ARPA ORDER NO. 189-1

MEMORANDUM
RM-5653-ARPA
APRIL 1969

COMBAT: A SERIES OF ON-LINE COMPUTER PROGRAMS FOR QUICK-RESPONSE FORCE COST ANALYSIS

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The RAND Corporation
SANTA MONICA · CALIFORNIA

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PREFACE

COMBAT* was designed to provide analysts involved in planning or war-gaming exercises with a new quick-response tool for estimating the cost of alternative military force structures. Since 1958, costs for the major Air Force missions, the weapon systems used to perform the missions, and the necessary resources have been estimated at Rand with the computer model PROM.** Although this model is still one of the most comprehensive vehicles for examining and comparing alternative force postures, it is of limited use in situations demanding a quick-response estimating capability, such as in war-game exercises, because of the lengthy series of steps required to prepare inputs. With the introduction, in 1966, of the new JOSS,*** which is based on the PDP-6 computer, the authors immediately recognized its potential for augmenting PROM as a cost-estimating tool. (The PDP-6 provided JOSS with an order-of-magnitude more capability than its predecessor.) JOSS's increased accessibility would make it possible for the analyst to participate in a gaming or planning exercise and to supply "instant estimates" of the cost of alternative weapons and forces. However, because JOSS was not designed to include all the force permutations and adjustments of which PROM was capable, some of the accuracy and detail provided by the original model was sacrificed.

The present description of the COMBAT model is intended not only to provide the potential user with the programs necessary to enable him to use the model but also to serve as an example to stimulate the

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*Cost Oriented Model Built to Analyze Tradeoffs.

**Program Management, Resources Management, and Objectives Management.

***JOSS is the trademark and service mark of The Rand Corporation for its computer program and services using that program. The first JOSS, as implemented on the JOHNNIAC computer (now retired) by J. C. Shaw, became operational at Rand with eight consoles in 1964. The time-shared system was designed to allow the user direct interaction with the computer through a familiar device (the typewriter) and in a familiar language (arithmetic or algebra). In contrast with other general purpose systems, the secret behind JOSS's versatility is that it was designed for the casual user rather than for the systems programmer.

development of similar cost-estimating models for use with other than military forces or systems.

This work was performed in support of the Strategic Gaming Project (previously called Integrated Ballistic Missile Defense Study), which is being carried out for the Advanced Research Projects Agency of the Department of Defense. It is one of several component studies which have enabled a computer automation of strategic war gaming and reports an early development of the computer mechanization of cost-estimating techniques for gaming purposes.

SUMMARY

COMBAT is composed of five individual weapon system cost-estimating models and a time-phased force cost-estimating model. The aircraft system estimates the costs of peacetime operation of aircraft systems of the U.S. Air Force. The missile system model estimates the costs of intercontinental ballistic-missile systems, configured either as fixed-site missiles or as mobile missiles. The ground-based defense system model estimates the costs of special ground systems such as command and control systems, radar sites, and ground-based ballistic-missile defense systems (the costs of the missiles are not included). The ship system model estimates the costs of ship-based offensive or defensive systems, including the missiles involved. The space system model estimates the costs of systems operating outside the earth's atmosphere.

These models are stored in a disc file and can be recalled from any of the JOSS consoles in the various Rand departments or remote locations. The programs were developed with Rand cost-estimating tools and techniques, which, in general, describe weapon systems in terms of operations, resources, and costs. For example, the inputs required to estimate the cost of an aircraft weapon system are typically based on the following kinds of information:

1. The number of aircraft, payloads, and associated items of equipment per squadron.
2. Personnel estimates for the various major functions, such as operations, maintenance, and support.
3. Activity rate in terms of flying hours per aircraft per year.
4. The cost-quantity relationships for the major hardware items in the weapon system.
5. The cost factors for estimating other procurement items, such as spares, aerospace ground equipment, and facilities.
6. The cost factors for estimating recurring costs of operations, maintenance, and support.

The outputs of these models are presented as static costs, without reference to time. Such static cost estimates can be used throughout a study to analyze the effect, on total system cost, of possible

changes both in equipment design and in the operational design of the weapon system. The speed with which the computer can function permits many variations to be examined within a short period of time in an iterative fashion.

The force structure cost-estimating model meets the need for time-phased costs. It records and presents the year-by-year cost implications of the base case, lists the year-by-year impact of any phase-out decisions, time phases the choices made with respect to new weapon systems and their phase-in schedules, and, finally, presents the total year-by-year cost of each force structure variation considered. These variations may then be compared with the base case force and with each other, in any useful manner.

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I. INTRODUCTION

Force cost analysis, as developed by Rand and by other groups, has been an essential tool in the military planning process for more than ten years. This type of analysis, which has been discussed in detail elsewhere, includes a force cost model that requires estimating procedures based on a laborious, manual calculating process. In 1958 the process was simplified through the development at Rand of a computer model called PROM, together with its associated displays. The model estimates costs for the major Air Force missions, the weapon systems used to perform the missions, and the necessary resources. Costs are displayed by weapon system and by major cost category (Research, Development, Test and Evaluation (RDT&E), Initial Investment, and Annual Operating) for a period extending at least ten years into the future.

PROM (and variations of the model) have given Air Force planners the ability to examine and to compare alternative force postures in terms not only of the total resources required for a specified force, but also in terms of the year-by-year incremental funding requirement for each force. Charles Hitch, former Assistant Secretary of Defense, incorporated many of the PROM concepts into the new planning/programming/budgeting process, implemented in 1961 by the Office of the Secretary of Defense. Such Planning, Programming, Budgeting Systems (PPBS) are no longer limited to the defense agencies but are becoming an increasingly important management tool for other Federal agencies, as well as for some state and local agencies.

Although the PROM model can be considered one of the most comprehensive vehicles for estimating the cost of alternative military force structures, it nevertheless entails a lengthy series of steps to prepare the necessary inputs for use in the model. As a result, PROM has been of limited use in situations demanding a quick-response estimating capability, such as in war-game exercises, where there is not enough time to fill out input sheets or punch cards, or to wait to use the computer--some or all of which are necessary in using PROM.

The need for a quick-response estimating tool became evident at Rand shortly after the Rand on-line time-shared computer system called

JOSS* was modernized and made accessible to staff members from multiple locations in each department. With the increased accessibility of JOSS, the cost analyst could envision a situation where he participated in a gaming or planning exercise and supplied "instant estimates" of the cost of alternative weapons and forces. The problem was to design a model for JOSS providing this capability. The price paid for the instant-response capability and easy use of PROM required sacrificing some of the accuracy and completeness of the model. Because the new model was not intended to include all the force permutations and adjustments of which PROM is capable, it augments rather than replaces PROM as a force cost-estimating tool. This Memorandum documents the result of the effort to design the new JOSS model, which was named COMBAT (Cost Oriented Model Built to Analyze Tradeoffs).

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*The JOSS system is described in detail by C. L. Baker, in *JOSS: Introduction to a Helpful Assistant*, The Rand Corporation, RM-5058-PR, July 1966.

II. THE COMBAT MODEL: GENERAL DESCRIPTION AND MODE OF OPERATION

There are six COMBAT models: five individual weapon system cost-estimating models and a time-phased force cost-estimating model. These models are stored in a disc file and can be recalled from any remote JOSS console located in the various Rand departments. The five individual weapon system models have been designed to estimate the total system cost of (1) aircraft systems, (2) strategic missile systems, (3) ground-based defense systems, (4) ship systems, and (5) space systems. The programs were developed with the use of the Rand cost-estimating tools and techniques, which, in general, describe weapon systems in terms of operations, resources, and costs. For example, the inputs required to estimate the cost of an aircraft weapon system are typically based on the following kinds of information:

1. The number of aircraft, payloads, and associated items of equipment per squadron.
2. Personnel estimates for the various major functions, such as operations, maintenance, and support.
3. Activity rate in terms of flying hours per aircraft per year.
4. The cost-quantity relationships for the major hardware items in the weapon system.
5. The cost factors for estimating other procurement items, such as spares. aerospace ground equipment, and facilities.
6. The cost factors for estimating recurring costs of operations, maintenance, and support.

The outputs of these models are presented as static costs, without reference to time. Such static cost estimates can be used throughout a study to analyze the effect on total system cost of possible changes both in equipment design and in the operational design of the weapon system. The speed with which the computer can function permits many variations to be examined within a short period of time in an iterative fashion.

To use the force structure cost-estimating model, which presents year-by-year costs, the force structures for new weapon systems and their estimated costs (which are obtained from the individual weapon system models) are introduced into the model in the following sequence:

1. The force structure inputs, i.e., the number of weapon system units that will be found in the inventory each year.
2. The RDT&E cost estimates for each new weapon system and the number of years necessary to complete each RDT&E program.
3. The initial investment cost estimates for the new forces that will eventually be brought into the inventory.
4. The annual operating cost estimate for each new weapon system.

The next sections of this Memorandum will present a programming guide to the five individual weapon system models and the time-phased force cost model.

III. AIRCRAFT WEAPON SYSTEM MODEL

The aircraft system model was designed to estimate the costs of peacetime operation of aircraft systems of the U.S. Air Force. Two different modes of operation were taken into account in the construction of the model:

1. The aircraft are on continuous peacetime patrol; i.e., the planes remain continuously aloft to the extent of their endurance (less the required safety margin); and
2. The aircraft fly a prescribed flying-hour program; i.e., the planes are under less stress than in Mode 1. The flying-hour program may be based on a requirement to exercise the aircraft and/or the crew to comply with a specified peacetime operational policy.

The essential difference between Modes 1 and 2 with respect to the use of the model is that in Mode 1 the number of aircraft required is determined by the model as a function of the number of stations to be manned, the endurance of the aircraft, and the time required for ground activities (inspections, maintenance, etc.); in Mode 2, which applies to all current USAF operations, the requirement in terms of a force of operational aircraft is one of the inputs provided for the model, rather than a calculation performed within the model.

The remainder of the treatment of aircraft system resource requirements (facilities, trained personnel, other equipment, etc.) is handled in the same way for both operational modes. The translation of resource requirements into a statement of costs is also the same for both modes.

The sequence of steps followed in the model to provide the system cost estimate is displayed in Fig. 1. These steps have been translated into a series of JOSS instructions, which are shown in Table 1. Also shown in the table are the instructions for determining the output format. As may be seen, the output information includes costs (by major cost category) and specific operational resource and cost data that have been found useful for performing cost sensitivity analyses in support of military systems analysis.

