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STRATEGIC WEAPON SYSTEMS STUDY 1975-1981 PHASE I-STRATEGIC FORCE OPTIONS FOR THE LATE NINETEEN SEVENTIES (U)

Volume VII: U.S. Air Defenses

August 19[illegible]

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Volume VII: U.S. Air Defenses

J. L. Freeh
A. Schwartz
T. Stanley
S. L. Waller

August 1970

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Gen. B. A. Schriever, USAF (Ret.)

(U) Editorial coordination and supervision were by J. P. Byrd, G. Lee, and J. S. McManus.

TABLE OF ORGANIZATION

CONTENTS

I. INTRODUCTION

(U) A preliminary review of the Continental United States (CONUS) air defense problem was completed in this portion (Phase I) of the Strategic Weapon System Study 1975-1981. This review included the Soviet air-breathing threat, the existing capabilities and proposed improvements to the U.S. air defense system and the primary issues pertinent to the analysis of alternative U.S. air defense postures.

(U) In this review, air defense is defined to include only those warning, surveillance, control and weapon systems which are associated with defense against bomber aircraft, air-to-surface missiles, and sea-launched cruise missiles. It does not include systems designed to provide warning or defense against ballistic missiles such as Ballistic Missile Early Warning System (BMEWS) or SAFEGUARD.

(U) This report presents a discussion of air defense issues, objectives and alternative postures; a review of the characteristics of the aerodynamic threat to the United States in the 1970s; a description of the current air defense system; and a description of some proposed improvements to the existing system.

II. OBJECTIVES AND ALTERNATIVE POSTURES

A. INTRODUCTION

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the tanker force. A bomber can be converted to a probe-and-drogue tanker and vice-versa in about 4 to 8 hours. The wingtip system requires special equipment on the tanker and refueling aircraft (factory installed), and it is believed that all BADGER receive part of the required refueling equipment in the factory. Conversion would then take 4 to 12 hours.

~~(TS)~~ Aerial refueling is a routine part of heavy bomber training. The BISON tankers, presently about half of the BISON force, are used to refuel the BISON bombers and the refuelable BEAR aircraft.

~~(TS)~~ It is believed that refueling plays a very minor role in medium bomber operations. At present, it is also believed that, even though over 100 BADGER are equipped to receive fuel (one-fifth the BADGER force), only 20 or so are configured as tankers. The BLINDER is generally thought to be refuelable, that is, refueling probes have been observed on all versions of the BLINDER. However, there is no evidence of any aerial refueling activity by operational units. If there could be a refueling program for the BLINDER initiated in the future, it is felt that modified BADGER aircraft would serve as probe-and-drogue type tankers.

Range Capabilities

~~(S)~~ The radius and range capabilities of the heavy and medium bombers are given in Table 1 for refueled and non-refueled missions and for a variety of payloads. The maps shown in Figs. 2 and 3 indicate the radius and range capabilities of the heavy and medium bombers, respectively, employed against North America. The distances are

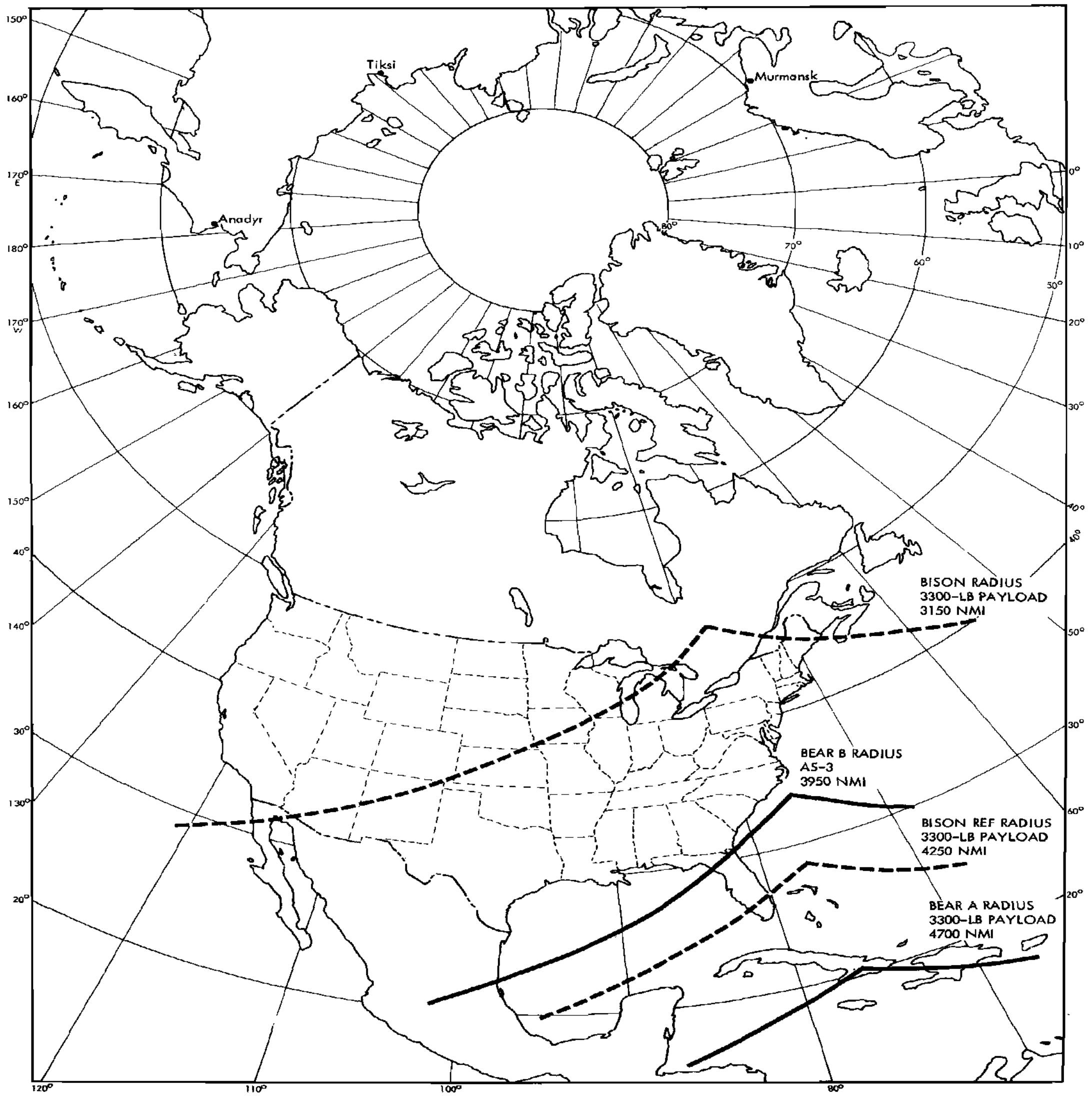

FIGURE 2 ~~(S)~~ Heavy Bomber Penetration Capabilities from Forward Bases on Direct Routes (U)

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Table 2 ~~(S)~~. SOVIET LRA AIR-TO-SURFACE MISSILE CHARACTERISTICS AND PERFORMANCE[a] (U)

	AS-3 KANGAROO	AS-4 KITCHEN	AS-5 KELT
Type Missile	Cruise	Boost-Cruise	Cruise
Length (ft)	46	37	31
Wing Span (ft)	30	11	15
Wing L.E. Sweep (deg)	58	71	58
Gross Weight (lb)	25,000	14,000	5,000
Warhead Weight (lb)	4,500-5,500	2,200	1,000-2,000
Power Plant	Turbojet	Liquid Rocket	Liquid Rocket
Guidance	Preprogrammed Autopilot with Command Override	Inertial	Preprogrammed Autopilot with Command Override
Accuracy (nmi)	1-3	1-2	1-2
Maximum Range (nmi)	350	300	120
Maximum Speed (Mach)	1.6 TO 2.0	5.0 TO 4.0 AT 80,000 ft	0.90 TO 1.2
Launch Aircraft	BEAR B & C (1 MSL)	BLINDER B (1 MSL)	BADGER G (2 MSLs)
Launch Altitude (ft)	36,000-39,000	Up to 47,000 ft depending on aircraft speed at launch	30,000-35,000
Launch Speed (kts/Mach)	430/0.75	Up to 860/1.5	440/0.77
Maximum Altitude (ft)	55,000	80,000	35,000
Launch Reliability (%)	90	90	90
Flight Reliability (%)	85	85	85
Overall Reliability (%)	75	75	75
IOC	1960-1961	1968	1965

[a] Although the AS-3, AS-4, and AS-5 are the only ASMs designed primarily for LRA use, the 55 nmi AS-1 and the 100 nmi AS-2, which were designed primarily for naval use, can also be used against land targets.

d. Possible Improvements in Soviet LRA Capabilities

~~(TS)~~ The Soviet Union is not believed to be developing a follow-on heavy bomber. It is felt that such a development is unlikely during the 1970s; but if the Soviets would introduce a new heavy bomber, the program would probably be detected and identified 3 to 4 years before an initial operating capability.

~~(S)~~ It is well known that the Soviet Union is actively involved in a supersonic transport program (TU-144). Such a program could provide the technology, the production facilities, and training necessary for the deployment of a new bomber in the post-1975 period.

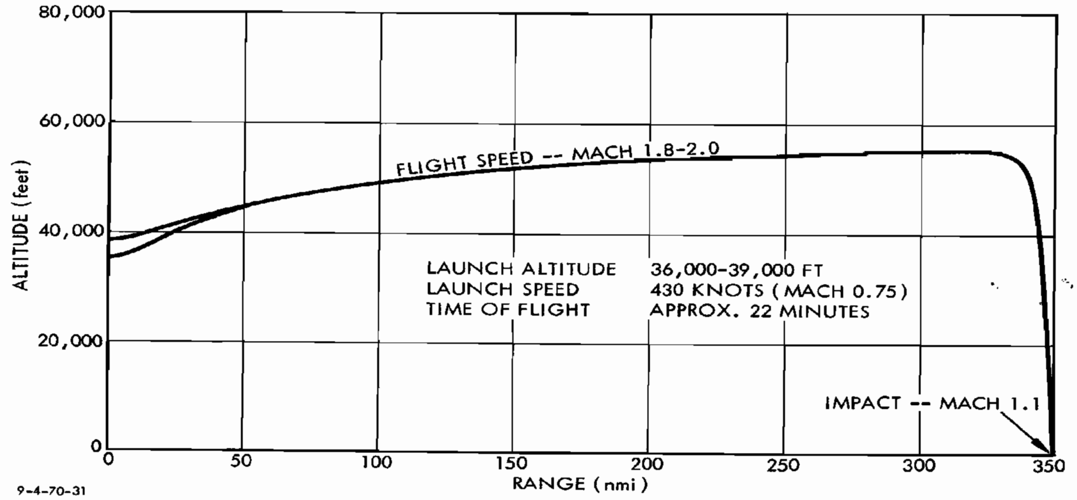

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FIGURE 4 ~~(S)~~ AS-3 KANGAROO

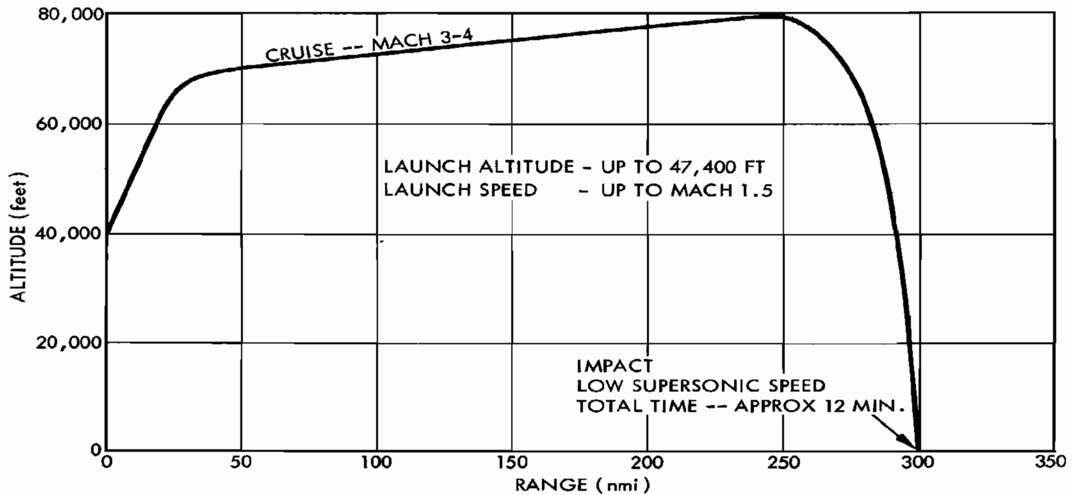

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FIGURE 5 ~~(S)~~ AS-4 KITCHEN (U)

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Table 3 ~~(S)~~. SOVIET CRUISE MISSILE SUBMARINE PERFORMANCE (U)

	Speed				Patrol Capabilities			Noise Levels	
	Cruise/Maximum		Submerged/Endurance(nmi)		Days on Station	Radius (nmi)	Patrol Duration	At Speed (knots)	LOFAR Band(dB)
	Surface	Snorkel	Maximum	Cruising					
Nuclear Powered (SSGN)									
E-I	20	-	26	-	30	4300	60	6	60
					15	6500	60	13	72
					0	8600	60		
E-II	20	-	25	-	30	4300	60	6	60
					15	6500	60	12	72
					0	8600	60		
Diesel Powered (SSG)									
J	10/19	7.0/8.5	15/12	3.0/150	30	1800	60	Undetermined	
					15	2700	60		
					0	3600	60		
W-Conversion	10/18	5.5/5.5	12/12	2.5/150	20	1200	40	5	60 Snorkel
(both Long					10	1800	40	5	45 Battery
Bin and Twin Cylinder)					0	2500	40		

~~(S)~~ Further timing characteristics are indicated below:

- Reaction time (time from fire order to first missile launch, assuming submarine on alert, preselected targets, continuous computation of firing data, and missiles checked out and ready for launch) - 20 to 40 min.
- Launch timing (time on surface before launch, 3 min). The E classes of submarines can launch 2 missiles almost simultaneously.
- Salvo time (launch all missiles first to last):[1]

W-CONV (2 or 4 missiles)	1 to 3 min
E-I (6 missiles)	5 min
E-II (8 missiles)	7 min
J (4 missiles)	1 to 3 min.

---

[1] ~~(S)~~ Some estimates are approximately twice as long.

b. Soviet Cruise Missiles

General

~~(S)~~ There are presently approximately a total of 350 SS-N-3 SLCMs carried by submarines. The intelligence community generally believes that the SLCMs would be used primarily against naval forces, although they are capable of striking coastal targets.

Cruise Missile Characteristics

~~(S)~~ The characteristics of the SS-N-3 are given below:

- Surface-launched type cruise.
- IOC - 1961.
- Warhead weight - 1100 to 2200 lb (HE or nuclear).[1]
- Propulsion - Turbojet with RATO boost.
- Guidance - Inertial with active radar terminal homing vs ships; simple inertial vs land targets; may have IR homing device as alternate or backup.
- Profile/Range (see Fig. 6 for some schematic trajectories).

  Low Trajectory: 1000 to 2000 ft; the maximum operational range is 250 nmi.

  Low/Medium Trajectory:
  (a) Low mode, steady at less than 2000 ft till lock on, terminal descent 15 to 20 nmi from target; operational range is 150 to 250 nmi; may develop to 300 nmi.

  (b) Medium mode, missile flies at 10,000 to 15,000 ft for 150 to 200 nmi. After lock on target, missile probably acts like low trajectory missile.

  High Trajectory: 30,000 to 40,000 ft, similar to medium trajectory, but at higher altitude, faster, and greater range, out to 450 nmi.

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[1] ~~(TS)~~ Possible yields are 3-100 KT or 1.2 MT.

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IV. FY 1971 CONUS AIR DEFENSE SYSTEM

A. INTRODUCTION

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V. PLANNED IMPROVEMENTS

A. GENERAL

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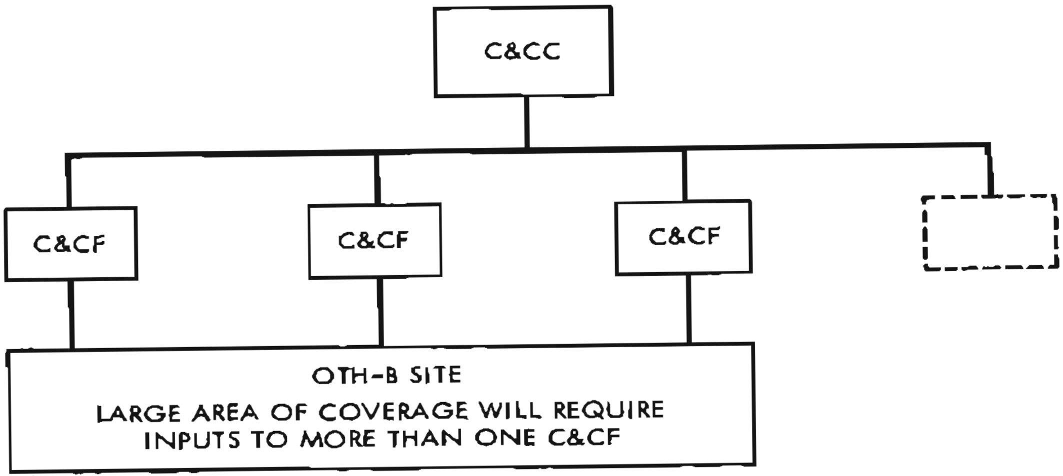

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FIGURE 26 (U) . Command and Control Structure (U)

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C. CAPABILITY OF PROJECTED CHANGES TO IMPROVE CONUS AIR DEFENSE

1. General

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[2] (U) See Chapters II and III.

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STRATEGIC WEAPON SYSTEMS STUDY 1975-1981
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Volume VIII: Cost Analysis

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PHASE I - STRATEGIC FORCE OPTIONS FOR THE LATE NINETEEN SEVENTIES (U)

Volume VIII: Cost Analysis

J. A. Davis, *Panel Chairman*
M. A. Ballou
J.S. Domin
K. P. Heinze

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Authors: J. L. Freeh; A. Schwartz; T. Stanley; S. L. Waller

VOLUME VIII — COST ANALYSIS

Authors: J. A. Davis; M. A. Ballou; J. S. Domin; K. P. Heinze

PREFACE

(U) This report presents the results of the Cost Analysis panel during the first phase of the Strategic Weapons System Study.

(U) The report is divided into three chapters. Chapter I presents an introduction to the report establishing the purpose and scope of the analysis. Chapter II describes the methodology that was employed and Chapter III presents the results of the cost analysis activity. The appendices describe the cost model, the input values, examples of the cost of alternative U.S. weapon system and planning forces and the cost estimates for the USSR strategic forces.

CONTENTS

APPENDICES

I. INTRODUCTION

(U) In this study, force structure cost analysis is the estimation of the costs of probable resource impact of alternative strategic force proposals. These resource implications are expressed as financial requirements to the Department of Defense in terms of Total Obligational Authority (TOA) by fiscal year in current year dollars. It is emphasized that the purpose of cost analysis activity is to estimate the relative or comparative costs of alternative forces, not to estimate accurate and precise costs suitable for inclusion into the DoD budget cycle process.

~~(S)~~ In the current force planning environment, the Offices of the Secretary of Defense and Joint Chiefs of Staff have generated a number of alternate force structures to serve as a basis for establishing future year force and financial requirements. Figure 1 displays the range of projected TOA budget levels represented by the OSD and JCS planning activities in terms of high, medium, and low annual and five-year total obligational authority requirements for the total DoD and the strategic direct mission area. Totals for the Strategic Offensive, Defensive, and Control and Surveillance sub-mission areas are also shown in Fig. 1.

(U) The force structure cost analysis in this study estimates the effects of alternate forces on the total obligational authority requirements for only the strategic force mission area. Within this mission area, interest is also focused on the three sub-mission areas, namely, Offense, Defense, and Control and Surveillance.

(U) The structuring of cost elements and cost categories used in the recent OSD and JCS planning exercises is an integral part of the methodology of this cost analysis.

(U) This structure not only indicates what weapon system or program elements are assigned to which sub-mission or mission area, but also implies the association of cost categories and/or cost elements for each system, allocation techniques, and the aggregation of costs to sub-mission and mission. Due to this structuring, it should be noted that base and individual support, training (formal), command, and logistics support functions are all considered sub-mission areas of the General Support Program. How these general functional support areas would fluctuate as a result of changes in the strategic sub-mission areas has not been addressed in this study. Hence, only those costs associated with each weapon system or program element have been included in the costs for that system as well as the costs of each sub-mission and the strategic mission. It is also important to note that costs of nuclear materials associated with the Atomic Energy Commission are not included in this study.

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II. METHODOLOGY

(U) The general approach to estimating the total obligational authority requirements of strategic forces used by the Cost Analysis Panel involved three steps:

Step 1. A point of departure which includes forces, time, and total obligational authority requirements with its implied structuring of cost categories and cost-estimating relationships was established.

Step 2. Cost input data on candidate weapon system options of interest to strategic weapon study panel members were obtained.

Step 3. Using data and procedures established in Steps 1 and 2, estimates were made of total obligational authority requirements of alternative strategic force structures or combinations of strategic weapon systems.

Chapter II is organized into three parts, each of which elaborates on one of the steps discussed above.

A. POINT OF DEPARTURE

(U) The illustrative force of the OSD Tentative Fiscal Guidance was selected as the point-of-departure force because it is currently the basic source document used at the beginning of the planning process within the OSD, JCS, and DoD environment. OSD cost analysts estimated TOA requirements for FY 1972 through FY 1976 based on the illustrative forces for FY 1971 through FY 1979 using a computerized cost model, the "electric FYDP", to assist in the computing.

(U) The cost model contains a combination of throughputs, estimating relationships, and cost factors for each strategic weapon system arrayed in a manner to facilitate estimating TOA requirements of alternate quantities of any weapon system or combination of weapon systems. Outputs of the model include RDT&E, Investment, and Operations cost by fiscal year for each weapon system with appropriate sub-mission and mission totals.

(U) The cost categories, cost elements, and cost estimating relationships for the strategic force part of the electric FYDP were used in this study effort for estimating TOA requirements for the alternate forces. The computational procedures used in the cost model are discussed in detail in Appendix A; the input values required for running the cost model are listed in Appendix B.

(U) Two graphs portraying the outputs of the model for an illustrative force are shown in Figs. 2 and 3. They summarize the estimated TOA for the strategic mission through FY 1981 by major cost category--i.e., RDT&E, Investment, and Operations--and by sub-mission--i.e., offense, defense, and control and surveillance.

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B. CANDIDATE WEAPON SYSTEMS

(U) The study team reviewed strategic weapon system candidates currently in the system concept formulation phase of development or beyond and developed a list of high potential new weapon system options. Some of these new system candidates were included in the alternate strategic forces studied and their cost streams over time were added to time-phased TOA requirements of the fiscal guidance forces to form new total strategic force costs. (See Appendix D and Part B of Chapter III.) Other new force improvement options that were not included in any of the six forces but were evaluated by the SWS team may be found in Appendix C.

(U) Individual strategic weapon system cost model input values were obtained from the electric FYDP input listing and other Fiscal Guidance documentation to the extent possible. Occasionally, an advanced strategic system candidate of interest was not considered in the Fiscal Guidance. In these cases appropriate weapon system cost model input values were obtained through an official service channel such as the Army DASSO for the SAM-D or the Air Force JSOP cost input/output listing for FY 1972 through FY 1979 for the Improved Manned Interceptor (F-15), AWACS, and WS-120A weapon systems, the SAC/SAMSO joint task force study for MINUTEMAN rebasing options, and ASD documentation for the LABP.

(U) All cost model input data were reviewed by panel members primarily to insure consistency of computational ground rules. Uncertainties inherent in estimates of new systems costs preclude high degrees of accuracy in the absolute values of cost estimates. However, the use of a single set of cost input values, cost categories, cost elements, force deployment and procurement schedules will permit comparisons of relative TOA requirements for alternate force structures. Since the cost ground rules used in this study are based on those used to establish the Fiscal Guidance, the resultant cost estimate need not agree precisely with estimates obtained from another source such as the Joint Forces Memorandum. Any two cost estimating systems may do a good job of discriminating between the costs of alternate force structures while differing in absolute value of total cost estimates when compared to each other.

(U) Figures 4, 5, and 6 display the type of information available from the outputs of the cost model for the B-1A, SAFEGUARD, and ULMS system options. Each figure shows RDT&E, Investment, and Operations TOA requirements by fiscal year (FY) for FY 1972 through FY 1981. The shaded area and the horizontal axis on the right of the figures display the force levels of each weapon system available for operational use by year. It is interesting

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to note that large quantities of obligational authority are required from up to five to ten years in advance of deployment of significant quantities of operational units.

C. ALTERNATIVE FORCE STRUCTURES

(U) Total obligational authority requirements for alternative force structures or combinations of strategic weapon systems were estimated for the strategic portion of six planning forces resulting from recent (March through August 1970) JCS and OSD analyses using the cost model discussed above. Figure 7 summarizes TOA requirements for the illustrative force for FY 1972 through FY 1981. A detailed reporting of the forces and costs of the six forces is included in Appendix D to this volume. These forces and costs were used as a building block for establishing offensive and defensive force options. TOA requirements for the offensive and defensive force options generated by the Strategic Weapons Study Team were then estimated and results of that analysis are contained in Part B of Chapter III.

(U) Because of the possibilities of cost overruns due to estimating uncertainties and the introduction of the Fiscal Guidance, a considerable amount of attention has been focused on various methods available for insuring that force costs in any fiscal year are kept within specified fiscal constraints. In general, annual force funding requirements can be reduced by one of the following methods:

(1) Extending the RDT&E cycle directly reduces annual RDT&E funding requirements and in some cases could also reduce total RDT&E funding requirements if the original cycle is based on accelerated development time assumptions which result in inefficient uses of resources. Extending the RDT&E cycle also delays the time

at which the weapon system will be available for use by DoD and also delays TOA requirements for investment and operations cost funding.

(2) Extending the production cycle will reduce annual procurement funding requirements and could reduce total procurement funds required to the extent that cost reductions are realized from the effects of a slower rate of production on initial tooling and facilities requirements. It should be noted that in certain cases where there are already in existence capacities for high rates of production, slowing the production rate could increase per unit costs[1] thereby cancelling some of the positive effects of slowing the production rate. Extending the production cycle also reduces the quantity of operational weapon systems available for use during the weapon build-up phase and delays the time at which full operational capability is reached. Operational cost funding is, therefore, also delayed.

(3) Phasing-out an existing system reduces or eliminates the operating and recurring investment costs associated with that system. It also denies the DoD use of that system.

(4) Other means of reducing funding requirements are to reduce force activity levels (e.g., reduction of missile test shots, or of aircraft annual flying hours) and accept lower troop proficiency levels. Also cutting back on test articles in an RDT&E program reduces annual and total RDT&E costs and possibly reduces the quality of the final product. Finally, transferring large portions of the active forces to a reserve or national guard status would also reduce funding requirements if reduced proficiency and readiness levels are acceptable.

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[1] (U) This assertion assumes that average per unit costs increase due to fixed cost spreading or inefficient use of a large production facility, and the cost increase is passed on to the customer (e.g., through cost-plus contracting).

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(U) There are probably many other methods of reducing strategic force costs available to the ingenious analyst, but each method probably implies some permanent or temporary degradation in force capability. Options which yield large annual funding reductions for small degradations in force capabilities are, of course, preferred options.

(U) The results of a sensitivity analysis of strategic force total TOA requirements to arbitrary increases in B-1A, SAFEGUARD, and ULMS investment cost estimates are displayed in Fig. 8. The analysis indicates that cost overruns can have a disruptive influence on force costs, and some form of force cutback or program delay may be necessary to keep force costs within fiscal guidance levels in the face of major cost overruns.

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III. RESULTS

(U) Results will be presentd in two major parts. The first part presents estimated total obligational authority for existing and potential strategic weapon systems for each element of the strategic offensive triad, the SAFEGUARD system, and other strategic offensive and defensive forces. The second part presents the results of analyses of offensive and defensive total force options as they relate to various budget levels including the fiscal guidance issued by the Office of the Secretary of Defense (OSD).

A. INDIVIDUAL WEAPON SYSTEM OPTIONS

(U) Results are presented in this section for various combinations of weapon systems or force packages. The bomber, land-based missile, sea-based missile, SAFEGUARD, other defensive forces, and offensive control and surveillance force packages are summarized as follows:

Step 1. A graph of total obligational authority requirements by fiscal year for FY 1972 through FY 1981 is shown for the existing elements (i.e., weapon systems currently in the inventory) of each force package. The maximum and minimum plots shown are the estimated TOA of the forces which were extracted from six planning forces resulting from recent OSD and JCS analyses. Appendix D to this volume is dedicated to a more detailed reporting and cost analysis of the strategic part of those planning forces.

Forces corresponding to the maximum and minimum of TOA requirements are shown on the bottom of each graph along with the particular planning force from which they were extracted.

Step 2. Similar maximum and minimum plots and associated force level data are shown for all force improvement options included in the planning forces.

Step 3. A plot of TOA requirements by fiscal year and associated force level data is shown for the additional candidate force improvement options which were evaluated by the various panels of the strategic weapons study group, but which were not included in the six OSD and JCS planning forces. These force improvement options are labeled SWS forces on the figures to distinguish them from OSD and JCS planning forces.

Step 4 Finally a bar chart is displayed which summarizes 5- and 10-year total TOA requirements for the existing elements and force improvement options of all force packages. A brief discussion of each of the force packages follows.

1. Bomber Forces

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(b)(1),(b)(3):42 USC § 2168 (a) (1) (C)

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[redacted]

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[redacted]

(b)(1),(b)(3):42 USC § 2168 (a) (1) (C)

[redacted]

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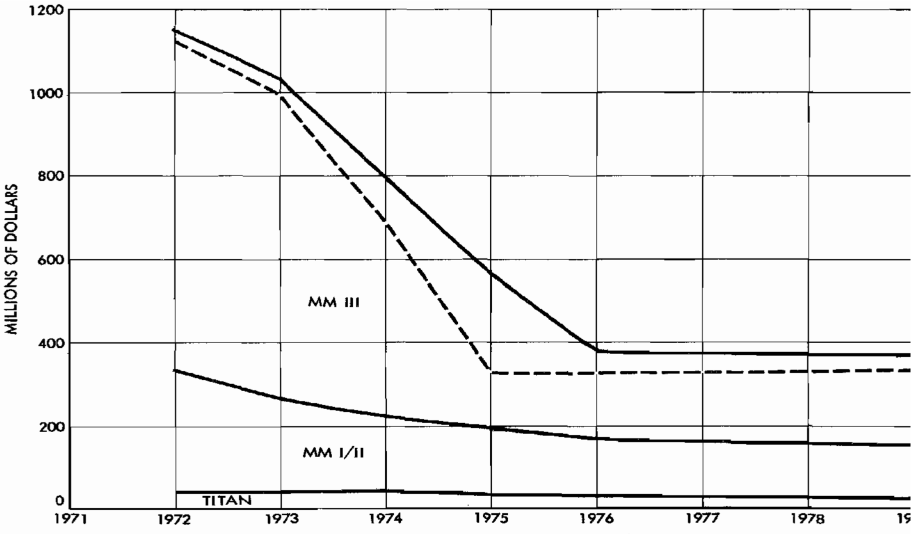

		1971	1972	1973	1974	1975	1976	1977	1978	19
MAXIMUM (JSOP)	TITAN	54	54	54	45	45	36	36	27	
	MINUTEMAN I/II	890	790	670	554	436	394	387	380	3
	MINUTEMAN III	110	210	330	446	564	606	613	620	6
MINIMUM (JFM-DECREMENT-B)	TITAN	54	0	0	0	0	0	0	0	
	MINUTEMAN I/II	890	790	670	554	450	450	450	450	4
	MINUTEMAN III	110	210	330	446	550	550	550	550	5

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FIGURE 15 ~~(TS)~~ Existing Land-Based Missile Package (U)

(b)(1),(b)(3):42 USC § 2168 (a) (1) (C)

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	1971	1972	1973	1974	1975	1976	1977	1978	197
HARD POINT DEFENSE - 1000 (HPD)	0	0	0	0	50	250	450	650	85
SHELTER-BASED MM-300 (SBMM)	0	0	50	150	250	300	300	300	30
AIR-CUSHIONED VEHICLES - 300 (ACV)	0	0	0	0	75	150	225	300	30
UGS + HPD - 500	UGS FOLLOWS UPGRADED SCHEDULE AND HPD-500 FOLLOWS HARD POINT DEFENSE - 500 SCHEDULE								

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FIGURE 17 ~~(TS)~~. MINUTEMAN Rebasing Options (U)

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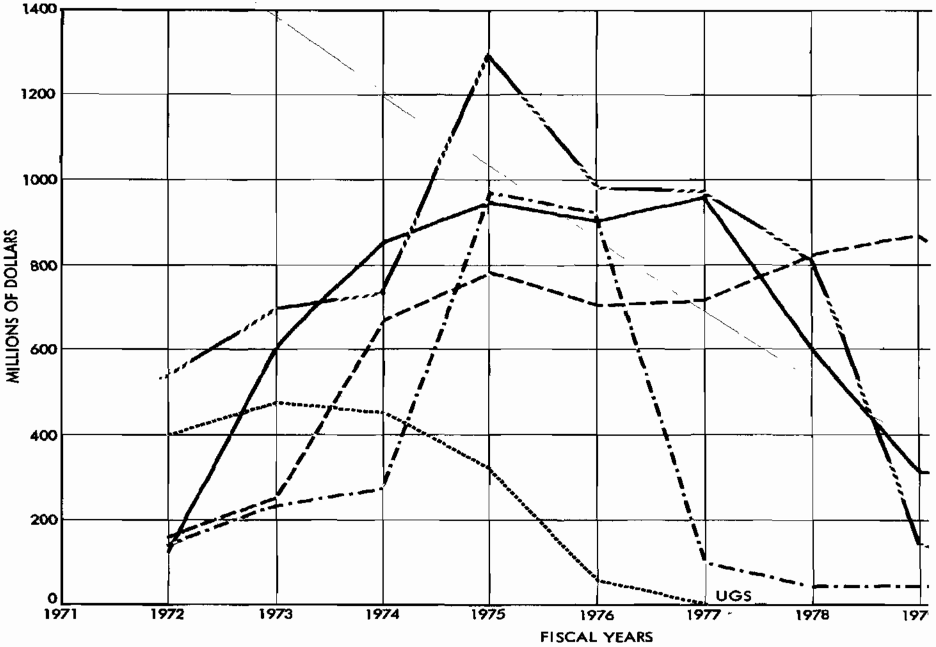
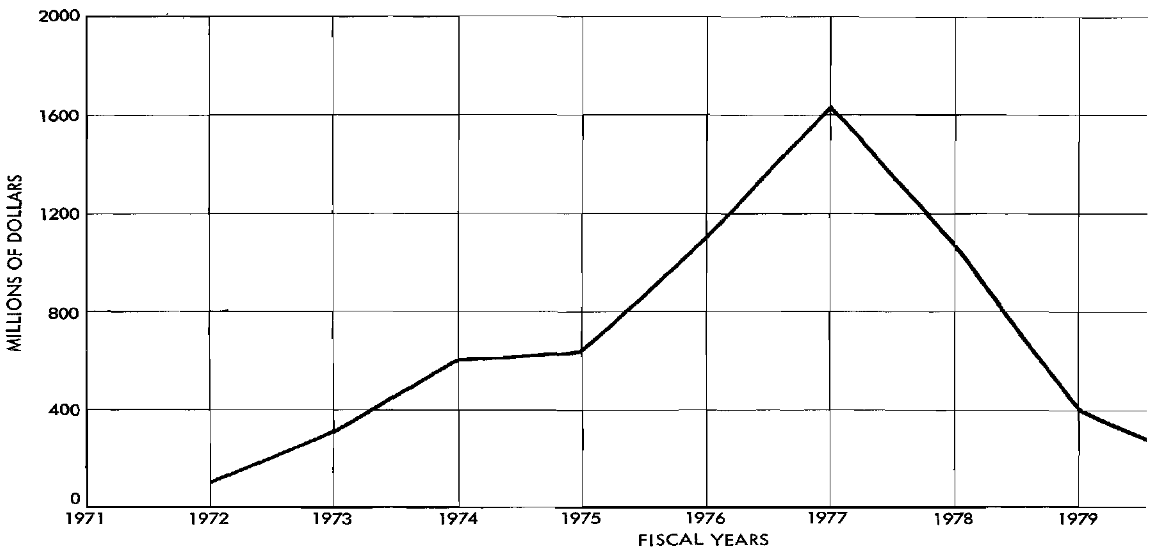


	1971	1972	1973	1974	1975	1976	1977	1978	197
UPGRADED SILOS (UGS	0	0	125	375	625	875	1000	1000	10
HARD POINT DEFENSE-500 (HPD)	0	0	0	0	50	250	450	500	5
SHELTER-BASED MM-500 (SBMM)	0	0	50	150	250	350	450	500	5
AIR-CUSHIONED VEHICLE-500 (ACV)	0	0	0	0	75	150	225	300	37
UGS+HPD-1000	UGS FOLLOWS UPGRADED SILOS SCHEDULE AND HPD-1000 FOLLOWS HARD POINT DEFENSE - 1000 SCHEDUL								

8-10-70-10

FIGURE 18~~(TS)~~. MINUTEMAN Rebasing Options (U)



WS-120A	0	0	0	0	0	0	10	140	280

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FIGURE 19 ~~(TS)~~. WS-120A Option (U)

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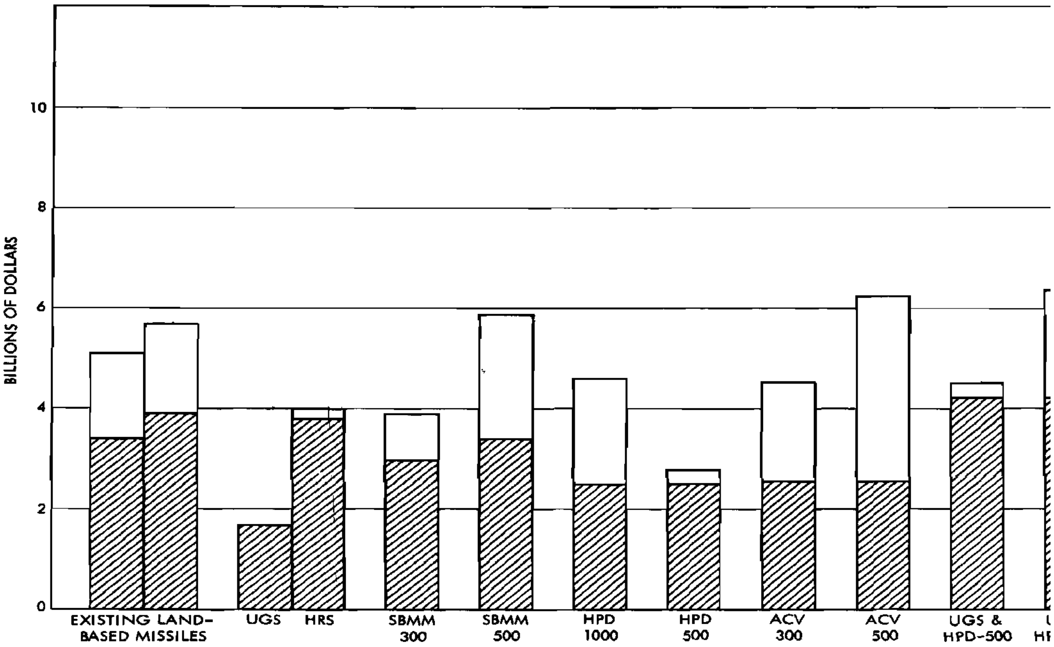
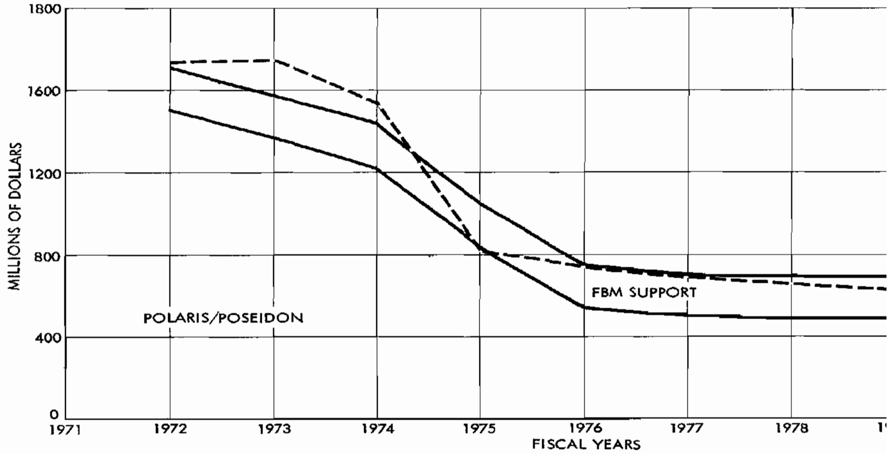


	MIN	MAX	MIN	MAX							
REFERENCE FORCE	DECR B	JSOP	JFM ALT.	FISC. GUID.	SWS	SWS	SWS	SWS	SWS	SWS	SWS
FIVE-YEAR TOTAL FY 1972 - FY 1981	3.43	3.88	1.71	3.80	2.98	3.42	2.52	2.52	2.56	2.56	4.23
TEN-YEAR TOTAL FY 1972 - FY 1976	5.08	5.71	1.71	3.97	3.91	5.91	4.60	2.78	4.56	6.24	4.50

8-10-70-12

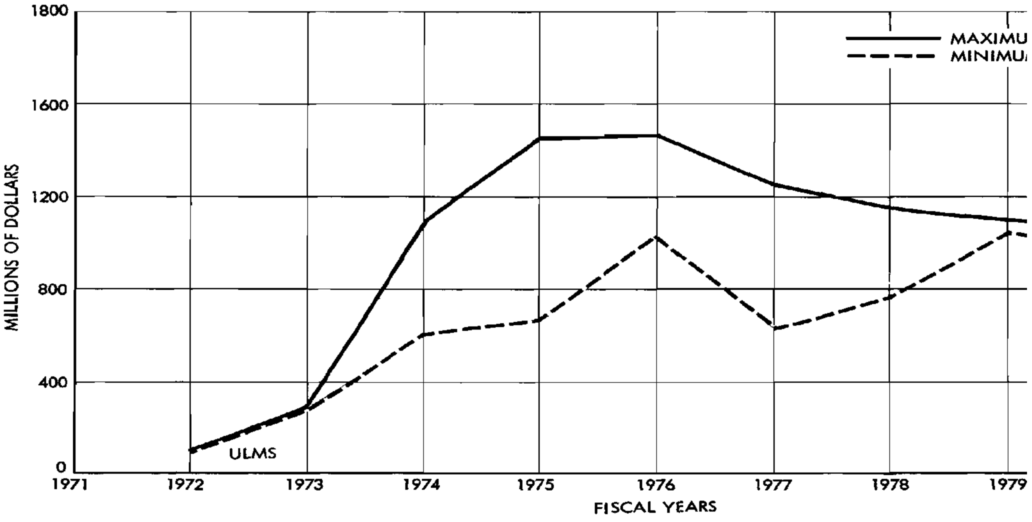
FIGURE 20 ~~(TS)~~ Estimated Total Obligational Authority for Land-Base
Missile Force Options (FY 1972 - FY 1981)
(In Billions of Dollars)(U)



MAXIMUM (JFM-ALTERNATIVE)	POLARIS/POSEIDON	41	41	41	41	41	41	41	41
	FBM SUPPORT	11	11	11	11	11	11	11	11
MINIMUM (FISCAL GUIDANCE)	POLARIS/POSEIDON	41	41	41	41	41	39	39	36
	FBM SUPPORT	11	11	11	11	11	11	11	11

8-10-70-13

FIGURE 21~~(TS)~~ Existing Sea-Based Missile Package (U)



MAXIMUM (JSOP)	0	0	0	0	0	0	0	1	3
MINIMUM (JFM-ALTERNATIVE)	0	0	0	0	0	0	0	0	0

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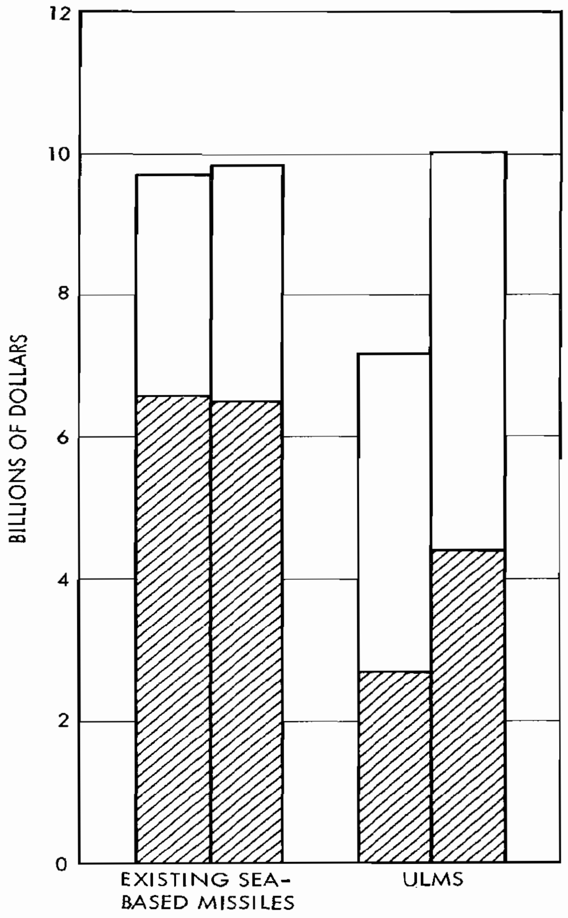
FIGURE 22~~(TS)~~. ULMS Force Options (U)



REFERENCE FORCE	FISC. GUID.	JFM ALT.
FIVE YEAR TOTAL FY 1972 - FY 1976	6.57	6.50
TEN YEAR TOTAL FY 1972 - FY 1981	9.71	9.92

JFM ALT.	JSOP
2.68	4.39
7.18	10.04

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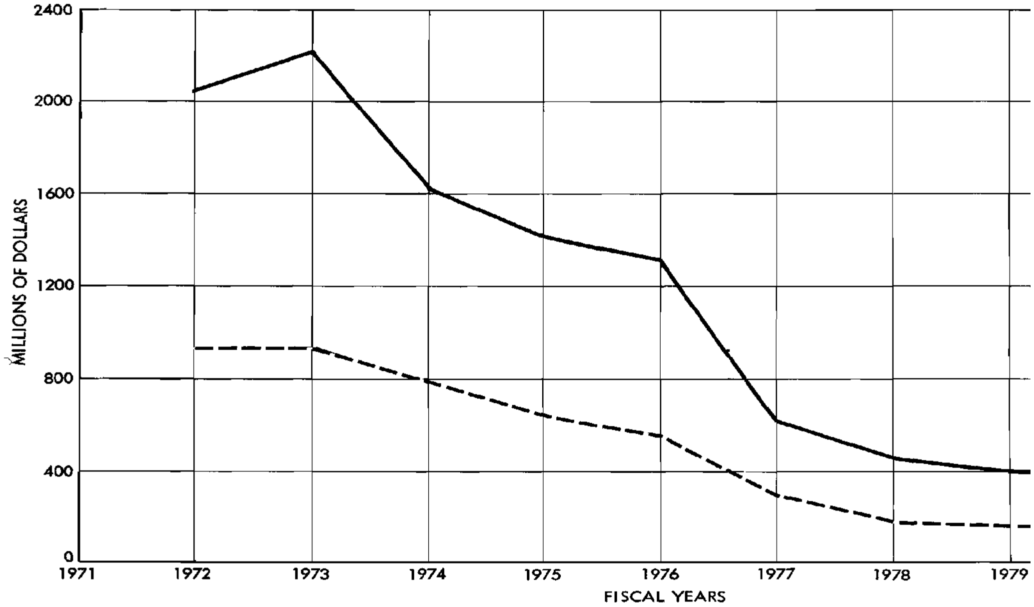
FIGURE 23(~~TS~~). Estimated Total Obligational Authority for Sea-Based Missile Force Options (FY 1972 - FY 1981)(Billions of Dollars)(U)



MAXIMUM (JFM-ALTERNATIVE)	0	0	0	0	2	3	6	12	12
MINIMUM (JFM-DECREMENT-B)	0	0	0	0	2	3	4	4	4

8-10-70-16

FIGURE 24 ~~(TS)~~ SAFEGUARD Packages (U)

8 SITE	0	0	0	0	2	3	6	8	8
1 SITE NCA	0	0	0	0	0	0	1	1	1

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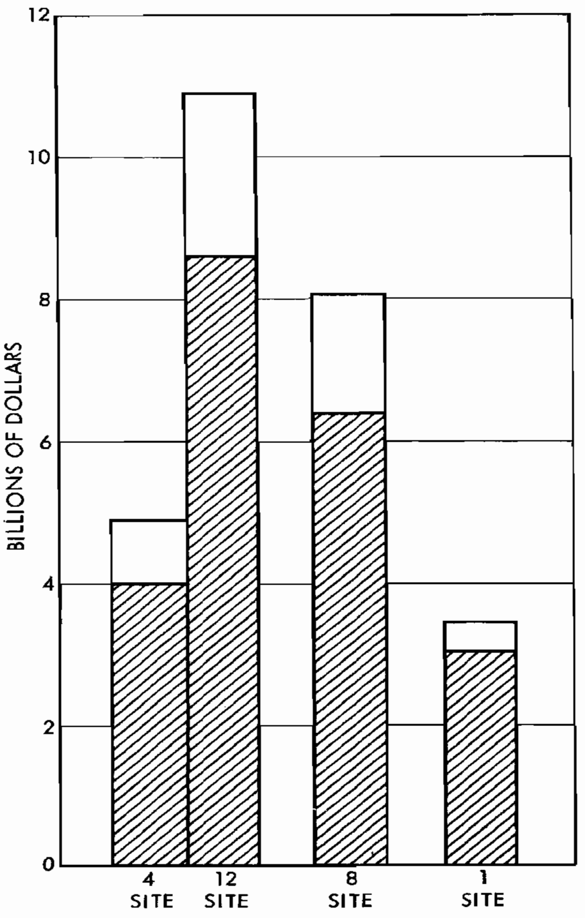
FIGURE 25(~~TS~~). SAFEGUARD Options (U)



	MIN	MAX		
REFERENCE FORCE	DECR B	JFM ALT.	SWS	SWS
FIVE-YEAR TOTAL FY 1972 - FY 1976	3.95	8.64	6.37	3.03
TEN-YEAR TOTAL FY 1972 - FY 1981	4.90	10.90	8.06	3.45

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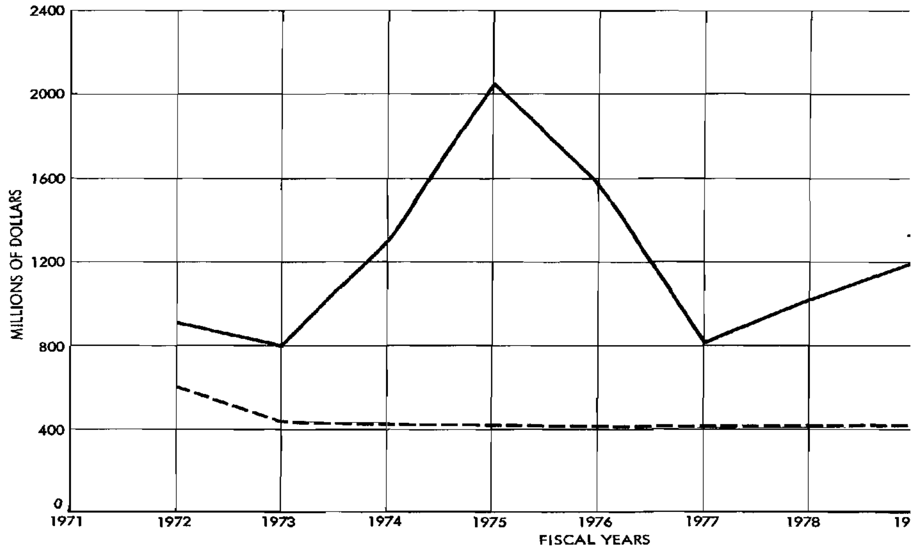
FIGURE 26~~(TS)~~. Estimated Total Obligational Authority for SAFEGUARD Options (FY 1972 - FY 1981)(Billions of Dollars)(U)



MAXIMUM (JSOP)	F-106	252	252	252	252	252	234	216	198
	IMI-F-15	0	0	0	0	0	18	36	54
	NIKE-HERCULES	1398	861	861	861	861	861	861	861
	SAM-D	0	0	0	0	0	0	0	0
	C-130 DEF A/L	0	0	0	0	0	18	40	40
	AEW & C	46	46	46	46	46	46	0	0
	AWACS	0	0	0	0	0	7	37	42
MINIMUM (FISCAL GUIDANCE)	F-106	220	100	100	100	100	100	100	100
	NIKE-HERCULES	1398	290	290	290	290	290	290	290
	AEW & C	46	0	0	0	0	0	0	0
	AWACS	0	0	0	0	0	0	0	0

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FIGURE 27 ~~(TS)~~. Defensive Force Package (Excludes SAFEGUARD -- Inclu
Defense Control and Surveillance)(U)

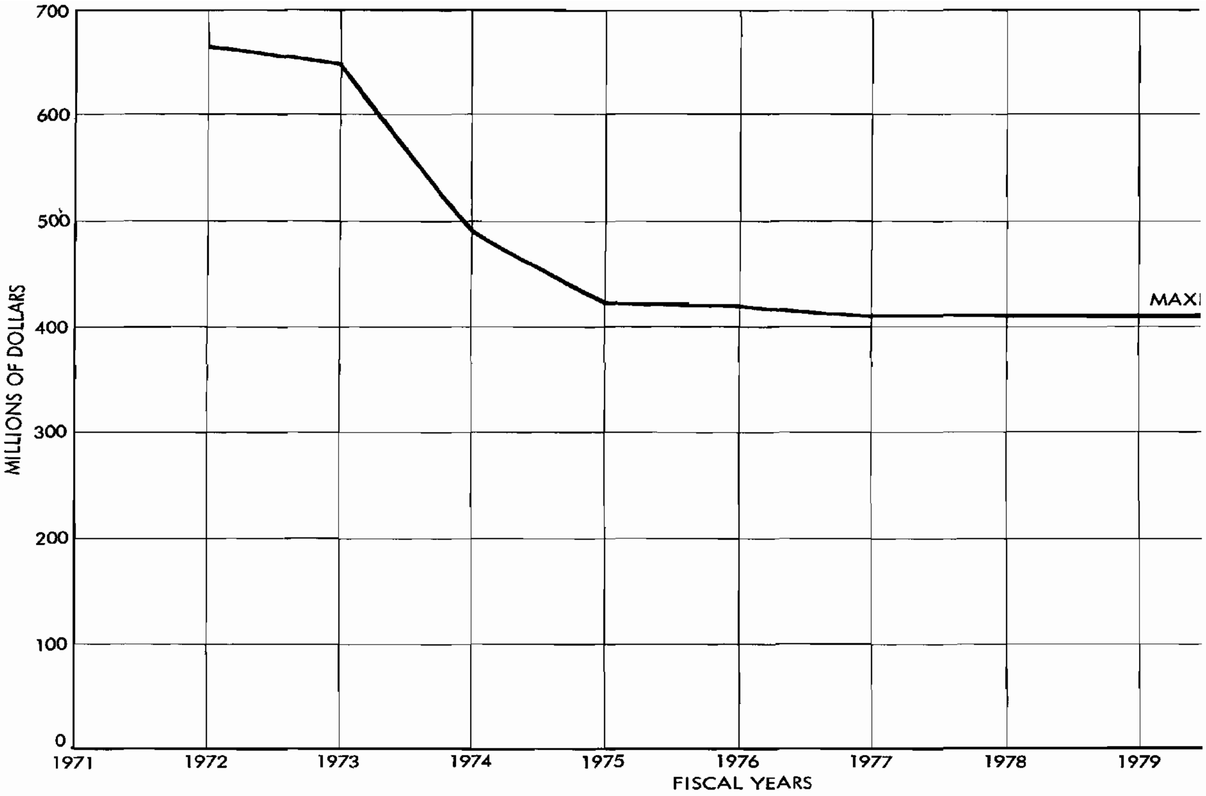

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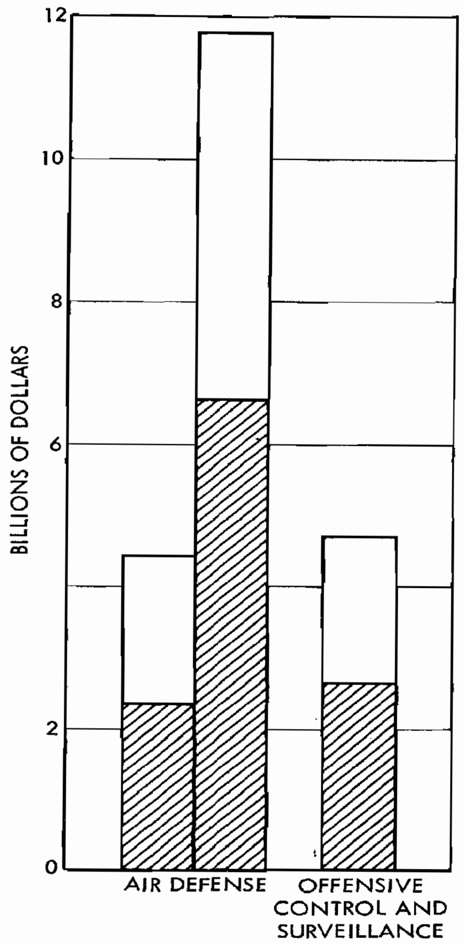
FIGURE 28 ~~(TS)~~. Offensive Control and Surveillance Forces (U)



	MIN	MAX	
REFERENCE FORCE	FISC. GUID.	JSOP	JFM ALT.
FIVE-YEAR TOTAL FY 1972 - FY 1976	2.33	6.64	2.64
TEN-YEAR TOTAL FY 1972 - FY 1981	4.43	11.88	4.69

8-10-70-21

FIGURE 29~~(TS)~~. Estimated Total Obligational Authority for Defensive Forces and Offensive Control and Surveillance Forces (FY 1972 - FY 1981)(Billions of Dollars)(U)

B. STUDY FORCE OPTIONS

(U) Estimated TOA requirements for strategic offensive and defensive force options are defined by the study team as they relate to various budget levels presented in this section of the report.

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(DAL) package containing arbitrary amounts of funds for the developments of an area defense system and an expanded civil defense program is added to the Low and High AD packages with the 12 site SAFEGUARD deployment to indicate that this option is well beyond any current funding considerations for both 5-year periods.

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TOTAL DOD BUDGETS IN FY 72-76	80-70-60
TOTALS FOR STRATEGIC FORCES	
- YEARLY AVERAGE	10-8-6
- 5-YEAR TOTAL	
TOTALS FOR OFFENSIVE FORCES	
- YEARLY AVERAGE	6-5-4
- 5-YEAR TOTAL	
TOTALS FOR DEFENSIVE FORCES	
- YEARLY AVERAGE	2-2-1
- 5-YEAR TOTAL	
TOTALS FOR CONTROL AND SURVEILLANCE FORCES	
- YEARLY AVERAGE	2-1-1
- 5-YEAR TOTAL	

*The high end generally corresponds to the FY 72-79 JSOP; the low end to the reduced (double-decremental) budget levels currently being considered.

