percentage of the nominal parts repair times) - CIRFTM ARRAY																
Card Type		Card No.	Shop 1&13	Shop 2&14	Shop 3&15	Shop 4&16	Shop 5&17	Shop 6&18	Shop 7&19	Shop 8&20	Shop 9&21	Shop 10&22	Shop 11&23	Shop 12&24		
48																

Since the environment and procedures at a CIRF could differ substantially from the conditions on an operating base, this card is provided to permit the user to specify a percentage by which the times for all the parts repair jobs at a given shop will be modified when they are conducted at a CIRF.

Card Type #49

EXOGENOUS FACTOR CHANGES - CHANGE ARRAY -

Card Type	Day	Hr	Type	Value	Day	Hr	Type	Value	Day	Hr	Type	Value	Day	Hr	Type	Value	Day	Hr	Type	Value
49	7	0	4	2	10	0	8	20												

These cards permit the user to change many of the key control variables or array elements at a time subsequent to the initiation of the simulation. The mechanism for accomplishing these changes is managed in subroutine MODIFY, where the specific kinds of changes to be used must be encoded. The changes supported with the current version of TSAR include PRINT, STATFQ, OVERTM, SLEEP, REST, etc; the complete list can be noted in that subroutine.

These time-dependent change data are stored in the CHANGES heap; entries may be introduced exogenously during initialization using Card Type #49, or adaptively during the course of the simulation, with a call to the NEWVAL entry point in subroutine MODIFY. Several changes may be entered with each card; data include the day and hour for the change, as well as the type of change and the new value. As illustrated in the MODIFY subroutine, array elements may also be changed in this fashion by "packing" information regarding the appropriate array element with either the "type" entry or the "value" entry.

TSAR, as currently written, provides a few illustrative possibilities for adaptive control of the simulation in subroutine MODIFY. Furthermore, subroutine ADAPT, which is called at midnight each day, provides a convenient context within which to introduce the logic necessary to schedule changes that would subsequently be activated with a call to NEWVAL in MODIFY.

Sample Data: The sample entries indicate that (1) the value of the variable PRINT (change Type #4) is to be changed to 2 at the beginning of the seventh day, and (2) the value of REST (change Type #8) is to be changed to 60 minutes (20 TTU) at the beginning of the tenth day.

INPUT-DATA LIST CONTROL CARD

The termination of the basic input data entered with Card Types #1 through #49 inclusive is denoted with a blank Card Type #99. This card is followed immediately by the Input-Data List Control Card. It controls which of the input data is to be reprinted as it is stored in the various storage arrays after program initialization. A "1" in any column between 5 and 45 inclusive (except #7, 11, 29, 32, 33, 34), will direct a listing of the data that were entered using Card Types of the same number; all time data will have been converted to TSAR time units (TTU) and in some cases the data will have been packed or repacked. The control data entered with Card Types #1 through #4 are summarized on the first page of the output.

The Type #50 Cards, which input the flight demand data, will follow this card.

SORTIE DEMAND DATA

Card Type #50

Several different types of sortie demand data are entered with this Card Type--unique demands, periodic demands, and alert levels, as well as changes in these demand data; several of these are illustrated in Fig. 8. To limit the size of data storage arrays, TSAR permits the sortie demands to be read at user controlled intervals, as will be explained.

The user may specify flight demands for specific days and at specific times, or he may specify a set of flight demands that repeat every day, each with a specified probability and at times selected from a specified (10 hour maximum) time block. Furthermore, up to 31 identical flights may be demanded within the same time block with a single periodic demand entry. The option for reoccuring or periodic flight demands provides the analyst a convenient means of specifying a demand pattern that varies randomly from day to day, as might be expected in a wartime environment. The user may also employ any combination of these options. The periodic flight demands must each be numbered by the user in the J-field (i.e., cols 3-5); the likelihood, in percent, that the flight is demanded on any given day is entered in Cols. 26-30.

The number of aircraft that are to be placed on alert are also specified with Card Type #50; in this case the "Flight Time" is interpreted as the time at which the alert requirement is to start. These cards are distinguished by a "-1" entry for "Hours Notice"; these demands are not periodic but rather persist until changed.

Mission priority is denoted with an integer from one to six inclusive; priority number one is the highest priority. Priorities two and four are reserved to denote demands for aircraft that have been placed on alert. Demands for scrambling alert aircraft are presumed to occur without advance notice (i.e., the "Hours Notice" entry should be zero).

Certain other conditions or constraints are noted in the format illustration. If the minimum flight size and the recovery base are not

FLIGHT DEMAND DATA - FLTRQT ARRAY - Periodic Only

Card Type	Per. Sched No.	Launch Base	Aircraft Type	Mission No.	Priority	Demand Prob	Max Flight Size	Min Flight Size	Hours Notice	Recovery Base	Flight Time Day	Flight Time Hr	Flight Time Min	No. of Flights (Periodic Only)	Block Time (10 Hr Max) Hrs	Block Time (10 Hr Max) Min
50						(Enter only for periodic flight schedules)	(≤ 16)	(If zero, set to max)	Set to zero to scramble alert aircraft. Set to -1 to set/change alert level	(If zero is set to launch base)	Do not enter for periodic flights					
50		2	2	3	1		8	6	6		7	19	15			
50	7	3	1	1	3	75	6	5	10	3		6	30			
50		1	1	2	2		4		-1		4	8	00			
50		1	2	2	1		4	4	8	1	4	12	00			
50		2	1	3	1	200	4	4	8	2	4	12	00			
50		3	2	1	1	200	4	4	8	3	4	12	00			
50																
50		2	2	3	1	-4	-4	3	2		7	17	15			
50																
50	9	1	1	2	2	50	2	2	0	1		9	30			
50	10	2	1	2	3		2	2	2			8	00	4	2	30
50	11	3	2	2	3		2	2	2			8	00	4	2	30
50	12		1	1	1		3	3	8			20	00	4	1	00

Fig. 8 -- Sortie Demand Data

entered, they are automatically set equal to the maximum flight size and the launching base, respectively. The desired launch time is entered in hours and minutes (e.g., 1545 for 1545 hours).

Several sets of flight demand data may be treated as a single composite flight, in which all elements must satisfy at least the minimum flight size requirement, or the entire flight will be canceled and all ready aircraft placed in the spare queues. With this feature the user may demand, for example, four CAP aircraft from one base, four defense suppression aircraft from another base, and four CAS aircraft from a third base. To demand a composite flight, card images must be sequential, and all but the first card image will be identified with 200 for the "demand probability." Up to six subflights may be combined into a single composite flight with up to 50 aircraft, in total. All elements of a composite flight must be scheduled for the identical launch time and the several card images defining the composite flight must be entered one after the other. The set of card images defining a composite flight may specify either a unique or periodic demand. If they are a periodic demand, the time-block feature and multiple demand feature normally available with such types of demand may not be used.

It is sometimes of interest to be able to simulate a "fly-when-ready" demand policy. This may be done by using periodic demand cards to specify several flights of, say, 12 aircraft (with as few as one acceptable) every hour and also by permitting aircraft to be launched up to an hour late. Whenever an aircraft completes maintenance during the flying day there will be a demand outstanding that it can fill.

Flight demand data are entered at the time of program initialization and up to once a day thereafter. Those data to be read at program initialization time are terminated with a Card Type #99, specifying the first day for reading subsequent data in cols 3-5. If a day greater than one is entered in that field, the periodic flights will be rescheduled for the 2nd day and other days before the one named. Flights are scheduled and any new flight data are read each day at 2000 hours.

Another special feature permits a flight to be reduced or canceled before it has been launched, thereby simulating the effects of such changes. This feature is actuated when a negative flight size is listed for a flight. When that is done the entry for the "number of hours notice" is interpreted as the number of hours before the flight that is to be reduced or canceled. Thus, if there is a demand for 12 aircraft at 1545, and a flight of -4 aircraft of the same type and mission from the same base is demanded at 1345, with a two hour notice, the 1545 flight demand is reduced from 12 to eight aircraft at 1345, and the minimum permissible size for that flight is the value entered after the value -4.

Whenever new flight data are read in (on the day specified by the preceding data terminator card) both unique and periodic flights may be demanded. As before, periodic flights will be numbered (cols 3-5) and whenever a number previously used is entered, the new data replace the old. Each new set of flight data is terminated with a Card Type #99; the number of days before the next entry must be placed in cols 3-5.

TSAR is now dimensioned so that 400 flights may be scheduled in any 24 hour period and 160 periodic flights may be stored at any one time.

Sample Data: These several cards illustrate the various sortie demand options. The first card specifies a demand calling for eight Type #2 aircraft (six minimum) to be launched from Base #2 at 1915 on Day 7; they are to be configured for mission Type #3 and are a top (#1) priority flight. The demand is received at 1315 (i.e., 1915-0600) on Day 7. Since no recovery base is noted, the flight is to be recovered at the launch base.

The second card indicates a flight that is to be launched from Base #3 with a 75 percent probability each day at 0630. Six Type #1 aircraft (five minimum) are to be prepared for Type #1 mission; the demand for this third priority flight is received in the evening at 2030 (10 hours before flight time).

The third card specifies that as of 0800 on the fourth day, four Type #1 aircraft will be maintained on alert for mission Type #2 at Base #1. This second priority requirement stands until changed.

The next three cards jointly specify a composite flight to be made up of three sections of four aircraft each from Bases #1, #2 and #3 to be launched at noon of the fourth day. The aircraft types and missions vary from section to section. The demand is received at 0400 on the fourth day and the entire flight must be canceled if all 12 aircraft are not ready; to enhance the likelihood that cancellation will not be required, top priority (#1) is assigned to this composite flight.

The seventh card exercises the sortie demand revision option. This card specifies that at 1715 on day 7 an order is received to reduce the flight size of a flight two hours later, by four aircraft (new minimum is three). Since the flight demand on the first card is for the same base, aircraft type, mission, and priority and is at the correct time, it is reduced to four aircraft (i.e., 8 - 4).

The next card specifies a recurring demand on Base #1; a demand without warning for two Type #1 aircraft configured for mission Type #2, to be launched immediately at 0930. This demand occurs with 50 percent probability each day. These aircraft will be drawn from the alert force generated by the requirement specified on the third card, if they are available.

The next to last two cards specify recurring demands for four 2-aircraft flights from Base #2 and from Base #3; these flights are to be launched each morning at times selected at random between 0800 and 1030. In all cases the demands are received only two hours before flight time. At Base #2, Type #1 aircraft are to fly #2 missions. A priority of 3 is specified for all of these flights. The flights will not be launched unless both aircraft are ready.

The last card also specifies a recurring demand, but it differs from all other illustrations in that no base is specified. This type of demand is permitted only when the control variables STATE and SELECT have both been initialized to one or greater. When that has been done, TSAR will assign these demands for four 3-aircraft flights between 2000 and 2100, to the base best able to handle them. They may be assigned to one or more bases, depending upon their capabilities.

Card Type #60

Card Type	Rank Order Position	From Base	To Base	Departure Freq	Departure Hr	Rank Order Position	From Base	To Base	Departure Freq	Departure Hr
INTRA - THEATER SHIPPING SCHEDULE CHANGES										
60	2	1	3	1	14					

Base-to-base shipping schedules may be changed at the same time that changes are made in flight data by entering #60 Type Cards along with #50 Type Cards; in fact, only Type #60 Cards need be entered. The time for entering such changes is controlled with Card Types #98 and #99 as described with the Type #50 Cards.

To change any particular schedule, or to add or eliminate a schedule, it is necessary to know the total number of schedules already entered with the #32 Card Types, and the position of any schedule that is to be changed within that overall number. The order of data entry is (1) rank order position of schedule that is changed/added/deleted, (2) departure point, (3) destination, and (4) departure hour. If a schedule is to be added, its rank order position must be one greater than the existing number of schedules. Two sets of data may be entered with each Card Type #6.

If the departure frequency is entered as a zero, no further shipments are planned for that schedule, unless subsequently revitalized with another Type #60 Card.

Sample Data: These entries indicate that the original shipment schedule from Base #1 to #3 (entered second on the #32 Type Cards) is to be changed from every other day to daily.

XX. SAMPLE CALCULATION--INPUTS

The illustrative entries used in the explanations of the data input procedures in Section XIX were (mostly) selected from a complete data base that describes four airbases with six squadrons of aircraft. Two bases have 48 aircraft each, one has 24 and one has 18 aircraft. The larger bases each operate two 24 PAA squadrons under the 66-5 maintenance doctrine (i.e., COMO), while the squadron sized bases operate in accordance with the 66-1 procedures. A fifth base is maintained in the rear for carrying out extended tasks and to provide for emergency recovery if the runways at all operating bases have been closed by air attack.

