# COMBAT--A SERIES OF ON-LINE COMPUTER PROGRAMS FOR FORCE COST ANALYSIS

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We are here today to talk about, and illustrate, a new force structure cost-estimating model called COMBAT. It is programmed for an on-line computer system, and designed with the war gaming activity in mind. COMBAT stands for cost oriented models built to analyze trade-offs.

The term "force structure" as we shall use it simply means a group of weapon systems aggregated into a force because they have a common goal or mission. The term "cost model" means a mathematical representation of the relationship between the weapons, their operations, and their estimated costs for some future time period. With this as an introduction, let us begin by giving you some idea of the factors which led to the development of the COMBAT cost models.

At The RAND Corporation, force structure design and analysis have been going on for almost 20 years. A force cost model was designed early in this period and in 1958 it was computerized. This model, and its associated displays, is called PROM. It estimates costs for the major Air Force missions, the weapon systems used to perform the missions, and the resources that are involved. Costs are displayed for each

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weapon system for at least 10 years into the future. These costs are shown by major cost category [Research, Development, Test, and Evaluation (RDT&E); Initial Investment; and Annual Operating.] PROM has provided Air Force planners with an ability to examine and compare alternative force postures in terms not only of the total resources required for a given force but also in terms of the year-by-year incremental funding requirement for each force. Many of the PROM concepts were incorporated by Charles Hitch into the new planning/programming/budgeting process for the Office of the Secretary of Defense, which was implemented in 1961. Planning, Programming, and Budgeting Systems (PPBS) are no longer unique to the defense agencies. They are becoming an increasingly important management tool for other federal agencies as well as for some state and local agencies. Computer technology must, of course, be given much of the credit for the interest in this system.

A few years ago, a new step forward was made at RAND which simplified and expanded the use of our computers. It was called JOSS,* which stands for Johnniac Open Shop System. It is an on-line sharing system which provides the analyst with an input-output typewriter with which he can communicate directly with our PDP-6 computer. No longer must the analyst worry about input sheets to be filled out, cards to be key punched, or queuing up to get on the computer. A wide variety of new programs have been designed and used at RAND to take advantage of this new system.

One particular group of programs has been designed as part of a new strategic war game. Here, we attempt to analyze the highest level decision processes in a "controlled" general war. Of major importance in the gaming is the technological performance of the weapons systems on both sides, and the decisions made with respect to the type of force structure selected. As the cost analysts in this project, we were asked to come up with a method of providing the effect, on cost, of such changes in force structure design as may be suggested during the the play of the game. Such changes might have to do with the design

*JOSS is the trademark and service mark of the RAND Corporation for its computer program and services using that program.

of the weapons, their operations, or with changes in force levels. What was needed was described to us as an "Instant PROM," and this is the need we have attempted to satisfy.

Before talking specifically about COMBAT--how it is constructed, and how it works--let us first describe briefly two conceptual approaches to the design and analysis of force postures.

The first approach is called the Fixed-Effectiveness approach. Given a level of effectiveness in the achievement of a specified goal. an analysis is made to determine which alternative is likely to achieve the goal at the least cost.

The second approach is called the Fixed-Cost approach. Given a level of cost to be used to achieve some given objective, an analysis is made to determine which alternative is likely to achieve the highest effectiveness for the given cost.

Either or both of these approaches may be used, and it is in the analysis of possible trade-offs between force design and cost that the COMBAT model can be most effectively used. COMBAT permits an immediate answer to the questions frequently asked by the planner or war gamer, namely: "How is the cost affected if I change the equipment design, operational mode of the system, force level, or force mix that I have selected?"

Using COMBAT, the answers to such questions can be presented quickly and within the context of a total force structure, the cost implications of which are spelled out in a year-by-year fashion over the relevant period of interest.

Let us now turn to an explanation of what the COMBAT models are. COMBAT is composed of five individual weapon system cost-estimating models and a time-phasing force cost-estimating model. These models are stored in a disc file and can be recalled using remote consoles tied into the on-line computer.

The five individual weapon system models have been designed to estimate the total system cost of the following kinds of weapon systems:

1. Aircraft systems
2. Missile systems
3. Ground Systems
4. Ship systems
5. Space systems

The programs were developed using the usual RAND cost-estimating techniques and inputs, which, in general, describe the weapon systems in terms of operations, resources, and costs. The inputs required to estimate the cost of an aircraft weapon system would typically require the following kinds of information:

1. The number of aircraft, payloads, and associated equipment per squadron.
2. Personnel estimates for the various major functions, that is, operations, maintenance, and support.
3. Activity rate, that is, 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, AGE, and facility.
6. The cost factors for estimating recurring costs of operations, maintenance, and support.

The outputs of these models are presented as static costs, that is, 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 in equipment design and in operational design of the weapon system. The speed with which the computer can function permits many variations to be examined, in an iterative fashion, and within a short period of time.

The force structure cost-estimating model, which presents costs in a year-by-year fashion, operates in the following manner:

1. The year-by-year costs of a "base case" are put into the model. (We shall discuss what we mean by a base case later.)
2. Any relevant cost reductions are put in also on a year-by-year basis. These reflect any phase-outs we may wish to make from the base case force structure.

3. The force structures for new weapon systems and their estimated costs (which are obtained from the individual weapon system models) are then put into the force cost model in the following sequence:

   First, the force structure inputs, that is, the number of weapon system units which will be found in the inventory each year, are put into the model.

   Next, the RDT&E cost estimates for each new weapon system and the number of years necessary to complete each RDT&E program are put in.

   Then, the initial investment cost estimates for the new forces which will eventually be brought into the inventory are put in.

   Finally, the annual operating cost estimate for each new weapon system is put in.

The output format for the force structure cost-estimating model provides time-phased costs for each new weapon system added to the base case. These new costs are shown by major cost category (RDT&E, Initial Investment, and Annual Operating).

This finishes the background description of why the on-line computer program called COMBAT was developed. We hope we have given you some idea of how it is structured and where we think it can be used in the analyses for military decisions.

## COST ANALYSIS EXAMPLE

To illustrate in a little more detail the use of the individual weapon system models, let us pose a situation which may be resolved with the help of the aircraft cost model. Let us assume that during a war game we have $6 billion to develop, purchase, and operate (for 5 years) an advanced manned bomber fleet. Let us further assume that only one design is available to us, and that we can buy and operate 125 of these aircraft for our $6 billion. Further, we discover that our 125 ai aircraft are not able to perform the mission we assigned to them. The problem then is: given our $6 billion limitation, how can we redesign the aircraft weapon system to perform the mission we have assigned to it? As we are sure you all understand, we can change either the major design characteristics of the aircraft itself (such as speed, range, weight, payload, etc.) or the mode of operating the system, such as the number of flying hours, the alert posture, or the deployment scheme. We can also look at changes in both aircraft design and operations in various combinations.

Figure 1 presents the total system cost (RDT&E, Initial Investment, plus 5 years of Annual Operating) of our original advanced bomber for various force sizes. Figure 2 presents a comparison of the costs of this system--with two alternatively designed aircraft systems in which we have reduced the speed and size of the aircraft. We can see that we can increase the number of aircraft in our force by redesigning the aircraft. We would then analyze the effect of reducing the weight or speed in terms of how well this new larger-sized bomber fleet would perform the mission. Such an analysis might result in the conclusion that a smaller fleet of more expensive aircraft is what we really need to satisfy our needs or that part of the mission has to be assigned to another weapon system in our force.