7-23-70-1

FIGURE 30 (~~TS~~). Fiscal Constraint Guidelines (Billions of Dollars)

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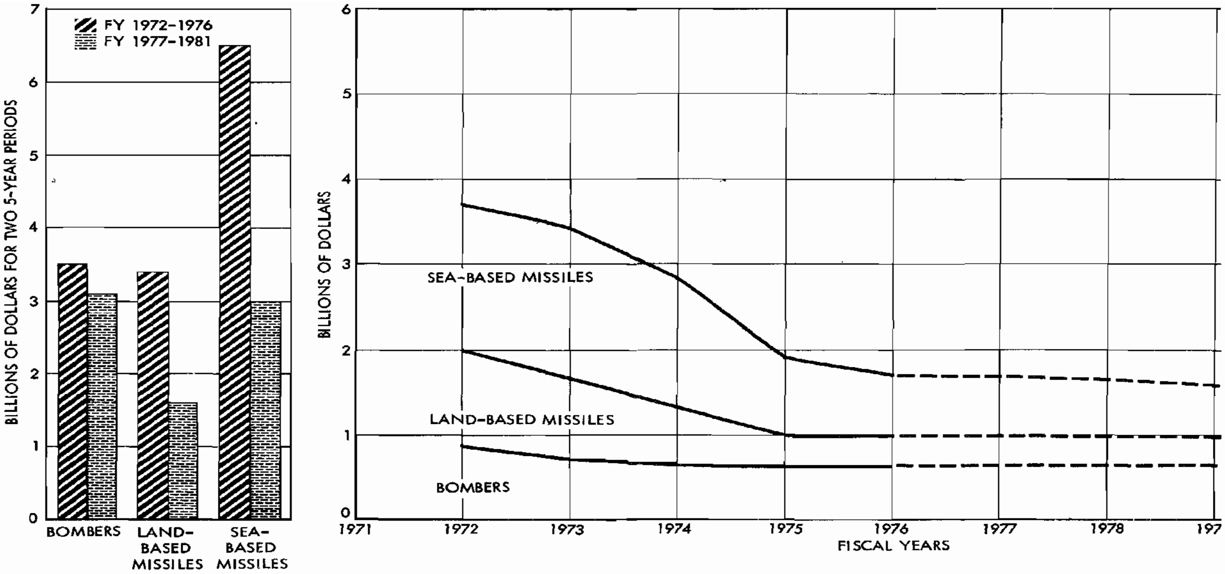

FORCE BUILDUP FOR	B-52	420	315	255	255	255	255	255	255	24
	FB-111A	60	60	60	60	60	60	60	60	6
	HOUNDOG	340	340	330	330	330	330	330	330	28
	KC-135	615	480	470	470	470	470	470	470	47
	TITAN	54	0	0	0	0	0	0	0	
	MM I/II	890	790	670	554	450	450	450	450	45
	MM III	110	210	330	446	550	550	550	550	55
	POLARIS/POSEIDON	41	41	41	41	41	39	39	36	3
	FBMS	11	11	11	11	11	11	11	11	1

*TOTAL OBLIGATIONAL AUTHORITY

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FIGURE 31 ~~(TS)~~. Estimated Costs* – Strategic Offensive Force Elements, SWS
(FY 1972 – 1976, FY 1976 – 1981)(U)

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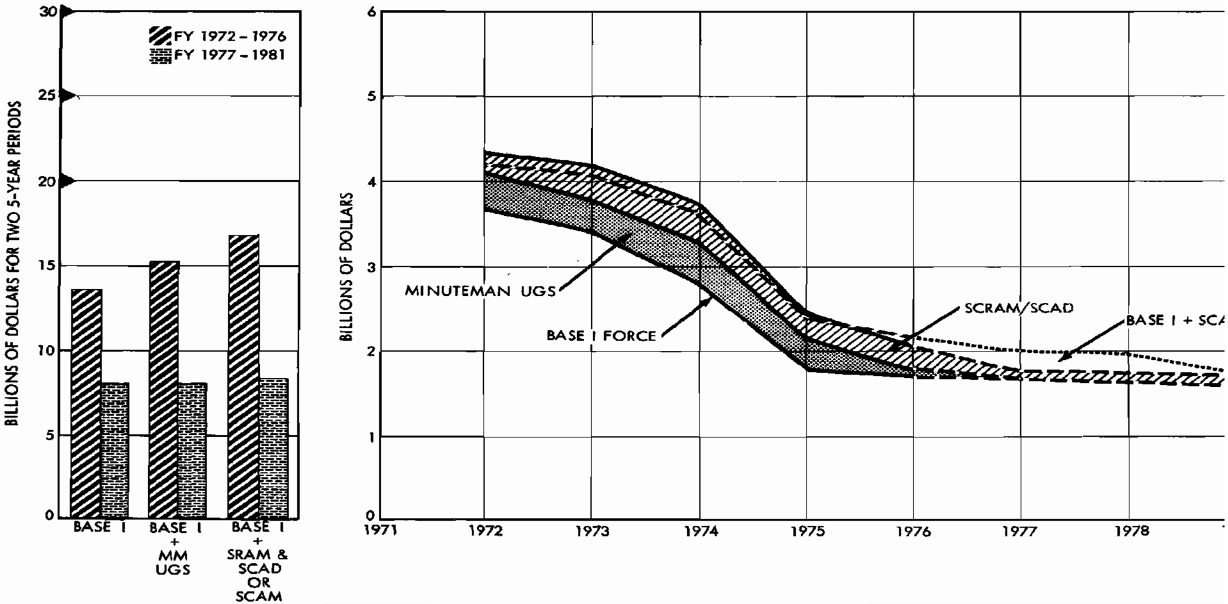

FORCE BUILDUP FOR	MM UGS	0	0	125	375	625	875	1000	1000
	SRAM	0	57	410	865	1350	1425	1425	1425
	SCAD	0	0	0	0	300	720	1020	1020
	SCAM	0	0	0	0	300	720	1560	2400

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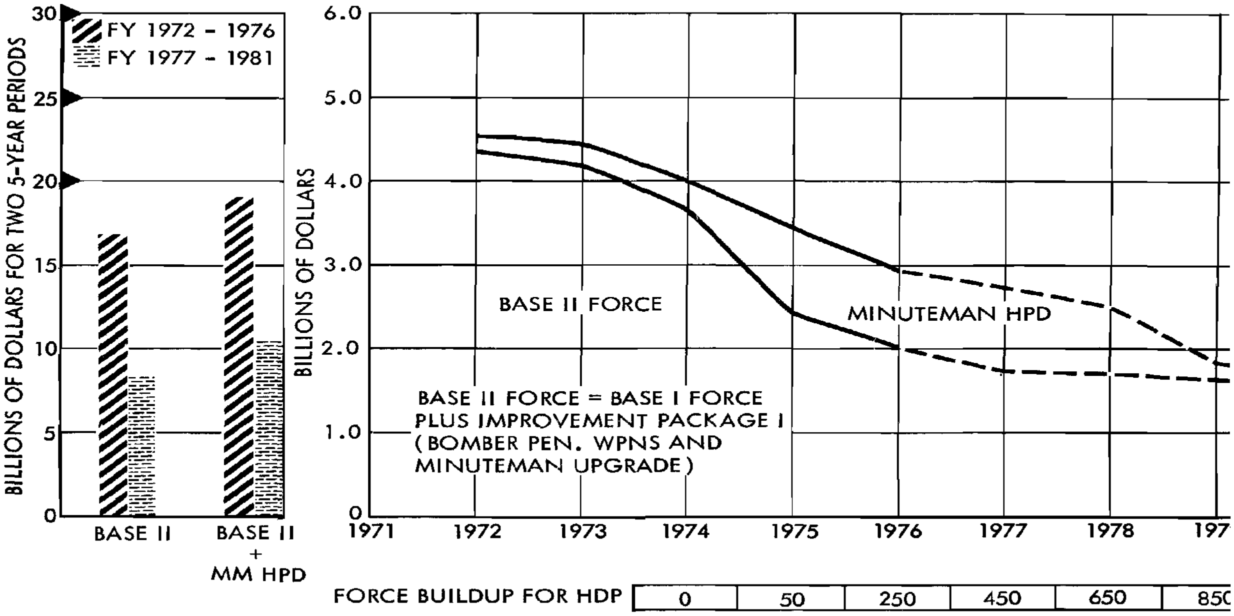
*TOTAL OBLIGATIONAL AUTHORITY

FIGURE 32 ~~(TS)~~. Estimated Costs* – Strategic Offensive Force Elements, SWS
Plus Modest Improvements to Bomber and Land-Based Missil
(FY 1972 - 1976, FY 1976 - 1981)(U)

~~TOP SECRET~~



*TOTAL OBLIGATI

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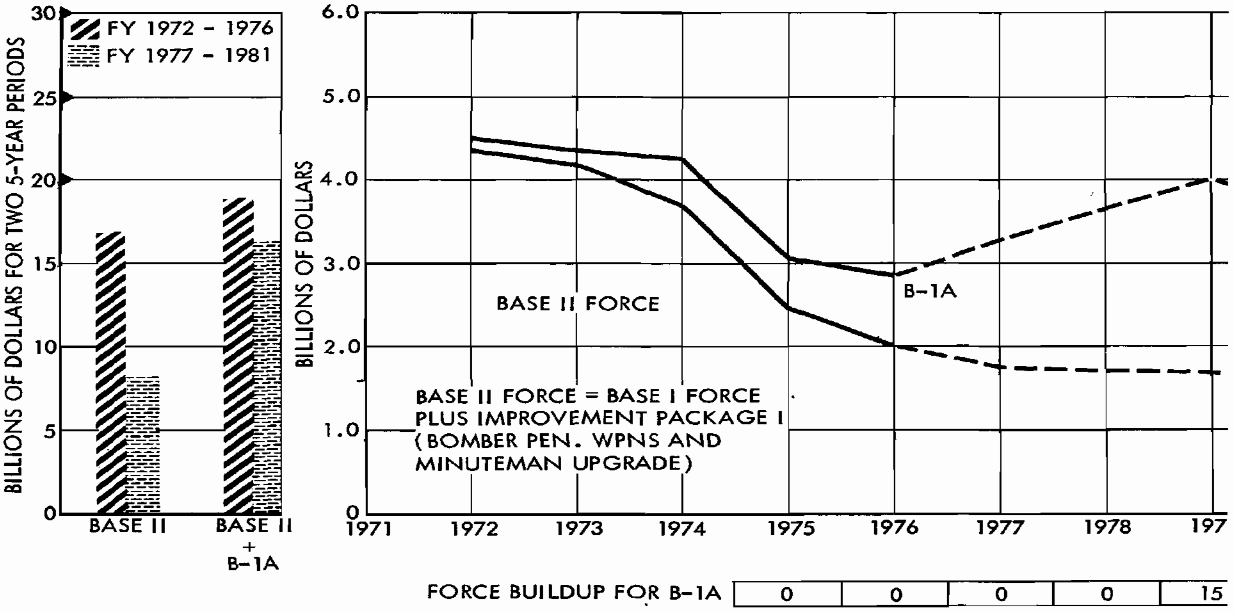
FIGURE 33 ~~(TS)~~. Estimated Costs* - Strategic Offensive Force Elements, SWS Bas Plus Hard Point Defense of MINUTEMAN UGS (FY 1972 - 1976, FY 1976 - 1981)(U)



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* TOTAL OBLIGATI

FIGURE 34 ~~(TS)~~. Estimated Costs* – Strategic Offensive Force Elements, SWS Bas
Plus B-1A (FY 1972 - 1976, FY 1976 - 1981)(U)

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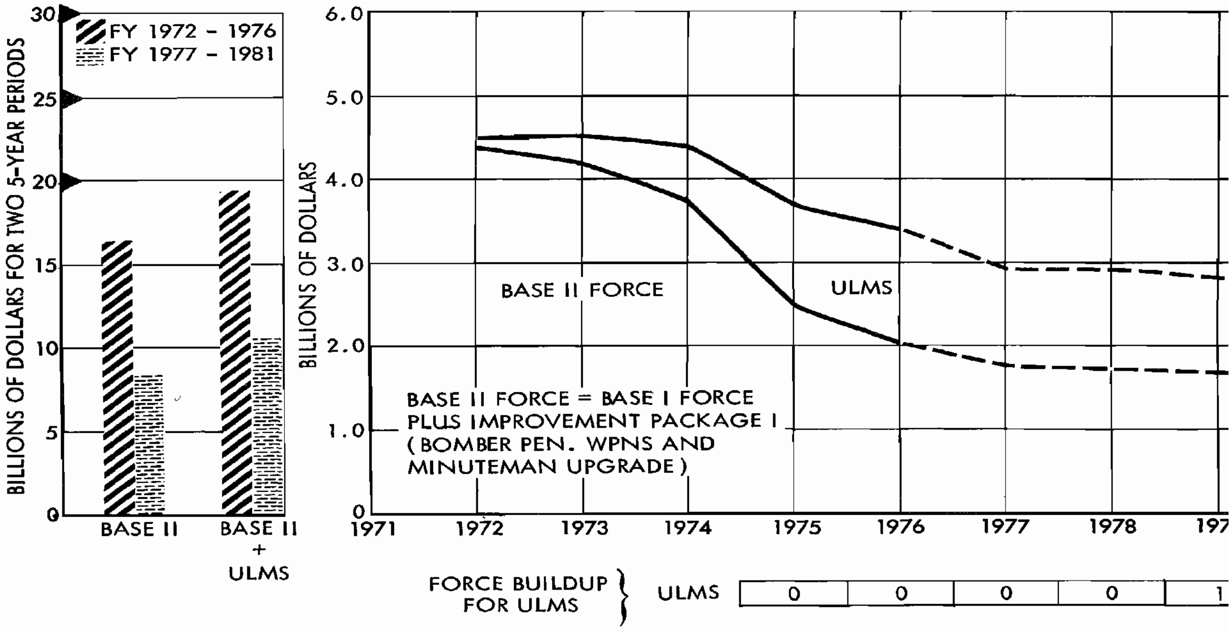
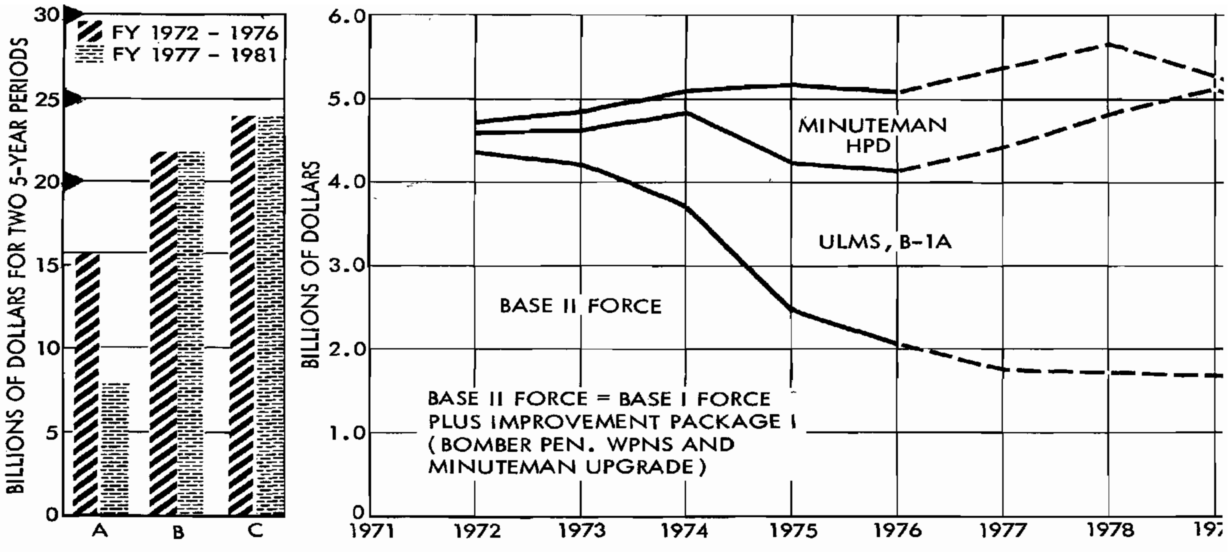


*TOTAL OBLIGAT

7-24-70-6

FIGURE 35 ~~(TS)~~. Estimated Costs* – Strategic Offensive Force Element, SWS Base Plus ULMS (FY 1972 – 1976, FY 1976 – 1981)(U)



FORCE BUILDUP FOR	ULMS	0	0	0	0	0	1
	B-1A	0	0	0	0	0	15
	HPD	0	50	250	450	650	85

A. BASE FORCE + IMPROVEMENT PACKAGE I (BOMBER PENETRATION WEAPONS AND MINUTEMAN UPGRADE)

B. BASE FORCE + IMPROVEMENT PACKAGE I + ULMS AND B-1A

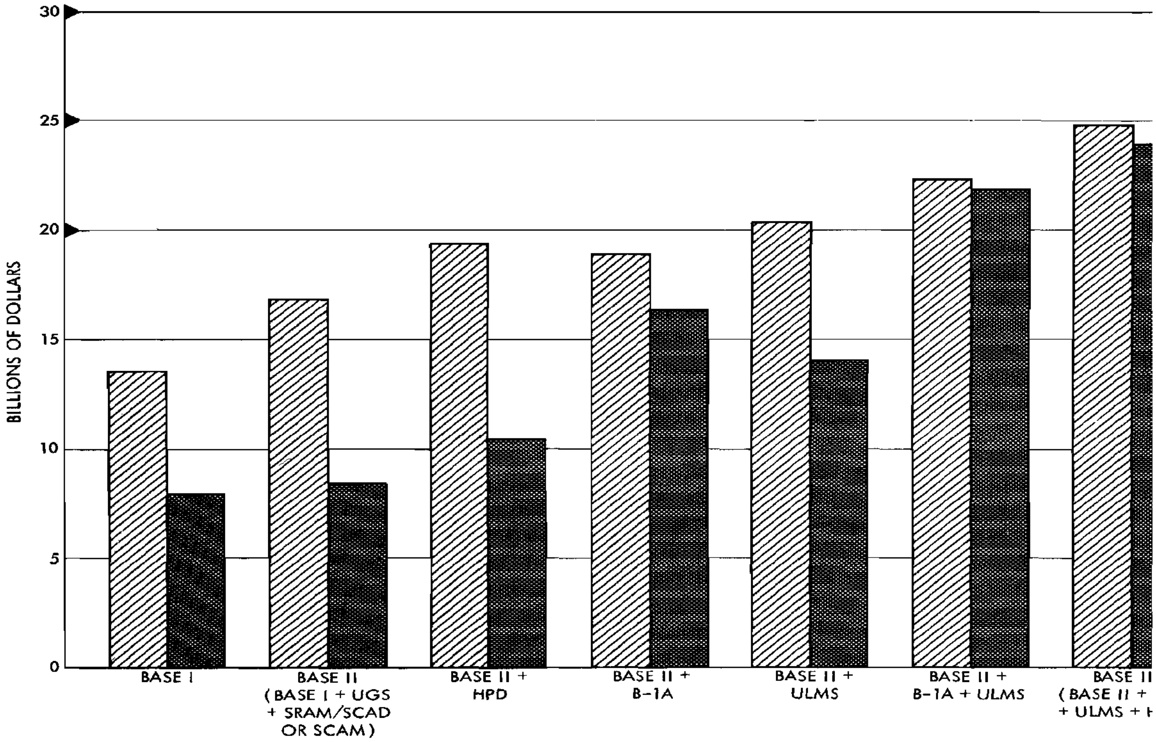
C. BASE FORCE + IMPROVEMENT PACKAGE I + ULMS, B-1A AND HPD

* TOTAL OBLIG

7-22-70-23

FIGURE 36 ~~(TS)~~. Estimated Costs* – Strategic Offensive Force Element, SWS Bas
Plus ULMS and B-1A and HPD (FY 1972 - 1976, FY 1977 - 1

~~TOP SECRET~~

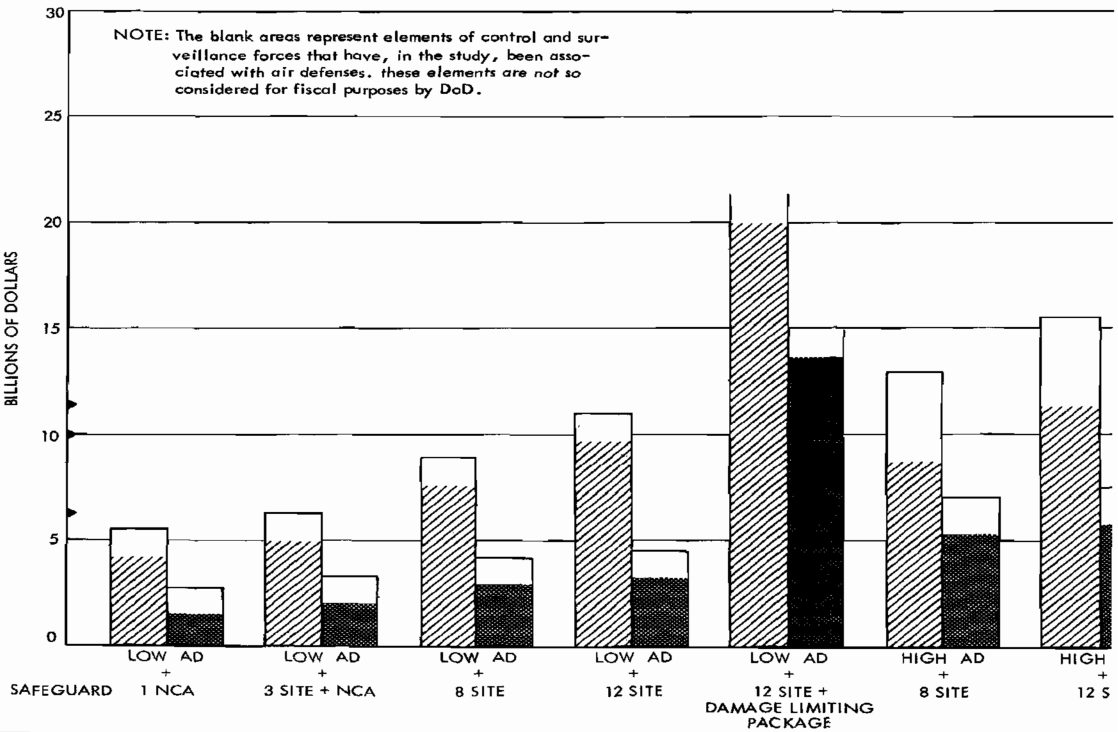


FY 1972 - FY 1976	13.58		16.83		19.35		18.88		20.30		22.34		24.86	
FY 1977 - FY 1981		7.93		8.39		10.47		16.24		14.00		21.86		2

7-24-70-2

FIGURE 37 (~~TS~~). SWS Offensive Force Options - Estimated Costs (FY 1972 - 1976, F

~~TOP SECRET~~



NOTE: The blank areas represent elements of control and surveillance forces that have, in the study, been associated with air defenses. these elements are not so considered for fiscal purposes by DoD.

FY 1972 - FY 1976	5.4		6.3		8.7		11.0		21+		13.0		15.7	
FY 1977 - FY 1981		2.5		3.1		3.8		4.4		14+		6.9		

8-21-70-1

LOW AD AND HIGH AD REPRESENT A RANGE OF PROPOSED AIR DEFENSE COMMITMENTS

FIGURE 38 ~~(TS)~~. SWS Defensive Force Options - Estimated Costs (FY 1972 - 1976, FY

APPENDIX A

COST MODEL DESCRIPTION

COST MODEL DESCRIPTION

(U) A computer program was developed to aid the Cost Analysis Panel in performing the calculations necessary to estimate the total cost of various strategic forces. The total cost of a strategic force is an aggregation of the total cost of several individual weapon systems, each of which comprises the cost of RDT&E, Investment, Operating and Support. The cost estimating equations used by the model to determine the cost of elements within these cost categories are of three general types.

(U) The first type takes the form of a constant equation. This type is used to throughput the total RDT&E cost and to add a constant sum to the Investment and Operating categories.

(U) The second type of equation is exponential. It is essentially a total cumulative cost curve from which the aircraft procurement, missile procurement, and military construction costs of the Investment category are derived. An occasional weapon system has more than one component that make up the cost of aircraft procurement, missile procurement, or military construction. The model has been programmed to compute the costs of these components using this same exponential equation form. Only the sum of the components within each class is given as output.

(U) The third type of equation is linear and is used to derive all the support costs as well as the aircraft, missile, and other procurement recurring costs.

(U) Listed in the table below are the cost elements the RDT&E, Investment, Operating, and Support categories that are of interest. Corresponding to each is the type of cost estimating equation incorporated into the program for computing their costs. Following the table is a more detailed description of each equation type and of the procedures included in the computer model for deriving total weapon system costs and total strategic forces costs.

Table A-1

	Any Year
RDT&E Thruput	Type I
Aircraft Procurement	Type II
Missile Procurement	Type II
Military Construction	Type II
Aircraft Procurement--Recurring	Type III
Missile Procurement--Recurring	Type III
Other Procurement--Recurring	Type III
Investment Thruput	Type I
Total Investment	Type I
Operating and Maintenance	Type III
Military Personnel	Type III
Operating Thruput	Type I
Total Operating	
Total Direct	
Base Operating Support	Type III
Training Support	Type III
Logistic Support	Type III
Total Support	
TOTAL WEAPON SYSTEM	

Type I

(U) This type indicates a throughput value. That is, the item is not computed in the program but is treated as a final estimate.

Type II

(U) The cost elements corresponding to this type are estimated using an equation of the form:

$$C_i = a\,(X_i^b - X_{i-1}^b)$$

where

C_i = the total cost of quantity $(X_i - X_{i-1})$ for any year i ranging from 1972 to 1981;

a = the unit cost at quantity 1;

X_i = the cumulative procurement quantity through the end of year i, i = 1972 to 1981; and

b = the exponent.

(U) The exponent b is calculated within the program by taking the quotient of the logarithm of 2 • k and the logarithm of 2, where k is the learning curve slope. Algebraically, $b = \log(2k)/\log 2$.

(U) The model also calculates the X_i's, the cumulative procurement quantities. The value of X_i for any given year, i, ($1972 \leq i \leq 1981$) is obtained by summing the yearly procurement, p_j, for all years up to and including year i. This can be expressed algebraically by the equation:

$$X_i = \sum_{j=1971}^{i} P_j$$

(U) Computer inputs that are required for Type II equations are:

a, the first unit cost (in millions of dollars);

k, the learning curve slope; and

p_j, the procurement quantity for year j, $j = 1971$ to 1981.

p_{1971} is considered to be the prior buy--the number of that particular element already procured by 1972.

Type III

(U) This type indicates that the cost of the element is derived by multiplying a cost factor by the average of year end forces. In generalized form the equation is:

$$C_i = f \cdot \frac{(y_i + y_{i-1})}{2}$$

where

C_i = the total cost in year i, i ranging from 1972 to 1981;

f = the cost factor corresponding to the element being estimated; and

y_i = the force level in year i, i ranging from 1972 to 1981.

(U) Necessary inputs for Type III equations are:

f, the cost (in millions of dollars) per unit of a given cost element; and

y_i, the number of units in the force structure in year i, i = 1972 to 1981.

(U) Upon completion of the computations necessary to arrive at the total cost of each weapon system, the computer prints out, in the sequence indicated in Table A-1, the cost of each element, in millions of dollars, for years 1972 to 1981. Included also are the total Investment, total Operating, and total Support costs as well as the total Direct (sum of all RDT&E, Investment, and Operating cost) and total Weapon System costs.

(U) The final table of output shows the aggregation of RDT&E, Investment, Operating, Direct, Support and Grand Total costs, for each of the 10 years between 1972 and 1981, of all the weapon systems within the specified strategic force.

APPENDIX B

WEAPON SYSTEM ESTIMATING RELATIONSHIPS

COST MODEL INPUT VALUES

(U) Tables B-1 through B-23 display the detailed input values for all weapon systems in the strategic forces discussed in Appendix D. Force level, procurement, and construction funding schedules of a particular force structure are shown for all weapon systems. These values, however, change when the force structure changes.

(U) A detailed explanation of the computation procedures for using these values is included in Appendix A, and force cost estimates resulting from their use are shown in Appendix D.

(b)(1)

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

APPENDIX C

COSTS OF ALTERNATIVE STRATEGIC WEAPON SYSTEMS

COSTS OF ALTERNATIVE STRATEGIC WEAPON SYSTEMS

(b)(1)

Table C-1 ~~(S).~~ COSTS OF ALTERNATIVE STRATEGIC WEAPON SYSTEMS (U)

(Total Obligational Authority in Millions of Dollars)

(b)(1)

(b)(1)

[redacted]

(b)(1)

[redacted]

APPENDIX D

COSTS OF ALTERNATIVE STRATEGIC PLANNING FORCES

COSTS OF ALTERNATIVE STRATEGIC PLANNING FORCES

(b)(1)

[redacted]

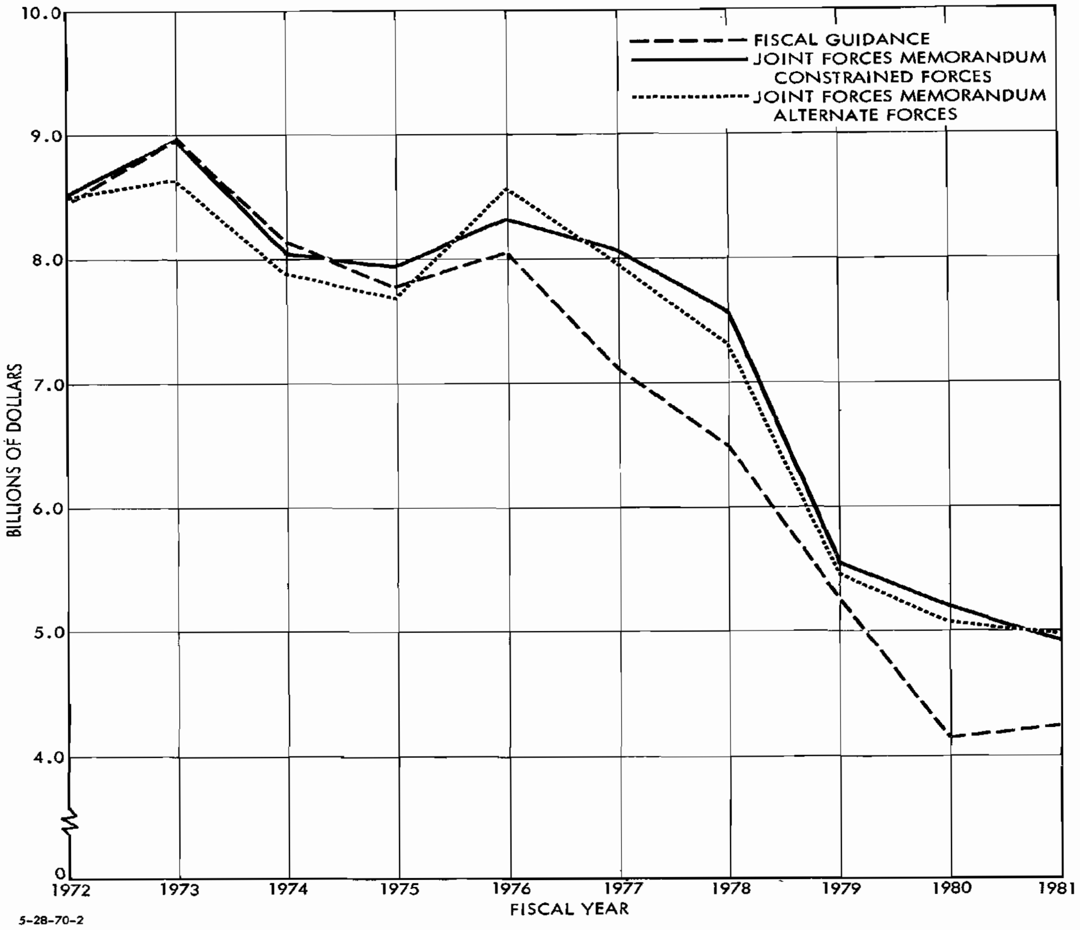


FIGURE D-1 ~~(TS).~~ Alternative Strategic Forces Estimated Total Obligational Authority (U)

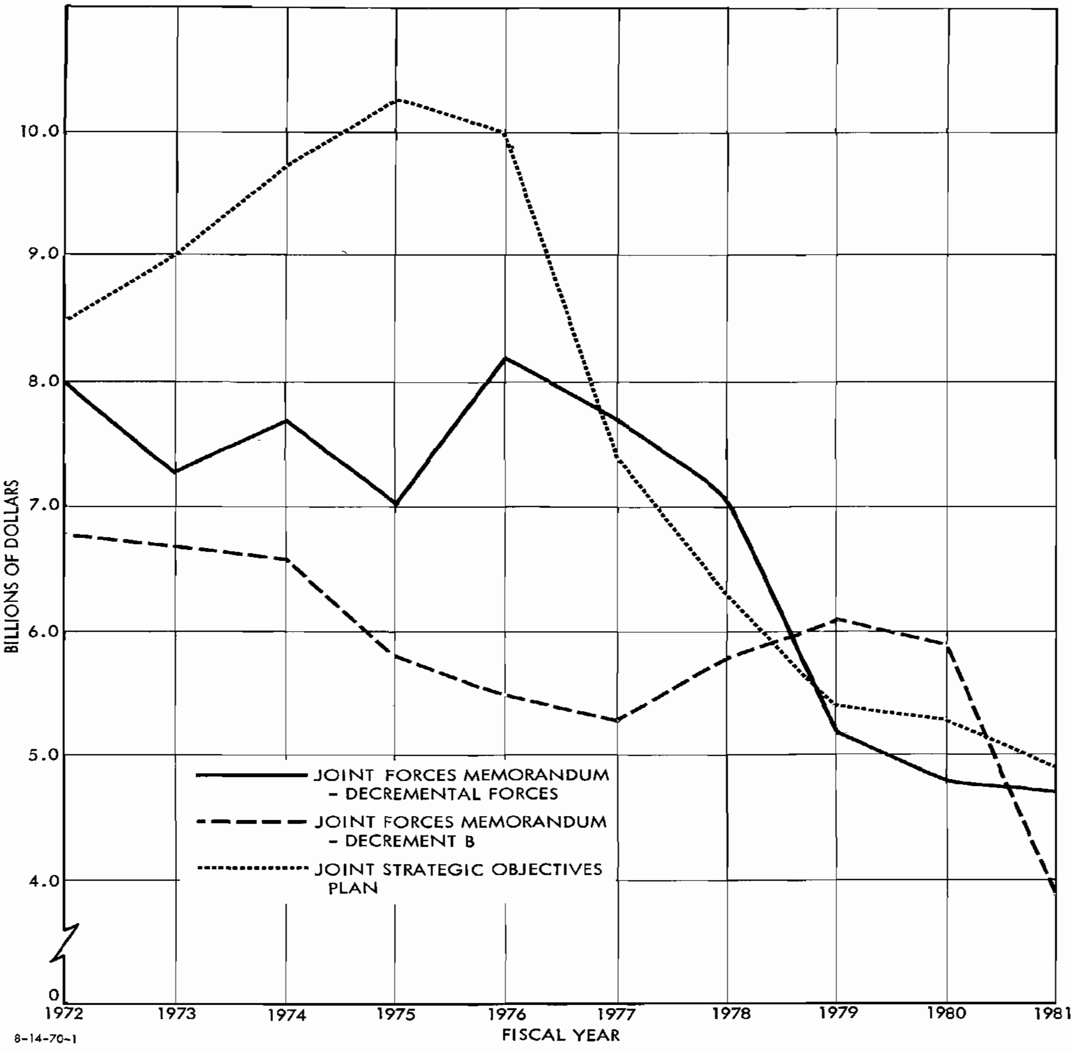


FIGURE D-2 ~~(TS)~~ Strategic Force Fiscal Guidance (Extrapolated)
(Total Obligational Authority) (U)

A. ILLUSTRATIVE FORCE

~~(S)~~ The illustrative force of the OSD Tentative Fiscal Guidance was used by OSD to generate fiscal guidance to the JCS and the Services for formulating force plans for FY 1972 through FY 1976. Tables D-1 through D-5 contain the detailed force and cost information for the illustrative force.

~~(S)~~ Selected systems which generate large outlays of funds due to their development and introduction into the inventory are the Air Force's B-1 aircraft system, the Navy's Undersea Long-range Missile System (ULMS), and the Army's Safeguard ABM defense system. Other systems worth noting are (1) the decline of the B-52 force, (2) the introduction of the MINUTEMAN (b)(1), and (3) the funds assoicated with the POSEIDON conversion program of 31 boats.

B. JOINT FORCES MEMORANDUM--CONSTRAINED FORCE

~~(TS)~~ The initial response by the Joint Chiefs of Staff to the OSD Fiscal Guidance Memorandum was the development of the JFM-constrained force. The constraint that was imposed upon the development of the force was that of funds. The total funding presented in the fiscal guidance was to be retained by Service total and by mission categories.

~~(TS)~~ Tables D-6 through D-10 present the force units and estimated TOA for the JFM-constrained force. The major changes in this force compared to the illustrative force were:

(b)(1)

(2) The phase-out of units already in the inventory were slowed down, if not completely avoided. This retention of units was present in all of the sub-missions.

(3) The ULMS IOC data was retained in FY 1979, but the rate of deployment was reduced.

(4) The B-1 system IOC date was moved 2 years forward to FY 1977.

(5) Three new systems were introduced into the inventory: namely, the AWACS in FY 1976, the IMI F-15 in FY 1976 and the SAM-D in FY 1979.

C. JOINT FORCES MEMORANDUM--ALTERNATE FORCE

~~(TS)~~ The Joint Chiefs of Staff also responded with an alternative force which retained the funding constraint by service total, but allowed funding transfers between major missions.

~~(TS)~~ Tables D-11 through D-15 present the force units and estimated TOA for the JFM-alternate force. The results indicate a decline in strategic force costs compared to the JFM-constrained force which was offset primarily by an increase in General Purpose Forces funding levels.

~~(TS)~~ The major changes in this force, when compared to the constrained force, are:

(1) B-1 procurement was reduced by one aircraft per year in FY 1974 and 1975 but increased in FY 1976. The delivery schedule slips by three months, and FY 1973 RDT&E funding requirements are reduced.

(2) ULMS initial operational date is delayed one year.

(3) POSEIDON boat conversions proceed at the JCS recommended rate, which is less than in the constrained force.

D. JOINT FORCES MEMORANDUM--DECREMENTAL FORCES

~~(TS)~~ The Joint Chiefs of Staff also responded to the OSD Fiscal Guidance with the JFM decremental force. The decremental force was designed to effect significant DoD-wide budget decreases.

~~(TS)~~ Tables D-16 through D-20 present the force units and estimated TOA for the JFM decremental force. The results indicate a decline in strategic force costs compared to the fiscal guidance, JFM constrained, and JFM alternate forces representing a part of the intended total DoD budget decline of $1.0 billion per year for each military department.

~~(TS)~~ The major changes in this force, when compared to the JFM--alternate force, are as follows:

(1) The SAFEGUARD system deployment was reduced from 12 sites to 8 sites.

(2) The B-52 C&Fs would be reduced from nine to five squadrons by FY 1973 and phased out by FY 1979. The B-52 G&H's would be reduced from 17 to 14 squadrons in FY 1970 with an appropriate reduction in the HOUNDOG missiles force in FY 1979.

(3) Numerous other dollar reductions result from the phase out of all TITAN missiles by FY 1972, cancellation of certain MINUTEMAN III guidance improvements, phase out of all five U.S. BOMARC squadrons, reduced F101/106 fighter interceptor forces, reduced NIKE-HERCULES batteries with a corresponding reduction in the Army Air Defense Command Posts, a one-year slippage in the IOC of the new Air Force Airborne Command Post, and a reduction in the force level of AEW&C (EC-121)aircraft.

E. JOINT FORCES MEMORANDUM, DECREMENT B

~~(TS)~~ After the JCS responded to the initial OSD fiscal guidance with a Joint Forces Memorandum containing the constrained, alternative, and decremental forces, the OSD requested that the JCS design two more planning forces and that they reflect an additional decrement from the total DoD budget of $2.0 billion per Service per year. The OSD-imposed ground rules for designing the first force (i.e., Decremental Alternative A) required that the strategic force remain within the original fiscal guidance. The strategic forces and TOA requirements for Decremental Alternative A are, therefore, identical to the JFM constrained force (described previously) which was designed under the same ground rules. The Decremental Alternative B strategic force was based on the assumption that the Naval Fleet Ballistic Missile System part of the strategic force would remain within the original fiscal guidance (i.e., unchanged from the JFM constrained force) whereas any other part of the strategic forces could be changed to achieve the required total DoD decrement. Tables D-21 through D-25 present the force units and their estimated TOA for this force.

~~(TS)~~ The major changes in this force when compared to the JFM Decremental forces, are as follows:

(1) The B-52 C&Fs would be phased out by FY 1973 and the B-1As IOC would be delayed 2 years to FY 1979. SRAM and KC-135 force levels would also be reduced reflecting the smaller bomber force.

(2) The SAFEGUARD system deployment was reduced from 8 to 4 sites.

(3) More of the NIKE-HERCULES missiles are kept in this force, but the plans to acquire the IMI-F-15 and SAM-D systems are dropped and only RDT&E money is provided for the AWACS system.

F. JOINT FORCES MEMORANDUM, JOINT STRATEGIC OBJECTIVES PLAN

~~(TS)~~ The JSOP forces differ from the previous five forces because they were not subject to fiscal constraints, but were derived by the JCS, based on considerations of U.S. strategic objectives.

~~(TS)~~ Tables D-26 through D-30 present the force units and their estimated TOA for this force.

~~(TS)~~ Compared to the previous five forces, the JSOP forces are characterized by:

(1) Earlier IOCs for new weapon systems such as the B-1A, ULMS, and AWACS.

(2) Retention of greater quantities of existing systems such as the B-52 and NIKE-HERCULES.

(3) Higher force levels for new systems such as MINUTEMAN III, SRAM, and SCAD.

~~(TS)~~ As a result of the above factors total strategic TOA requirements for JSOP strategic forces are the highest of the six forces discussed in this appendix.

Table D-1 ~~(S)~~ ILLUSTRATIVE FORCE - STRATEGIC FORCE STRUCTURE (U)

(Extrapolated)

(b)(1)

[redacted]

Table D-2 ~~(S)~~. ILLUSTRATIVE FORCE - STRATEGIC RDT&E (U)
(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-3 ~~(S)~~ ILLUSTRATIVE FORCE - STRATEGIC INVESTMENT (U)
(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

[redacted]

Table D-4 ~~(S)~~ ILLUSTRATIVE FORCE -STRATEGIC OPERATIONS (U)
(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-5 ~~(S).~~ ILLUSTRATIVE FORCE - STRATEGIC TOTAL (U)
(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-6 ~~(TS)~~ JOINT FORCES MEMORANDUM--CONSTRAINED FORCES STRATEGIC FORCE STRUCTURE (U)

(Extrapolated)

(b)(1)

[redacted]

Table D-7 ~~(TS)~~. JOINT FORCES MEMORANDUM CONSTRAINED FORCES STRATEGIC RDT&E (U)

(Total Obligational Authority) (Millions of Dollars)*

(b)(1)

[redacted]

Table D-8 ~~(TS)~~. JOINT FORCES MEMORANDUM CONSTRAINED FORCES STRATEGIC INVESTMENT (U)

(Total Obligational Authority) (Millions of Dollars)*

(b)(1)

Table D-9 ~~(TS).~~ JOINT FORCES MEMORANDUM CONSTRAINED FORCES STRATEGIC OPERATIONS (U)

(Total Obligational Authority) (Millions of Dollars)*

(b)(1)

Table D-10 ~~(TS)~~. JOINT FORCES MEMORANDUM--CONSTRAINED FORCES STRATEGIC MISSION--TOTAL COSTS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

[redacted]

Table D-11 ~~(TS)~~. JOINT FORCES MEMORANDUM--ALTERNATIVE FORCES STRATEGIC FORCE STRUCTURE (U)

(b)(1)

Table D-12 ~~(TS)~~ JOINT FORCES MEMORANDUM--ALTERNATIVE FORCES
STRATEGIC RDT&E (U)
(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-13 ~~(TS).~~ JOINT FORCES MEMORANDUM--ALTERNATIVE FORCES STRATEGIC INVESTMENT (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-14 ~~(TS)~~ JOINT FORCES MEMORANDUM--ALTERNATIVE FORCES STRATEGIC OPERATIONS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-15 ~~(TS)~~ JOINT FORCES MEMORANDUM--ALTERNATIVE FORCES STRATEGIC MISSION--TOTAL COSTS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-16 ~~(TS)~~. JOINT FORCES MEMORANDUM--DECREMENTAL FORCES STRATEGIC FORCE STRUCTURE (U)

(Extrapolated)

(b)(1)

Table D-17 ~~(TS)~~ JOINT FORCES MEMORANDUM--DECREMENTAL FORCES STRATEGIC RDT&E

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-18 ~~(TS)~~ JOINT FORCES MEMORANDUM--DECREMENTAL FORCES STRATEGIC INVESTMENT (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-19 ~~(TS)~~. JOINT FORCES MEMORANDUM--DECREMENTAL FORCES STRATEGIC OPERATIONS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-20 ~~(TS).~~ JOINT FORCES MEMORANDUM--DECREMENTAL FORCES STRATEGIC MISSION - TOTAL COSTS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

[redacted]

Table D-21 ~~(TS)~~. JOINT FORCES MEMORANDUM DECREMENT B STRATEGIC FORCE STRUCTURE (EXTRAPOLATED) (U)

(b)(1)

Table D-22 ~~(TS).~~ JOINT FORCES MEMORANDUM DECREMENT B STRATEGIC RDT&E (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

[redacted]

Table D-23 ~~(TS).~~ JOINT FORCES MEMORANDUM DECREMENT B STRATEGIC INVESTMENT (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-24 ~~(TS)~~. JOINT FORCES MEMORANDUM DECREMENT 8 STRATEGIC OPERATIONS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

[redacted]

Table D-25 ~~(TS)~~ JOINT FORCES MEMORANDUM DECREMENT B STRATEGIC MISSION--TOTAL COSTS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-26 ~~(TS)~~. JOINT FORCES MEMORANDUM--JOINT STRATEGIC OBJECTIVES PLAN STRATEGIC FORCE STRUCTURE (U)

(b)(1)

Table D-27 ~~(TS)~~ JOINT FORCES MEMORANDUM--JOINT STRATEGIC OBJECTIVES PLAN STRATEGIC RDT&E (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-28 ~~(TS)~~. JOINT FORCES MEMORANDUM--JOINT STRATEGIC OBJECTIVES PLAN STRATEGIC INVESTMENT (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-29 ~~(TS)~~. JOINT FORCES MEMORANDUM--JOINT STRATEGIC OBJECTIVES PLAN STRATEGIC OPERATIONS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

Table D-30 ~~(TS)~~ JOINT FORCES MEMORANDUM--JOINT STRATEGIC OBJECTIVES PLAN STRATEGIC MISSION--TOTAL COSTS (U)

(Total Obligational Authority)(Millions of Dollars)*

(b)(1)

APPENDIX E

COSTS OF USSR STRATEGIC OFFENSIVE AND DEFENSIVE FORCES

(b)(1)

[redacted]

(b)(1)

[redacted]

(b)(1)

[redacted]

	1971	1972	
ATTACK FORCES			
Heavy Bombers	0.3 - 0.4	0.2 - 0.4	0
Missile Submarines	1.2 - 1.6	1.0 - 1.5	0
Land Based ICBMs	3.4 - 4.0	3.4 - 3.6	3
Peripheral Weapons (MR/IR)	1.6 - 2.5	1.7 - 2.5	1
Joint Support Costs	0.1 - 0.1	0.1 - 0.1	0
TOTAL ATTACK	6.6 - 8.6	6.4 - 8.1	6
DEFENSE FORCES			
Interceptors	2.5 - 3.1	2.3 - 2.8	1
Surface-to-Air Missiles	3.0 - 4.1	2.8 - 4.0	2
Anti-Ballistic Missiles	0.3 - 0.5	0.3 - 1.0	0
Air Defense Surv. & Cont.	0.9 - 1.3	0.9 - 1.4	1
Anti-Satellite	0.1 - 0.1	0.1 - 0.1	0
TOTAL DEFENSE	6.8 - 9.1	6.4 - 9.3	6
TOTAL STRATEGIC FORCE COST	13.4 - 17.7	12.8 - 17.4	12

Note: This summary of Soviet cost projections constitutes t
mates by the Intelligence Community for the period 1971 thro

(b)(1)

[redacted]

	1971		1972		1973	
INTERCEPTOR AIRCRAFT						
Fresco (Mig-17)	(950)	$ 179	(800)	$ 151	(600)	$ 113
Farmer (Mig-19)	(250)	52	(200)	41	(150)	31
Fishpot (SU-9)	(750)	251	(700)	234	(675)	226
Flashlight (Yak)	(150)	30	(125)	25	(100)	20
Firebar (Yak 28)	(350)	116	(350)	116	(350)	116
Fiddler (TU-2B)	(125)	190	(125)	46	(125)	46
Flagon A (SU-?)	(475)	686	(600)	720	(725)	567
Foxbat (Mig-?)	(25)	781	(75)	742	(125)	674
Non-Unit Related Costs		295		189		151
TOTAL INTERCEPTORS	(3075)	$2580	(2975)	$2264	(2850)	$1944
SURFACE-TO-AIR MISSILES (SAM)						
SA-1 Launchers	(3255)	$ 345	(2400)	$ 259	(1550)	$ 173
SA-2 Launchers	(4800)	1285	(4500)	1207	(4200)	1125
SA-3 Launchers	(880)	364	(880)	311	(880)	311
SA-5 Launchers	(1290)	966	(1530)	1044	(1800)	907
Non-Unit Related Costs		1		1		1
TOTAL SAM	(10,225)	$2961	(9310)	$2822	(8430)	$2517
ANTI-BALLISTIC MISSILE INSTALLATIONS (ABM)						
Early Warning Radar	(4)	$ 81	(6)	$ 68	(6)	$ 93
Regional Radars (inc. Moscow)	(2)	123	(2)	118	(2)	377
Moscow ABM Cmd. Spt. Costs	(0)	6	(0)	6	(0)	6
ABM Launchers (Moscow) ABM-1[a]	(64)	84	(64)	84	(64)	84
ABM Launchers (Short) Z-1[a]	(0)	0	(0)	0	(0)	0
ABM Launchers (Long) Z-2[a]	(0)	0	(0)	0	(0)	109
TOTAL ABM (RAD&LNCHR) COSTS		$ 294		$ 276		$ 669
AIR DEFENSE SURV. & CONTROL SYSTEMS (INCL. SUB-CONTROL)						
Radar Sites (Ground)	(850)	$ 304	(850)	$ 304	(850)	$ 304
Air Defense Districts	(9)	13	(9)	13	(9)	13
Air Defense Zones	(40)	48	(40)	48	(42)	50
Air Defense Sectors	(57)	41	(47)	33	(40)	29
Sub-Control Radar Stations	(130)	23	(145)	26	(160)	29
Moss AWACS Aircraft	(5)	18	(10)	22	(15)	14
Non-Unit Related Costs		431		468		541
TOTAL AIR DEFENSE COSTS		$ 878		$ 914		$ 980
ANTI-SATELLITE INSTALLATIONS						
Detection & Tracking Radars	(8)	45	(8)	45	(8)	45
Anti-Satellite Launch Sites	(0)	46	(0)	46	(0)	46
TOTAL ANTI-SATELLITE INSTALL.		91		91		91
TOTAL STRATEGIC DEFENSE COSTS		$6804		$6367		$6201

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[a] Force quantities show on-site operational launchers: costs are based on t
and ABM-Z-2, but one missile per launcher for ABM-Z-1.

(b)(1)

[redacted]

	1971		1972		1973	
INTERCEPTOR AIRCRAFT						
Fresco (Mig-17)	(1050)	$ 250	(900)	$ 214	(700)	$ 167
Farmer (Mig-19)	(300)	79	(250)	65	(200)	52
Fishpot (SU-9)	(800)	323	(750)	303	(725)	292
Flashlight (Yak)	(175)	45	(150)	38	(125)	32
Firebar (Yak-28)	(400)	160	(400)	160	(400)	160
Fiddler (TU-2B)	(150)	293	(175)	80	(175)	80
Flagon A (SU-?)	(500)	771	(650)	828	(775)	673
Foxbat (Mig-?)	(50)	777	(100)	957	(175)	953
Non-Unit Related Costs		371		229		187
TOTAL INTERCEPTORS	(3425)	$3069	(3375)	$2874	(3275)	$2596
SURFACE-TO-AIR MISSILES						
SA-1 Launchers	(3255)	$ 417	(3255)	$ 417	(3255)	$ 417
SA-2 Launchers	(5340)	1655	(5340)	1618	(5340)	1620
SA-3 Launchers	(1120)	717	(1240)	608	(1240)	523
SA-5 Launchers	(1650)	1276	(1890)	1302	(2160)	1309
SA-Z-1 Launchers	(0)	0	(0)	0	(0)	31
Non-Unit Related Costs		1		1		1
TOTAL SAM	(11,365)	$4066	(11,725)	$3964	(11,995)	$3901
ANTI-BALLISTIC MISSILE INSTALLATIONS (ABM)						
Early Warning Radars	(6)	$ 139	(7)	$ 151	(8)	$ 188
Regional Radars (Moscow)	(2)	121	(2)	81	(3)	62
Regional Radars (Other)	(0)	46	(0)	327	(1)	596
Moscow ABM Command & Support	(0)	13	(0)	13	(0)	13
ABM Launchers (Moscow) ABM-1[a]	(64)	108	(64)	108	(64)	108
ABM Launchers (Short) Z-1[a]	(0)	0	(0)	0	(0)	109
ABM Launchers (Long) Z-2[a]	(0)	109	(0)	289	(0)	740
TOTAL ABM (RAD&LNCHR) COSTS		$ 536		$ 969		$1816
AIR DEFENSE SURV. & CONTROL SYSTEMS (INCL. SUB-CONTROL)						
Radar Sites (Ground)	(0)	$ 506	(0)	$ 506	(0)	$ 506
Air Defense Districts	(11)	23	(11)	23	(11)	23
Air Defense Zones	(40)	60	(40)	60	(42)	62
Air Defense Sectors	(66)	59	(57)	51	(57)	51
Sub-Control Radar	(155)	42	(170)	46	(185)	50
Moss (Flat Jack) & O/L AWACS	(15)	40	(25)	49	(30)	33
Non-Unit Related Costs		599		687		775
TOTAL AIR DEFENSE COSTS		$1329		$1422		$1500
ANTI-SATELLITE INSTALLATIONS						
Detection & Tracking Radars	(8)	57	(8)	57	(8)	57
Anti-Satellite Launch Sites	(4)	46	(6)	22	(8)	29
TOTAL ANTI-SATELLITE INSTALL.		103		79		86
TOTAL STRATEGIC DEFENSE COSTS		$9103		$9308		$9899

---

[a] Force quantities show on-site operational launchers: costs are based on
and ABM-Z-2, but one missile per launcher for ABM-Z-1.

(b)(1)

[redacted]

(b)(1)

[redacted]

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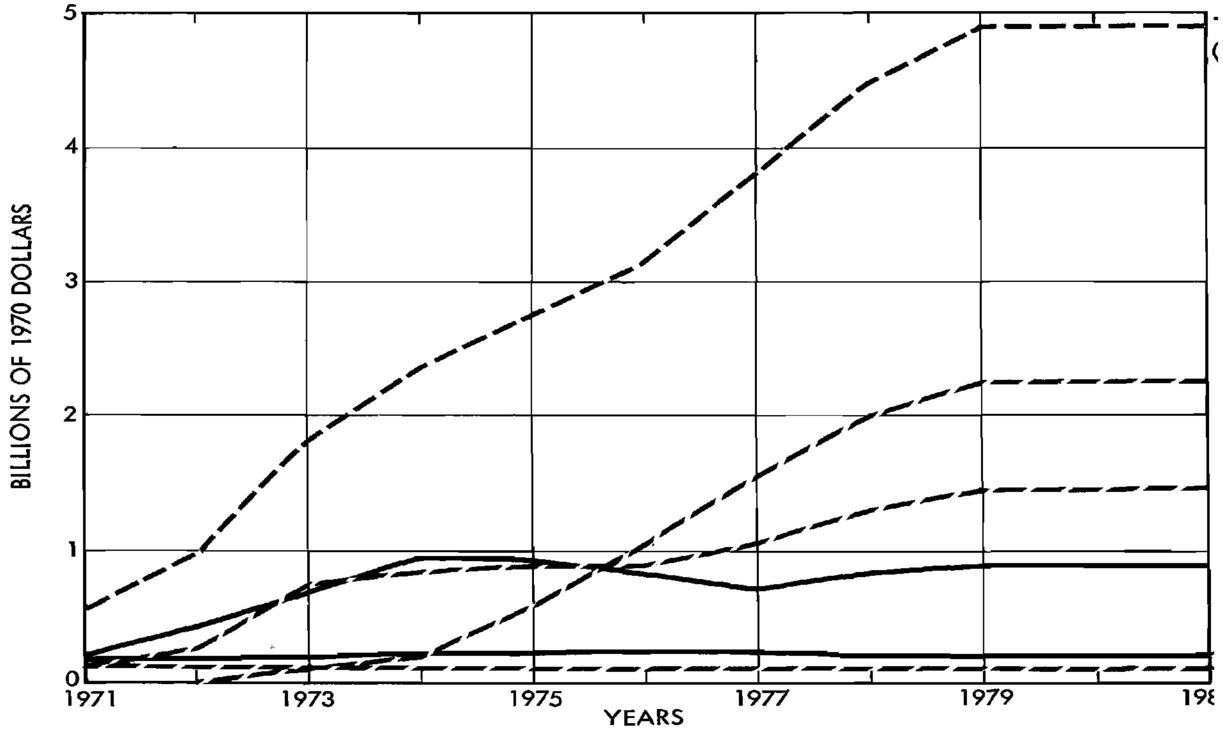

FIGURE E-6 ~~(S)~~. Cost for the ABM Mission Area Within the Defense Po
of the High Base Case Soviet Strategic Force
(Costs by Weapon System)(U)

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WSEG REPORT 155

SIMETTE

SIMEX PROTOTYPE DEVELOPMENT

September 1970

Volume I: Main Paper

Comprising PRC Report R-1521

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

WEAPONS SYSTEMS EVALUATION GROUP
400 ARMY NAVY DRIVE
ARLINGTON, VIRGINIA 22202

21 September 1970

MEMORANDUM FOR CHAIRMAN, JOINT CHIEFS OF STAFF

SUBJECT: SIMEX Prototype Development

I. FOREWORD

(U) The abstract of WSEG Report 155 is contained in Section II below. Detailed WSEG comments on the study are contained in Section III.

II. ABSTRACT

(U) Title: WSEG Report 155, "SIMETTE, SIMEX Prototype Development (U)," September 1970.

(U) Conducted by: WSEG For: JCS

This study is responsive to the requirements contained in DJSM-1250-69, 11 August 1969.

(U) Purpose: The primary purpose of this study is the development of a prototype Exchange and Interaction module as a test bed for SIMEX, and as a working simulation to address the multisystem interaction problems of a two-sided global nuclear war. In addition, computer and Data Management System (DMS) requirements and a Battle Plan Generator (BPG) algorithm for SIMEX are examined further.

(U) Methodology: Using the detailed requirements provided by WSEG Report 149, the study designed a simulation model to include all principal interactions in a two-sided nuclear war. The model was made in a modular manner so that many highly aggregated subsections could be replaced if further development of SIMEX were pursued. Where available, routines and logic from existing models were incorporated directly into SIMETTE. Generally, the model was designed to place no constraints on possible forces, command structure, or doctrine which might need to be simulated in future studies. Further investigation was made of possible computers and a DMS for SIMEX, and a limited allocation model was developed for use in a BPG.

(U) Principal Findings:

1. Where the scope of game-dependent factors has been a limiting factor in study credibility, SIMETTE is unique in comparison with other models as a high confidence tool for the study of exchanges and interactions.

2. The SIMEX concept and design are reconfirmed as technically feasible.

3. The allocation method for the BPG is rapid in execution and compatible with the principal operational constraints. The acceptable quality of its results and its compatibility with more refined allocation methods make it an effective departure point for cases where a high degree of refinement is desired in weapon allocation.

4. When compared with comparable CDC equipment, the IBM System 360 series of computer equipment is preferred for SIMEX because of greater core capability with a built-in growth potential.

5. The use of SIMSCRIPT, and the associated use of process logic in the design, extend the utility of SIMETTE because of the resulting flexibility and modularity.

6. An extensive input preparation effort is required in using the SIMETTE model for problems of large scope. This factor emphasizes the requirement for an automated Data Management System to fully exploit the capability of the model. The principal candidate DMS for SIMEX remains ADEPTS/TDMS.

7. The prototype is capable of application to current problems, provided the number of game objects is restricted, for example, by localizing the game.

III. WSEG COMMENTS

(U) This study represents the first nine months of work outlined in Plan 3, WSEG Report 149, "SIMEX Simulation Exchange," October 1969. It is responsive to the tasks specified in that plan; however, resource limitations precluded extensive testing of the simulation model, and treatment of footprint constraints for the BPG.

(U) The allocation program developed for the BPG is a technique for rapidly obtaining reasonably optimal weapons allocation while simultaneously considering constraints.

(U) Work on the SIMETTE model further demonstrates the feasibility of the simulation concept of SIMEX.

(U) The study includes further analysis of computer requirements for SIMEX and recommends a specific family of computers, optimum for SIMEX purposes. Although acceptable from this point of view, any computer selection made would have to consider other potential uses for the computer.

(U) The SIMETTE design includes the capability to trace the history of effects on strategic elements, even in cases where such effects were unintended. This permits detailed analysis of occurrences of particular interest, a feature not available in other large-scale simulations where details of the interactions of the simulation model are most frequently lost in highly aggregated reports of results.

(U) SIMETTE appears to have utility to simulate various nuclear effects on targets, weapons, sensors, command and control, as well as offensive and defensive weapons interactions in a two-sided nuclear exchange. To gain a better insight into its potential for solving current problems, WSEG will exercise and evaluate SIMETTE further in accordance with DJSM-563-70, 17 April 1970.

(U) It is recommended that this study be forwarded to potential users of the simulation, to include JSTPS, JSIPS, NORAD, SAC, and the Services.

ARTHUR W. OBERBECK
Lieutenant General, USA
Director

WSEG REPORT 155

SIMETTE

SIMEX PROTOTYPE DEVELOPMENT

PRC Report R-1521

Volume I: Main Paper

September 1970

Prepared For
WEAPONS SYSTEMS EVALUATION GROUP
Under Contract DAHC 15-69-C-0123

PLANNING RESEARCH CORPORATION
7600 Old Springhouse Road
McLean, Virginia 22101

BRADDOCK DUNN & McDONALD

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893-1800

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VOLUME I: MAIN PAPER

I. INTRODUCTION

A. General

Weapons Systems Evaluation Group (WSEG) Report 125 recommended development of a large, two-sided, global nuclear exchange simulation model as a means of studying the multisystem interaction problem. WSEG Report 149 documented the requirement specifications and development costs of the requisite set of simulation procedures, designated SIMEX.