DICTIONARIES

One of the first tasks in developing a TSAR data base is to develop dictionaries of the various categories of resources to be simulated. Figure 9 presents the dictionaries that define the resources considered in the sample calculations to be discussed here. In addition to all-purpose generalists (APG) on the flight line, each squadron is assigned seven different types of specialists. Similar specialists are also assigned at wing level for intermediate level maintenance (ILM), i.e., for repairing aircraft spare parts. Munitions specialists and civil engineering personnel all are assigned to the wing.

Provisions exist for two types of AGE to be held by the squadrons; all other AGE and equipment are available to fill any on-base demand. The various items in the other resource classes are also specified in the dictionaries.

	PERSONNEL				AGE			PARTS	
	Sqd#1	Sqd#2	Wing	(Shop)	Sqd#1	Sqd#2	Wing		
APG	1	21		(1)				1	9
Autopilot	2	22	72	(2)	2	12		2	10
INS	3	23	73	(3)	5	15		3	11
Egress	4	24	74	(4)			3	4	12
Pneudraulics	5	25	75	(7)			4	5	13
Radar	6	26	76	(7)			6	6	14
Navigation	7	27	77	(9)			7	7	15
	8	28	78	(10)			8	8	
					(AIS #1)		16	SRUs	
					(AIS #2)		17	101	112
					(AIS #3)		18	102	113
Munitions							22	103	114
Loaders			62	(28)			25	104	115
			63	(28)			21	105	116
							23	106	117
							28	107	118
Munitions								108	
Assemblers			64	(30)			31	Battle Damage	
			65	(30)			32	201	
							34	202	
Civil Engineers								203	
Type A			191		Trucks		96	204	
Type B			192		Scrapers		97		
Type C			194		Dozers		99		

MUNITIONS			TRAP		BUILDING MATERIALS	
1	4	11	1	4	1	4
2	5	12	2	5	2	6
3	6		3			

Fig. 9--Resource Designator Dictionary

The identifying number assigned to each resource type is arbitrary and should be selected by the user in whatever manner is appropriate. The only restrictions are that the numbers selected must be no larger than the relevant storage arrays, and the designators for civil engineering personnel and equipment should be larger than (NOPEOP - CEPEO) and (NOAGE - CEAGE), respectively. In the present illustration the PEOPLE array is dimensioned for 200 types of personnel and ten are reserved for civil engineering types; thus any designator as great as 190 may be used for personnel that are not civil engineers. And when two or more designators are used for the same type of specialist assigned to two or more organizations, the lowest numbered specialist must be in the first squadron, as shown (also see instructions for Card Type #21 and Card Type #45/1).

DATA ORGANIZATION

The simplest and least error prone method of organizing data for a TSAR simulation is to order the data input card images by their Card Type numbers. Similarly, the large data collections that define the various tasks are also best organized by ordering them by their task number; thus the on-equipment tasks defined by Card Types #5 would be ordered by the task number appearing in columns 3-5. It is much easier to locate and check data entries when they are organized in this manner.

There are few mandatory rules regarding the order of data entry, but what rules there are must be observed; they are:

- The first card in the input card-image deck is either blank or has "1"s in the columns corresponding to the Card Types that are to be listed at entry time.
- Card Types #1 through #4 must be entered in numerical order and before any other Card Types.

  (Note the special rules regarding columns 3-5 of Card Type #1 and TEST on Card Type #2)
- Card Types #20, #41, and #42 must be entered in numerical order.

  (Note special rules for entering aircraft missions on Card Type #41)

- When resource data are not entered specifically for each base, but take advantage of the convenience features described for these data, the resultant data base depends on card order.
- The sortie demand data are entered using the #50 Card Types after all Card Types #1 through #49 are entered. The #50 Cards are preceded by a "99" card and a card that controls input data listings. The Type #50 Cards are followed by a "99" card specifying the day for the next addition or modification to the flight or intra-theater transportation schedules. Subsequent changes to these schedules are specified with additional Type #50 Cards followed by another Type #99 card specifying the number of days that should elapse before the next inputs are to be read, if any.

Figures 10 through 17 present the data-entry card-images specifying the sample problem discussed in this and the following section. As noted above, many of these cards were used in explaining the entries on the various data input formats in Section XIX. They are presented here as they would be organized for submission to the computer. The remainder of this section outlines the nature of this sample problem and the intent of the various entries for each of several related blocks of data.

<u>CONTROL VARIABLES</u>

Card Type #1 designates, on Fig. 10, three trials of a seven day simulation. Five aircraft bases and one aircraft type are to be simulated (NBASE = 5 and NTYPE = 1); crews are to be monitored (CREWS = 1), and munitions are to be assembled (BUILD = 1).

Theater resources are to be monitored centrally (TSAR = 1) and aircraft parts arriving from CONUS will be managed centrally (CONSIG = 1) using CMODE = 570. Since no personnel or equipment are provided at the highest numbered base (Base #8--see Card Types #21 and #22), there can be no centralized parts repair. The attack damage data that will be entered were not generated by TSARINA (AIDA = 0).

```
1111     1111111111111 11111111111111111111111111             INPUT LIST DEMAND
 1  8    7    3    0    1    5    1    1    1    1  570    1                    0
    *****************************************************************
         THIS DATA BASE HAS BEEN PREPARED SPECIFICALLY FOR THE
         TSAR DOCUMENTATION.    THE DATA ARE ENTIRELY FICTITIOUS.
         THE DETAILS HAVE BEEN SELECTED TO PROVIDE ILLUSTRATIONS
         OF ESSENTIALLY ALL FEATURES OF THE TSAR SIMULATION.
         MOST OF THESE INPUT DATA ARE THE SAME AS THOSE USED TO
         ILLUSTRATE THE USE OF THE INPUT FORMATS IN SECTION XIX
    *****************************************************************
 2  1    0    1    4    5   97    2    5    0    0         1    1   10    5    7
 2  2   -1    0   -1    0   -1    0    0    0    0    0   70    1    1    1    0
 3  1    4    1    0    0    2    2   10    5  150    4    1  1 1    0    0    4
 3  2    2    2    2 10 0   50  150    0    8  0 0    5    0    8    0    0    0
 3  3    1    1   24    1    0    8    7   -1   50   33    1    1  204    0  100
 4  1   12   30   20    7  215  445   30    4    0  480  240  480    0   43   12
 4  2    3    2   40   50              0        15           0  0 0  0 0  0 0  0
 4  3    0    0    0    0    0    0    0    0    0

 5  1   2        102  2 1       2
 5  2   2     1   25  2 1  3 2  2 3                   3        4        7
 5  3   2         15  3 2           -400  1   4
 5  4   2         40  1 2       2   -350      5
 5  5   2         30  2 1           -250      0
 5  6   31    2   20  3 3       3                              1 60 10
 5  7   3     3   15  3 2       2         2           8          50           1
 5  8   3    -1   40  3 1            400              9
 5  9   3         10  3 2       2    300              0                       1
 5 10   52    4   25  4 2                                        80
 5 11   5         18  4 1  5 2  4
 5 12   5     5    8  4 1       4                                40 25
 5 13   71        32  6 2       5         3          14
 5 14   71    6   12  5 2            500                        100
 5 15   92        28  7 1       6 2                  16
 5 16   9     7   16  7 2       6 3  250                        100
 5 17   10    8   22  8 2       7                                75
 5 18   10    9   14  8 1                            19          45  5
 5 19   10        15  8 2           -330     23   21   20
 5 20   10   10   25  8 1           1000             21          77 14
 5 21   10        16  8 1  7 1       700             22
 5 22   10   15   24  8 2            800                         75
 5 23   10   12   19  8 1       7   -150     24   21   21         100
 5 24   10   14   32  8 2            600     25   21   21          60
 5 25   10   -1   12  8 1       7   -520             26
 5 26   10   11   32  8 1            800             27         100
 5 27   10        14  8 2       6 7-600      28
 5 28   10   13   24  7 1           -400                        100

 5 41   2         10  1 2                                  0             33   1
 5 42  25 16205   15 63 2            600                  5                 1 1
 5 43  25 13012    8 62 4           1000                  8                 1 2
 5 44  25 12911    5 63 2           1000                  5                 1 1

 5101   1   20110001 31 1            250                100    100100 33   1
 5102   12  202 8001 31 2            250                 40    100100 32   1
 5103   12  203 6001 31 1            250                 60    100100 32   1
 5104   1   204 4001 31 2            250                 80    100100 33   1

         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 10 -- TSAR Input -- Sample Control Data and On-Equipment Tasks

```
 6       1  25   2 2  1 1              2  35   3 2
 6       3  48   6 1  7 1
 7  1    1  500         2  251         6  834         7  760        10  392
 7  1   11  385        12  980        13  473        14  270        15  357
 7  1   16  669        17  140        18  553
 8  1    1    2  66  72 1 22     1
 8  2    2    3        -1  101
 8  1    3    3  46  73 2  3                4    5  84  74 2  4      2
 8  2    5    5        -2  104              8   10        -1  107    3
 8  1    6    7  40  76 2 25                7    9  38  77 2 16      3
 8  2    9   10        -2  109
 8  1   10   10  26  77 1 16               12   10  19  78 2 17
 8  2   11   10        -1  112             13   10        -1  116
 8  1   14   10  42  78 1                  15   10  27  77 1
 8  3  101  102  68  73 1  3   131 30   3 102  103  96  73 1      134 10   4
 8  3  103  601  44  73 1  3       20     104  105  60  74 1  4       25
 8  3  105  106  76  74 2  4       10     106  603  88  74 2          40
 8  3  107  108  62  77 2 18       33     108    0 108  77 1 18       67
 8  3  109  110 120  78 2 17       20     110  111  80  78 1 17       55
 8  3  111    0 100  78 1 17       25     601  602  60  73 1        -1 10
 8  3  602    0  80  73 2        -1 30     603    0  45  74 1        -1 25
 8  3  112  113  16  77 1 16       16     113  114  27  78 2 16       31
 8  3  114  115  12  77 2 16       27     115    0  31  77 1 16       26
 8  3  116  117  31  78 2 18    -1 19     117  118  23  77 1 18   138 44
 8  3  118    0  17  77 2 18       37
 8  3  131  132  48  77 1 16        0     132  133  60  77 1 16       20
 8  3  133    0  20  77 1 16       80     134  135  16  78 1 17       33
 8  3  135    0  17  78 1 17       67     138  139   7  78 1 17       10
 8  3  139  140  11  78 1 17       30     140    0   9  78 1 17       60
 9       1 105  73 1         0    2 126  74 1  4      0
 9       3  92  77 1 11      0    4 112  72 1         0
10       2    2  626        -1   51         3    3   78  50   3 2
10      51   52   25  40   2 1              52   53   70  80   2 1
10      53    0    52400   0 0  0 0
10       4    5  519  80   5 1               5    7   48  75   6 1
10       6    9   96  40   7 1               7   10  339 110  78 1
10       8   27  215 120  65 1
10      16   10       -1                    17   10        -2
10      18   10       -3
10      21   30  62   80  64 2              23   30  115 200  65 2
10      28   27  107 160  64 1
10      31   28  68   40  64 2              32   28   91  20  64 1
10      34   27  417 100  65 1              36   30  319 120 192 2
10      37   30  62   60 191 2              39   30   84  90 194 2

         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 11 -- TSAR Input -- Alternate On-Equipment Tasks, Part and Equipment Repair Data

```
11       1  40  65 3 21   6  1    2 120  64 4 23           3  70  65 3 2123
11       4  30  65 3 21   4  2    5 105  64 4 23    21      6  95  64 2 23      2
11      11 140  64 4             12  45  64 2            21 140  64 4
12       1    1    1  110    2   90
12       1    2    3  100    4   60
12       1    3    5  190
13  1   1  15 3  112  31   62 4 10    5 2 32   63 3
13  2   2  20    2 8 31   62 4
13  3   3  12    3 4 32   63 3
13  4   4  10    1 6 31   62 4       4 2 32   62 4
13  5   5  18    6 4      62 4       3 2 32   62 4
14  1 10 1   21 34   62 2  8 1   41 28 8 62 2
14  2  5     12      63 2
14  3  3     12      63 2  2      31       62 2
14  4  8     42      62 2
14  5  4     31      62 2
15  1    1  6    6     5   41    3   60   150    1 62 4    2    4 11 1 12 2
15  2    1 60  101  104   40    0    0   14  2 2  1      5    0    0    0    0
16  1    1 906    8   50   10    1   85   10   20 1 60 3 45 7 3215 2060  8
16  1    2 606        35    6    1   60   50   10 2 30 8 2020 1060  5         1
16  1    3 756    5   40         1   25   40   50 2 50 5 3510 2360  7         1
17  1    1    1         1         4   48   12    032750  150  200
17  2 1100   80  100  100  100    0    0    0    0    0    0    0    0    0    0
17  1    2    1              1    4   48   12    032750  150  200
17  2 2100  100  130  100  100    0    0    0    0    0    0    0    0    0    0
17  1    3    2    1              2   24   12    032750  150  200
17  2 3110  110  110  100  100    0    0    0    0    0    0    0    0    0    0
17  1    4    2    1    1    1    2   18   12    032750  150  200
17  2 4110  110  110  100  100    0    0    0    0    0    0    0    0    0    0
17  1    5    1    1    1    1    1    0    0    0 8000    0    0
17  2 5100  100   80  100  100    0    0    0    0    0    0    0    0    0    0
18  1 8 30 8    8    8 20 8    8    8 20 8    8    8    8    8    8    8    8
18  2 8    8    8    8    8    8    8    8    8    6         4    4    6 60 2
19  1   10   12    0   14    0

         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 12 -- TSAR Input -- Munitions Assembly, Weapons Loading, Aircraft, Mission, and Base Data