Figure 3 shows the effect of change in the operations of the aircraft weapon system on total system cost. Here we can see that by making changes in the mode of operations (assuming we have elected to stay with aircraft Design A), we can get additional aircraft by going to operational mode 2 and even more by operating in mode 3. Again, at this point we don't know how effective the larger forces would be in performing the mission.

To produce the bomber cost estimates in Figs. 1-3, we would use the aircraft individual weapon system model. A flow diagram for this model is shown in Fig. 4. Figure 5 presents the input documentation sheets which we would use to record the inputs for each set of cost estimates. A blank output format for the aircraft cost model is identified as Fig. 6. This output reflects the 5-year system cost for a force of 210 aircraft.

Figure 1

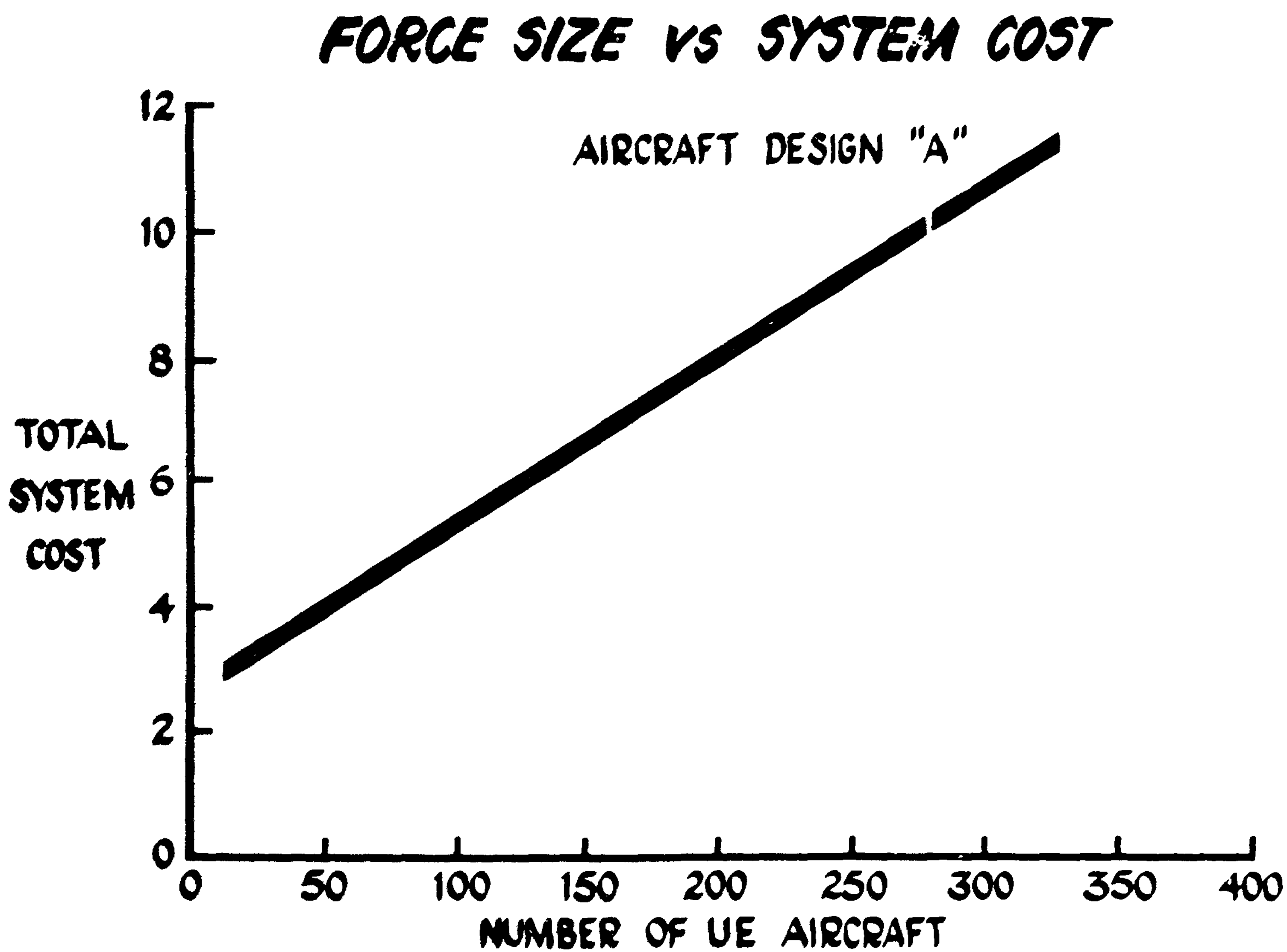
FORCE SIZE VS SYSTEM COST
AIRCRAFT DESIGN "A"
TOTAL
SYSTEM
COST
12
10
8
6
4
2
0
0
50
100
150
200
250
300
350
400
NUMBER OF UE AIRCRAFT

Figure 2

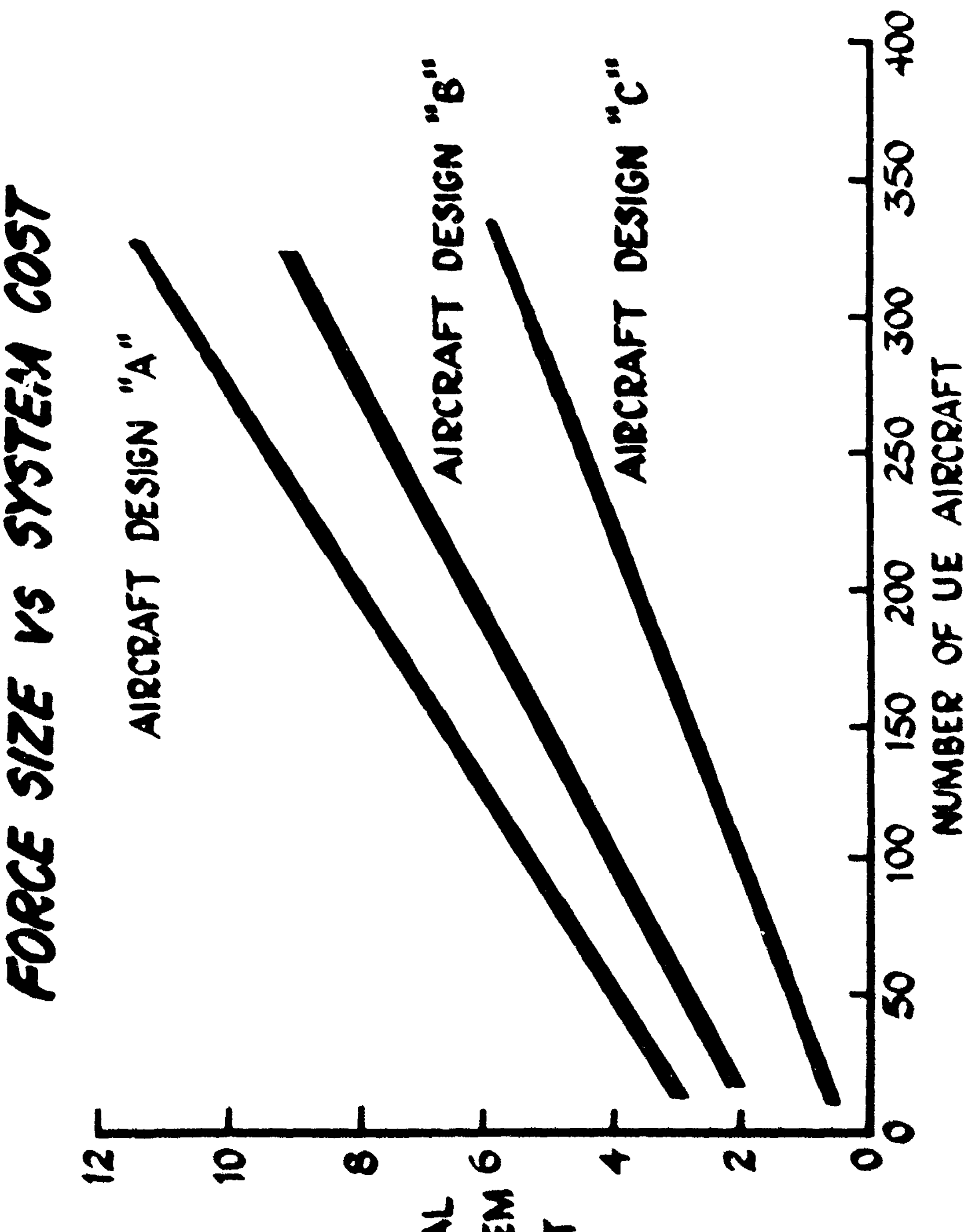
FORCE SIZE VS SYSTEM COST
AIRCRAFT DESIGN "A"
AIRCRAFT DESIGN "B"
AIRCRAFT DESIGN "C"
TOTAL SYSTEM COST
0
2
4
6
8
10
12
NUMBER OF UE AIRCRAFT
0
50
100
150
200
250
300
350
400