The three key segments envisioned for SIMEX were an automated battle plan generator (BPG) to develop the strike plans for model inputs for various scenarios; an Exchange and Interactions (E&I) module which simulates the exchange and interactions of opposing forces; and, third, a highly capable data management system (DMS) in which the former two segments would be embedded.

This study is a continuation of work toward SIMEX with effort devoted to each of the three key segments described above, with principal emphasis placed on completion of the development of a prototype E&I model, SIMETTE.

B. Study Objectives

This study had as its goals:

- Completion of the development of the E&I model prototype, SIMETTE, to include operational codes and documentation
- Continuation of the design effort on the BPG to include the development of the allocation algorithms with selected constraints to be used for SIMEX
- Continuation of effort on the selection of the DMS for SIMEX

- A recommendation, with justification, of the proposed object computer and required ancillary equipment for the ultimate SIMEX

SIMETTE, a prototype of the E&I module of SIMEX, was undertaken to demonstrate the concepts proposed for SIMEX, to serve as a foundation on which more detailed development could be based and to serve as a useful intermediate study tool itself. The operational prototype would thus be both a test bed for SIMEX and a working simulation for application to multisystem interaction problems.

Fundamental to the SIMETTE effort was to have been the representation of offensive and defensive forces, sensors, command and control (C&C), and nuclear effects (direct and cumulative) in a two-sided exchange. Representation of these elements and their associated decision functions were considered necessary to examine the interactions between them in a dynamic manner.

C. Report Organization

This report of SIMETTE E&I model prototype development and related developments in the SIMEX system comprises six volumes.

Volume I, Main Paper, includes discussions of SIMETTE model capabilities, demonstration case results, and required computer use capacity. The latter includes extrapolations to larger equipment systems and/or expanded problem applications. The results of supplemental effort in the choice of a preferred DMS and a computer for the SIMEX system and progress in BPG development effort is also summarized.

A summary of development effort results and study findings completes the Main Paper.

Volume II, User's Manual, discusses input data requirements and creation sheet formats for SIMETTE. Detailed instructions for completing creation sheets as well as sample forms are also included.

Volume III, SIMETTE Computer Programs and Methodology, is a technical discussion of the subroutines which comprise the main simulator, preprocessor, and postprocessor programs. An analytical discussion of missile defense logic (ABM and SAM defenses) is also included in this volume.

Volume IV, SIMETTE Operator's Manual, contains computer operators instructions for SIMETTE model execution on the IBM system 360/50 computer. An extraction of SIMETTE error listings is also included.

Volume V, SIMETTE Program Listings, includes simulator, preprocessor, and postprocessor program listings as well as data listings.

Volume VI, Related SIMEX Effort, contains related SIMEX development effort on a DMS, a computer for the SIMEX system, and an allocator program for offensive BPG. The latter includes program capabilities, test case results, instructions for run preparation, and relationship with similar purpose programs, particularly various efforts developed in the Weapons Employment Study (WEPS) project (WSEG Report 148).

II. SUMMARY

The development effort described in this report resulted in a prototype E&I model, SIMETTE, which is to be used both as a test bed for SIMEX as well as a working simulation of multisystem interactions. This report includes the codes for the operational SIMETTE as well as the requisite documentation and operating instructions for its use. The demonstration case results, as documented in Section IV of the Main Paper, confirms the technical feasibility of the SIMETTE design as a test bed for SIMEX as well as lends credence to its use as a working simulation.

The SIMETTE model consists of three principal parts. These include a preprocessor, simulator, and postprocessor. These parts comprise nearly 11,000 SIMSCRIPT statements. The test case, employing a mix of weapon and delivery vehicle types, nuclear effects and site types along with operating system programs, used the available 512,000 bytes of IBM system 360/50 core. It is estimated that the 1,048,000 byte memory of the 360/50 computer can handle 800 moving objects and 500 fixed sites.

The results of the test cases executed demonstrated the technical capability of the SIMETTE model for considering:

- Full two-sided exchanges (2 offenses and 2 defenses)
- Multiplicity of system types including land and sea-based ballistic missiles, area and terminal ABM, bombers, SAM's and manned interceptors (MI's)
- Multisystem interactions, planned and inadvertent
- Extensive nuclear effects including blackout and dust

In addition, the full spectrum of missile/defensive ABM engagements and interactions was demonstrated together with aircraft/MI and SAM.

Even with a small population of game elements in the demonstration test cases, run results indicated a significant number of game entities as well as the intended targets were influenced to varying extents by weapon bursts.

Specific instances of interactions of an unplanned nature that occurred in the demonstration test cases are as follows.

- Damage to threat objects other than that object intended to be the objective target in an ABM engagement. (An ABM round scored a direct hit on a RV and damaged a nearby inflight decoy also.)
- An ABM burst intended for an incoming RV damaged a friendly ABM inflight toward another threat object.
- Dust erosion of incoming RV's was evidenced a number of times.
- A weapon burst destroyed two collocated targets and had measurable overpressure effects on five other targets some distance away. The same burst produced a fireball which partially occluded three widely dispersed radars.

In the course of work toward development of an automatic BPG, a computerized weapons laydown allocator employing a marginal return method of allocation was coded and run for a variety of test cases. The allocator includes optional range and cross-targeting constraints, variable damage inflicted limits, variable offensive weapons expenditures, and intermediate results reporting. Test run experience confirmed the predictions made in WSEG Report 149 both as to rapid program execution even for sizable weapon/target combinations and in the allocation method compatibility with the principal operational constraints. In this regard, the program should be compatible with the FOOTCALL program developed in WSEG Report 148 (WEPS project) which employs a marginal return method of allocation of MIRV's.

Experience with SIMETTE development as well as the reported experience of DCA in their development work on ADEPTS/TDMS served to reconfirm preferred employment of this system as the principal candidate DMS for SIMEX use.

Continuing examination of the IBM ystem 360 series of computers and CDC series (6400 and greater) indicated that the preferred computer for SIMEX to be the IBM 360 series because of its availability, large memory, and operational software. The recently announced IBM System 370 series is an attractive alternative and is advantageous for near-future term expansion because of compatibility with the 360 series, larger core capacity, and improved execution speed.

The limited test experience to date of the prototype E&I model, SIMETTE, provided a graphic illustration of the model's capability for revealing inadvertent interactions between game elements in the context of a general nuclear war scenario. Also demonstrated was its capability to:

- Represent game elements as individual entities
- Represent direct and cumulative nuclear effects
- Represent secondary nuclear effects (dust erosion, blackout, etc.)
- Enable replaceability of algorithms including
  - Weapon effect propagation
  - Weapon and supporting system characterization
  - Decisionmaking channeling
- Represent extensive scope of multisystem interactions

SIMETTE is immediately applicable to interaction problems in which the number of entities is restricted. This can be accomplished by localizing a problem, as in end-game applications, or by applications in which the level of conflict simulated is reduced.

Practical limitations of applying the prototype to large global problems because of the absence of a capable DMS and a computer with sufficient core memory are therefore removed as a barrier to the use of SIMETTE in many problems of current interest.

Practical experience gained in these applications of the prototype when combined with current estimates of study requirements will assist in refinement of the establishment of priorities for the evolutionary development toward SIMEX capabilities as well as contribute to the solution of the multisystem interaction problem.

III. SIMETTE DESCRIPTION

A. General Structure

SIMETTE is an event-stepped Monte Carlo prototype of the E&I module envisioned for SIMEX, a large, two-sided global nuclear exchange simulator, representing both offensive and defensive forces, which is described in WSEG Report 149. The prototype was built to demonstrate the concepts proposed for SIMEX and to serve as the foundation on which the more detailed structure of SIMEX would be based. Since most of the logic structure proposed for SIMEX has been embodied within SIMETTE, it should be applicable to the multisystem interaction problem through simulation of nuclear exchanges. Current development of SIMETTE on an IBM 360/50 computer will facilitate expansion of the model through the use of larger and faster members of the compatible 360 family. SIMSCRIPT I.5, well adapted to an event-stepped simulation model, is used as the program language.

The operational concept of SIMETTE, Exhibit III-1, shows the relationship of the E&I model and its ancillary preprocessor and postprocessor. Input data, both user provided on the creation sheets described in Volume II and various technical tables, is converted to punched card format and read into the preprocessor where it is processed and converted to the format required for model input. An error check of the data is performed and a printout of all data and possible errors are made for users' examination to increase the probability of a successful run. Further, the preprocessor provides a record of all input and initialization data to the postprocessor to assist in postgame analysis.

The E&I model, using the game inputs provided by the preprocessor, conducts the simulation. The occurrence of game significant

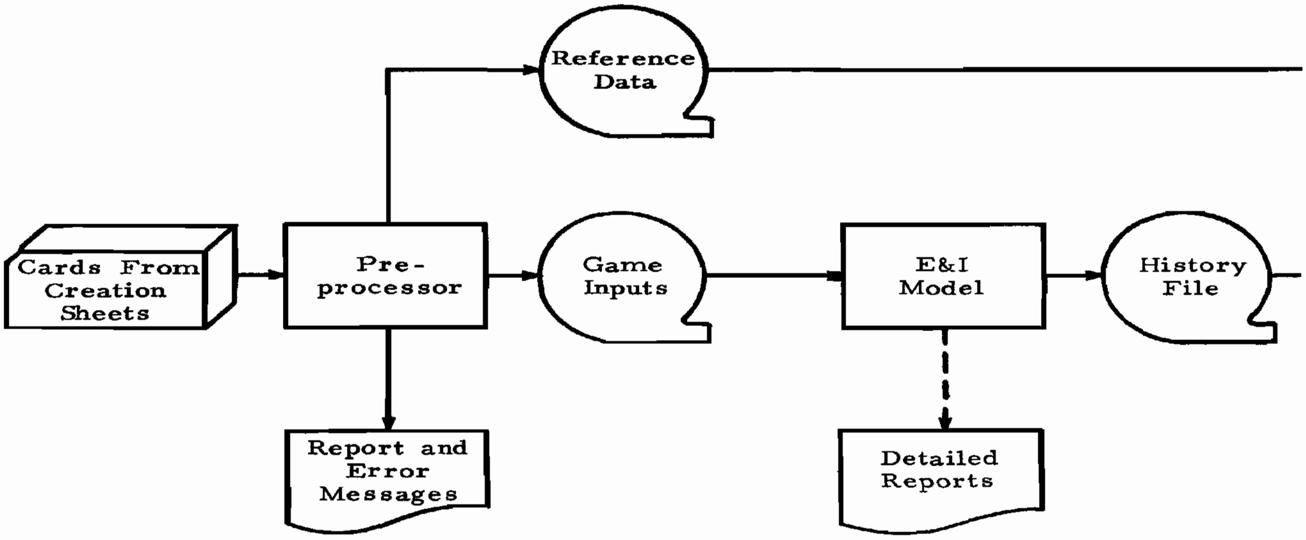

EXHIBIT III-1 SIMETTE OPERATIONAL CONCEPT events, whether scheduled externally through input data or generated internally by interactions, is recorded along with the game time of their occurrence in a history file. The postprocessor, using the preprocessor reference data and the history file, will then generate summary reports and may be used to provide additional reports for a more detailed diagnostic examination of the game. The TRACE subroutine, providing diagnostic functions as called by the option of the user, represents a key feature of the design. Other principal characteristics of the design are (1) the use of process logic which enables modular replacement of systems by the addition (or substitution) of characteristic operational parameters and (2) the design's fundamental capability to scan all outcome-dependent game elements at the time of occurrence of critical events. This section presents a description of the various elements of the E&I model, the preprocessor, and postprocessor.

B. Description of the Model

The model represents most of the significant elements involved in the two-sided multisystem interaction. These and their interrelationships are shown in Exhibit III-2. All moving vehicles, such as missiles, aircraft, ASM's, and decoys, are uniquely represented and flown along four-dimensional paths to permit evaluation of interactions with sensor volumes and nuclear effects. The following is a brief description of the system and concepts included within the model.

1. Offensive Command and Control

The user inputs the offensive command and control (C&C) environment and actions by specifying the scenario and creating the offensive strike plans. The model will accept varied launch times and windows for both bombers and missiles. There is no retargeting capability incorporated in the model at this time.

A command structure is represented and messages may pass from sensors to command sites and from command sites to weapon sites. Message transmission depends on the command site state—dead or alive. The time for transmission is simulated by input distributions or a single value to represent either internal or external delays.

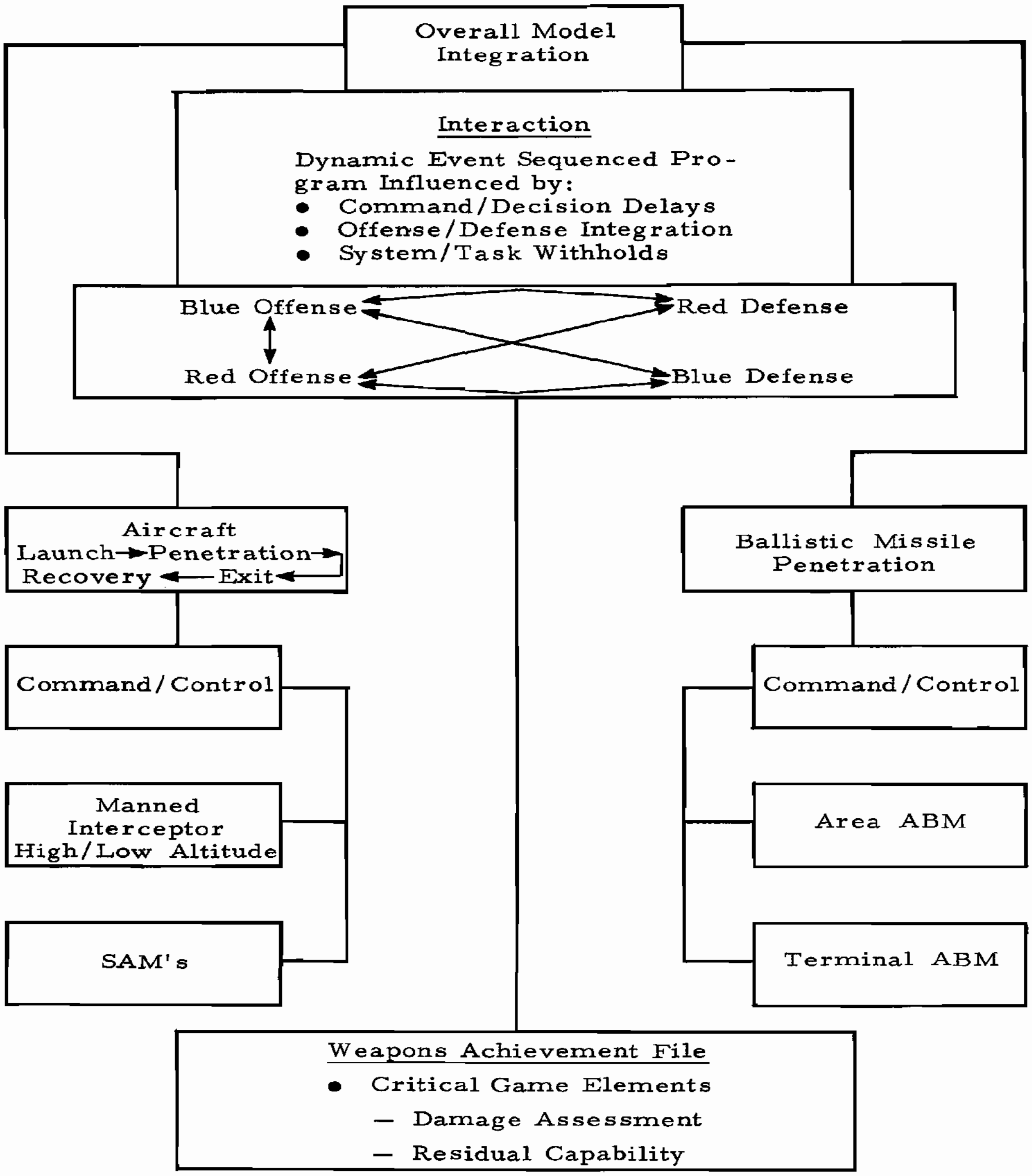

EXHIBIT III-2 SIMETTE MODEL INTEGRATION

Alternate sites can be represented and used if the primary command site is destroyed. The condition of communication links between command sites is not played.

2. Offensive Missiles

Representation of land and sea launched ballistic missiles employs the concept of paths, path segments, and a further refinement to individual legs of the segments. Given specific launch and target coordinates, the preprocessor generates an elliptical path to be flown for each missile-target pair with adjustments made for a rotating earth. As presently designed, the path is partitioned into three distinct segments: boost, exoatmospheric coast (ballistic trajectory), and reentry (see Exhibit III-3). The boost segment is represented as a straight line from launch to burnout utilizing constant acceleration to achieve the requisite velocity.

Missile burnout is represented by the termination of the boost segment, and deployment of reentry vehicles and decoys initiates the exoatmospheric coast segment. SIMETTE is capable of representing single RV's, multiple RV's (MRV's), multiple independently targeted RV's (MIRV's), and both exoatmospheric and endoatmospheric decoys. The exoatmospheric coast segment consists of the representation of ballistic trajectories flown by the individual vehicles from deployment by the parent missile to a point short of atmospheric reentry. These are elliptical trajectories following Kepler's Laws. The booster or parent missile is not represented in the exoatmospheric coast phase unless entered as a decoy or decoys.

MRV's are flown as a cluster through the exoatmospheric segment and are deployed in a circular pattern about the centroidal target point. The input dispersion figure is used to determine the radial distance from actual ground zero (AGZ), and the individual RV's are equally spaced around the circumference of that circle. A random draw is then made to determine the orientation of the cluster pattern impact points.

The boost segment for a MIRV bus is computed for a nominal target within the footprint. RV's are created at the termination of

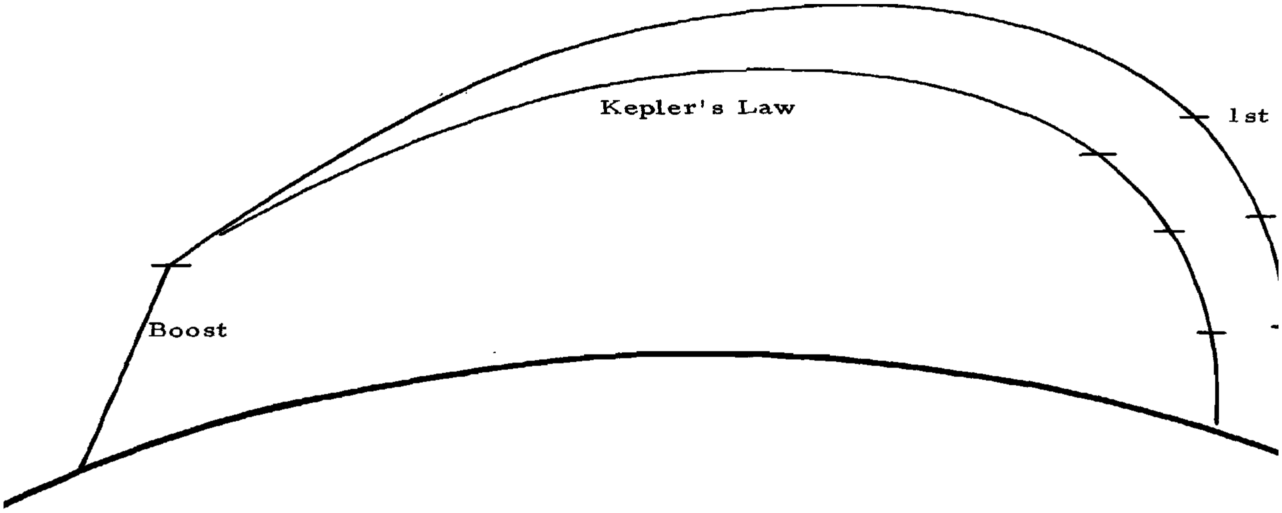

EXHIBIT III-3 GENERALIZED MISSILE PROFILE the boost phase and each RV-target pair determines the specific ballistic trajectory to be flown by that RV.

Decoys may be deployed in conjunction with single RV's, MRV's, and MIRV's in any combination specified by the user. Specification of two dispersion parameters, time and distance, will permit random distribution of decoys about the basic RV trajectory. The time parameter is the standard deviation of a normal distribution about the RV used to initiate the decoy flight path ahead of or trailing that of the RV. The distance parameter is the circular error probable (CEP) of a circular normal distribution that establishes a radial distance for the decoys perpendicular to the RV flight path.

The final segment of the offensive missile path is reentry, and it is further subdivided into three straight line legs: initial reentry, deceleration, and a terminal constant velocity leg to point of burst. The subdivision of the reentry segment into these three legs is to allow for the variation of the altitude regime in which deceleration will occur. Application of equations of reentry physics, considering the parameters of reentry angle, velocity, and ballistic coefficient, are used to determine this altitude regime. In some instances the third leg, constant velocity to burst point, would not be used since the RV may not have decelerated to its terminal velocity by the time it reaches the scheduled burst altitude. The point of burst is determined by user input height of burst (HOB) over target and computed AGZ. The HOB is as specified (i.e., altitude distributions are not played).

All of the above path computations are accomplished in the preprocessor and stored for call-up when that specific launch event is scheduled to occur. The initial computation will be the Monte Carlo determination of AGZ coordinates utilizing input CEP for the specific missile-RV-combination applied to the desired ground zero (DGZ) coordinates. The missile paths generated, therefore, are based on these computed AGZ's. If no reentry angle is given, the preprocessor will compute a minimum energy trajectory. The user may alternately specify the reentry angle to create lofted or depressed trajectories.

An example of the expandability of the current SIMETTE logic structure would be the representation of Fractional Orbit

Bombardment System (FOBS). FOBS representation would require use of an orbital trajectory with a terminal deboost phase. With user specified orbital altitude, the requisite orbital velocity would be computed and used as the required burnout velocity. For the reentry segment, angle and velocity would have to be specified in addition to the ballistic coefficient. The existing computational routines would then be used to describe the reentry legs. Exhibit III-4 summarizes the ballistic missile submodel.

3. Bombers

Bombers are flown from their launch bases to targets and subsequent post-strike recovery bases. As in the case of offensive missiles the entire bomber mission from launch through post-strike recovery constitutes his path, and it is partitioned into major segments (see Exhibit III-5). A segment could cover the departure from launch base to a refueling point and another, the transit to the H-hour coordination line (H-HCL). Further, subdivision of these segments would contain the detailed legs of the bomber profile between path points and represent climb out, initial departure legs, and refueling track on through arrival at H-HCL. Judicious aggregation of legs into segments permits specific segments to be used numerous times for different missions. Between the specified end-points of each leg, great circle routes are flown at constant velocity. If the end points specify different flight altitudes, a constant rate of climb or descent is assumed between the end points. In the absence of an automated BPG, a user specified four-dimensional flight path (latitude, longitude, altitude, and time) is required for the model to be able to determine and schedule interactions such as penetration of sensor and SAM volumes. Further, the position of bombers and all other vehicles must be known at all times so that the effects of nearby nuclear weapons bursts may be evaluated.

Bombers are capable of launching ASM's and decoys as well as drop bombs. Since ASM's and decoys will be flown, their desired flight paths must also be specified. Flight paths of ASM's and bombs will terminate in creation of nuclear bursts. For bombs, the time interval from release to burst permits representation of free-fall,

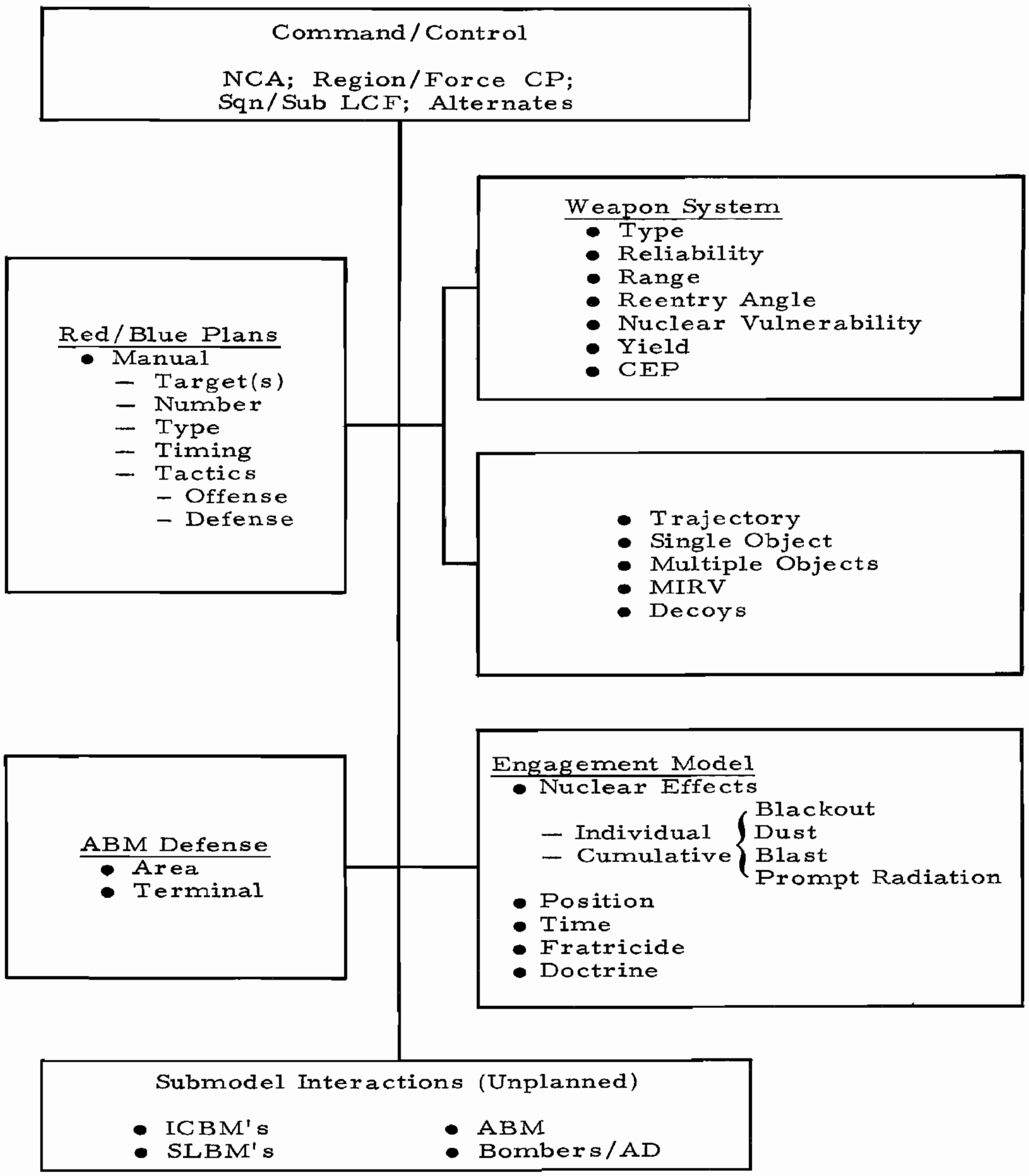

EXHIBIT III-4 BALLISTIC MISSILES (Red/Blue Offense)

Path Points

Takeoff and Land
Altitude Change
Course Change
Speed Change
Bomb Drop
Weapon Launch
Coordination
Times

Sortie/Mission

Segments

Legs–Path
Points

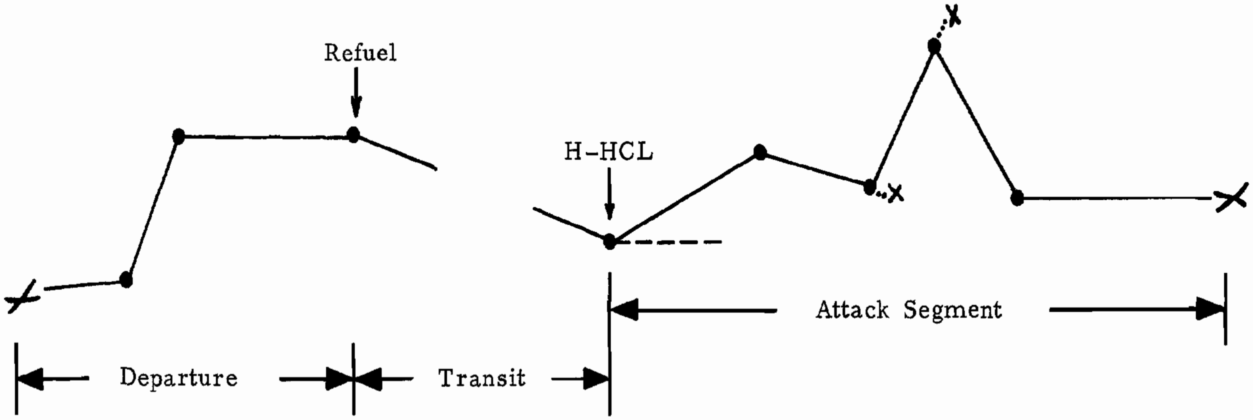

EXHIBIT III-5 GENERALIZED BOMBER PROFILE retarded drop, laydown, or delayed fuzing options. The terminal points of ASM and bomb flight paths represent DGZ and the altitude of the final path point will specify burst height. As in the case of offensive missiles, the preprocessor will apply a CEP computation for the specific weapon system to determine AGZ.

Bomber defensive capability against manned interceptors (MI's) can be represented in the model. A specified missile inventory is attributed to each bomber, along with a probability of kill (P_k) and an employment doctrine. At the time of intercept a P_k determination would be made against the interceptor. The probability of achieving successful refueling is included in an overall mission success probability. Recovery at a post-strike base or destruction ends game play for a specific bomber. Bomber electronic countermeasure (ECM) and chaff are not now included within the game. Elements of the bomber submodel are shown in Exhibit III-6.

4. Sensors

Sensors provide the stimuli to defensive C&C and subsequent defensive reactions. When a vehicle first penetrates a sensor's maximum range volume, the initial detection range and time are computed. Subsequent elapsed times to accomplish designation, track, intercept track, and discrimination are specified by the user. Except for initial sensor volume penetration, the accomplishment of these sensor functions causes messages to be transmitted to defense C&C for appropriate decision and action. The model will observe the occurrence of nuclear bursts within the sensor volume and compute the degradation of such bursts on sensor performance. The effects on sensor performance of active ECM employment by the offensive forces is not represented.

The input sensor volume serves effectively as a filter. Only those objects and bursts within a sensor's volume are considered when computing interactions with that sensor. The time and place of entry into this volume is computed and made an event. When a vehicle enters the volume, a time of exit or impact is computed and a future event is created and its time noted. Additionally, time and range of initial detection are computed using the object's radar cross-section, input

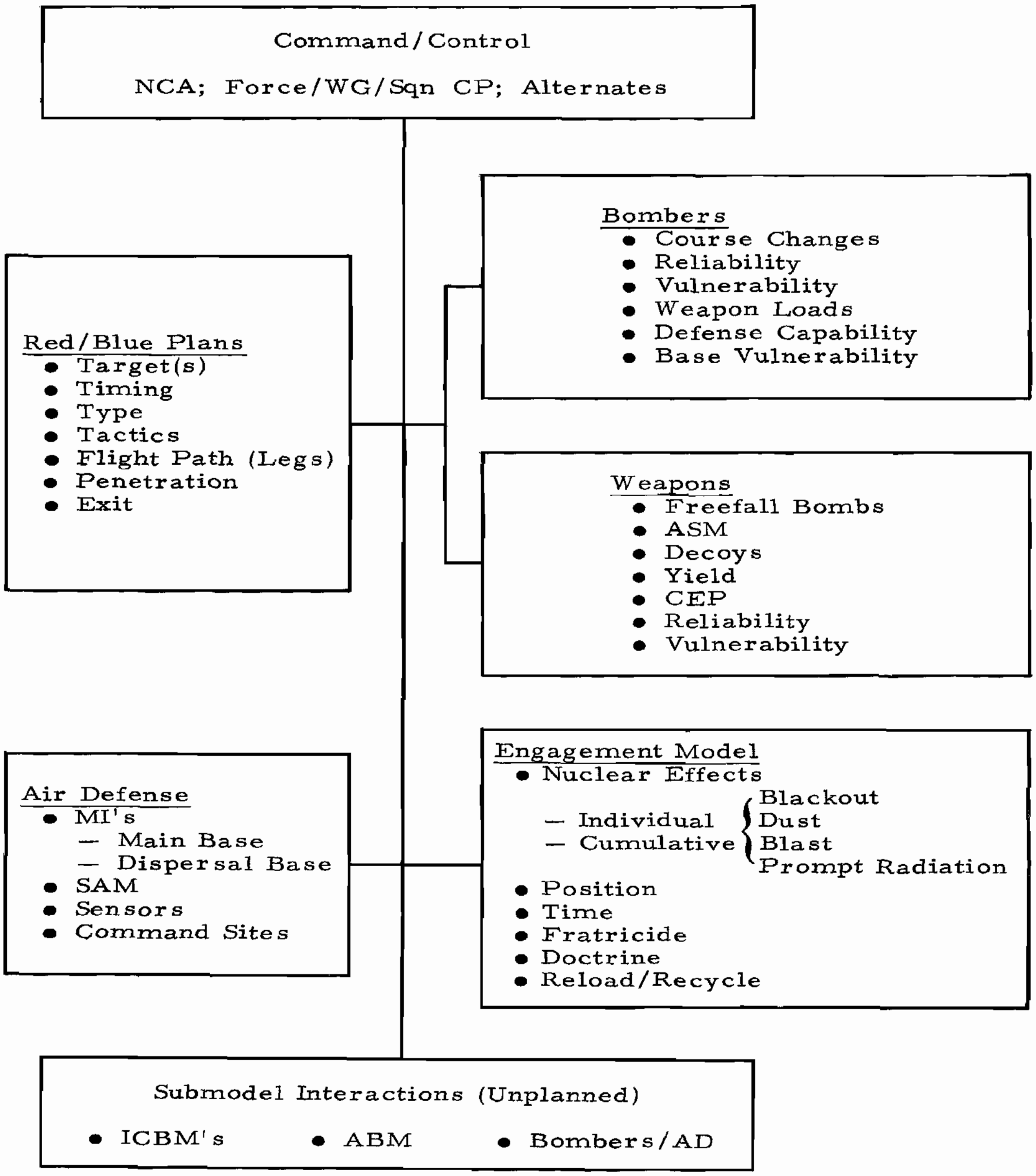

EXHIBIT III-6 MANNED BOMBERS (Red/Blue Offense) threshold signal/noise (S/N) ratio required for detection, and attenuation effects of nuclear bursts. Once detected, the object passes through the other sensor states representing the radar capability.

Exoatmospheric decoys are removed from game play at the point of maximum deceleration during reentry. This essentially coincides with the maximum thermal pulse experienced and therefore permits discrimination at that point. Endoatmospheric decoys, however, reenter the atmosphere along with the RV's and are not discriminated. The only difference between this type decoy and the RV will be the absence of a warhead.

The object can leave the detected or tracked state if nuclear attenuation intervenes between the object and the sensor. If this occurs, the object drops back to the undetected state and must repeat the sensing process if the sensor memory time (maximum blackout interval) is exceeded.

As input, the sensor can be saturated when it tracks N objects. When the N + 1 object is detected, the sensor will drop, but not forget, the object evaluated as the least threat. When the sensor has tracking capability available, it will resume track of the dropped object assuming it is still in its volume.

Friendly forces are not "seen" by the sensor, and do not use up radar capability. This is based on the assumption of perfect identification friend or foe (IFF) capability.

5. Defensive Command and Control

Command and control (C&C), acting on the stimulus of information concerning potential threat objects provided by sensors, is the driving force for the defensive portion of the model. For MI's and SAM's, defense doctrine is based on user specified decision parameter values of resource allocation such as 1-on-1 or 2-on-1. As a result of extensive automaticity of projected ABM systems, doctrine for ABM defenses are determined through a decision variable which varies according to dynamic changes in the game. The factors that make up the decision variable include remaining defended value, threat density, guidance status, residual defense assets, and time available to intercept.

The ABM missile defense C&C is provided impact prediction in the form of value threatened by a particular object. This value is the value of the DGZ assigned the threat object by the strike plan.

The defensive C&C structure, with lines of succession for primary decision authority within that structure, will be user specified. If a sufficient number of alternate C&C sites are specified, integrity of the command structure can be maintained in the event of destruction of one or more elements. Communications, essential to support the C&C function, are represented by variable internal delays at both sending and receiving sites as well as an external delay between the communicating sites. The condition of the communications lines is not played.

Within the C&C logic for ABM defense (shown schematically in Exhibit III-7), exists the capability of rank-ordering incoming threat RV's. Such ordering is permitted by the use of a matrix of residual threatened target value for all targets within the defended volume. Before commitment of a defensive missile from a specific site, intercept geometry limitations and the relative capability of the various sites within the command are considered. Further consideration is given to site or guidance system saturation, residual weapon inventories, and the latest time at which an intercept can be completed (i. e., the time at which the RV exits from the ABM performance volume). Minimum altitude of intercept, as dictated by warhead yield and damage limiting criteria, will further constrain commitment decisions.

For the air breathing threat (shown schematically in Exhibit III-8), the MI's are launched on receipt of threat designation and vectored to the closest loiter point or points in the direction of the threat. Upon receipt of sensor track information, an intercept is initiated if within the capability of one or more interceptors and depending on doctrinal guidance. If the bomber flight path changes during the course of intercept, thus changing the intercept geometry beyond the fighter range, reassignment of the intercept to other fighters may be made.

6. Defensive Forces

Two types of ABM's, one short range and one long range, are played for each side. The performance factors, such as velocity

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Weapons Systems Evaluation Group
Route Sheet

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Suspense Date:

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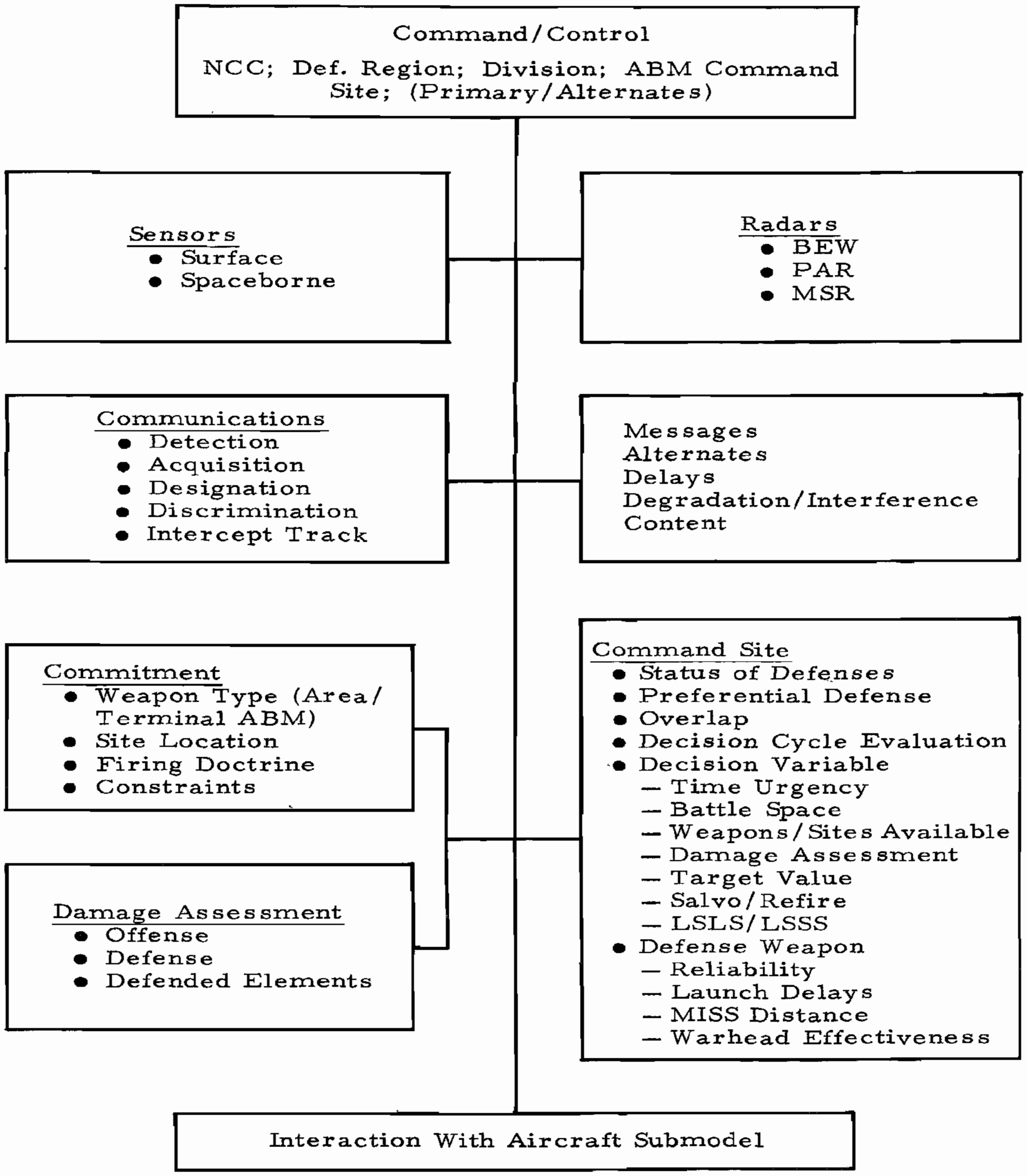

EXHIBIT III-7 MISSILE PENETRATION (Red and Blue Defense)

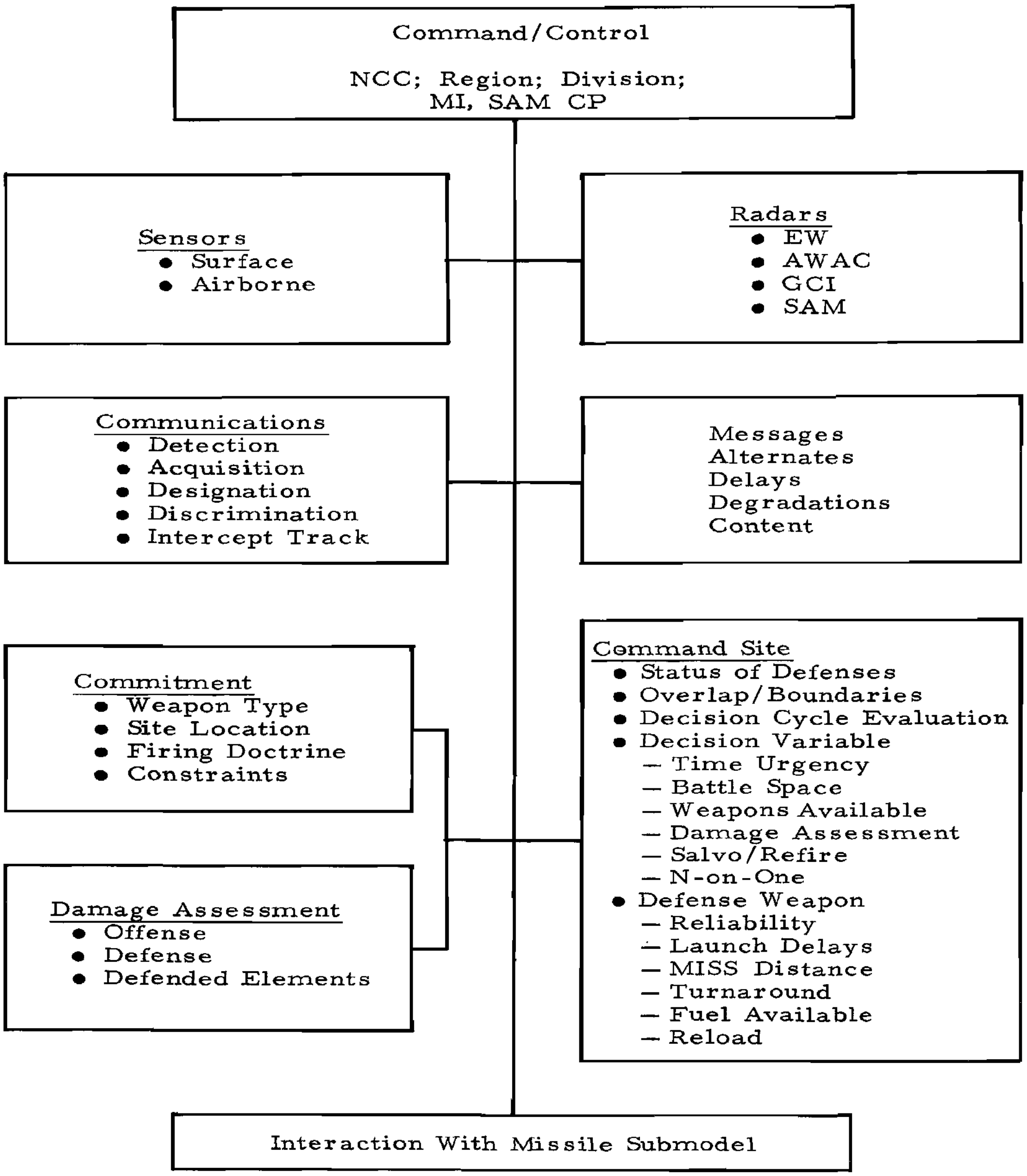

EXHIBIT III-8 AIRCRAFT PENETRATION (Blue and Red Defense) and flyout curves, are coded into the program. Range, however, is specified by an input maximum performance volume, allowing for different coverage capabilities. The ABM's will be capable of exoatmospheric and endoatmospheric intercepts. The time and position of intercept are calculated from the defense missile flyout curves and the RV path; the ABM path is represented by straight line segments. After the decision to launch has been made, the desired point of intercept is computed. This is modified by spherical error probable (SEP) information, and the ABM flies to the actual point of burst. Each ABM site possesses only one type of missile, clustered so that a single performance volume applies to all missiles at that site.

The intercept capability of MI's is constrained by fuel considerations derived from speed and fuel consumption rates for cruise and combat conditions in conjunction with fuel capacity and reserve requirements. The fighter aircraft are flown to the intercept point where a P_k determination of the fighter-bomber interaction is made. If neither is killed, a reengagement would be made if sufficient fighter fuel and ordnance remained. Multiple pass capability is provided by inclusion of ordnance for several passes and specifying reengagement time. Interceptors will be returned to base for recycling when ordnance loads are depleted or when fuel considerations so dictate. Variable recycle time is available. Modification or removal of the fuel constraint may be played in the advent of hot pursuit, where fuel is the constraining factor for reengagement and where a bomber is not killed on the first intercept. Return to an alternate base or continuation to fuel exhaustion are alternates that are specified by user input doctrine.

SAM's are flown against air breathing threats in a manner similar to ABM. However, because SAM's are in general a terminal defense, only time urgency is considered a governing factor in SAM commitment. Further, only intercepts at the maximum SAM performance contour and at a half-way contour are considered for a particular site. Thus, a limited shoot-look-shoot doctrine is available. However, the user can specify N intercepts at each contour.

Once the decision is made to launch SAM's, the model computes the desired point of intercept, modifies this with SEP information, and then flies the SAM to the actual point of burst. Both nuclear and non-nuclear warheads are permitted for SAM's. Launch and in-flight reliabilities are considered prior to launch. When a site has committed all its resources, it is removed from the game in order to save computational time.

7. Nuclear Bursts

Nuclear bursts are created at the end of the designated path for each warhead deployed. Prompt effects from neutron, gamma, and X-ray emissions are modeled using attenuating factors from existing models. Typical burst emissions, such as for a 1 MT burst, are scaled using standard scaling factors. Atmospheric attenuation is utilized in effects computations. Energy spectra variations are subsumed in the game parameters and enhanced warheads can be represented.

Geographical filters will be used to limit the space examined for possible object-effects interactions. The vulnerability thresholds of the various objects will be compared with the dosage received. If exceeded, the object is killed. If not exceeded, the object will file its dosage. A user specified decay rate can decrease the filed dosage as a function of time. If a further dose is received, the cumulative dosage will be compared to threshold values to determine if a kill has been made. There is no consideration of combined effects at this time—each is treated separately.

Other nuclear effects played, pressure front, fireball, dust cloud, and beta patch, are modeled as expanding volumes with decreasing effects. Standard-size volumes are scaled to the actual yield. The volumes interact with objects, or, in the case of the beta patch, with sensors, and subsequent damage to the objects are assessed. Salvage fuzing, yield degradation as a function of sublethal exposure to damaging effects, and a variable probability of successful fuzing are not represented in the prototype.

C. Input Preprocessor

The preprocessor eliminates or simplifies much of the labor required to translate game inputs from a convenient form for the user into a form acceptable by the SIMETTE model. In its initial implementation, it will accept input only in card image format, and that format must match the input creation sheets which are designed for the model and are described in this volume. It will not currently accept data from established sources unless such data are reformatted. However, the preprocessor has been designed to facilitate the later incorporation of such improvements as translation routines, data libraries, etc.

The primary purpose of the preprocessor is to construct, and place on external storage equipment, that data needed to run the SIMETTE model. From the users point of view, these data consists of site data (missile sites, airfields, sensors, and C&C structure), performance and operational characteristics of vehicles and weapons systems, and mission plans. For bomber missions, specific flight plans must be input including those of ASM's and decoys. For ICBM's, the flight path is computed based on specified launch and target sites. In addition to the numerous unit conversion operations (e.g., degrees into radians), whenever possible the preprocessor derives input numbers required by the model from simpler and more convenient user-supplied data. It also constructs numerous cross-reference tables from user-generated input data.

As a separate job step, before the model is executed, the user has an opportunity to look at his data after it has been checked by the preprocessor and to correct any errors detected. Because of this check, the user has a much higher expectation of success when the SIMETTE model is actually run.

Even though preparation of a full-sized game will require considerable time and effort by the user, his labors are greatly reduced by the preprocessor even in its initial form. Also, once the initial data has been collected for such things as site and performance characteristics, these become a part of the data file, and preparation of subsequent games should be much easier.

D. Output and Report Generation

A master history file will maintain a record of all game significant events, interactions, and the time of their occurrence. In relation to vehicles, the following events will be recorded: launch; path points; penetration of various game volumes such as sensors, dust clouds, and defended volumes; intercepts; effects interactions; and kills. All nuclear bursts will be recorded. Messages recorded are launch orders, change of sensed status, and damage or loss of game entities.

From data available in this history file, report formats can be constructed to suit user needs. A representative report, shown in Exhibit III-9, will be available in SIMETTE to cover a summarization of weapons and delivery vehicle histories giving planned number and yield, attrition due to defensive or nondefensive causes, and successful detonation and yield. An unresolved category is included to account for those vehicles still in process at the point in time for which the report is made, since they may be produced at selected points in game time in addition to the final reports, to provide a degree of understanding of game evolution.

E. TRACE

The TRACE function was developed as a diagnostic tool for the operator/analyst team in debugging the computer program and offers the user the opportunity to examine specific events in great detail. The TRACE function primarily acts as a monitor within the model and causes a complete printout for designated subroutine functional steps when those subroutines have been called and are operating in the simulation. Virtually all of the principal subroutines have designated TRACE flags that may be set. These may be designated to operate for any length of time desired, the entire game or only a specific portion thereof (by designating start and stop times). There may also be a limit set to the number of times this selected routine will be printed out. Any number of these TRACE flags may be set during a particular simulation run, each with its own specific values for duration and number of events to be recorded.

An example of this would be setting TRACE flag for the prompt effects routine where a detailed examination of possible interactions and kills due to these effects is desired. For each nuclear burst that occurs in the game, the prompt effects routine is called up, and each time it is

Wpn Systems			Wpns Carried				System Lost Wpns				Released W				
							Def Attr		Nondef. Attrition		Def Attr		Nondef. Attrition		D
Class	Type	No.	Class	Type	No.	Yield	No.	Yield	No.	Yield	No.	Yield	No.	Yield	N
101	1	75	107	55	25	25	X	X	X	X	.	.	.	.	
				56	50	75	X	X	X	X	.	.	.	.	
			Subtotal		75	100	X	X	X	X	.	.	.	.	
	2	100	107	56	20	30	X	X	.	.					
				58	35	105	X	X	.	.					
				59	135	27	X	X	.	.					
			Subtotal		190	162	X	X							
Class 101 Total		175			265	262									
102	15	48	107	63	48	48									
			Subtotal		48	48									
	16	112	107	66	560	280									
			Subtotal		560	280									
Class 102 Total		160			608	328									
Blue Force Total		335			873	590									

EXHIBIT III-9 OFFENSIVE FORCE SUMMARY—COUNTRY BLU called, the TRACE flag will cause a printout to be made. All sites or moving objects considered by this routine will be identified by a single line of printout when that site or object receives no incident flux of neutron, gamma, or X-ray. Where a dosage of any or all of these effects is received (lethal or nonlethal) values will be printed.

Lacking a fully automated DMS which would be readily called on to retrieve specific data from the history file without preparation of an elaborate program for postprocessor report generation, the TRACE function offers an intermediate study tool to examine selected position of the history file. Although a large volume of computer printout may have to be examined in detail to extract this information, it does offer a current analysis tool in looking at the details of the multisystem interactive process prior to the availability of a fully automated DMS. When a run indicates an area of interest or questions that should be examined in greater detail, that particular game may be rerun with the appropriate TRACE flags set to span the period of interest. All of the pertinent detailed interaction information will then be available for analysis.

The TRACE output comes from two basic sources within the model:

- Event routines which represent vehicle movement, sensor observations, nuclear bursts, and messages; these events characterize the overall processes and chronology of the game
- Utility routines that perform the detailed computations and logical processes to support the event routines

The specific details of invoking the desired level of TRACE output is described in the User's Manual, Volume IV. Exhibit III-10 shows a summary of the types of data available from the TRACE output. For further details and formats, the user is referred to Program Listings, Volume V.

EXHIBIT III-10 SUMMARY OF TRACE SUBROUTINE OUTPUT

- Traces events and utility routines
- Invoked by user-specified routines
- Provides detailed game history during user-specified game intervals

EVENT VEHCL — MOVEMENT OF A VEHICLE

TAIL NO.
OPERATION, e.g., takeoff, free flight, drop bomb, etc.
STARTING POINT (x, y, z)
ENDING POINT (x, y, z)
DURATION OF MOVEMENT
NUCLEAR EFFECTS HISTORY
    NEUTRONS, GAMMA, X-RAY, OVERPRESSURE AND ABLATION (if appropriate)
WHICH SENSORS HAVE VEHICLE IN VIEW
WHICH DEFENSIVE WEAPONS TARGETED AGAINST VEHICLE

EVENT OBSER — OBSERVATION PROCESS OF A VEHICLE BY A SENSOR

SENSOR SITE NO.
VEHICLE BEING OBSERVED
STATUS OF OBSERVATION, e.g., acquired, target tracked, occluded, etc.
TIME PROCESS WILL BE COMPLETED
ENTRY & EXIT TIME FOR SENSOR VOLUME

EVENT BURST — NUCLEAR DETONATION

TAIL NO. OF GENERATING VEHICLE
LOCATION & TIME OF BURST
TYPE OF WARHEAD PRODUCING BURST (gives yield)
PHASE, i.e., prompt, overpressure, fireball, or dust cloud
DURATION AND ENDPOINT OF PHASE

EVENT MSGE — MESSAGES REPRESENTING COMMUNICATION FUNCTIONS

LMSGE — LAUNCH MESSAGES
    SITE NO. ISSUING THE LAUNCH ORDER
    LAUNCH SITE NO.
    LAUNCH WINDOW OR TIME OF LAUNCH
    PROCESS CODE OF LAUNCH OPERATION, i.e., delay, site failure, initiate vehicle, etc.

EXHIBIT III-10 CONTINUED

EVENT MSGE — Continued

- SMSGE — SENSING MESSAGES (communication of sensing status to C&C)
    - SENSOR SITE NO.
    - VEHICLE BEING SENSED
    - ASSOCIATED OBSER EVENT
    - OBSERVATION STATUS REPORTED
- DMSGE — DAMAGE MESSAGES
    - VEHICLE OR SITE KILLED
    - ORIGIN OF VEHICLE OR NEXT HIGHER SITE
    - TYPE OF KILLING EFFECT, i.e., radiation, overpressure, etc.
    - MULTIPLE OF KILL THRESHOLD
    - MULTIPLE OF KILL THRESHOLD FROM LAST EXPOSURE
- IMSGE — INITIALIZING MESSAGES (used to establish initial inventories of Bombers and Fighters at their airfields)
    - AIRFIELD SITE NO.
    - EQUIPMENT TYPE
    - NO. IN INITIAL INVENTORY

NON-EVENT TRACE — UTILITY ROUTINES

- PRINTOUT OF INDIVIDUAL COMPUTATIONS AND LOGICAL PROCESSES
- FOR EXAMPLE,
    - KINEM—kinematics of vehicle or Burst movements
        - LOCATION AT SPECIFIC GAME TIME
    - DUST—details of vehicle erosion when penetrating a dust cloud
        - CLOUD LOCATION, SIZE & MASS
        - DISTANCE TRAVELED THRU CLOUD
        - AMOUNT OF EROSION
        - TIME THRESHOLD EXCEEDED (if appropriate)

IV. DEMONSTRATION TEST RESULTS

A. Introduction

The program test case results discussed in this section are organized in two parts. The two-sided exchange capability of SIMETTE is described, followed by descriptions of multisystem interactions and related examples. The scenario of the former examples may be characterized as thin in terms of the total inventory of game elements but sufficiently varied in system type to have enabled an extensive exercise of offense/defense interaction with each game element considered as an individual entity. The scenario game conditions were global in terms of geographic deployment and movement of offensive systems.

The low density of inventory game elements insufficiently demonstrated multisystem interactions, a characteristic of SIMETTE which received particular emphasis in its design and development. To demonstrate this aspect of program capability and the attendant capability for revealing fratricide, multiple kills and special nuclear effects (dust ablation, radar blackout, etc.), specific cases were run centering attention on a licalized portion of game geography, relatively dense in game elements. In the illustration of dust ablation and blackout effects, attack timing was perturbed so that the particular effect could be highlighted to better study algorithm behavior.

In the course of these runs, unplanned interactions were revealed (offensive and defensive fratricide; multiple kills), which significantly demonstrated the intended capability of the program design to monitor and record inadvertent interactions.

B. Two-Sided Global Exchanges

Demonstration test case runs of two-sided exchange included ICBM's, bombers, defensive systems, and support elements (radars and command sites). Elements comprising the test case are summarized in Exhibit IV-1. Although an extensive variation of systems was employed, total numbers were kept small so as to minimize possible pertubations that might arise with a more extensive inventory of game elements, and to focus attention on the fundamental algorithms (launch and decision orders, vehicle movements, nuclear effects propagation, and defensive radar functions).

As shown in Exhibit IV-1, the forces comprising the two-sided exchange between Red and Blue consisted of ICBM's (one with MIRV warheads and a decoy), manned bombers (ASM's and gravity bombs), ABM's, ABM and Air Defense acquisition/guidance radars and command sites, manned interceptors and SAM's. The latter were maintained in a "HOLD FIRE" mode in order to fully exercise the engagement of manned bombers by MI's. Also included in the game were the requisite primary and alternate (where applicable) basing sites for weapon delivery systems.

The chronology of game events for two model runs are listed separately in Exhibits IV-2 and IV-3. In case 1, (Exhibit IV-2), the exchange of offensive forces, the radar functions required for ABM engagement, and ABM engagement of reentry threat objects behaved normally. The MI's were not scrambled due to defense dependency upon sensor (radar) inputs— the bombers underflew the radar coverage and were not detected.

To correct this radar coverage was lowered for the case 2 run, bombers were detected, and MI's were scrambled. The results of the run, summarized in Exhibit IV-3 contained extensive MI action (commencing at game time, 12.06.56) including allocation to loiter points, commitment to intercept, intercept, bomber kill, and MI recovery. The scheduled launch time for the Blue ICBM was changed from 0.00.04 in case 1 to 11.00.08 in case 2. This delay in launch time permitted its prelaunch destruction at 0.32.52 in case 2 and cancellation of the scheduled launch.

These examples also illustrate an ICBM through boost phase, the creation of individual objects (RV's and decoys) and resulting specific

EXHIBIT IV-1 DEMONSTRATION CASE EXCHANGE FORCES

Site/Entity	Designation	Inventory	
		Red	Blue
Ballistic Missile Launch Site (Silo)	R/B ICBML	1	1
Ballistic Missile	R/B ICBM	1[a]	1
Reentry Objects			
• Warheads	R/B ICBMW	5	1
• Decoys	R/D ICBMD	1	0
ABM Launch Site	R/B ABML	1	1
ABM	R/B ABM	1	2
Bomber Primary Base	R/B BMBFLDP	1	1
Manned Bomber	R/B BMB	8[b]	8[b]
Gravity Bomb	R/B GRVB	1	1
ASM	R/B ASM	1	0
Manned Interceptor Base			
• Primary	R/B FTRFLDP	1	1
• Alternate	R/B FTRFLDA	1	0
Manned Interceptor	R/B FTR	10	5
Air Defense Radar[c]	R/B ADR	1	1
ABM Radar[c]	R/B ABMR	1	1
Air Defense Command Site[d]	R/B ADCS	1	1
ABM Command Site[d]	R/B ABMCS	1	1
SAM Launch Site	R/B SAML	1	1
SAM[e]	R/B SAM	2	2

[a] MIRV'ed payload consisting of five warheads and one decoy.