```
20  1   12   48   54
20  2   12   48   60
20  3   1    24   30
20  4   1    18   24
20 77    1   24  120
20 99    1   72
21  1    1 4848 3030       1 2    2 1616  8 8       2 2    3  8 8  4 4       3 3
21  1    4 1212  8 8       5 2    5  4 4  2 2       7 2    6  4 4  2 2       7 2
21  1    7  8 8  4 4       9 2    8  8 8  4 4      10 2
21  1   21 4848 3030       1 2   22 1616  8 8       2 2   23  8 8  4 4       3 3
21  1   24 1212  8 8       5 2   25  4 4  2 2       7 2   26  4 4  2 2       7 2
21  1   27  8 8  4 4       9 2   28  8 8  4 4      10 2
21  1   31 2020 1010       1 2
21  1   62 5656 3636      28 4   63 4848 3333      28 3   64 8080 5454      30 4
21  1   65 8888 5656      30 3
21  1   72 1010  6 6       2 2   73  4 4  4 4       3 2   74  2 2  2 2       5 2
21  1   75  4 4  2 2       7 2   76  5 5  3 3       7 2   77  5 5  3 3       9 2
21  1   78  8 8  4 4      10 2
21  1  191 6080 3040      30    192 3248 1624      30    194 4040 2020      30
21 88    1    2
21  3    1 4848 3030       1 2    2 1616  8 8       2 2    3  8 8  4 4       3 3
21  3    4 1212  8 8       5 2    5  4 4  2 2       7 2    6  4 4  2 2       7 2
21  3    7  8 8  4 4       9 2    8  8 8  4 4      10 2
21  3   31 1010  5 5       1 2
21  3   62 3232 2020      28 4   63 2424 1515      28 3   64 5454 2828      30 4
21  3   65 4040 2828      30 3
21  3  191 4060 2030      30    192 2632 1316      30    194 2828 1414      30
21 88    3    4
21 88    3    5
21  5   31 4040 2020       1 2
22  1    2  4 4  4 2    3  2 2  2 3    4  3 3  3 5    5  1 1  1 7    6  2 2  2 9
22  1    7  1 1  110    8  1 1  127   12  4 4  4 2   15  1 1  1 7
22  1   16  1 1  110   17  2 2  210   18  1 1  110
22  1   21 1818 1830   23 1010 1030   34  1 1  127   22  1 1  1 2   25  1 1  1 7
22  1   31  8 8  828   32  6 6  628   28  1 1  127
22  1   96 2424 2430   97 1616 1630   99  8 8  830
22 88    1    2
22  3    2  5 5  5 2    3  1 1  1 3    4  2 2  2 5    5  2 2  2 7    6  2 2  2 9
22  3    7  1 1  110    8  1 1  127
22  3   16  1 1  110   17  1 1  110   18  1 1  110
22  3   21 1010 1030   22  1 1  1 2   25  1 1  1 7   23  6 6  630   28  1 1  127
22  3   31  4 4  428   32  3 3  328   34  1 1  127
22  3   96 1414 1430   97 1010 1030   99  5 5  530
22 88    3    4
22 88    3    5
22  5    6  3 3  3 9
22 66    1    1   78    6   30   18   16
22 66    2    5  249    6   26   21   17
22 66    3    9  131    6   33   26   18
22 77    1 1200  700  560  140  973 1680 1320  912  415 1265

         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 13 -- TSAR Input -- Aircraft, Personnel, and Equipment Resource Data

```
23   1  201   0      0 0     0  101  204   0     0 0     0  101
23   2  201   0      0 0     0  101  204   0     0 0     0  101
23   3  201   0      0 0     0  101  204   0     0 0     0  101
23   4  202   0      0 0     0  101  203   0     0 0     0  101
23   5  201  10      0 0    10  101  204  10     0 0    10  101
23201     1  70    45    68    19     4    27    85     2    18    66
23201    11  43    28    63
23201   101  55    38   101                      101   101
23201   111       101   101   101   101                101
23203     1  85    45    80    19    84    76  1 90    40    35    87
23203    11  67    45    77
23203   101  65    49   101                      101   101
23205     1  50    40    50    10     0    20    70     0    10    66
23205    11  43    28    63
23205   101  55    38   101                      101   101
23205   111       101   101   101   101                101
23208     1100    100   100   100   100   100   100   100   100   100
23 66     1   460    57   186   921    14   780   207    96   107   112
23 66    11    17   162    93
23 66   101    58    95    47   116    21    71    36    85    22    91
23 66   111    17    82    44   152    72    27    51   111
23 66   201   109    67    19    49
23 70     1     1     1    48    80   120    72    48    10    20
23 70     2     1     1    48    80   120    72    48    10    20
23 70     3     2     1    24    80   120    72    48    10    25
23 70     4     2     1    18    80   120    72    48    10    25
23 70     5     1     1                      72    48    10    20
23 72     1     1   150    75   120    75
23 72     2     1   150    75   120    75
23 72     3     1   120    75   120    75
23 72     4     1   120    75   120    75
23 74     1     5     2     3
23 74     2     5     1     4
23 74     3     5     1     2
23 74     4     5     2     1
23 76     1     2
23 76     3     4
23 78     7     1    10     5     2     3     6     9
23 78   101     4     7
23 78   117     8
24  1     1   200     2   160     3   100     4    60     5    80     6   100
24  1   101  4000   102  2500   103  2000   104  1000   105  1600   106  2000
24  1    11    50    12    75   111   500   112   800
24 88     1     2
24  3     1   100     2   100     3    60     4    40     5    40     6    60
24  3   101  1600   102  1400   103  1000   104   600   105   600   106   800
24  3    11    40    12    50   111   250   112   400
24 88     3     4

         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 14 -- TSAR Input -- Spare Part Resource Data

```
25  1    1   20    2   20    3   10    4   20    5 5000
25  2    1   20    2   20    3   10    4   20    5 5000
25  3    1   12    2   12    3    8    4   16    5 2500
25  4    1   12    2   12    3    8    4   16    5 2500
26  1    1 6000    2 8000    4 2000    6 1000
26  2    1 5600    2 4800    4 3500    6 1650
26  3    1 1860    2 3890    4  870    6 5500
26  4    1 2220    2 3400    4  850    6 3400
27       130000    230000    320000    416000    530000
28  1   1    2    3    4    5    6    7    8    9   10   11   12   13  202  203
29        1    1    1    2    4    7   42   43   44    0    3    5
29        1    2    9   10   26   29    0    0
29  5    1    1   29    0   30    0    0
30  1  1 1          1                        1              1    1
30  1  1 2                    1                        1
30  2  1 1                         1              1                   1
30  2  1 2               1              1
30  3  1 1                    1    1
30  3  1 2      1                                                1
30  4  1 1               1    1                        1
30  4  1 2          1                   1
31        5   17    1    1    5    7
31                      3    4    3    4   10  104    5    2   11    7   12
31        7   21    2    8    4    1
32        1    2  117    1    3  214    1    4  214    2    3  214    2    4  214
32        2    1  117    3    1  219    4    1  219    3    2  219    4    2  219
32        3    4  220    4    3  220
32        1    5  1 4    5    1  116    2    5  1 4    5    2  116
32        3    5  1 4    5    3  116    4    5  1 4    5    4  116
32        1    8  1 4    8    1  116    2    8  1 4    8    2  116    8    5  1 4
32        3    8  1 4    8    3  116    4    8  1 4    8    4  116    5    8  1 4
33        1    2             20        98    2    1             20        98
33        1    3             36        96    3    1             36        96
33        1    4             36        94    4    1             36        94
33        2    3             30        96    3    2             30        96
33        2    4             40        94    4    2             40        94
33        3    4             36        94    4    3             36        94
33        1    5             20        99    5    1             20        99
33        2    5             12        99    5    2             12        99
33        3    5             16        99    5    3             16        99
33        4    5             14        99    5    4             14        99
33        1    8             18        99    8    1             18        99
33        2    8             16        99    8    2             16        99
33        3    8             22        99    8    3             22        99
33        4    8             24        99    8    4             24        99
33        5    8             12        99    8    5             12        99

         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 15 -- TSAR Input -- Other Resources, Weather, and Shipping Schedules

```
34   1    1  600     9
34   2    1  600     9
34   3    1   13     1  600     9
34   4    1   13     2  600     9
34   5    1  600     9
35        1   20     2   15     3  -30    4    20    5   24    6  -15
35        7   21     8   24     9   10
36   1    4   30     1          3  230 1430
36   2    3   30     1          3  230 1430
36   3    8          1          6  130 1530
36   4    8          1          6  130 1530
36   5    6   30     1             230 1430
37        1  1    100  0 0     0    2  2     100  0 0    0    3  1    200  0 0     0
37        4  2    200  0 0     0    5  1     100  0 0    0    7  3    100  0 0     0
37        9  2    200  0 0     0   10  3     200  0 0    0   35  8    250  0 0     0
37       25  4    100  0 0     0   27  5     100  0 0    0   28  5    250  0 0     0
37       30  5    200  0 0     0   36 10     100  0 0    0
38        1 605419410       96 4       6 1  4 2   11
38        2 3018191 8192 6 97 6       2 2
38        310048194 4       96 2       4 4        12
38        4 8054192 8       99 1 97 2  8 1  3 4
38        5 5018191 8       97 2       4 2        11
38        8 40491911619210 96 5 99 2  1 6        16
38       10 80491912419216 96 8 99 4  2 6        18
38       11 8082194 6       96 2       6 1  4 2    0
38       1212054194 2       96 1       4 4         0
38       16 605019112192 6 96 3 99 1  1 6         0
38       1810050191161921296 5 99 2  2 6         0
39       36    1   35    2    2    3    4    4    7    5
39        5    6   10    7    9    8    1    9    3   10    5   11
40   3    2    5   38
40                       1         20                   4        34
40                       5    3    15                   5    8   43
40                       9    5    40   40   20   80    9    7   30   40   30   20
40                       9    3    15   16   30   72    9   36   10
40                      10    1    10   40   70        10    2  100
40                       8    1    15   10   70   92
41   1 1 24 24
41   2 1 24    24
41   3 1      1212
41   4 1  9     9
42        1    1   10    1   20    2    5    4   15    6
42        2    1   15    2   10    4             20    4
42        3    1   20    1   15    3              8    5
42        4    1   20    1   15    3             12    3
43        1  312     6    3 15     6    8  112    6
45   1    1   21              2   22        72    3   23        73
45   1    4   24         74   5   25        75    6   26        76
45   1    7   27         77   8   28        78
45   1   62                  63                  64
45   1   65                 191                 192
45   2    5    6     7                  2    3
45   2   62   63                       64
45   3    6    5     7                  3    2    4
45   3   63   62                       64   65
46        2   12        22    5   15        25
47        1 48 6 48 6 48 6 48 6 48 6 48 6 48 6 48 6 48 6 48 6
47        3  8 6  8 6  8 6  8 6  8 6  8 6  8 6  8 6  8 6  8 6

99
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

Fig. 16 -- TSAR Input -- Reporting Schedules, Facility Repair and Damage Data, et al.