Figure 3

# FORCE SIZE VS SYSTEM COST

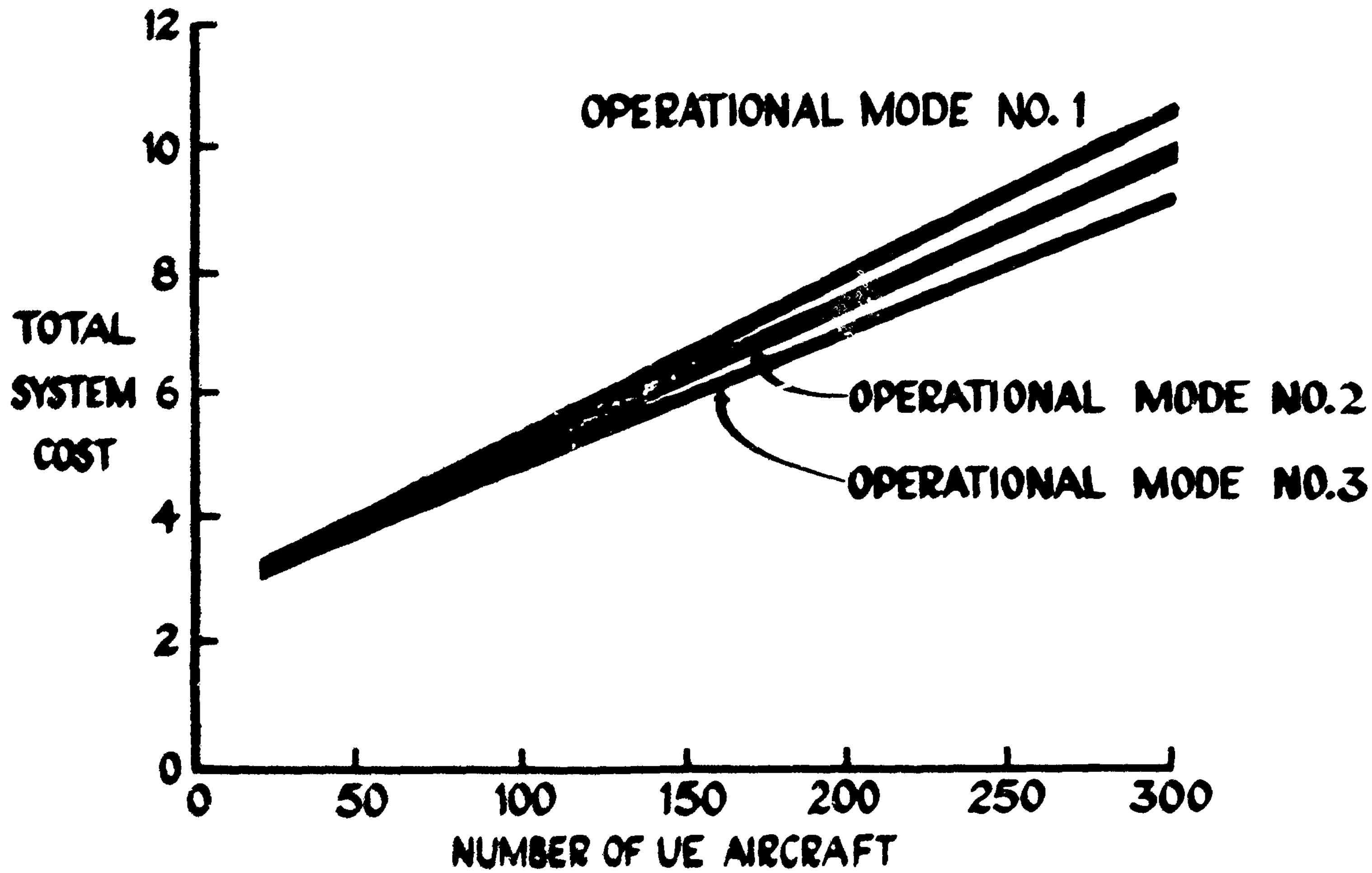

Figure 4

**ACMOD**

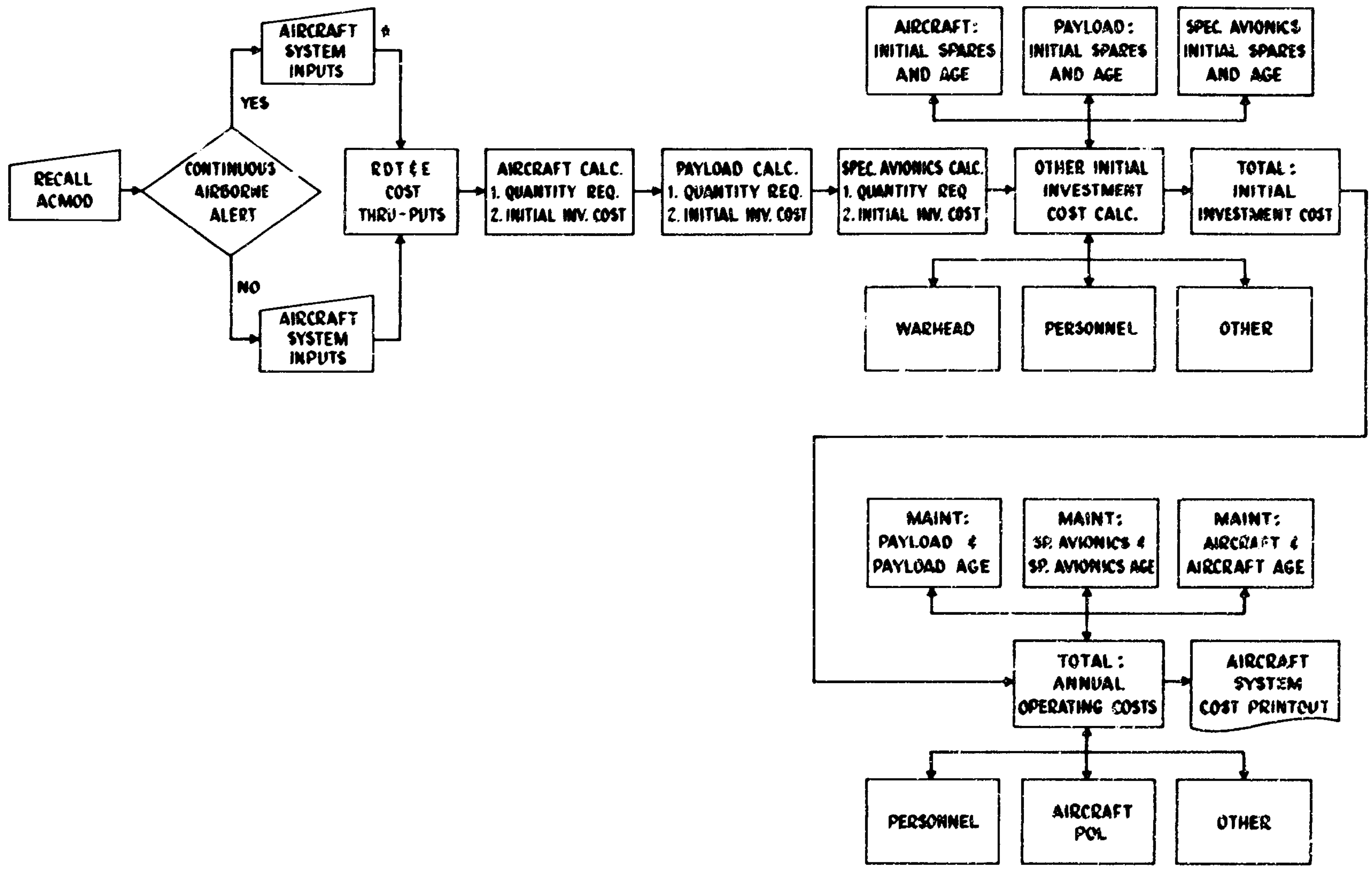

Figure 5
ACMOD

AIRCRAFT MODEL

INPUT DOCUMENTATION SHEET

| | | | | |
|---|---|---|---|---|
| | Y = | | | Number of Years |
| | U = | | | UE per squadron |
| For peacetime airborne patrol | y(1) = | | | Endurance of aircraft |
| | y(2) = | | | Reserve flying hour per flight |
| | y(3) = | | | Flying time from base to station |
| | y(4) = | | | Length of periodic in hours |
| | y(5) = | | | Flying hours per periodic inspection |
| | y(6) = | | | Length of post-flight in hours |
| | y(7) = | | | Flying hours per post-flight inspection |
| | y(8) = | | | Percentage of unscheduled maintenance (hours) |
| | y(9) = | | | Percentage of unscheduled maintenance (sorties) |
| | y(10)= | | | Preflight, servicing, debriefing, etc., hours |
| | y(11)= | | | Extra down-time per sortie in hours |
| | y(12)= | | | Length of maintenance shift in hours |
| | y(13)= | | | Number of 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 & attrition) |
| | F = | | | FH/sqn/yr |
| | Z = | | | Payload per squadron (0 if none) |
| | R = | $ | $x10^6$ | 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 O&M personnel |
| | C(1) = | $ | $x10^6$ | Cost of aircraft theoretical unit 1 (in millions) |
| | L(1) = | | % | Aircraft procurement learning slope (cumulative average) |
| | Q(1) = | | | Procurement level--aircraft |
| | W(1) = | $ | $x10^6$ | Cost per warhead (in millions) |
| | D(1) = | | | Number of warheads per squadron |
| | C(2) = | $ | $x10^6$ | Cost of payload theoretical unit 1 (in millions) |
| | L(2) = | | % | Payload procurement learning slope (cumulative average) |
| | Q(2) = | | | Procurement level--payload |
| | C(3) = | $ | $x10^6$ | Cost of spec avionics pkg theoretical unit 1 (millions) |

Figure 5--Continued
ACMOD AIRCRAFT MODEL--Continued

| | | | |
|---|---|---|---|
| L(3) = | | % | Spec avionics pkg procurement learning slope (cum avg) |
| Q(3) = | | | Procurement level--spec avionics pkg |
| C(4) = | | % | Initial investment support--aircraft spares (% of A/C proc cost) |
| C(5) = | | % | Initial investment support--aircraft AGE (% of A/C proc cost) |
| C(6) = | | % | Initial investment support--payload spares (% of payload proc cost) |
| C(7) = | | % | Initial investment support--payload AGE (% of payload proc cost) |
| C(8) = | | % | Initial investment support--spec avionics pkg spares (% of spec avionics pkg proc cost) |