[b] Of eight bombers on each side, one was on alert status, remaining seven nonalert.

[c] Dual purpose radar function (air defense and ABM) was employed in this test case.

[d] Dual purpose decision function (air defense and ABM) was employed in this test case.

[e] SAM's were placed in "HOLD FIRE" mode in order to fully exercise the MI/bomber engagement submodel.

EXHIBIT IV-2 CHRONOLOGY OF EVENTS: TWO-SIDED EXCHANGE (CASE 1)

TIME	EVENT DESCRIPTION
0.00.04	Launch BICBM → RBMBR FLD.
0.01.33	Launch RICBM → (6 TGTS.)
0.02.25	RICBM → 5 RICBBW + 1 RICBMD
	RICBMW(1) → BBMBRFLDP
	RICBMW(2) → BICBML
	RICBMW(3) → BFTRFLDP
	RICBMW(4) → BABML
	RICBMD(5) → BSAML
	RICBMW(6) → BADR
0.19.34	RABMR SEES BICBM
0.21.19	BABMR SEES RICBMW(1)
0.21.23	BABMR SEES RICBMD(5)
0.21.25	BABMR SEES RICBMW(2)
0.21.28	BABMR SEES RICBMW(4)
0.21.29	BABMR SEES RICBMW(3)
0.21.31	BABMR SEES RICBMW(6)
0.25.28	Launch RABM → BICBMW
0.27.27	Launch BABM → RICBMW(1)
0.27.47	Launch BABM → RICBMD(5)
0.28.29	RABM INTERCPTS/KILLS BICBMW
0.31.02	BABM INTERCPTS/KILLS RICBMW(1)
0.31.19	BABM INTERCPTS/KILLS RICBMD(5)
0.32.30	RICBMW(6) STRKS/KILLS BADR
0.32.49	RICBMW(4) STRKS/KILLS BABML
0.32.50	RICBMW(3) STRKS/KILLS BFTRS/FTRFLDP
0.32.52	RICBMW(2) STRKS/KILLS BICBML
1.00.08	Launch BBMBR → RICBML
1.06.54	Launch RBMBR → ADR BBMBRFLDP
9.52.51	RBMBR Launches → RASM ADR
10.00.21	RASM STRKS BADR (Previously Killed by RICBMW(6)
10.40.23	RBMBR Launches RGRVBMB → BBMBRFLDP
10.40.33	RGRVBMB STRKS/KILLS BBMBRFLDP
13.08.55	BBMBR Launches BGRVBMB → RICBML
13.14.55	BGRVBMB STRKS/KILLS RICBML

EXHIBIT IV-3 CHRONOLOGY OF EVENTS: TWO-SIDED EXCHANGE (CASE 2)

TIME	EVENT DESCRIPTION
0.01.33	Launch RICBM → (6TGTS)
0.02.25	RICBM → 5 RICBBW + 1 RICBMD
	RICBMW(1) → BBMBRFLDP
	RICBMW(2) → BICBML
	RICBMW(3) → BFTRFLDP
	RICBMW(4) → BABML
	RICBMD(5) → BSAML
	RICBMW(6) → BADR
0.21.19	BABMR SEES RICMBW(1)
0.21.23	BABMR SEES RICMBD(5)
0.21.25	BABMR SEES RICBMW(2)
0.21.28	BABMR SEES RICBMW(4)
0.21.29	BABMR SEES RICBMW(3)
0.21.31	BABMR SEES RICBMW(6)
0.27.27	Launch BABM → RICBMW(1)
0.27.47	Launch BABM → RICBMD(5)
0.31.02	BABM INTRCPTS/KILLS RICBMW(1)
0.31.19	BABM INTRCPTS/KILLS RICBMD(5)
0.32.30	RICBMW(6) STRKS/KILLS BADR
0.32.49	RICBMW(4) STRKS/KILLS BABML
0.32.50	RICBMW(3) STRKS/KILLS BFTRS/FTRFLD
0.32.52	RICBMW(2) STRKS/KILLS BICBMSITE
1.00.08	Launch BBMBR → RICBML
1.06.54	Launch RBMBR → BADR
9.52.51	RBMBR Launches RASM → BADR
10.00.21	RASM STRKS BADR (Previously Killed)
10.40.23	RBMBR Launches RGRVBMB → BBMBRFLDP
10.40.33	RGRVBMB STRKS/KILLS BBMBRS/BMBRFLDP

EXHIBIT IV-3 (CONTINUED)

TIME	EVENT DESCRIPTION
11.00.08	(Scheduled Launch BICBM: (DEAD))
12.06.56	RADR SEES BBMBR
12.06.56	Launch 4 RFTR → Loiter Points
12.07.03	RADR INTRCPT TRK on BBMBR
12.07.03	VECTOR 2 RFTR → BBMBR
12.07.03	VECTOR 2 RFTR → Loiter Points
12.19.54	2 RFTR Arrive Loiter Point
12.22.28	1st RFTR 1st PASS → BBMBR (NO KILL) (2nd Pass Schld. at 12.26.28)
12.22.28	2nd RFTR 1st Pass → BBMBR (KILL)
12.22.28	1/2 RFTR ReVectored → Loiter Points
12.28.52	2 RFTR Arrive Loiter Points
13.03.35	END LOITER 2nd ASSGND RFTR → RFTRFLDP
13.06.48	END LOITER 1st ASSGND RFTR → RFTRFLDP
13.17.05	2nd ASSGND RFTR Arrives RFTRFLDP (Refuel/Remain Alert)
13.20.17	1st ASSGND RFTR Arrives RFTRFLDP
13.34.57	END LOITER 2 UNASSGND RFTR RFTRFLDP
13.47.55	2 UNASSGND RFTR Arrive RFTRFLDP

detonations. Bombers launch ASM's against distant targets and drop gravity bombs. ABM launches result in threat target destructions and fighters engage the bomber, fire and miss, recycle for a second pass, and a second fighter succeeds in his intercept of the bomber threat.

C. Illustration of Selected System Interactions

1. Introduction

The "thinness" of forces comprising the exchange demonstration test case precluded extensive interactions between game entities from occurring to any significant extent. Therefore, examples of interactions were extracted from selected test cases and submodel runs. These included the effects of dust ablation on ballistic reentry objects, interruption of radar track functions as a result of fireball blackout from a weapon burst, fratricide and multiple kills.

In the first two instances, dust and blackout effects, the attack was deliberately timed to enhance the desired effect. In the case of fratricide and multiple kills the interactions were unplanned and inadvertent, and as a result provided a significant demonstration of SIMETTE's capability for monitoring and recording these kinds of effects.

These examples are presented in the following sections with a description and sufficient game-relevant data to understand the conditions and circumstances of the interaction only. No attempt has been made to describe a complete scenario or game run.

2. Dust Ablation of Reentry Objects

Selected results of four dust submodel runs are illustrated in Exhibit IV-4. In each case a ballistic reentry object was timed to penetrate the dust/debris cloud from 25 MT and 4 MT weapon bursts at varying times after detonation as a means of checking variations in dust/debris cloud volume and density. Inspection of the exhibit shows these variations to be as expected, i.e., increasing cloud volume and decreasing cloud density with increasing time for the same yield and smaller but more dense cloud volume with lesser yield. Also, the total ablation decreases at increasing times of penetration as should be the case.

EXHIBIT IV-4 EFFECTS OF DUST ABLATION OF BALLISTIC REENTRY OBJECTS

Case No.	Burst Yield (MT)	Penetration Time After Burst (hrs·min·sec)	Dust Cloud Volume (n.mi.^{3} x 10^4)	Dust Cloud Density (g/n.mi.^{3} x 10^6)
1	25	0.00.49	3.1025	77.37
2	25	0.05.49	13.997	12.77
3	25	0.09.49	28.357	4.58
4	4	0.05.49	1.0851	26.27

[a] Kill threshold ≥ 5 g/cm^2 total ablation.

3. Effect of Blackout on Radar Performance

A chronology of events relating to interruption of radar acquisition/track functions as a result of nuclear induced fireball blackout was extracted from a game run and is summarized in Exhibit IV-5. In this example, a high altitude nuclear detonation of an ABM round aimed at a reentry threat object (No. 1) interrupts the track of a second, later arriving threat object by the indicated affected radar site (site 99), until such time as the threat object exited the occlusion zone (6. 55. 43 in game time). The program automatically monitors and records all sites whose viewing volumes are partially occupied by the blackout patch. In this particular case, the geometry of the situation was such that only the ABM radar site 99 experienced interruption of threat object track; ABM radar sites 98 and 100 were unaffected.

4. Fratricide (Friendly ABM's)

Exhibit IV-6 comprises the chronology of events of an ABM fire unit engaging independent threat reentry objects which enter the fire unit's engagement capability contour at roughly the same game time. A total of four ABM's Nos. 1 and 4 were scheduled against threat object No. 1; and ABM's Nos. 2 and 3 against threat object No. 2.

The first ABM (ABM No. 2) scheduled against threat object No. 2 aborted at launch; a second ABM launch attempt (ABM No. 3) at this threat object was successful. However, this ABM received a lethal effect while in flight from an ABM burst (ABM No. 4) aimed at threat object No. 1. Note that threat object No. 1 was previously killed by ABM No. 1, precluding the necessity of a nuclear detonation by ABM No. 4. A self-destruct event would normally have precluded the burst event of ABM No. 4 but was disallowed for this particular run. However, had ABM No. 1 failed to kill object No. 1, the ABM No. 4 would have proceeded normally to its planned intercept point and detonated to provide this fratricide example.

The net result of the engagement was:

- Two independent threat objects acquired and tracked by an ABM radar
- The scheduled launch of four ABM's—two at each object

EXHIBIT IV-5 FIREBALL BLACKOUT—ZONE OF RADAR OCCLUSION (Interruption of radar functions by nuclear detonations at high altitude)

Game Time (hrs.min.sec)	Event Description
(≤6.47.41)	Acquisition, track, and intercept track of threat object No. 1
6.47.41	Threat object No. 2 enters site 97 viewing volume
6.47.43	Site 98* acquires threat object No. 2
6.54.21	Site 99* acquires threat object No. 2
6.54.36	Launch of ABM at threat object No. 1
6.54.59	Threat object No. 2 exits viewing volume of site 98*
6.55.05	Site 100* acquires threat object No. 2
6.55.25	Detonation of ABM aimed at threat object No. 1
6.55.25	ABM burst fireball formation; occupies viewing volumes of radar sites 91, 92, 94, 97, 99*, 100*, 101
6.55.33	Threat object No. 2 exits viewing volume of site 97
6.55.35	Threat object No. 2 occluded from radar site 99*
6.55.43	Threat object No. 2 exits occlusion cone (site 99*); reacquired by site 99
6.55.51	Threat object No. 2 exits viewing volume of sites 99* and 100*
7.05.25	Fireball blackout occlusion dissipates

Note: Starred (*) sites are ABM-related radars; unstarred radar sites are early warning or air defense radars. The model records and monitors all radars whose viewing volumes are occupied by a blackout path, regardless of effect on a particular type of radar.

EXHIBIT IV-6 FRATRICIDE (FRIENDLY ABM'S)
(Chronology of Game Run Events)

Conditions: Two threatening reentry objects were within the engagement capability contour of an ABM fire unit.

Game Time (hrs.min.sec)	Event Description	
	Reentry Object 1	Reentry Object 2
6.54.07	Enters Radar Site 99 Sense Volume	
6.54.15	Threat Track by Site 99	
6.54.19	Intercept Track by Site 99	
6.54.21		Enters Radar Site 99 Sense Volume
6.54.28	Launch of ABM No. 1	
6.54.29		Threat Track by Site 99
6.54.33		Intercept Track by Site 99
6.54.42		Launch Abort of ABM No. 2
6.54.50		Launch of ABM No. 3
6.54.52	Launch of ABM No. 4	
6.55.23	ABM No. 1 Intercepts, Detonates, Delivers Lethal Dose	
6.55.33	ABM No. 4 Reaches Intended Intercept Position; Detonates	ABM No. 3 Receives Lethal Effect from ABM No. 4 Burst
6.55.39		(Scheduled Intercept by ABM No. 3)

- Intercept and kill of object No 1 by the first ABM round fired
- Abort of the first ABM scheduled for launch at object No. 2
- Detonation of the second ABM (ABM No. 4) aimed at (dead) threat object No. 1
- Receipt of a lethal dose by ABM No. 3 (inflight toward threat object No. 2) generated by ABM No. 4

5. Multiple Kills by ABM

One of the principal requirements specified for the SIMEX E&I simulator was the capability to monitor and record effects and influences on other game entities as well as the objective target. An example of this is the multiple kills of reentry threat objects by an ABM burst when only one object had been the intended target. In the game run example extracted and summarized in Exhibit IV-7, reentry threat object No. 1 was the intended candidate for interception by a single ABM round. Run results revealed that two other reentry objects in the vicinity of the burst received lethal neutron doses as well as the intended target of the ABM round, object No. 1. Of particular interest is the fact that one of the unintended targets (object No. 3) actually received a larger neutron flux than the intended target. Further examination of the results indicated that the ABM detonated a small distance from its planned intercept position, and as a result, was inadvertently in closer proximity to threat object No. 3.

6. Side-1 ICBM Mission 12

In one example, Mission 12, an ICBM carrying two warheads (yield, 500 KT each) and three decoys, was targeted against a Side-2 ABM complex (ABM launch site 48). Both warheads were to arrive almost simultaneously. Exhibit IV-8 summarizes the resultant events of interest as a function of game time. The first arriving warhead detonated some distance off intended target (site 48, range 2.1 n.mi.); however it generated sufficient blast overpressure on the intended target to constitute a lethal effect according to the conditions employed.

EXHIBIT IV-7 EXAMPLE OF MULTIPLE KILLS BY ABM

Reentry Threat Object	1[a]	2	3
Neutron Flux Accumulation	1.3×10^{17}	8.95×10^{15}	2.07×10^{18}
Overkill[b] (Multiples Over Threshold)	521.6	35.8	8280.8

[a] Threat object No. 1 was the intended target of the ABM round.

[b] Threshold neutron flux accumulation $\geq 2.5 \times 10^{14}$.

EXHIBIT IV-8 CHRONOLOGY OF SIDE-1 ICBM MISSION 12
(Multisystem Interactions)

Game Time (hrs.min.sec)	Event Description
5.59.33	Mission 12, ICBM launched/targeted against SIDE-2 ABM complex (2 WHDS + 3 decoys)
6.27.04	WHD No. 1 (500 KT yield; aimed at ABM launch site 48) surface bursts
6.27.04	WHD No. 2 receives 5.4 x 10^{20} neutrons (range = 0.85 n.mi.) (Kill threshold = 2 x 10^{14} neutrons)
6.27.14	SIDE-2 ABM launch site 48 receives 5.49 psi overpressure; range = 2.1 n.mi. (Kill threshold = 4.0 psi)
6.27.27	SIDE-2 ABM guidance radar site 99 receives 1.52 psi; range = 4.5 n.mi. (Kill threshold = 1.5 psi)
6.27.27	SIDE-2 ABM launch control facility 141 receives 1.52 psi; range = 4.5 n.mi. (Kill threshold = 2.5 psi)
6.28.32	Overpressure front dissipated

Although this detonation was too far removed to produce any appreciable radiation effects on its intended target, it did produce 5.4×10^{20} neutrons on the second warhead at a range of approximately 0.85 n.mi. This particular type of warhead had a specified kill threshold of 2×10^{14} neutrons and was therefore a victim of fratricide. This illustrates SIMETTE's capability of recognizing and evaluating multisystem interactions.

Also recorded was a lethal blast overpressure effect on an ABM guidance radar site (No. 99) at a range of 4.5 n.mi. from the burst and a measurable but nonlethal overpressure effect at an ABM LCF collocated with the radar. Finally, 1 minute and 28 seconds after the burst, the blast overpressure front was recorded as dissipated.

7. Side-1 ICBM Mission 25

Drawing from the two-sided exchange test case referenced above, another example of multisystem interaction can be seen in Mission 25 of SIDE-1. As in Mission 12, this payload consisted of two warheads (500 KT yield each) and three decoys. The two warheads were both targeted against a primary bomber field of SIDE-2. This field had an initial inventory of eight bombers, of which five were launched between 6.25.09 and 6.26.02. The three uncommitted bombers remained on the ground.

Mission 25 was launched at 5.59.33 game time with the first warhead detonating at 6.30.38, at an altitude of 1,500 feet above ground. The detonation produced a flux of 5×10^{17} neutrons at the airfield which was more than fatal compared to the kill threshold of 5×10^{13} (associated with the aerospace ground equipment (AGE) and related equipment at the base). This environment was also fatal to the three bombers located at the base with specified kill thresholds of 3×10^{13} neutrons.

A fighter base with a complement of five interceptors was located approximately 3 n.mi. from the bomber field. This airfield received 1.4×10^{13} neutrons which was sufficient to destroy its AGE whose threshold was set at 1×10^{13}. The fighter aircraft stationed at the base had a threshold of 2×10^{13} and were therefore not killed by neutrons.

However, they also received 80 rads of gamma radiation which exceeded their established kill threshold of 50 rads. Thus, the detonation of a single warhead from Mission 25 killed not only its primary target but achieved a secondary kill of a nearby fighter base and its associated equipment.

The complete chronology of Mission 25 is shown in Exhibit IV-9. Note that the second warhead of this mission, detonated at 6. 30. 51, fails to achieve any kills due to the success of the first warhead. This results from the computational procedure incorporated into SIMETTE that once a site or object is considered dead from any source, no further effects are computed.

D. Sizing Considerations

SIMETTE is designed to accommodate an unlimited number of objects. The number of objects that can be submitted to a game run is constrained only by the size of core memory available. Test case results have enabled estimates to be established for problem sizes that can be run on currently available computers.

Core memory is used for the simulation program itself, static test case data, data which is dynamically used and generated during the game, and the operating software system required by the computer. Static test case data consists of descriptions and parameters needed to define sites such silos, radars, command headquarters, etc. Dynamic core is used to hold path legs for missions in progress, bursts records, sensor and C&C messages, and path information for active defensive missions. Dynamic core requirements depend upon the number of objects in the game and the scenario timing, i.e., more dynamic core is required when there are many missions active than when there are only a few active missions.

The test cases were run on an IBM 360/50 computer with 512, 000 bytes of memory. The 360 operating system requires about 146, 000 bytes, and the simulation program requires about 216, 000 bytes. The largest test case played required about 69, 000 bytes for static data. This case consisted of specifications for 162 sites, and type parameters for 30 warhead types, 12 radar types, 14 missile site types, 8 airfield types, 26

EXHIBIT IV-9 CHRONOLOGY OF SIDE-1 ICBM MISSION 25

Game Time (hrs.min.sec)	Event Description
5.59.33	Launch ICBM Mission 25 against SIDE-2 bomber field (64) (2 warheads and 3 decoys)
6.25.09	Launch bomber No. 1 from base 64
6.25.23	Launch bomber No. 2 from base 64
6.25.36	Launch bomber No. 3 from base 64
6.25.49	Launch bomber No. 4 from base 64
6.26.02	Launch bomber No. 5 from base 64
6.30.38	First warhead detonates against bomber field site 64 (500 KT yield; 1,500 feet altitude) Bomber base site 64 receives 5×10^{17} neutrons (Kill threshold = 5×10^{13} neutrons*) 3 bombers on ground also killed (threshold = 3×10^{13} neutrons) Fighter base site 70 receives 1.4×10^{13} neutrons (Kill threshold = 1×10^{13} neutrons*) 5 fighters on ground receive 80 rads gamma radiation (Kill threshold = 50 rads)
6.30.51	Second warhead detonates—no additional kills

*Kill threshold associated with AGE and associated equipment.

C&C types, 71 types of vehicles, and 16 volume types. This test case then left the remaining core of only 81,000 bytes available for dynamic storage. This was sufficient to play 10 bomber missions and 16 missile missions.

Larger problems may be run on the IBM system 360/65 available at the NMCSSC which has 1,024,000 bytes of memory. Extrapolation of test results indicates that a problem consisting of about 800 moving objects and 500 fixed sites could be accommodated on this larger machine. Adaption of the simulator to this larger machine will be rather straightforward because of software compatibility in the 360 series computers. Also a possibility exists for using the 360/91 at the Applied Physics Laboratory which could handle an even larger problem in its 2,048,000 byte memory.

V. APPLICABILITY OF SIMETTE

A. Prototype Capabilities and Limitations

The purpose of the original SIMEX study was to recommend techniques for the evaluation of multisystem, multicountry offense/defense interactions. This study recommended a comprehensive E&I simulation model supported by a BPG to facilitate preparation of the large volume of data necessary to run such a model and a DMS to handle the reference data files for the BPG and to analyze the results of E&I runs. The components of the SIMEX system are described in detail in WSEG Report 149.

Prior to the full development of SIMEX, it was decided to proceed with a prototype development of the E&I model to verify the validity of the approach and to gain insights into the problems associated with such a development. This prototype is called SIMETTE.

As a prototype, SIMETTE does not contain all of the features and functions of the more sophisticated SIMEX model. However, it does incorporate a majority of the basic elements of such a model and, as such, has numerous capabilities not found in other models currently available. Some of these features are:

- Global, strategic multicountry nuclear exchange model
- Individual representation of all objects (reentry vehicles, bombers, ABM's, MI's, etc.) and sites (missile silos, radars, airfields, etc.)
- Nuclear effects representation
  - Prompt radiation: gamma, X-ray and neutron
  - Overpressure against fixed and moving targets
  - Dust clouds for vehicle ablation
  - Sensor blackout (cookie-cutter occlusion cone or full attenuation computations)

- Nuclear effects evaluation
  - Compute effects received by each object/site in vicinity of the detonation
  - Cumulative effects (with time decay as appropriate)
  - Comparison with individually specified kill thresholds
- Command and control structure for offense and defense may be modified as attrition is experienced
- Simplified communications model between active sites and C&C
- Sensor driven defense with individual representation of sites, radars, and vehicles associated with ABM, SAM, and MI defenses

In addition, some of the desirable features of SIMETTE cannot be stated in a positive manner. For example, nuclear effects are not constrained to a specific target but any object within range of the effects. Radar blackout from a nuclear detonation is not treated as a degradation factor but is dependent on the particular object/radar/burst geometry and timing. There are numerous "filters" incorporated into the model to exclude undesirable or illogical operations. The filters are of a physical as well as logical nature. For example, the model does not attempt to track a MI with an ABM or ballistic missile early warning system (BMEWS) type of radar.

There are also features of SIMETTE related to its design rather than how it operates. In particular:

- Modular design and implementation to facilitate modification and expansion.
- In the absence of a DMS and BPG envisioned for SIMEX, a preprocessor has been added to simplify and edit check the user supplied input data. A postprocessor has been added to extract summary reports from the game's history file.
- The game "size" is independent of the model. How big a game can be run is dictated solely by the size of the available core memory to contain the program and data. On the

other end of the size spectrum, a game could be run consisting of a single defensive unit (or target) and a single threat.

During the development phase of SIMETTE a sufficient number of test cases and submodel runs were conducted to demonstrate that the prototype has the capability to:

- Represent dust clouds resulting from surface or near-surface bursts and, when reentry objects penetrate such clouds, they are eroded and may be killed as a result.
- Represent ionized radiation clouds (fireballs) from nuclear detonations that may preclude a radar from acquisition/ track of an object (friend or foe).
- Record fratricide or bonus kills whenever planning inadvertently places more than one object/site in the vicinity of nuclear detonation.
- Achieved kills due to radiation effects and overpressure in addition to dust erosion.
- Coordinate the ABM, SAM, and MI defensive elements through the C&C structure.
- Represent successfully all of the game elements and their interactions within a single model.

SIMETTE, as a prototype, does not contain all of the features and functions intended for the full E&I model of SIMEX. Some of the additional features that would be desirable in SIMEX are:

- Active ECM and chaff
- Degradation of performance as a function of cumulative environment (e.g., salvage fuzing)
- Electromagnetic pulse (EMP) from nuclear bursts
- FOB's and satellite systems (weapons and sensors)
- Exclusion corridors for friendly offense/defense (ABM)
- SAM/MI interface and coordination
- Discrimination of real threats from decoys and associated errors in interpretation

- Errors in evaluation of defensive action (e.g., a threat is declared dead but is still alive and conversely, declared alive but dead)
- Multiple levels of detail in representation of nuclear effects
- Multiple levels of detail in the kinematics of moving objects such as more refined ICBM trajectory
- More refined and detailed command, control, and communications submodel
- A BPG to ease preparation of inputs
- A DMS to handle data files and analyze game results

Of the items in the above list, the most critical in applications of large scope are the last two. All models of this type, whether it be SIMETTE or some other available model, suffer from two major deficiencies regardless of how well they perform. First, the preparation of game inputs is primarily a manual process requiring large amounts of manpower and time with its associated tedium and errors. Secondly, no matter how many summary or detailed reports are produced, there is never the exact data available to the user to readily identify the various cause and effects relationships in his particular game. This is not to say that such reports are unnecessary, but they constitute only the first step of a thorough analysis.

The key to alleviating these deficiencies is a comprehensive DMS to store, retrieve, and update the data files needed by the BPG and to receive the game's detailed output for retrieval and selective analysis by the user. No model in the class of SIMEX or SIMETTE can realize its full potential and efficiency until it has been supplemented by a DMS.

It is recognized that the addition of a DMS could be an expensive and time consuming step. However, by using a systems that is currently available such as TDMS (recommended for SIMEX) and pursuing an evolutionary approach, its incorporation could be accomplished with a moderate level of effort. The most logical step in such an evolutionary approach would be to use the DMS to support the preprocessor and/or postprocessor of SIMETTE. It could be used initially as a simple repository of data for subsequent recall and reuse. Gradually, as time and resources permit, it could assume more and more of the pre- and postprocessor functions until they were completely embedded within the DMS. This condition would then provide an ideal framework within which to develop a BPG, should such a system be required, but would in no way be a commitment to such a development.

Further, SIMETTE has been planned and designed to accommodate growth and expansion. In fact, most of the features listed above for SIMEX have been recognized since the beginning of the project and, thus, SIMETTE has been designed specifically to accommodate their addition even though they are not now included. Because of this preplanning and the modular design, many of these features can be added with minimal time and effort.

Recognition that multi-system interactions could influence retaliatory capability in an environment created by offensive and defensive bursts prompted the introduction of a SIMEX design as a means to study the problem. As demonstrated by the limited results summarized in a previous section, SIMETTE has the capability for revealing interactions which indicate a substantial influence on engagement outcomes and which no other reported analytic technique is capable of considering. As a result, SIMETTE has immediate application to many current problems of interest not fully analyzable by other methods in terms of scope or detail. Applications intended to reveal the influence of multisystem interactions would provide insight into meaningful problems, as well as serve to verify the utility of SIMETTE as an operational tool. Selected examples of these applications are discussed in the next part.

B. Applications

SIMETTE was designed as a means for simulating the exchange and interactions between the offensive and defensive forces of opposing sides in all levels of nuclear war up to and including global general war. Unique to the design is its capability to monitor and record multisystem interactions. Particular emphasis in the design also included consideration of:

- Game elements as individual entities
- Secondary nuclear effects (dust erosion, blackout, etc.)
- Replaceability of algorithms including
    - Weapon effect propagation
    - Weapon and supporting system characterization
    - Decisionmaking channeling

As with other large simulations, SIMETTE shares a common limitation—input data preparation, a task which would require a significant expenditure of time and man-effort for problems of large scope without the aid of an operating DMS. However, this limitation is substantially removed without compromising program capability for problems in which geographic considerations are limited or a reduced inventory of system elements is provided as input.

Development and test experience indicates that the prototype, SIMETTE, can be used to study current problems of interest. This discussion identifies the types of problems that the prototype could be applied to.

Problems to which SIMETTE can be applied include assessment of:

- The survivability through boost/launch phase of offensive elements (ICBM's and manned bombers) defended by ABM in a geographically bounded locale and subjected to varying attack levels, penetration tactics, attacking system characteristics, etc.
- Penetration requirements (tactics, numbers, and composition) of an offensive attack on an (b)(1) defended by a "thick" ABM defense.
- Manned bomber penetration requirements (defense suppression, tactics, penaids, timing, etc.) in an intensively defended area, emphasizing varying defense command/control representations and a diversity of defensive weapons.

- Defense effectiveness of a "thin" ABM defense under "light" attack in a global scenario.

In the first two cases defended elements would be subject to the following possible mechanisms:

- Attrition due to direct weapon effects damage by attacking warheads
- Attrition due to secondary effects resulting in warhead detonations (such as dust erosion)
- Defensive capability to limit damage by attacking warheads to the offensive forces in the first case and the (b)(1) in the second case
- Defensive contribution to the nuclear environment in the defensive battle space which may have either a direct or an indirect effect upon the defended elements
- Degradation of defensive battle space due to the evolving nuclear environment

A basic scenario could be developed for such a study as discussed above and would consist of:

- Enemy missile missions including ICBM's with single warheads, multiple warheads and decoys directed against the defensive elements and defended elements.
- Offensive missions planned to depart from the defended area toward objective targets
- Site locations and systems parameters of offensive and defensive elements within the defended area

In the cited cases, scenario variations would focus on all or part of the following factors as appropriate:

- Timing alterations of the offensive attack in all examples
- Timing alterations of the offensive launch in the trans-attack period
- Varying attack density as a function of elapsed time interval ("compressed" versus "strung-out" attacks, etc.)

- Penetration tactics (warhead/decoy mixes; stand-off/pin-down attacks; attack partition between objective targets and defense suppression; etc.)
- Offensive/defense coordination to include defensive ABM (or AD) holds as a function of time windows, geographic fly-out contours or a combination of both
- Command/control network characterizations (dispersed/ autonomous/ centralized/close control)

All moving elements in the game, enemy offensive, friendly offensive and defensive, would be subject to direct weapon effects, dust erosion or unintended fratricide effects as influenced by the specified timing and tactics governing their employment.

The number of moving objects that can be handled by SIMETTE is limited only by the size of available core memory. Application of SIMETTE to a missile defense study is therefore possible because steps may be taken to constrain the use of memory by objects participating in the game. This constraint may be accomplished in two ways, either or both of which contribute to the feasibility of conducting the study within the bounds of available computers. First, the geometry of concern would include only the specific number of objects and sites contained with the defended area and the enemy missions against that area. Secondly, artifacts can be introduced which will contribute to a reduction of storage requirements.

For example, offensive vehicles are of interest only in their ability to depart safely from the defended area. Offensive bomber missions can therefore be submitted to a game run with only the number of flight path legs necessary to achieve takeoff and departure from the defended area. The remaining flight path legs need not be entered and thereby not require the additional memory storage. Likewise, offensive missile missions could be terminated at the conclusion of the boost phase which can be presumed to be outside of the defensive battle space. With a minor modification to the preprocessor the enemy attacking missile missions may be launched from a position instead of a site, thereby eliminating the need to hold the site specification data in memory.

SIMETTE game runs of limited scenarios will provide valuable insights as to resulting interactions not available by other means. However, care should be exercised when extrapolating results to global implications. Excursions of game scenarios may be designed and run to establish some measures for extrapolation.

These or similar immediate applications can reveal a depth of understanding not available by existing methods of analysis. Furthermore, they can provide practical experience to assist in refinement of the establishment of priorities for the evolutionary development required to achieve SIMEX capabilities.

VI. PRINCIPAL FINDINGS

Where the scope of game-dependent factors capable of consideration has been a limiting factor in study credibility, the SIMETTE prototype is unique in comparison with other computer models or analytic techniques as a high confidence and multipurpose tool for the study of exchanges and interactions. This is supported by the documented design logic and demonstrated test case results.

The SIMEX concept and design is uniquely suited for the study of multisystem interactions and exchanges in general nuclear war situations and is reconfirmed as technically feasible. This is supported by the experience of a demonstration test case executed by the prototype Exchange and Interactions (E&I) model, SIMETTE.

The computerized allocation method for BPG demonstrated in this study is rapid in execution and highly compatible with the principal operational constraints. Although off-optimal in payoff efficiency, its flexibility rapidity, and compatibility with operational constraints lends extensive practicability for its application in many circumstances. The acceptable quality of its results and its compatibility with more refined and rigorous allocation methods makes it an efficient departure point for cases where a high degree of refinement is desired in weapon resource allocation.

Although slightly less capable than comparable CDC equipment from the viewpoint of execution time, the IBM System 360 series of computer equipment is preferred as the computer for SIMEX because of greater core capacity with a built-in growth potential for the system 360 series compared to comparable CDC equipment. Inasmuch as the dynamic core storage requirements of the simulator is extensive and a potential limiting factor in the utility of SIMEX for large problems, core capacity was the principal factor in computer preference selection.

The use of SIMSCRIPT as the program simulation language and the associated use of process logic in the simulator design extends the long-term utility of SIMETTE in applications to general war-related studies because of the resulting flexibility and modularity. This current and long-term utility to problems of large scope is limited only by:

- The extent to which supporting algorithms for emulating weapon effects and system operability are rigorously characterizable
- The extent to which parallel development of an automated data management system (DMS) and battle plan generator (BPG) is realized
- The extent to which supporting computer and ancillary equipment is made available for SIMEX applicable problems

This study effort indicated that a lengthy and extensive input preparation effort would likely be required in game runs of problems of large scope. This factor and the massiveness in scope of the possible categories of run output (that a user may require) emphasize the requirement for an automated DMS in order that model capability can be fully exploited. The principal candidate DMS for SIMEX remains as ADEPTS/TDMS.

In the absence of an automated DMS system and computer with adequate core memory, the prototype is capable of application to current problems of interest in which the number of game objects is restricted and still provide a degree of understanding not now available by other computational methods.

As indicated by the experience of this effort, the investment in the design of SIMEX and development of SIMETTE can provide immediate benefits. Several courses of action on the use of SIMETTE suggest themselves as progressive evolutionary steps, in the following order of priority.

- Apply SIMETTE to current studies of interest to identify possible solutions to multisystem interaction problems
- Allow some evolutionary growth of SIMETTE to support the immediate needs of study requirements
- Support the application of SIMETTE by using an available DMS for game run analysis and data file maintenance as a prototype endeavor

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WSEG REPORT 155

SIMETTE

SIMEX PROTOTYPE DEVELOPMENT

September 1970

Volume II: SIMETTE User's Manual

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I. INTRODUCTION

The purpose of this volume is to acquaint potential users with the data requirements of the prototype model and establish the instructions for input data preparation. A familiarity with model capability will be of assistance in understanding the material contained in this volume. A narrative description of the model will be found in Volume I, Main Paper, of this report and should be read prior to examination of the instructions for data preparation contained in this volume. Technical descriptions and the algorithms of the subroutines which comprise SIMETTE are to be found in Volume III, SIMETTE Computer Programs and Methodology, of this report.

This volume contains instructions for completing the Code Description Tables and for preparation of input data forms. Exhibits of the required creation sheets are also included. Completion of Code Description Tables, presented in Section II, is essential before attempting to prepare the input data forms discussed in Section III. The Code Description Tables are organized in a series of classes, subclasses, and types to take advantage of associations based on common entity descriptive attributes. Once filled out, these tables should be consistently used by all those involved in preparation of the input data forms.

The organization of the input data forms are such as to provide logical grouping into the general categories of site related data, vehicle (moving objects) performance specifications, warhead specifications, nuclear vulnerability for all sites and vehicles, and vehicle path and path-related information. The instructions in Section III provide the detailed instructions for preparation of the data forms and indicate the cross referencing of data between these forms.

II. CODE DESCRIPTION TABLES

Class and type codes are used in SIMETTE to identify groups of entities having common characteristics. The purpose of such groupings is to permit a single listing of the common characteristics of like entities. Thus, only unique characteristics such as the location of an airfield need be associated directly with the entity's name. The one time definition of the common characteristics for each given type entity significantly reduces user labor in preparing input data forms.

The entities covered by class and type codes are vehicles, bursts, and sites. The general class codes are:

100 series--vehicles
200 series--bursts
500 series--missile sites
600 series--airfields
700 series--sensor sites
800 series--command centers
900 series-(b)(1)
1000 series--other military targets

The specific class codes such as 101 (offensive land based missiles) are used for addressing subclasses of entities.

Exhibits II-1, II-2, and II-3 give the code description tables for vehicles, bursts, and sites respectively. Type codes are listed in each of the tables under the class or subclass headings. Series numbering of the type codes can only be repeated for each general class code, as shown in the exhibits. The class and subclass codes, because of their association to the computer program, cannot be modified by the user. On the other hand, the type codes can be arbitrarily defined or rearranged as long as they are used consistently on the data input forms. The numbers and descriptions given in the exhibits for the type codes are only illustrative of how they might be defined for a two-sided strategic war. Before filling out the SIMETTE data input forms, the user should list and describe in the code description tables, all type codes to be used for a given simulation run. These tables should then be referred to by all people filling out the input forms for the given simulation run.

EXHIBIT II-1 VEHICLE CODE DESCRIPTION

Class	Type	Description
101		Offensive Missiles, Land
	1	Blue ICBM, Mod 1
	2	Blue ICBM, Mod 2
	3	Blue ICBM, Mod 3
	4	Red ICBM, Mod 1
	5	Red ICBM, Mod 2 (FOBS)
	6	Red ICBM, Mod 3
	7	Red ICBM, Mod 4
102		Offensive Missiles, Sea
	8	Blue SLBM, Mod 1
	9	Blue SLBM, Mod 2
	10	Blue SLBM, Mod 3
	11	Red SLBM, Mod 1
	12	Red SLBM, Mod 2
	13	Red SLBM, Mod 3
103		Air Defense Missiles
	14	Blue SAM, Mod 1 (High Altitude)
	15	Blue SAM, Mod 2 (Low Altitude)
	16	Red SAM, Mod 1
	17	Red SAM, Mod 2
104		Anti-Ballistic Missiles (ABM's)
	18	Blue ABM, Mod 1 (Short Range)
	19	Blue ABM, Mod 2 (Long Range)
	20	Red ABM, Mod 1 (Short Range)
	21	Red ABM, Mod 2 (Long Range)
105		Manned Bombers
	22	Blue Bomber, Mod 1
	23	Blue Bomber, Mod 2
	24	Blue Bomber, Mod 3 (Supersonic)
	25	Red Bomber, Mod 1
	26	Red Bomber, Mod 2
	27	Red Bomber, Mod 3 (Supersonic)
106		Manned Interceptors
	28	Blue Interceptor, Mod 1
	29	Blue Interceptor, Mod 2
	30	Blue Interceptor, Mod 3
	31	Red Interceptor, Mod 1
	32	Red Interceptor, Mod 2
	33	Red Interceptor, Mod 3

EXHIBIT II-1 (CONTINUED)

Class	Type	Description
107		Reentry Vehicles
	34	Blue RV, Small, Mod 1 (Single)
	35	Blue RV, Small, Mod 2 (Cluster)
	36	Blue RV, Small, Mod 3 (MIRV)
	37	Blue RV, Medium, Mod 1 (Single)
	38	Blue RV, Medium, Mod 2 (Cluster)
	39	Blue RV, Medium, Mod 3 (MIRV)
	40	Blue RV, Large, Mod 1 (Single)
	41	Blue RV, Large, Mod 2
	42	Red RV, Small, Mod 1 (Single)
	43	Red RV, Small, Mod 2 (Cluster)
	44	Red RV, Small, Mod 3 (MIRV)
	45	Red RV, Medium, Mod 1 (Single)
	46	Red RV, Medium, Mod 2 (Cluster)
	47	Red RV, Medium, Mod 3 (MIRV)
	48	Red RV, Large, Mod 1 (Single)
	49	Red RV, Large, Mod 2
108		Penaids (Offensive Missile)
	50	Blue Exoatmospheric Decoy
	51	Blue Endoatmospheric Decoy
	52	Red Exoatmospheric Decoy
	53	Red Endoatmospheric Decoy
109		Air-to-Surface Missiles (ASM's)
	54	Blue ASM, Mod 1
	55	Blue ASM, Mod 2
	56	Blue ASM, Decoy
	57	Red ASM, Mod 1
	58	Red ASM, Mod 2
	59	Red ASM, Decoy
110		Free-Fall Bombs
	60	Blue Bomb, Small, Mod 1 (Low Altitude CEP)
	61	Blue Bomb, Small, Mod 2 (High Altitude CEP)
	62	Blue Bomb, Medium, Mod 1 (Low Altitude CEP)
	63	Blue Bomb, Medium, Mod 2 (High Altitude CEP)
	64	Blue Bomb, Large, Mod 1 (Low Altitude CEP)
	65	Blue Bomb, Large, Mod 2 (High Altitude CEP)
	66	Red Bomb, Small, Mod 1 (Low Altitude CEP)
	67	Red Bomb, Small, Mod 2 (High Altitude CEP)
	68	Red Bomb, Medium, Mod 1 (Low Altitude CEP)
	69	Red Bomb, Medium, Mod 2 (High Altitude CEP)
	70	Red Bomb, Large, Mod 1 (Low Altitude CEP)
	71	Red Bomb, Large, Mod 2 (High Altitude CEP)

EXHIBIT II-2 BURST CODE DESCRIPTION

Class	Type	Description
201		Offensive Missile Warheads
	1	Blue WD, Small, Mod 1
	2	Blue WD, Small, Mod 2
	3	Blue WD, Medium, Mod 1
	4	Blue WD, Medium, Mod 2
	5	Blue WD, Large, Mod 1
	6	Blue WD, Large, Mod 2
	7	Red WD, Small, Mod 1
	8	Red WD, Small, Mod 2
	9	Red WD, Medium, Mod 1
	10	Red WD, Medium, Mod 2
	11	Red WD, Large, Mod 1
	12	Red WD, Large, Mod 2
		SAM Warheads
	13	Blue WD, Mod 1
	14	Blue WD, Mod 2
	15	Red WD, Mod 1
	16	Red WD, Mod 2
		ABM Warheads
	17	Blue WD, Mod 1
	18	Blue WD, Mod 2
	19	Red WD, Mod 1
	20	Red WD, Mod 2
		Air-to-Surface Missile (ASM) Warheads
	21	Blue WD, Mod 1
	22	Blue WD, Mod 2
	23	Red WD, Mod 1
	24	Red WD, Mod 2
		Bomb Warheads
	25	Blue WD, Mod 1
	26	Blue WD, Mod 2
	27	Blue WD, Mod 3
	28	Red WD, Mod 1
	29	Red WD, Mod 2
	30	Red WD, Mod 3

EXHIBIT II-3 SITE CODE DESCRIPTION

Class	Type	Description
501		Offensive Missile Sites (Land-based)
	1	Blue, Land, Soft
	2	Blue, Land, Hard
	3	Red, Land, Soft
	4	Red, Land, Hard
502		Offensive Missile Sites (Sea-based)
	5	Blue, Sub Mod 1
	6	Blue, Sub Mod 2
	7	Red, Sub Mod 3
	8	Red, Sub Mod 4
503		Defensive Missile Sites (SAM)
	9	Blue SAM, Short Range
	10	Blue SAM, Long Range
	11	Red SAM, Short Range
	12	Red SAM, Long Range
504		Defensive Missile Sites (ABM)
	13	Blue ABM, Short Range
	14	Blue ABM, Long Range
	15	Red ABM, Short Range
	16	Red ABM, Long Range
601		Bomber Airfields
	1	Blue Main Base - Full Support
	2	Blue Dispersion Base - Limited Capability
	3	Red Main Base - Full Support
	4	Red Dispersion Base - Limited Capability
602		Interceptor Airfields
	5	Blue Main Base - Full Support
	6	Blue Dispersion Base - Limited Capability
	7	Red Main Base - Full Support
	8	Red Dispersion Base - Limited Capability
701		Early Warning Sensors
	1	Blue EW Aircraft
	2	Blue EW Missiles
	3	Red EW Aircraft
	4	Red EW Missiles

EXHIBIT II-3 (CONTINUED)

Class	Type	Description
702		ABM Radars (Detection and Control)
	5	Blue Long Range
	6	Blue Terminal
	7	Red Long Range
	8	Red Terminal
703		Air Defense Radars (Detection and Control)
	9	Blue GCI
	10	Blue AWAC
	11	Blue SAM
	12	Red GCI
	13	Red AWAC
	14	Red SAM
801		Offensive Command Centers (Land-based)
	1	Blue Missile LCF
	2	Blue Bomber CP
	3	Blue Offensive Headquarters
	4	Blue National Command Center
	5	Red Missile LCF
	6	Red Bomber CP
	7	Red Offensive Headquarters
	8	Red National Command Center
802		Offensive Command Centers (Sea-based)
	9	Blue Missile LCF
	10	Red Missile LCF
803		Defensive Command Centers (Air Defense)
	11	Blue Interceptor Base CP
	12	Blue SAM CP
	13	Blue Air Defense Division
	14	Blue Defense Region
	15	Blue Defense Headquarters
	16	Red Interceptor Base CP
	17	Red SAM CP
	18	Red Air Defense Division
	19	Red Defense Region
	20	Red Defense Headquarters

EXHIBIT II-3 (CONTINUED)

Class	Type	Description
804		Defensive Command Centers (ABM)
	21	Blue ABM CP, Short Range
	22	Blue ABM CP, Long Range
	23	Blue Missile Defense Division
	24	Red ABM CP, Short Range
	25	Red ABM CP, Long Range
	26	Red Missile Defense Division
901		(b)(1)
	1	Blue, Config. 1
	2	Blue, Config. 2
	3	Red, Config. 1
	4	Red, Config. 2
1001		Other Military Targets
	1	Blue (b)(1)
	2	Blue [redacted]
	3	Blue [redacted]
	4	Red [redacted]
	5	Red [redacted]
	6	Red [redacted]

III. INPUT INSTRUCTIONS

A. General

The input data required for a SIMETTE model run are to be entered on 26 distinct forms developed to simplify the task of collecting and recording the data. The type forms and instructions for completing them are presented in this volume in a sequence that is convenient for the model user. However, before the completed forms are submitted to be key punched, they must be ordered according to the sequence shown in Exhibit III-1. This is necessary since the punched cards must be entered into the computer for the preprocessor program in the indicated sequence. The five form codes followed by asterisks in Exhibit III-1 all utilize the same Form N, but it is necessary for key punching to list separately each of the five kinds of nuclear vulnerability data represented by these codes.

For the user, the forms are ordered in this volume so that the input data is requested in a logical order. The basic ordering of forms is as follows:

- Site related data
- Vehicle specifications
- Warhead specifications and nuclear vulnerability
- Vehicle movement related data

General and specific instructions for each form are presented in the next section.

The rest of this section is devoted to presenting instructions that are common to all forms.

To avoid confusion between certain letters and numbers, the following symbols should be used:

Letter	Number
Ø	0
I	1
Ƶ	2
S	5
G	6

When the same letters or numbers are repeated in column, the user may underline the entry or portion of entry to be repeated and then draw a line from the underlined item down through the last row in which it is repeated. The line should be terminated with an arrowhead. The following are two examples:

<u>RICBM</u>	501	<u>700</u>
│	502	│
↓	503	↓

Various descriptive and identification codes, including the class and type codes described in Section II are called for in the forms. All are strictly numeric (all numbers) except for the unique name codes assigned to sites, sortie segments, and paths. The name codes can be alphanumeric. That is, they can use either letters, numbers, or a combination of letters and numbers. For instance, RICBM 501 might be the code name given to the five hundred and first red ICBM launch site. No other entity in the game run would be given this same code name so that each time it is used it would refer only to that entity.

It is not necessary to fill in all the columns assigned to a name or any other code. However, since a space left blank is equivalent to a zero entry, it is important to start numbering from the right-most column. For instance:

0	2	0	0
0	0	2	0
0	0	0	2

may be written

	2	0	0	two hundred
		2	0	twenty
			2	two

If a name does not use all columns assigned to it, then the leftmost columns should be left blank. For instance:

	R	A	B	M	1	1	0
		R	M	H	Q	1	2

In all cases, where an entity name is repeated on several data forms, it is essential that the same name orientation (same blank spaces) be maintained within the assigned columns. For instance:

R	I	C	B	M	0	1	
	R	I	C	B	M	0	1

would be interpreted by the computer as two different name entities.

Periods or dots are used in columns for two purposes. One purpose is to separate an entry into distinct parts such as degrees, minutes, and seconds of latitude. The other purpose is to act as a decimal point. In either case the column containing the dot is to be left blank. The user cannot introduce nor remove any dot in the forms. Where no decimal point is available, then the number entered in a field will be an integer.

EXHIBIT III-1 FORM SEQUENCE FOR KEYPUNCH

Sequence Number	Form Code	Title
1	OP	Run Options
2	C	Volume Specifications
3	WS	Warhead Specifications
4	SS	Sensor Site Specifications
5	NR*	Radar Site Nuclear Vulnerability
6	MS	Missile Site Specifications
7	NM*	Missile Site Nuclear Vulnerability
8	AS	Airfield Specifications
9	NA*	Airfield Nuclear Vulnerability
10	CS	Command Site Specifications
11	NC*	Command Site Nuclear Vulnerability
12	V1	Vehicle Specs.: Booster, RV, & Decoy
13	V2	Vehicle Specs.: Fighter
14	V3	Vehicle Specs.: Bomber and ASM
15	V4	Vehicle Specs.: ABM and SAM
16	NV*	Vehicle Nuclear Vulnerability
17	R	Game Reference Times
18	W	Bomber Windows from H-HCL
19	D	Missile Launch Windows from E-hour
20	SV	Site Value Data
21	A	Site Data

EXHIBIT III-1 (CONTINUED)

Sequence Number	Form Code	Title
22	A1	Command & Control Structure
23	A2	ABM Denial Zone Definition
24	A3	Self-Defense Areas
25	T	Bomber Missions
26	B	Bomber Sortie Data
27	E	Missile Missions
28	P	Missile Path Generation
29	L	Loiter Points
30	TF	Trace Flag Values

*Uses form N; second letter must be inserted by user.

B. Form Instructions

SIMETTE Form A - Site Data

Form Purpose: This form identifies, locates and describes each site to be treated in a given simulation run. Identifying codes permit indexing more detailed site characteristics on related input forms. This includes indexing characteristics of equipment located or based at the site. If a site contains a radar or defense missiles with non-uniform coverage in azimuth, then a reference axis permits proper orientation of the coverage volume. Also, if vehicles such as bombers, fighters, SAMs or ABMs are based at the site, then an initial inventory of each type vehicle can be indicated. For those sites commanding one or more radars used for ABM guidance, insert the maximum number of guidance channels in the initial inventory field of the command site.

General Instructions: All names assigned to sites must be unique alphanumeric designations. Codes for owner country, site class and type, equipment type, and value table identifier must be selected carefully to avoid improper indexing. If more than one type of equipment will be located at a given site during the play of the game, then a unique site name must be defined for each different type of equipment that will be associated with the site. Dummy collocated sites are also required if the site reports to more than one command center.

Specific Instructions:

Columns	Heading	
4-11	Name	Enter a unique alphanumeric code to identify each specific site.

Columns	Heading	Instruction
13-21	Latitude	Enter degrees, minutes, and seconds of latitude, N if north or S if south, for each site location.
23-32	Longitude	Enter degrees, minutes, and seconds of longitude, E if east and W if west, for each site location.
34-38	Altitude	Enter site altitude in feet above mean sea level.
40-45	Volume Reference Axis	Fill in only if the site has a radar or defense missile with non-uniform coverage in azimuth. A volume having identical coverage patterns in all vertical slices requires no orientation. The volume reference axis is the true azimuth (measured clockwise from north) desired for the first slice of the volume type defined in Form C. The volume type associated with the sensor site is designated in Form SS. The volume type for the missile site is given in Form MS.
47-49	Owner Country	Enter numeric code to designate the country that owns the site. Any number of countries can be played.
51-57	Site Class/ Type	Indicate the class and type of site by inserting the appropriate numeric code for each from the Site Code Description Table.
59-61	Equipment Type	Indicate by numeric code the type of vehicle or sensor positioned at the site. For vehicles select the appropriate code from the Vehicle Code Description Table. In the case of a fighter or bomber base, codes for all vehicle types that can be based or operated from that site should be listed even if no initial inventory is indicated. This is required if it is desired to land and recycle various types of aircraft at the site. A separate line entry and different unique site name is needed for each type of equipment listed for a site. For sensors repeat the site type code for the equipment type code.

Columns	Heading	Instruction
62-64	Initial Inventory	Enter the number of units of the specified type of equipment initially located at the site. For command sites, enter the number of guidance channels available to the ABM or SAM radars under the site's command. This number must be associated with the first site upward from the radar in the command structure with decision level of 2 (entered on Form A1).
67-69	Value Table Identifier	Use a numeric code to identify value table in Form SV that defines the value history of the site. If the site cannot be defended by ABMs, then no identifier is required.

SIMETTE	SITE DATA	FORM A
	Date ______________ Page ________ of ________	

		Name	Latitude (deg • min • sec)	N or S	Longitude (deg • min • sec)	E or W	Altitude (feet)	Volume Reference Axis (deg • min)	Owner Country	Site Class	Site Type	Equipment Type	Initial Inventory	Value Table Identifier	
1	A		• •		• •			•							
2	A		• •		• •			•							
3	A		• •		• •			•							
4	A		• •		• •			•							
5	A		• •		• •			•							
6	A		• •		• •			•							
	A		• •		• •			•							
8	A		• •		• •			•							
9	A		• •		• •			•							
	A		• •		• •			•							
11	A		• •		• •			•							
12	A		• •		• •			•							
13	A		• •		• •			•							
14	A		• •		• •			•							
15	A		• •		• •			•							
16	A		• •		• •			•							
17	A		• •		• •			•							
18	A		• •		• •			•							
19	A		• •		• •			•							
20	A		• •		• •			•							

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SIMETTE Form SV - Site Value Data

Form Purpose: This form defines the initial value and time change of this value (if any) for each site capable of being defended by ABMs. The value indicates the relative weight placed on the defense of each site. It is used as a parameter in the weapon assignment routine for ABMs.

General Instructions: Values to be used range from 0 to 1 with the most valuable site or sites to be defended having the largest value. Sites having no value should be omitted or assigned a value of 0. Since the model in its present stage of development, does not automatically reduce site values as offensive and defensive assets are expended, a decrease in site value should be input in such a manner as to reflect the average expenditure of assets that would occur in the specific game scenario timing. Therefore, if a site becomes less valuable as the battle progresses because of the expenditure of vehicles (e.g., bombers, ICBMs, ABMs, SAMs, etc.) located at or related to the site, then the initial site value can be decreased in time steps. Any number of time value points can be used by continuing down the rows. In other words, after the three points in a given row are used, then a fourth point to sixth point may be used in the next row, etc. If no changes to the initial value are made, the site value will remain constant at the initial value. If it is not desired to play preferential defense of sites, then all sites should be assigned a value of one initially and no changes should be made with time. In this case all sites can use the same value history table, i.e., a singular value identifier. For those value tables cross referenced by Form A3, the value entries will be automatically increased by an increment of 0.5 for each ABM or SAM self-defense zone in which the corresponding sites are located.

Specific Instructions:

Columns	Heading	Instruction
4-6	Identifier	Enter the numeric code to identify value history table that follows. The code must be related to one or more sites defined in Form A.
9-13	Initial Value	Enter an initial site value from 0 to 1.
17-25	Time	Specify a time in hours, minutes, and seconds after the start of the game for which it is desired to decrease the site value.
27-31	Value	Indicate the site value (0 tol) desired at the specified time. This value must be less than the initial value to show expenditure of site-related resources as the battle proceeds.
35-49	Time/ Value	Specify a second time/value point, if required, to show a change of value. If a second point is not defined, then the value given for the first point will apply throughout the remainder of the game.
53-67	Time/ Value	Specify a third time/value point if required to show a further step change in value.

SIMETTE

SITE VALUE DATA

Date ______________

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FORM SV

20 June 1970

	1	2	Identifier	Initial Value	Time (hrs • min • sec)	Value	Time (hrs • min • sec)	Value	Time (hrs • min • sec)	Value
1	S	V		•	• •	•	• •	•	• •	•
2	S	V		•	• •	•	• •	•	• •	•
3	S	V		•	• •	•	• •	•	• •	•
4	S	V		•	• •	•	• •	•	• •	•
5	S	V		•	• •	•	• •	•	• •	•
6	S	V		•	• •	•	• •	•	• •	•
7	S	V		•	• •	•	• •	•	• •	•
8	S	V		•	• •	•	• •	•	• •	•
9	S	V		•	• •	•	• •	•	• •	•
10	S	V		•	• •	•	• •	•	• •	•
11	S	V		•	• •	•	• •	•	• •	•
12	S	V		•	• •	•	• •	•	• •	•
13	S	V		•	• •	•	• •	•	• •	•
14	S	V		•	• •	•	• •	•	• •	•
15	S	V		•	• •	•	• •	•	• •	•
16	S	V		•	• •	•	• •	•	• •	•
17	S	V		•	• •	•	• •	•	• •	•
18	S	V		•	• •	•	• •	•	• •	•
19	S	V		•	• •	•	• •	•	• •	•
20	S	V		•	• •	•	• •	•	• •	•

SIMETTE Form A1 - Command and Control Structure

Form Purpose: This form defines the functional C&C for all offensive and defensive military sites to be played in the game. In particular it permits play of alternate C&C centers in addition to the normal chain of command and flow of information. If sensor or weapon sites are isolated from the command structure by the destruction of the next higher and all alternate C&C centers, then these sites are effectively removed from game play. In this instance, the sensor sites will be prevented from communicating data on the threat to the weapon sites and the weapon sites will be prevented from launching their weapons.

General Instructions: For a weapon site, only command centers required for or capable of assigning the site's weapons should be specified in the C&C structure for the site. For a sensor site, the C&C structure defined for it should be such that threat data is channeled to the highest surviving command authority requiring the threat data and capable of assigning the defensive weapons. This means that related sensor and defense weapon C&C structures should have common higher and alternate command centers.

Specific Instructions:

Columns	Heading	Instruction
4-11	Site Name	Enter the same alphanumeric code name as listed in columns 4-11 on the Site Data Form A.
14-21	Next Higher	Enter the alphanumeric code name for the next higher command site. This is the command site to which the site listed in columns 4-11 normally reports.
24-67	Alternate C&C Center: First Through Fifth	List the order of succession to command in the C&C structure for the site listed in columns 4-11 should the next higher and subsequent command sites be destroyed. These entries implicitly assume the existence of a supporting communications network.
71	Decision Authority Level	Enter the level of C&C authority for the site listed in columns 4-11 for making pertinent decisions. A "0" indicates that the site makes

Columns	Heading	Instruction
71 (Cont.)		no pertinent decisions. A "2" indicates secondary decision authority. Since sensor and weapon sites cannot have decision authority in the game, enter a zero for them. Command sites can be collocated with sensor or weapon sites if it is desired to have local decision authority.

SIMETTE

COMMAND & CONTROL STRUCTURE

____

____

Date ______________

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FORM A1

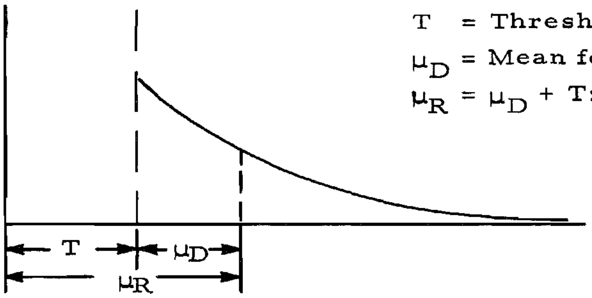
20 June 1970

					Alternate C&C Center						
			Site Name	Next Higher	First	Second	Third	Fourth	Fifth	Decision Authority Level	
1	A	1									
2	A	1									
3	A	1									
4	A	1									
5	A	1									
6	A	1									
7	A	1									
8	A	1									
9	A	1									
10	A	1									
11	A	1									
12	A	1									
13	A	1									
14	A	1									
15	A	1									
16	A	1									
17	A	1									
18	A	1									
19	A	1									
20	A	1									

SIMETTE Form AS - Airfield Specifications

Form Purpose: This form specifies launch parameters associated with bomber and fighter airfields. It further provides time constraints for recycling fighter aircraft.

General Instructions: The four entries in columns 29-57 deal with flightline aborts, addressing the probability of aborts and the time required to return the aircraft to an operational status. The threshold value listed establishes a lower bound to recovery time. The mean time listed in columns 39-47 is the mean of the distribution chosen plus the threshold value as indicated in the diagram below.



T = Threshold

μ_D = Mean for the distribution chosen

$\mu_R = \mu_D + T$: This is the mean for the recovery time listed in columns 39-47.

Specific Instructions:

Columns	Heading	Instruction
4-7	Class	Enter the numeric class code from the Site Code Description Table for the airfield.
9-11	Type	Enter the type code from the Site Code Description Table for the airfield.
14-18	Takeoff Time	Enter the elapsed time in minutes and seconds from receipt of a launch order until the first aircraft is airborne. A fully alert status is assumed.