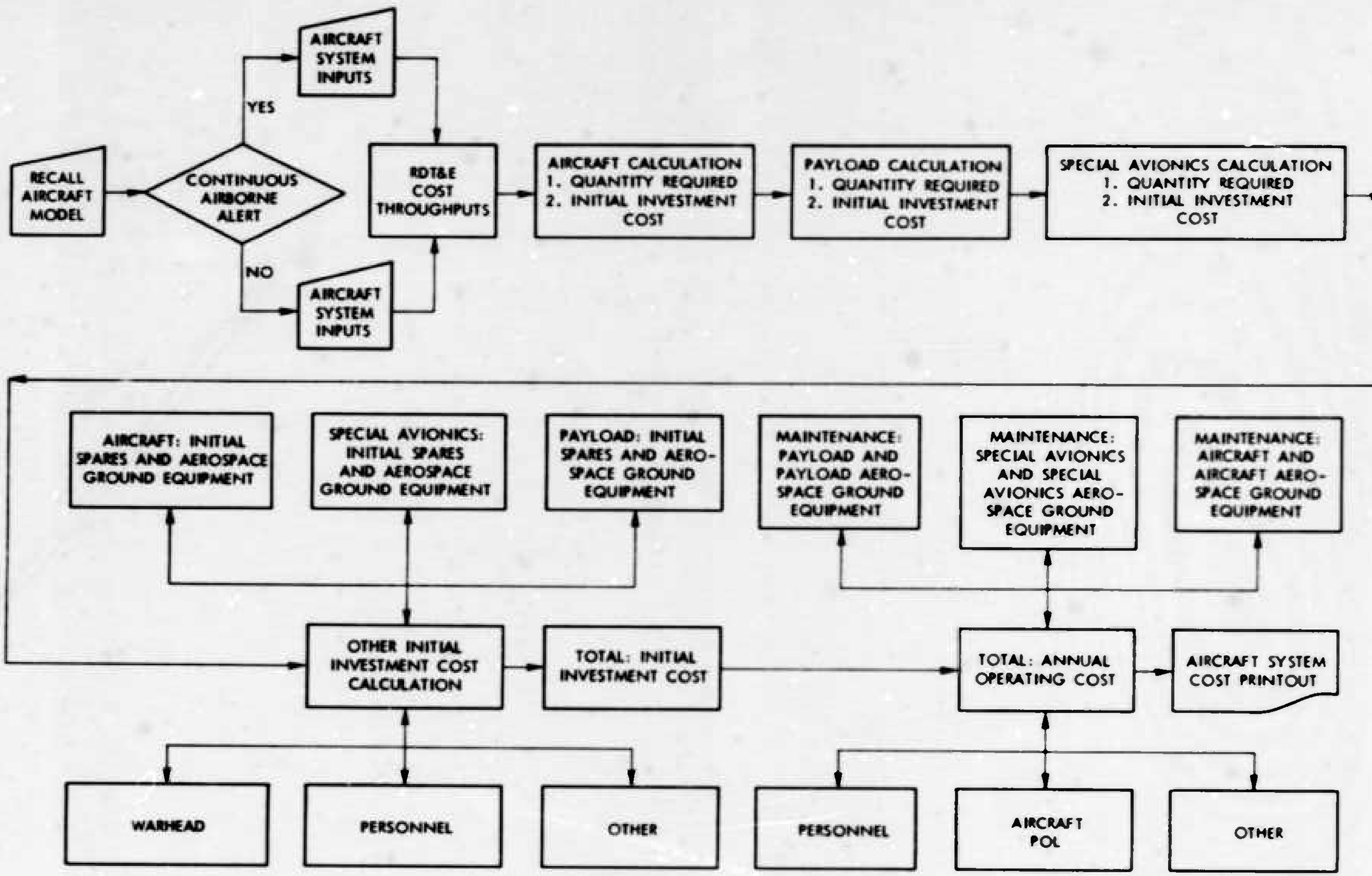

Fig. 1--Aircraft System Model

Table 1

AIRCRAFT SYSTEM MODEL: JOSS INSTRUCTIONS

```
1.001 Page.
1.002 Type "Type aircraft system number for x (three digits)".
1.003 Demand x.
1.004 Type "For continuous airborne alert, type 1 for z; otherwise type 0".
1.005 Demand z.
1.01 Demand Y.
1.02 Demand U.
1.03 Do part 82 for i=1(1)15 if z=1.
1.04 Demand S.
1.05 Demand B.
1.06 Demand F.
1.07 Demand Z.
1.08 Demand R.
1.11 Do part 71 for i = 1(1)4.
1.21 Do part 72 for i = 1(1)3.
1.31 Do part 73 for i = 4(1)11.
1.41 Do part 74 for i = 1(1)12.
1.5 To part 10.

10.1 Set q = S•U + S•B if z=0.
10.11 Set q = G + B if z=1.
10.12 Set t = q + Q(1).
10.2 Set b(1) = log[L(1)/100]/log(2).
10.3 Set c(1) = t•C(1)•[t*b(1)]-Q(1)•C(1)•[Q(1)*b(1)] if Q(1)>0.
10.31 Set c(1) = q•C(1)•[q*b(1)] if Q(1)=0.
10.41 Set p = Z•S.
10.42 Set c(2) = 0 if p=0.
10.43 To step 10.70 if p=0.
10.5 Set b(2) = log[L(2)/100]/log(2).
10.61 Set g = p + Q(2).
10.62 Set c(2) = g•C(2)•[g*b(2)]-Q(2)•C(2)•[Q(2)*b(2)] if Q(2)>0.
10.63 Set c(2) = p•C(2)•[p*b(2)] if Q(2)=0.
10.70 Set c(3) = 0.
10.71 To part 11 if C(3)=0.
10.72 Set b(3) = log[L(3)/100]/log(2).
10.73 Set N = q + Q(3).
10.74 Set c(3) = N•C(3)•[N*b(3)]-Q(3)•C(3)•[Q(3)*b(3)] if Q(3)>0.
10.75 Set c(3) = q•C(3)•[q*b(3)] if Q(3)=0.
10.8 To part 11.

11.08 Set P(5) = P(1) + P(2).
11.09 Set M = S•[P(5) + P(3) + P(4)•P(5)/100].
11.1 Set c(4) = C(4)•c(1)•10*(-2).
11.2 Set c(5) = C(5)•c(1)•10*(-2).
11.3 Set c(6) = C(6)•c(2)•10*(-2).
11.4 Set c(7) = C(7)•c(2)•10*(-2).
11.41 Set c(8) = C(8)•c(3)•10*(-2).
11.42 Set c(9) = C(9)•c(3)•10*(-2).
```

Table 1--*continued*

```
11.5 Set c(10) = C(10)·S.
11.6 Set c(11) = C(11)·M·10*(-6).
11.7 Set I = sum[i=1(1)11:c(i)].
11.8 To part 20.

20.1 Set f = F·S.
20.20 Set a(1) = A(1)·c(2)·10*(-2).
20.201 Set a(2) = A(2)·c(7)·10*(-2).
20.202 Set a(3) = A(3)·c(3)·10*(-2).
20.203 Set a(4) = A(4)·c(9)·10*(-2).
20.21 Set a(5) = A(5)·f·10*(-6).
20.22 Set a(6) = A(6)·f·10*(-6).
20.23 Set a(7) = A(7)·c(5)·10*(-2).
20.24 Set a(8) = A(8)·c(1)/100.
20.25 Set a(9) = A(9)·P(1)·S·10*(-6).
20.26 Set a(10) = A(10)·[P(2) + P(3) + P(4)·P(5)/100]·S·10*(-6).
20.27 Set a(11) = A(11)·M·10*(-6).
20.28 Set a(12) = A(12)·S·10*(-6).
20.3 Set r(1) = sum[i=1(1)12:a(i)].
20.4 Set r(2) = Y·r(1).
20.5 To part 30.

30.1 Set T = R + I + r(2) + W(1)·S·D(1).
30.2 To part 40.

40.09 Page.
40.10 Type x in form 1.
40.11 Type _,_,_.
40.12 Type Y in form 99.
40.13 Type form 98.
40.14 Line.
40.2 Type R  in form 2.
40.3 Type I in form 3.
40.40 Type D(1)·S·W(1) in form 97 if D(1)·S·W(1)>0.
40.41 Type Y, r(2) in form 4.
40.42 Line.
40.5 Type T in form 5.
40.51 Type _,_,_.
40.6 Type S, U, F in form 6.
40.7 Line.
40.71 Type q, c(1) in form 8.
40.8 Type Z·S, c(2) in form 7 if Z·S>0.
40.911 Type q, c(3) in form 96 if C(3)>0.
40.912 Line if c(3)>0.
40.92 Type M in form 10.
40.93 Type S·P(1), S·P(2), S·P(3) + S·P(4)·P(5)/100 in form 11.
40.94 Line.
40.95 Type D(1)·S, D(1)·S·W(1) in form 12 if D(1)·S>0.
40.96 To part 1.

71.1 Demand P(i).
```

Table 1--*continued*

72.1 Demand C(i).
72.2 Demand L(i).
72.3 Demand Q(i).
72.4 Demand W(1) if i = 1.
72.5 Demand D(1) if i = 1.

73.1 Demand C(i).

74.1 Demand A(i).

82.1 Type form 20 + i.
82.2 Line.
82.3 Demand y(i).
82.4 Line.
82.5 To part 83 if i=15.

83.1 Set S=ip[(G/U)+.5].
83.2 Set F=G·n·12/S.
83.3 Set B=ip[.265·G + .9].
83.4 To step 1.07.

Form 1:

Aircraft System ___

Form 2:

RDT E = ____.___

Form 3:

Initial Inv = _______.___

Form 4:

Annual Op (__yrs) = ______.___

Form 5:

TOTAL = _______.___

Form 6:

Number of squadrons ___._; UL per squadron ___; FH/sqn/yr______

Form 7:

Total payload proc. _____; Total payload proc. cost $_____.__ (millions)

Form 8:

Total aircraft proc. ___; Total aircraft proc. cost $_____.__ (millions)

Form 10:

Total Personnel ______

Form 11:

Oper. Pers ______ Maint Pers ______ Support Pers _______

Table 1--*continued*

Form 12:
Warhead Qty. (total) _____ Warhead cost (total) $ ____.__ (millions)

Form 21:
Endurance of Aircraft

Form 22:
Reserve Flying Hours per Flight

Form 23:
Flying Time from Base to Station

Form 24:
Length of Periodic in Hours

Form 25:
Flying Hours per Periodic Inspection

Form 26:
Length of Post-Flight in Hours

Form 27:
Flying Hours per Post-Flight Inspection

Form 28:
Percentage of Unscheduled Maintenance (Hours).

Form 29:
Percentage of Unscheduled Maintenance (Sorties)

Form 30:
Preflight, Servicing, Debriefing, Etc. Hours

Form 31:
Extra Down-Time per Sortie in Hours

Form 32:
Length of Maintenance Shift in Hours

Form 33:
Number of Shifts per Day

Form 34:
Number of Stations per System

Form 35:
Number of Aircraft per Station

Form 96:
Spec. av. pkg. proc. ____; Spec. av. proc. cost $ ____.__ (millions)

Table 1--*continued*

Form 97:

Warheads = ____.___

Form 98:

(millions of dollars)

Form 99:

__ YEARS SYSTEM COSTS

```
E:  V-(2•y(3))
G:  ip(s)
V:  y(1)-y(2)
d:  V•y(4)/y(5)
h:  (V+y(11))+[(24•v)/(y(12)•y(13))]
l:  720/h
m:  720•y(14)•y(15)•V/E
n:  l•V
s:  [(m/n)+.9]
u:  V•y(6)/y(7)
v:  [(1+y(8))•(d+u)]+[(1+y(9))•y(10)]
```

Finally, an input documentation list is given, as shown in Table 2, that identifies all of the necessary inputs for use in the model. At Rand this list serves the dual purpose of providing the means to prepare the necessary inputs as well as a record for subsequent reference (which may be required for further sensitivity analysis).

Table 2

AIRCRAFT SYSTEM MODEL: INPUT DOCUMENTATION LIST

	Input Code	Input Value	Input Descriptors
	Y =		Number of years
	U =		Unit equipment per squadron
For Peacetime Airborne Patrol	y(1) =		Endurance of aircraft (hours)
	y(2) =		Reserve fuel per flight (hours)
	y(3) =		Flying time from base to station (hours)
	y(4) =		Length of periodic inspection (hours)
	y(5) =		Flying hours per periodic inspection
	y(6) =		Length of postflight inspection (hours)
	y(7) =		Flying hours per postflight inspection
	y(8) =		Percentage of unscheduled maintenance per flying hour
	y(9) =		Percentage of unscheduled maintenance per sortie
	y(10) =		Preflight, servicing, debriefing, etc. (hours)
	y(11) =		Extra downtime per sortie (hours)
	y(12) =		Length of maintenance shift (hours)
	y(13) =		Number of maintenance shifts per day
	y(14) =		Number of stations per system
	y(15) =		Number of aircraft per station
	S =		Number of squadrons
	B =		Other aircraft per squadron (command support and attrition)
	F =		Flying hour per squadron per year
	Z =		Payload per squadron (0 if none)
	R =	$	RDT&E cost (in millions)
	P(1) =		Number of operating personnel per squadron
	P(2) =		Number of maintenance personnel per squadron
	P(3) =		Number of support personnel per squadron
	P(4) =		Additional support personnel: % of operations and maintenance personnel
	C(1) =	$	Cost of aircraft theoretical unit one (in millions)
	L(1) =		Aircraft procurement learning slope in percent (cum avg)

Table 2--*continued*

Input Code	Input Value	Input Descriptors
Q(1) =		Procurement level: aircraft
W(1) =	$	Cost per warhead (in millions)
D(1) =		Number of warheads per squadron
C(2) =	$	Cost of payload theoretical unit one (in millions)
L(2) =		Payload procurement learning slope in percent (cum avg)
Q(2) =		Procurement level: payload
C(3) =	$	Cost of special avionics package theoretical unit one (in millions)
L(3) =		Special avionics package procurement learning slope in percent (cum avg)
Q(3) =		Procurement level: special avionics package
C(4) =		Initial investment support: aircraft spares (% of aircraft procurement cost)
C(5) =		Initial investment support: aircraft aerospace ground equipment (% of aircraft procurement cost)
C(6) =		Initial investment support: payload spares (% of payload procurement cost)
C(7) =		Initial investment support: payload aerospace ground equipment (% of payload procurement cost)
C(8) =		Initial investment support: special avionics package spares (% of special avionics package procurement cost)
C(9) =		Initial investment support: special avionics package aerospace ground equipment (% of special avionics package procurement cost)
C(10) =	$	Initial investment other cost per squadron (in millions)
C(11) =	$	Initial investment other cost per personnel
A(1) =		Direct maintenance cost: payload (% of payload procurement cost)
A(2) =		Direct maintenance cost: payload aerospace ground equipment (% of payload aerospace ground equipment procurement cost)
A(3) =		Direct maintenance cost: special avionics package (% of special avionics package procurement cost)
A(4) =		Direct maintenance cost: special avionics package aerospace ground equipment (% of special avionics package procurement cost)
A(5) =	$	POL cost per flying hour
A(6) =	$	Direct aircraft maintenance cost per flying hour
A(7) =		Direct maintenance cost: aircraft aerospace ground equipment (% of aircraft aerospace ground equipment procurement cost)

Table 2--*continued*

Input Code	Input Value	Input Descriptors
A(8) =		Modification and replacement cost per year (% of aircraft procurement cost)
A(9) =	$	Operation personnel pay and allowance and replacement training cost per operation personnel
A(10) =	$	Support personnel pay and allowance and replacement training cost per support personnel
A(11) =	$	Other personnel cost per personnel
A(12) =	$	Other squadron cost per squadron

IV. MISSILE WEAPON SYSTEM MODEL

The missile system model was designed to estimate the costs of intercontinental ballistic-missile systems, configured either as fixed-site missiles or as mobile missiles. (Both are treated in the same way by the model.) A flow diagram displaying the sequence of steps is presented in Fig. 2. The JOSS instructions for this model are shown in Table 3 and the input documentation list in Table 4.