| C(9) = | | % | Initial investment support--spec avionics pkg AGE (% of spec avionics pkg proc cost) |
| C(10)= | $ | $x10^6$ | Initial investment other cost per squadron (in millions) |
| C(11)= | $ | | Initial investment other cost per personnel |
| A(1) = | | % | Direct maintenance cost--payload (% of payload proc cost) |
| A(2) = | | % | Direct maintenance cost--payload AGE (% of payload AGE proc cost) |
| A(3) = | | % | Direct maintenance cost--spec avionics pkg (% of spec avionics pkg proc cost) |
| A(4) = | | % | Direct maintenance cost--spec avionics pkg AGE (% of spec avionics pkg proc cost) |
| A(5) = | $ | | POL cost per flying hour |
| A(6) = | $ | | Direct aircraft maintenance cost ($/FH) |
| A(7) = | | % | Direct maintenance cost--aircraft AGE (% of aircraft AGE proc cost) |
| A(8) = | | % | Modification and replacement cost per year (% of aircraft proc cost) |
| A(9) = | $ | | Op personnel pay and allowance and replacement training cost ($/op personnel) |
| A(10)= | $ | | Support personnel pay and allowance and replacement training cost ($/support personnel) |
| A(11)= | $ | | Other personnel cost ($/personnel) |
| A(12)= | $ | | Other squadron cost ($/squadron) |

Figure 6

OUTPUT FORMAT FOR AIRCRAFT WEAPON SYSTEM COST MODEL

Aircraft System

5 YEARS SYSTEM COSTS
($ million)

RDT&E =
Initial Inv =
Warheads =
Annual Op (5 yrs) =

TOTAL =

Number of squadrons    UE per squadron    FH/sqn/yr
Payload per squadron    Payload proc cost $    (millions)

Total aircraft proc.    Total aircraft proc. cost $    (millions)

Total Personnel
Oper. Pers    Maint Pers    Support Pers

Warhead Qty. (Total)    Warhead cost (Total) $    (millions)

It is possible to analyze the cost impact of many variations and combinations of the foregoing types of cost sensitive design and operational parameters. The on-line computer permits it to be done quickly and in an iterative fashion so that the results can be used as part of the war gaming deliberations and analysis. The total time needed to generate the cost estimates shown in Figs. 1-3 would be about 10 minutes, assuming that the estimating factors were available.

In a similar fashion, the time-phased force cost-estimating model can be used to analyze various force mixes of the five categories of weapon systems. This has been previously mentioned. Now we can examine the impact on cost (over time) of various phase-in options.