```
                                             ***  FORMATTED INPUT DATA
50  1    1    1    1    1         3    2    8            600    6  120
50  2    1    1    1    3         3    2    8            930    5  100
50  3    1    1    1    1         3    2    8           1300    6  300
50  4    1    1    1    3         3    2    8           1900    5  230
50  5    1    1    2    3         3    2    6            600    6  130
50  6    1    1    2    1         3    2    6            930    5  100
50  7    1    1    2    3         3    2    6           1300    6  400
50  8    1    1    2    1         3    2    6           1800    5  300
50  9    2    1    1    3         3    2    7            600    6  100
50 10    2    1    1    5         3    2    7            930    5  200
50 11    2    1    1    1         3    2    7           1300    5  300
50 12    2    1    1    3         3    2    7           1800    6  200
50 13    2    1    3    1         3    2    5            600    5  230
50 14    2    1    3    5         3    2    5            930    6  300
50 15    2    1    3    3         3    2    5           1300    6  200
50 16    2    1    3    5         3    2    5           1800    5  400
50 17    3    1    2    1         3    2    9            630    4  400
50 18    3    1    2    3         3    2    9           1200    3  400
50 19    3    1    2    3         3    2    9           1800    4  300
50 20    3    1    3    3         3    2    9            630    4  400
50 21    3    1    3    1         3    2    9           1200    3  400
50 22    3    1    3    3         3    2    9           1800    4  300
50 23    4    1    3    1         3    2    7            600    3  400
50 24    4    1    3    3         3    2    7           1200    4  300
50 25    4    1    3    1         3    2    7           1800    2  400
50 26    4    1    1    3         3    2    7            600    4  300
50 27    4    1    1    1         3    2    7           1100    3  300
50 28    4    1    1    3         3    2    7           1630    4  400
99 60

         1         2         3         4         5         6         7
123456789012345678901234567890123456789012345678901234567890123456789012345678
```

Fig. 17 -- TSAR Input -- Flight Demand Data

Card Type #2/1 calls for substantial daily output (PRINT = 4) with cumulative shop statistics to be printed every five days (CUMSTA = 5). A chronological record of on-equipment tasks is to be presented for the aircraft numbers that are initially assigned to Base #3; this record is to be prepared for the first five days of each trial (SCROLL - 5 days, first aircraft #97). Civil engineering reconstruction is to be accomplished as required (CEWORK = 1), and the resources associated with damaged shops are to remain at risk to subsequent attacks. Ten personnel types and five equipment types are reserved for assignment to the civil engineers. When a base is damaged, an effort will be made to pursue reconstruction on all facilities whose priority is as great as the priority assigned to Shop #7 (facility #7--see Card Type #39).

The first ten entries on Card Type #2/2, which control the several random number streams that may be repeated exactly on each trial, release that control over sortie selection, resource status reports, and uncertain task probabilities.

The other entries on Card Type #2/2 delineate the policies for managing reparable spare parts. Parts normally NRTSed to CONUS will be repaired in theater, if possible, when a base's overall LRU stocks fall below 70 percent of the initial stock level. And when a base's back shop is damaged and can not be used for parts repair, a base with an undamaged shop is sought (SEEKSH = 1). Furthermore, repaired parts are not automatically retained at the base where they are repaired, or sent to the base from which they originated; instead they are shipped to that base defined by the SEND logic in the CONTRL subroutine as having the greatest need for the part (SHPREP = 1). Also, an LRU that requires an SRU that is not normally stocked at a given base will be NRTSed (NRTPOL = 1). Last, if there is no shipping schedule to the base that has been designated to receive a NRTSed part, the part is NRTSed to CONUS (TODOCK = 0).

Card Type #3/1 indicates that combat operations will be conducted from four bases, and that unscheduled maintenance tasks are to be deferred when they are not essential for the designated mission (POSTPN = 1) but are not to be forgotten (IGNORE = 0). Battle damaged tasks are to be completed prior to other unscheduled maintenance (CONCUR = 0).

Tasks with criticality greater than 66 may be deferred for two sorties, if not essential for the intended mission (LTHDEF = 2), and parts may be cannibalized from aircraft that already have a part missing, whether or not a reparable of the type required is on base (CANMOD = 2). Cannibalization may not remove over 10 parts from any aircraft (MXHOLE = 10). Parts not normally cannibalized may be cannibalized if five or more aircraft require that part (and if CANNTM is not -1); furthermore, LRUs may be cross-canned. Interrupted and waiting tasks and parts repairs are to be ordered in accordance with TSAR's priority algorithms (ORDIT = 1, ORDWT = 1).

Card Type #3/2 designates many of the policies that are to be used to manage the transfer of aircraft. Whenever an aircraft is transferred to accomplish maintenance that is mandatory at a rear base, all other required tasks, as well as all deferred tasks that are required for any mission, are scheduled for completion at the rear base (JOBCON = 2). Also, whenever aircraft at a combat base are lost, or are transferred to the rear for the repair of battle damage, a filler aircraft, if available, will be sent forward as a replacement (FILLAC = 2), except that the number of aircraft at the combat base shall not exceed the base's shelter capacity (FLEVEL = 2). In addition to the aircraft that are transferred to accomplish tasks that are mandatory in the rear, any aircraft will be transferred to the rear if the required maintenance is estimated to take in excess of 10 hours (or in excess of 15 hours, when five or more hours are required at the forward base to ready it for the ferry flight). Filler aircraft are launched as replacements at the same time that aircraft are launched for ferry flights to the rear (QUIK = 0). To provide aircraft spare parts for the tasks that will be done in the rear as a result of the policy of transferring aircraft requiring more than ten hours maintenance, 8 percent of all aircraft spares will be stocked at the fifth base (RPARTS = 8). Furthermore that base will be used to recover aircraft that cannot land at combat bases because all runways are closed (EMERG = 5). Preflight tasks are not to be restricted during refueling (NOFUEL = 0).

The UNCER entry specifies that the unscheduled maintenance task probabilities that occur in wartime--i.e., during the simulation--are to be different from the values that are derived from peacetime data and are entered with Card Type #7. The differences are to be determined using Distribution #8 in the TTIME subroutine (UNCER = 8); the initial value is to be treated as the mean of the distribution, with the wartime value of the breakrate determined by a random selection from that distribution. These breakrates will be assumed to be invariant with the achieved sortie rate (VBREAK = 0).

Card Type #3/3 designates that the parts are to be initialized at the bases designated with the #23/70 Type Cards (OUTFIT = 1) and that WRSK kits are to be stocked using TSAR's approximation to the Air Force DO-29 cost-optimization procedures (PMODE = 1).

Parts shortages other than those in the pipelines are to be simulated; stock levels are to be under the prescribed levels by 8 percent across the board (SHORT = 8). In addition, certain parts suffer shortages of 1/6 to 1/2; the likelihood of that shortage will be proportional to part cost (TOOFEW = -1). Parts are to be initialized in depot pipelines at nominal levels (FULL = 0) and their selection is to be governed by the binomial approximation (RANDM = 1). If there are insufficient spares procured to fill the pipeline, they are obtained by creating holes in aircraft (ZNORS = 1). All pipeline deliveries are to be delayed by seven days (HIATUS = 7). The parts initialization process, including the randomly chosen shortages, are to be repeated for each trial (NEWPRT = 1) rather than using the same sets of assumptions for each trial (NEWPRT = 0). To limit unnecessary processing, the highest numbered part is declared (NPART = 204).

Card #4/1 specifies that aircrews must have a minimum of 12 hours off each day and that they must be on the ground for at least 30 minutes between flights. The administrative delays for parts and equipment repairs are reduced to one-seventh of their nominal values, if no serviceables are available when a broken part is removed from an aircraft and is to be repaired on base, or if no other serviceable piece of equipment is on base. The flying day is expected to be largely complete by 8:00 PM (ENDAY = 20) and deferred maintenance may be initiated after that hour. To initiate such maintenance, the nominal task completion time must be no later than 0445 (LSTTOD = 445) at which time munitions loadings that have been delayed should be initiated; otherwise delayed loadings should start at 0215 (LOADTM = 215). Thirty minutes overtime (OVERTM = 30) is permitted if it is required to complete unscheduled maintenance tasks or munitions assembly jobs. No parts may be cannibalized from any aircraft that has an estimated ready-to-fly time within four hours.

Eight hours are required to package all resources that are to be shipped to another base within the theater. And after an air attack, the civil engineers will be engaged for four hours in taking care of the disruptive effects of fires, broken fuel and water lines, clogged roads, etc. before they can begin reconstruction. All unscheduled maintenance, back shop work, and munitions assembly jobs will be similarly disrupted for eight hours.

Card Type #4/2 indicates that daily projections of each base's sortie generation capability will be prepared and transmitted to the theater manager (STATE = 3); this occurs at 1930 hours in the evening and these data are used for decisions regarding the recovery and reassignment of aircraft for the next 24 hours; the data are also used, as necessary, for allocating demands for sorties (SELECT = 2). The factors that control these aircraft reallocations are set to 40 and 50 percent, respectively. The 66-1 organizations at Bases #3 and #4 are projected to average 15 minutes longer than prescribed for on-equipment tasks with COMO, because of their less convenient locations. The time horizon for planning purposes, as a function of the time of day, is to be that provided by TSAR's default conditions (see Section IV).

TASK DESCRIPTIONS

Easily the most difficult data preparation chore for TSAR is development of data defining what jobs need to be done and how often, what resources are required for their accomplishment, and how long they would be expected to take. Card Types #5 (#6), #8 (#9), #10, #11, #13, #14, and #38 are used to enter these data for unscheduled aircraft maintenance, parts repair, equipment repairs, munitions assembly, aircraft reconfiguration and loading, and for the civil engineer's base recovery tasks.

Thirty-six on-equipment aircraft maintenance tasks (Card Type #5) are illustrated in Fig. 10; 28 are unscheduled tasks, four deal with refueling and basic munitions, and four relate to battle damage. Tasks #2, #7, and #18 constitute task networks. Three alternative task procedures are defined (Card Type #6) on Fig. 11.

Parts repair procedures (Card Type #8) are included for 15 parts; four (#2, #8, #11, and #13) involve SRUs and #5 and #9 have optional repair procedures. Four alternative repair procedures are defined (Card Types #9).

Equipment repair procedures are provided for 16 types of equipment; for one of these (#2), the necessary procedure is selected at random from procedures #51, #52, and #53. Repair procedures are not given for equipments #16, #17, and #18; instead they are identified (by the negative numbers) as AIS stations type #1, #2, and #3 and handled according to the procedures described in connection with Card Types #22/66 and #22/77.

Munitions assembly procedures (Card Type #11) are listed for the 8 types of munitions in Fig. 12; alternative procedure #21 is specified for munition type #5. Three assembly procedures can take advantage of cross-trained or task-assist-qualified personnel. Civil engineering reconstruction and recovery procedures are entered with Card Types #38 for the seven basic procedures and for four alternative procedures.

MISSION AND MUNITIONS DATA

The standard combat loads for the three missions to which aircraft type #1 can be assigned are specified with Card Type #12 in Fig. 13. SCL #1 is the preferred load for mission #1, with SCL #2 acceptable as an alternative; the effectiveness indices for sorties that are launched successfully with these combat loads are 110 and 90, respectively. Resource requirements for uploading the various combat loads and for configuring aircraft for those combat loads are specified with Card Types #13 and #14.

The various data that define operational factors for aircraft type #1 and for that aircraft's three missions are specified on Card Types #15 and #16. Special base information, shift schedules, and task incompatibility data are entered on Card Types #17, #18, and #19.

BASE RESOURCES

The resources available at each base at the beginning of the simulation are defined with Card Types #20 thru #27. When the resources on two or more bases are the same, in part or in total, the features described in Section XIX can be used to reduce the required number of card images.

The initial numbers of aircraft and pilots allocated to each base are specified in Fig. 13 on the Type #20 Cards. Their initial mission configuration and unfinished maintenance are specified by the Type #41 and #42 Cards on Fig. 16. Aircraft may either be cocked and ready, at zero time, or undergoing unscheduled maintenance. Specific quantities of aircraft spare parts may also be entered into maintenance at each air base with the Type #42 Cards.

Base maintenance personnel are established with the Type #21 Cards shown on Fig. 13. Since Bases #1 and #2 and Bases #3, #4, and #5 are to have identical numbers of personnel, the #21/88 Type Card is used to duplicate the personnel at Base #1 for Base #2, and to duplicate the personnel at Base #3 for Bases #4 and #5. Finally additional battle damage repair specialists (personnel #31) are assigned to Base #5. Personnel organization of the two-squadron COMO bases (#1 and #2) are controlled by the Typ #45/1 Cards on Fig. 16; as noted, for example, personnel types #1, #2, and #3 in the first squadron are the same types of specialists as the #21, #22, and #23 personnel in the second squadron. And types #72 and #73 personnel provide the same specialties at wing level as #2 and #3 personnel do in the first squadron. Equipment assignments are controlled similarly with the Type #46 Cards. The kinds of cross-training and task-assist training that the various specialists have received (at those bases specified on Card Type #17), are summarized with the #45/2 and #45/3 Cards. Personnel types #6 and #7, for example, are cross-trained for designated tasks that are normally performed by type #5 personnel, and personnel types #5 and #7 are trained to assist #6 personnel on those tasks that are so specified.

Equipment stocks are specified with #22 Type Cards; as for personnel, the equipments at Bases #1 and #2 and at Bases #3, #4, and #5 are to be the same. The #22/66 and #22/77 cards provide performance specifications for the three types of AIS stations.

The initial base stocks of spare parts may be entered for each base using Card Type #23, or the user may elect to take advantage of TSAR's automatic parts initialization subroutines by using the Special Type #23 formats; these special features are to be used in this example. Although spare parts for battle damage repair also will be generated automatically (see Card Type #15), it is necessary that the NRTS rate for these parts be specified at each base; the first Type #23 card on Fig. 14 specifies that all such damaged parts are to be NRTSed 100 percent of the time at all bases (since there is no entry in the J column).

The policy factors that govern (non-battle-damage) spare parts stocks to be laid in at each base are entered with the #23/70 and #23/72 Type Cards, and the NRTS data and unit cost data for each type of part are entered with the #23/20x, #23/30x, and #23/66 Card Types. Note that advantage is taken of the #23/76 Card Type to specify the same NRST rates at Bases #1 and #2 and at Bases #3 and #4. Bases to be solicited for lateral resupply are listed with #23/74 Type Cards. The #23/78 Type Cards designate the "tray" for each of the parts that are repaired with the AIS equipment.

Initial stocks of assembled and unassembled munitions, TRAP, POL, and building materials are indicated on Fig. 15.

As indicated with the Type #29 Cards the same maintenance procedures are to be followed at all bases except Base #5, the emergency recovery base; only battle damage repair and refueling are specified for this recovery base.

WEATHER

The weather conditions for the first 4 weeks of the simulated period are indicated on Fig. 15 for each base with the Type #30 Cards. Weather at Base #1 is inadequate for operations with #1 type aircraft on days 3, 8, 11, 12, 19, and 24; weather conditions at the other bases are also noted.

SHIPPING AND COMMUNICATION

Only token shipments are scheduled (see Fig. 15) to the theater from CONUS, including four #1 type aircraft for Base #2 at 2100 on the seventh day of the simulation (Card Type #31). The other CONUS shipment, on day five, supplies Base #1 with a few people, some munitions and TRAP and 1.2 million pounds of POL. All other shipments from CONUS are spare parts in the depot pipelines, or the aircraft, personnel, and parts that are resupplied after they have been lost or broken during the simulation. The nominal resupply times for these classes of resources are specified by Card Type #43 on Fig. 16.

The transportation schedules between operating bases (Card Type #32) specify that shipments leave each base every other afternoon for all other bases, except that Bases #1 and #2 are to have daily service between bases. Shipment times range from 20 to 40 hours, with loss rates of between two and six percent (Card Type #33). Transportation to and from the rear maintenance base (#5) and the central supply point (Base #8) occurs daily and takes from 12 to 24 hours; 1 percent attrition is assumed.

Fig. 16 indicates that parts that are NRTSed at the MOBs (main operating bases) and the rear maintenance base--Bases #1, #2, and #5--are directed to be sent to (the depot in) CONUS, on Card Type #34. The two squadron bases, however, NRTS some of their parts to one of the MOBs and some to CONUS. Bases #3 and #4 send parts #1 through #13 to Bases #1 and #2, respectively, for repair, and send the rest of the part types to CONUS. Card Type #35 provides specific cannibalization times for several types of parts; note that part types #3 and #6 may be cannibalized only when at least five aircraft are already NORS for that part type.

Each base transmits two reports each day on the current status of certain resources (defined by CMODE on Card Type #1); the reports are sent shortly after midnight and in the early afternoon and take from 3-1/2 to 8 hours to become available to the centralized theater resource manager, as detailed on Card Type #36.

AIRBASE ATTACK

Only one airbase attack is scheduled to occur in the scenario examined in this simulation. As specified with the Type #40 Cards shown on Fig. 16, Base #3 is attacked at 0538 on day 2. Several on-base assets are damaged or destroyed. The first card indicates that 20 percent of all maintenance personnel and 34 percent of all munitions were lost; the second card specifies that 15 and 43 percent, respectively, of TRAP types #3 and #8 were also lost. Aircraft and shelter losses, losses to personnel and equipment engaged in maintenance activities on those aircraft, and facility damage are indicated on the other Type #40 cards, as is explained in Section XIX.

CIVIL ENGINEERING TASKS

The size and reconstruction procedures are specified for all relevant facilities on the Type #37 Cards on Fig. 16. Seven distinct repair/recovery procedures are specified. For convenience in this illustration, all bases are treated the same; the base number is not entered, so all are presumed to have identical facilities

The requirements for the civil engineering repair and recovery procedures are entered using the Type #38 Cards. The first seven procedures are the basic techniques called for with the Type #37 Cards; the other four are alternative procedures. As outlined in Sections XIV and XIX, the time and material requirements apply to each unit of damage.

The priorities for reconstruction are controlled by the entries on Card Type #39. In this case, priority is given to facilities, by number, in the following order: #100, #99, #2, #4, #7, etc. Repair of the runway (#36) and taxiways (#35) get the first and second priorities; if sufficient resources are available, the several work centers (shops) then get attention in the order noted.

Following Card Types #41 through #47, discussed above, the Type #99 Card signifies that all input data except the flight demand data have been entered.

FLIGHT DEMANDS

Only one of the several options that are available for specifying flight demands have been used for this sample calculation. Each Type #50 Card shown on Fig. 17 calls for several flights of three aircraft to be launched at times picked each day at random from a time block of one to four hours. The first card calls for six three-aircraft flights to be launched on mission #1 between 0600 and 0720. The base has an eight hour notice of these demands and two aircraft are acceptable if three are not available. Altogether, four groups of flights are to be launched on mission #1 and four other groups on mission #2 from Base #1. The total demand at Base #1 is for 22 flights of each mission type on each day.

Base #2 has similar demands, except that the missions they are to fly are types #1 and #3. The two single-squadron bases each have three sets of demands for two types of missions, for a total of 66 sorties at Base #3 and 60 at Base #4.

XXI. SAMPLE CALCULATION--OUTPUTS

As explained in Section XV, TSAR provides the user a variety of output options. This section will illustrate most of those options with reproductions of the results for the sample problem developed in the preceding section.

Figure 18 displays the formatted title page that summarizes the user selected values for many of the control variables. As noted at the top, a seven day simulation is to be run for a total of three trials. Four operating bases and one rear maintenance base, as well as one base for theater distribution, are involved in the simulation. A variety of other control variables are recorded in the upper and center sections of this page. Key array dimensions are listed at the bottom. As noted earlier, the user has two optional controls over the reproduction of input data. He may specify that some, or all, of the input card images be reproduced directly, or he may direct that the input data is to be listed after it has been formatted for the storage arrays; neither of these options is illustrated here.

Figure 19 is a sample of the parts initialization summary. The first data indicate the costs for the battle damage spares that have been provided for the four combat bases; the "actual" costs reflect the 8 percent parts shortage specified in Card Type #3/3. Those spares for which greater shortages exist are listed next; for example, parts #2 and #4 are short by 24.7 and 37.7 percent, respectively. The parts procurement policy factors, the delivery schedule for the spare parts in the base-CONUS-base pipeline, and the initial stock levels are then listed for Base #2. The pipeline data were automatically formatted in the manner specified for Card Type #31. When examined in the context of those specifications, it will be seen that the parts in the pipeline are distributed over the 10-day order-and-ship time specified on the #23/70 Cards; the first deliveries are assumed to be delayed by seven days (HIATUS = 7). On the eighth day, 4 LRUs and 1 SRU are due in--one Type #2 part and three Type #7 parts in addition to one #112 SRU. Since the theater manager was directed to control distribution of incoming parts, the parts are consigned to Base #8 (i.e., MAXB), the Base reserved for