Columns	Heading	Instruction
21-25	Fighter Turnaround Time	Enter the average elapsed time in minutes and seconds required to combat service each fighter aircraft. It is computed from landing to subsequent takeoff. Repair of combat damage is not considered.
29-33	Flightline Abort - Probability	Enter the probability, 0 to 1.0, that the assigned aircraft will not be available for launch for reasons other than combat damage.
36-37	Recovery Time Distribution - Dist. Type	Enter the numeric code for the distribution type chosen to describe recovery time following a flightline abort. 0 = constant, 2 = Poisson, 5 = negative exponential.
39-47	Mean	Enter the mean recovery time in hours, minutes, and seconds required to return the aborted aircraft to an operational status.
49-57	Threshold	Enter the minimum time in hours, minutes, and seconds required to return the aborted aircraft to operational status.

UNCLASSIFIED

SIMETTE	AIRFIELD SPECIFICATIONS	FORM AS
	______________________ ______________________ Date ______________ Page ________ of ________	20 Jun 1973

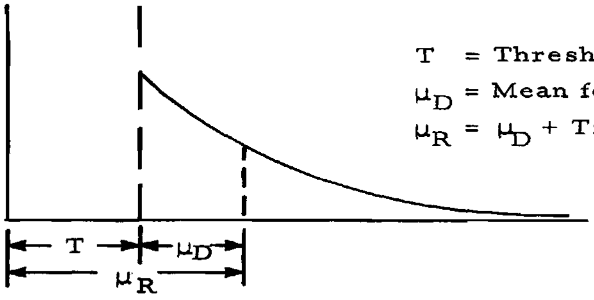
							Flight Line Abort				
								Recovery Time Distribution			
					Take-Off Time	Fighter Turn-Around Time			Mean	Threshold	
			Class	Type	(min • sec)	(min • sec)	Probability	Dist. Type	(hrs • min • sec)	(hrs • min • sec)	
	1	2	4 5 6 7	9 10 11	14 15 16 17 18	21 22 23 24 25	29 30 31 32 33	36 37	39 40 41 42 43 44 45 46 47	49 50 51 52 53 54 55 56 57	73 74 75 76 77 78 79 80
1	A	S			•	•	•		• •	• •	
2	A	S			•	•	•		• •	• •	
3	A	S			•	•	•		• •	• •	
4	A	S			•	•	•		• •	• •	
5	A	S			•	•	•		• •	• •	
6	A	S			•	•	•		• •	• •	
7	A	S			•	•	•		• •	• •	
8	A	S			•	•	•		• •	• •	
9	A	S			•	•	•		• •	• •	
10	A	S			•	•	•		• •	• •	
11	A	S			•	•	•		• •	• •	
12	A	S			•	•	•		• •	• •	
13	A	S			•	•	•		• •	• •	
14	A	S			•	•	•		• •	• •	
15	A	S			•	•	•		• •	• •	
16	A	S			•	•	•		• •	• •	
17	A	S			•	•	•		• •	• •	
18	A	S			•	•	•		• •	• •	
19	A	S			•	•	•		• •	• •	
20	A	S			•	•	•		• •	• •	
	1	2	4 5 6 7	9 10 11	14 15 16 17 18	21 22 23 24 25	29 30 31 32 33	36 37	39 40 41 42 43 44 45 46 47	49 50 51 52 53 54 55 56 57	73 74 75 76 77 78 79 80

UNCLASSIFIED

SIMETTE Form MS - Missile Site Specifications

Form Purpose: This form provides launch performance parameters associated with each type of offensive and defensive missile site.

General Instructions: The four entries in columns 29 to 57 deal with launch failures, addressing the probability of a launch failure and the time required to return failed missiles to an operational status. The threshold value listed establishes a lower bound to recovery time. The mean time listed in columns 39-47 is the mean of the distribution chosen plus the threshold value as indicated in the diagram below.



T = Threshold

μ_D = Mean for the distribution chosen

$\mu_R = \mu_D + T$: This is the mean for the recovery time listed in columns 39-47.

Specific Instructions:

Columns	Heading	Instructions
4-7	Class	Enter the numeric class code from the Site Code Descript on Table.
9-11	Type	Enter the numeric type code from the Site Code Description Table.
15-17	Launch Sequence	Enter the elapsed time in seconds from time an order is given by the Launch Control Facility (LCF) until first missile motion. For defense missiles, this is also the minimum time between successive launches from a given site.
20-22	Decision Process	Enter the elapsed time in seconds from the receipt of a luanch message by the LCF until the LCF gives the order to launch

Columns	Heading	Instructions
26-30	Site Failures - Probability	Enter the probability, 0 to 1.0, that the assigned missile will not be operationally available for launch.
33-34	Recovery Time Distribution - Dist. Type	Enter the numeric code for the distribution type chosen to describe recovery time following a launch failure. 0 = constant, 2 = Poisson, 5 = negative exponential.
36-44	Mean	Enter the mean recovery time in hours, minutes, and seconds. The mean is μ_R as described above in the general instructions.
46-54	Threshold	Enter the minimum time in hours, minutes, and seconds required to return the failed missile to an operational staus.
58-59	Missiles Per Salvo	For defensive missile sites, enter the number of missiles fired in each salvo. For ABM sites 1 will always be entered. For SAM sites a variable number may be entered. No entry will be made for offensive missile sites.
62-64	Volume Type	Enter a numeric code for the volume type designated for the maximum intercept contour of defensive missile sites. This code will cross-reference to Form C which describes the physical bounds of all game volumes.
66-71	Minimum Altitude	Enter minimum altitude (feet) for the volume type referred to above. This will be the altitude of the volume center above the site referencing this volume type.

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SIMETTE

MISSILE SITE SPECIFICATIONS

FORM MS

Date ______________

Page ________ of ________

					Site Failures						
							Recovery Time Distribution				
							Mean	Threshold			
	Class	Type	Launch Sequence (sec)	Decision Process (sec)	Probability	Dist. Type	(hrs • min • sec)	(hrs • min • sec)	Missiles per Salvo	Volume Type	Minimum Altitude (feet)
1					•		• •	• •			
2					•		• •	• •			
3					•		• •	• •			
4					•		• •	• •			
5					•		• •	• •			
6					•		• •	• •			
7					•		• •	• •			
8					•		• •	• •			
9					•		• •	• •			
10					•		• •	• •			
11					•		• •	• •			
12					•		• •	• •			
13					•		• •	• •			
14					•		• •	• •			
15					•		• •	• •			
16					•		• •	• •			
17					•		• •	• •			
18					•		• •	• •			
19					•		• •	• •			
20					•		• •	• •			

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

UNCLASSIFIED

SIMETTE Form SS - Sensor Site Specifications

Form Purpose: This form provides the operating characteristics necessary in the game play for each class and type of sensor represented.

General Instructions: The time factors listed for the functions of designation, target track, intercept track, and discrimination are time elapsed intervals required from completion of a prior sensor function until the listed function occurs. The last three columns of the form address the radar performance in terms of initial detection. For a given target cross-section and specified signal-to-noise threashold, the range is that at which the probability of initial target detection is 0.50.

Specific Instructions:

Columns	Heading	Instruction
4-7	Class	Enter numeric sensor site class code from the Site Code Description Table.
9-11	Type	Enter numeric sensor site type code from the Site Code Description Table.
14-16	Volume Type	Enter numeric code that corresponds to the appropriate volume description in Form C for sensor coverage. This volume is used for triggering sensor events when a vehicle penetrates it.
18-21	Maximum Viewing Range	Enter the maximum sensor range in nautical miles. This value will be used for filtering purposes.
23-25	Maximum Guidance Capability	Enter the maximum number of target vehicles that the sensor can simultaneously guide defense missiles against.
28-30	Time Factor - Designation	Enter time after initial detection in seconds required by sensor to designate target as a threat object. Designation is not used for ABM and SAM radars. Enter zero for them.
32-34	Time Factors - Threat Track	Enter time after completion of designation in seconds required by sensor to establish track on threat object.
36-38	Time Factors - Intercept Track	Enter time after completion of threat track in seconds required by sensor to establish accurate track to permit intercept.

Columns	Heading	Instruction
40-42	Time Factors - Discrimination	Enter time after completion of designation in seconds required by sensor to identify object as either a threat or decoy.
45-47	Maximum Blackout Interval	Enter maximum time in seconds that radar can be blacked out without having to re-establish threat track.
50-55	Radar Frequency	Enter radar frequency in megahertz.
57-60	Radar Performance - Range	Enter the range in nautical miles at which the probability of initial target detection is 0.50.
62-65	Radar Performance - X Section	Enter the radar target cross-section in square meters.
67-71	Radar Performance - S/N Threshold	Enter the signal-to-noise threshold in db for initial target detection.

SIMETTE

SENSOR SITE SPECIFICATIONS

Date ____________

Page ______ of ______

FORM SS

						Time Factors (sec)						Radar Performance			
	Class	Type	Volume Type	Maximum Viewing Range (n.mi.)	Max. Guid. Cap.	Designation	Threat Track	Intercept Track	Discrimination	Maximum Blackout Interval (sec)	Radar Frequency (mHz)	Range (n.mi.)	X-Section (m2)	S/N Threshold (db)	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	
S S											.		.	.	

SIMETTE Form CS - Command Site Specifications

Form Purpose: This form identifies all classes and types of command sites to be considered in the game. In addition, it specifies the threshold values to be used in ABM assignment, the denial zone override threshold for self-defense, and ABM (or SAM) preference of usage.

General Instructions: All classes and types of command sites to be considered in the game must be listed. A threshold value will be assigned only to the type of the immediate or next higher command level for each ABM site. Form A1 gives the next higher command site name for each ABM site, and Form A specifies the class and type of command site for each command site name. No threshold value should be listed for any of the other class and type command sites. For command site types associated with ABM denial zones, enter the threshold value that will cause zone override in the interest of self-defense. Assign an ordered sequence by vehicle type codes, for the preferred use of ABM interceptors.

Specific Instructions:

Columns	Heading	Instruction
4-7	Class	Enter the numeric code for the class of command site. Use 801 for an offensive command center and 802 for a defensive command center.
9-11	Type	Enter the appropriate numeric code from the Site Code Description Table for the type of command site within the particular class.
14-18	Threshold Value	Specify a threshold value from 0 to 2 for the appropriate ABM command site types. The higher the value used, the more restrictive will be the assignment of ABMs from the missiles site corresponding to the type command site. The purpose of the threshold value is to control a single threat object in a shoot-shoot-shoot mode. It is also intended to further conserve ABMs by not engaging objects which threaten targets of little value or which show little promise of being killed. The product of the following four factors:

Columns	Heading	Instruction
14-18 (Contd)	Threshold Value	(1) relative time urgency ranging from 1 to 2, (2) relative proportion of remaining interceptors ranging from 0 to 1, (3) potential relative threatened value saved ranging from 0 to 1, and (4) single shot kill probability ranging from 0 to 1, for a given pairing of candidate interceptor site and threat object is compared against the threshold value. If the product is a maximum for the decision cycle and exceeds the threshold value, then an interceptor is launched from the site against the threat object.
21-25	Denial Zone Override Threshold	Specify a threshold value for the appropriate ABM or SAM command site type with which an interceptor denial zone is associated. If a threat object is aimed at a target whose value table currently exceeds this threshold, then the zone will be overriden and the intercept performed.
28-30	1st ABM Preference By Type Code	Enter the first choice of ABM (or SAM) system, by vehicle type code, to be used in intercepting threatening objects, subject to physical performance constraints.*
32-34	2nd ABM Preference	Enter the second choice of ABM system to perform an intercept if the first choice cannot engage the threat.
36-38	3rd ABM Preference	Enter the ABM vehicle type code to be used if the 1st and 2nd choices are unable to engage.
40-42	4th ABM Preference	Enter the ABM vehicle type code to be used if the 1st, 2nd and 3rd choices are unable to engage.
44 46	5th ABM Preference	Enter the ABM vehicle type code to be used if the 1st, 2nd, 3rd and 4th choices are unable to engage.

---

*If more ABM systems are present in the game than are specified by the explicit preference entries, they will be assumed to be of equal preference.

Columns	Heading	Instruction
49-70	Optional Comments	Comments entered here will not be used within the model but will appear in the master input listing for assistance in post-game analysis.

SIMETTE	COMMAND SITE SPECIFICATIONS	FORM CS
	____________________ Date ____________________	OCT 1971
	____________________ Page __________ of __________	

	1	2	3	CLASS (4–7)	8	TYPE (9–11)	12–13	THRESHOLD VALUE (14–18)	19–20	DENIAL ZONE OVERRIDE THRESHOLD (21–25)	26–27	ABM PREFERENCE BY TYPE CODE 1ST (28–30)	31	2ND (32–34)	35	3RD (36–38)	39	4TH (40–42)	43	5TH (44–46)	47–48	OPTIONAL COMMENTS (49–70)	71–80
1	C	S						•		•													
2	C	S						•		•													
3	C	S						•		•													
4	C	S						•		•													
5	C	S						•		•													
6	C	S						•		•													
7	C	S						•		•													
8	C	S						•		•													
9	C	S						•		•													
10	C	S						•		•													
11	C	S						•		•													
12	C	S						•		•													
13	C	S						•		•													
14	C	S						•		•													
15	C	S						•		•													
16	C	S						•		•													
17	C	S						•		•													
18	C	S						•		•													
19	C	S						•		•													
20	C	S						•		•													

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SIMETTE Form C - Volume Specifications

Form Purpose: This form defines the limiting volumes within which defense sensors may detect and track threat objects and those within which defense missiles (SAM's and ABM's) may intercept the threat objects. These are limiting volumes, not necessarily nominal ones. Actual detection and intercept points may occur well within the volumes. The volumes are defined by specifying surface points for a number of azimuth slices emanating out from the sensor or missile site.

General Instructions: The origin point of each azimuth slice corresponds to the site location for which the volume is being generated. Virtually any convex volume surface can be described for a site by using enough surface points per slice and enough slices per volume. The volume's orientation with respect to a particular radar or defense missile site is accomplished by the volume reference axis specified in Form A for the site name. Where the volume is uniform with respect to azimuth (i.e., any azimuth slice would have the same surface points), only two vertical slices are required to define the volume. The first vertical slice could be at 0° azimuth and the second at 360° azimuth. Further, if the volume is a hemisphere, then only two surface points at elevation angles of 0° and 90° are required for each of the two azimuth slices.

The characteristics used to define a volume may be anything the user desires. The importance of a volume is that nothing happens outside of that volume. Thus, if the user wishes to specify a missile strike volume giving at least a 90 percent chance of kill, he may do so. However, no intercepts will be attempted outside that volume.

Specific Instructions:

Columns	Heading	Instruction
3-5	Volume Type	Enter a unique numeric code for each volume type.
7-8	Slice No.	Number each vertical slice in a clockwise direction. Any number of slices (2 or more) may be used to describe the volume.

Columns	Heading	Instruction
10-11	No. of Points	Enter the number of surface points used to define the limits of the particular vertical slice. Any number of points (2 or more) may be used to define a slice.
13-21	Azimuth	Enter the azimuth in degrees, minutes, and seconds of the particular vertical slice. The first vertical slice defining the left boundary (if any) of a volume should be set at 0 degrees, 0 minutes, and 0 seconds azimuth. All other slice azimuths will be measured in a clockwise direction relative to this first slice.
23-31	Elevation	Enter the elevation angle in degrees, minutes, and seconds from origin to surface point of a particular vertical slice. Elevation angle is measured from the horizontal. It is positive (0 to 90°) in the up direction and negative (0 to -90°) in the down direction. Start with lowest elevation surface point and move upward.
32-38	Range	Enter the range in nautical miles from origin to surface point on the particular vertical slice.
40-55	Elevation and Range	Enter the elevation and range coordinates of the next surface point in the upward direction on the particular vertical slice.
57-72	Elevation and Range	Enter the elevation and range coordinates of the next surface point (if any) in the upward direction on the particular vertical slice. If more than three points are needed to define a slice, continue on subsequent lines, leaving the volume type blank (columns 3-5).

SIMETTE

VOLUME SPECIFICATIONS

____

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Date ______________________

Page __________ of __________

FORM C

20 June 1970

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

		Volume Type	Slice No.	No. of Points	Azimuth (deg • min • sec)	Surface Points Elevation (deg • min • sec)	Range (n.mi.)	Elevation (deg • min • sec)	Range (n.mi.)	Elevation (deg • min • sec)	Range (n.mi.)	
1	C				• •	• •	•	• •	•	• •	•	
2	C				• •	• •	•	• •	•	• •	•	
3	C				• •	• •	•	• •	•	• •	•	
4	C				• •	• •	•	• •	•	• •	•	
5	C				• •	• •	•	• •	•	• •	•	
6	C				• •	• •	•	• •	•	• •	•	
7	C				• •	• •	•	• •	•	• •	•	
8	C				• •	• •	•	• •	•	• •	•	
9	C				• •	• •	•	• •	•	• •	•	
10	C				• •	• •	•	• •	•	• •	•	
11	C				• •	• •	•	• •	•	• •	•	
12	C				• •	• •	•	• •	•	• •	•	
13	C				• •	• •	•	• •	•	• •	•	
14	C				• •	• •	•	• •	•	• •	•	
15	C				• •	• •	•	• •	•	• •	•	
16	C				• •	• •	•	• •	•	• •	•	
17	C				• •	• •	•	• •	•	• •	•	
18	C				• •	• •	•	• •	•	• •	•	
19	C				• •	• •	•	• •	•	• •	•	
20	C				• •	• •	•	• •	•	• •	•	

SIMETTE Form VI - Vehicle Specs: Booster, RV, and Decoy

Form Purpose: This form provides the requisite characteristics for offensive missile boosters, RV's, and decoys.

General Instructions: The last three entries in columns 60-71 address the distribution of a number of objects of the same type about the basic RV trajectory. Entries here will apply to the dispersion parameters for clustered MRV's and decoys. For MRV's, the time parameter does not apply and should be left blank. For MRV's, the distance parameter establishes a radial distance normal to the basic RV trajectory. The MRV's are uniformly spaced on the circle generated by this radial distance, and the MRV pattern is randomly oriented in azimuth. For decoys, the time parameter is the standard deviation of a normal distribution about the RV used to initiate the decoy ahead or trailing the RV. The distance parameter is the CEP of a circular normal distribution that establishes a random radial distance for the decoys perpendicular to the RV flight path. The two parameters therefore essentially define a cylindrical distribution of decoys about the RV trajectory. Each MIRV, however, is to be treated as a separate RV.

Specific Instructions:

Columns	Heading	Instruction
4-7	Class	Enter the numeric class code from the Vehicle Code Description Table.
9-11	Type	Enter the numeric type code from the Vehicle Code Description Table.
13-17	Probability of Successful Operation	Enter the probability, 0 to 1.0, that the vehicle will perform its requisite functions successfully. For a booster, it is the probability of successful operation, given a successful launch. For RV's and decoys, it is the probability of successful deployment and operation to the end of its programmed flight. This figure does not include burst reliability.
19-23	Maximum Velocity	Enter the vehicle's maximum velocity in feet per second. This entry is used only as a filter. It should be larger than the expected velocity.

Columns	Heading	Instruction
25-29	Radar X - Section	Enter the nominal radar cross-section of the vehicle in square meters.
31-38	Shape/ Erosion Coefficient	Enter the value of the shape/erosion coefficient in grams per kilojoule for the erosion of the vehicle's ablative material. This is used in reentry and dust cloud penetration calculations.
40-47	Ballistic Coefficient	Enter the ballistic coefficient of a reentry body in pounds per square foot.
49-51	Warhead Type	Enter the numeric warhead code from the Burst Code Description Table for the warhead carried by the RV. This code will cross-reference to Form WS for warhead specifications.
54-58	CEP	Enter the CEP in feet for RV's and endoatmospheric decoys. There should be no entry for boosters and exoatmospheric decoys. There is currently no consideration made in the model for random variation in height of burst.
60-61	No. of Objects	Enter the number of objects of the same type that are deployed about the basic RV trajectory. This field is used only for decoys and MRV's.
63-65	Dispersion Time	Enter the time parameter (standard deviation for a normal distribution) in seconds discussed above in the general instructions, to establish the distribution of the decoy vehicles about the RV and along its trajectory. This field is not to be filled out for MRV's.
67-71	Dispersion Distance	Enter the distance parameter (CEP for decoys and fixed distance for MRV's) in nautical miles, discussed above in the general instructions, to establish the circular normal distribution of decoy vehicles in a plane normal to the RV trajectory or the radial distance of the MRV's about the basic trajectory.

SIMETTE

VEHICLE SPECS.: BOOSTER, RV, & DECOY

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Date ______________________

Page __________ of __________

FORM V1

20 June 1970

			Class		Type		Probability of Successful Operation		Maximum Velocity (feet/sec)		Radar X-Section (m^2)		Shape/Erosion Coefficient		Ballistic Coefficient		Warhead Type		CEP (feet)		No. of Objects		Dispersion Time (sec)		Dispersion Distance (n.mi.)		
	1	2	4 5 6 7	3 8	9 10 11	12	13 14 15 16 17	18	19 20 21 22 23	24	25 26 27 28 29	30	31 32 33 34 35 36 37 38	39	40 41 42 43 44 45 46 47	48	49 50 51	52 53	54 55 56 57 58	59	60 61	62	63 64 65	66	67 68 69 70 71	72	73 74 75 76 77 78 79 80
1	V	1					.				.		.		.										.		
2	V	1					.				.		.		.										.		
3	V	1					.				.		.		.										.		
4	V	1					.				.		.		.										.		
5	V	1					.				.		.		.										.		
6	V	1					.				.		.		.										.		
7	V	1					.				.		.		.										.		
8	V	1					.				.		.		.										.		
9	V	1					.				.		.		.										.		
10	V	1					.				.		.		.										.		
11	V	1					.				.		.		.										.		
12	V	1					.				.		.		.										.		
13	V	1					.				.		.		.										.		
14	V	1					.				.		.		.										.		
15	V	1					.				.		.		.										.		
16	V	1					.				.		.		.										.		
17	V	1					.				.		.		.										.		
18	V	1					.				.		.		.										.		
19	V	1					.				.		.		.										.		
20	V	1					.				.		.		.										.		

SIMETTE Form V2 - Vehicle Specs: Fighter

Form Purpose: This form specifies the capabilities and in-flight characteristics for each type of fighter played in the game. Form AS, which gives Airfield Specifications, describes the fighter ground delays. Straight-line paths from base to loiter or intercept points are played for the fighters. No variations are currently considered for speed, fuel consumption, and fighter vs. bomber P_k with altitude.

General Instructions: None.

Specific Instructions:

Columns	Heading	Instruction
4-6	Equipment Type	Enter vehicle equipment type code from Vehicle Code Description Table for the MI to be described.
9-12	Probability AOCM Per Sortie	Give probability of in-flight aircraft abort on operational combat mission for reasons other than combat damage.
15-19	Fuel Capacity	Enter the normal total fuel capacity in pounds for a combat mission.
22-25	Combat - Average Velocity	Enter the average combat rated speed in knots to be used during engagements.
27-30	Combat - Fuel Rate	Enter the average combat rated fuel consumption in pounds per hour to be used during engagements.
33-36	Cruise - Average Velocity	Enter the average cruise speed in knots to be used during periods when the fighter is not actively committed to a specific engagement.
38-41	Cruise - Fuel Rate	Enter the average fuel consumption in pounds per hour to be used in cruise conditions.
44-47	Average Time Reengage	Enter the average elapsed time in minutes from the weapon release point on one pass to arrival at the weapons release point on a subsequent pass against the same bomber.
50-51	Arms Loads	Enter the weapons load of the fighter in terms of the number of firing passes normally provided by such load. For example, if engagement doctrine calls for expenditure of two missiles per pass and a total of four missiles are carried, then two arms loads would be specified.

Columns	Heading	Instruction
54-57	P_k vs. Bomber	Enter the average probability of kill for the fighter against the bomber for the arms load expended on a single intercept pass. Each reengagement would have the same P_k. This P_k includes aircraft armament system reliability, probability of detection and conversion, and single-shot probability of kill for each weapon employed in a single arms load expenditure.
60-63	Fuel Reserve	Enter the normal fuel reserve in pounds required over home station.
66-70	Radar X - Section	Enter the nominal radar cross-section in square meters for the fighter.

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FORM V2

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						Combat		Cruise						
			Equipment Type	Probability AOCM per Sortie	Fuel Capacity (lbs)	Average Velocity (knots)	Fuel Rate (lbs/hr)	Average Velocity (knots)	Fuel Rate (lbs/hr)	Average Time Reengage (min.)	Arms Loads	P_K vs Bomber	Fuel Reserve (lbs)	Radar X-Section (m^2)
1	V	2		•						•		•		•
2	V	2		•						•		•		•
3	V	2		•						•		•		•
4	V	2		•						•		•		•
5	V	2		•						•		•		•
6	V	2		•						•		•		•
7	V	2		•						•		•		•
8	V	2		•						•		•		•
9	V	2		•						•		•		•
10	V	2		•						•		•		•
11	V	2		•						•		•		•
12	V	2		•						•		•		•
13	V	2		•						•		•		•
14	V	2		•						•		•		•
15	V	2		•						•		•		•
16	V	2		•						•		•		•
17	V	2		•						•		•		•
18	V	2		•						•		•		•
19	V	2		•						•		•		•
20	V	2		•						•		•		•

SIMETTE Form V3 - Vehicle Specs: Bomber and ASM

Form Purpose: This form specifies the capabilities and in-flight characteristics for each type of bomber, ASM, bomb, and decoy played in the game. Form AS (Airfield Specifications) describes bomber delays on the ground, and Forms T (Bomber Missions) and B (Bomber Sortie Data) describe paths for bombers, bombs, ASM's, and decoys.

General Instructions: None.

Specific Instructions:

Columns	Heading	Instruction
4-7	Class	Enter the numeric class code from the Vehicle Code Description Table for the specific class of vehicle whose performance is being described: bomber, ASM, bomb, or decoy.
9-11	Type	Enter the numeric code from the Vehicle Code Description Table for the specific type of vehicle whose performance is being described.
14-18	Bombers Only— Pk vs. Fighter	Enter the probability of the bomber defensive system killing the attacking interceptor aircraft. A singular P_k, independent of intercept geometry, is currently used. This entry and that in columns 21-22 are used to describe the bomber defensive capability against MI's through the use of defensive missiles.
21-22	Bombers Only— Arms Loads	Enter the number of arms loads of defensive weapons attributed to each type bomber. An arms load is defined as the weapons expended at a single firing, and the specification of number of arms loads therefore limits the maximum number of intercepts that could be countered by the bomber.
25-29	Probability of Successful Operation	Enter the probability, 0 to 1.0, that the vehicle will operate successfully to completion of its mission. For the bomber, mission completion would constitute the last scheduled launch of a bomb or ASM. It does not account for combat attrition.
32-35	Velocity - Maximum	Enter the maximum permissible speed of the vehicle in knots. This acts as an error filter for data presented in Form B and as an interaction filter in the game.

Columns	Heading	Instruction
37-40	Velocity - Minimum	Enter the minimum permissible speed of the vehicle. This again acts as an error filter for data presented in Form B.
43-47	Radar X - Section	Enter the nominal radar cross-section for the vehicle in square meters. There is no attempt to use the cross-section as a function of viewing aspect or sensor frequency at present.
50-54	ASM Only - CEP	Enter the CEP in feet for the ASM's and bombs at point of detonation.
57-59	ASM Only - Warhead Type	Enter the numeric code from the Burst Code Description Table for the type warhead carried by the ASM or bomb.

SIMETTE	VEHICLE SPECS.: BOMBER & ASM	FORM V3
	____________ ____________ Date ____________ Page ______ of ______	20 June 1970

					Bombers Only			Velocity (knots)			ASM Only	
			Class	Type	P_K vs Fighter	Arms Loads	Probability of Successful Operation	Maximum	Minimum	Radar X-Section (m^2)	CEP (feet)	Warhead Type
1	V	3			.		.			.		
2	V	3			.		.			.		
3	V	3			.		.			.		
4	V	3			.		.			.		
5	V	3			.		.			.		
6	V	3			.		.			.		
7	V	3			.		.			.		
8	V	3			.		.			.		
9	V	3			.		.			.		
10	V	3			.		.			.		
11	V	3			.		.			.		
12	V	3			.		.			.		
13	V	3			.		.			.		
14	V	3			.		.			.		
15	V	3			.		.			.		
16	V	3			.		.			.		
17	V	3			.		.			.		
18	V	3			.		.			.		
19	V	3			.		.			.		
20	V	3			.		.			.		

SIMETTE Form V4 - Vehicle Specs: ABM and SAM

Form Purpose: This form provides operational data for the ABM and SAM. Their flyout performance curves have been incorporated in the data base for use in intercept computations.

General Instructions: Give singular values for P_k and SEP. The initial model design does not consider intercept range or geometry variations in these two factors. Further a spherical distribution of miss distance is assumed.

Specific Instructions:

Columns	Heading	Instruction
4-7	Class	Enter the numeric vehicle class code. Use 104 for an ABM vehicle and 103 for a SAM vehicle.
9-11	Type	Enter numeric vehicle type code from the Vehicle Code Description Table.
14-18	Probability of Successful Operation	Enter the probability, 0 to 1.0, that the missile will be successfully launched.
21-25	Maximum Velocity	Enter the maximum velocity for missile in feet per second. This value will be used for filtering purposes.
28-35	Shape/ Erosion Coefficient	Enter the value of the shape/erosion coefficient in grams per kilojoule for the erosion of the vehicle's ablative material. This is used in the dust cloud penetration calculations.
38-40	Warhead Type	Enter the numeric warhead type code from Burst Code Description Table.
43-47	Expected P_k	Enter the expected probability, 0 to 1.0, that the defense missile will kill a typical threat vehicle. This value will be used in the weapon assignment routine. If no warhead type is specified in columns 38-40, then the expected P_k will also be used as an actual single-shot P_k and a random draw will be made to determine kill or no kill. This permits the user to represent nonnuclear warheads or nuclear warheads too small to contribute significantly to the nuclear environment. The use of P_k values whenever possible will greatly increase the efficiency of the game.

Columns	Heading	Instruction
50-54	Spherical Error Probable	Enter the SEP in feet for the miss or burst distance from the target.
57-61	Radar X - Section	Enter the nominal cross-section for the defense missile in square meters.

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VEHICLE SPECS.: ABM & SAM

Date __________

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FORM V4

20 June 1970

	1	2	Class	Type	Probability of Successful Operation	Maximum Velocity (ft/sec)	Shape/Erosion Coefficient	Warhead Type	Expected P_K	Spherical Error Probable (feet)	Radar X-Section (m^2)
1	V	4			•		•		•		•
2	V	4			•		•		•		•
3	V	4			•		•		•		•
4	V	4			•		•		•		•
5	V	4			•		•		•		•
6	V	4			•		•		•		•
7	V	4			•		•		•		•
8	V	4			•		•		•		•
9	V	4			•		•		•		•
10	V	4			•		•		•		•
11	V	4			•		•		•		•
12	V	4			•		•		•		•
13	V	4			•		•		•		•
14	V	4			•		•		•		•
15	V	4			•		•		•		•
16	V	4			•		•		•		•
17	V	4			•		•		•		•
18	V	4			•		•		•		•
19	V	4			•		•		•		•
20	V	4			•		•		•		•

UNCLASSIFIED

SIMETTE Form WS - Warhead Specifications

Form Purpose: This form provides warhead characteristics essential to nuclear effects computations for all RV, defensive missile, and bomb warheads.

General Instructions: The three entries in columns 26 to 42 are linear scaling factors used to modify basic product distribution in the computation of neutron, gamma, or X-ray effects. An entry greater than 1.0 would indicate enhancement of that effect, while an entry less than 1.0 would indicate suppression. An entry of 1.0 in these sections will result in a standard product distribution to each of these effects. To simplify input, a blank entry is interpreted as 1.0.

Specific Instructions:

Columns	Heading	Instruction
4-6	Type	Enter the numeric type code of the warhead from the Burst Code Description Table.
9-13	Probability of Successful Initiation	Enter the probability, 0 to 1.0, that the fuzing and firing circuitry will function and initiate the prescribed nuclear burst. This figure is that expected in a benign environment and does not take into consideration kill or degradation of the warhead through exposure to nuclear effects before burst.
16-22	Yield	Enter the warhead design yield in megatons.
26-42	Product Scaling Factors - Neutrons, Gamma, X-Ray	Enter the linear product scaling factors, described above in general instructions, to account for the enhancement or suppression of neutron, gamma, and X-ray products for the particular weapon.
45-70	Optional Comments	Comments entered here will not be used within the model but will appear in the master input listing for assistance in postgame analysis.

SIMETTE	WARHEAD SPECIFICATIONS	FORM WS
	______________ ______________ Date ______________ Page ________ of ________	20 June 1970

	Type	Probability of Successful Initiation	Yield (MT)	Product Scaling Factors			Optional Comments
				Neutrons	Gamma	X-Ray	
	1–6	9–13	16–22	26–30	32–36	38–42	45–80
1	W S	•	•	•	•	•	
2	W S	•	•	•	•	•	
3	W S	•	•	•	•	•	
4	W S	•	•	•	•	•	
5	W S	•	•	•	•	•	
6	W S	•	•	•	•	•	
7	W S	•	•	•	•	•	
8	W S	•	•	•	•	•	
9	W S	•	•	•	•	•	
10	W S	•	•	•	•	•	
11	W S	•	•	•	•	•	
12	W S	•	•	•	•	•	
13	W S	•	•	•	•	•	
14	W S	•	•	•	•	•	
15	W S	•	•	•	•	•	
16	W S	•	•	•	•	•	
17	W S	•	•	•	•	•	
18	W S	•	•	•	•	•	
19	W S	•	•	•	•	•	
20	W S	•	•	•	•	•	

SIMETTE Form N - Nuclear Vulnerabilities

Form Purpose: This form provides the necessary data for computations of nuclear vulnerability for all game significant entities. Kill thresholds ascertain the levels of exposure to the various effects at which the entity is killed. The decay parameters will be used to adjust over time the accumulation of multiple sublethal exposures.

General Instructions: The kill thresholds listed for the various nuclear effects and ablation are those critical levels above which the vehicle, site, or sensor will be either physically destroyed or degraded to the point where its internal components are rendered inoperable. The latter could apply to an intercepted RV that is not physically destroyed by an ABM burst but whose fuzing and firing components have been rendered inoperable as a result of effects encountered. Subsequent detonation of the RV warhead would therefore be precluded.

This form is used to enter nuclear vulnerability data for radar sites, missile sites, airfields, command sites, and vehicles. It is necessary, however, for keypunching to enter each of these five different kinds of data on separate sheets. Thus, no sheet should have more than one type of classification code appearing in columns 1 and 2.

Specific Instructions:

Columns	Heading	Instruction
1-2		Enter one of the following classification codes to indicate which entity type the vulnerability data apply to:

Code	Entity Description
NV	All vehicles, i.e., offensive and defensive missiles, reentry vehicles, penaids, ASM's, bombers, bombs, and interceptor aircraft.
NM	Offensive and defensive missile sites.
NA	Bomber and interceptor aircraft airfields
NR	Sensor sites (radar)
NC	Command and control sites

Columns	Heading	Instruction
4-7	Class	Enter the numeric class code from the Code Descriptoin Tables.
9-11	Type	Enter the numeric type code from the Code Description Tables.
14-21	Kill Thresholds - Neutrons	Enter the number of neutrons per square centimeter, divided by 10^9 to obtain kill from neutron flux.
23-29	Kill Thresholds - Gamma	Enter the gamma kill threshold, in rads.
31-35	Kill Thresholds - X-Ray	Enter the number of calories per square centimeter to produce a kill from X-Rays.
37-42	Kill Thresholds - Overpressure	Enter the overpressure in poinds per square inch required to kill
44 48	Kill Thresholds - Ablation	Enter the number of grams per square centimeter of ablative material that must be eroded from vehicle surface to kill it. This factor will only be enetered for re-entry vehicles and missiles
52-57	Decay Parameters - Neutrons	Enter the decay parameter value for neutrons. This is used to determine the rate at which the cumulative damage effect of neutrons on the target vehicle decays with time. The fraction of the effect after an elapsed time of Δt hours is equal to $e^{-\Delta t \cdot D}$, where D is the decay parameter. For D equal to zero (0), there is no decay in the cumulative dosage effect with time. For D equal to 90, immediate and complete decay of the effect is assumed. For D equal to -1, the effect is not considered at all.
59-64	Decay Parameters - Gamma	Enter the decay parameter value for gamma rays. It is determined in the same way as explained for neutrons.
66-71	Decay Paramenters - X-Ray	Enter the day parameter value for X-Rays. It is determined in the same way as explained for neutrons.

SIMETTE

NUCLEAR VULNERABILITIES

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Date ________________

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FORM N

				Kill Thresholds					Decay Parameters		
		Class	Type	Neutrons (N cm^2·10^{-9})	Gamma (rads)	X-Ray (cal/cm^2)	Overpressure (psi)	Ablation (gm cm^2)	Neutrons	Gamma	X-Ray
1	N						.	.	.	.	.
2	N						.	.	.	.	.
3	N						.	.	.	.	.
4	N						.	.	.	.	.
5	N						.	.	.	.	.
6	N						.	.	.	.	.
7	N						.	.	.	.	.
8	N						.	.	.	.	.
9	N						.	.	.	.	.
10	N						.	.	.	.	.
11	N						.	.	.	.	.
12	N						.	.	.	.	.
13	N						.	.	.	.	.
14	N						.	.	.	.	.
15	N						.	.	.	.	.
16	N						.	.	.	.	.
17	N						.	.	.	.	.
18	N						.	.	.	.	.
19	N						.	.	.	.	.
20	N						.	.	.	.	.

SIMETTE Form R - Game Reference Times

Form Purpose: This form provides reference times essential in game play for launch release and coordination of the offensive forces of each country.

General Instructions: All times given will be referenced to game start time and will be entered as hours, minutes, and seconds after game start. A separate line entry will be used to establish L, E, and H-hour reference times for each country involved in the exchange. It is necessary to specify these times for the retaliatory attack as well as the preemptive attack since NCA decision time and doctrine for response are not modeled. This will provide user control of both the preemptive and retaliatory scenarios.

Specific Instructions:

Columns	Heading	Instruction
4-6	Country Code	Enter the numeric code for the country from which the offensive weapons systems (bombers and missiles) are being launched.
10-18	L-Hour	L-hour is defined as a launch reference time for bomber forces and would be the time after game start that bombers would be cleared for launch. L-hour would differ for each side and be dependent on whether that country were engaged in preemptive or retaliatory launch of the bomber force. For the preemptive launch, timing could be such as to permit simultaneous, initial detection of both the bomber and missile forces by enemy sensors. A retaliatory L-hour would be a function of initial detection of an impending attack and doctrine for bomber launch in such a case.
22-30	E-Hour	E-hour is defined as a launch reference time for offensive missiles and would be the time after game start that release is given for the launch of the missiles force. E-hour would differ for each side and be dependent on whether a preemptive or retaliatory launch of the missile force is involved. For the preemptive attack E-hour could be coordinated with L-hour as described above. For the

Columns	Heading	Instruction
22-30 (Cont.)		retaliatory case E-hour would be predicated on the initial detection of an incoming attack, NCA decision time, and doctrine governing release of the offensive missile force.
34-42	H-Hour	H-hour is defined as a reference time from which bomber window times at H-HCL are measured. For the preemptive attack it is a constraint to preclude premature penetration of enemy defenses and coordination of bomber attacks over target. For the retaliatory attack it is a constraint to ensure proper coordination of bomber attacks where initial launch times of the bomber force are such that proper coordination over target would not be ensured if there were no constraint imposed on departure times from H-HCL.
46-72	Optional Comments	Comments entered here will not affect the use of game reference times within the model but will appear in the master input listing for assistance in postgame analysis.

SIMETTE

GAME REFERENCE TIMES

Date ____________

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FORM R

20 June 1970

				Country Code						L-Hour (hrs • min • sec)												E-Hour (hrs • min • sec)												H-Hour (hrs • min • sec)												Optional Comments																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
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SIMETTE Form W - Bomber Windows from H-HCL

Form Purpose: This form will provide for adjustment of bomber flight path timing to ensure coordination over target. The windows will specify time spans during which specific sorties will be cleared to proceed en route to their target. Delayed arrival time at H-HCL may require bombers to hold until the next window start time occurs.

General Instructions: All window start times will be referenced to the H-hour given in Form R for each country whose bombers are being considered. For example, with an H-hour designated in Form R as 6 hours after game start, and a window scheduled to start 1 hour and 10 minutes after H-hour (7 hours and 10 minutes after game start), the window start time would be listed as 01.10.00 on the form. It is not necessary to use more than one window.

Specific Instructions:

Columns	Heading	Instruction
3-6	Window Identifier	Enter a numeric code for identification and cross-reference with that listed in columns 13-16 of Form T.
9-17	First Choice - Start Time	Enter the starting time for the first time period during which the bomber is permitted to cross the H-hour coordination line (H-HCL).
19-27	First Choice - Duration	Enter the duration of the window in hours, minutes, and seconds.
31-71	Second Choice - Third Choice - Start Time and Duration	Enter the start time and duration for subsequent windows if required.

SIMETTE

BOMBER WINDOWS FROM H-HCL

Date ____________

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FORM W

20 June 1970

Window Identifier

First Choice: Start Time (hrs • min • sec) — Duration (hrs • min • sec)

Second Choice: Start Time (hrs • min • sec) — Duration (hrs • min • sec)

Third Choice: Start Time (hrs • min • sec) — Duration (hrs • min • sec)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	W										•			•							•			•									•			•							•			•									•			•							•			•											
2	W										•			•							•			•									•			•							•			•									•			•							•			•											
3	W										•			•							•			•									•			•							•			•									•			•							•			•											
4	W										•			•							•			•									•			•							•			•									•			•							•			•											
5	W										•			•							•			•									•			•							•			•									•			•							•			•											
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8	W										•			•							•			•									•			•							•			•									•			•							•			•											
9	W										•			•							•			•									•			•							•			•									•			•							•			•											
10	W										•			•							•			•									•			•							•			•									•			•							•			•											
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13	W										•			•							•			•									•			•							•			•									•			•							•			•											
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19	W										•			•							•			•									•			•							•			•									•			•							•			•											
20	W										•			•							•			•									•			•							•			•									•			•							•			•											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

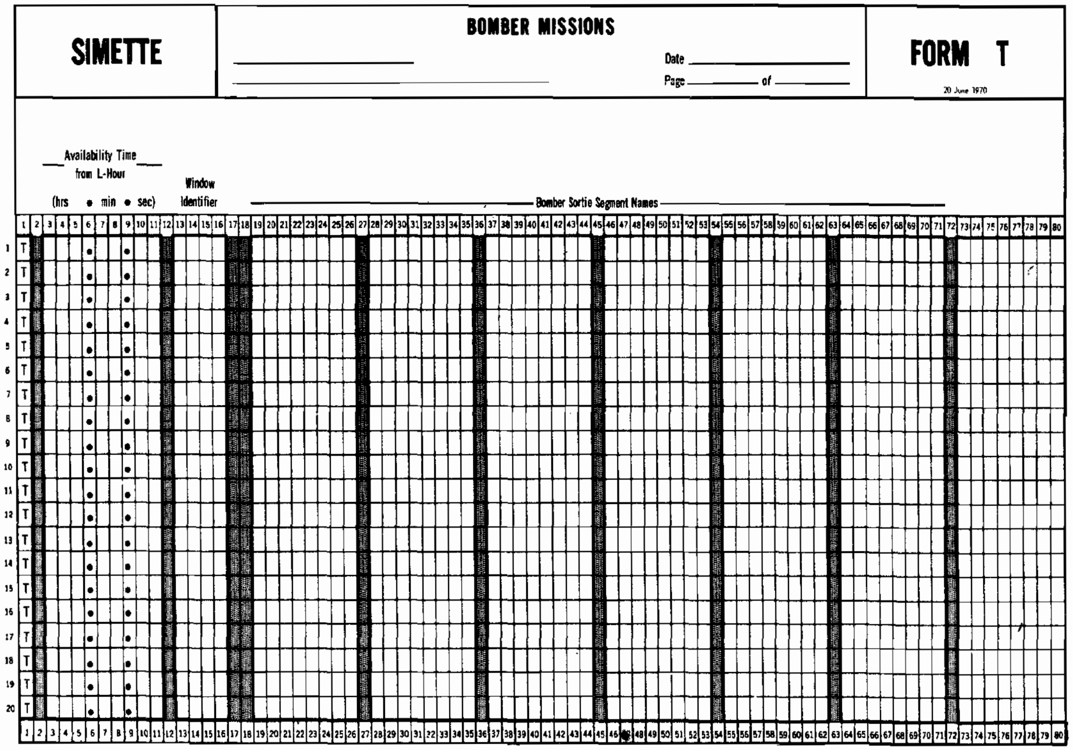
SIMETTE Form T - Bomber Missions

Form Purpose: This form uniquely defines each bomber mission in terms of availability time for takeoff and the names of path segments to be flown from launch to recovery. Dividing the bomber flight paths into segments consisting of one or more legs permits the segments to be used as building blocks for bomber missions which have common path segments.

General Instructions: None.

Specific Instructions:

Columns	Heading	Instruction
3-11	Availability Time From L-Hour	Enter the time in hours, minutes, and seconds that bombers are expected to be available for takeoff after L-hour as defined on Form R. The availability times listed constitute the launch schedule for the bomber sorties.
13-16	Window Identifier	Enter the numeric code to cross-reference the set of windows listed in Form W that establish time periods during which bombers will be cleared to depart the H-HCL.
19-71	Bomber Sortie Segment Names	Enter the alphanumeric code names in sequence for all segments of the bomber path from base of departure to post-strike recovery base. Each of the segments, consisting of one or more legs, are defined in Form B and may be common to several bomber sorties. If more than six entries are needed to define a mission, continue on the next line, leaving columns 3-16 blank.



SIMETTE

BOMBER MISSIONS

Date __________

Page ______ of ______

FORM T

20 June 1970

Availability Time from L-Hour (hrs • min • sec)

Window Identifier

Bomber Sortie Segment Names

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
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19	T					•			•																																																																					
20	T					•			•																																																																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

SIMETTE Form B - Bomber Sortie Data

Form Purpose: This form will provide a detailed four-dimensional description of the flight paths (latitude, longitude, altitude, and time) for all bombers and bomber-launched weapons. Aggregation of detailed path legs into sortie segments will permit utilization of the same segments by more than one bomber where such common flight segments would not be critical to game play or outcome, thus saving time in bomber path layout.

General Instructions: All names assigned for sortie segments, starting and ending sites, and weapons launched should be chosen to give a unique alphanumeric designation. Names used for the base from which a bomber departs, its post-strike recovery base, and target names for ASM or bombs should correspond to the alphanumeric names used to describe those facilities in the Form A - Site Data. The flight path for an ASM may be a singular straight line path from point of launch to the target or may consist of discrete path legs to describe a variable, preprogrammed profile (turn point coordinates, altitudes, and times) to the target. As with a bomber profile, either would constitute the sortie segment for the ASM. Form B is organized to permit pairing of data: segment designation in row B1, followed by a description in rows B2, of the path legs making up that segment. More than six path legs can be used in a sortie segment bv skipping over a B1 row and continuing with path leg descriptions in the next B2 rows.

Specific Instructions:

B1: Sortie Segment

Columns	Heading	Instruction
4-11	Name	Enter the unique alphanumeric code name to identify the sortie segment. For bombers it will be the name associated with the aggregation of path legs described in rows B2 for the segment. For bomber-launched weapons (ASM's, decoys, or bombs), the name is that assigned in B2, columns 58-65, when that weapon is launched.

Columns	Heading	Instruction
13-15	Equipment Type	Enter the appropriate numeric code from the Vehicle Code Description Table for the vehicle type (bomber or bomber-launched weapon) whose segment is being described in the subsequent B2 section.
18-25	Site Names - Starting	Enter the unique alphanumeric code name for the point at which the sortie segment begins. For bombers this will be the airfield of origin or the terminal point of a previous segment. For a bomber-launched weapon no entry will be made, since there is no unique name associated with the point at which the weapon is launched. The position, altitude, and time of launch are uniquely defined on the path leg in B2 on which the weapon is launched. For intermediate points, i.e., end of one segment and start of the next, an entry is optional. If used, it must match in sequence the data specified on Form T.
27-34	Site Names - Ending	Enter the unique alphanumeric code name for the end point of the sortie segment. The descriptive parameters of this point (latitude, longitude, and altitude) will be those given for the last path leg in the following Section B2 except where it is a recovery base. For ASM's and bombs the end point will be the alphanumeric name of the designated target.

B2: Path Legs

Columns	Heading	Instruction
4-5	Proc. Code	Enter the numeric process code from the following list that describes what functional operation is taking place for the bomber or bomber-launched weapon on that leg: 2. Proceed en route 3. Refuel 4. Hold at H-HCL 5. Launch operation of ASM, decoy, or bomb 6. Turn active ECM equipment on 7. Turn active ECM equipment off Process code 1, for takeoff, and 8, for landing, will be added automatically to each mission. Procedure codes 6 and 7 are used to

Columns	Heading	Instruction
4-5 (Cont.)		designate points in the vehicular path when active ECM becomes a pertinent factor. Although active ECM is not currently incorporated in the model to degrade defense sensor performance, the switching codes are designated and available for later use. For the case where two or more weapons (ASM's, decoys, or bombs) are launched at a given point, procedure code 5 would be used in columns 4-5 and zero time legs entered to identify the second and subsequent weapons launched at that geographic location. A single weapon launch can be designated at the end of a path leg with procedure code 2 by simply filling in columns 50-65.
7-8	Move. Type	Enter one of the following numeric movement type codes that specifies the vehicle's movement on the leg: 3. A great circle path at constant speed 4. A constant bearing path at constant speed
10-19	Latitude	Enter the latitude in degrees, minutes, and seconds north (N) or south (S) for the end point of each path leg. It is unnecessary to enter the latitude or longitude for the last path leg of a segment where that segment terminates at a named site such as a post-strike recovery base for bombers or named targets for ASM's and bombs. The alphanumeric code entered in B1 Ending identifies this point.
21-30	Longitude	Enter the longitude in degrees, minutes, and seconds east (E) or west (W) for the end point of each path leg.
32-37	Altitude	Enter the altitude in feet above mean sea level for the end point of the path leg except where the end point is used to specify the burst point of a bomber-launched weapon. In this case, give the desired height of burst in feet above the target. Where the altitude at the end point differs from that at the start, a uniform rate of climb or descent will be used across the entire leg to accomplish this altitude change.
39-47	Elapsed Time	Enter the elapsed time (en route time) for each path leg in hours, minutes, and seconds. A constant velocity will be calculated for the vehicle over the leg based on the leg length

Columns	Heading	Instruction
39-47 (Cont.)		and the elapsed time. Do not enter a finite elapsed time for procedure codes 4, 5, 6, or 7 as these are considered zero length and zero time legs. For procedure code 4, the time held at H-HCL will be dependent on bomber arrival at that point and the release window available (see Form W).
50-52	Weapon Launched - Class	For weapons launched by the parent bomber, enter the appropriate numeric vehicle class code to indicate the class as an ASM, decoy, or bomb. This column is also used to indicate a warhead burst at the terminal point of an ASM or bomb segment. Therefore, the numeric burst code, 201, should be entered for burst events.
54-56	Weapon Launched - Type	Enter the appropriate numeric vehicle type code for bomber-launched ASM's, decoys, or bombs. For creation of nuclear bursts enter the numeric type code for the particular ASM or bomb warhead.
58-65	Weapon Launched - Sortie Name	For each ASM, decoy, or bomb launched, enter a unique alphanumeric name to identify that weapon. This name would then appear in a subsequent section B1 (columns 4-11) with a B2 section to fully describe the flight path of that weapon. No name will be entered for a warhead burst.

SIMETTE	**BOMBER SORTIE DATA** __________ Date __________ __________ Page _____ of _____	**FORM B** 20 June 1970

SORTIE SEGMENT

Name — Equipment Type — Site Names: Starting — Ending

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

1 B 1

PATH LEGS

Proc. Code — Move. Type — Latitude (deg • min • sec) — N or S — Longitude (deg • min • sec) — E or W — Altitude (feet) — Elapsed Time (hrs • min • sec) — Weapon Launched: Class — Type — Sortie Name

2 B 2
3 B 2
4 B 2
5 B 2
6 B 2
7 B 2

8 B 1

9 B 2
10 B 2
11 B 2
12 B 2
13 B 2
14 B 2

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

SIMETTE Form D - Missile Launch Windows From E-Hour

Form Purpose: This form specifies times during which there will be no restrictions imposed on the launch of specific offensive missiles. These data further permit constraints to be applied to launch timing to ensure coordination over target.

General Instructions: All window start times will be referenced to the E-hour given in Form R for each country whose offensive missiles are being considered. This time will be expressed as hours, minutes, and seconds elapsed from E-hour. It is not necessary to use more than one window.

Specific Instructions:

Columns	Heading	Instruction
3-6	Window Identifier	Enter the numeric code for identification and cross-reference with that listed in columns 13-16 of Form E.
9-17	First Choice - Start Time	Enter the starting time for the first time period during which free launch of the missile is permissible.
19-27	First Choice - Duration	Enter the duration of the window in hours, minutes, and seconds.
31-71	Second Choice to Third Choice - Start Time and Duration	Enter the start times and duration for subsequent windows if required.

SIMETTE

MISSILE LAUNCH WINDOWS FROM E-HOUR

Date ______________

Page ________ of ________

FOR

20 J

									First Choice																						Second Choice																						Third Choice																			
			Window Identifier						Start Time										Duration												Start Time										Duration												Start Time										Duration									
									(hrs			●	min		●	sec)			(hrs			●	min		●	sec)					(hrs			●	min		●	sec)			(hrs			●	min		●	sec)					(hrs			●	min		●	sec)			(hrs			●	min		●	sec)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
1	D											●			●							●			●									●			●							●			●									●			●							●			●			
2	D											●			●							●			●									●			●							●			●									●			●							●			●			
3	D											●			●							●			●									●			●							●			●									●			●							●			●			
4	D											●			●							●			●									●			●							●			●									●			●							●			●			
5	D											●			●							●			●									●			●							●			●									●			●							●			●			
6	D											●			●							●			●									●			●							●			●									●			●							●			●			
7	D											●			●							●			●									●			●							●			●									●			●							●			●			
8	D											●			●							●			●									●			●							●			●									●			●							●			●			
9	D											●			●							●			●									●			●							●			●									●			●							●			●			
10	D											●			●							●			●									●			●							●			●									●			●							●			●			
11	D											●			●							●			●									●			●							●			●									●			●							●			●			
12	D											●			●							●			●									●			●							●			●									●			●							●			●			
13	D											●			●							●			●									●			●							●			●									●			●							●			●			
14	D											●			●							●			●									●			●							●			●									●			●							●			●			
15	D											●			●							●			●									●			●							●			●									●			●							●			●			
16	D											●			●							●			●									●			●							●			●									●			●							●			●			
17	D											●			●							●			●									●			●							●			●									●			●							●			●			
18	D											●			●							●			●									●			●							●			●									●			●							●			●			
19	D											●			●							●			●									●			●							●			●									●			●							●			●			
20	D											●			●							●			●									●			●							●			●									●			●							●			●			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72

SIMETTE Form E - Missile Missions

Form Purpose: This form identifies the first available time of launch for each offensive missile and cross-references the free launch times given in Form D to the missile paths of Form P.

General Instructions: None.

Specific Instructions:

Columns	Heading	Instruction
3-11	Availability Time From E-Hour	Enter the time in hours, minutes, and seconds from the E-hour of Form R that the missile is intended to be launched.
13-16	Window Identifier	Enter the numeric code identifier for the desired windows in Form D to set free launch times. Although a window identifier must be specified for each missile path, it need not be a different identifier, i.e., one window identifier may be common to several missile paths for the same country.
19-26	Path Name	Enter the alphanumeric code name identifier of the missile path used in Form P.
30-71	Optional Comments	Comments entered here will not be used within the model but will appear in the master input listing for assistance in postgame analysis.

SIMETTE	**MISSILE MISSIONS**	**FORM E**
	Date ______ Page ______ of ______	[illegible] 1970

	Availability Time from E-Hour (hrs		•	min	•	sec)		Window Identifier		Path Name		Optional Comments		
	1	2	3 4 5	6	7 8	9	10 11	12	13 14 15 16	17 18	19 20 21 22 23 24 25 26	27 28 29	30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71	72	73 74 75 76 77 78 79 80
1	E			•		•									
2	E			•		•									
3	E			•		•									
4	E			•		•									
5	E			•		•									
6	E			•		•									
7	E			•		•									
8	E			•		•									
9	E			•		•									
20	E			•		•									
11	E			•		•									
12	E			•		•									
13	E			•		•									
14	E			•		•									
15	E			•		•									
16	E			•		•									
17	E			•		•									
18	E			•		•									
19	E			•		•									
20	E			•		•									
	1	2	3 4 5	6	7 8	9	10 11	12	13 14 15 16	17 18	19 20 21 22 23 24 25 26	27 28 29	30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71	72	73 74 75 76 77 78 79 80

SIMETTE Form P - Missile Path Generation

Form Purpose: This form provides the data essential to develop the flight path from launch to target for ICBM's or SLBM's and their deployed RV's and decoys.

General Instructions: A single line entry on this form provides data necessary for generation of the missile path from launch site to target for a single RV or decoy or cluster of such objects deployed by the offensive missile. To represent deployment by that missile of other RV's or decoys directed against additional targets, subsequent rows of data will be entered. In such cases, it is unnecessary to repeat the first three fields of data: path name, booster type, or launch site.

The specification data override, column 52, and the four subsequent sections would be used only to override the same data listed for that particular type vehicle in Form V1. This would be used when the specific mission dictated variation from the standard CEP, number of objects deployed, or dispersion parameters. The last three entries in columns 60-71 address the distribution of a number of objects of the same type about the basic RV trajectory. Thus, entries here will apply to the dispersion parameters for clustered MRV's and decoys.

For MRV's, the time parameter does not apply and should be left blank. The distance parameter for MRV's establishes a radial distance normal to the RV flight path. The MRV's are uniformly spaced on the circle generated by this radial distance, and the MRV pattern is randomly oriented in azimuth.

For decoys, the time parameter is the standard deviation of a normal distribution about the RV used to initiate the decoy ahead of or trailing the RV. The distance parameter is the CEP of a circular normal distribution that establishes a random radial distance for the decoys perpendicular to the RV flight path.

These two parameters, therefore, essentially define a cylindrical distribution of the decoys about the basic RV trajectory.

Specific Instructions:

Columns	Heading	Instruction
3-10	Name	Enter a unique alphanumeric name to identify each missile path.
12-14	Booster Type	Enter the numeric code from the Vehicle Code Description Table for the booster flying this missile path. Each booster must also be described in Form V1.
16-23	Launch Site	Enter the unique alphanumeric name for the missile launch site defined in Form A.
25-32	Target Site	Enter the unique alphanumeric name for the intended target site. This must correspond to the name listed in Form A so that target parameters will be available to the model.
34-36	Reentry Object Type	Enter the numeric code from the Vehicle Code Description Table for the reentry object to be deployed at the end of the boost segment. Each reentry vehicle must also be described in Form V1.
38-43	Burst Height	Enter the desired height of burst in feet above the target.
45-49	Reentry Angle	Enter the desired reentry angle of the vehicle in degrees and minutes. This can be used to simulate lofted or depressed trajectories. If no entry is made in this section, a minimum energy trajectory will be computed for the object.
52	Spec. Data Override	If there is a need to modify any of the data in columns 54 to 71 of this form from that listed in the comparable sections of Form V1, enter a 1 in this column. As described in the general instructions above, this permits deviation from standard data for a specific mission profile. No entry in this column will indicate that there is to be no change in that data for this mission. An example of a change could be an increase in the CEP and reduction in the number of objects as required by a maximum range profile from the nominal values given in Form V1.
54-58	CEP	Enter the CEP in feet for RV's and endoatmospheric decoys. There should be no entry for boosters and exoatmospheric decoys. There is currently no consideration made in the model for random variation in height of burst for air bursts.

Columns	Heading	Instruction
60-61	No. of Objects	Enter the number of objects of the same type that are deployed about the basic RV trajectory.
63-65	Dispersion Time	Enter the time parameter (standard deviation for a normal distribution) in seconds, discussed in the general instructions, to establish the distribution of the decoy vehicles about the RV and along its trajectory. This field is not to be filled out for MRV's.
67-71	Dispersion Distance	Enter the distance parameter (CEP for decoys and fixed distance for MRV's) in nautical miles, discussed above in the general instructions, to establish the circular normal distribution of decoy vehicles in a plane normal to to the RV trajectory or the radial distance of the MRV's about the basic trajectory.