Previously, we mentioned a base case, which refers, in essence, to an attempt to establish a point of origin in order to carry out a comparative analysis. For the current example, let us assume that the base case consists of the total DOD strategic forces as presented in Program I of the DOD 5-Year Force and Financial Plan. An unclassified representation of this program structure is shown in Fig. 7. It includes forces of the three major services involved in both the strategic offense and continental defense missions. Also included in the total program are support force elements as well as the tactical force elements. We have shown the forces as if no new decisions will be made in the future. This is called a "spend-out" assumption and the cost impact of this assumption is shown graphically in Fig. 8. The base case, and its estimated cost over time, is the benchmark from which our new force structures are developed, costed, and compared.

To continue with our example, let us assume that we do make some new decision--specifically, that we are going to add some new offensive and defensive capability as shown in Fig. 9. As you can see, all of this new capability is phased into our force posture during 1975. The year-by-year cost of this new force (Variation A) is shown in Fig. 10.

If for some reason, the large peak of funds required in 1973 appears infeasible or undesirable, we can examine alternative phase-in schedules. Two such alternatives (Variations B and C) appear in Fig. 11.

Figure 7

# STRATEGIC WAR FORCES UNITS & COSTS (ILLUSTRATIVE BASE CASE)

| | NUMBER OF OPERATING FORCE UNITS | | | | | | | | | | | | | TOA BILLIONS (1967 DOLLARS) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USAF | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| STRATEGIC AIRCRAFT | | | | | | | | | | | | | | | | | | | | | | | | |
| BOMBERS | 600 | 550 | 550 | 500 | 500 | 500 | 500 | 500 | 500 | 400 | 400 | 400 | 400 | 1.1 | 1.2 | 1.2 | .5 | .5 | .5 | .5 | .5 | .5 | .4 | .4 |
| AIR TO SURFACE MISSILES | 200 | 200 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | .2 | .3 | .3 | .2 | .2 | .1 | .1 | .1 | .1 | .1 | .1 |
| TANKER | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 |
| STRATEGIC RECON | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 | .1 |
| STRATEGIC MISSILES | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1.4 | 1.1 | .8 | .5 | .3 | .3 | .3 | .3 | .3 | .2 | .2 |
| CMD, CONTROL & COMM | | | | | | | | | | | | | | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 |
| SUPPORT SAC | | | | | | | | | | | | | | | | | | | | | | | | |
| ADV FLYING TNG | | | | | | | | | | | | | | | | | | | | | | | | |
| HQ SAC | | | | | | | | | | | | | | .6 | .6 | .6 | .6 | .6 | .6 | .6 | .6 | .6 | .6 | .6 |
| BASE OPERATIONS | | | | | | | | | | | | | | | | | | | | | | | | |
| AIRCRAFT DEFENSE | 400 | 400 | 350 | 350 | 350 | 300 | 300 | 300 | 250 | 250 | 200 | 200 | 150 | .2 | .2 | .2 | .2 | .2 | .2 | .1 | .1 | .1 | .1 | .1 |
| CMD, CONTROL & COMM | | | | | | | | | | | | | | .8 | .7 | .6 | .6 | .6 | .5 | .5 | .5 | .5 | .5 | .5 |
| SUPPORT ADC | | | | | | | | | | | | | | | | | | | | | | | | |
| ADV FLYING TNG | | | | | | | | | | | | | | | | | | | | | | | | |
| HQ ADC | | | | | | | | | | | | | | .3 | .3 | .3 | .3 | .3 | .3 | .3 | .3 | .3 | .3 | .3 |
| BASE OPERATIONS | | | | | | | | | | | | | | | | | | | | | | | | |
| U. S. N. | | | | | | | | | | | | | | | | | | | | | | | | |
| STRATEGIC SUB MSL | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 1.0 | 1.0 | .8 | .8 | .8 | .8 | .8 | .8 | .8 | .8 | .8 |
| HQ & HQ SUPPORT | | | | | | | | | | | | | | | | | | | | | | | | |
| U.S. ARMY | | | | | | | | | | | | | | | | | | | | | | | | |
| SURFACE TO AIR MISSILES | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | | | | | | | | | | | |
| CMD, CONTROL & COMM | | | | | | | | | | | | | | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 | .2 |
| HQ & HQ SUPPORT | | | | | | | | | | | | | | | | | | | | | | | | |
| BASE OPERATION | | | | | | | | | | | | | | | | | | | | | | | | |
| GRAND TOTAL | | | | | | | | | | | | | | 6.3 | 6.1 | 5.5 | 4.4 | 4.2 | 4.0 | 3.9 | 3.9 | 3.9 | 3.8 | 3.8 |

Figure 8

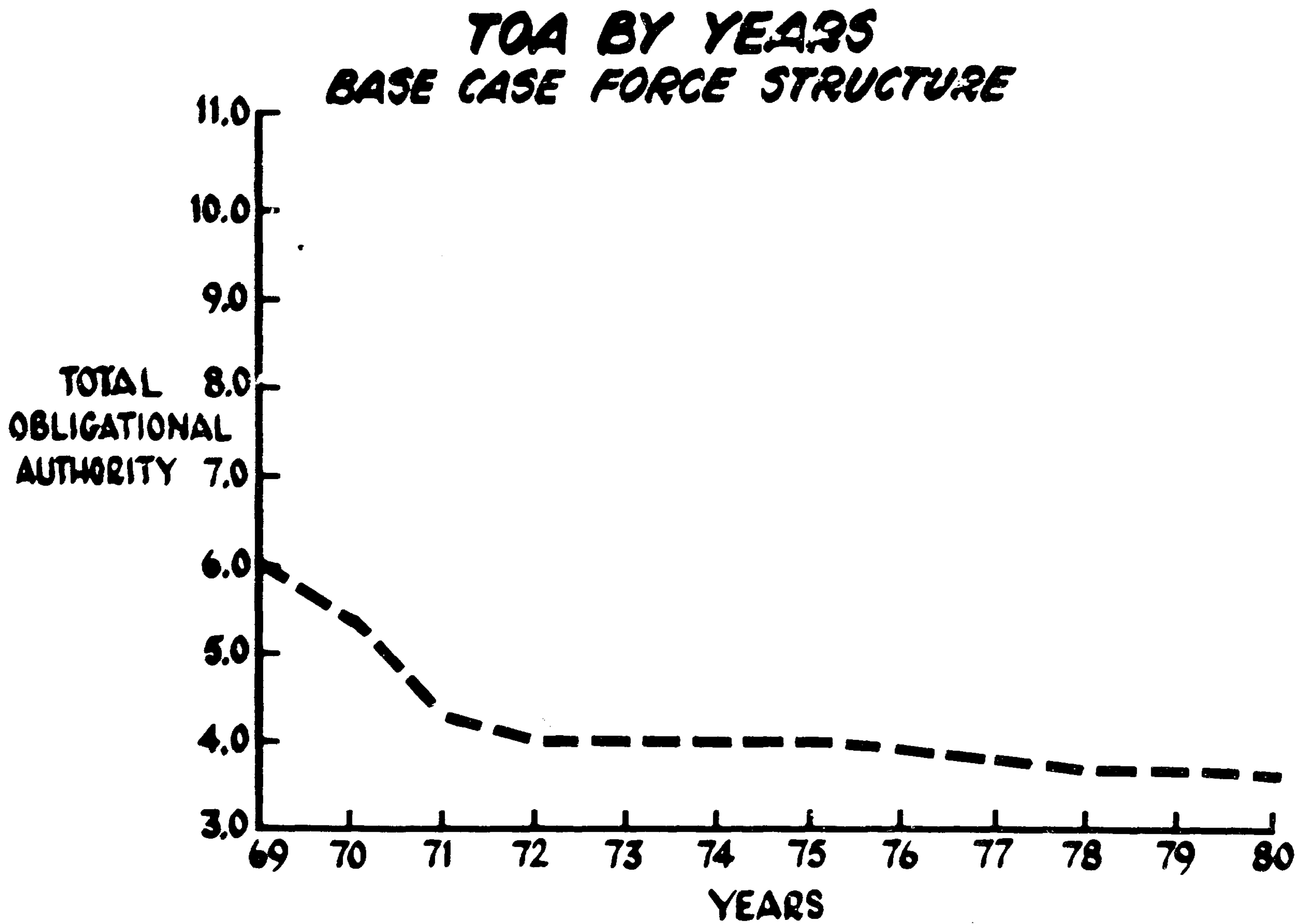
TOA BY YEARS
BASE CASE FORCE STRUCTURE
TOTAL OBLIGATIONAL AUTHORITY
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
69
70
71
72
73
74
75
76
77
78
79
80
YEARS