```
                          ************************                    JUNE 11, 1981        08:08 PM
                          THE 'T S A R' SIMULATION
                          ************************

          THEATER SIMULATION OF AIRBASE RESOURCES AND SORTIE GENERATION IN WARTIME

                            DEVELOPED AT THE RAND CORPORATION
                             FOR THE UNITED STATES AIR FORCE
                                    BY D. E. EMERSON

 BASES : OPERATING 4  OTHER 2          SIMULATION LENGTH   7 DAYS          NUMBER OF TRIALS   3            EXTEND 0
 ****************************          **************************          ******************              PMODE  1
                                                                      DEFINE PARTS 1  SHORTAGE  8%  PIPELINE 1  RANDM 1
                                                                       CRITICAL SHORTAGES  -0.1 %  (0.50-0.83)
ORDER INTERRUPTED TASKS     1      INITIAL AIRCRAFT   138           CANNIBALIZATION MODE          2
ORDER WAITING TASKS         1      INITIAL CREWS      168           LEAST DOWN TIME TO CANN       4 HRS
DEFER NON-CRITICAL TASKS    1                                       CANN TIME IS  150% NOMINAL PLUS   0 MIN DELAY
REFUEL SEPARATELY           0      SEED                 1           MAX HOLES PER AC  10       "DOCANN"     5
OVERFLOW CONTROL            2      TRIAL   0    TEST  0 (    0    0)  CANNIBALIZE SRUS   4

    END NOMINAL FLYING DAY  20:00    MISSION INPUT HOUR       20:00    CREW OFF DUTY 12 HRS       PRINT             4
    COMMENCE UPLOAD (NOM)    2:15    ALLOWABLE OVERTIME       30 MIN   GROUND TIME   30 MIN       VERIFY            1
                    (LAST)   4:45                                      REPORTS       10 (15)      DELAY DATA        5 DAYS
                                                                       START REPORTS 0.0 DAYS     STORE STATISTICS 0
    ASSEMBLE MUNITIONS        1      BREAK-RATES: UNCER  8  VARIABLE 0  IGNORE DEFERRABLE TASKS 0  PRINT PARTS      24

                      SHIPPING DATA                                           AIRBASE ATTACK FACTORS
                      *************                                           **********************

CONUS SHIPMENTS         200(2500)    RESUPPLY SHIPMENTS     2000       FACILITIES/BASE 100        REBUILD        1
THEATER SHIPMENTS                                                      CE PERSONNEL     10        ATTACKS       40
     PREPARATION TIME  480 MIN             DAILY NOMINAL      28       CE EQUIPMENT      5        DAMAGE DATA 2000
     MAXIMUM PACKAGES 2500                 MAXIMUM           100       CE MATERIALS     25        CRIT BLDG #    7
                                           MAXIMUM STORAGE   400       CE DELAYS       240 MIN    SHOP DELAYS  480 MIN

                                              RESOURCE MANAGEMENT
                                              *******************
                                            THEATER CONTROL MODE  570
THEATER MANAGEMENT         1     INITIAL REVIEW TIME  43 HRS   CONCURRENT DAMAGE REPAIR    0     EXPEDITE PARTS REPAIR       7
TSAR CONTROL MODE          7     REVIEW INTERVAL      12 HRS   REAR MAINTENANCE CONTROL    2     SHIP PARTS WHERE NEEDED     1
CIRF PRIORITY THRESHOLD    4     REVIEW POLICY         5       FILLER CONTROL              2     RR PARTS NRTS THRESHOLD   70%
TSAR ORDER THRESHOLD       0     BASE ORDER THRESHOLD  0       FILLER LEVEL                2     SHIP IF SHOP DAMAGED        1
PRIORITIZATION MODE        0     CONSIGN PARTS         1       FILLER CALL THRESHOLD     0.0 HRS SHIP IF SRU NOT STOCKED     1
ASSESS BASE STATE          3     SELECT RECOVERY BASE  2       AC ROTATION THRESHOLD     7.5 HRS HOLD REPARABLE TO SHIP      0
                                                                        (     50    150)
                                          DIMENSIONS OF STORAGE ARRAYS
                                          ****************************

AIRCRAFT   400              PERSONNEL TYPES 200          TASKS          1000              REPAIRS       250
AIR CREWS  800              PARTS           600          INTERRUPTED     400              WAITING      1200
BASES        7              AGE & EQUIPMENT 100          REQUIRED       2500              DEFFRRED     4000
AC TYPES     3              MUNITIONS        25          ADMIN DELAY    1500              NOR          2000
MISSIONS     4              TRAP             25          INCOMPATIBLE     90              FLIGHTS      2000