SIMETTE

MISSILE PATH GENERATION

Date ____________

Page ________ of ________

FORM P

20 June 1970

		Name	Booster Type	Launch Site	Target Site	Reentry Object Type	Burst Height (feet)	Reentry Angle (deg • min)	Spec. Data Over-Ride	CEP (feet)	No. of Objects	Dispersion Time (sec)	Dispersion Distance (n.mi.)	
	1	2 3 4 5 6 7 8 9 10	11 12 13 14 15	16 17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32 33	34 35 36 37	38 39 40 41 42 43 44	45 46 47 48 49	50 51 52 53	54 55 56 57 58 59	60 61 62	63 64 65 66	67 68 69 70 71 72	73 74 75 76 77 78 79 80
1	P							•					•	
2	P							•					•	
3	P							•					•	
4	P							•					•	
5	P							•					•	
6	P							•					•	
7	P							•					•	
8	P							•					•	
9	P							•					•	
10	P							•					•	
11	P							•					•	
12	P							•					•	
13	P							•					•	
14	P							•					•	
15	P							•					•	
16	P							•					•	
17	P							•					•	
18	P							•					•	
19	P							•					•	
20	P							•					•	
	1	2 3 4 5 6 7 8 9 10	11 12 13 14 15	16 17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32 33	34 35 36 37	38 39 40 41 42 43 44	45 46 47 48 49	50 51 52 53	54 55 56 57 58 59	60 61 62	63 64 65 66	67 68 69 70 71 72	73 74 75 76 77 78 79 80

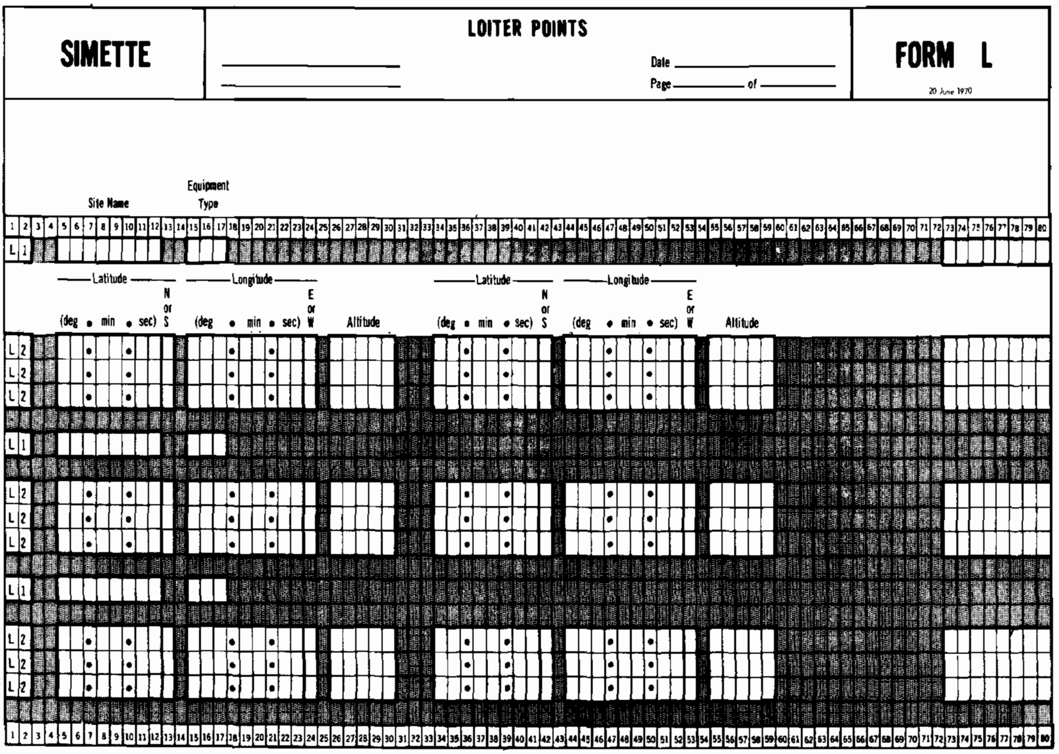
SIMETTE Form L - Loiter Points

Form Purpose: This form establishes loiter points to which fighter aircraft may be assigned from a given fighter airfield.

General Instructions: For each combination of fighter airfield and aircraft type given in row L1, enter the three-dimensional parameters in rows L-2 for the set of desired loiter points. Where the possibility of temporary basing or recycling of more than one fighter aircraft type exists from an airfield, loiter points applicable to all aircraft that might operate from the airfield would be specified. In this case a separate, unique name would be assigned to the airfield for each type fighter both here and in Form A - Site Data. This is necessitated by the model requirement for a unique site identification for each vehicle or equipment type associated with it, and therefore multiple basing capability for a given airfield requires that unique names be assigned to that airfield, one for each type of fighter aircraft.

Specific Instructions:

Columns	Heading	Instruction
L1		
5-12	Site Name	Enter the unique alphanumeric name of the fighter airfield with which the loiter points of rows L2 are associated.
15-17	Equipment Type	Enter the fighter aircraft numeric code from the Vehicle Code Description. The site name and equipment type entries should conform to the unique combination listed in Form A. This is discussed in the general instructions above.
L2		
5-13 and 34-42	Latitude	Enter the latitude in degrees, minutes, and seconds, north or south, for the loiter point.
15-24 and 44-53	Longitude	Enter the longitude in degrees, minutes, and seconds, east or west, for the loiter point.
26-30 and 55-59	Altitude	Enter the altitude above mean sea level nominally specified for the fighter assignment at the loiter point.



SIMETTE

LOITER POINTS

Date ____________

Page ______ of ______

FORM L

20 June 1970

Site Name

Equipment Type

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

1 L 1

Latitude (deg • min • sec) N or S — Longitude (deg • min • sec) E or W — Altitude — Latitude (deg • min • sec) N or S — Longitude (deg • min • sec) E or W — Altitude

2 L 2

3 L 2

4 L 2

5 L 1

6 L 2

7 L 2

8 L 2

9 L 1

10 L 2

11 L 2

12 L 2

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

SIMETTE Form OP - Run Options

Form Purpose: This form provides the user a range of selectable options primarily concerning the doctrine to be used in the fighter game. Additional options address nuclear effects and sensor attenuation submodules and total game run time.

General Instructions: No more than a single entry can be made for each option in a given simulation run. Except for the simulation length option, lack of a user entry will result in a default choice for that option. Furthermore, a preferred choice will be used where more than one entry is filled in by the user on a multiple choice option.

Specific Instructions:

Columns	Description	Instruction
4-12	Total length of the simulation	Enter maximum game time in hours, minutes, and seconds to be allowed for the simulation run. If this space is left blank or set equal to zero, the preprocessor will stop and no run will be made.
14-22	Fighter scramble on early warning—Max. allowable azimuth difference between threat vehicle and loiter point	Enter the maximum allowable azimuth angle in degrees, minutes, and seconds between fighter base to threat vehicle azimuth and fighter base to loiter point azimuth. Fighter will not be scrambled to a loiter point where this angle is exceeded. If no entry is made, then 15° will be used for maximum azimuth difference.
24-25	Fighter scramble on early warning—Number of loiter points to be used per threat vehicle	Indicate maximum number of loiter points to which fighters will be scrambled against a given threat vehicle. If this space is left blank, then a value of 2 will be used for the maximum number of loiter points.
27-28	Fighter scramble on early warning—Number of fighters assigned to each loiter point	Enter the maximum number of fighters that can be assigned to each loiter point for a given threat vehicle. If left blank, a value of 2 will be used for maximum number of fighters.

Columns	Description	Instruction
30-35	Fighter assignment rules—Max. range from fighter to threat vehicle for assignment	Specify maximum range in nautical miles from fighter to threat vehicle for which the fighter can be assigned to intercept the threat vehicle. If left blank, a value of 500 nautical miles will be used for the maximum range.
37-38	Fighter assignment rules—Max. number of fighters assigned to each threat vehicle	Indicate the maximum number of fighters that can be assigned to each threat vehicle. If left blank, a value of 4 will be used for maximum number of fighters
40-41	Fighter assignment rules—Alternate basing of fighters permitted?	If fighters are to be permitted to land and recycle at other than home bases, then put an "X" in column 40. If recycling is permitted only at home bases, put an "X" in column 41. If both columns are left blank or if both are filled in, then no alternate basing of fighters will be permitted.
43, 44, and 45	Fighter assignment rules—Fighter in engagement but short on fuel: 43—Always break-off 44—Reengage only if 1-on-1 45—Always reengage	Enter an "X" in the column for the action the fighter is to take during an engagement when it runs low on fuel (i.e., the time at which the fighter has just enough fuel to return to base). If all columns are left blank, then the fighter will always break-off. If more than one column is marked, then the lower numbered column marked will be the action taken.
47, 48	Nuclear effects options: 47—Accumulate effects on dead sites 48—Do not accumulate effects on dead sites	Enter an "X" in the column for the action desired as to the accumulation of nuclear effects on dead sites. If both columns are left blank or if both are filled in, then no accumulation of effects on dead sites is played.
50, 51, and 52	Sensor attenuation: 50—No attenuation 51—Total blackout in occlusion cone 52—Full attenuation computation	Enter an "X" in the column for the action desired for the play of sensor attenuation from nuclear bursts. If all columns are left blank, then full attenuation computation is made. If more than one column is marked, then the higher number column marked will be the action taken.

Columns	Description	
54-56	Defended Country Code	Enter the country code for which an active defense has been structured in the game. This is to be used for end-game applications only.
58-62	Game Duration	Enter the time in minutes and seconds required to fly offensive missiles out of the battle zone of the defended country for an end-game application. If columns 54-56 left blank, this field will be ignored.

SIMETTE

RUN OPTIONS

Date ______

Page ______ of ______

1 2
O P Run Options

4 5 6 7 8 9 10 11 12
☐☐☐ • ☐☐ • ☐☐ Total Length of the Simulation (hrs • min • sec)

FIGHTER SCRAMBLE ON EARLY WARNING

14 15 16 17 18 19 20 21 22
☐☐☐ • ☐☐ • ☐☐ Max. Allowable Azimuth Difference Between Threat Vehicle and Loiter Point (deg • min • sec)

24 25
☐☐ Number of Loiter Points to be Used per Threat Vehicle

27 28
☐☐ Number of Fighters Assigned to Each Loiter Point

FIGHTER ASSIGNMENT RULES

30 31 32 33 34 35
☐☐☐ • ☐☐ Max. Range from Fighter to Threat Vehicle for Assignment (n.mi.)

37 38
☐☐ Max. Number of Fighters Assigned to Each Threat Vehicle

Alternate Basing of Fighters Permitted

40
☐ Yes

41
☐ No

FIGHTER ASSIGNMENT RULES (Continued)

Fighter in Engagement but Short on Fuel:

43
☐ Always Break-Off

44
☐ Reengage Only if 1-on-1

45
☐ Always Reengage

NUCLEAR EFFECTS OPTIONS

47
☐ Accumulate Effects on Dead Sites

48
☐ Do not Accumulate Effects on Dead Sites

SENSOR ATTENUATION

50
☐ No Attenuation

51
☐ Total Blackout in Occlusion Cone

52
☐ Full Attenuation Computation

ONE-SIDED GAME

54 55 56
☐☐☐ Defended Country Code

58 59 60 61 62
☐☐ • ☐☐ Game Duration of C
From Defended Co

SIMETTE Form TF - Trace Flag Values

Form Purpose: This form provides the user with the capability of turning trace information on or off for selected routines for the entire game or only a specific portion thereof.

General Instructions: A single line entry on this form provides the time and numeric code that defines individual simulation events and subroutines that will or will not produce trace information. Also for the speicified time, the number of repetitions each routine supplies information is defined.

A numerical code is used to specify trace for each simulation event and subroutine or function. The trace numerical code is:

EXOGENOUS EVENT ROUTINES

1 - ORDER
2 - PDATA
3 - BEGIN
4 - VDATA
5 - CDATA
6 - TFLAG

ENDOGENOUS EVENT ROUTINES

21 - BURST
22 - IMSGE, LMSGE, SMSGE
23 - OBSER
24 - STOP
25 - BVHCL, FVHCL, MVHCL
26 - BLARV
27 - DMSGE
28 - WVHCL
29 - SMSGE

SUBROUTINES AND FUNCTIONS

31 - BLAST
32 - CSC
33 - DENS
34 - ALTB
35 - DIST
36 - DRAW
37 - DUST
38 - EFFECT
39 - ERROR
40 - INTERP
41 - AMOD
42 - KINEM
43 - NETWRK
44 - PROMPT
45 - REMOVE
46 - REPORT
47 - SEC
48 - SENSE
49 - TRANS
50 - VOLUME
51 - AMAX
52 - AMIN
53 - APEX
54 - ATTEN
55 - AZ
56 - CLAS
57 - COMMUN
58 - FDEFND
59 - MDEFND
60 - DISCR
61 - FAR
62 - FILT FIRBL
63 - KCRD
64 - NPATH
65 - NUC
66 - REASGN
67 - RFCRD
68 - SCLS
69 - SES
70 - TABL
71 - TOF
72 - TREE
73 -

At the input time, columns 5 to 13, the first index and second index columns 15 to 25, stipulates the routines of trace interest. For instance, if trace is desired from all routines, first index = 1 and second index = 73 or if trace is asked of only one routine, say DMSGE, then first and second index is set to 27. The trace flag value, columns 27 to 31, denotes if trace is or is not to be suppressed for those routines specified by the first and second index flags. A trace flag value of zero will suppress trace. A non-zero trace flag value defines the number of times each specified routine will prod ce trace.

If only selected printout is desired at any given time, two distinct trace flag cards are usually required. One, to "turn on" those routines of interest and a second card to suppress information from the remaining routines.

For normal use, trace information from messages and vehicle events usually provides the user with sufficient data to analyze the game. If other routines are to be traced, the user should expect huge quantities of printout.

Specific Instructions:

Columns	Description	Instruction
5-13	Time	Enter the time in hours, minutes, and seconds of desired interest.
15-19	First index	Enter the numeric code that defines the event or subroutine that is or is not to be traced. If a series of routines are desired to be traced, first index is the lowest numeric code value for the particular series of interest.
21-25	Second index	Enter the numeric code that defines the last event or subroutine that is or is not to be traced. If the user is concerned with only one subroutine, second index equals first index. If a series of routines are to be traced, second index is the highest numeric code value for the particular series of interest.

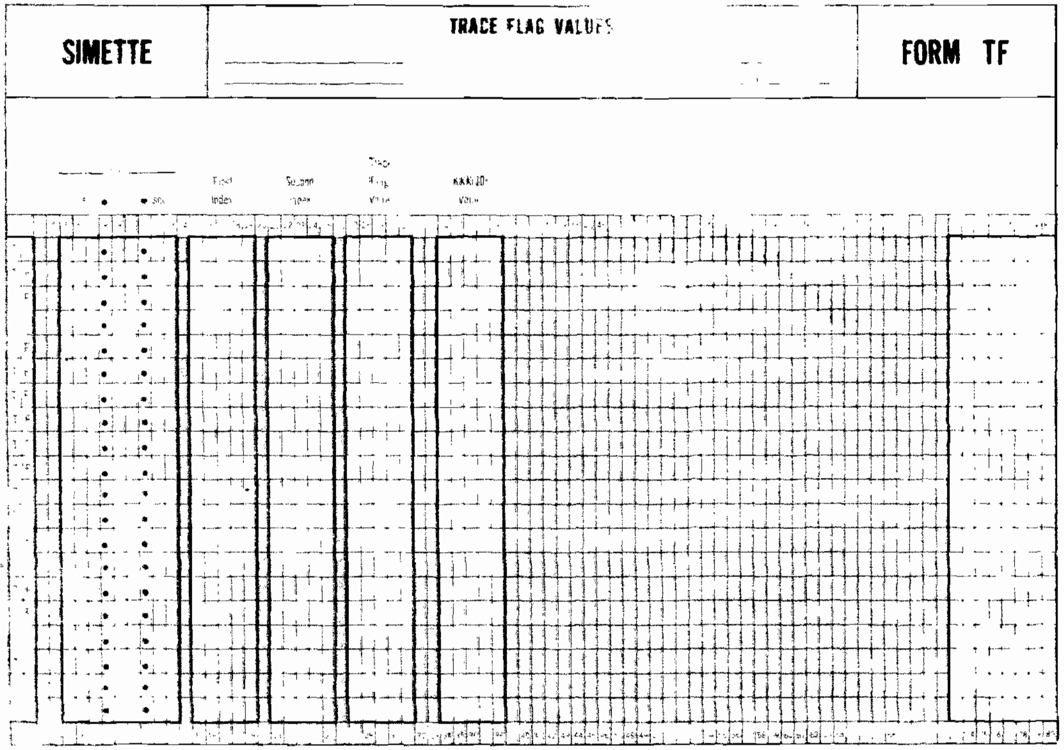
Columns	Description	Instruction
27-31	Trace flag value	Enter the number of times the routines defined by the first and second index flags are to be printed. A value of zero will suppress printout for the designated routines.
34-72		Special flags of system trace that should not be used by the user.

NOTE:

If a given game data deck has already been run through the pre-processor program and the user wishes to change the TRACE output options without rerunning the pre-processor, this may be accomplished with the addition of a few data cards. There is no creation sheet for these cards and they are not part of the pre-processor input. These cards must be placed directly behind the game run deck described in Volume IV, SIMETTE Operator's Manual. The data card format for direct TRACE output control is shown below. The terms FIRST INDEX, SECOND INDEX, and TRACE FLAG VALUE have the same meaning as defined for the Form TF.

1 2 3 4 5 6 7 8 9	10 11 12 13 14	15 16 17 18 19	20 21 22 23 24	25
TIME (Hr/Min/Sec)	FIRST INDEX	SECOND INDEX	TRACE FLAG VALUE	

The program will read the first card at game time 0:00. If no card is present, further reads are terminated. The TIME entry on the first card tells the program when to read the second card, the second card tells when to read the third card, etc.



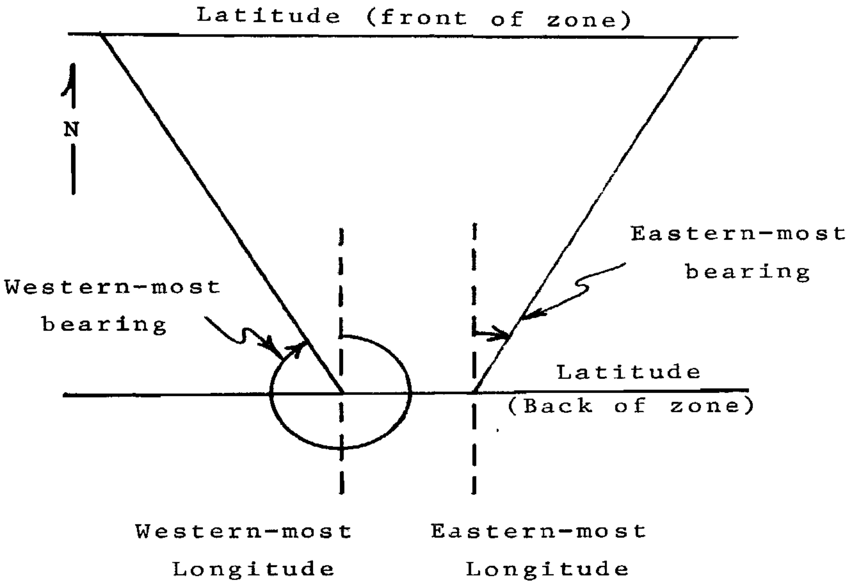
SIMETTE | **TRACE FLAG VALUES** | **FORM TF**

SO	First Index	Second Index	Trace Flag Value	KKKIJO- Value

SIMETTE Form A2-ABM Denial Zone Definition

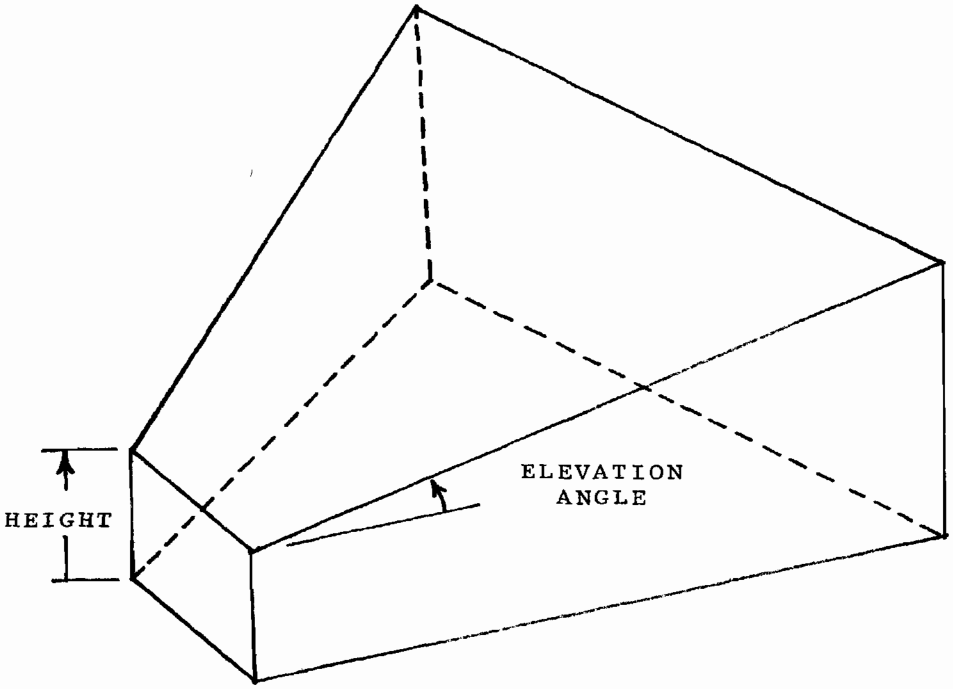
Form Purpose: This form permits the definition of a zone or flyout carridor within which ABMs under the designated command site are not allowed to perform an intercept. The zone may override for self-defense if the value of the target threatened by the object to be engaged exceeds the override threshold entered on Form CS.

General Instructions: The SIMETTE model permits the definition of zones within which specified ABM systems are not allowed to perform intercepts. These zones may be "turned on and off" at various points in game time to coordinate their use with the planned friendly flyout schedule. The zones must be oriented along the north-south axis between two designated latitudes. In plan view, the zones are trapezoidal in shape as illustrated below:



Denial zone, plan view.

The top of the zone is a plane, tilted at an elevation angle from a specified height at the "back" of the zone. (If the friendly offensive missiles are flying north, then the back is defined as the southern latitudinal boundary. If the missiles are flying south, then the back is the northern latitudinal boundary). Thus, in three dimensions, the denial zone would be:



Denial Zone, three dimensional.

Other than the requirement that the front and back boundaries be latitudinal lines, the only restriction on zone definition is that it must not contain either the north or south poles within its boundaries.

Specific Instructions:

Columns	Heading	Instruction
4-11	Site Name	Enter the name of the command and control site (normally an LCF) that has been listed as the next higher (Form A2) of the ABM (or SAM) missile site(s) to which the zone applies.

Columns	Heading	Instruction
14-19	Latitude From	Enter the latitude (in degrees and minutes, North or South) of the back of the zone.
21-26	Latitude To	Enter the latitude (in degrees and minutes, North or South) of the front of the zone.
29-35	Western-Most Longitude	Enter the longitude (in degrees and minutes, East or West) along the back latitude that defines the western-most corner of the zone.
37-42	Western-Most Bearing	Enter the bearing (in degrees and minutes) relative to north of the zone side from the western-most longitude. (The bearing may indicate an expanding or narrowing zone from back to front.)
45-51	Eastern-Most Longitude	Enter the longitude (in degrees and minutes, East or West) along the back latitude that defines the eastern-most corner of the zone.
53-58	Eastern-Most Bearing	Enter the bearing (in degrees and minutes) relative to north of the zone side from the eastern-most longitude. (The bearing may indicate an expanding or narrowing zone from back to front.)
61-62	Elevation Angle	Enter the elevation angle (in degrees) of the top plane of the zone. The angle is measured at the back of the zone relative to the local horizontal.
64-66	Height	Enter the height (in nautical miles) from the ground to the edge of the zone top along the back latitude.
68-71	Window Identifier	Enter the identifier of the window times specifying when the zone is to be in effect. For those intervals of time when the zone is not in effect, intercepts by the associated ABM system will be unconstrained. (The window identifier referenced here must have a corresponding entry on Form D.)

SIMETTE

ABM DENIAL ZONE DEFINITION

SIMETTE

FORM A2

OCT 1971

Date ____________

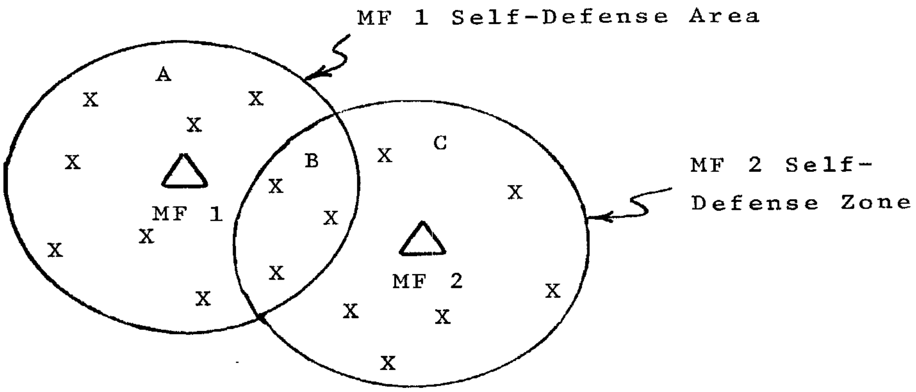
Page ________ of ________

		SITE NAME	LATITUDE FROM (DEG•MIN)	N OR S	LATITUDE TO (DEG•MIN)	N OR S	WESTERNMOST LONGITUDE (DEG•MIN)	E OR W	WESTERNMOST BEARING (DEG•MIN)	EASTERNMOST LONGITUDE (DEG•MIN)	E OR W	EASTERNMOST BEARING (DEG•MIN)	ELEV. ANGLE (DEG)	HEIGHT (NMI)	WINDOW IDENTIFIER
1	A2		•		•		•		•	•		•			
2	A2		•		•		•		•	•		•			
3	A2		•		•		•		•	•		•			
4	A2		•		•		•		•	•		•			
5	A2		•		•		•		•	•		•			
6	A2		•		•		•		•	•		•			
7	A2		•		•		•		•	•		•			
8	A2		•		•		•		•	•		•			
9	A2		•		•		•		•	•		•			
10	A2		•		•		•		•	•		•			
11	A2		•		•		•		•	•		•			
12	A2		•		•		•		•	•		•			
13	A2		•		•		•		•	•		•			
14	A2		•		•		•		•	•		•			
15	A2		•		•		•		•	•		•			
16	A2		•		•		•		•	•		•			
17	A2		•		•		•		•	•		•			
18	A2		•		•		•		•	•		•			
19	A2		•		•		•		•	•		•			
20	A2		•		•		•		•	•		•			

SIMETTE Form A3 - Self-Defense Areas

Form Purpose: The form provides the data necessary for the model to determine if a threatening object is aimed at a site within an ABM self-defense area and may, therefore, override any intercept denial zone. This is accomplished by listing the ABM missile launch sites that are located within the area associated with each value table identifier. The value table identifier is, in turn, associated with one or more sites whose values it represents through the data entered on Form A.

General Instructions: The easiest method of describing the entries necessary for this form is to construct a simple example. Assume that there are two ABM missile fields, MF 1 and MF 2, with self-defense areas as shown below:



The additional sites within the areas are shown by an "X" and are assumed to have the same intrinsic value. If all of the sites in the area marked A (including MF 1) are associated with value table identifier 1, then the Form A3 entry for that table would list ABM site MF 1 only. Similarly, for the value table associated with sites in area C only MF 2 would be listed. For the value table associated with sites in area B, both MF 1 and MF 2 would be listed. If at any time during a run of the simulator an object is aimed at a site in area A, the threat will be preferentially engaged as long as interceptors remain at MF 1. For a threat aimed at a site in area B, it will be preferentially engaged as long as interceptors remain at either MF 1 or MF 2. For the value table identifiers of sites not contained in any self-defense areas, no entry is necessary on

Form A3. Also, if a value table is associated with more than seven ABM sites, the entry may be continued on the next line by leaving the value table identifier field blank.

Specific Instructions:

Columns	Heading	
5-8	Value Table Identifier	Enter the value table identifier number.
10-17 19-26 28-35 37-44 46-53 55-62 64-71	ABM Launch Site Name	Enter the name of each ABM launch site located within the area associated with the value table identifier. Make entries in any order from left to right. A blank entry ends the card reading operation. For more than seven entries, continue on the next line leaving the value table identifier field blank.

SIMETTE

SELF-DEFENSE AREAS

Date ______

Page ______ of ______

FORM A3

OCT 1971

VALUE TABLE IDENTIFIER

ABM LAUNCH SITE NAME

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	A	3																																																																														
2	A	3																																																																														
3	A	3																																																																														
4	A	3																																																																														
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18	A	3																																																																														
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20	A	3																																																																														

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WSEG REPORT 155

SIMETTE

SIMEX PROTOTYPE DEVELOPMENT

September 1970

Volume III: SIMETTE Computer Programs and Methodology

Comprising PRC Report R-1521

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WSEG REPORT 155

SIMETTE

SIMEX PROTOTYPE DEVELOPMENT

PRC Report R-1521

Volume III: SIMETTE Computer Programs and Methodology

September 1970

Prepared For
WEAPONS SYSTEMS EVALUATION GROUP
Under Contract DAHC 15-69-C-0123

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VOLUME III. SIMETTE COMPUTER PROGRAMS AND METHODOLOGY

FOREWORD

This volume presents the general structure of the SIMETTE model and the methodology which is the basis for missile defense simulation. Each of the major computer routines of the SIMETTE system is described. The descriptions include routine usage, program methodology, and functional flow charts. Furthermore, inputs, outputs, and functions and subroutines called are characterized. Volume V lists the computer instructions in SIMSCRIPT and the documentation tables for data entries required by the simulation algorithms.

I. GENERAL STRUCTURE

A. Introduction

The SIMETTE system consists of three parts:

- Preprocessor
- Simulation
- Postprocessor

The preprocessor converts user and other furnished data into the input form required by the simulation program. The preprocessor accepts the user provided data described in Volume II - Users Manual. It also accepts technical tables for use by functional subroutines such as atmospheric data and nuclear effects attenuation tables.

The simulation emulates cause and effect relationships between game input events and the subsequent internally caused events. For each event the program adjusts the simulated world. The randomness of equipment failures, time delays, and kill probabilities is emulated by use of Monte Carlo procedures.

The postprocessor converts simulation output to a form that enhances visibility into the results of a simulation run.

Exhibit I-1 illustrates the general structure for the composite of computer programs of the SIMETTE system. The preprocessor is fed user and technical data, and develops initial conditions and exogenous events for use by the simulator. In addition, indexing data is delivered for use by postprocessing routines. The simulator programs operate on the preprocessed data and deliver the results of a game run to a postprocessor. The postprocessor then associates game results with preprocessor indexes and develops summary outputs for enhanced visibility.

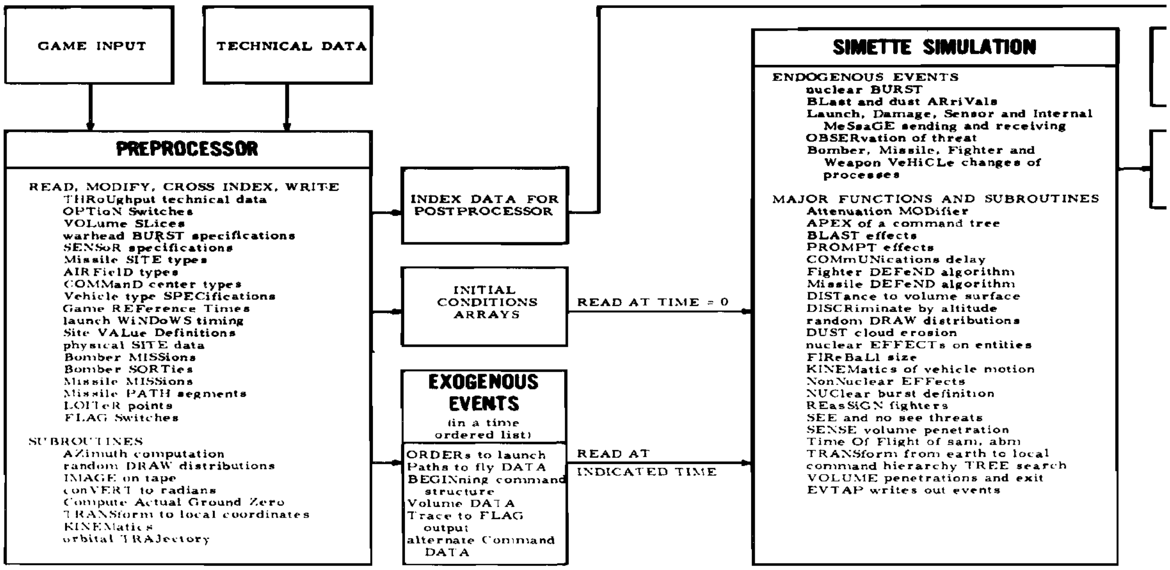


EXHIBIT I-1 SIMETTE STRUCTURE AND INFORMATION FLOW

B. Basic Concepts

The simulation proper is structured around the basic concepts explicit in the SIMSCRIPT language. SIMETTE is an event sequenced program that operates to change the status of a world that is described in terms of entities, attributes, and sets.

The events of SIMETTE are of two kinds:

- EXOGENOUS (causation due to circumstances outside of the simulated world)
- ENDOGENOUS (causation due to circumstances internal to the simulated world)

The data structure of SIMETTE allows the simulated world to be described in terms of:

- Entities (individuals)
- Attributes (descriptive values for each entity)
- Sets (groups of individuals)

The simulation operates according to the dictates of

- Initial conditions for all permanent entities
- A time ordered list of exogenous events
- An internally maintained time ordered list of endogenous events

The simulation first reads the initial conditions data (provided by the preprocessor) to define the state of the world to be simulated at the beginning of simulation procedures. The program then reads the first exogenous event and adjusts the world according to the programmed logic associated with the event.

The program also causes endogenous events to be scheduled for future consideration and adjusts the state of temporary and permanent entities. The causation of events to be scheduled is performed by the SIMSCRIPT system programs that place an upcoming event in a calendar position commensurate with all other upcoming events. Endogenous events are considered along with exogenous events, each at their proper time.

As time moves forward, the next event in the calendar is chosen for processing.

C. Events

The exogenous events of SIMETTE are:

ORDER = Initial ORDERs from higher headquarters to launch offensive vehicles or to position manned interceptors or bombers

PDATA = Path and mission DATA that define the flight of a vehicle and subsequent launch of weapons

BEGIN = Develops BEGINning command structure and adjusts initial conditions arrays as necessary

VDATA = Reads in Volume surface DATA

TFLAG = Sets Trace FLAGs for output of events and programs

CDATA = Reads in alternate Command structure DATA

The endogenous events of SIMETTE are:

BURST = Nuclear detonation (BURST)

BLARV = BLast front ARriVes at entity, or vehicle arrives at dust cloud

LMSGE = Sending and receipt of a Launch MeSsaGE

SMSGE = Sending and receipt of a Sensor MeSsaGE

DMSGE = Sending and receipt of a Damage MeSsaGE for possible destruction of an entity

IMSGE = Internally useful MeSsaGE used for simulation operations

OBSER = OBSERvation of an entity by a sensor system

BVHCL = Bomber VeHiCLe enters its next assigned process

MVHCL = Missile VeHiCLe enters its next assigned process

WVHCL = Weapons VeHiCLe (including SAM, ABM, gravity bomb) enters its next assigned process

FVHCL = Fighter (manned interceptor) VeHiCLe enters its next assigned process

STOP = STOP and report

D. Data Structure

The data of SIMETTE consists of entities and attributes.[1] Entities are of two types: permanent and temporary. Permanent entities are allocated computer storage for the entire game. These entities are of

---

[1] The tables shown in Volume V define all of the attribute values, entities, and sets used in SIMETTE.

the generally useful variety and provide data that are needed at all times during the simulation. Temporary entities represent individuals that have transient existence. Entities of both types may be grouped together into sets.

1. Permanent Entities

Permanent entities are as follows:

VSPEC = Vehicle type SPECifications
BSPEC = Burst SPECifications for each type of warhead detonation
MSITE = Missile SITE type specifications
ASPEC = Airfield SPECifications
SSPEC = Sensor type SPECifications
CSPEC = Command Site type SPECifications
ISITE = Integer values for each physical SITE
FSITE = Floating point (real) values for each physical SITE
CONTR = Process CONTRol attributes

In addition to the above, there are miscellaneous tables and arrays for system constants, atmosphere tables, option switches, volume surface coordinates, communications delays, tables for attenuation of nuclear effects, system parameters, and pointer tables. All of these are addressed by computer logic in terms of entity names and attribute names or indices.

2. Temporary Entities

In SIMETTE, many individuals are transient in nature. For example, vehicles are created, exist for a time, and (perhaps when a nuclear detonation occurs) are destroyed. Dynamic storage algorithms are provided by SIMSCRIPT for storage and retrieval of this type of data. When computer storage is no longer needed for a particular entity, it may be used by another. Temporary entites are of two forms:

- Event notices—data associated with an event. These data are dynamically stored in the endogenous events list. (Event notices are always ranked by time.)
- Temporary entities—all of the other dynamically stored data

All temporary entities may be ranked within a set by an assigned attribute value.

Event notices are listed in the previous Subsection I. C. The remaining temporary entities are described below.

PATH = Data that describe a segment of a vehicle (or burst) flight path. In the path segment data record, the process for the vehicle to perform during or at the end of the segment is named and the address of the next segment for the vehicle to fly is indicated. If a subsidiary vehicle is to be launched (for example, a bomb or air-to-surface missile), the address of the new vehicles' path segment entity is indicated. The technical parameters for movement of vehicles according to different equations of motion, and for the size and position of nuclear "fireballs" are attributes of the PATH entity.

POINT = Range and elevation of a point on a volume surface. (The entity POINT is filed in a set for an azimuth slice owned by a particular volume, and is rank-ordered by elevation angle.

CRECD or CREC2 = Temporary entity for recording command membership. CRECD is also used in the defensive algorithms to represent enemy threats posted at a command site. When used in missile defense algorithms the entity is rank-ordered in two ways:

- By the amount of available time to launch a missile interceptor
- By the time of flight of a missile interceptor to the threat intercept point

FPREC = Temporary entity that contains the address of the first path segment in path sets

NOTE = Note of assignment of fighters to bombers or of fireball occlusions of an observed threat being viewed by a sensor.

PLACE = Stores the place of a site in a command hierarchy.

3. Sets

In SIMSCRIPT programs, the construction of sets allows addressing of several temporary entities as a group. The entities contained in a set may be rank-ordered within a set by any defined attribute of the entity. The sets used in SIMETTE are as follows:

EVENTS = Endogenous events, rank-ordered by time of event occurrence

ASGN = Assignment notes for MI's assigned to a bomber, or for notes about sensor observations being occluded by a nuclear environment

COMM = Entities (of all types) that report to a command site

COPY = The group of observation records that define the observed status of a single vehicle being viewed by several sensors

FREC = The group of first addresses of paths. This set allows simulation logic to choose among several sets of path segments.

STAC = The group of entities in a limb of a command hierarchy tree

VOL = Set of points (elevation and range) that describe the edge of a volume azimuth slice

E. SIMETTE Operations

1. General

The operations of SIMETTE can be explained by following a simplified series of events and processes that could occur. In this section lists of statements are presented to illustrate SIMETTE from four points of view. These are:

- An offensive launch order is transmitted from higher headquarters.
- An object pierces the field of view of a sensor.
- A nuclear detonation occurs.
- Defense responds to sighting of a threat object.

2. An Offensive Launch Order is Issued

The following statements discuss events that could occur upon issuance of an exogenous (or endogenous for defense missile logic) order to launch.

- The launch order is converted to a message and sent to the receiving site.
- After a delay due to internal processing at the sender site, transmission time, and delay for processing at the receiver site, a launch process is invoked.

- The launch will occur if:
  - The site is alive and operational
  - Site/missile maintenance is not being performed (if maintenance is being performed, the launch order is reinvoked after a time interval)
  - The system launch window is opened (if the window is not opened, the launch order is reinvoked at the next opening)
  - The vehicle and site pass reliability tests performed on a Monte Carlo basis
- If launch can occur, a vehicle is created (a record is generated and stored in computer memory to represent the vehicle).
- The path process segment data for the vehicle to fly is connected to the vehicle.
- The vehicle begins flying (according to the dictates of its path segment record, and the first vehicle event is caused to occur; i.e., launch).
- As dictated, the vehicle moves from one process segment to the next.
- If the process code so indicates, the vehicle will launch subsidiary vehicles. The subsidiary is created and attached to the proper path process segment.
- At the end of some path segment for the vehicle (or its subsidiary), a nuclear detonation may occur. If the burst occurs, a BURST record is created and attached to a path record that defines the growth, movement, and other characteristics of the burst. Also a BURST event is caused to occur.
- As each vehicle moves from one path process segment to another, traversals of sensor volumes of view are predicted. At the instant of piercing, sensor observation processes are invoked.

- As each vehicle moves from one path process segment to another, traversal of rising and expanding dust clouds are predicted, along with encounters with blast fronts.
- If the vehicle encounters dust or blast fronts, damage processes are invoked.

3. Vehicle Enters a Sensor Field of View

The following statements discuss the possible sequence of events from the sensor point of view, following the event of an object piercing a sensor volume.

- When a vehicle (offensive object) penetrates a sensor volume, a "dummy" observation record is created and an event of possible future observation is caused.
- The instant of actual observation is computed according to charcteristics of the nuclear environment, radar, and vehicle; and an observation event of the acquisition type is caused.
- At the instant of "actual" observation (acquisition) a radar sensor message is transmitted to the appropriate command site and a series of further observation processes is caused at their appropriate time. These are: designate, track, track for intercept, discriminate, and exit field of view.
- Observation records for a single vehicle piercing more than one sensor field of view are grouped together in a set known as COPY. (This allows logic of defense to be imposed on an object blacked out from view by one sensor, but not another.)
- Threats may be occluded while in a sensor volume by fireballs and other nuclear effects that result from weapon bursts.
- For each vehicle/burst occlusion that occurs within a sensor volume, a set of notes is created that relates sensor, bursts, and vehicles to times that occlusions occur. (This logic computes time of "see" or "no see" of objects being viewed by a sensor.)

4. A Nuclear Detonation Occurs

The following steps illustrate a trail of logic that would be followed when a nuclear detonation occurs.

- A burst entity is created.
- A path record is created to describe the growth, movement, and radar sensing signal attenuative characteristics due to the burst.
- The path record is attached to the burst entity.
- A burst observation record is filed with pertinent sensors so that sensor logic can address information to compute times of occlusion of threat objects.
- Sensor occlusion logic is invoked and notes of occlusion are created and filed for sensor/vehicle observations.
- Stationary entities (sites) are searched out and if they are inside a critical radius, they are given doses of prompt nuclear emissions.
- Positions of moving entities are calculated, and if they are inside a critical radius, they also are given doses of prompt nuclear emission.
- Damage from prompt nuclear effects is accrued to affected entities (with consideration of recoverability of the entity from previous doses) and damage messages are sent.
- A prediction is performed to find vehicles that will enter dust clouds. For vehicles that enter dust clouds, an erosion event is caused. The erosion event occurs at the time a vehicle would be killed or at the instant the vehicle exits the cloud.
- A prediction is performed to find vehicles that encounter blast fronts. At the instant of encounter, a blast arrival event is caused.
- For sites, the prediction of blast front arrival is also performed, and a blast arrival event is caused.

- Damages accrued from the various nuclear effects to each entity are compared to the corresponding vulnerability thresholds for the entity. If one or more of the thresholds is exceeded, the entity is killed.

5. Defense Responds to Threats as Observed

- As a result of receipt of a sensor message signifying a threat object, a computation is performed to define defense battle spaces that the threat will pierce.
- A threat object record is generated and is posted at the appropriate command site(s).
- The rank-ordered position of the new threat is computed according to the importance of the new threat relative to all other threats.
- The rank-ordered list is reviewed each time the following occurs:
  - A new threat appears
  - A launch initiation takes place
  - An intercept occurs
- After review of all threats in the rank-ordered list, defense resources are assigned. For ABM defense, the review considers:
  - Remaining time available to launch an interceptor
  - The ability of other defenders to parry the threat
  - The number of interceptors remaining at each launch site
  - The value of the threat as seen by defense
  - The modified value of the threat as adjusted by a time versus value function
- Launch orders for defensive launches are sent by the defense command to the appropriate launch site.
- Defense resources are decremented for each launch of an interceptor missile.
- Radar tracking channels available are decremented or incremented as they are used or become available.

For manned interceptors (MI's) engaging bomber threats, the following logic is invoked:

- MI's are sent to strategic orbit points (loiter points) on early warning
- When track of bombers is established, engagement logic is invoked
    - MI's are rank-ordered by least time to intercept
    - According to policy, a number of aircraft are assigned to engage the bomber
- The results of the engagement are computed according to a kill probability formulation
    - Both survive
    - Bomber killed
    - Fighter killed
    - Both killed
- Depending on the results of an engagement, current fuel on board interceptors, armaments remaining, proximity of home (or alternate) base, MI's may:
    - Reengage
    - MI's may be sent to home (or alternate)
    - Sent to a loiter point
    - MI's may be flown to fuel exhaustion
- If indicated, new interceptors may be assigned to the bomber.

II. PROGRAM DESCRIPTIONS

A. Discussion and Methodology/Flow Charts

This section contains a discussion of each major computer program in SIMETTE. Each discussion includes:

- The program name and acronym meaning
- Discussion of usage of the program
- A list of inputs
    - Formal parameters and arguments
    - Data derived from storage
- A list of outputs
    - Formal results
    - Adjustment to stored data entities that are created, destroyed, caused, and canceled
- Subroutines and functions called
    - Major subroutines and functions relevant to understanding of program context are listed.
    - FORTRAN library functions and subroutines are not shown.
    - Subroutines such as ERROR, TRACE, REMOVE, etc., are generally not listed.
- Methodology
    - A narrative description of the important functional operations of subroutines is included to allow insight into the methodology incorporated in SIMETTE.
- Flow chart
    - The flow charts aimed toward functional understanding of the routines are presented. The programs, listed in Section V, are written in a high-level language—

SIMSCRIPT—allowing detailed trace of logic flow to be performed by noting the "GO TO" and IF statements. Extensive commentary and preambles are included in the program listings to further assist in following the content of computer programs.

Unclassified parameters are used in the nuclear effects and blackout computations that are included in the program. These parameters were used for model checkout purposes and, in some cases, should not be used for computation of actual nuclear effects.

FUNCTION ALTB (II)
Find ALTernate Base

Discussion of Usage

Function ALTB returns the identification number of the air base site closest to a manned interceptor. The input to the subroutine is the address of an interceptor. The site index number returned identifies a site that meets the following conditions:

- The site is alive
- The site has the same type of equipment as the manned interceptor
- The site is in the same command as the interceptor

If no site can be found that meets the above conditions, a zero is returned.

Input Arguments

II = Address of manned interceptor

Output

II = Index of closest site (if none found, II = 0)

Subroutines and Functions Called

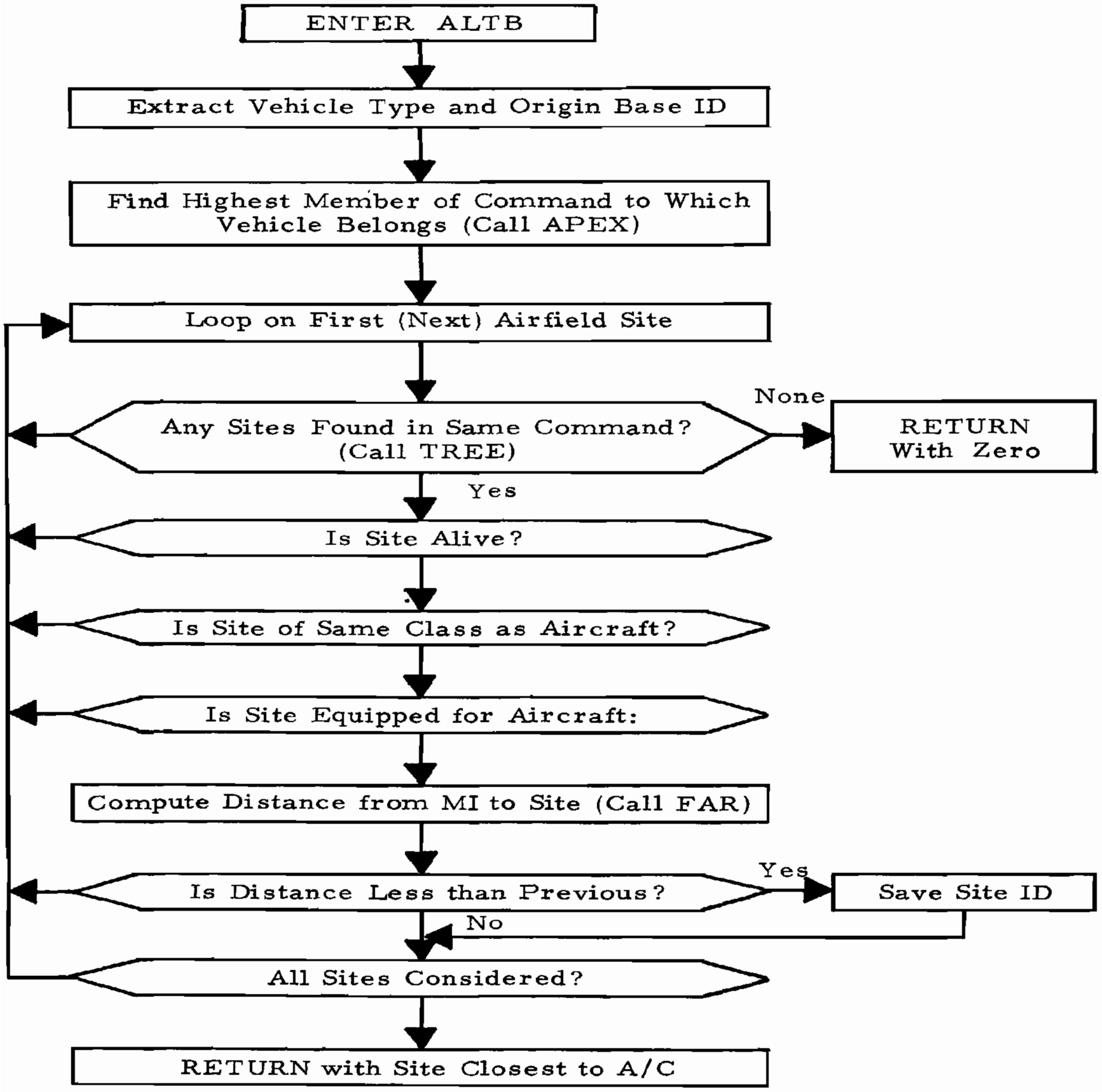
APEX = Searches out highest member site of a command

FAR = Computes the distance between a manned interceptor and a site

TREE = Searches out entities in a command tree structure

Methodology

The program locates air bases within the same command as the manned interceptor and performs conditional tests of site adequacy to the needs of the fighter. For each air base that passes the above conditions, the distance from the aircraft to the site is computed and the program returns control to the calling routine with the index number of the site that is closest. If no sites are found a zero is returned.



LOGIC FLOW CHART — FUNCTION ALTB

SUBROUTINE AMOD(II,NN)
Attenuation MODification

Discussion of Usage

Subroutine AMOD determines a time interval during which a vehicle cannot be seen by a radar because of interference due to a nuclear burst. Several other parameters are also computed for sensing algorithms. In this version of AMOD, a linear relationship for attenuation as a function of distance within a cone of restricted vision is used to find the signal/noise ratio of a sensor whenever the ratio is below a designated blackout threshold.

Input Arguments

II = The address of an entity (OBSER record address) subject to sensing

NN = Address of a NOTE that contains relationship information about a burst, vehicle, sensor interaction

Output

Update of the NOTE regarding the burst, vehicle, sensor interaction are as follows:

NPAR1 = Range of vehicle from sensor at entrance into a nuclear bursts "cone of occlusion"

NPAR2 = Range of a vehicle from sensor at exit from a nuclear bursts "cone of occlusion"

NPAR3 = Attenuation rate of change when vehicle enters cone (set to 9999 if vehicle is blacked out when at start of vehicle process)

NPAR4 = Attenuation rate of change when vehicle exits cone (set to -9999 if vehicle blacked out at end of vehicle process)

NTIM2 = Time blackout starts

NTIM4 = Time blackout ends

Subroutines and Functions Called

KINEM = Computes position of vehicle at any time during a path segment

TRANS = Computes line-of-sight values from sensor to vehicle and burst (azimuth, elevation, and range)

SUBROUTINE AMOD (Continued)

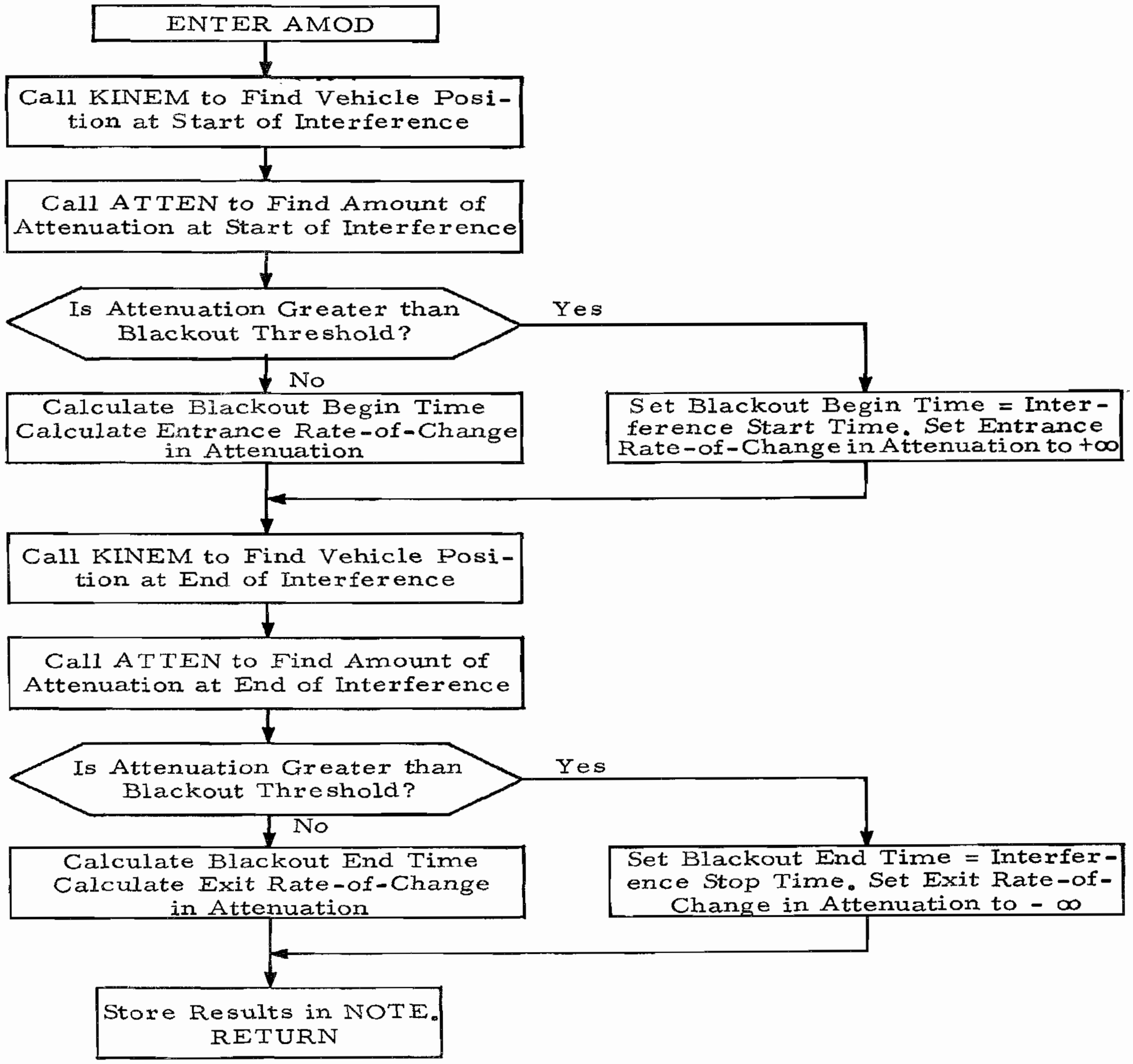
ATTEN = Computes attenuation along line-of-sight due to nuclear effects

Methodology

During the movement of a vehicle through a region where sensing attenuation occurs (coned occlusion) because of interference from a nuclear burst, the rate of change in attenuation is assumed to be a positive constant until full blackout occurs. Upon leaving blackout, the rate-of-change is assumed to be a negative constant until the vehicle leaves the interference region. These rates of change and times at which blackout starts and ends are computed by AMOD based upon a line-of-sight attenuation calculations (ATTEN).

First, the vehicle position at the start of sensing interference is determined. The line-of-sight attenuation valid for this position is then calculated and compared against a threshold value to determine whether or not blackout exists. If the vehicle is in blackout at this time, the starting rate-of-change in attenuation is set to 99999, and the start of blackout is taken to be the same as the time the interference begins. If the attenuation is below the threshold, the time blackout starts (the threshold value is attained) and initial rate-of-change in attenuation are calculated, assuming attenuation to be a linear function of time.

Next, the vehicle position at the end of the sensing interference is determined. By an analogous procedure to that described for start of blackout, the time at which blackout terminates and the ending rate of change in attenuation are calculated. All of the results that have been determined are then stored into attributes of the NOTE record for the vehicle-burst-sensor interaction.



SUBROUTINE — AMOD

FUNCTION APEX(JJ,ISTAT)

APEX of Command Structure

Discussion of Usage

For a specified site "JJ," the function searches through a command structure to locate a primary decisionmaker. Upon user option the search upward would terminate when a site does not meet or exceed the operational conditions indicated by a requisite status code. If the requisite code is zero, any higher site found would be accepted. If the search cannot locate a primary decisionmaker, it will return with the highest secondary decisionmaker that can be found. If no decisionmaker can be found, zero is returned. Codes that define the operational status of a site for comparison to requisite status are found in Table C-21, Operational Status.

Input Arguments

JJ = Index number for a site looking for its primary decisionmaker

ISTAT = Parameter to specify minimum acceptable status of a decisionmaking site

Output

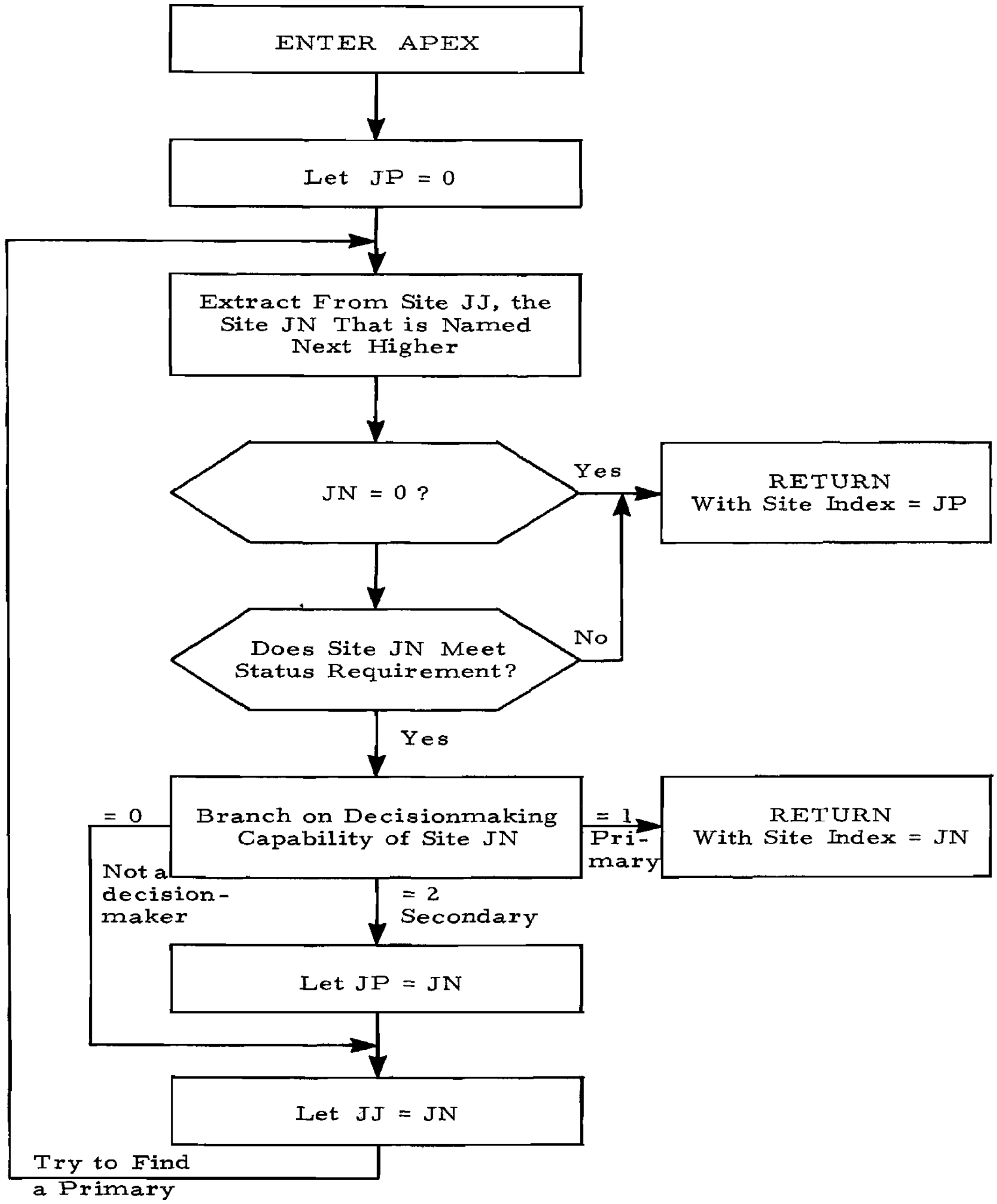
APEX = Index number of a primary or secondary decisionmaking site; if none found, APEX = 0

Subroutines and Functions Called

Normal.