Figure 9

# FORCE VARIATIONS

FISCAL YEAR

VARIATION "A" 1975

| NEW SYSTEMS | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOMBER SQS | - | - | - | - | - | - | 9 | 9 | 9 | 9 | 9 | 9 |
| MISSILES SQS | - | - | - | - | - | - | 10 | 10 | 10 | 10 | 10 | 10 |
| DEFENSE | - | - | - | - | - | - | 100 | 100 | 100 | 100 | 100 | 100 |

Figure 10

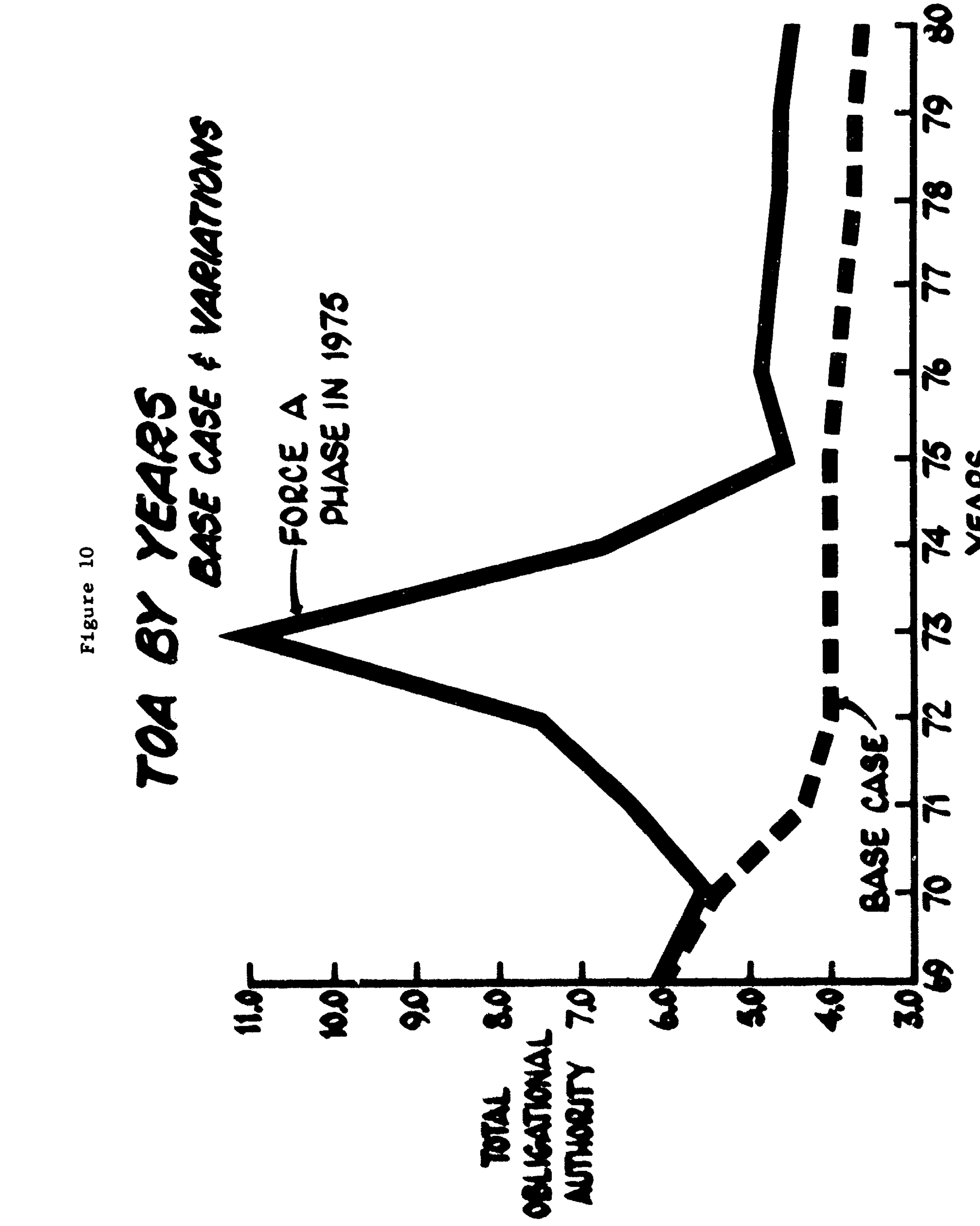
TOA BY YEARS
BASE CASE & VARIATIONS
FORCE A
PHASE IN 1975
BASE CASE
TOTAL
OBLIGATIONAL
AUTHORITY
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
69
70
71
72
73
74
75
76
77
78
79
80
YEARS

Figure 11

# FORCE VARIATIONS

| | NEW SYSTEMS | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VARIATION "B" 1974-1977 | BOMBER SQS | - | - | - | - | - | - | 2 | 5 | 7 | 9 | 9 | 9 |
| | MISSILES SQS | - | - | - | - | - | - | 2 | 4 | 7 | 10 | 10 | 10 |
| | DEFENSE | - | - | - | - | - | 25 | 40 | 60 | 75 | 90 | 100 | 100 |
| VARIATION "C" 1974-1980 | BOMBER SQS | - | - | - | - | - | - | 1 | 3 | 5 | 7 | 9 | 9 |
| | MISSILES SQS | - | - | - | - | - | - | 1 | 2 | 3 | 5 | 7 | 10 |
| | DEFENSE | - | - | - | - | - | 25 | 40 | 60 | 75 | 90 | 100 | 100 |

FISCAL YEAR

In Variation B, the new capability would be phased in by stages between 1974 and 1977; in Variation C, in stages between 1974 and 1980. The effects of these alternative phase-in options on the year-by-year costs can be seen in Fig. 12.

As in the previous example, we are only dealing with the effects on costs of changes in force design alternatives. It would take about 10 minutes to estimate year-by-year costs of each force variation using the on-line computer and the COMBAT force structure cost model.

Figure 13 presents a summary flow diagram for the COMBAT force structure time-phasing model. Figure 14 presents the input documentation sheet we would use to record the inputs for each force variation. Figure 15 presents a sample format for the base case and for Variation C.

## CONCLUSIONS

We have illustrated the kinds of costs that the new COMBAT model has been designed to estimate. These kinds of estimates have been made in the past. With COMBAT, however, they can be made quickly using an on-line computer system. We feel this quick response capability can provide a new dimension to the analysis of force-oriented issues. A group of military analysts or war gamers can use this capability to examine the cost impact of force posture changes in an iterative fashion in a relatively short period of time.