TASK TYPES   750     REPAIR TYPES 750     AGE REPAIRS  100      CE REQTS    20      STANDARD COMBAT LOADS  30
ALTERNATES   200     ALTERNATES   200     AMMO ASSEMBLY 30      CE TASKS   400      CONFIGURATIONS         30
**************************************************************************************************************
```

Fig. 18 -- TSAR Output -- Key Control Variables and Dimension Data

BATTLE DAMAGE SPARES -- COSTS BY BASE -- (THOUSANDS) ACTUAL: 686 695 385 286
AUTHORIZED: 756 756 390 292

ITEM	2	PERCENT SHORT	0.247
ITEM	4	PERCENT SHORT	0.377
ITEM	6	PERCENT SHORT	0.445
ITEM	7	PERCENT SHORT	0.441
ITEM	8	PERCENT SHORT	0.535
ITEM	12	PERCENT SHORT	0.239
ITEM	13	PERCENT SHORT	0.484
ITEM	104	PERCENT SHORT	0.370
ITEM	114	PERCENT SHORT	0.382

BASE STOCKAGE CONDITIONS: BASE # 2 KIND # 1 NO SRUS: 0 TYPE AC 1 NO AC 48 SHORTAGE 8%
ALPHA 1.50 0.75 BETA 1.20 0.75
REPAIR TIMES (P-W): 3.0 2.0 ORDER/SHIP TIMES (P-W): 10. 20. TRAVEL TIME: 0.0 SORTIE RATES (P-W): 80 120

COST OF PARTS FOR BASE # 2 ACTUAL $ 6260 TOTAL $ 9654 (THOUSANDS) LRUS 5864 9170 SRUS 396 484

8	17	8	3	1	2	3	3	7	3	1	112	0	0	0
9	17	8	3	1	5	3	1	12	0	0	0	0	0	0
10	17	8	3	1	1	3	1	2	3	1	3	3	1	7
0	0	0	3	1	107	3	1	108	0	0	0	0	0	0
11	17	8	3	1	1	3	3	2	3	1	107	3	1	115
12	17	8	3	1	1	3	2	2	3	1	6	3	4	7
0	0	0	3	1	101	3	1	115	0	0	0	0	0	0
13	17	8	3	1	2	3	1	3	3	1	6	3	2	7
0	0	0	3	1	12	0	0	0	0	0	0	0	0	0
14	17	8	3	1	2	3	1	3	3	1	5	3	1	7
0	0	0	3	1	108	0	0	0	0	0	0	0	0	0
15	17	8	3	3	2	3	1	3	3	1	7	3	1	9
0	0	0	3	1	10	0	0	0	0	0	0	0	0	0
16	17	8	3	1	1	3	1	3	3	2	7	0	0	0
17	17	8	3	4	1	3	1	2	3	1	6	3	2	7
0	0	0	3	1	101	3	1	117	0	0	0	0	0	0

PARTS AT BASE # 2

1	2	3	5	6	7	8	9	10	11	12	13	14	15	101	102	103	107	108	112	113	114	115	117	118
17	16	27	19	10	21	3	11	16	9	2	6	18	17	4	2	8	4	7	1	3	3	0	1	2
26	38	37	21	26	86	4	13	17	10	6	6	18	18	8	3	9	6	11	2	4	4	3	2	2

201	204
28	28
31	31

Fig. 19 -- Illustrative Parts Stockage Initialization Results

the theater manager when the parameter TSAR is initialized greater than zero.

The initial stock data list both the numbers of serviceables and the total numbers that are "authorized"--i.e., the number that would be available without shortages and if no parts were in the pipeline. For example, the policy factors would normally lead to the procurement of 38 type #2 parts and 86 type #7 parts, but because of shortages and the parts that are in the pipeline from CONUS, only 16 serviceable Type #2 parts and 21 Type #7 parts are on base.

The outcome of air base attacks are recorded in the manner illustrated in Fig. 20. In this case the results are for the air base attack sustained at Base #3 at 0536 on day 2; seven aircraft were damaged beyond the point of repair and 29 casualties were sustained, but no spare parts were lost. Civil engineering resources were assigned to open the runway (facility #36) and to reconstitute the parts repair capabilities for Shops #3, #5, and #7. Crater repairs on the runway will be completed at 1124 on day three and the shops will be reopened between day six and day 12, if there are no further air attacks. The numbers of each type of personnel, equipment, munitions, TRAP, and building materials that survived the attack are also listed as well as the surviving quantity of POL, the total numbers of spare parts, and the number of serviceable aircraft shelters.

Figure 21 illustrates several of the mid-day TSAR reports. The first line indicates that at 0900 two tasks have been deferred at the five bases, two aircraft are awaiting parts, and 27 aircraft have outstanding battle damage tasks. The noon shop status information is shown for the first three bases. Bases #1 and #2 each have 45 aircraft assigned at this time, including survivors from the original force and some replacements for those lost in battle. Eight battle damage repair tasks are ongoing in Shop #1 at Base #1 and four have been interrupted or are waiting to be initiated. Other shops also have ongoing and waiting on-equipment tasks and parts repairs. Shop #30 has 15 weapon-assembly jobs in progress. Bases #1 and #2 have a large number of tasks waiting at Shop #5; these lengthy queues have formed because the type #4 equipment that malfunctions 5.2 percent of the time on the average, and

```
BASE # 3 SUSTAINED AN AIR ATTACK AT  536 ON DAY  2       7 AIRCRAFT WERE DESTROYED AND  0 WERE DAMAGED.

    28 CASUALTIES WERE SUSTAINED.
    0 AIRCRAFT SPARE PARTS WERE LOST

FACILITY # 36 ON BASE # 3 RECEIVED  12% DAMAGE.  RECONSTRUCTION BEGAN ON DAY  2 AT  5.6HRS;   COMPLETE ON DAY  3 AT 11.3HRS
FACILITY #  7 ON BASE # 3 RECEIVED  32% DAMAGE.  RECONSTRUCTION BEGAN ON DAY  2 AT  5.6HRS;   COMPLETE ON DAY  6 AT 13.5HRS
FACILITY #  5 ON BASE # 3 RECEIVED  40% DAMAGE.  RECONSTRUCTION BEGAN ON DAY  2 AT  5.6HRS;   COMPLETE ON DAY 12 AT  3.0HRS
FACILITY #  3 ON BASE # 3 RECEIVED  16% DAMAGE.  RECONSTRUCTION BEGAN ON DAY  2 AT  5.6HRS;   COMPLETE ON DAY  9 AT 13.9HRS

          RESOURCES AT BASE # 3

PERSONNEL     1    2    3    4    5    6    7    8   31   62   63   64   65  191  192  194
             44   14    7   11    4    4    7    7   10   28   21   49   34   40   26   28

EQUIPMENT     2    3    4    5    6    7    8   16   17   18   21   22   23   25   28   31   32   34   96   97   99
              5    1    2    2    2    1    1    1    1    1   10    1    6    1    1    4    3    1   14   10    5

MUNITIONS     1    2    3    4    5    6   11   12
           1122  990  670  422  422  546  177  245

  TRAP        1    2    3    4    5
             18   12    9   16 2438

MATERIALS     1    2    4    6
           1428 3602  742 5476

  SURVIVING POL     19720   SPARE PARTS: LRU  153    SRU   16      AIRCRAFT SHELTERS:  21
```

Fig. 20 -- Sample Air Output for Base Attacks

9:00 DEFERRED 2 HOLES/DAMAGED 2/ 27 BY BASE 1/ 7 1/ 5 0/ 2 0/ 2 0/ 11

HOUR 12:00 AIRCRAFT BY BASE 45 45 16 17 12

SHOP STATUS AT 12:00 O'CLOCK

BASE 1 (45 AIRCRAFT)

SHOP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27	28	29	30
TASKS ONGOING	8	0	1	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	4	8	
REPAIRS	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				15
TASKS WAITING	2	0	0	0	15	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0
TASKS INTER	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
REPAIRS WAIT	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
REPAIRS INTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				

TRAY STATUS 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000

BASE 2 (45 AIRCRAFT)

SHOP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27	28	29	30
TASKS ONGOING	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
REPAIRS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				7
TASKS WAITING	0	0	0	0	29	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TASKS INTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
REPAIRS WAIT	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
REPAIRS INTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				

TRAY STATUS 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000

BASE 3 (16 AIRCRAFT)

SHOP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27	28	29	30
TASKS ONGOING	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
REPAIRS	0	0	-16	0	-40	0	-32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				7
TASKS WAITING	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2
TASKS INTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
REPAIRS WAIT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
REPAIRS INTER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				

TRAY STATUS 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000

Fig. 21 -- Mid-day TSAR Shop Reports

that is required on over 13 percent of the sorties, has experienced even more failures than expected. (This observation could be deduced from the complete results, but is not apparent from these sample outputs). Shop #5 has 15 tasks waiting at Base #1 and 29 at Base #2. The negative entries for ongoing repairs at Base #3 are actually a record of the damage level at shops damaged by air attack; the minus sign signals that this is the appropriate interpretation.

When AIS are employed, "Tray Status" indicates the current repair capability of the several stations, by indicating which, if any, of the LRUs *cannot* currently be repaired; a "1" in that tray position corresponding to a particular LRU indicates that that LRU cannot currently be repaired if there is only one string of the required type of station. In this case all stations at each base are fully operable.

Figure 22 illustrates the results of the calculations that are performed each evening at 1930 to provide proxies for each base's sortie generation capabilities for the subsequent day; these estimates are requested when STATE > 0 and are based on the current resource status at each base. Based on these estimates of the relative sortie generation capability at each base, aircraft #10 and #21 were transferred from Base #1 to Base #4 to obtain a more equitable distribution of aircraft. The CANFLY array data are listed by aircraft type; the first three columns are for missions #1 to #3 at Base #1, the next three columns for Base #2, etc. The final line lists the SORCAP array data for each of the four operating bases.

The first of the end-of-day reports appear at the bottom of Fig. 22; overall parts supplies as well as the numbers of assembled and unassembled munitions of each type are presented for each base. Other end-of-day reports (for the fourth day of simulated operations) are shown in Fig. 23. Base status is shown only for Base #1, so that other reports can be illustrated as well. A total of 128 aircraft are assigned at the four bases, and 22 are at the rear maintenance base; 45 aircraft have been lost in combat, or as a result of air base attack, and 71 aircraft have sustained damage during the four days.

On the fourth day at the four bases, 227 sorties were flown and 716 have been flown to date. The numbers of flights and sorties demanded

```
SORTIE GENERATION CAPABILITIES

ACTYPE # 1
 152   232   206   155   237   210    39    52    53    79   106   107
 152   232   206   155   237   210    36    52    52    54   106    79
 152   232   206   155   237   210    36    52    52    54   106    79

 232   237    52   106

AIRCRAFT #  10 TRANSFERRED FROM BASE # 1 TO # 4 AT     870
AIRCRAFT #  21 TRANSFERRED FROM BASE # 1 TO # 4 AT     870

21:00 DEFERRED   3 HOLES/DAMAGED   4/ 30 BY BASE   0/  7   1/  4   0/  2   1/  2   2/ 15

          HOUR   0:00    AIRCRAFT BY BASE    43     47     16     16     21

          BASE  1  LRUS   158   SRUS    38   MUNITIONS    1062    POL   29090

                   MUNITIONS     1     2     3     4     5     6    11    12
                               332   160   144    60    86   100    79   101
                              3106  2500  1832  1000  1468  2000   332   500

          BASE  2  LRUS   195   SRUS    34   MUNITIONS    1084    POL   29415

                   MUNITIONS     1     2     3     4     5     6    11    12
                               440   160    82    60    94   124    55    69
                              3196  2500  1988  1000  1492  1916   416   668

          BASE  3  LRUS   153   SRUS    16   MUNITIONS     536    POL   19705

                   MUNITIONS     1     2     3     4     5     6    11    12
                                74    66    62    26    26    70   108   104
                              1048   924   600   396   396   452    69   165

          BASE  4  LRUS   113   SRUS    11   MUNITIONS     595    POL   15565

                   MUNITIONS     1     2     3     4     5     6    11    12
                               172   100    44    40    54    44    67    74
                              1180  1400   988   600   528   728   190   316

          BASE  5  LRUS   355   SRUS    76   MUNITIONS       0    POL   29710

 0:00 DEFERRED   3 HOLES/DAMAGED   5/ 30 BY BASE   0/  6   1/  4   0/  1   1/  2   3/ 17
```

Fig. 22 -- Evening Report of Estimated Capabilities and End-of-day Resources

```
DAY  4    TRIAL #  1    TOTAL AIRCRAFT 150    ( 45      71)                                        COMPUTER TIME:    19.46 SEC

AIRCRAFT BY BASE     43          44          19          22          22
RESERVES BY TYPE     27

               AIRCRAFT WITHDRAWN/SENT FORWARD BY BASE   27/ 33   29/ 28   25/ 22   22/ 21
               SORTIES:  DAILY TOTAL  227  CUMULATIVE: TOTAL   716  BY BASE:    279   232   113   92

FLIGHTS LAUNCHED  21  16   0   0  16   0  11   0   0   8   7   0   0   0   0   0
        DEMANDED  22  22   0   0  22   0  22   0   0  11  11   0  11   0   9   0

  EFFECTIVENESS   66  47   0   0  51   0  59   0   0  21  38   0   0   0   0   0

SORTIES FLOWN     62  47   0   0  46   0  31   0   0  21  20   0   0   0   0   0
        DEMANDED  66  66   0   0  66   0  66   0   0  33  33   0  33   0  27   0
           FRAC  .94 .71 .00 .00 .70 .00 .47 .00 .00 .64 .61 .00 .00 .00 .00 .00

        PERCENT AIRCRAFT READIED IN "N" HOURS (CUM)
                  2 HR:     32     26     23     20
                  4 HR:     48     40     45     56
                  6 HR:     56     45     51     64
                  8 HR:     59     51     67     7?