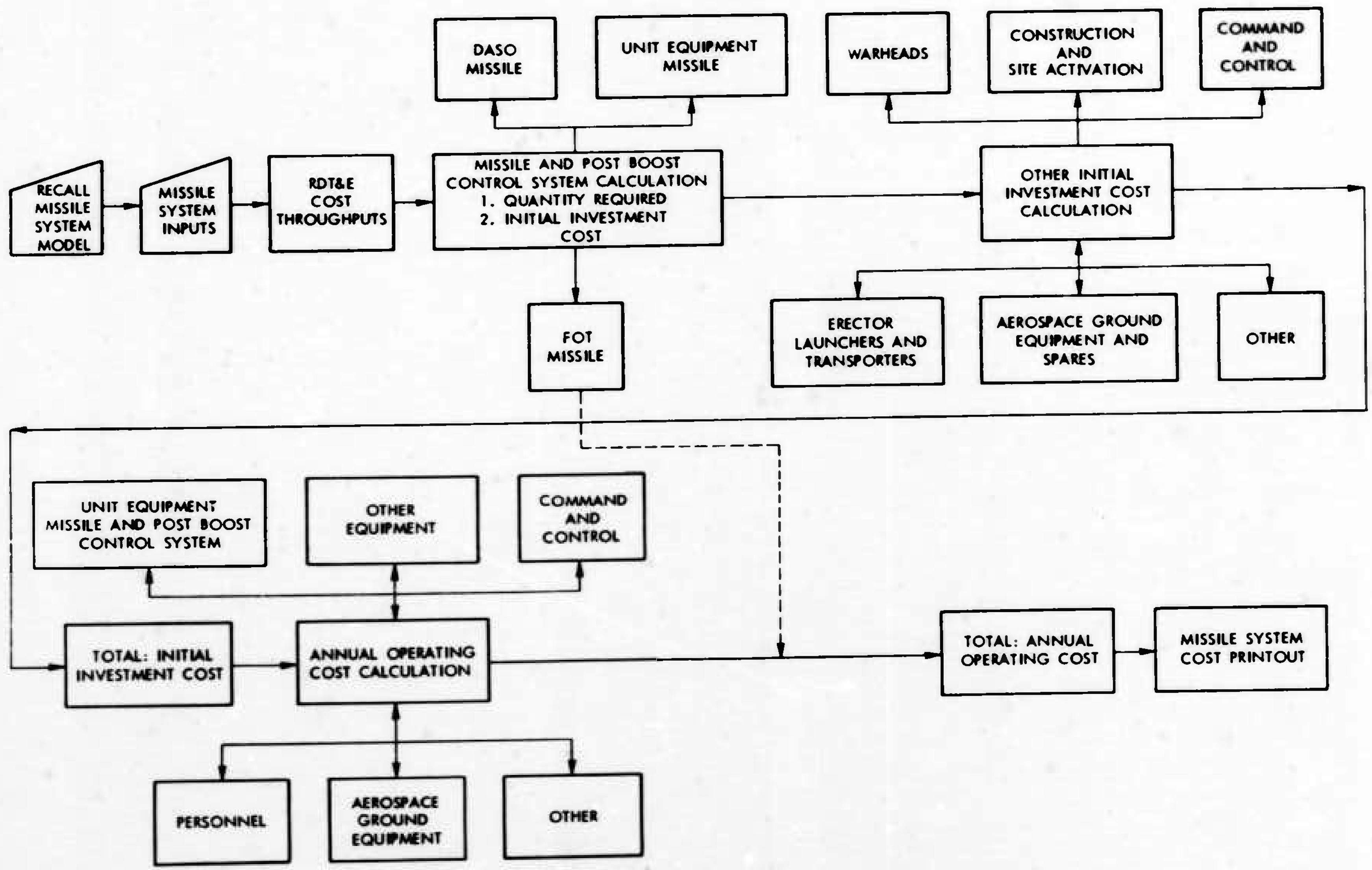

Fig. 2--Missile System Model

Table 3

MISSILE SYSTEM MODEL: JOSS INSTRUCTIONS

```
1.01 Page.
1.02 Type "type missile system number for x (three digits or less)".
1.03 Demand x.
1.04 Demand Y.
1.05 Demand S.
1.07 Demand R.
1.08 Do part 50 for i= 1(1)2.
1.09 Do part 51 for i=1(1)4.
1.10 Do part 52 for i=1(1)10.
1.11 Demand s(1).
1.12 Demand s(2).
1.13 Do part 53 for i=1(1)9.
1.14 To part 10.

10.1 Set q(1)= S•Q(1).
10.21 Set b(1)= log[L(1)/100]/log(2).
10.22 Set c(50)=p(1)•C(1)•p(1)*b(1) if p(1)>0.
10.23 Set c(50)=0 if p(1)=0.
10.31 Set f=D(1)+p(1).
10.32 Set c(1)=f•C(1)•f*b(1)-c(50).
10.41 Set q(2)=q(1)+f.
10.42 Set c(2)=q(2)•C(1)•q(2)*b(1)-c(1)-c(50).
10.51 Set q(3)=q(2)+F(1)•Y•S.
10.52 Set c(3)=q(3)•C(1)•q(3)*b(1)-[c(2)+c(1)+c(50)].
10.6 To part 11.

11.1 Set q(4)=S•Q(2).
11.2 Do part 54 for i=4(1)6 if q(4)=0.
11.31  To part 12 if q(4)=0.
11.32 Set b(2)=log[L(2)/100]/log(2).
11.33 Set c(51)=p(2)•C(2)•p(2)*b(2) if p(2)>0.
11.34 Set c(51)=0 if p(2)=0.
11.41 Set g=D(2)+p(2).
11.42 Set c(4)=g•C(2)•g*b(2)-c(51).
11.51 Set q(5)=g+q(4).
11.52 Set c(5)=q(5)•C(2)•q(5)*b(2)-c(4)-c(51).
11.61 Set q(6)=q(5)+F(2)•Y•S.
11.62 Set c(6)=q(6)•C(2)•q(6)*b(2)-[c(4)+c(5)+c(51)].
11.7 To part 12.

12.1 Set c(7)=C(3)•S•Q(3).
12.2 Set c(8)=C(8)•q(1).
12.3 Set c(9)=C(9)•S.
12.41 Set c(10)=s(1)•q(1)•[c(3)/(F(1)•Y•S)]•10*(-2) if F(1)>0.
12.42 Set c(10)=0 if F(1)=0.
12.51 Set c(11)=s(2)•q(4)•[c(6)/(F(2)•Y•S)]•10*(-2) if F(2)>0.
12.52 Set c(11)=0 if F(2)=0.
12.6 Set c(12)=C(4)•q(1).
```

Table 3--*continued*

```
12.7 Set c(13)=C(5)•q(1).
12.8 Set c(14)=C(6)•q(1).
12.90 Set c(15)=C(7)•q(1).
12.901 Set c(16)=C(10)•S.
12.91 Set I(1)=c(2)+c(5)+c(8)+c(9)+c(10)+c(11)+c(13)+c(16).
12.92 Set I(2)=sum[i=1(1)16:c(i)].
12.93 Set M=S•[P(1) +P(2)+P(3)+P(4)•(P(1)+P(2))/100].
12.94 To part 13.

13.1 Set a(1)=A(1)•I(1)•10*(-2).
13.2 Set a(2)=A(2)•c(2)•10*(-2).
13.3 Set a(3)=A(3)•c(5)•10*(-2).
13.4 Set a(4)=A(4)•[c(8)+c(9)]•10*(-2).
13.5 Set a(5)=A(5)•M•10*(-6).
13.6 Set a(6)=A(6)•M•10*(-6).
13.7 Set a(7)=A(7)•S.
13.8 Set a(8)=A(8)•c(13)•10*(-2).
13.81 Set a(9)=A(9)•c(16)•10*(-2).
13.82 Set a(10)=sum[i=1(1)9:a(i)•Y].
13.9 To part 20.

20.1 Page.
20.21 Type form 1.
20.22 Type _,_,_.
20.23 Type x in form 2.
20.24 Type _,_.
20.25 Type Y in form 3.
20.26 Type form 4.
20.27 Line.
20.28 Type R in form 5.
20.29 Type I(2) in form 6.
20.31 Type Y, a(10) in form 8.
20.32 Line.
20.33 Type R+I(2)+a(10) in form 9.
20.34 Type _,_,_.
20.35 Type S in form 10.
20.36 Type q(1) in form 11.
20.37 Type q(4) in form 12.
20.371 Type D(1) in form 15.
20.372 Type F(1)•S•Y in form 16.
20.373 Type s(1)•q(1)/100 in form 17.
20.374 Type q(6) + s(1)•q(1)/100 in form 14.
20.39 Type M in form 13.
20.391 Line.
20.392 Type sum[i=1(1)7:c(i)] in form 18.
20.393 Type sum[i=1(1)3:c(i)] in form 19.
20.394 Type sum[i=4(1)6:c(i)] in form 20.
20.395 Type c(7) in form 21.
20.4 To part 1.
```

Table 3--*continued*

50.1 Demand D(i).
50.2 Demand F(i).

51.1 Demand P(i).

52.1 Demand C(i).
52.2 Demand L(i) if i<3.
52.3 Demand Q(i) if i<4.
52.4 Demand p(i) if i<3.

53.1 Demand A(i).

54.1 Set c(i)=0.

Form 1:

MISSILE SYSTEMS MODEL

Form 2:

Missile System ___

Form 3:

___ Years System Costs

Form 4:

(millions of dollars)

Form 5:

RDT E = $______

Form 6:

Initial Inv. = $______

Form 8:

Annual Op. (__yrs) = $______

Form 9:

TOTAL = $______

Form 10:

Number of Squadrons ___

Form 11:

UE Missile Requirement ____

Form 12:

UE PBCS Requirement ____

Form 13:

Total Personnel Requirement ____

Table 3--*continued*

Form 14:

Total Missile Requirement ______

Form 15:

DASO Requirement ______

Form 16:

FOT (Total) Requirement ______

Form 17:

Initial Spare Missiles ______

Form 18:

Total Missile Procurement Cost $______ million

Form 19:

Missile (less PBCS) $______ million

Form 20:

PBCS $______ million

Form 21:

Warhead $______ million

Table 4

MISSILE SYSTEM MODEL: INPUT DOCUMENTATION LIST

Input Code	Input Value	Input Descriptors
Y =		Number of years
S =		Number of squadrons
R =	$	RDT&E cost (in millions)
D(1) =		DASO missiles (unit equipment)
F(1) =		FOT missiles (unit equipment) per squadron per year
D(2) =		DASO missiles (Post Boost Control System)
F(2) =		FOT missiles (Post Boost Control System) per squadron per year
P(1) =		Number of operating personnel per squadron
P(2) =		Number of maintenance personnel per squadron
P(3) =		Number of support personnel per squadron
P(4) =		Number of support personnel: % of operations and maintenance personnel
C(1) =	$	Unit equipment missile unit one cost (in millions)
L(1) =		Unit equipment missile cum avg learning slope (%)
Q(1) =		Number of unit equipment missiles per squadron
p(1) =		Number of unit equipment missiles previously procured
C(2) =	$	Post Boost Control System missile unit one cost (in millions)
L(2) =		Post Boost Control System missile cum avg learning slope (%)
Q(2) =		Number of Post Boost Control System missiles per squadron
p(2) =		Number of Post Boost Control System missiles previously procured
C(3) =	$	Warhead cost per warhead (in millions)
Q(3) =		Number of warheads per squadron
C(4) =	$	Military construction cost per unit equipment missile (in millions)
C(5) =	$	Aerospace ground equipment cost per unit equipment missile
C(6) =	$	Site activation cost per unit equipment missile
C(7) =	$	Other initial investment cost per unit equipment missile
C(8) =	$	Erector-launcher initial investment cost per unit equipment missile
C(9) =	$	Transporter initial investment cost per squadron

Table 4--*continued*

Input Code	Input Value	Input Descriptors
C(10) =	$	Command and control cost per squadron
s(1) =		Initial spares cost for unit equipment missile (% of initial unit equipment missile cost)
s(2) =		Initial spares cost for Post Boost Control System missile (% of initial Post Boost Control System missile cost)
A(1) =		Annual modification cost (% of initial equipment cost)
A(2) =		Annual unit equipment depot maintenance and replenishment spares cost (% of unit equipment missile cost)
A(3) =		Annual Post Boost Control System depot maintenance and base spares cost (% of initial Post Boost Control System cost)
A(4) =		Annual maintenance and replenishment spares (% of other equipment initial cost)
A(5) =	$	Annual pay and allowances per personnel
A(6) =	$	Other annual cost per personnel
A(7) =	$	Other annual cost per squadron (in millions)
A(8) =		Annual aerospace ground equipment maintenance and replenishment spares cost (% of initial aerospace ground equipment cost)
A(9) =		Annual command and control maintenance and replenishment spares cost (% of initial command and control cost)

V. GROUND-BASED DEFENSE SYSTEM MODEL

The ground-based defense system model was designed to estimate the costs of special ground systems such as command and control systems, radar sites, and ground-based ballistic-missile defense systems. The costs of the missiles used in the special ground systems were not included. Such costs were estimated through the use of the missile model described above. As a result, the calculation of the total cost implications of ground-based defense systems necessitates the use of both models. A flow diagram depicting the sequential steps in the ground system model is shown in Fig. 3. The JOSS instructions and input documentation list are given in Tables 5 and 6.

In this model, there are two different methods of treating radar subsystems. A capability has been provided to input and store in the program the resource parameters for radar subsystems that do not vary for the alternative system configurations whose costs are being estimated. By contrast, there is also the capability to estimate the cost of those radar subsystems that *do* vary; however, in this instance the resource parameters are not stored but must be furnished as inputs for each iteration. The intention here was to enable the model to deal with many different kinds of radars but to limit the input requirements to only those radars that change according to the system configuration.

In Table 5, the radar subsystems are dealt with from Part 31 on. Part 32 deals with the inputs for radars whose parameters will vary with system configuration, and Parts 41 on deal with the radars whose parameters will not vary and which, therefore, will be stored in the program.

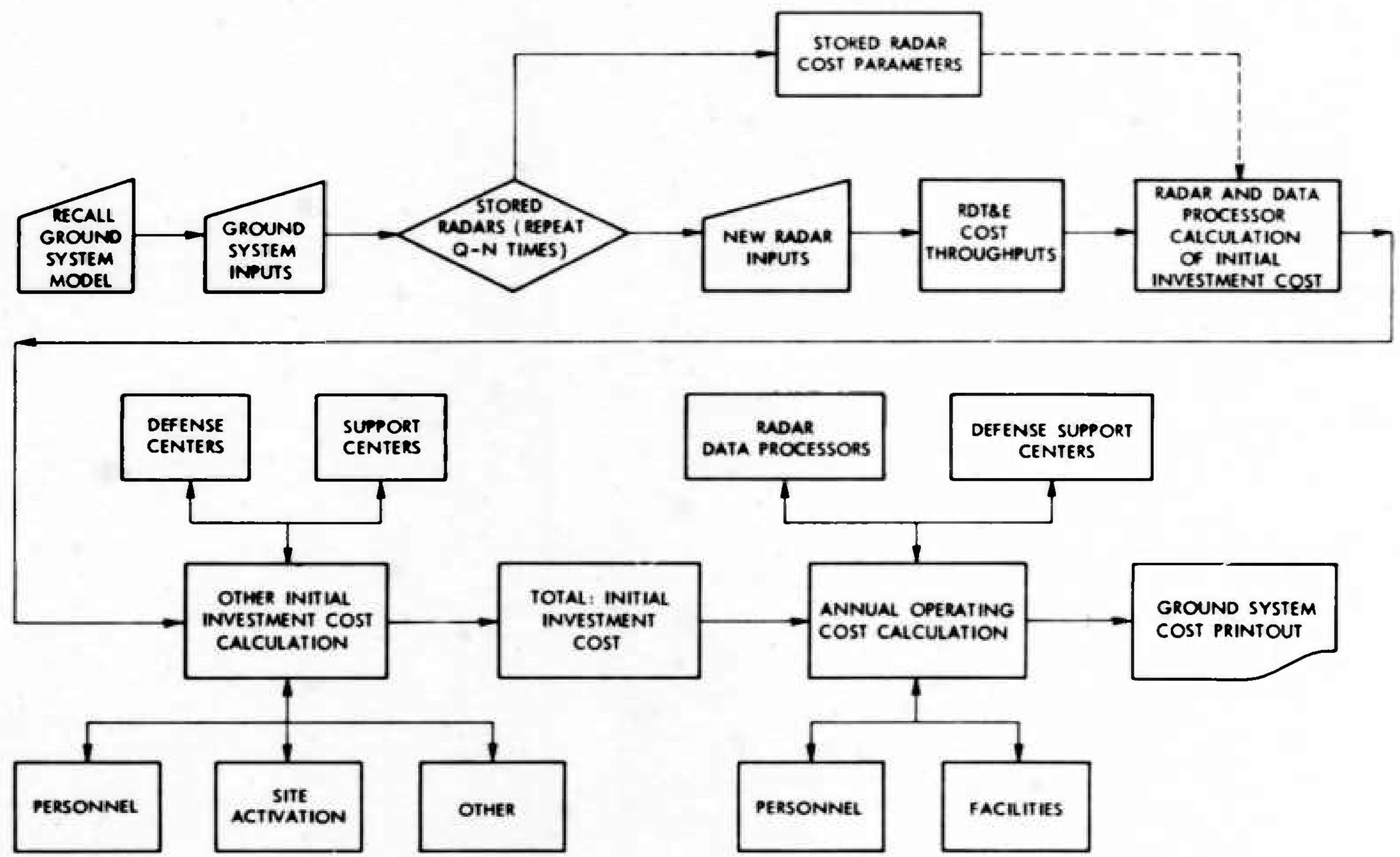

Fig. 3--Ground-based Defense System Model

Table 5

GROUND-BASED DEFENSE SYSTEM MODEL: JOSS INSTRUCTIONS

```
1.01 Type "Type Ground System Number for x (three digits)".
1.02 Demand x.
1.03 Demand Y.
1.04 Demand R.
1.051 Type "Defense Center Inputs".
1.0511 Set j=1.
1.052 Do part 30 for i=1(1)6.
1.0521 Set j=2.
1.061 Type "Non-defense Center Inputs".
1.062 Do part 30 for i=1(1)6.
1.071 Demand Q as "Number of different radars in system (Q)".
1.072 Demand N as "Number of radars not stored in program (N)".
1.081 Do part 31 for i=1(1)Q-N if (Q-N)>0.
1.082 To step 1.09 if N=0.
1.083 Do part 32 for i=Q if N=1.
1.084 Do part 32 for i=(Q-N+1)(1)Q if N>1.
1.09 To part 10.

10.11 Set I(1)=sum[i=1(1)Q:s(i)•C(i,1)•(s(i)*b)].
10.12 Set I(2)=sum[i=1(1)Q:s(i)•C(i,2)].
10.13 Set I(3)=sum[i=1(1)Q:d(i)•C(i,3)•(d(i)*b)].
10.14 Set I(4)=sum[i=1(1)Q:d(i)•C(i,4)].
10.15 Set I(5)=D(1,7)+D(2,7).
10.16 Set p(1)=sum[i=1(1)Q:s(i)•P(i,1)+d(i)•P(i,2)].
10.17 Set p(2)=D(1,1)•D(1,2)+D(2,1)•D(2,2).
10.18 Set p(3)=p(1)+p(2).
10.21 Set I(6)=1.35•I(1)+1.18•I(3)+1.1•[I(5)+I(2)+I(4)].
10.31 Set a=.03•[I(1)+I(3)]+.32•I(5)+.02•[I(2)+I(4)]+.015•p(3).
10.32 Set A=Y•a.
10.5 To part 20.

20.1 Page.
20.21 Type _,_,_.
20.22 Type form 1.
20.23 Type _,_.
20.24 Type X in form 2.
20.25 Type _,_.
20.31 Type Y in form 3.
20.32 Type form 4.
20.33 Type _,_.
20.41 Type R in form 5.
20.42 Type I(6) in form 6.
20.43 Type Y, A in form 7.
20.44 Line.
20.45 Type I(6)+A+R in form 8.
20.51 Type _,_,_.
20.52 Type form 9.
20.53 Do part 25 for i=1(1)Q.
20.54 Line.
```

Table 5--*continued*

```
20.55 Type I(1)+I(3)+D(1,1)•D(1,4)+D(2,1)•D(2,4) in form 11.
20.56 Type I(2)+I(4)+D(1,1)•D(1,3)+D(2,1)•D(2,3) in form 12.
20.57 Line.
20.61 Type p(3) in form 13.
20.7 Page.
20.8 To part 1.

25.1 Type n(i),s(i),s(i)•C(i,1)•(s(i)*b),d(i),d(i)•C(i,3)•(d(i)*b) in form 10.

30.08 To step 30.1 if i=1.
30.09 Done  if D(j,1)=0.
30.1 Demand D(j,i).
30.11 Set D(j,7)=0 if D(j,1)=0.
30.2 Set D(j,7)=D(j,1)•[D(j,3)+D(j,4)+D(j,6)]•[1+D(j,5)/100] if i=6.

31.1 Demand n(i).
31.2 Demand s(i).
31.3 Demand d(i).
31.4 Do part 40+n(i).

32.09 Set n(i)=99.
32.1 Demand s(i).
32.2 Demand d(i).
32.3 Demand C(i,1).
32.4 Demand C(i,2).
32.5 Demand C(i,3).
32.6 Demand C(i,4).
32.7 Demand P(i,1).
32.8 Demand P(i,2).

41.1 Set C(i,1)=116.
41.2 Set C(i,2)=45.
41.3 Set C(i,3)=32.
41.4 Set C(i,4)=0.
41.5 Set P(i,1)=95.
41.6 Set P(i,2)=18.

42.1 Set C(i,1)=141.
42.2 Set C(i,2)=64.
42.3 Set C(i,3)=44.
42.4 Set C(i,4)=0.
42.5 Set P(i,1)=138.
42.6 Set P(i,2)=18.

43.1 Set C(i,1)=211.
43.2 Set C(i,2)=102.
43.3 Set C(i,3)=44.
43.4 Set C(i,4)=0.
43.5 Set P(i,1)=208.
43.6 Set P(i,2)=18.
```

Table 5--*continued*

44.1 Set C(i,1)=78.
44.2 Set C(i,2)=23.
44.3 Set C(i,3)=31.
44.4 Set C(i,4)=3.4.
44.5 Set P(i,1)=60.
44.6 Set P(i,2)=18.

45.1 Set C(i,1)=35.
45.2 Set C(i,2)=15.4.
45.3 Set C(i,3)=18.2.
45.4 Set C(i,4)=0.
45.5 Set P(i,1)=60.
45.6 Set P(i,2)=0.