Figure 12

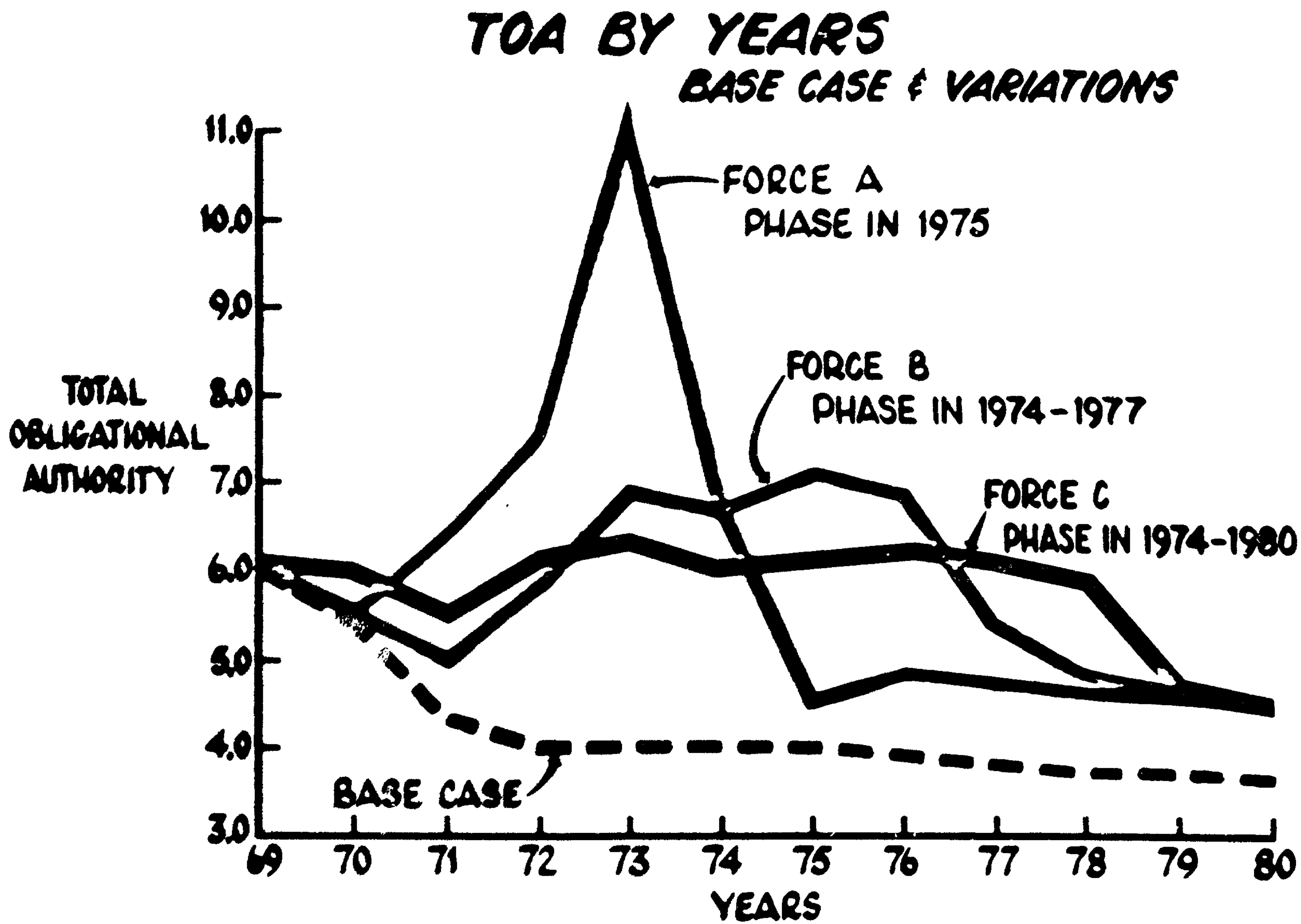
TOA BY YEARS
BASE CASE ¢ VARIATIONS
TOTAL OBLIGATIONAL AUTHORITY
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
FORCE A
PHASE IN 1975
FORCE B
PHASE IN 1974-1977
FORCE C
PHASE IN 1974-1980
BASE CASE
69
70
71
72
73
74
75
76
77
78
79
80
YEARS