                                         SORTIES LAUNCHED DURING HOUR ENDING AT:
BASE  1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:0010:0011:0012:00   1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:0010:0011:0012:00

 1       0    0    0    0    0    6   21    9    0   12   12    0      0    6   15    5    3    0    3    3   12    2    0    0
 2       0    0    0    0    0    6   18    6    0    9    2    6      0   12    0    0    0    0    9    4    5    0    0    0
 3       0    0    0    0    0    0    3    9    3    2    0    0      0    0   11    2    0    0    6    2    3    0    0    0
 4       0    0    0    0    0    0    0    0    0    0    0    0      0    0    0    0    0    0    0    0    0    0    0    0

                                 SHOPS ON BASE  1     (AIRCRAFT  43            BATTLE DAMAGED:  CURRENT   6    TOTAL  29)
 SHOP NO          1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25
 ON-EQUIP         3   8  11   0  34   0   9   0   4   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0 226  (   1)
MAN HOURS(X10)   87   1  13   0   9   0  23   0   3   8   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  10 125  24   0
 OFF-EQUIP        0   0   3   0   5   0   3   0   1   5   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  (   0   3)
MAN HOURS(X10)    0   0   4   0   6   0   2   0   0   8   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 285
AGE REPAIR        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
MAN HOURS(X10)    0   0   0   0   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

    SHOP          1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  27  28  29  30
TASKS             6   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1
REPAIRS           0   0   0   0   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0                11
TASKS WAITING     0   0   0   0  25   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   5
TASKS INTER       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
REPAIRS WAIT      0   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
REPAIRS INTER     0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

              CUMULATIVE NORS-HOURS BY BASE       36       66       30       24       114

 TASKQ   REPQ   WAIT     INTER   RQD   DEF       NORQ  FLTS LIMBO     BUILD BCKLG CEJOB      SHIP SHIPQ RESUP     CHANGE SPLITS
   36      5     76          7   185     1          6   130    79        28    10     3        50   128   243          0      2
    0      0      0          0     0     0          0     0     0         0     0     0         0     0     0          0      0

                             SERVICEABLE PARTS                              REPARABLE PARTS           CONDEMNED PARTS
                    BASE     SHIPPED    FROM      FROM      FROM              TO        TO      TO
                                      OPS-BASE    HDQ       CONUS          OPS-BASE    HDQ     CONUS
                     1         28        16        0         0                 0        0       38                25
                     2         21        13        0         0                 0        0       42                19
                     3         20         1        0         0                25        0        0                11
                     4         22         3        0         0                13        0        0                 5
                     5         32         0        0         0                 0        0       18                40
                     7          0         0        0         0                 0        0        0                 0