46.1 Set C(i,1)=45.
46.2 Set C(i,2)=9.3.
46.3 Set C(i,3)=18.2.
46.4 Set C(i,4)=3.4.
46.5 Set P(i,1)=83.
46.6 Set P(i,2)=18.

47.1 Set C(i,1)=21.
47.2 Set C(i,2)=5.4.
47.3 Set C(i,3)=12.4.
47.4 Set C(i,4)=0.
47.5 Set P(i,1)=20.
47.6 Set P(i,2)=10.

48.1 Set C(i,1)=78.
48.2 Set C(i,2)=30.
48.3 Set C(i,3)=38.3.
48.4 Set C(i,4)=3.4.
48.5 Set P(i,1)=138.
48.6 Set P(i,2)=18.

Form 1:

GSMOD

Form 2:

__ Years System Costs

Form 3:

__ years System Costs

Form 4:

(millions of dollars)

Form 5:

RDT E $ ____

Table 5--*continued*

Form 6:

Initial Investment $ ____

Form 7:

Annual Op. (__ yrs) $ ____

Form 8:

TOTAL $ ____

Form 9:

Radar	Radar Qty	Radar Cost	DP Qty	DP Cost

Form 10:

__	__	$ ____	__	$ ____

Form 11:

Total Hardware Cost $ ____

Form 12:

Total Facilities Cost $ ____

Form 13:

Total Personnel ____

b: log(.95)/log(2)

D(0,0) = 0

D is sparse

Table 6

GROUND-BASED DEFENSE SYSTEM MODEL: INPUT DOCUMENTATION LIST

	Input Code	Input Value	Input Descriptors
	X =		Ground system number (three digits)
	Y =		Number of years
	R =	$	RDT&E cost (in millions)
	D(1,1) =		Number of defense centers
	D(1,2) =		Personnel per defense center
	D(1,3) =	$	Construction/facilities cost per defense center (in millions)
	D(1,4) =	$	Command and control cost per defense center (in millions)
	D(1,5) =		System integration cost (% of construction and equipment cost)
	D(1,6) =	$	Other cost per defense center (in millions)
	D(2,1) =		Number of support centers
	D(2,2) =		Personnel per support center
	D(2,3) =	$	Construction/facilities cost per support center (in millions)
	D(2,4) =	$	Command and control cost per support center (in millions)
	D(2,5) =		System integration cost (% of construction and equipment cost)
	D(2,6) =	$	Other cost per support center (in millions)
	Q =		Number of different radars in system
	N =		Number of radars whose cost parameters are not stored in program
Stored Radars (Repeat Q-N Times)	n(i) =		Radar system number as stored in program
	s(i) =		Quantity of radar n(i) in system
	d(i) =		Quantity of data processors related to radar n(i) in system
New Radar Inputs (Repeat N-Times)	s(i) =		Quantity of radar "i" in ground system
	d(i) =		Quantity of data processors related to radar "i" in system
	C(i,1) =	$	Unit one cost for radar "i" (in millions)
	C(i,2) =	$	Construction cost per radar "i" (in millions)
	C(i,3) =	$	Unit one cost for data processor (in millions)
	C(i,4) =	$	Construction cost per data processor (in millions)
	P(i,1) =		Personnel per radar "i"
	P(i,2) =		Personnel per data processor

VI. SHIP SYSTEM MODEL

The ship system model was designed to estimate the costs of ship-based offensive or defensive systems, *including* the missiles involved. The flow diagram for this model is shown in Fig. 4 and the JOSS instructions and input documentation list in Tables 7 and 8.

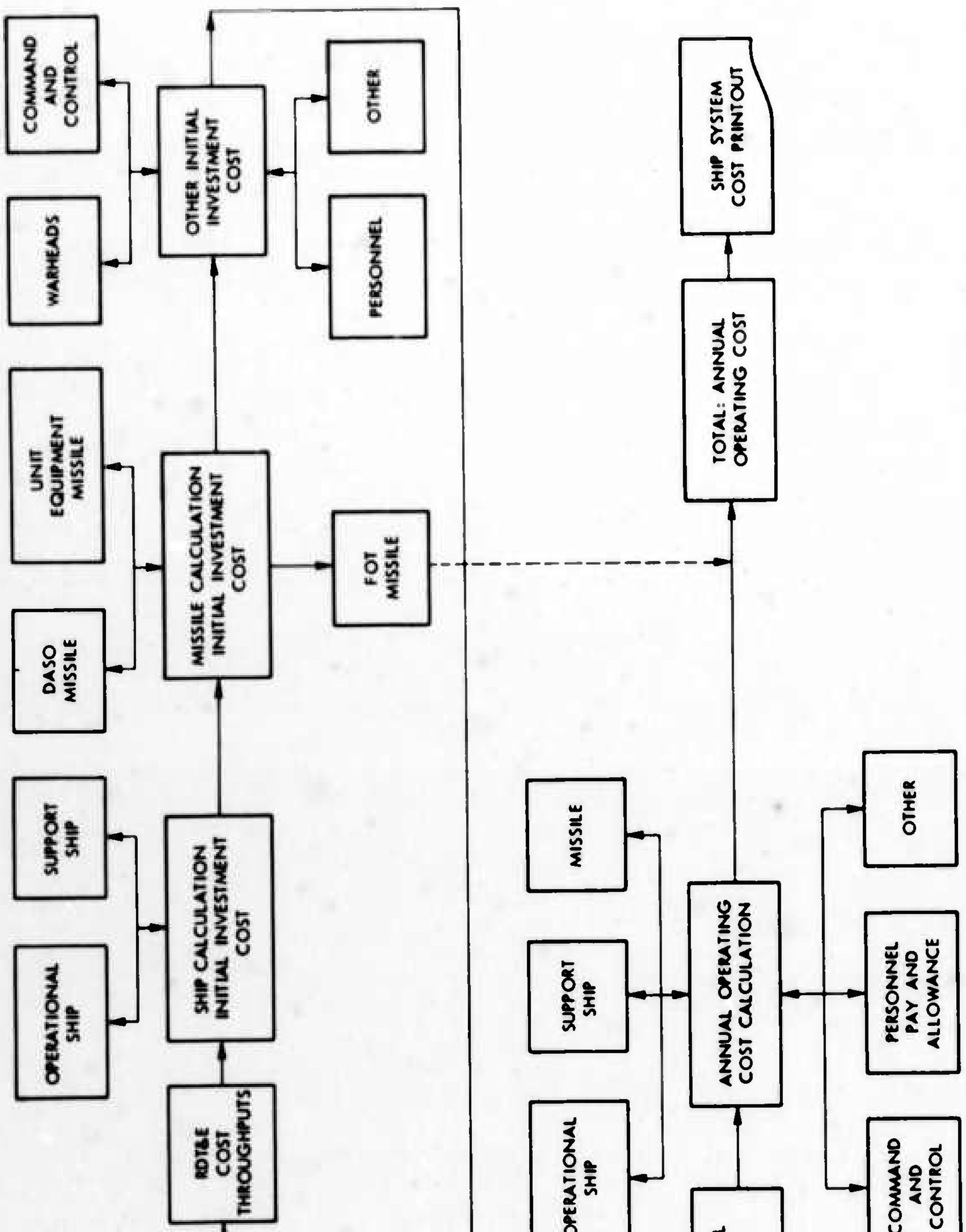

Fig. 4--Ship System Model

Table 7

SHIP SYSTEM MODEL: JOSS INSTRUCTIONS

```
1.01 Page.
1.02 Type form 1.
1.03 Demand x as "Ship system number...three digits (x)".
1.04 Demand Y.
1.05 Demand S(1).
1.06 Demand S(2).
1.07 Demand M(1).
1.08 Demand M(2).
1.09 Demand M(3).
1.10 Demand P.
1.11 Demand R.
1.12 Do part 20 for i=1(1)10.
1.13 Do part 21 for i=1(1)10.
1.14 To part 10.

10.01 Set c(1)=S(1)•C(1).
10.02 Set c(2)=S(1)•C(2).
10.03 Set c(3)=S(1)•C(3).
10.04 Set c(4)=C(4).
10.10 Set c(5)=M(2)•C(5)•[M(2)*b] if M(2)>0.
10.11 Set c(5)=0 if M(2)=0.
10.12 Set q(1)=M(2)+M(1)•S(1).
10.13 Set c(6)=q(1)•C(5)•[q(1)*b]-c(5).
10.14 Set q(2)=q(1)+M(3)•S(1)•Y.
10.15 Set c(7)=q(2)•C(5)•[q(2)*b]-c(6)-c(5).
10.21 Set c(8)=C(6)•S(1)•P•10*(-6).
10.22 Set c(9)=C(7)•Q•M(1)•S(1).
10.23 Set c(10)=C(8)•M(1)•S(1)•10*(-6).
10.24 Set c(11)=C(9)•[c(1)+c(2)]•10*(-2).
10.25 Set c(12)=C(10)•c(5)•10*(-2).
10.30 Set a(1)=A(1)•c(1)•10*(-2).
10.31 Set a(2)=A(2)•c(6)•10*(-2).
10.32 Set a(3)=A(3)•c(1)•10*(-2).
10.33 Set a(4)=A(4)•c(2)•10*(-2).
10.34 Set a(5)=A(5)•c(6)•10*(-2).
10.35 Set a(6)=A(6)•S(2).
10.36 Set a(7)=A(7)•S(1).
10.37 Set a(8)=A(8)•M(1)•S(1)•10*(-6).
10.38 Set a(9)=A(9)•P•S(1)•10*(-6).
10.39 Set a(10)=A(10)•P•S(1)•10*(-6).
10.40 Set I=sum[i=1(1)12:c(i)].
10.41 Set r=sum[i=1(1)10:a(i)].
10.5 To part 11.

11.1 Page.
11.2 Type form 1.
11.31 Line.
11.32 Type x in form 2.
11.33 Line.
```

Table 7--*continued*

11.34 Type T in form 3.
11.35 Type form 4.
11.36 Type _,_,_.
11.37 Type R in form 5.
11.38 Type I in form 6.
11.39 Type Y,r·Y in form 7.
11.40 Line.
11.401 Type I+R+r·Y in form 8.
11.41 Type _,_,_,_.
11.42 Type S(1),c(1) in form 9.
11.43 Type M(1)·S(1),c(6) in form 10.
11.44 Type Q·M(1)·S(1), C(7)·Q·M(1)·S(1) in form 11 if Q>0.
11.45 Type P·S(1) in form 12.
11.46 Type S(2) in form 13.
11.47 Page.
11.48 To part 1.

20.1 Demand C(i).
20.2 Demand L if i=5.
20.3 Demand Q if i=7.

21.1 Demand A(i).

Form 1:
SHIP SYSTEM MODEL

Form 2:
Ship System No. ___

Form 3:
__ years system costs

Form 4:
(millions of dollars)

Form 5:
RDT E $_____.

Form 6:
Initial Inv. $_____

Form 7:
Annual Op. (__yrs) $_____

Form 8:
TOTAL $_____

Form 9:
Total ships proc. _____ Ship proc. cost $_____ (millions)

Table 7--*continued*

Form 10:
Total UE missile proc. _____ Missile proc. cost $_____ (millions)

Form 11:
Total warhead proc. _____ Warhead proc. cost $_____ (millions)

Form 12:
Total personnel ______

Form 13:
Total support ships _____

b: [log(L/100)/log(2)]

Table 8

SHIP SYSTEM MODEL: INPUT DOCUMENTATION LIST

Input Code	Input Value	Input Descriptors
Y =		Number of years
S(1) =		Number of operational ships
S(2) =		Number of support ships
M(1) =		Number of unit equipment missiles per operational ship
M(2) =		Number of DASO missiles
M(3) =		Number of FOT missiles per operational ship per year
P =		Number of personnel per operational ship
R =	$	RDT&E cost (in millions)
C(1) =	$	Initial investment cost per operational ship (in millions)
C(2) =	$	Command and control cost per operational ship (in millions)
C(3) =	$	Other initial investment cost per operational ship (in millions)
C(4) =	$	Initial investment cost for support ship (in millions)
C(5) =	$	Missile unit one cost (in millions)
L =		Missile cum avg learning slope (%)
C(6) =	$	Initial personnel cost per personnel ($)
C(7) =	$	Initial investment cost per warhead (in millions)
Q =		Warheads per missile
C(8) =	$	Other initial investment cost per missile ($)
C(9) =		Initial ship spares (% of operational ship and command and control initial investment cost)
C(10) =		Initial missile spares (% of unit equipment missile initial investment cost)
A(1) =		Annual ship modification cost (% of operational ship initial investment cost)
A(2) =		Annual missile modification cost (% of unit equipment missile initial investment cost)
A(3) =		Annual operational ship operations and maintenance cost (% of operational ship initial investment cost)
A(4) =		Annual command and control operations and maintenance cost (% of command and control initial investment cost)
A(5) =		Annual unit equipment missile operations and maintenance cost (% of unit equipment missile initial investment cost)
A(6) =	$	Annual support ship cost (in millions)
A(7) =	$	Other annual cost per operational ship (in millions)
A(8) =	$	Other unit equipment missile cost per unit equipment missile ($)
A(9) =	$	Annual pay and allowance per personnel ($)
A(10) =	$	Other annual personnel cost per personnel ($)

VII. SPACE SYSTEM MODEL

The space system model was designed to provide a capability for estimating the costs of systems based outside the earth's atmosphere. Two kinds of operational modes were envisioned (as in the case of the aircraft system model), essentially representing

1. A mode where the system is in continuous orbit and fulfilling its peacetime mission as, e.g., a communications satellite; and
2. A mode where the satellite is held in readiness, either on a launch pad or in a silo, and is not launched except in times of war or crisis. Because the costing methodology is concerned only with peacetime conditions, it is assumed that satellites in this mode are not launched.