Figure 13

**COMBAT**

**FORCE STRUCTURE TIME PHASING MODEL**

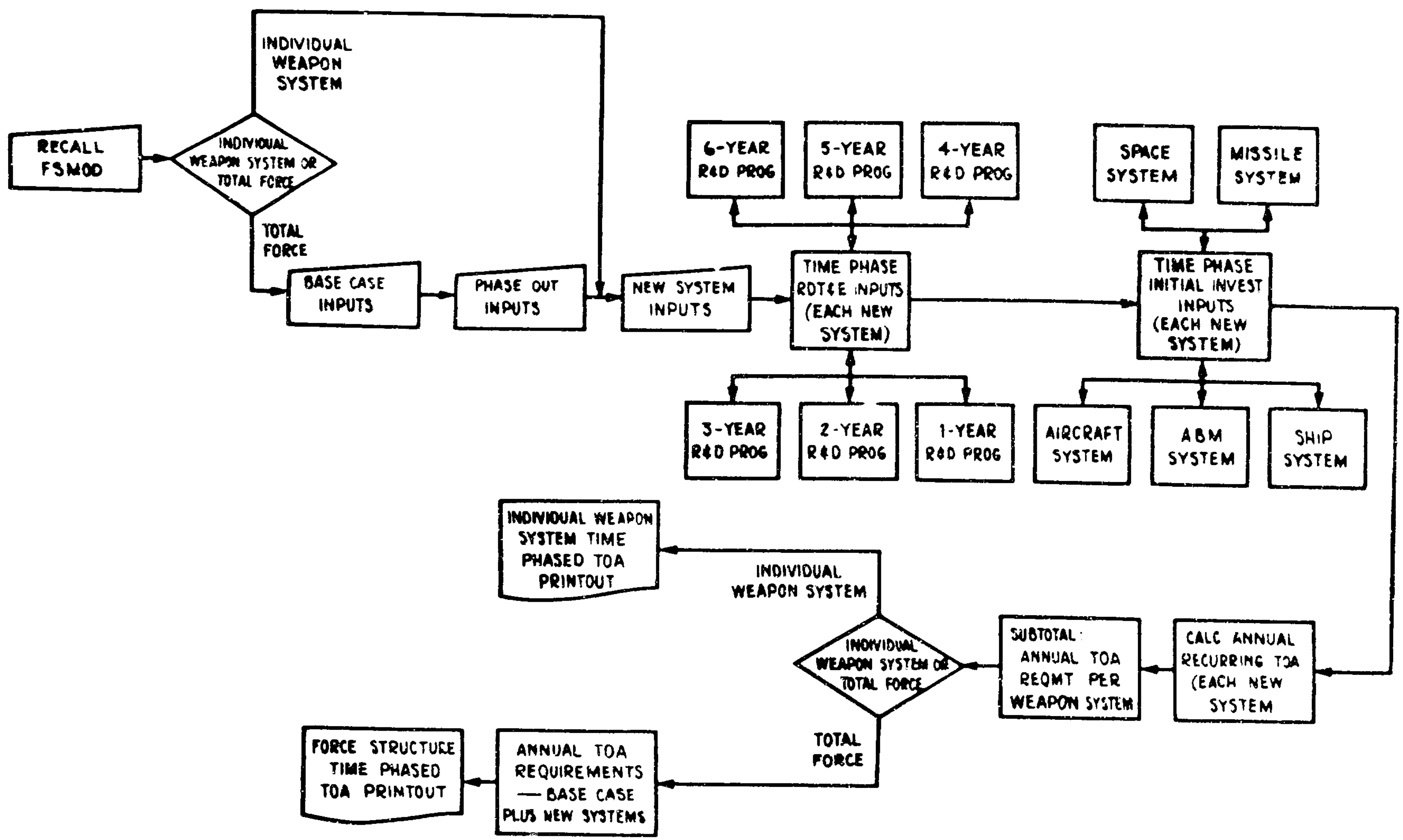

Fig. 14--FSMOD

Force Structure Time Phasing Model

Input Documentation Sheet

| | | | | | |
|---|---|---|---|---|---|
| | 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) | = | $ | $\times 10^9$ | Base Case Inputs (billions) -- year N-7 |
| | B(-6) | = | $ | $\times 10^9$ | year N-6 |
| | B(-5) | = | $ | $\times 10^9$ | year N-5 |
| | B(3) | = | $ | $\times 10^9$ | year N+3 |
| | B(4) | = | $ | $\times 10^9$ | year N+4 |
| | a | = | | | a = 1 for phaseouts; 0 for no phaseouts. |
| Phase Out Inputs | P(-7) | = | $ | $\times 10^9$ | Phaseout inputs (billions) -- year N-7 |
| | P(-6) | = | $ | $\times 10^9$ | year N-6 |
| | P(-5) | = | $ | $\times 10^9$ | year N-5 |
| | P(3) | = | $ | $\times 10^9$ | year N+3 |
| | P(4) | = | $ | $\times 10^9$ | 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)<br>1xx = aircraft<br>2xx = missile<br>3xx = ABM<br>4xx = ground electronics<br>5xx = space<br>6xx = ship |
| | V(i) | = | | | ue aircraft or missile per squadron if W/S No. i is an aircraft or missile system; 1 if W/S No. i is a ship or satellite system; 100 if W/S No. i is an ABM system. |
| | I(i) | = | $ | $\times 10^6$ | Total initial investment cost for W/S No. i (in millions) |
| | D(i) | = | | | IOC date for W/S No. i. |
| | u(i) | = | | | Maximum number of missile/aircraft squadrons, ships, satellites or percent of ABM or ground electronic system operational during year N-7 to N+4 for W/S No. i. |

Fig. 14--continued

| | | | |
|---|---|---|---|
| Y(i) = | | yrs. | Years to complete R&D program for W/S No. i. |
| R(i) = | $ | $x10^6$ | Total R&D program cost beginning year N-7 for W/S No. i (in millions). |
| O(i) = | $ | $x10^6$ | Annual operating cost per aircraft/missile squadron, ship, satellite or 100% implemented ABM/ground electronics system for W/S No. i (in millions). |
| S(i,D(i)) = | | | No. of squadrons/ships/satellites or percent of ABM/ground electronics system operational in year N+D(i) for W/S No. i. |
| S(i,D(i)+1) = | | | No. of squadrons/ships/satellites or percent of ABM/ground electronics system operational in year N+D(i)+1 for W/S No. i. |
| S(i,3) = | | | No. of squadrons/ships/satellites or percent of ABM/ground electronics system operational in year N+3 for W/S No. i. |
| S(i,4) = | | | No. of squadrons/ships/satellites or percent of ABM/ground electronics system operational in year N+4 for W/S No. i. |

Figure 15

**OUTPUT FORMAT FOR BASE CASE**
**AND FORCE VARIATION "C"**

TOTAL FORCE MODEL
Illustrative Base Case
(Billions of Dollars)

| w/s | UE/ sqn | yrs 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Base Case | | | 6.1 | 5.4 | 4.3 | 4.0 | 4.0 | 4.0 | 4.0 | 3.9 | 3.8 | 3.7 | 3.7 | 3.6 |

Figure 15--continued

Annual Operating Costs (TOA)
(millions of dollars)

| w/s | UE/ sqn | yrs 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 111 | 30 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 89 | 178 | 267 | 356 | 400 |
| 311 | 100 | 3 | 0 | 0 | 0 | 0 | 0 | 63 | 163 | 250 | 338 | 413 | 475 | 500 |
| 211 | 50 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

New Systems Costs (TOA)
(millions of dollars)

| w/s | UE/ sqn | yrs 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 111 | 30 | 2 | 0 | 0 | 0 | 500 | 600 | 322 | 467 | 533 | 622 | 511 | 356 | 400 |
| sub-total | | | 0 | 0 | 0 | 500 | 600 | 322 | 467 | 533 | 622 | 511 | 356 | 400 |
| 311 | 100 | 3 | 0 | 563 | 1038 | 1315 | 1260 | 1218 | 1178 | 933 | 705 | 518 | 475 | 500 |
| sub-total | | | 0 | 563 | 1038 | 1815 | 1860 | 1540 | 1644 | 1466 | 1327 | 1029 | 831 | 900 |
| 211 | 50 | 4 | 0 | 50 | 175 | 245 | 458 | 450 | 495 | 833 | 945 | 1148 | 203 | 0 |
| sub-total | | | 0 | 613 | 1213 | 2060 | 2318 | 1990 | 2139 | 2298 | 2272 | 2176 | 1033 | 900 |

Base Case + New systems (TOA)
(Billions of Dollars)

| w/s | UE/ sqn | yrs 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Base Case | | | 6.1 | 5.4 | 4.3 | 4.0 | 4.0 | 4.0 | 4.0 | 3.9 | 3.8 | 3.7 | 3.7 | 3.6 |
| New Systems | | | .0 | .6 | 1.2 | 2.1 | 2.3 | 2.0 | 2.1 | 2.3 | 2.3 | 2.2 | 1.0 | .9 |
| Phase Outs | | | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| Total | | | 6.1 | 6.0 | 5.5 | 6.1 | 6.3 | 6.0 | 6.1 | 6.2 | 6.1 | 5.9 | 4.7 | 4.5 |

Figure 15--continued

New Systems

Total Operational Squadrons/Ships/Sites

| w/s | UE/ sqn | yrs 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YEARS | | | | | | | | | | | |
| 111 | 30 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 5 | 7 | 9 | 9 |
| 311 | 100 | 3 | 0 | 0 | 0 | 0 | 0 | 25 | 40 | 60 | 75 | 90 | 100 | 100 |
| 211 | 50 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 5 | 7 | 10 |

Research and Development Costs (TOA)
(millions of dollars)

| w/s | UE/ sqn | yrs 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YEARS | | | | | | | | | | | |
| 111 | 30 | 2 | | | | 500 | 500 | | | | | | | |
| 311 | 100 | 3 | | 125 | 250 | 125 | | | | | | | | |
| 211 | 50 | 4 | | 50 | 175 | 200 | 75 | | | | | | | |

Initial Investment (TOA)
(millions of dollars)

| w/s | UE/ sqn | yrs 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YEARS | | | | | | | | | | | |
| 111 | 30 | 2 | 0 | 0 | 0 | 0 | 100 | 322 | 444 | 444 | 444 | 244 | 0 | 0 |
| 311 | 100 | 3 | 0 | 438 | 788 | 1190 | 1260 | 1155 | 1015 | 683 | 368 | 105 | 0 | 0 |
| 211 | 50 | 4 | 0 | 0 | 0 | 45 | 383 | 450 | 495 | 833 | 945 | 1148 | 203 | 0 |