          UNSCHEDULED MAINTENANCE REQUIREMENTS BY BASE    0.776    0.819    0.782    0.703
```

Fig. 23 -- TSAR Daily Summary Report

and flown are listed next for each mission and base; the first four columns indicate the flying for each of the four missions at Base #1; the next four columns are for Base #2, etc. Of the 66 mission #1 sorties demanded at Base #1, 62 were flown. No sorties were flown at Base #4 because of bad weather.

The rates at which aircraft have been made ready for another combat sortie are indicated for each of the operating bases; at base #1, 32 percent were readied within two hours of the time that they landed, and 48 percen. within four hours.

The hourly record of sortie production shows, for example, that performance declined during the day at Base #1, with 36, 24, 29, and 20 sorties being launched during the four launch periods for which 36, 30, 36, and 30 sorties had been demanded.

The shop status reports include not only the current activity, as in the noon report, but also the totals of the on-equipment, off-equipment, and equipment repair jobs that were completed during the preceding 24 hours, and the cumulative numbers of manhours expended in each shop. The number in parentheses at the right end of the on-equipment task line is the cumulative number of parts cannibalization actions; in this case only one has occurred. The two numbers in parentheses at the right end of the off-equipment line are the cumulative number of LRUs that have been cannibalized to obtain an SRU; and the cumulative number of repairs that have been expedited; in this case, three repairs have been expedited at Base #1.

The cumulative number of hours at each base that aircraft have been NMCS (NORS) is listed after the mid-day shop status reports; as noted, parts availability has most seriously constrained aircraft at the rear maintenance base. The current number of active entries in each of the dynamic storage arrays is listed next; the lower numbers, all zero in this example, provide a record of the number of potential entries that had to be discarded because the storage array was full. The cumulative spare parts shipping record is shown near the bottom of Fig. 23 and the last line provides a cumulative record of the fraction of sorties at each base that required some type of unscheduled maintenance when they recovered.

A sample of the daily aircraft activity record, controlled by the variable SCROLL, is shown in Fig. 24 for the 24 aircraft numbered from 97 through 120 (the numbers of the aircraft that were originally assigned at Base #3). The data at the top of the table indicates (1) how many sorties had been flown during the preceding 24 hours,[1] (2) the base to which the aircraft is currently assigned, (3) the current status, and (4) the number of parts that are missing from the aircraft. Status is defined as the sum of "1" if one or more on-equipment tasks have been interrupted, "2" if one or more tasks are waiting, and "4" if one or more tasks are in process. Following these data each column contains the chronological record of activity completions for the aircraft. Each three lines provide (1) the time that the first attempt was made to start a task, (2) the time the task was completed, and (3) the task designation. The times are in hours and minutes. Reconfiguration, mission-dependent munitions uploading, and refueling are designated as CONF, ARM, and FUEL, respectively. A completed sortie is denoted by LAND, and an aircraft that is lost, in air combat or on-base, is denoted by KILL. An aircraft transfer is designated as TRAN. All other tasks are designated with the task number. In this example, aircraft #103 was lost in combat on the flight that was launched at 0630 and was expected to land at 0824. Aircraft #105 completed two combat sorties (at 1045 and 1621) and then was transferred to the rear maintenance base at 1700 following refueling.

The final results for the trial are illustrated in Figs. 25, 26, and 27 . The total numbers of flights and sorties of each mission type are shown for each base; four columns of figures apply for each of the four bases, one for each of the four possible types of missions.

The total sorties are also listed by priority, with the same general format as at the top of the figure. The cumulative numbers of on- and off-equipment tasks are listed at the bottom of the figure for each shop.

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[1] If this datum is "-1", the aircraft that had been reported in this column was lost during the day and has not yet been replaced--e.g., aircraft #103.

DAY 4 DAILY AIRCRAFT ACTIVITIES

(SORTIES BASE STATUS HOLES)

97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
2	3	3	3	3	2	-1	1	2	0	1	2	0	1	0	3	2	0	2	1	2	2	2	2
3	3	1	3	5	5	0	3	5	4	3	3	3	2	4	1	3	5	3	3	1	3	3	1
0	0	2	0	4	4	0	0	2	0	0	0	2	4	0	4	0	4	0	4	2	0	4	2
0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
2115	2139	633	2033	703	1924	630	2333	1451	906	1451	736	0	657	0	636	2154	2103	2121	2012	715	12	703	715
409	6	748	139	830	1024	824	1227	909	824	939	836	0	851	0	757	15	1433	524	24	845	30	830	818
11	8	LAND	11	LAND	11	LAND	16	11	CONF	2	LAND		LAND		LAND	6	103	11	11	LAND	102	LAND	LAND
409	2239	754	642	836	1409	0	1227	933	824	939	842	0	857	0	803	15	0	524	215	851	30	836	824
448	18	809	742	857	1530	824	1327	1045	857	1133	915	0	927	0	824	115	0	603	312	912	200	851	845
ARM	20	44	LAND	1	LAND	KILL	TRAN	LAND	ARM	5	FUEL		FUEL		44	TRAN		ARM	ARM	44	10	44	44
736	2133	754	748	836	1536	0	1333	1051	824	1133	915	0	0	0	803	121	0	833	215	851	200	836	824
836	303	818	836	924	1603	0	1357	1106	912	1206	1015	0	0	0	839	209	0	918	312	924	300	900	900
LAND	24	43	42	42	44		43	44	ARM	FUEL	TRAN				43	42		LAND	ARM	43	TRAN	43	43
842	303	818	836	924	1536	0	1357	1051	0	1133	1021	0	0	0	803	209	0	924	642	851	306	836	900
915	412	842	909	933	1624	0	1412	1115	0	1212	1051	0	0	0	854	224	0	939	742	939	348	924	924
43	21	FUEL	FUEL	CONF	42		44	43		ARM	FUEL				42	44		44	LAND	42	44	42	FUEL
842	412	818	836	924	1624	0	1412	1051	0	1133	1051	0	0	0	854	209	0	924	748	939	306	924	900
921	545	848	918	957	1657	0	1418	1139	0	1233	1221	0	0	0	854	233	0	1045	821	1003	354	957	1403
44	22	ARM	12	FUEL	FUEL		CONF	42		18	10				ARM	43		43	FUEL	ARM	42	FUEL	11
842	833	818	1418	924	2036	0	1412	1139	0	1233	1221	0	0	0	854	233	0	1045	0	939	306	924	1548
930	918	857	1524	1006	2154	0	1421	1212	0	1421	1321	0	0	0	918	306	0	1118	0	1003	421	1021	1654
42	LAND	ARM	LAND	12	LAND		CONF	FUEL		23	TRAN				FUEL	FUEL		FUEL		FUEL	43	ARM	LAND
930	924	818	1530	933	2200	0	1412	1139	0	1233	1327	0	0	0	854	233	0	1045	0	939	421	924	1700
939	939	1027	1554	1012	2233	0	1445	1218	0	1433	1342	0	0	0	1151	309	0	1124	0	1015	427	1021	1757
CONF	44	11	43	ARM	FUEL		FUEL	ARM		24	44				11	CONF		ARM		ARM	CONF	ARM	44
930	924	1442	1530	1451	2233	0	1421	1139	0	1133	1327	0	0	0	1451	309	0	1045	0	1333	421	924	1700
1003	1045	1545	1618	1557	2333	0	1500	1336	0	1606	1351	0	0	0	1609	409	0	1151	0	1445	430	1045	1812
FUEL	43	LAND	42	LAND	TRAN		ARM	11		11	43				LAND	ARM		7		LAND	CONF	7	43
930	1045	1551	1618	1603	0	0	1936	1536	0	1854	1351	0	0	0	1615	309	0	1045	0	1451	421	924	1700
1103	1118	1606	1651	1627	0	0	2021	1621	0	1957	1357	0	0	0	1639	409	0	1154	0	1506	454	1451	1824
7	FUEL	44	FUEL	43			LAND	LAND		LAND	CONF				FUEL	ARM		16		44	FUEL	11	42
939	1045	1551	1815	1603	0	0	2027	1627	0	2003	1351	0	0	0	1615	703	0	1451	0	1451	430	2036	1824
1118	1124	1615	1927	1639	0	0	2057	1700	0	2018	1400	0	0	0	1651	830	0	1557	0	1515	524	2154	1848
ARM	ARM	43	LAND	44			44	FUEL		44	CONF				ARM	LAND		LAND		43	ARM	LAND	FUEL
939	1045	1551	1933	1639	0	0	2027	1700	0	2003	1351	0	0	0	1615	836	0	1603	0	1451	736	2200	1824
1118	1221	1636	1948	1648	0	0	2115	1800	0	2027	1424	0	0	0	1754	900	0	1654	0	1536	836	2248	1900
ARM	12	42	44	CONF			43	TRAN		43	FUEL				ARM	43		44		42	LAND	42	ARM
1409	1451	1636	1948	1639	0	0	2027	1806	0	2027	1400	0	0	0	1615	836	0	1603	0	1536	842	2248	1824
1530	1557	1700	2021	1712	0	0	2124	1836	0	2100	1439	0	0	0	1903	924	0	1721	0	1600	906	2321	1936
LAND	LAND	12	FUEL	FUEL			42	FUEL		FUEL	ARM				11	42		42		FUEL	44	FUEL	ARM
1536	1603	1636	1948	1648	0	0	2124	0	0	2027	1536	0	0	0	2027	924	0	1721	0	1536	842	0	0
1609	1633	1700	2054	1748	0	0	2157	0	0	2136	1621	0	0	0	2148	957	0	1730	0	1603	915	0	0
FUEL	44	FUEL	7	ARM			FUEL			16	LAND				LAND	FUEL		CONF		CONF	43		
1609	1603	1636	0	1648	0	0	2124	0	0	0	1627	0	0	0	0	924	0	1721	0	1536	915	0	0
1709	1651	1718	0	1748	0	0	2230	0	0	0	1721	0	0	0	0	1021	0	1754	0	1612	924	0	0
TRAN	43	18		ARM			12				43					ARM		FUEL		CONF	CONF		

Fig. 24 -- Sample from Aircraft Activity Report

FINAL RESULTS TRIAL # 2

SURVIVING AIRCRAFT 147

485	FLIGHTS FLOWN	96	88	0	0	99	1	76	0	0	37	28	0	38	0	22	0
910	REQUIRED	154	154	0	0	154	3	158	0	0	73	73	0	77	1	63	0
1735	EFFECTIVENESS	301	250	0	0	302	3	391	0	0	103	156	0	111	0	118	0
1373	SORTIES FLOWN	276	252	0	0	280	3	210	0	0	105	82	0	103	0	62	0
2730	REQUIRED	462	462	0	0	462	9	474	0	0	219	219	0	231	3	189	0
0.503	FRAC	.60	.55	.00	.00	.61	.33	.44	.00	.00	.48	.37	.00	.45	.00	.33	.00

SORTIE STATISTICS FOR PRIORITY # 1

583	FLOWN	172	145	0	0	57	3	64	0	0	36	32	0	27	0	47	0
987	DEMANDED	252	210	0	0	105	9	105	0	0	72	63	0	63	3	105	0
0.59	FRAC	.68	.69	.00	.00	.54	.33	.61	.00	.00	.50	.51	.00	.43	.00	.45	.00

SORTIE STATISTICS FOR PRIORITY # 3

638	FLOWN	104	107	0	0	151	0	66	0	0	69	50	0	76	0	15	0
1407	DEMANDED	210	252	0	0	252	0	138	0	0	147	156	0	168	0	84	0
0.45	FRAC	.50	.42	.00	.00	.60	.00	.48	.00	.00	.47	.32	.00	.45	.00	.18	.00

SORTIE STATISTICS FOR PRIORITY # 5

152	FLOWN	0	0	0	0	72	0	80	0	0	0	0	0	0	0	0	0
336	DEMANDED	0	0	0	0	105	0	231	0	0	0	0	0	0	0	0	0
0.45	FRAC	.00	.00	.00	.00	.69	.00	.35	.00	.00	.00	.00	.00	.00	.00	.00	.00

SHOPS ON BASE 1 (AIRCRAFT 36 BATTLE DAMAGED: CURRENT 7 TOTAL 44)

SHOP NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
ON-EQUIP	29	43	66	0	71	0	40	0	35	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1188	(0)
OFF-EQUIP	0	1	13	0	13	0	15	0	1	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(0 4)
AGE REPAIR	0	4	1	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

SHOPS ON BASE 2 (AIRCRAFT 39 BATTLE DAMAGED: CURRENT 7 TOTAL 60)

SHOP NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
ON-EQUIP	30	37	62	0	55	0	41	0	26	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	991	(0)
OFF-EQUIP	0	2	6	0	12	0	12	0	5	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(0 1)
AGE REPAIR	0	2	1	0	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

SHOPS ON BASE 3 (AIRCRAFT 17 BATTLE DAMAGED: CURRENT 1 TOTAL 7)

SHOP NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
ON-EQUIP	2	7	15	0	20	0	0	0	12	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	401	(0)
OFF-EQUIP	0	1	0	0	0	0	0	0	1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(0 2)
AGE REPAIR	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

SHOPS ON BASE 4 (AIRCRAFT 19 BATTLE DAMAGED: CURRENT 2 TOTAL 17)

SHOP NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
ON-EQUIP	9	14	12	0	15	0	0	0	7	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	372	(0)
OFF-EQUIP	0	1	1	0	0	0	0	0	3	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(0 7)
AGE REPAIR	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

SHOPS ON BASE 5 (AIRCRAFT 36 BATTLE DAMAGED: CURRENT 26 TOTAL 0)

SHOP NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
ON-EQUIP	56	14	51	0	83	0	37	0	60	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(3)
OFF-EQUIP	0	1	11	0	41	0	14	0	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(0 22)
AGE REPAIR	0	3	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

CUMULATIVE NORS-HOURS BY BASE 18 18 24 48 126

ALL STORAGE QUEUES WERE ADEQUATE FOR TRIAL 2

Fig. 25 -- Sortie Data and Shop Summary Data for Trial #1

QUANTITIES AND TIMES FOR ON-EQUIPMENT TASKS AT BASE 1

SHOP	1	2	3	5	7	9	10	25	27	28	29
NUM TASKS	29	43	66	71	40	35	68	1188	344	629	569
AVG TIME-HR	62.6	1.3	2.0	0.8	1.6	1.5	4.1	0.4	2.0	0.5	0.4
STAN DEV-HR	37.6	1.5	2.1	1.1	0.8	1.4	4.0	0.3	3.6	0.2	0.0
MAN HRS X10	184	3	21	3	14	7	21	0	28	245	45
STAND. TIME	0.0	1.2	1.1	0.7	1.4	1.1	3.7	0.4	0.0	0.0	0.0

QUANTITIES AND TIMES FOR OFF-EQUIPMENT REPAIRS AT BASE 1

SHOP	2	3	5	7	9	10	30
NUM REPAIRS	1	13	13	15	1	53	649
AVG TIME-HR	46.9	53.0	56.4	50.7	47.2	45.8	2.6
STAN DEV-HR	0.0	17.1	6.4	5.5	0.0	12.3	1.4
MAN HRS X10	0	5	7	6	0	13	541
STAND. TIME	51.3	50.8	51.8	50.0	49.9	50.5	0.0

NUMBERS OF LRUS AND SRUS PROCESSED BY AIS STATIONS

STATION	1	2	3	4	5	6	7	8	9	10
LRUS	9	18	2	0	0	0	0	0	0	0

QUANTITIES AND TIMES FOR EQUIPMENT REPAIRS AT BASE 1

SHOP	2	3	5	27	28	30
NUM REPAIRS	4	1	3	7	4	2
AVG TIME-HR	10.9	3.7	8.9	11.8	53.0	13.0
STAN DEV-HR	1.4	0.0	3.2	1.4	6.6	0.0
MAN HRS X10	1	0	1	4	1	1

RESOURCES AT BASE # 1

PERSONNEL	1	2	3	4	5	6	7	8	21	22	23	24	25	26	27	28	31	62	63	64	65	72	73	74
	48	16	8	12	4	4	8	8	48	16	8	12	4	4	8	8	20	56	48	80	88	10	4	2

PERSONNEL	75	76	77	78	191	192	194
	4	5	5	8	60	32	40

EQUIPMENT	2	3	4	5	6	7	8	12	15	16	17	18	21	22	23	25	28	31	32	34	96	97	99
	4	2	3	1	2	1	1	4	1	1	2	1	18	1	9	1	1	8	4	1	24	16	8

MUNITIONS	1	2	3	4	5	6	11	12
	1404	2644	1636	1060	1202	2108	156	97

TRAP	1	2	3	4	5
	16	7	10	7	4322

MATERIALS	1	2	4	6
	6000	8000	2000	1000

SURVIVING POL 27150 SPARE PARTS: LRU 157 SRU 32 AIRCRAFT SHELTERS: 48

Fig. 26 -- End-of-Trial Shop Summaries and Residual Resource Lists

AIRCRAFT DELAYS DUE TO RESOURCE LIMITATIONS
****
BASE 1

DELAYS DUE TO LIMITATIONS OF PERSONNEL

TYPE	3	5	8	23	25	31	62	63	65
NUM DELAYS	13	3	15	5	3	21	98	316	150
AVG DELAY-HR	1.1	0.6	0.8	1.3	0.3	56.3	0.7	0.3	0.4
STAN DEV-HR	0.9	0.3	0.7	1.1	0.4	47.1	2.4	0.2	0.8

DELAYS DUE TO LIMITATIONS OF AGE

TYPE	3	4	6	7	8	15	21	28	32
NUM DELAYS	33	14	1	13	46	5	8	28	21
AVG DELAY-HR	2.7	1.3	8.7	2.4	7.9	0.8	1.3	3.0	0.2
STAN DEV-HR	2.8	1.9	0.0	4.1	4.8	0.8	1.0	4.2	0.1

DELAYS DUE TO LIMITATIONS OF PARTS
(ALSO, REPAIR DELAYS DUE TO SRUS)
HOLES 0 HOLES/UE 0.0 HOLES/AC WITH HOLES 0.0 HOLES/NORS AC 0.0

TYPE	12
SHOP	10
NUM DELAYS	3
AVG DELAY-HR	4.2
STAN DEV-HR	3.2
AC "HOLES"	0

PARTS AT BASE # 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	101	102	103	107	108	112	113	114	115	117
9	9	14	8	4	7	28	2	3	5	1	2	8	19	14	2	1	6	5	7	2	3	1	2	1
2	5	2	0	8	5	1	3	6	0	4	4	1	4	4	0	0	0	0	0	0	0	0	0	0

118	201	202	203	204
2	9	3	2	10
0	0	0	0	0

THEATER-WIDE: HOLES 4 HOLES/AIRCRAFT 0.027 HOLES/AIRCRAFT WITH HOLES 1.000 HOLES/NORS AIRCRAFT 1.000

CUMULATIVE BENT PARTS BY BASE 259 217 48 50 234

****
********** TRIAL # 3 **********
****

SEED -263726595

PARTS SHORTAGE FACTORS 8 % -0.1 % 50 33

ITEM	1	PERCENT SHORT	0.478
ITEM	4	PERCENT SHORT	0.277
ITEM	6	PERCENT SHORT	0.259
ITEM	104	PERCENT SHORT	0.415

Fig. 27 -- On-Equipment Task Delay Statistics, and Other End-of-trial Data

Samples of the shop statistics for Base #1 are shown in Fig. 26; as will be noted, the cumulative number of tasks, their average time, and the standard deviation of those times are listed for each shop. For those shops for which it is computed (in subroutine AVGTSK), the average task time in an unlimited resource environment is listed last. A comparison of this time, with the actual average time, provides a rough estimate of resource shortages. Similar data are presented for off-equipment parts repair and for equipment repairs; these data include the times taken up by the administrative delays. When AIS is used, a record of activity by station also is included.

More accurate and specific indications of resource constraints are provided by the data listed in Fig. 27. This figure summarizes the cause and the extent of all aircraft maintenance delays. As will be noted, each type of personnel, equipment, etc. for which a shortage caused an on-equipment task to be delayed is recorded. These statistics provide an excellent indication of the bottlenecks and very obvious indications of where extra resources could be of help in improving the bases' launch records. In this instance there have been 21 delays for battle damage repair specialists at Base #1 that averaged over two days in length. A greater number of such specialists clearly would have reduced this heavy backlog of work.

The status of spares at each base is also available; the number of on-base serviceables and reparables are listed for each part type. The total number of spares that were removed from aircraft during the simulation are also shown for each base.

The beginnings of the next trial are shown at the bottom of Fig. 27. The value of the seed for the random number generator is printed at the beginning of each trial, so that a particular trial can be repeated, if necessary, to obtain additional information. Since, in this instance, spare parts shortage computations and other computations were to be repeated each trial, the beginnings of that process appear next.

Figure 28 illustrates the summary data provided at the completion of the specified number of trials. Data include the average number of sorties generated each day at all operating bases as well as the average numbers of sorties of each mission type at each base; the standard

OVERALL PERFORMANCE IN 3 TRIALS

DAILY SORTIES FLOWN - DAILY TOTAL AND MEAN AND STANDARD DEVIATION BY MISSION AND BY BASE

DAY	TOTAL																
1	300.3	51.7	60.3	0.0	0.0	54.0	0.0	44.7	0.0	0.0	27.0	25.0	0.0	22.3	0.0	15.3	0.0
		3.4	4.6	0.0	0.0	5.7	0.0	4.8	0.0	0.0	1.6	2.8	0.0	3.4	0.0	3.1	0.0
2	155.3	32.0	34.7	0.0	0.0	36.0	0.0	23.3	0.0	0.0	0.0	0.0	0.0	19.3	0.0	10.0	0.0
		3.7	6.2	0.0	0.0	14.4	0.0	12.4	0.0	0.0	0.0	0.0	0.0	1.7	0.0	3.7	0.0
3	120.7	0.0	0.0	0.0	0.0	42.3	4.3	21.3	0.0	0.0	16.3	10.7	0.0	18.0	0.7	7.0	0.0
		0.0	0.0	0.0	0.0	13.2	2.6	6.2	0.0	0.0	3.9	1.2	0.0	4.3	0.9	0.8	0.0
4	203.3	58.7	38.3	0.0	0.0	32.3	0.0	29.3	0.0	0.0	25.3	19.3	0.0	0.0	0.0	0.0	0.0
		3.4	6.2	0.0	0.0	9.9	0.0	5.4	0.0	0.0	3.7	1.7	0.0	0.0	0.0	0.0	0.0
5	147.0	30.0	40.0	0.0	0.0	46.7	0.0	30.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		1.4	2.9	0.0	0.0	2.6	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	99.3	28.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0	15.3	0.0
		9.6	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.0	0.5	0.0
7	253.0	36.0	47.0	0.0	0.0	56.3	0.0	43.0	0.0	0.0	26.7	22.3	0.0	10.3	0.0	11.3	0.0
		18.8	0.8	0.0	0.0	7.3	0.0	6.2	0.0	0.0	4.7	2.6	0.0	7.4	0.0	2.4	0.0
TOTALS		236	257	0	0	267	4	191	0	0	95	77	0	88	0	58	0

AVERAGE SORTIES PER TRIAL 1279.0

Fig. 28 -- Summary Sortie Results for All Trials

deviation is also listed in the latter case. The output is concluded with records of the average numbers of sorties generated throughout the simulation for each mission and each base, and at all bases.

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