The number of satellites and boosters required for Mode 1 is calculated in the model as a function of the number of orbiting satellites, the number of satellites per booster, the mean time to failure, and the estimated reliability of the booster. For Mode 2, the number of satellites and boosters is an input into the model. The flow diagram for the space model is shown in Fig. 5 and the JOSS instructions and input documentation list in Tables 9 and 10.

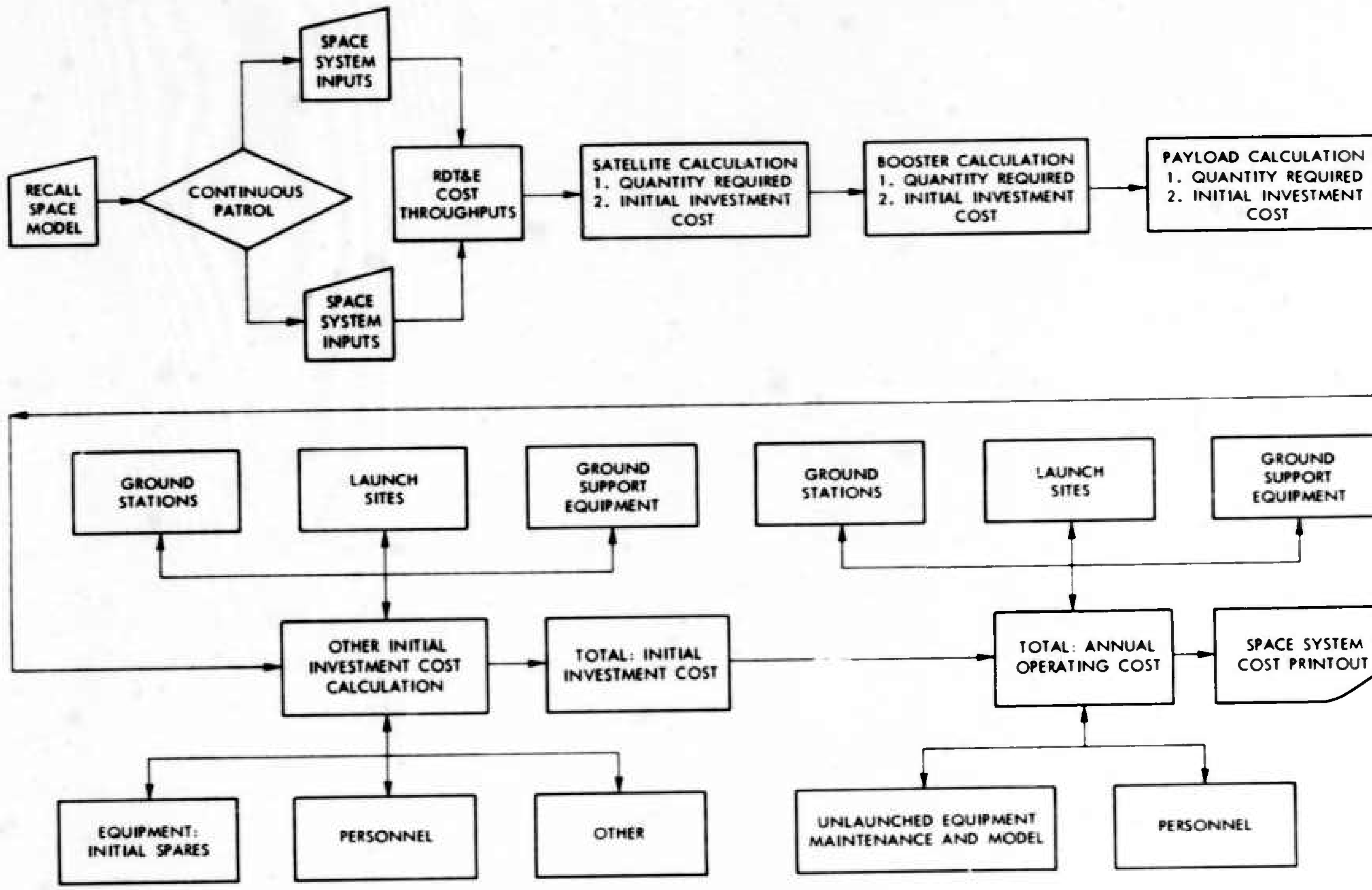

Fig. 5--Space System Model

Table 9

SPACE SYSTEM MODEL: JOSS INSTRUCTIONS

```
1.01 Page.
1.02 Type form 1.
1.03 Type "Type space system number for x (three digits)".
1.04 Demand x.
1.05 Type "For continuous patrol, type z=1; for launch during crisis".
1.06 Type "     type z=0.".
1.07 Demand z.
1.08 Demand Y.
1.10 Do part 48 for i=1(1)4.
1.11 Demand P(1).
1.12 Demand P(2).
1.13 To step 1.17 if z=1.
1.14 Demand N.
1.15 Demand S.
1.16 To step 1.20 if z=0.
1.17 Demand U.
1.18 Demand M.
1.19 Demand r.
1.20 Demand R.
1.21 Do part 51 for i=1(1)12.
1.22 Do part 53 for i=1(1)9.
1.23 To part 10.

10.001 To step 10.06 if z=1.
10.01 Set n(4)=S.
10.02 Set q(1)=S•N•n(1).
10.03 Set q(2)=S•N.
10.04 Set q(3)=S•N•n(2).
10.05 To step 10.10.
10.06 Set q(1)=(Y•U•100)/(M•r).
10.07 Set q(2)=ip[(q(1)/n(1))+.5].
10.08 Set q(3)=ip[(n(2)/n(1))•q(1)+.5].
10.10 Set c(1)=q(1)•C(1)•[q(1)*b(1)].
10.21 Set c(2)=q(2)•C(2)•[q(2)*b(2)]  if Q(2)=0.
10.22 Set h=q(2)+Q(2) if Q(2)>0.
10.23 Set c(2)=h•C(2)•[h*b(2)]-Q(2)•C(2)•[Q(2)*b(2)] if Q(2)>0.
10.31 Set c(3)=q(3)•C(3)•[q(3)*b(3)] if q(3)>0.
10.32 Set c(3)=0 if q(3)=0.
10.40 Set c(4)=C(4)•n(3).
10.41 Set c(5)=C(5)•n(4).
10.42 Set c(6)=C(6)•n(3).
10.43 Set c(7)=C(7)•n(4).
10.51 Set c(8)=[C(8)•c(1)]/100.
10.52 Set c(9)=[C(9)•c(2)]/100.
10.53 Set c(10)=[C(10)•c(3)]/100.
10.61 Set c(11)=C(11)•sum[i=4(1)7:c(i)/100].
10.62 Set c(12)=C(12)•[P(1)•n(3)+P(2)•n(4)]•10*(-6).
10.71 Set a(1)=A(1)•n(3).
10.72 Set a(2)=A(2)•n(4).
```

Table 9--*continued*

```
10.73 Set a(3)=A(3)•[c(1)+c(2)+c(3)]/100.
10.74 Set a(4)=A(4)•c(1)/100.
10.75 Set a(5)=A(5)•c(2)/100.
10.76 Set a(6)=A(6)•c(3)/100.
10.80 Set a(7)=A(7)•[c(6)+c(7)]•10*(-2).
10.81 Set a(8)=A(8)•[P(1)•n(3)+P(2)•n(4)]•10*(-6).
10.82 Set a(9)=A(9)•[P(1)•n(3)+P(2)•n(4)]•10*(-6).
10.9 To part 20.

20.01 Page.
20.02 Type form 1.
20.03 Type _,_,_.
20.04 Type x in form 2.
20.05 Type form z+30.
20.06 Line.
20.07 Type Y in form 3.
20.08 Type form 98.
20.09 Type _,_,_.
20.091 To step 20.30 if z=0.
20.20 Type form 4.
20.21 Line.
20.22 Type R in form 5.
20.231 Type sum[i=8(1)10:c(i)] in form 11.
20.232 Type sum[i=4(1)7:c(i)] in form 6.
20.235 Type c(11) + c(12) in form 7.
20.2351 Line.
20.236 Type sum[i=4(1)12:c(i)] + R in form 8.
20.237 Line.
20.241 Type Y in form 9.
20.242 Line.
20.243 Type sum[i=1(1)3:c(i)] in form 10.
20.244 Type sum[i=3(1)6:a(i)•Y] in form 14.
20.245 Type Y•[a(1)+a(2)+a(7)] in form 13.
20.246 Type Y•[a(8)+a(9)] in form 12.
20.2461 Line.
20.247 Type sum[i=1(1)3:c(i)] + sum[i=1(1)9:a(i)•Y] in form 8.
20.248 Line.
20.29 To step 20.41.
20.30 Type form 4.
20.31 Line.
20.32 Type R in form 5.
20.331 Type sum[i=1(1)3:c(i)] in form 10.
20.332 Type sum[i=8(1)10:c(i)] in form 11.
20.333 Type sum[i=4(1)7:c(i)] in form 6.
20.336 Type c(11) + c(12) in form 7.
20.3361 Line.
20.337 Type sum[i=1(1)12:c(i)]+R in form 8.
20.341 Type _,_,_.
20.342 Type Y in form 9.
20.343 Line.
20.344 Type sum[i=3(1)6:a(i)•Y] in form 14.
```

Table 9--*continued*

```
20.345 Type Y·[a(1)+a(2)+a(7)] in form 13.
20.346 Type Y·[a(8)+a(9)] in form 12.
20.347 Line.
20.348 Type sum[i=1(1)9:a(i)·Y] in form 8.
20.349 Line.
20.41 Type sum[i=1(1)12:c(i)] + sum[i=1(1)9:a(i)·Y] +R in form 15.
20.51 Type _,_.
20.52 Type U in form 20 if z=1.
20.53 Type S,N,n(1) in form 21 if z=0.
20.531 Line.
20.54 Type Y in form 16.
20.55 Type q(1), q(2), q(3) in form 17.
20.56 Line.
20.57 Type P(1)·n(3) + P(2)·n(4) in form 18.
20.58 Type P(2)·n(4), P(1)·n(3) in form 19.
20.6 To part 1.

46.1 Done if i=4 and z=0.
48.2 Demand n(i).

51.1 Demand C(i).
51.2 Demand L(i) if i≤3.
51.3 Demand Q(i) if i=2.

53.1 Demand A(i).
```

Form 1:

SPACE MODEL

Form 2:

Space System ___

Form 3:

___ Years System Costs

Form 4:

Non-recurring costs

Form 5:

RDT E $_____

Form 6:

Ground Equipment $_____

Form 7:

Other $_____

Form 8:

Subtotal $_____

Table 9--*continued*

Form 9:

Recurring costs (__ yrs)

Form 10:

Hardware $____

Form 11:

Hardware Spares $____

Form 12:

Personnel $____

Form 13:

Ground Eq. Maint./Mod. $____

Form 14:

Hardware Maint./Mod. $____

Form 15:

TOTAL $____

Form 16:

__ Years Hardware Quantity

Form 17:

Satellites ____ Boosters ____ Payloads ____

Form 18:

Total personnel _____

Form 19:

Launch Site Personnel _____ Ground Station Personnel _____

Form 20:

____ Satellites on Continuous Patrol

Form 21:

Ground Alert Sqns. ___ Boosters/Sqn. ___ Satellites/Booster ___

Form 30:

Ground Alert

Form 31:

Continuous Patrol

Form 98:

(millions of dollars)

b(i): log(L(i)/100)/log(2)

Table 10

SPACE SYSTEM MODEL: INPUT DOCUMENTATION LIST

	Input Code	Input Value	Input Descriptors
	x =		Space system number (three digits)
	z =		1: Continuous patrol 0: Ground alert
	Y =		Number of years
	n(1) =		Number of satellites per booster
	n(2) =		Number of payloads per booster
	n(3) =		Number of ground stations in system
	n(4) =		Number of launch sites in system (for ground alert, program sets this variable equal to number of squadrons)
	P(1) =		Number of personnel per ground station
	P(2) =		Number of personnel per launch site
Ground Alert	N =		Boosters per squadrons
Ground Alert	S =		Number of squadrons
Continuous Patrol	U =		Number of satellites on continuous patrol
Continuous Patrol	M =		Mean time until failure for satellite (number of years)
Continuous Patrol	r =		Booster reliability (% probability of success per launch)
	R =	$	RDT&E (in millions)
	C(1) =	$	Satellite unit one cost (in millions)
	L(1) =		Satellite cum avg learning slope (%)
	C(2) =	$	Booster unit one cost (in millions)
	L(2) =		Booster cum avg learning slope (%)
	Q(2) =		Previous booster quantity procured
	C(3) =	$	Payload unit one cost (in millions)
	L(3) =		Payload cum avg learning slope (%)
	C(4) =	$	Initial facilities investment cost per ground station (in millions)
	C(5) =	$	Initial facilities investment cost per launch site (in millions)
	C(6) =	$	Ground support equipment investment cost per ground station (in millions)
	C(7) =	$	Ground support equipment investment cost per launch site (in millions)

Table 10--*continued*

Input Code	Input Value	Input Descriptors
C(8) =		Initial satellite spares (% of *total* satellite procurement cost)
C(9) =		Initial booster spares (% of *total* booster procurement cost)
C(10) =		Initial payload spares (% of *total* payload procurement cost)
C(11) =		Initial ground equipment spares (% of initial ground equipment cost)
C(12) =	$	Initial personnel cost per personnel
A(1) =	$	Annual facilities maintenance cost per ground station (in millions)
A(2) =	$	Annual facilities maintenance cost per launch site (in millions)
A(3) =		Annual unlaunched hardware modification cost (% of *total* hardware procurement cost)
A(4) =		Annual unlaunched satellite depot maintenance and replenishment spares cost (% of *total* satellite procurement cost)
A(5) =		Annual unlaunched booster depot maintenance and replenishment spares cost (% of *total* booster procurement cost)
A(6) =		Annual unlaunched payload depot maintenance and replenishment spares cost (% of *total* payload procurement cost)
A(7) =		Annual ground support equipment maintenance and replenishment spares cost (% of ground support equipment initial investment cost)
A(8) =	$	Annual pay and allowance per personnel
A(9) =	$	Other annual cost per personnel

VIII. FORCE STRUCTURE COST-ESTIMATING MODEL

The models discussed previously present only static costs in terms of RDT&E, initial investment, and the sum of a number of years of operating costs. Some situations, however, require an analysis of the time-phased impact of these costs. For example, one such situation is found in a war game, where there is a constant interrelationship between the force structure decisions of one side and the responses of the opposing side. The players are given an inventory of existing forces at their disposal and the cost implication of these forces, together constituting what is usually referred to as a "base case." The forces are extrapolated over a period of time (perhaps 10 or 15 years into the future) under what is termed the "spendout assumption," which implies that no new decisions will be made with respect to the forces assumed to be in the inventory at the beginning of the exercise. The players then have the task of varying the base case by introducing new capabilities and, if desired, phasing out existing capabilities, subject, of course, to the technological and time restraints imposed by the new capabilities. In such exercises, there is usually some year-by-year budgetary constraint that limits the choices open to the participants.

The force structure model meets the need for time-phased costs. It records and presents the year-by-year cost implications of the base case, lists the year-by-year impact of any phase-out decisions, time phases the choices made with respect to new weapon systems and their phase-in schedules, and, finally, presents the total year-by-year cost of each force structure variation considered. These variations may then be compared with the base case force and with each other, in any useful manner either during the game or in critiquing after the game. Figure 6 shows the flow diagram of the force model and Tables 11 and 12 the JOSS instructions and input documentation list.

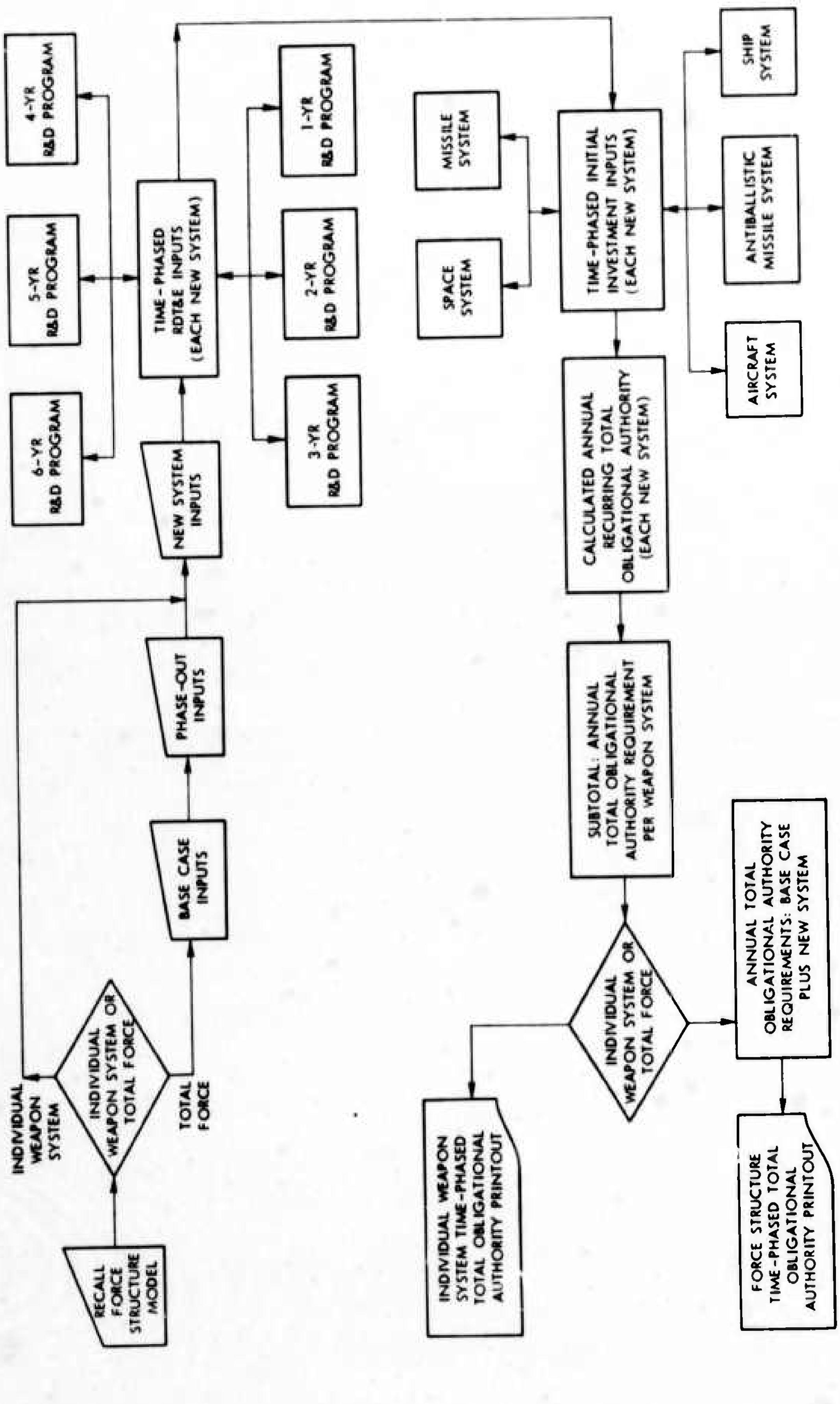

Fig. 6--Force Structure Cost-estimating Model

Table 11

FORCE STRUCTURE COST-ESTIMATING MODEL: JOSS INSTRUCTIONS

```
1.01 Type "For total force structure (including base case) time phasing,".
1.02 Type "  type J=1; for individual weapon system time phasing, J=2".
1.03 Demand J.
1.04 Type "For detailed output, type M=0; for summary output, M=1".
1.05 Demand M.
1.06 To part 3 if J=2.
1.1 Type "Base Case Inputs".
1.2 Do part 9 for j=-7(1)4.
1.3 Type "Type 1 for a if there are phase-outs; otherwise 0".
1.31 Demand a.
1.4 Type "Phase-out inputs" if a=1.
1.5 Do part 8 for j=-7(1)4.
1.6 To part 2.

2.1 Type "New Systems Inputs".
2.2 Demand n.
2.3 Do part 10 for i=1(1)n.
2.4 To part 20.

3.2 Delete part 20, part 23, part 24, part 25, part 28.
3.3 Recall item 15 (tpmod).
3.4 To part 2.

8.1 Set P(j)=0.
8.2 Demand P(j) if a=1.

9.1 Demand B(j).

10.10 Demand W(i).
10.11 Demand V(i).
10.12 Demand I(i).
10.13 Demand D(i).
10.131 Demand u(i).
10.14 Demand Y(i).
10.15 Demand R(i).
10.16 Demand O(i).
10.17 Do part 29 for j=-7(1)D(i).
10.18 Do part 30 for j=D(i)(1)4.

11.1 Set Z(i,1)=R(i).

12.1 Set Z(i,1)=.50·R(i).
12.2 Set Z(i,2)=.50·R(i).

13.1 Set Z(i,1)=.25·R(i).
13.2 Set Z(i,2)=.50·R(i).
13.3 Set Z(i,3)=.25·R(i).
```

Table 11--*continued*

```
14.1 Set Z(i,1)=.10•R(i).
14.2 Set Z(i,2)=.35•R(i).
14.3 Set Z(i,3)=.40•R(i).
14.4 Set Z(i,4)=.15•R(i).

15.1 Set Z(i,1)=.05•R(i).
15.2 Set Z(i,2)=.20•R(i).
15.3 Set Z(i,3)=.40•R(i).
15.4 Set Z(i,4)=.25•R(i).
15.5 Set Z(i,5)=.10•R(i).

16.1 Set Z(i,1)=.05•R(i).
16.2 Set Z(i,2)=.15•R(i).
16.3 Set Z(i,3)=.20•R(i).
16.4 Set Z(i,4)=.35•R(i).
16.5 Set Z(i,5)=.20•R(i).
16.6 Set Z(i,6)=.05•R(i).

20.00 Page.
20.10 To step 20.21 if M=1.
20.101 Type _,_,_,_,_,_,_,_,_,_.
20.11 Type form 50.
20.13 Type form 51.
20.14 Type form 52.
20.15 Line.
20.16 Type form 3.
20.17 Type form 4.
20.18 Line.
20.19 Do part 23 for j=-7(1)4.
20.201 Page.
20.21 Type form 1.
20.22 Type _,_.
20.23 Type form 2.
20.24 Line.
20.25 Type form 3.
20.26 Type form 4.
20.27 Line.
20.28 Do part 22 for i=1(1)n.
20.281 To step 20.341 if M=1.
20.29 Type _,_.
20.30 Type form 5.
20.301 Type form 97.
20.31 Line.
20.32 Type form 3.
20.33 Type form 4.
20.34 Line.
20.341 Do part 54 for j=-7(1)4.
20.342 Do part 51 for i=1(1)n.
20.[illegible]0 To step 20.358 if M=1.
20.[illegible] Type _,_,_.
20.[illegible]2 Type form 7.
```