Methodology

Each site entity has an attribute that names a site that is next higher in command. Each successive higher site is interrogated to see if it meets the criteria of operational status described by an attribute of the higher site. The chain may be broken by a next higher site that does not meet the status condition, or the top of the structure is reached. When a site attribute naming a higher site is zero, no higher command site is indicated and the search terminates.



FUNCTION — APEX

FUNCTION ATTEN (II,T,X,Y,Z,ZZ)
Compute Two-Way ATTENuation Factor Along Line-of-Sight to Target Through a Burst

Discussion of Usage

This function determines the two-way attenuation factor produced by a nuclear detonation along a line-of-sight between a target and a sensor. The factor includes attenuation contributed to by fireball, delayed beta and gamma, prompt X-rays (secondary effects), and burst debris.[1]

Input Arguments

II = Address of an observation record of a burst

T = Time at which attenuation is to be measured

X, Y, Z = Azimuth, elevation, and range of an observed object relative to a sensor

ZZ = Altitude of object

Data from Burst Observation Record

OSENS = Identification of sensor site owning burst

OIDEN = Address of burst entity

OLOCX, OLOCY, OLOCZ = Location: longitude, latitude, and altitude of burst at start of the path movement segment

Data from Burst Record

BSTAR = Time of detonation

BPATH = Address of path which describes burst movement and characteristics

BLOCZ = Height of burst at detonation

BTYPE = Type of burst

---

[1] Extracted from General War Antiballistic Missile System Model (ABM-1 Model), Analytical Manual, Vol. V, Simulation Subsystem, CSM-AM-68-68, 15 Nov. 1968, NMCSSC.

FUNCTION ATTEN (Continued)

Data from Path of Burst

PPAR1 = RO—Initial fireball radius (n.mi.)
PPAR2 = NEO—Initial fireball free electron density
PPAR5 = RTEQ—Fireball radius at equilibrium
PPAR6 = TTORD—Time when toroid forms
PPAR7 = RTORD—Radius at time toroid forms (n.mi.)

Data from Burst Specifications (BSPEC)

- Weapon yield
- Threshold reference altitude for prompt X-ray attenuation

Data from Sensor Specifications (SSPEC)

- Frequency of radar

Data from Sensor Site

- Location of Sensor

Output

ATTEN = Two-way attenuation factor for line-of-sight between sensor and target

Subroutines and Functions Called

KINEM = To compute position of burst at indicated time (in earth-centered coordinates)
TRANS = To compute azimuth, elevation, and range of burst center relative to sensor
FIRBL = To compute fireball radius

Methodology

The relative positions of the sensor, burst, and vehicle being sighted, are computed for the indicated time. The radius RB of the

FUNCTION ATTEN (Continued)

"fireball" is then computed (using function FIRBL) for the indicated time.[1]

The program branches according to geometric parameters of the interaction. The branch decision depends on the following:

- Both sensor and vehicle are within "fireball" effects volume
- Only sensor within effects volume
- Only vehicle within effects volume
- Vehicle and sensor outside effects volume but within cone of occlusion

The program then computes the attenuation due to:

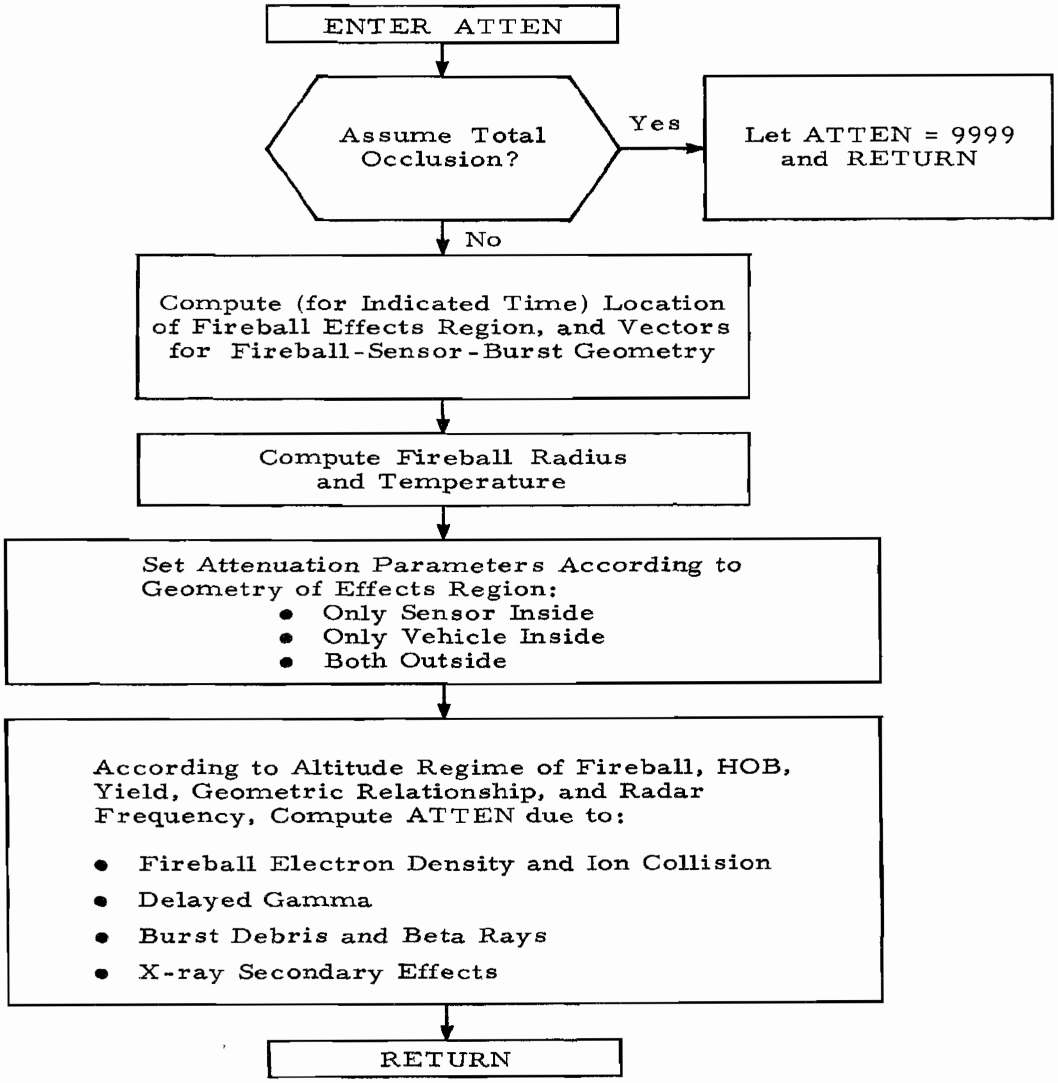
- Thermal
- Delayed gamma radiation
- Beta
- Burst debris
- Secondary effects of prompt X-rays (for bursts above a specified altitude)

The contribution of each of the above factors is then added to generate a line-of-sight two-way attenuation factor for the burst-sensor-vehicle interaction.

If a "cookie cutter" approach to the attenuation problem is specified by user input, the value 9999 is returned indicating total occlusion of any object within the occlusion cone. The occlusion cone is constructed based on the total radius of occlusive effects region of the nuclear detonation.

---

[1] The radius of the "fireball" here is construed to mean the radius of lingering occlusive effects of a nuclear detonation on sensor visibility. The actual formulas for attenuative effects, size, and growth of "fireballs" are classified. The generalized formulas included in the programs are for checkout purposes only and are not suitable for actual estimation of nuclear effects for attenuation of sensor signals.



FUNCTION — ATTEN

FUNCTION AZ (SLON,SLAT,FLON,FLAT,PATH)
Compute AZimuth (Bearing)

Discussion of Usage

This function calculates the azimuth from one longitude, latitude, location to another. Azimuth is measured positive clockwise from north.

Input Arguments

SLON = Origin longitude
SLAT = Origin latitude
FLON = Longitude of point to which azimuth is computed
FLAT = Latitude of point to which azimuth is computed
PATH = 3—Great circle
4—Constant bearing

Output

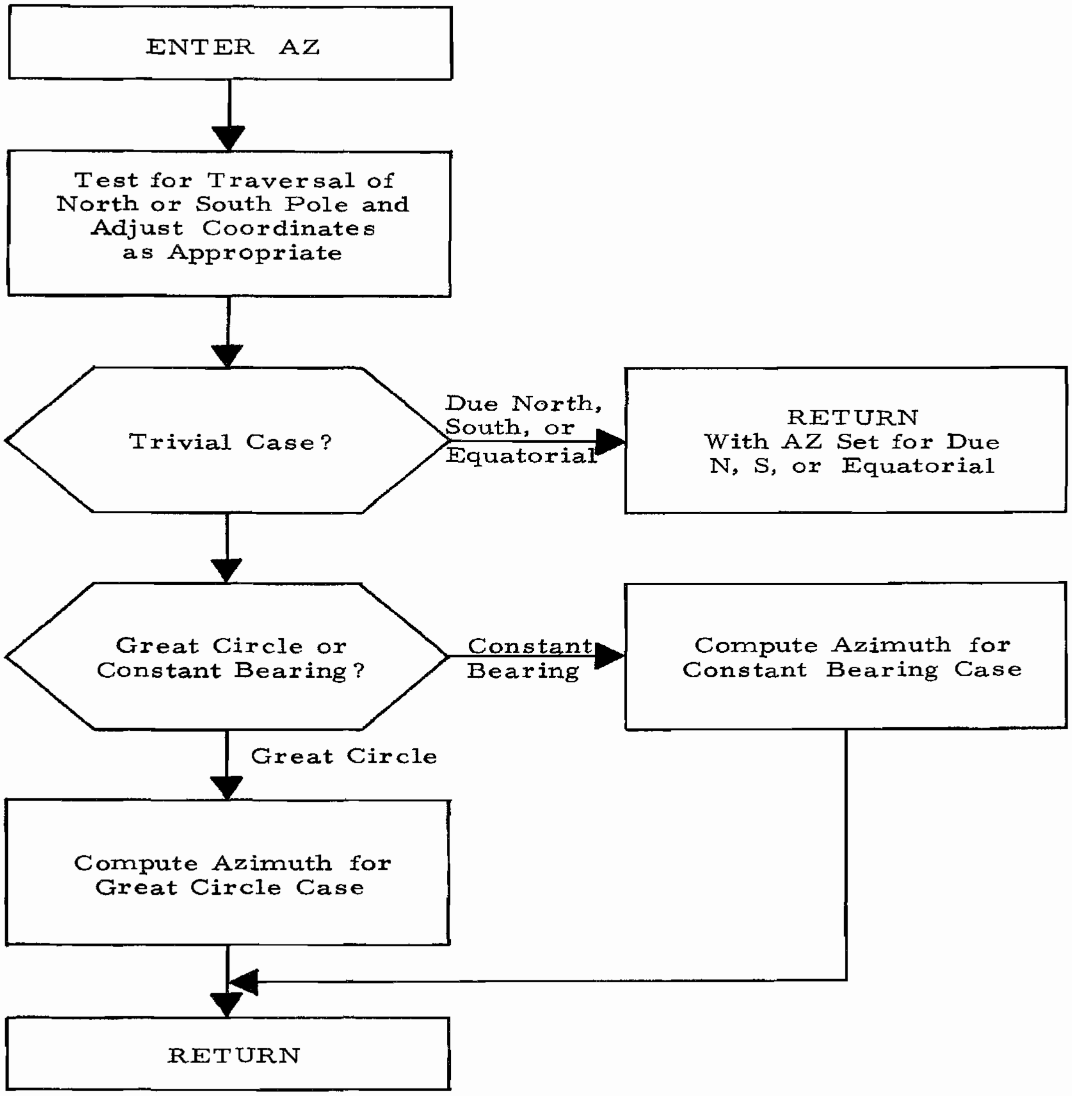
Azimuth (radian measure).

Subroutines and Functions Called

Standard FORTRAN library routines.

Methodology

The program uses the equations of spherical geometry in an earth centered coordinate system where latitude is measured from the north pole from zero to pi (0 to π) radians, and longitude is measured from 0 to 2π positive east of prime meridian.


ENTER AZ
Test for Traversal of North or South Pole and Adjust Coordinates as Appropriate
Trivial Case?
Due North, South, or Equatorial
RETURN With AZ Set for Due N, S, or Equatorial
Great Circle or Constant Bearing?
Constant Bearing
Compute Azimuth for Constant Bearing Case
Great Circle
Compute Azimuth for Great Circle Case
RETURN

FUNCTION — AZ

EXOGENOUS EVENT BEGIN
BEGIN Simulation

Discussion of Usage

The BEGIN event is designed to perform various data processing, conversion, and option switch setting operations at the start of the simulation (i.e., simulation time = zero). The context of the "event" is that of an interface between preprocessed data and the simulation proper. Interfacing computer code can be placed in the BEGIN event to allow for temporary program changes. In the design of any simulation it is recognized that operational models require the ability to interface with data that may be of different format and units especially when certain classified information must be used.

The BEGIN routine performs some processing functions not appropriate to a preprocessor. Included are the following:

- Create and cause the endogenous event for recursive report generation and stopping the simulation (EVENT STOP).
- Establish records of command (Command RECorD) for entities (such as sensor sites, missile sites, etc.) and file these records in appropriate COMMand sets. This function establishes command relationships.

Input Arguments

- Initial conditions data
- Called at simulation time = 0

Output

- Creates and causes the event to stop the simulation and permits on-line recursive reports (note: the recursive reporting function is normally relegated to the postprocessor)
- Generates cross indices for command site and set relationships

Subroutines and Functions Called

CLAS = To extract class from the subclass codes

KRCD = To generate a command set record for the site and to file the record in appropriate command set

ERROR = Prints out error messages

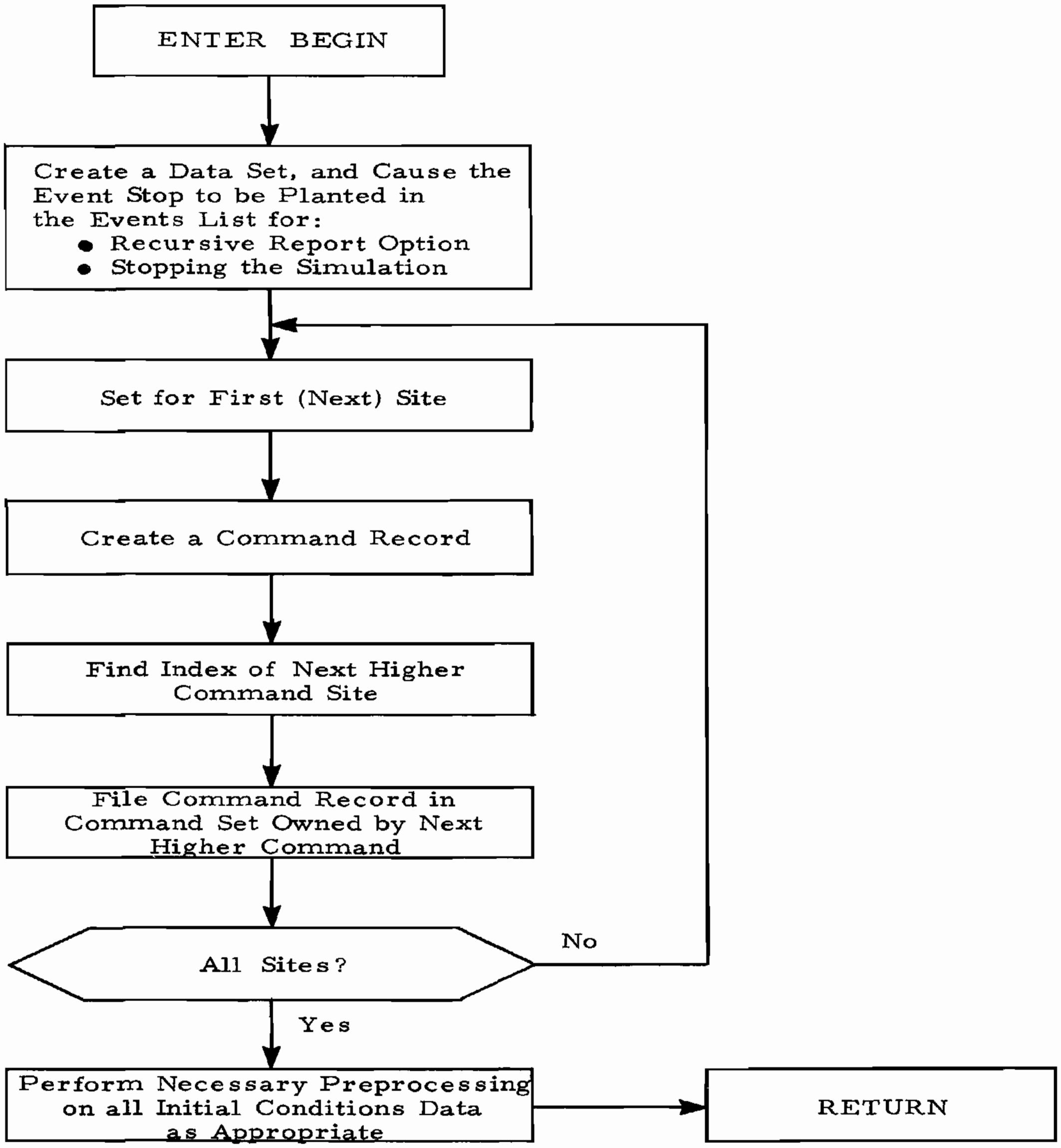
EXOGENOUS EVENT BEGIN (Continued)

Methodology

The program allocates two data words for the event to stop the simulation and/or recursively printout report data.

In developing command and control sets, a record is generated to identify the membership of each site in a set owned by its higher command. These command records are filed in sets for each command site: the sets thereby identify, by type, all sites reporting to and owned by command sites.

Data conversions that prove to be necessary interfaces between simulation and initial conditions data are performed as needed.



EXOGENOUS EVENT — BEGIN

SUBROUTINE BLAST (II,JJ,K,P,T)
BLAST Pressure Front Computation

Discussion and Usage

The BLAST subroutine, another functional subroutine called by the nuclear effects logic, computes the overpressure upon a given entity caused by a particular nuclear detonation at the time the pressure front reaches the given entity. The entity may be a moving vehicle or a fixed location site. At the calculated time of blast arrival an event (BLARV) is caused.

Input Arguments

II = Address of a burst entity
JJ = Index of a fixed site or address of entity
K = Code for type of entity being affected
  1 — Vehicle
  ≠1, fixed site
T = Distance between burst and entity

Output

P = Blast overpressure
T = Time for arrival of pressure front
BLARV = Event notice caused at TIME T as follows:
  BLID = Address of burst causing the effect
  TAID = Identification of site entity or address of vehicle being affected
  TATY = Code for type of entity being affected
  PEOP = Peak overpressure (psi)

Subroutines and Functions Called

TRANS = Translates position in earth coordinates to local coordinates
ATMOI = Computes atmospheric parameters based on altitude
KINEM = Computes position of a moving vehicle (used here to generate vectoring parameters)

SUBROUTINE BLAST (Continued)

Methodology

The BLAST subroutine has two modes of operation:

- For blast front affecting a site at a fixed location
- For a blast front affecting a moving vehicle

The computation of time for arrival of a blast front at a fixed site is performed by the formula:

$$T = Z/R$$

where: Z = Slant range between detonation point and site
R = Velocity of sound modified by atmospheric density

Explicitly, the parameter R is:

$$R = V_{SA} \sqrt{1 + \frac{6}{7} \frac{P_0}{P_A}}$$

where: V_{SA} = Velocity of sound at average altitude between site and detonation
P_0 = Peak overpressure (psi) at site
P_A = Atmospheric pressure in ambient air at average altitude between detonation and site

The computation of time that a blast front would intersect a moving vehicle is performed as follows:

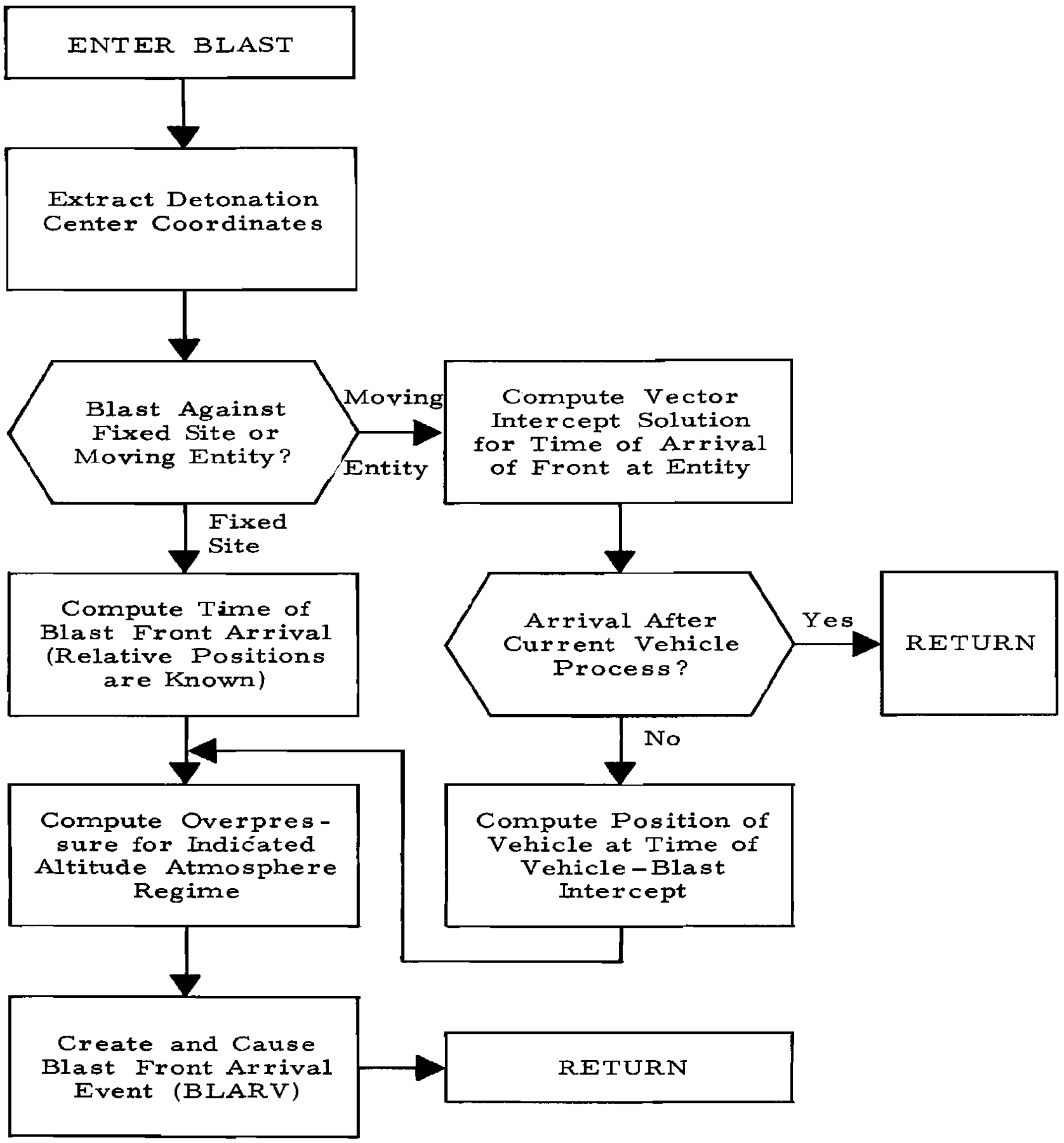
- The 3 x 3 matrix is produced to relate the vehicle movement vectors with the point of burst detonation in a rectangular coordinate system
- According to the altitude regime of the burst, a coefficient related to temperature of the atmosphere is computed. The altitude regimes are:
  - Less than 11 Km
  - Between 11 and 20.4 Km
  - Above 20.4 Km

SUBROUTINE BLAST (Continued)

According to the temperature, (^{o}K) the velocity of the blast front is computed and the earliest interception time of the blast wave and the moving vehicle is generated. The location of the vehicle at the time of interception is then computed (with a call to KINEM), and the slant range from the detonation point to the vehicle is generated. Once the geometric relationships between a detonation point and a vehicle or site at the moment of blast front arrival has been computed, the blast overpressure can be computed. Blast overpressure is computed according to the yield of the weapon detonated, the atmospheric density, pressure and temperature at the altitude regimes of the affected vehicle (or site) and detonation point, and the slant range distance between the detonation point and the affected object.

In order to reflect different phenomena of nuclear detonation and atmospheric interactions, different equations for overpressure are applied for different regimes of the altitude.

After computation of the overpressures, a blast arrival event is created and caused to occur at the time of the blast front arrival.



SUBROUTINE — BLAST

ENDOGENOUS EVENT BURST
Nuclear BURST

Discussion of Usage

The BURST event determines the next applicable process that a burst undergoes in the simulation. It calls functional subroutines to determine and measure the effects of the burst upon other game elements during the ensuing burst process. When an initial burst event is placed in the event list (usually as the end result of some Vehicle process) the data regarding the burst is created and stored in computer memory.

Input Arguments

- Address of the burst entity record
- Data from entity record

  BLOCX, BLOCY, BLOCZ = Location: longitude, latitude, and altitude of burst at time of detonation

  BPATH = Address of data record that describes the movement, growth, and other characteristics of a burst

Output

The event for further change (removal) of the burst is caused.

Subroutines and Functions Called

EFFECT = For consideration of the effect of a detonation on game entities

SENSE = For consideration of effect of a detonation on sensors

RFCRD = For filing the burst in the proper command set

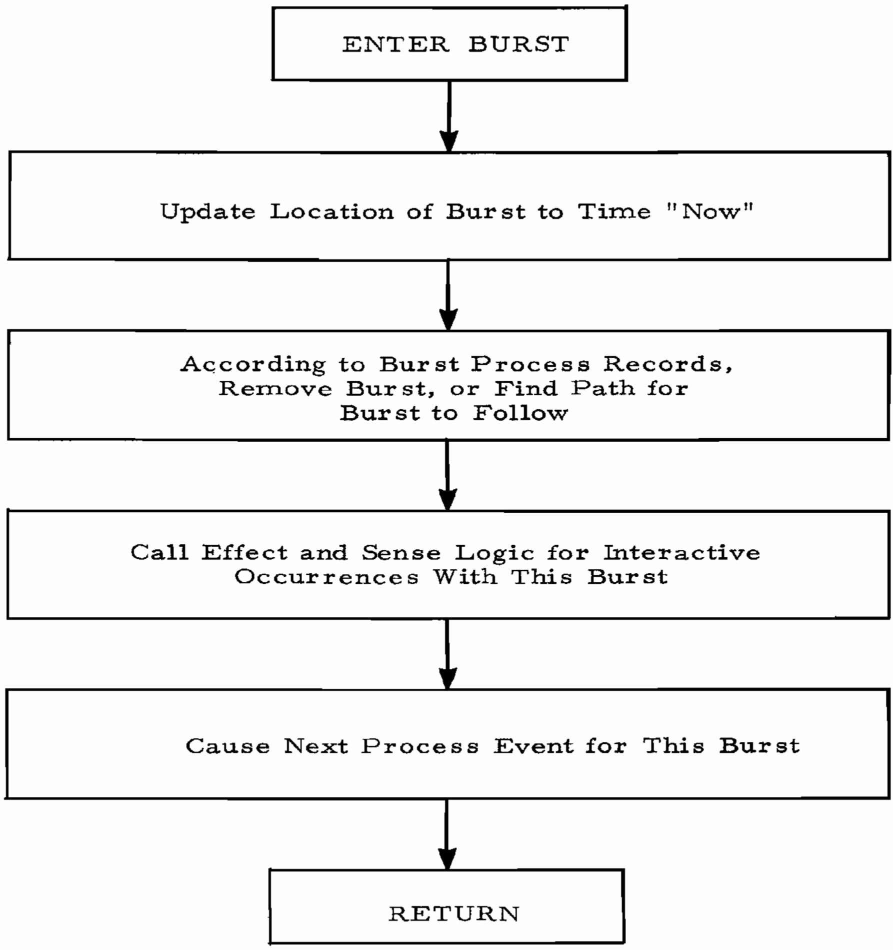
RANDM = For testing if detonation actually occurs, or does not occur due to warhead failure

Methodology

This event occurs at the end of a given process for a particular burst entity. Note that the burst temporary entity was first created at the end of some vehicle process. The burst event also signifies the start of a new process (if any) that a burst would follow as specified in the burst control specification records.

The logic of the burst event is in three sections:

- Section A—Logic applicable to the end of a burst process.
- Section B—Logic involved with determination of the next process a burst is to follow.
- Section C—Logic associated with the start of a new process for a burst initiation, or burst expansion, or removal along with prediction of the effects of the new burst process such as destruction of entities or inhibition of sensing (radar) capabilities.



ENDOGENOUS EVENT — BURST

ENDOGENOUS EVENT BVHCL
Bomber VeHiCLe

Discussion of Usage

This event occurs at the end of a given process for a bomber vehicle. It also signifies the start of a new process (if any) as prescribed by the path process (flight plan) data. The path processes applicable to a bomber vehicle are:

1. (Not used)
2. Proceed enroute
3. Refuel
4. Hold
5. Bomber launch of air-to-surface missile, bomb, or other subsidiary vehicle
6. Turn on electronic countermeasure device[1]
7. Turn off electronic countermeasure device[1]

Input Arguments

Vehicle Event Record

VCLAS = Code for class of entity
VTYPE = Code for type of vehicle
VCOMM = Address of record for command membership
VPATH = Address of current path record
VORIG = Index of originating site

Vehicle Specifications

Probability of successful operation (used at launch initiation)

Path Data (as Specified by VPATH Above)

PPAR1 = Velocity throughout path segment
PPAR2 = Bearing at beginning of path segment

---

[1] Not implemented.

ENDOGENOUS EVENT BVHCL (Continued)

PPAR3 = Index to hold-at-control-line until window occurs

PPAR5 = Code for type of entity to be created (if applicable)

PPAR6 = Code for class of entity to be created (if applicable)

PPAR7 = Index to launch windows

PTYPE = Code for type of path representation (3 = Great Circle, 4 = Rhumb Line)

PPROC = Code for type of process (see above)

PNEXT = Address of next path segment for "this" vehicle

PALTN = Address of alternate path segment for subsidiary vehicle

PLOCX = Location (longitude) of vehicle at end of segment

PLOCY = Location (latitude) of vehicle at end of segment

PLOCZ = Location (altitude) of vehicle at end of segment

PDURA = Time duration of path process

Output

- Location of vehicle adjusted
- New path process segment data found (if any)
- Vehicle removed (if specified)
- Next process event for vehicle caused
- Command records reranked and filed

Subroutines and Functions Called

NPATH = To search out next path segment data and create subsidiaries

REASGN = To trigger MI logic

RFCRD = To rerank and file the command membership records

EFFECT = To predict nuclear effects (lingering) that may occur to the vehicle during next path process

SENSE = To predict possible sensing of vehicle during its next path process

REMOVE = To remove the bomber entity if indicated in the current path segment record

ENDOGENOUS EVENT BVHCL (Continued)

Methodology

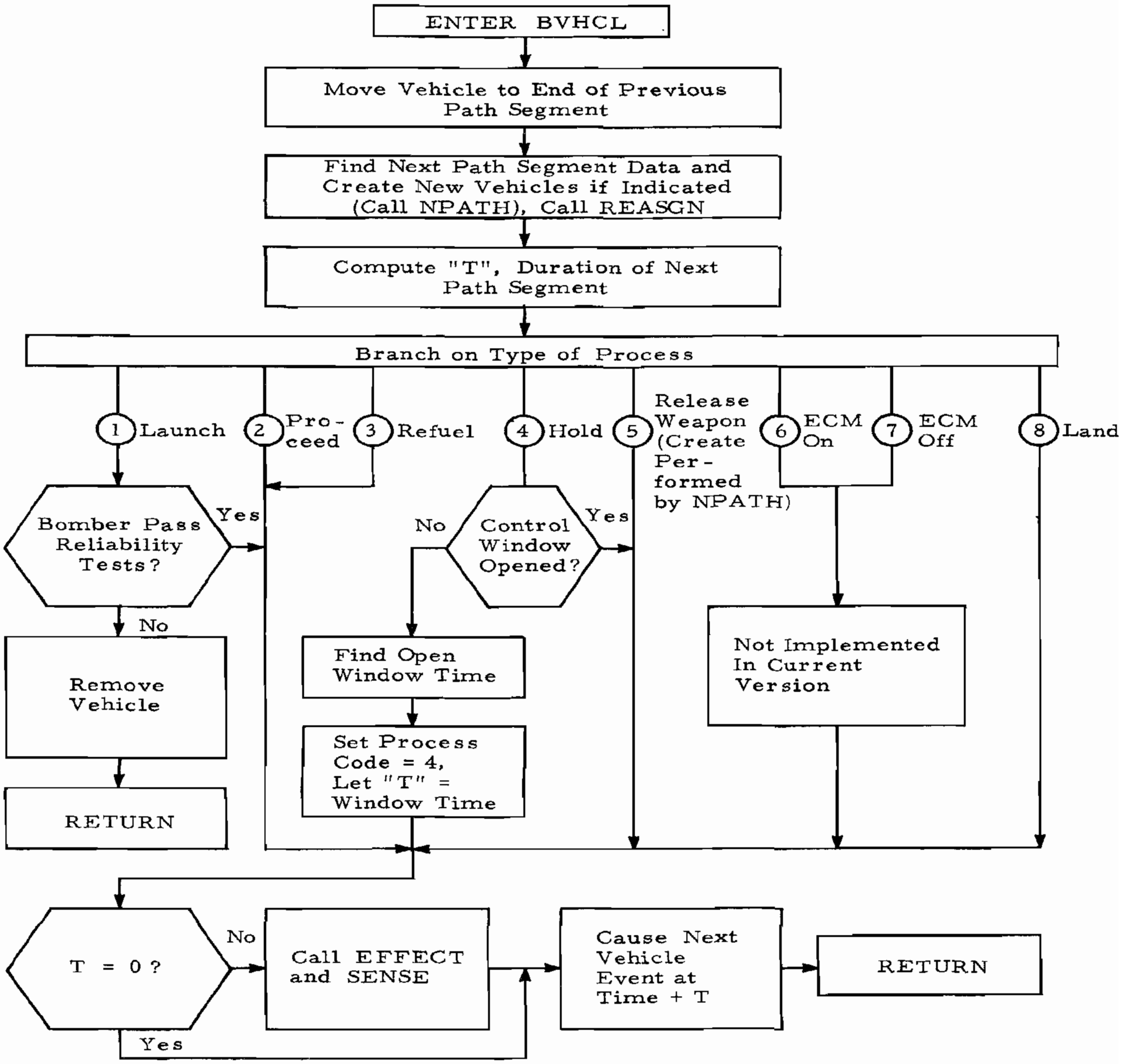
This event is invoked at the end of each path process segment. The logic is in three Sections.

- Section A — Logic applicable to the end of the current path process segment
- Section B — Determination of the next path process segment (if any)
- Section C — Start of the next path process segment

Section A "moves" the bomber to the end point of the current segment (which is the beginning point of the next segment), creates new vehicles if indicated, and calls REASGN to trigger MI defense logic.

Section B finds the data for the new segment for the bomber.

Section C performs the logic associated with the kind of process indicated in the path process data set (processes 1 to 8 above), calls the nuclear effects and sense logic to predict interactions, and causes the bomber vehicle event to occur at the time indicated for the vehicle's next process.



ENDOGENOUS EVENT — BVHCL

EXOGENOUS EVENT CDATA
Command Alternate DATA

Discussion of Usage

Event CDATA allows alternate command structures to be entered by exogenous means. This is performed by reading in alternate command and control site indices for each game site entity.

CDATA can be operated only once during a simulation run.

Input Arguments

For each site, the following information is read:

- Site index
- Number of alternates
- Index of each alternate to the above site

Output

A command record (CRECD) is created which contains the index number of the alternate command site.

The command record is filed in the set of alternate commands for the site.

Subroutines and Functions Called

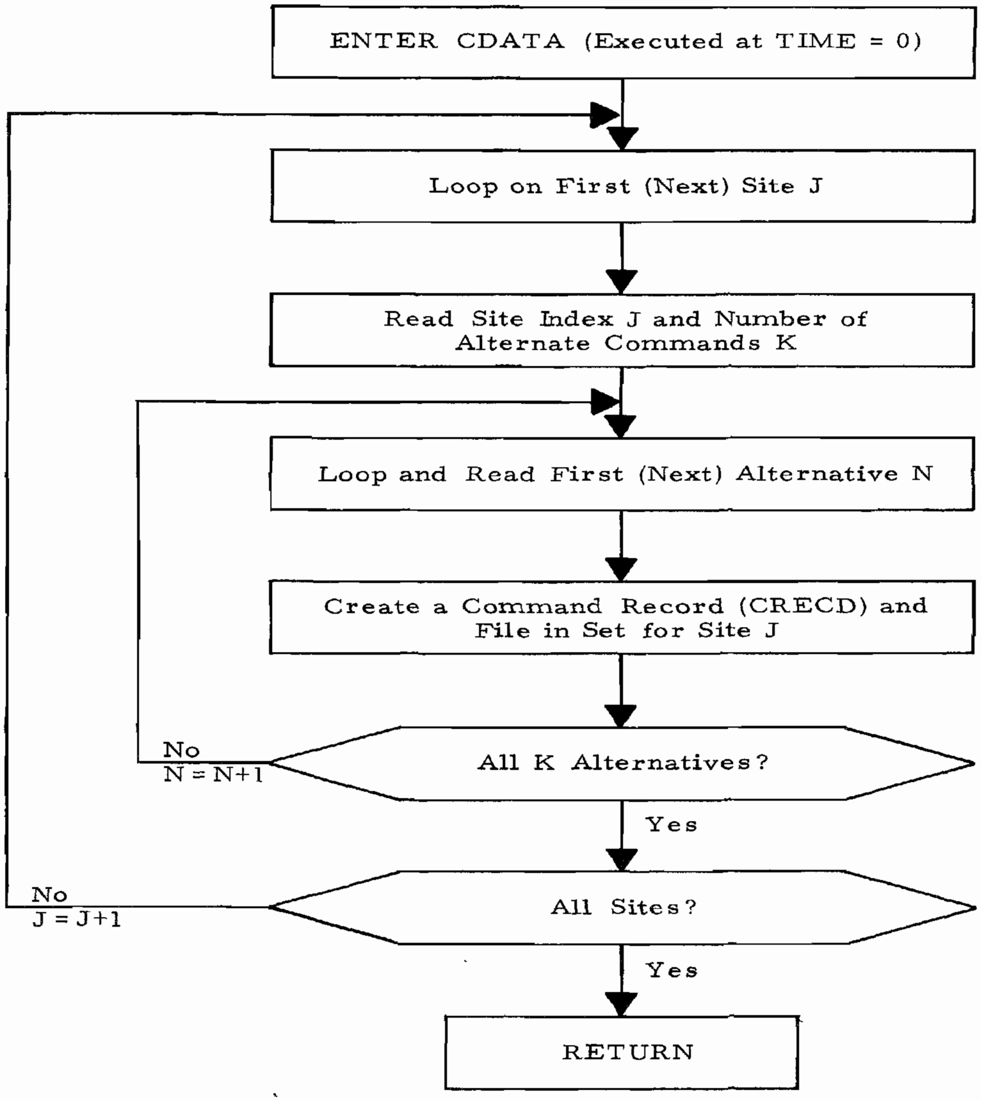
None.

Methodology

The event CDATA reads, for each site, the alternate command and control site indices, and files the alternates through use of a command record (CRECD). This record contains the index of the alternate to be filed in the set of alternatives for the site. The set structure is

COMM (10,J)

where: "10" = The set of alternative commands
J = The index of the site having alternate command sites


ENTER CDATA (Executed at TIME = 0)
Loop on First (Next) Site J
Read Site Index J and Number of Alternate Commands K
Loop and Read First (Next) Alternative N
Create a Command Record (CRECD) and File in Set for Site J
All K Alternatives?
No
N = N+1
Yes
All Sites?
No
J = J+1
Yes
RETURN

EVENT — CDATA

FUNCTION COMUN(II,JJ)
COMmUNications Delay

Discussion of Usage

This function computes the communications delay between origin site "II" and destination site "JJ." The delay is in three parts:

- Internal delay at origin site
- External delay from origin to destination
- Internal delay at destination

Input Arguments

II = Index of origin site
JJ = Index of destination site

Origin Site Data

- The parameter and type of mathematical distribution appropriate to internal communications at origin site
- The parameter and type of mathematical distribution appropriate to external communications delay

Destination Site Data

- The parameter and type of mathematical distribution appropriate to internal communications delay at the destination site

Output

Total message delay

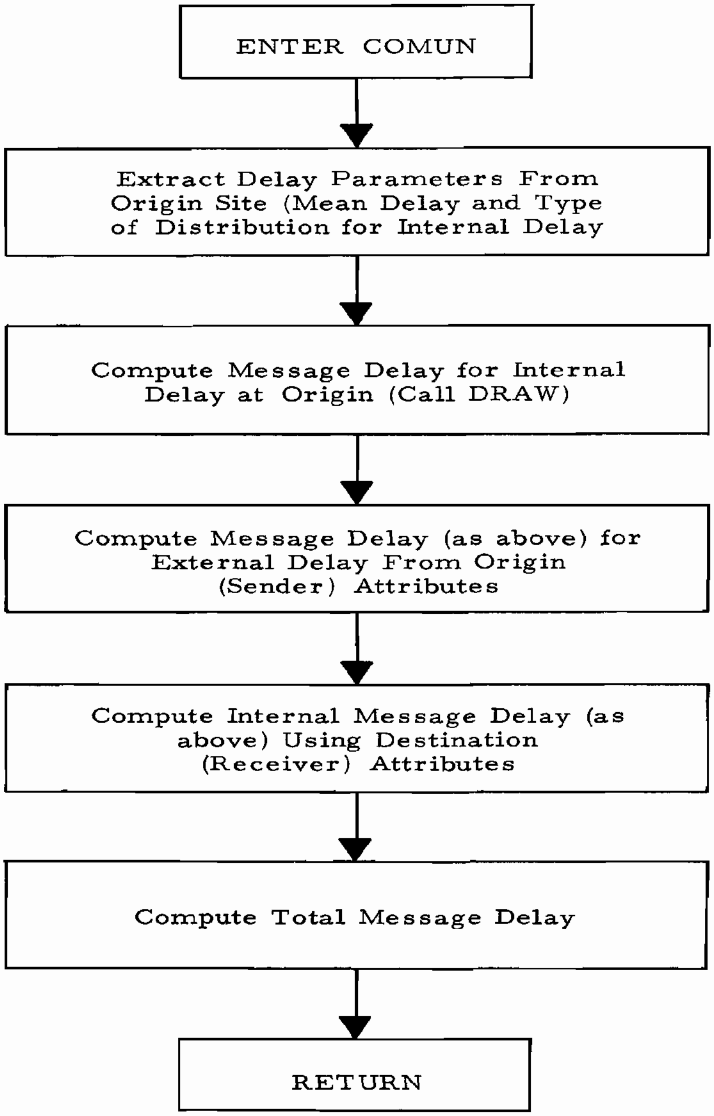
Subroutines and Functions Called

DRAW = Uses a SIMSCRIPT generated pseudo random number X , $0 \leq X \leq 1$, as an argument for computing a probability value from an indicated standard mathematical probability distribution (e.g., normal, poisson, exponential, etc.)

Methodology

Internal delay is computed for origin site, according to the predetermined characteristics of the origin site. External delay is computed (with information also derived from origin site attributes) and finally, the internal delay at destination site is computed. Each delay is independently computed as a random (Monte Carlo) draw from specified delay probability distribution.

The sum of the three delays is then computed and presented for output.



FUNCTION — COMUN

SUBROUTINE DIST(II,X,Y,Z)

DISTance from a Volume Boundary to an Object

Discussion of Usage

This subroutine computes the distance of a point P from a surface of a volume measured along a vector from the center of a local coordinate system.

Input Arguments

II = Index of volume surface description

X = Azimuth of a point P relative to the local center

Y = Elevation angle of a point P relative to the local center

Z = Range of the point relative to the local center

Output

X = Angle out of azimuth if point is out of range of azimuth values for the volume, otherwise, unchanged from input

Y = Angle out of elevation if point is out of elevation angle bounds, otherwise, unchanged from input

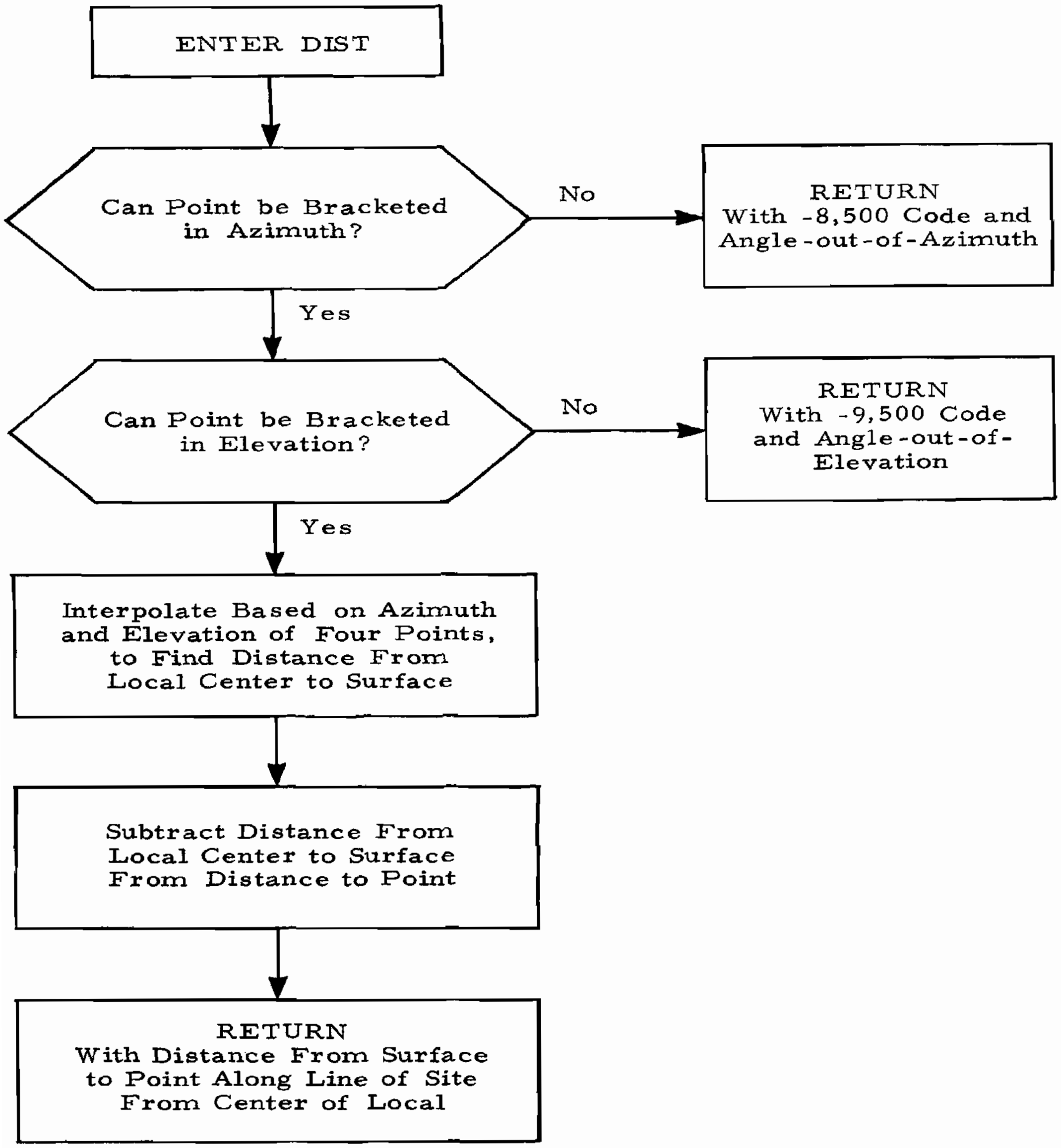
Z = Distance from volume surface to point P if within azimuth and elevation bounds; if out of azimuth, Z = -8,500; if out of elevation (but within azimuth), Z = -9,500

Subroutines and Functions Called

None.

Methodology

The program finds the two volume azimuth slices that bracket the point P . If bracketed in azimuth, the program finds two volume elevation angle values that bracket the point P . If P is bracketed in both azimuth and elevation, the program continues. The ranges associated with the 4 azimuth/elevation angle points of the volume that bracket P are then interpolated (in polar coordinate local geometry) to find the range from the center of coordinates to the volume surface along a line of sight to the point P . This range to the surface of the volume is then subtracted from the input range of the point P . This process yields the distance from the volume surface to the point P .



SUBROUTINE — DIST

ENDOGENOUS EVENT DMSGE
Damage Report MeSsaGE

Discussion of Usage

DMSGE performs the function of allowing printout of data regarding game elements that have suffered nuclear effects, were otherwise damaged, or became inoperable.

Input Arguments

Event Notice DMSGE

MCLAS = 303—Damage message

MTYPE = Type of damage message: nuclear or nonnuclear

MORIG = Message origin

MDEST = Message destination

Parameters of DMSGE for Nuclear Effects

MPAR1 = Address of burst causing nuclear effect consequences

MPAR2 = Type of effect causing the damage

MPAR3 = Amount of nuclear effect previously experienced by entity (multiples of killing threshold up to the time of report)

MPAR4 = Amount of nuclear effect from "this" burst (multiples of killing threshold)

Parameters of DMSGE for Bomber/MI Engagements

MPAR1 = Address of vehicle doing the killing

MPAR2 = Class of the killing vehicle:
105—Bomber
106—MI

Output

Data in local variables for cumulation of damage and output of damage history.

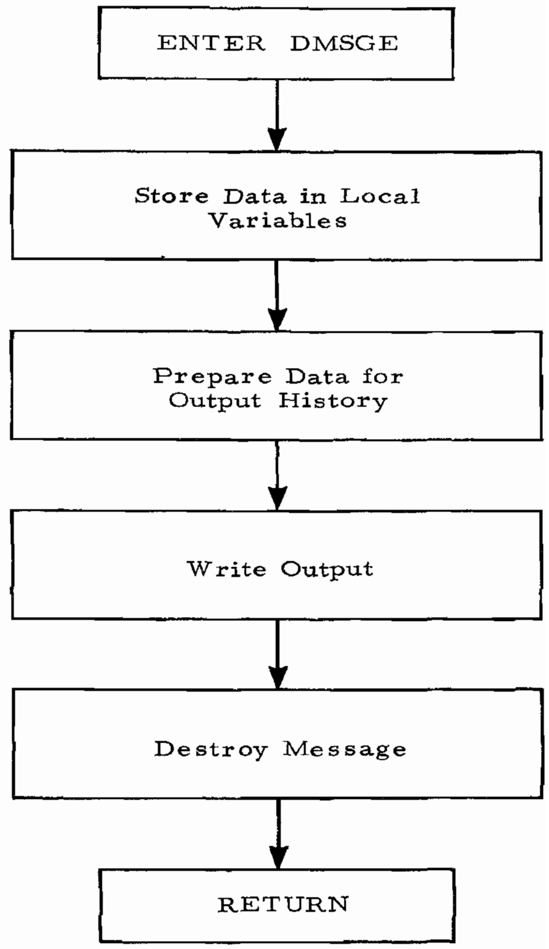
Subroutines and Functions Called

None.

ENDOGENOUS EVENT DMSGE (Continued)

Methodology

Information regarding the damage is stored in local variables, and the damage message (DMSGE) is destroyed. The information regarding the damage report is presented for output history files. In future versions, damage reports may be used to adjust defense algorithms.



ENDOGENOUS EVENT — DMSGE

FUNCTION DRAW(I,A,B,C)
Random DRAW from Specified Distribution

Discussion of Usage

This function provides a random draw from a specified standard probability distribution. A function RANDM is used to provide a random variable (between 0 and 1) from which the corresponding functional value is computed according to a specified standard probability distribution.

Input Arguments

I = Type of distribution
A = First parameter of distribution
B = Second parameter of distribution
C = Third parameter of distribution

Type = I	Name	A	B	C
0	Constant	Value	--	--
1	Normal	Mean	Std. Dev.	--
2	Poisson	Mean	Threshold	--
3	Erlang	A + C = Mean	Shape	Threshold
4	Weibull	Scale	Shape	Threshold
5	Exponential	Mean (from threshold)	Threshold	--
6	Lognormal	Mean	Std. Dev. of Logs	--

Output

DRAW = Value computed according to requisite probability distribution

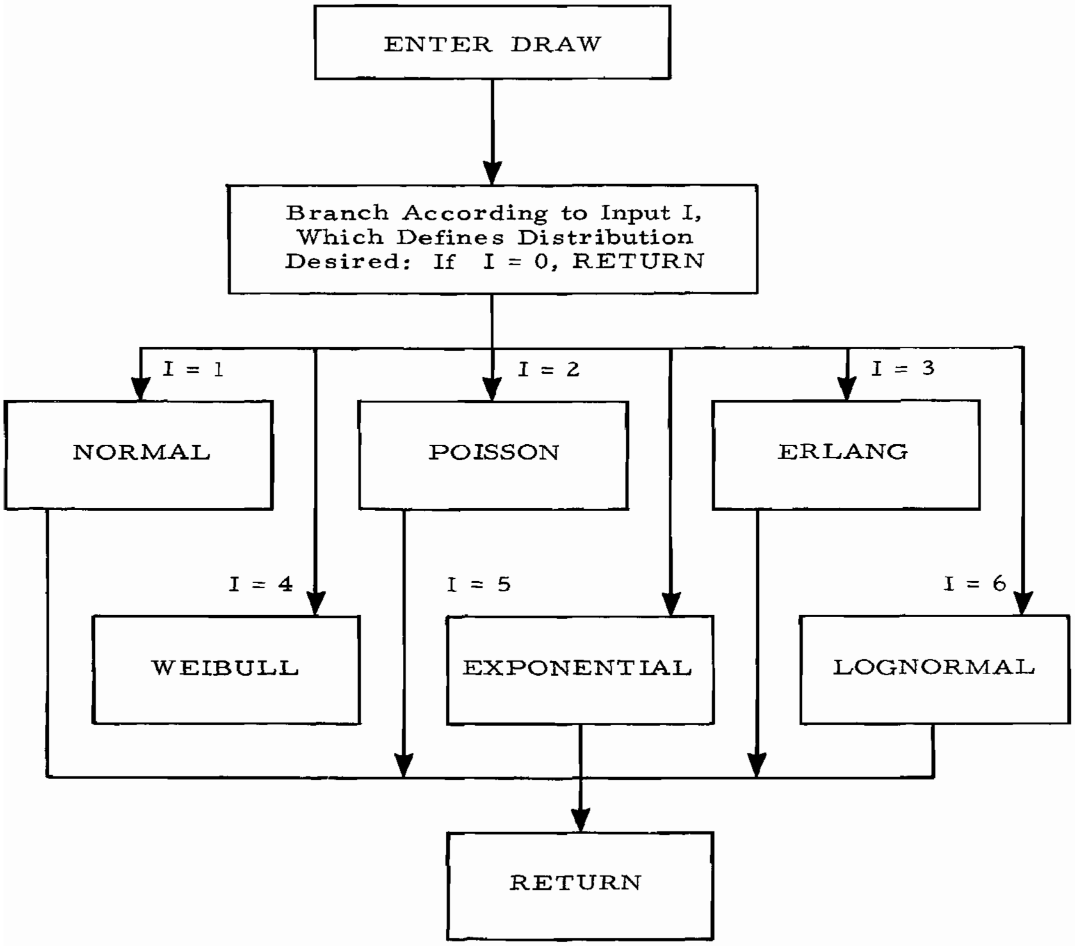
Subroutines and Functions Called

RANDM = Provided by SIMSCRIPT to compute a random variable X, $0 \le X \le 1$

FUNCTION DRAW (Continued)

Methodology

The program branches, according to input "I," to the set of statements that modify a random variable X , $0 \leq X \leq 1$, according to the requisite distribution and the pertinent input parameters of that distribution. The random number seed, used by RANDM, is stored by the SIMSCRIPT system.



FUNCTION — DRAW

SUBROUTINE DUST (II,JJ,A,T)
Vehicle Erosion from DUST Cloud Transit

Discussion of Usage

This subroutine calculates the amount of erosion incurred by a vehicle transiting a dust cloud.

Input Arguments

II = Address of dust cloud (burst) entity
JJ = Address of vehicle entity

Output

A = Amount of dust erosion
T = Time at which erosion occurs
BLARV = Event notice caused at time erosion occurs as follows:
- BLID = Burst address
- TAID = Vehicle address
- TATY = Minus 1 (-1), to indicate dust effects
- PEOP = Amount of erosion accumulated

Subroutines and Functions Called

KINEM = To compute the entrance and exit points of a vehicle penetrating a dust cloud

Methodology

The purpose of this routine is to compute the amount of erosion experienced by a vehicle transiting a dust cloud formed by a nuclear detonation on or near the earth's surface. The routine is called, for a particular vehicle and a particular cloud.

The first process of this routine is to determine if the vehicle path projection and the cloud intersect. The vehicle's movement is defined by its path-process. The cloud movement is assumed to be in the vertical direction over the point of detonation. Required for this is cloud radius as a function of weapon yield and burst altitude and vertical cloud displacement as a function of time after burst. The initial fireball radius, R_o, is given by:

$$R_o = \frac{Y^{1/3}}{55.59} \exp\ (o.06645 Z_o)$$

where Y is the weapon yield in kilotons and Z_o is the altitude of detonation in nautical miles.

The vertical displacement, Z, of the cloud center is given by:

$$Z = \begin{cases} K\ (12\Delta t) & \text{if } \Delta t \leq 1 \text{ min.} \\ K\ (\ 6 + 6\Delta t) & \text{if } 1 < \Delta t \leq 3 \text{ min.} \\ K\ (15 + 3\Delta t) & \text{if } 3 < \Delta t \leq 7 \text{ min.} \\ K\ (36) & \text{if } \Delta t > 7 \text{ min.} \end{cases}$$

where Δt is time elapsed since detonation and, $K = 0.734619 R_o$. The cloud continues to rise, and expand in size until it stabilizes at altitude, seven minutes after detonation. From the kinematics of the vehicle and cloud movements the time, T, at which the vehicle and cloud center are at the same altitude is then determined. If they cross, then it is necessary to determine if intersection occurs. For this, the radius and thickness of the cloud at time, T, [R(T)] are required. The radius, R(T), is given by:

$$R(T) = \begin{cases} R_o + 0.142857\ (f_R - R_o)\ \Delta t' & \text{if } \Delta t' \leq 7 \text{ min.} \\ f_R\ (0.275\ \Delta t - 0.925) & \text{if } \Delta t' > 7 \text{ min.} \end{cases}$$

where R_o is the initial fireball radius and the constant, f_R is given by:

$$f_R = 0.0132472\ (\log_{10} Y)^{2.3}\ Y^{0.4}$$

As before, $\Delta t'$ is the elapsed time from detonation to T. The cloud thickness, T_c, is given by:

$$T_c = \begin{cases} f_H \, [2.016167 \, \Delta t' - 0.25510 \, (\Delta t')^2 + \\ \qquad 0.014154 \, (\Delta t')^3] & \text{if } t' \leq 7 \text{ min.} \\ f_H \, (6.465) & \text{if } \Delta t' > 7 \text{ min.} \end{cases}$$

where the constant, f_H, is given by:

$$f_H = 0.3 \, (\log_{10} Y) + 0.1$$

Since the time required for a vehicle to transit a cloud is very short the cloud size in this interval is assumed to be constant corresponding to the point in time when the vehicle and cloud center are at the same altitude.

(U) The density of dust within the cloud is next determined once it has been established that the vehicle intersects the cloud. This is done by dividing the total mass of the cloud by its volume at time, T. The total mass of dust in the cloud is given by:

$$M = \begin{cases} C \, [0.001 + 0.855 \, \Delta t' + 0.0135 \, (\Delta t')^2] & \text{if } \Delta t \leq 6 \text{ min.} \\ C & \text{if } 6 < t \leq 7 \text{ min.} \\ C \, (1.35 - 0.05 \, \Delta t') & \text{if } 7 < t \leq 17 \text{ min.} \\ C \, [\, 0.5 \, (\dfrac{10}{\Delta t' - 7})^{1.5}] & \text{if } \Delta t > 17 \text{ min.} \end{cases}$$

where $\Delta t'$ is defined above and the constant, C, is given by:

$$C = 9.06618 \times 10^8 \, f_P \, Y$$

where Y is the yield in kilotons and f_P the pickup factor is expressed in units of megatons of surface material per megaton of yield.