Table 11--*continued*

```
20.353 Type form 97.
20.354 Line.
20.355 Type form 3.
20.356 Type form 4.
20.357 Line.
20.358 Do part 53 for i=1(1)n.
20.359 To step 20.42 if M=1.
20.36 Page.
20.37 Type form 6.
20.371 Type form 97.
20.38 Line.
20.39 Type form 3.
20.40 Type form 4.
20.41 Line.
20.42 Do part 52 for i=1(1)n.
20.50 Type _,_,_.
20.51 Type form 8.
20.52 Type form 97.
20.53 Line.
20.54 Type form 3.
20.541 Type form 4.
20.55 Line.
20.58 Do part 27 for i=1(1)n.
20.59 Type _,_.
20.60 Type form 53.
20.61 Type form 52.
20.62 Line.
20.63 Type form 3.
20.64 Type form 4.
20.65 Line.
20.651 Do part 23 for j=-7(1)4.
20.652 Line.
20.66 Do part 24 for j=-7(1)4.
20.661 Do part 31 for j=-7(1)4.
20.67 Do part 25 for i=-7(1)4.
20.87 Line.
20.88 Do part 95.
20.89 Type a,b,c,d,e,f,g,h,k,l,m,p in form 96.
20.90 Page.
20.91 To part 2.

22.09 Do part Y(i)+10.
22.1 Do part 26 for j=-7(1)4.
22.2 Do part 95.
22.3 Type W(i),V(i),Y(i),a,b,c,d,e,f,g,h,k,l,m,p in form 18.

23.1 Set y(j)=B(j).
23.2 Do part 95 if j=4.
23.3 Type a,b,c,d,e,f,g,h,k,l,m,p in form 98 if j=4.
```

Table 11--*continued*

```
24.1 Set y(j)=C(j)/1000.
24.2 Do part 95 if j=4.
24.3 Type a,b,c,d,e,f,g,h,k,l,m,p in form 95 if j=4.

25.1 Set E(i)=B(i)+C(i)/1000-F(i).
25.2 Set y(i)=E(i).

26.1 Set y(j)=S(i,j).

27.1 Do part 28 for j=-7(1)4.

28.1 Set y(j)=s(i,j).
28.2 Set E(j)=sum[U=1(1)i:s(U,j)].
28.3 Done if j<4.
28.4 Do part 95.
28.5 Type W(i),V(i),Y(i),a,b,c,d,e,f,g,h,k,l,m,p in form 18.
28.60 Set a=E(-7).
28.61 Set b=E(-6).
28.62 Set c=E(-5).
28.63 Set d=E(-4).
28.64 Set e=E(-3).
28.7 Type a,b,c,d,e,E(-2),E(-1),E(0),E(1),E(2),E(3),E(4) in form 93.
28.8 Line.

29.1 Set S(i,j)=0.

30.1 Demand S(i,j).

31.1 Set y(j)=P(j).
31.2 Do part 95 if j=4.
31.3 Type a,b,c,d,e,f,g,h,k,l,m,p in form 94 if j=4.

51.12 Set c=Z(i,3) if Y(i)>2.
51.13 Set d=Z(i,4) if Y(i)>3.
51.14 Set e=Z(i,5) if Y(i)>4.
51.15 Set f=Z(i,6) if Y(i)>5.
51.16 Do part 90 for j=1(1)Y(i).
51.161 Done if M=1.
51.17 Type W(i),V(i),Y(i),Z(i,1) in form 24+D(i) if Y(i)=1.
51.18 Type W(i),V(i),Y(i),Z(i,1),Z(i,2) in form 23+D(i) if Y(i)=2.
51.19 Type W(i),V(i),Y(i),Z(i,1),Z(i,2),c in form 22+D(i) if Y(i)=3.
51.20 Type W(i),V(i),Y(i),Z(i,1),Z(i,2),c,d in form 21+D(i) if Y(i)=4.
51.21 Type W(i),V(i),Y(i),Z(i,1),Z(i,2),c,d,e in form 20+D(i) if Y(i)=5.
51.22 Type W(i),V(i),Y(i),Z(i,1),Z(i,2),c,d,e,f in form 19+D(i) if Y(i)=6.

52.1 Set S(i,-8)=0.
52.12 Set z=ip[W(i)/100].
52.2 Do part 55 for j=-7(1)4.
52.21 Done if M=1.
52.3 Do part 95.
52.4 Type W(i),V(i),Y(i),a,b,c,d,e,f,g,h,k,l,m,p in form 18.
```

Table 11--*continued*

```
53.08 Do step 56.2 for j=-10(1)4.
53.09 Set z=ip[W(i)/100].
53.1 Do part 60 for k=D(i)(1)4.
53.2 Do part 68 for j=-7(1)4.
53.21 Done if M=1.
53.3 Do part 95.
53.4 Type W(i),V(i),Y(i),a,b,c,d,e,f,g,h,k,l,m,p in form 18.

54.1 Set C(j)=0.
54.2 Do part 56 for i=1(1)n.

55.09 Set y(j)=[S(i,j) + S(i,j-1)]·O(i)/2 if z≠5.
55.10 Set y(j)=[S(i,j)]·O(i) if z=5.
55.11 Set y(j)=y(j)/100 if 2<z<5.
55.12 Set s(i,j)=y(j)+s(i,j).
55.2 Set C(j)=C(j)+y(j).

56.1 Set s(i,j)=0.
56.2 Set q(j)=0.

60.1 Done if S(i,k) = S(i,k-1).
60.2 Set v=S(i,k)-S(i,k-1).
60.3 Set p=(v/u(i))·I(i).
60.4 To part 60+z.

61.1 Set a=0.
61.2 Set b=.45·p.
61.3 Set c=.55·p.
61.4 Set d=0.
61.5 To part 67.

62.1 Set a=.10·p.
62.2 Set b=.75·p.
62.3 Set c=.15·p.
62.4 Set d=0.
62.5 To part 67.

63.1 Set a=.25·p.
63.2 Set b=.30·p.
63.3 Set c=.30·p.
63.4 Set d=.15·p.
63.5 To part 67.

64.1 Set a=.06·p.
64.2 Set b=.60·p.
64.3 Set c=.28.p.
64.4 Set d=.06·p.
64.5 To part 67.

65.1 Set a=.12·p.
65.2 Set b=.62·p.
```

Table 11--*continued*

65.3 Set c=.23·p.
65.4 Set d=.03·p.
65.5 To part 67.

66.1 Set a=.80·p.
66.2 Set b=.15·p.
66.3 Set c=.05·p.
66.4 Set d=0.
66.5 To part 67.

67.09 Set k=k-1 if z=3.
67.1 Set q(k-3)=q(k-3)+a.
67.2 Set q(k-2)=q(k-2)+b.
67.3 Set q(k-1)=q(k-1)+c.
67.4 Set q(k)=q(k)+d.

68.1 Set s(i,j)=s(i,j)+q(j).
68.2 Set C(j)=C(j)+q(j).
68.3 Set y(j)=q(j).

90.09 To step 90.3 if [D(i)-Y(i)]<-6.
90.1 Set C(D(i)-Y(i)-2+j)=Z(i,j)+C(D(i)-Y(i)-2+j).
90.2 Set s(i,D(i)-Y(i)-2+j)=Z(i,j).
90.3 Set C(-8+j)=Z(i,j) + C(-8+j) if [D(i)-Y(i)]<-6.
90.4 Set s(i,-8+j)=Z(i,j) if [D(i)-Y(i)]<-6.

95.11 Set a=y(-7).
95.12 Set b=y(-6).
95.13 Set c=y(-5).
95.14 Set d=y(-4).
95.15 Set e=y(-3).
95.16 Set f=y(-2).
95.17 Set g=y(-1).
95.18 Set h=y(0).
95.19 Set k=y(1).
95.20 Set l=y(2).
95.21 Set m=y(3).
95.22 Sat p=y(4).

Form 1:

New Systems

Form 2:

Total Operational Squadrons/Ships/Sites

Form 3:
UE/ yrs ------------------------YEARS-------------------------------

Form 4:
w/s sqn R D N-7 N-6 N-5 N-4 N-3 N-2 N-1 N N+1 N+2 N+3 N+4

Table 11--*continued*

Form 5:

Research and Development Costs (TOA)

Form 6:

Annual Operating Costs (TOA)

Form 7:

Initial Investment (TOA)

Form 8:

New Systems Costs (TOA)

Form 17:

Form 18:

Form 19:

Form 20:

Form 21:

Form 22:

Form 23:

Form 24:

Form 25:

Form 26:

Form 27:

Form 28:

Form 50:

TOTAL FORCE MODEL

Table 11--*continued*

Form 51:

Base Case

Form 52:

(billions of dollars)

Form 53:

Base Case + New Systems (TOA)

Form 93:
subtotal ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

Form 94:
Phaseouts __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__

Form 95:
New Systems __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__

Form 96:
Total __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__

Form 97:

(millions of dollars)

Form 98:
Base Case __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__ __.__

Table 12

FORCE STRUCTURE COST-ESTIMATING MODEL: INPUT DOCUMENTATION LIST

	Input Code	Input Value	Input Descriptors
	J =		J = 1 for total force structure (including base case) time phasing; J = 2 for individual weapon system time phasing
Base Case Inputs	B(-7) =	$	Base case inputs (in billions): year N-7
	B(-6) =	$	Base case inputs (in billions): year N-6
	B(-5) =	$	Base case inputs (in billions): year N-5
	B(3) =	$	Base case inputs (in billions): year N+3
	B(4) =	$	Base case inputs (in billions): year N+4
	a =		a = 1 for phaseouts; 0 for no phaseouts
Phaseout Inputs	P(-7) =	$	Phaseout inputs (in billions): year N-7
	P(-6) =	$	Phaseout inputs (in billions): year N-6
	P(-5) =	$	Phaseout inputs (in billions): year N-5
	P(3) =	$	Phaseout inputs (in billions): year N+3
	P(4) =	$	Phaseout inputs (in billions): year N+4
	n =		Number of new weapon systems to be time phased
New System Inputs (Repeat N-Times)	W(i) =		Weapon system identification code for weapon system No. i (three digits) 1xx = aircraft 2xx = missile 3xx = antiballistic missile 4xx = ground electronics 5xx = space 6xx = ship
	V(i) =		Unit equipment aircraft or missile per squadron if weapon system No. i is an aircraft or missile system; 1 if weapon system No. i is a ship or satellite system; 100 if weapon system No. i is an antiballistic-missile system
	I(i) =	$	Total initial investment cost for weapon system No. i (in millions)
	D(i) =		Initial operational capability date for weapon system No. i
	u(i) =		Maximum number of missile/aircraft squadrons, ships, satellites, or percentage of antiballistic-missile or ground electronics systems operational during year N-7 to N+4 for weapon system No. i

Table 12--*continued*

Input Code	Input Value	Input Descriptors
Y(i) =		Years to complete R&D program for weapon system No. i
R(i) =	$	Total R&D program cost beginning year N-7 for weapon system No. i (in millions)
O(i) =	$	Annual operating cost per aircraft/missile squadron, ship, satellite, or 100% implemented antiballistic-missile/ground electronics system for weapon system No. i (in millions)
S(i,D(i)) =		Number of squadrons/ships/satellites or percentage of anti-ballistic-missile/ground electronics systems operational in year N+D(i) for weapon system No. i
S(i,D(i)+1) =		Number of squadrons/ships/satellites or percentage of anti-ballistic-missile/ground electronics systems operational in year N+D(i)+1 for weapon system No. i
S(i,3) =		Number of squadrons/ships/satellites or percentage of anti-ballistic-missile/ground electronics systems operational in year N+3 for weapon system No. i
S(i,4) =		Number of squadrons/ships/satellites or percentage of anti-ballistic-missile/ground electronics systems operational in year N+4 for weapon system No. i

IX. CONCLUDING REMARKS

It is the hope of the authors that the COMBAT model, as described in this Memorandum, will be of use to those who require a quick-response military cost-estimating tool and who have access to an on-line computer system such as JOSS. It is further hoped that COMBAT may serve as an example to stimulate the development of similar cost-estimating models for use with other than military forces or systems. As presented, the methodology is relatively simple and should be readily adapted to new areas.

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10. ABSTRACT

The paper

A description of COMBAT, the Cost Oriented Model Built to Analyze Tradeoffs, that enables the analyst to participate, through Rand's time-shared computer system JOSS, in a war-gaming or planning exercise and to supply instant estimates of the cost of alternative weapons and forces. COMBAT is composed of five individual weapon system cost-estimating models (aircraft, missile, ground-based, ship, and space) and a time-phased force cost-estimating model. The study is intended not only to instruct analysts on the use of the model but also to stimulate the development of similar cost-estimating models for use with other than military forces or systems.

11. KEY WORDS

Aircraft
Missiles
Weapon systems
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COMBAT (Computer Force Cost Model)