(U) The total erosion[1] experienced is then determined according to:

---

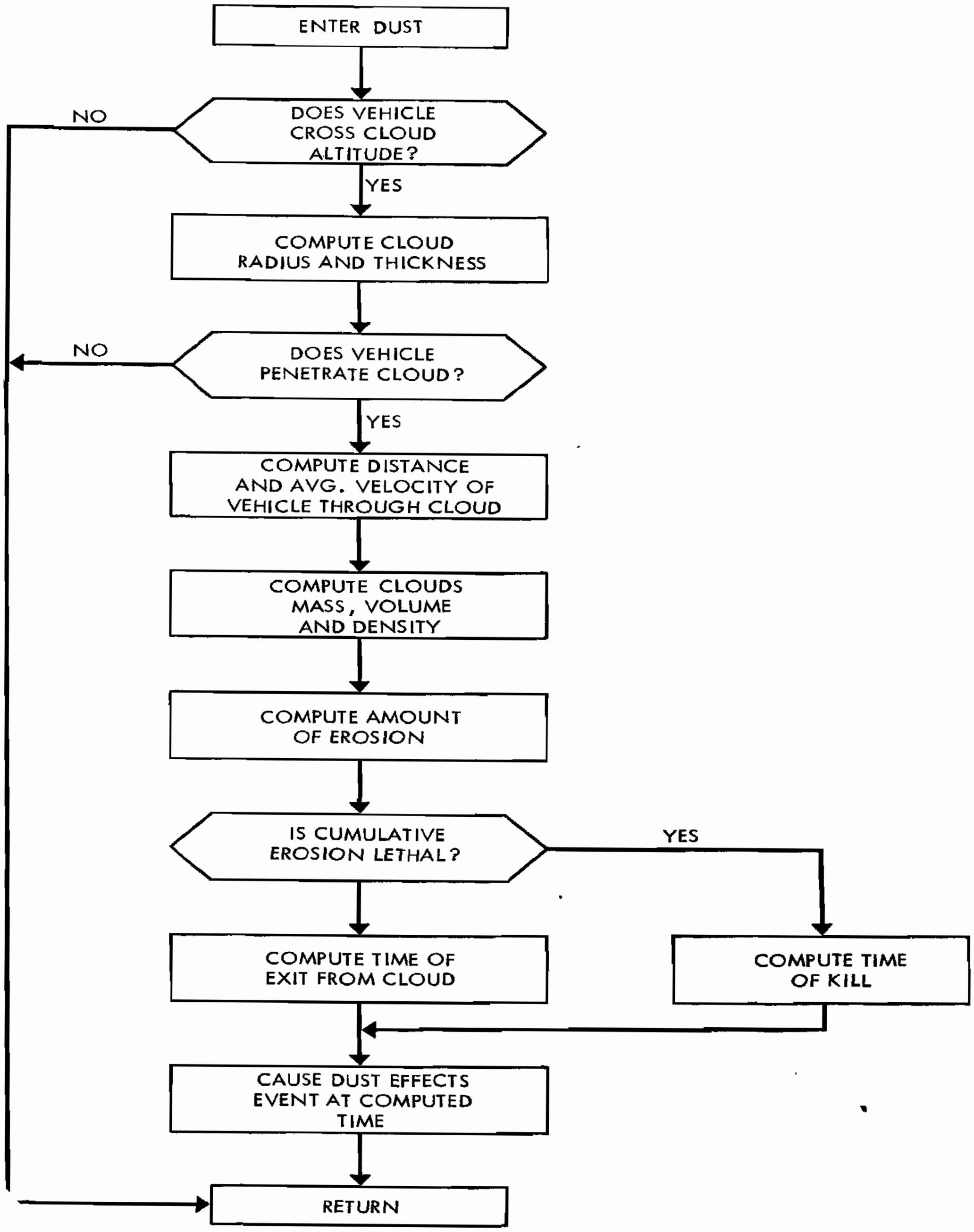
[1] SAMURI Model

$$A = 7.716 \times 10^{-18} \; p \; D \; \bar{v}^2 \; f_E$$

where 7.716×10^{-18} is a units conversion constant and

p = average dust density in cloud
D = distance traveled by the vehicle through the cloud
$\bar{v}$ = average velocity of vehicle through the cloud
f_E = erosion coefficient of the vehicle based on its shape and hardness.

If this erosion, combined with the vehicle's previous erosion history, is not fatal, then a dust event is scheduled at the time of exit from the cloud to accumulate the total erosion. If the combined erosion exceeds a used input specified kill threshold, then the time of kill is computed and a damage event message as well as a dust event is scheduled.


ENTER DUST
DOES VEHICLE CROSS CLOUD ALTITUDE?
NO
YES
COMPUTE CLOUD RADIUS AND THICKNESS
DOES VEHICLE PENETRATE CLOUD?
NO
YES
COMPUTE DISTANCE AND AVG. VELOCITY OF VEHICLE THROUGH CLOUD
COMPUTE CLOUDS MASS, VOLUME AND DENSITY
COMPUTE AMOUNT OF EROSION
IS CUMULATIVE EROSION LETHAL?
YES
COMPUTE TIME OF EXIT FROM CLOUD
COMPUTE TIME OF KILL
CAUSE DUST EFFECTS EVENT AT COMPUTED TIME
RETURN

SUBROUTINE EFFECT (II,JJ)
EFFECTs of Nuclear Detonations on Game Elements

Discussion of Usage

This subroutine contains logic concerning the effects, consequences, and destructive interactions of a burst upon other entities being simulated. First, a series of filters are used to select entities that might be affected by the burst. For candidate entities, functional subroutines are called to measure immediate and lingering effects.[1] These effects are appropriately combined with those from previous burst exposures to determine possible changes in the entity performance characteristics. For lingering effects of blast and dust, arrival events are created to cause changes to entities at the appropriate times in the future.

Subroutine EFFECT is called whenever a vehicle or burst is created or enters a new process. For a vehicle the lingering effects of all previously occurring bursts upon the vehicle are determined. For a burst, the prompt and lingering effects of the burst upon all other simulated entities are measured.

In subroutine EFFECT, the burst types considered are nuclear detonations. The only effect types considered are those caused by gamma, neutron, and X-ray radiations, blast overpressure, and dust cloud erosion.

Input Arguments

II = Identification (address) of blast/dust, vehicle, or burst event

JJ = Code for class of entity to be processed

0 - Blast/dust occurrence (BLARV)
1 - Vehicle (BVHCL, MVHCL, WVHCL, FVHCL)
2 - Burst (BURST)

---

[1] Lingering nuclear effects on radar visibility are not included here, but are included in sensor and observation logic.

SUBROUTINE EFFECT (Continued)

Output

- Update vehicle entities as follows:
  - VNEUT = Neutron flux experience
  - VGAMM = Gamma radiation experience
  - VXRAY = X-ray experience (calories)
  - VPRES = Blast overpressure experience
  - VDUST = Dust erosion encountered
  - VEROS = Time of last accumulation of dust erosion
- For sites the equivalent attributes (except for those concerned with dust erosion) are adjusted
- Messages are created for damage reporting as follows:
  - MORIG = Index of originator of message
  - MDEST = Index of destination of message
  - MCLAS = 303—Report of destruction or damage
  - MTYPE = Type of damage
  - MPAR1 = Address of burst entity
  - MPAR2 = Type of nuclear effect causing damage report to be sent
  - MPAR3 = The amount of cumulative nuclear effect experienced (fractions or multiples of killing threshold)
  - MPAR4 = Amount of nuclear effect experienced by an entity from the particular burst
  - MARRT = Damage report is produced at time of nuclear effect
- The event notice BLARV is scheduled when blast arrival or dust erosion is created by subroutines BLAST and DUST. This notice is removed from memory by EFFECT.

Subroutines and Functions Called

FILT = To filter from consideration entities that would not be affected by a nuclear burst or to filter out bursts that would not affect a moving entity

KINEM = To compute and predict positions of vehicles and bursts

SUBROUTINE EFFECT *(Continued)*

TRANS = To compute relative positional information for bursts and vehicles

PROMPT = To calculate neutron, gamma, and X-ray doses on game elements

BLAST = To compute blast overpressure and cause blast arrival event (BLARV) at time of interaction

DUST = To compute erosive effect of dust on a moving vehicle and to cause a dust occurrence event (also called BLARV) at the time of interaction

Methodology

The EFFECTs program branches depending on the type of call. The program can accept calls from a blast arrival or dust erosion (BLARV) event, a vehicle event, or a detonation (BURST) event.

Call by BURST

If the program is called by a BURST event the following computation and logic is performed:

- Burst data are extracted from the burst entity.
- For all pertinent moving or fixed entities of the proper country, region, command, process, and status, a geometric test on distance is performed. The parameter of the geometric test is the maximum radius of nuclear effects that could result in injury to some entity.
- For moving entities (vehicles), program KINEM computes the position at time of detonation. For fixed sites the position is known from site location attributes.
- Program TRANS is then called to compute the distance from detonation point to the game element. The results of TRANS allow the geometric filter to be imposed.
- The previously experienced nuclear environment of a vehicle or site is then extracted from attributes of the particular entity under consideration and program PROMPT is called.
- Program PROMPT calculates the new environment generated by the particular burst under consideration and places the result in the vehicle or site entity record

SUBROUTINE EFFECT (Continued)

- The previous environment experienced by the vehicle or site is modified according to the "recovery" ability of the entity under consideration. The "recovery" ability is computed according to an exponential decay function with two parameters: (1) time-since-last-effect, and (2) decay of effects (recovery ability) of the particular entity type being considered.
- The modified cumulative dose of previous nuclear experience of the entity is added to the present dose and then compared to a "kill threshold" appropriate to the entity type.
- A damage message (DMSGE) is then created. The damage message may (or may not depending on game option switch settings) cause the removal of a game entity if damage experience exceeds a kill threshold.

The EFFECT program called by BURST must also handle lingering effects of nuclear detonations. Two types of lingering effects are considered:

- BLAST overpressure (subroutine BLAST)
- DUST erosion to moving entities (subroutine DUST)

These programs are called and may schedule a blast arrival event (BLARV) for sites and vehicles, or a dust arrival event (also called BLARV) for vehicles moving through dust clouds.

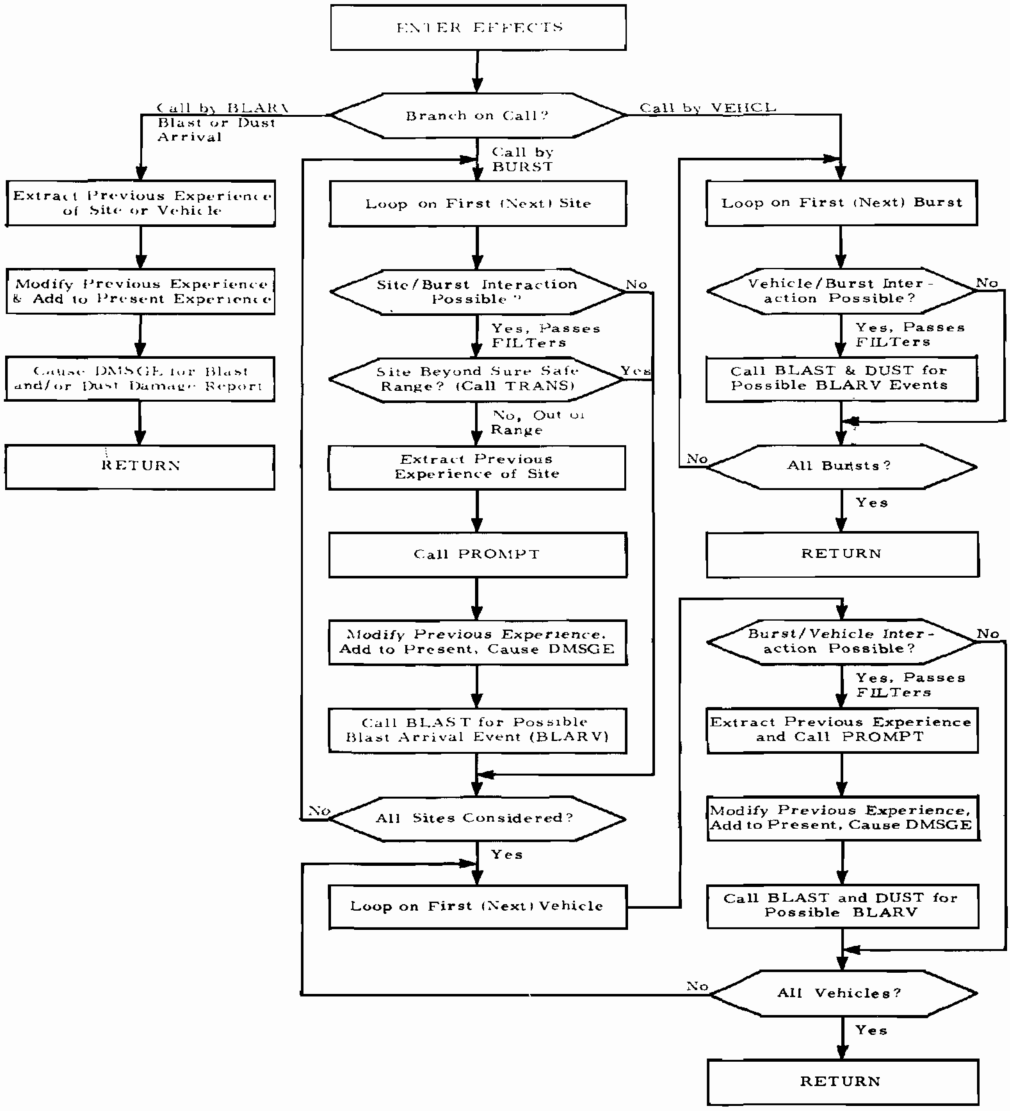
Call by a Vehicle Event

Lingering effects must be considered for vehicles that enter new processes or were not created at the time of a nuclear detonation. (The search described above for "all pertinent entities" would not uncover vehicles that were not yet created or were in a process that would not be considered.) For this reason, the effects routine will accept calls from vehicle events.

If the EFFECTs routine is called by a vehicle event, a search for all "pertinent" burst entities (dust clouds or blast fronts) is performed, and BLARV events may be scheduled by the BLAST and DUST routines.

Call by BLARV (Blast Front Arrival at an Entity or Vehicle Arrival at a Dust Cloud)

If the EFFECTs program is called by a blast arrival or dust event (BLARV), the previously discussed damage computations are performed and a damage message is sent.



SUBROUTINE — EFFECT

SUBROUTINE ERROR(NROUT, IERR)
ERROR Routine

Discussion of Usage

The error routine is used to print out messages regarding error conditions in simulation routines, and/or to produce information for tracking and debugging purposes.

Input Arguments

NROUT = Number of routine (see listing of program for routine numbers)

IERR = If IERR = 0 , trace headers are printed, otherwise, trace headers and error messages are printed (the particular message printed is equivalent to the number IERR).

The tape number on which to write the error messages is read in by array "TYPE" shown in the initial conditions.

Output

- Error messages[1]
- Trace headers

Subroutines and Functions Called

None.

Methodology

The program branches on the type of error condition, then branches to write statements associated with a particular routine number. According to the setting of IERR, the program prints a particular message associated with the kind of error.

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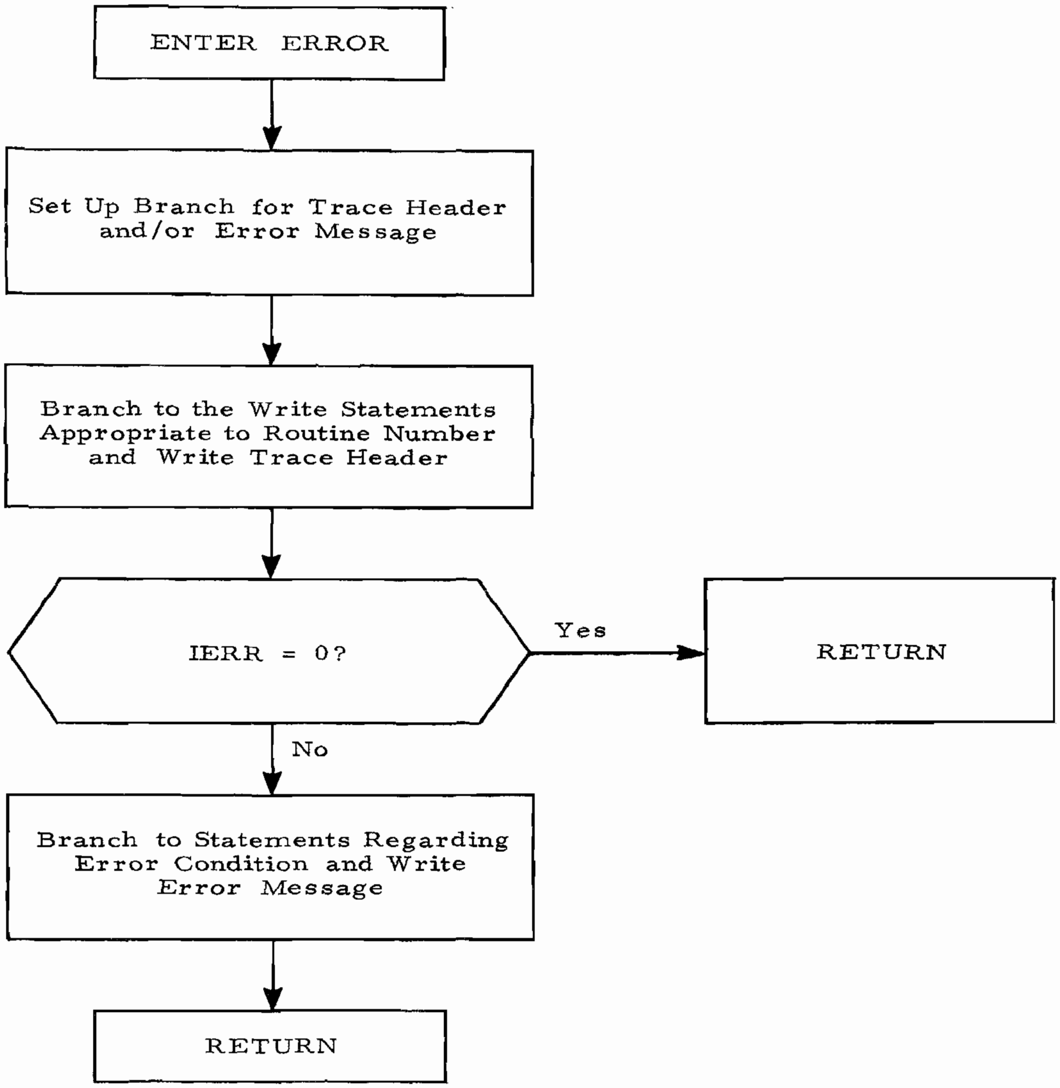
[1] See Vol. III, Operators Manual, for more complete discussion of error conditions.



SUBROUTINE — ERROR

SUBROUTINE FDEFND(LL,MM,VV,IS)
Fighter (Manned Interceptor) DEFeND

Discussion of Usage

This subroutine allocates manned interceptors to preestablished loiter (strategic orbit points) locations when enemy bombers are seen by early warning sensors. When tracks of bombers are established, fighters are vectored to a point of intercept. The subroutine is called when an enemy bomber is first seen, tracked, or changes its path segment. The change of path segment of the bomber implies a possible change of bomber course.

Input Arguments

LL = Index of a primary decisionmaking command site
MM = Index of a record about the observed bomber (OBSER)
VV = Interpolation value for computing fighter positions
IS = Type of sensing
  2 — First acquisition of a bomber by a sensor
  4 — Bomber changes track

Data From Observation (Bomber) Record

OIDEN = Address of bomber vehicle record

Data From Command Sensor Message

$$\left.\begin{array}{l}\text{MLOCX}\\ \text{MLOCY}\\ \text{MLOCZ}\end{array}\right\} =$$ Location: longitude, latitude, and altitude of bomber according to command intelligence

Data From Bomber Vehicle Record

VPATH = Address of path record that bomber is flying
VTYPE = Type of bomber

Data From Bomber Path Record

$$\left.\begin{array}{l}\text{PLOCX}\\ \text{PLOCY}\\ \text{PLOCZ}\end{array}\right\} =$$ Longitude, latitude, altitude of bomber at end of path segment

PPAR1 = Velocity of bomber

SUBROUTINE FDEFND (Continued)

Output

- Note of assignment of fighters to bomber created with the following entries:
  NTYPE = 2—Manned interceptor type of assignment
  NREFR = Address of fighter vehicle path assignment to the bomber
- Path data is created for fighters to:
  - Fly to engagement
  - Engage target
  - Fly to home base
- "Old" path data is destroyed
- Next fighter vehicle event is caused to occur at the computed time

Subroutines and Functions Called

KINEM = To compute locations of MI's and bombers
TRANS = To compute relative azimuth, elevation, and range of bomber to MI
AZ = To compute bearing of bomber relative to MI
TREE = To find alternate airfield within a command site

Methodology

The FDEFND subroutine has two modes of operation:

- First Mode—fighters are dispatched from air bases to strategic defense orbit points (loiter points) on early warning from sensors
- Second Mode—assignment of fighters to particular bomber tracks when tracking information is available, or when a bomber changes course

In the early warning mode, candidate loiter points are selected from the air bases under the appropriate command, and rank-ordered according to the angular deviation between the loiter point, the base, and the bomber.

SUBROUTINE FDEFND (Continued)

Command record(s) are created and destroyed as follows for candidate flights to loiter points:

- CMEMB = Airfield index
- CRANK = Angular deviation from perpendicular to the line of defense (the line of defense is defined by the positions of loiter points)
- CPATH = Address path record that leads to a loiter point

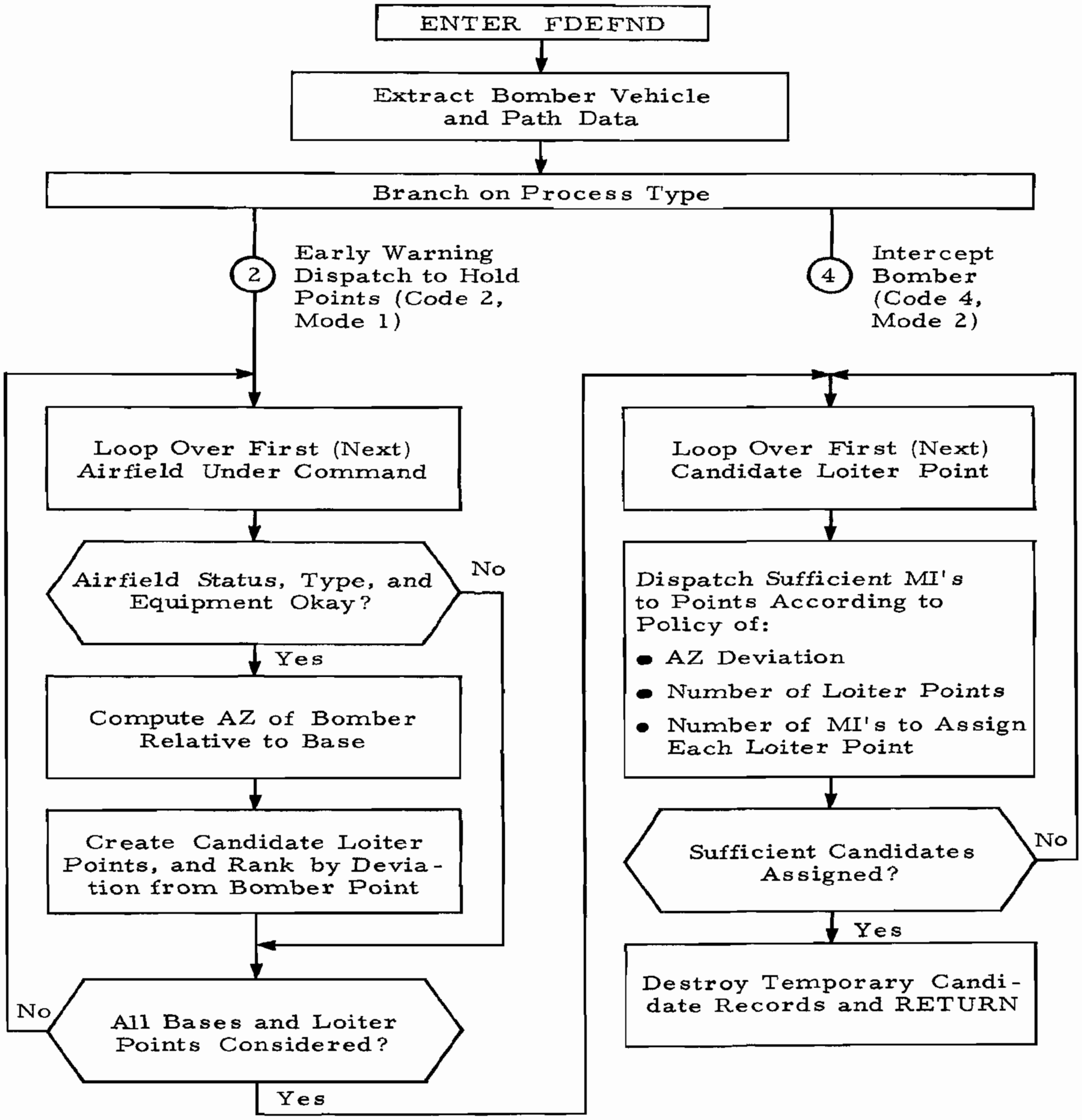
Fighters are then dispatched to loiter points based on policy of:

- Deviation angle (loiter points directly in line with airfield and bomber are given highest priority)
- Number of loiter points required for a single bomber
- Number of MI's to assign to a loiter point

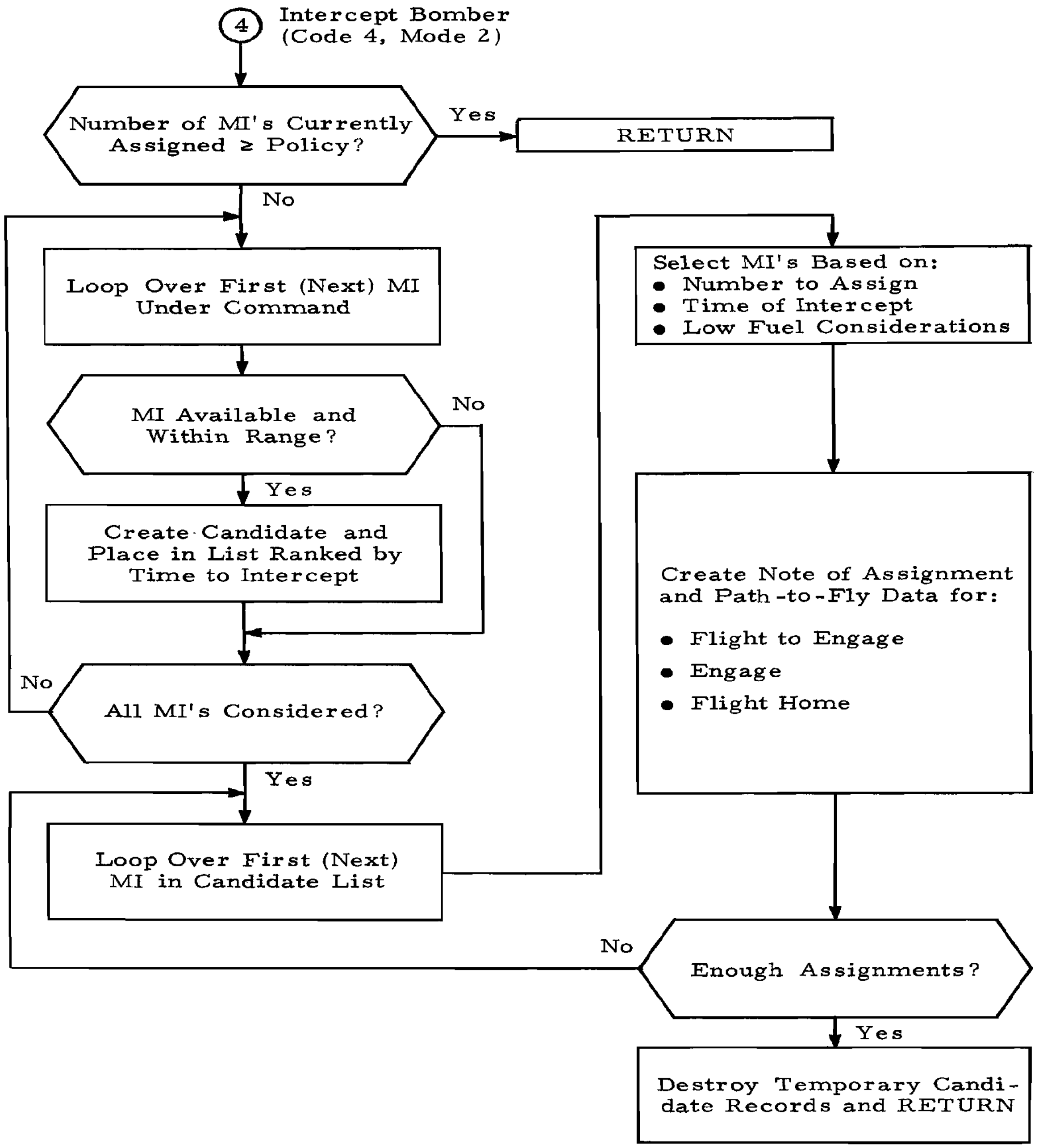
In the second mode, available MI candidates are ranked on time-to-intercept. A sufficient number of MI's (that also meet fuel requirements) are assigned from the top of the rank-ordered list to engage the bomber.

Command records for flight to intercept candidates are created and destroyed as follows:

- CMEMB = Vehicle address
- CRANK = Time to intercept
- CPAR1 = Longitude of intercept point
- CPAR2 = Latitude of intercept point
- CPAR3 = Altitude of intercept point
- CPAR4 = Fuel capacity of interceptor



SUBROUTINE — FDEFND



SUBROUTINE — FDEFND (Continued)

ENDOGENOUS EVENT FVHCL

Fighter (Manned Interceptor) VeHiCLe Process Logic

Discussion of Usage

The logic of FVHCL is invoked at the end of each path process segment for manned interceptor (MI) vehicles. This event simulates the action of MI's when they reach the point of last assignment.

The processes for fighter vehicles are enumerated as:

2 — End of flight to loiter point
3 — End of loiter (hold)
4 — End of flight to engagement
5 — Engagement of target bomber
6 — Flight to base from loiter point
7 — End of maintenance
8 — Flight to base (from other than loiter point)
9 — End of reloiter or flight to reloiter

Input Arguments

Vehicle Record for MI's

VPATH = Address of current path segment
VORIG = Index to base of fighter origin
VTYPE = Type of MI
VCOMM = Command set to which MI belongs
VGENE = Address of bomber to which fighter is assigned to engage

$$\left.\begin{matrix}\text{VLOCX}\\\text{VLOCY}\\\text{VLOCZ}\end{matrix}\right\} = \text{Location of vehicle: longitude, latitude, and altitude}$$

VPASS = Number of remaining armament passes for MI against bomber

Data from Associated Path Record (Identified by VPATH Above)

PNEXT = Address of next path segment
PPROC = MI process code (see 2 to 9 above)

ENDOGENOUS EVENT FVHCL (Continued)

PLOCX, PLOCY, PLOCZ = Location of vehicle at end of process: longitude, latitude, and altitude

PDURA = Time duration for path segment

PPAR1 = Velocity in segment (great circle)

PPAR7 = Address of path data for loiter point

PPAR8 = Fuel remaining at end of path segment

Vehicle Specifications Data for MI Type Vehicle

- Fuel consumption table number
- Average velocity during engagement or while flying to engagement
- Average velocity for normal cruise
- Average time for reengagement of target
- Number of armament passes against a bomber
- Damage message control code

Output

- New path segment for the MI as appropriate
- Damage message (or nonnuclear kill type) created and caused for bomber or MI, or both, depending on outcome of engagement
- Fighter vehicle event recaused as appropriate
- Entities removed from game if indicated

Subroutines and Functions Called

REMOVE = To remove game entities and associated data

EFFECT = To predict lingering nuclear effect interactions with fighter (blast only); prompt effects are computed through with BURST logic

SENSE = To predict sensor/fighter interactions (if appropriate)

KINEM = To compute current location

TRANS = To compute azimuth, elevation, and range parameters

NNEFF = To compute outcome of bomber/interceptor engagement

FAR = To compute distance

Methodology

First, the fighter vehicle's next path process data are extracted. Based on the process code from the new path (codes 2 to 9 as described above), the program branches to the appropriate logic. The path segment data used here are dynamically generated by FDEFND, IMSGE, and REASGN. The logic of each type of process is now described.

Process Code 1

Not used in this program.

Process Code 2—End of Flight to Loiter Point

The location of the vehicle is changed to the end of previous path segment, the vehicle is placed on its next path segment, and the next vehicle event is caused. EFFECT and SENSE are called to predict nuclear effects (lingering) and sensor interactions.

Process Code 3—End of Loiter (Hold)

The logic is the same as process code 2, above.

Process Code 4—End of Flight to Engagement

The logic is the same as process code 2.

Process Code 5—Engagement

Current location of the fighter is extracted from its path record and the bombers location is computed along with the fuel required to reengage.

The outcome of the engagement is computed according to the probabilities of bomber killing fighter and fighter killing bomber. The program then branches according to the following cases:

1—Both survive
2—Bomber killed
3—MI (fighter) killed
4—Both killed

Case 1, Both Survive

The number of armament passes of both fighter and bomber are decremented. Program checks are made for the following:

- Next path segment planned for fighter
- Home base operational status
- Alternate base existence and status
- Fuel and armament remaining

Policy parameters are used to determine if fighter should reengage when fuel is not sufficient to return home or recover at other bases.

Case 2, Bomber Killed

The armament passes are decremented for the fighter, and a bomber damage message (DMSGE) is sent. Notes of MI's assignments to the bomber are destroyed, and other MI's are reassigned. Extraneous path records are destroyed and a new path to loiter point, home base, alternate base, or flight to exhaustion is created, as appropriate, and a new vehicle event for the MI is caused.

Case 3, MI (Fighter) Killed

Notes about the MI assignment to bomber are removed, a MI damage message is sent, and the number of armament passes of the bomber are decremented by one.

Case 4, Both Killed

The logic of Case 3 is used along with the logic of Case 2.

Process Code 6—Fly to Base from Loiter (Strategic Orbit Point)

If the assigned base is dead, the MI and its associated data are removed from game. If the base is alive, the vehicle is positioned at the base, and given a path segment with process code 7.

ENDOGENOUS EVENT FVHCL (Continued)

Process Code 7—End of Maintenance and Service

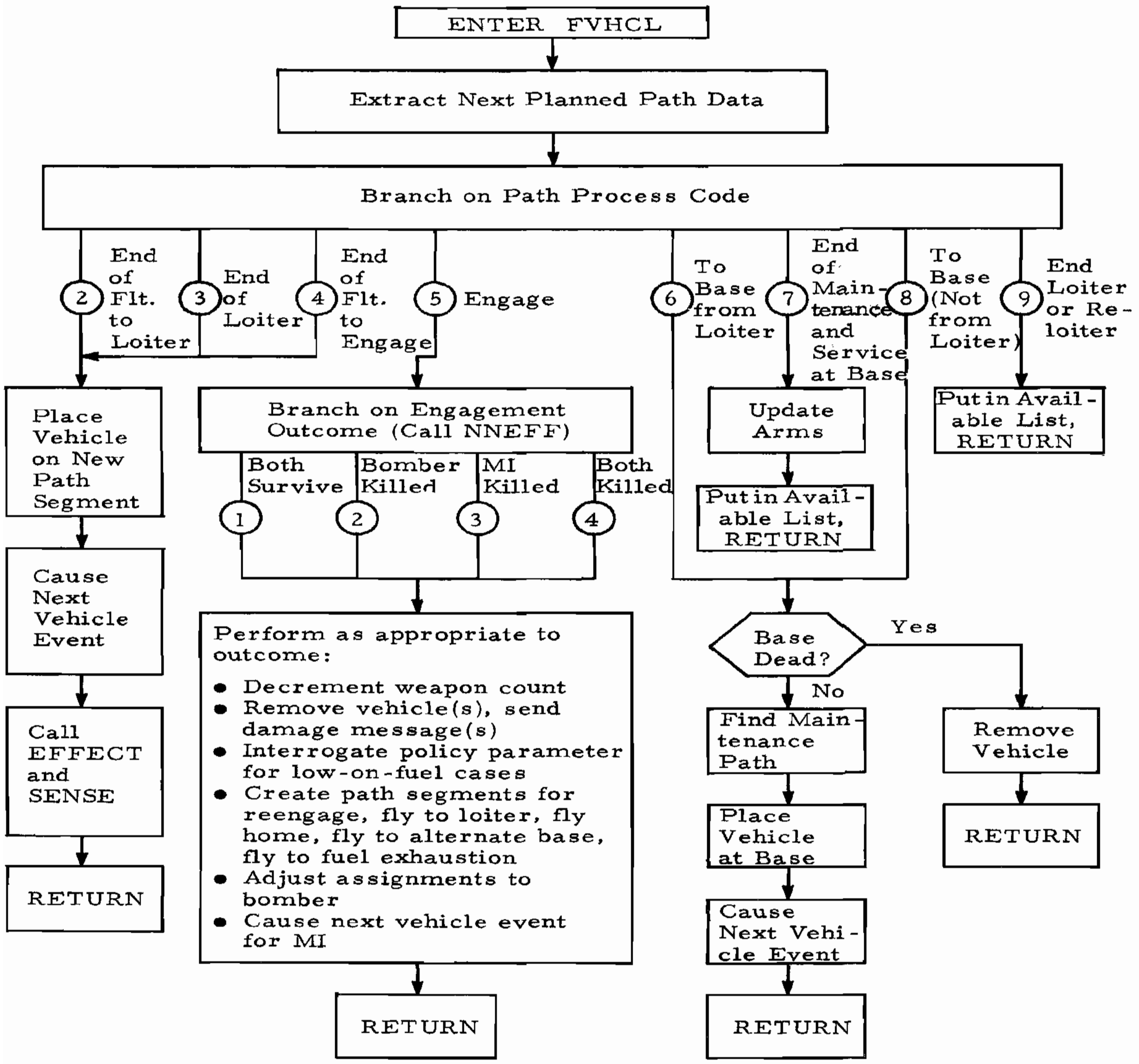
The vehicle is rearmed and made available for assignment.

Process Code 8—Fly to Base from Other than Loiter Point

If the base is dead, the MI and its associated data are removed from the game. If the base is not dead, a maintenance and service path is found, and the vehicle is positioned at the base and given a path segment with process code 7.

Process Code 9—End of Reloiter (or End of Flight to Reloiter)

Vehicle is positioned at the loiter point for start-of-next-path segment, and made available for assignment.



ENDOGENOUS EVENT — FVHCL

ENDOGENOUS EVENT IMSGE
Initialization MeSsaGE to Preposition Fighters and Bombers

Discussion of Usage

The event IMSGE, creates fighters and bombers at designated sites. The endogenous event IMSGE is initially triggered by exogenous event "ORDER."

Input Arguments

Event Notice IMSGE

MPAR1 = Index of site to position fighters or bombers
MPAR3 = Number of fighters or bombers to be positioned
MCLAS = 304—Messages, initialization of vehicle(s)

Output

Vehicle Created at Site

VCLAS = Class of vehicle (commensurate with site class)
VTYPE = Type of vehicle (commensurate with site)
VPATH = Address of path assigned to vehicle
VORIG = Site of vehicle origin
VLOCX = Longitude of vehicle/site
VLOCY = Latitude of vehicle/site
VLOCZ = Altitude of vehicle/site
VCOMM = Address of record that denotes command set membership for the vehicle/site
VPASS = Number of armament passes for an engagement

- Number of fighters or bombers at field is adjusted according to the specified number of vehicles initiated.

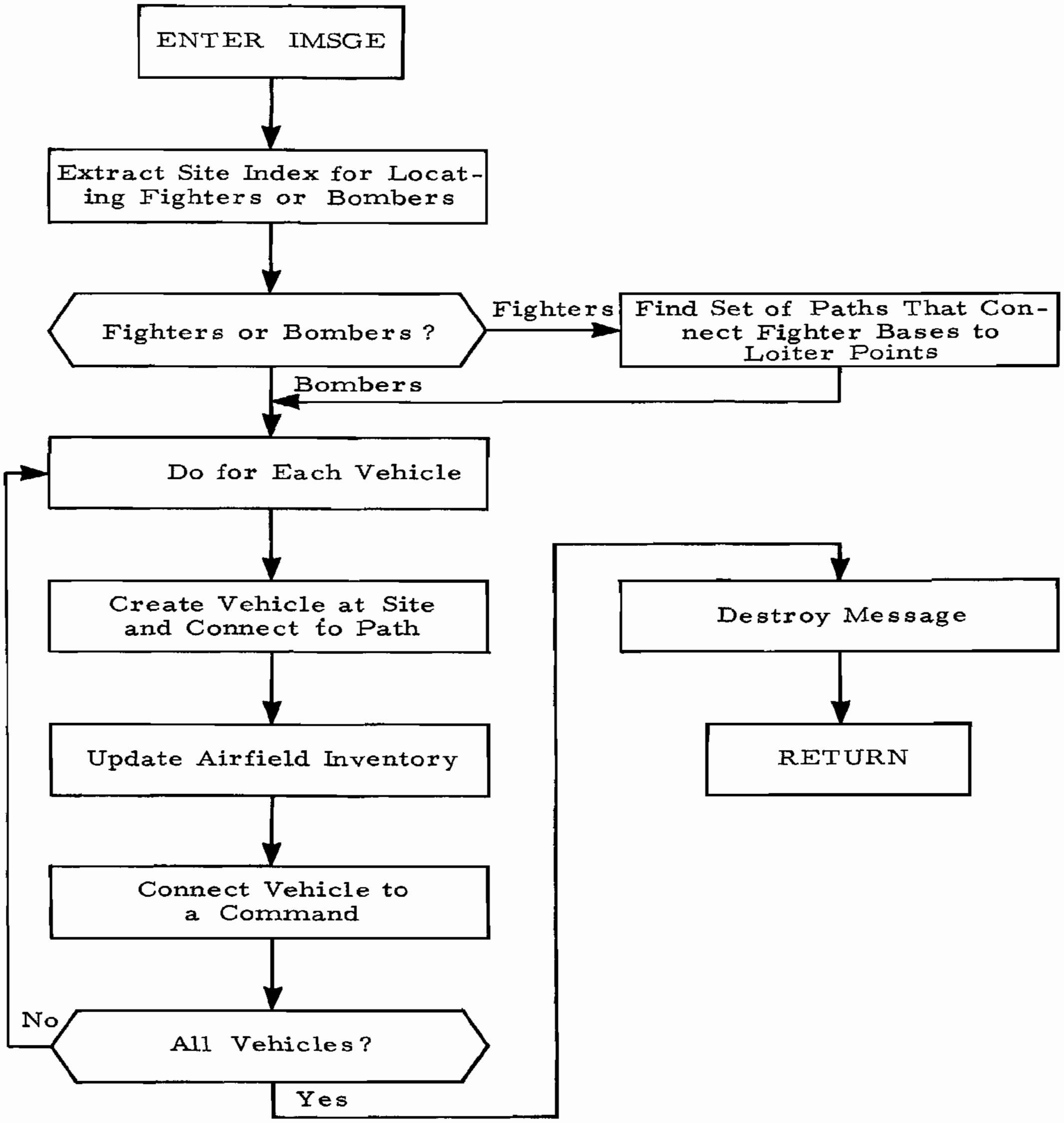
Subroutines and Functions Called

None.

ENDOGENOUS EVENT IMSGE (Continued)

Methodology

IMSGE extracts the index of the site at which to locate the specified number of fighters or bombers. A vehicle record is then created for each fighter or bomber. The site attribute for number of fighters or bombers is adjusted as appropriate, and a command record to identify the vehicles with a command is created. The program also cross indexes fighters to the set of possible paths that connect fighter fields to strategic orbiting points.



ENDOGENOUS EVENT — IMSGE

SUBROUTINE KINEM(II, JJ, V, T, X, Y, Z)
KINEMatics of Moving Objects

Discussion of Usage

This subroutine determines the position in earth coordinates of an object at any instant of time or fraction of path segment. Several types of movements are allowed. These are:

- Straight line (with or without acceleration)
- Orbital (free fall trajectory based on Keplers' Laws)
- Great circle
- Rhumb line
- Vertical movement of fireball if within the earth's atmosphere; translation according to earth's rotation if outside the atmosphere

The stringing together of path segments allows a total path to be built of many combinations of individual segments (see PDATA). The program KINEM interpolates between end points of any one segment. The earth coordinate system used by KINEM consist of latitude 0 to π radians measured from the north pole, longitude from 0 to 2π measured positive east from the prime meridian, and altitude measured in nautical miles above mean sea level. Time is in decimal hours.

Input Arguments

II = Address of event notice for a vehicle or burst object

JJ = Class of entity

V = Fraction of path segment (to be used when interpolating to find position of an object in terms of fraction of path segment)

T = Time (used when interpolating on time to find the position of an object); If T = 0 , interpolation will be based on fraction of path "V"

Data From Vehicle Record

VSTOP = Stop time of current segment

VPATH = Address of current path segment record

VLOCX = Location (longitude) of vehicle at start of current segment

SUBROUTINE KINEM (Continued)

VLOCY = Location (latitude) of vehicle at start of current segment
VLOCZ = Location (altitude) of vehicle at start of current segment

Data From Burst Record

BSTOP = Stop time of current segment
BSTAR = Time of detonation
BPATH = Address of current path segment record
BLOCX = Location (longitude) of burst center at start of process
BLOCY = Location (latitude) of burst center at start of process
BLOCZ = Location (altitude) of burst center at start of process

Path Segment Data From Path Record (For Vehicles or Bursts)

PTYPE = Code for type of path representation
PLOCX = Location (longitude) of vehicle or burst at end of segment
PLOCY = Location (latitude) of vehicle or burst at end of segment
PLOCZ = Location (altitude) of vehicle or burst at end of segment
PDURA = Time duration of current path segment (hours)

Path Segment Data From Path Record for Path Types

Path Type 1, Linear

PPAR1 = Velocity at start of path segment (n.mi./hour)
PPAR2 = Acceleration throughout path segment (n.mi./hour^2)

Path Type 2, Orbital

PPAR1 = Eccentricity of ellipse
PPAR2 = Semilatus rectum of ellipse
PPAR3 = Longitude of the line of nodes
PPAR4 = Declination of the trajectory plane
PPAR5 = Range angle of the line of nodes (measured from the apogee)
PPAR6 = Time at start of trajectory
PPAR7 = Range angle at start of path segment
PPAR8 = Range angle at end of path segment

SUBROUTINE KINEM (Continued)

Path Type 3, Great Circle

PPAR1 = Velocity throughout path segment (n.mi./hour)

Path Type 4, Rhumb Line

PPAR1 = Velocity throughout path segment (n.mi./hour)

Path Type 5, Fireball Rise

PPAR1 = Initial fireball radius (Km)

Output

V = Fraction of path segment

T = Time that object will be at the calculated point

X = Longitude of vehicle at time T (0 to 2π radians measured positive east of prime meridian)

Y = Latitude of vehicle (0 to π measured from north pole)

Z = Altitude, nautical miles above mean sea level

Subroutines and Functions Called

AZ = Compute azimuth (bearing relative to north)

Methodology

The computer address of a path segment record is obtained from the vehicle or burst record. The path segment record contains the code for the type of path and the parameters that define motion along the path. If the object is at the beginning or end of a segment, the program returns with the appropriate information extracted directly from the path segment data. In the nontrivial cases program KINEM branches according to the path type code:

1 = Linear

2 = Orbital

3 = Great circle

4 = Rhumb line

5 = "Fireball" movement

Linear Path

The program branches according to the type of interpolation: time, or fraction of segment. If interpolation on time, (i.e., $T \neq 0$) the fraction of time from segment beginning is computed, and adjustment is made for acceleration. The fraction of segment length is then computed.

If interpolation on fraction of length of segment is desired (i.e., $T = 0$ on input), the time required to arrive at the point is computed according to a quadratic relationship.

Program KINEM then computes the position of the vehicle in earth coordinates, and makes proper adjustments for crossing north or south poles, and/or prime meridian, and if necessary converts the position to be within 0 to π latitude, and 0 to 2π longitude positive east of prime meridian.

Elliptical (Inertial Space—Orbital) Path Segment

Option 2, elliptical path segment, first performs computations to generate basic orbital parameters: semimajor axis, inverse of mean angular motion, and the eccentric anomaly at start of trajectory. The program then branches based on the type of interpolation desired: time, or fraction of segment. If interpolation on time-in-segment is desired, the following is performed:

- Compute time of apogee and mean anomaly
- Eccentric anomaly at the specified time is computed accordint to an iterative procedure that ensures fast convergence
- Altitude is then computed along with range angle for the vehicle at the specified time
- The final computations include latitude and longitude with adjustments for earth's rotational effects and coordinate limitations

If interpolation is made on fraction of range angle, the following is performed:

SUBROUTINE KINEM (Continued)

- Range angle is computed directly from input data stored with the path segment record
- Altitude is derived from elliptical relationships
- Time to reach the point of specified range angle is computed
- The program then computes latitude and longitude and adjusts for earth's rotational effects and coordinate limits

Great Circle Path Segment

The first computation under the great circle segment type includes generation of the great circle arc angle of the total segment. The bearing at beginning of the segment is computed by program AZ. If interpolation is on time, the fraction of arc is computed according to the fraction of time-in-segment, over total time of the segment. If interpolation is on fraction-of-segment distance, the fraction of arc is computed according to the input value, and time is computed for output. In either case, final computations are performed to ensure that output values are within coordinate limitations.

Constant Bearing Path Segment (Rhumb Line)

Option 4 of KINEM involves interpolation to find the position of a vehicle moving along a constant bearing path segment. The first steps include calculation of the great circle range angle of the total path, and the bearing along the path (with program AZ). If interpolation is to be performed on time, the fraction of segment arc is computed according to time-in-segment over total time of segment.

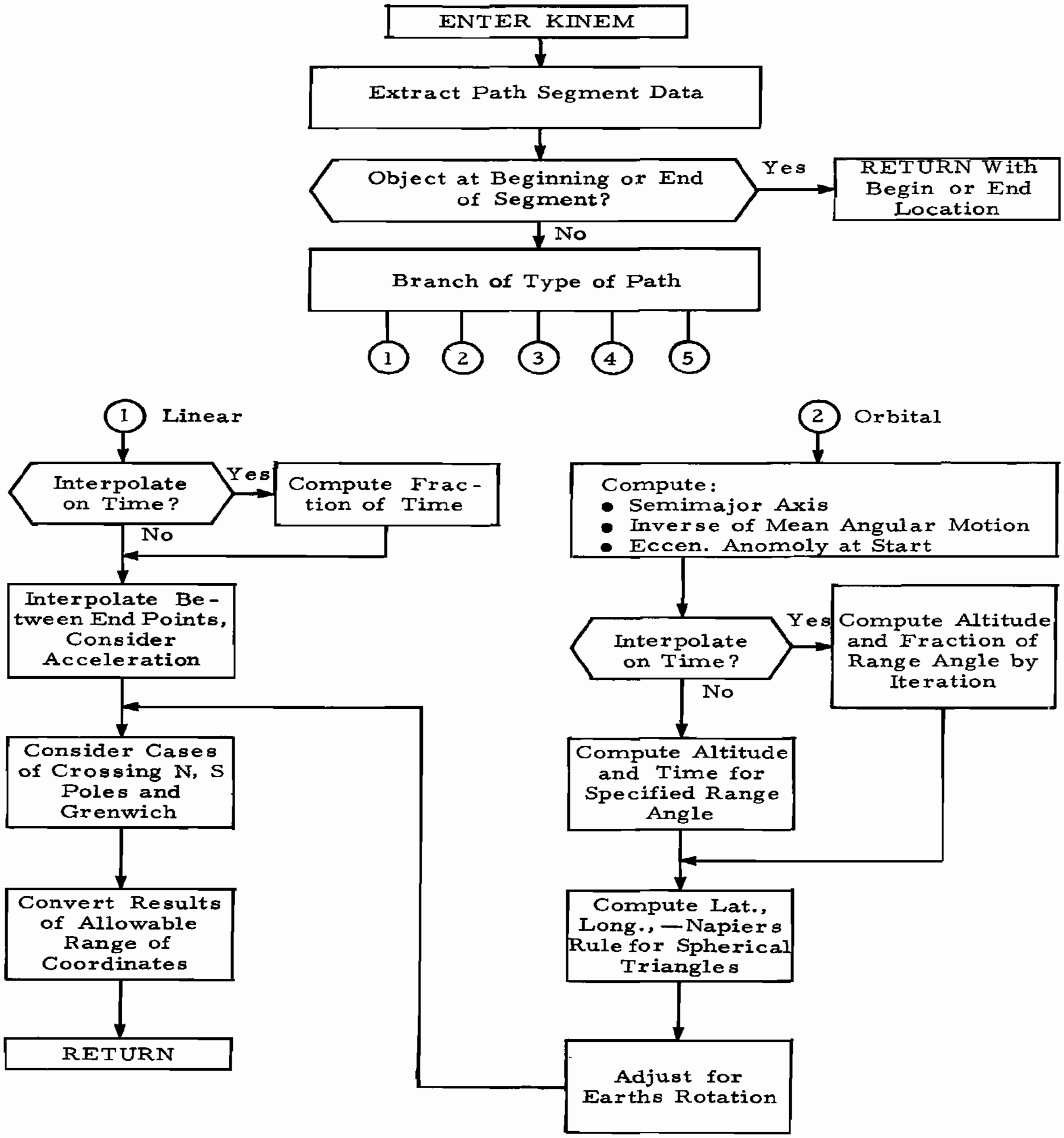
If the interpolation is on fraction-of-distance, the input value is used. The final computations adjust the great circle values according to the constant bearing criteria.

Nuclear Fireball Movement

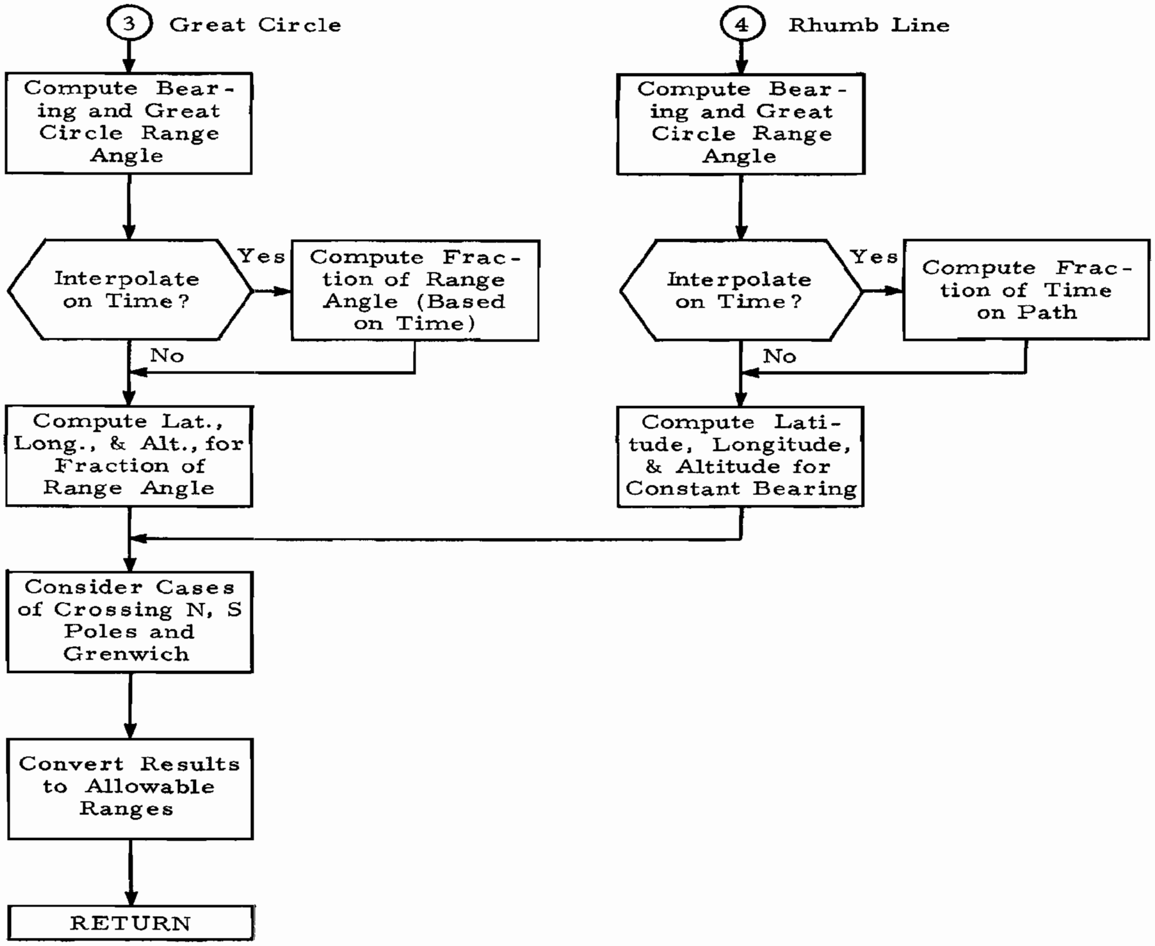
Option 5 of KINEM computes the position of the center of a nuclear fireball at a specified simulation time. First, the age of the fireball (time since detonation) is calculated. The program then branches

SUBROUTINE KINEM (Continued)

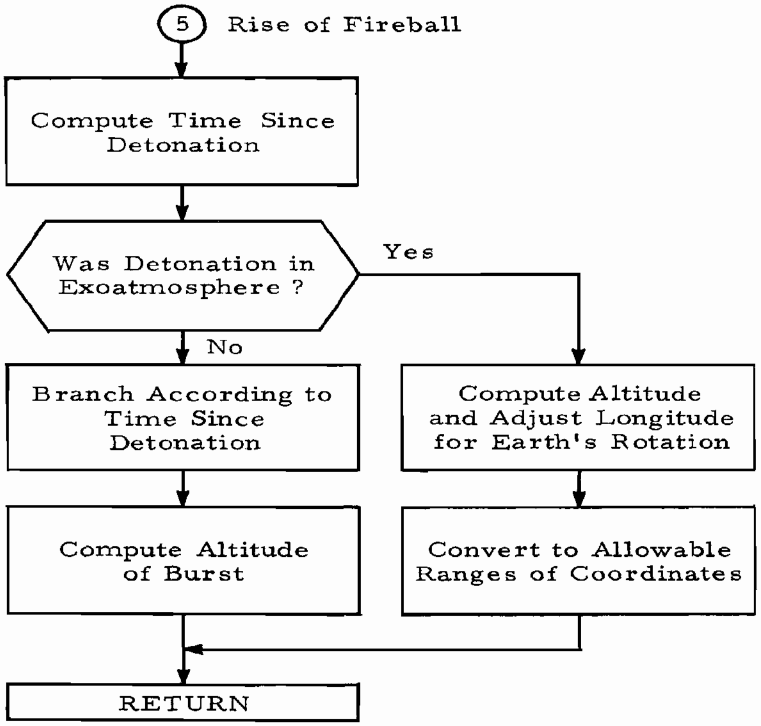
according to whether the detonation occurred within or above the atmosphere. For a burst within the atmosphere, the vertical position at the indicated time (time since detonation) is computed. For an exoatmospheric detonation, a vertical rise is computed as well as a translation due to the earth's rotation. The calculated position is converted to allowable range of coordinates as necessary.



SUBROUTINE — KINEM



SUBROUTINE — KINEM (Continued)



SUBROUTINE — KINEM (Continued)

ENDOGENOUS EVENT LMSGE
Launch MeSsaGE

Discussion of Usage

Event LMSGE contains the logic regarding message transmission delay, receipt, and processing for launch of offensive or defensive missiles, or aircraft. The original messages for launch of offensive missiles or bombers are generated by the exogenous event ORDER, which simulates "order from higher headquarters." Manned interceptor and defensive missile launch messages are generated endogenously according to dynamic game conditions.

Input Arguments

Event Notice LMSGE

MARRT = Message arrival time
MCLAS = 301—Launch order messages
MTYPE = Vehicle subclass to launch
MCONT = Code for processing of message
  1—Communications delay (i.e., message send, transmit, and receive processes)
  2—Tests for maintenance and launch window availability
  3—Launch initiation delay
  4—Vehicle creation (launched)
MCOMM = Address of record for command membership
MORIG = Message origin (index of site of sender; command site)
MDEST = Message destination (index of site of receiver; launch site)

Message Parameters for Missiles and Bombers

MPAR1 = Index of launch site
MPAR2 = Index of first path segment in path records
MPAR3 = Index of launch window (if any)
MPAR4 = Time of launch (set to zero if "launch when ready")

ENDOGENOUS EVENT LMSGE (Continued)

Message Parameters for ABM's

MPAR1 = Index of launch site

MPAR2 = Address of a command record (CREC2) that names (has address of) a target

MPAR3 = Number of rounds to be fired

MPAR4 = Required time of launch

Output

- MCONT = Index to next applicable process for this message
- Removal of message if completed or no longer applicable
- Adjustment (as appropriate) of launch site operational status to:
  - 10 = Site and/or vehicle malfunction, recovery possible
  - 21 = Launch site operationally ready but launch window not available
  - 90 = Operationally ready
- Adjustment of number of equipment at site
- Creation of a vehicle entity record, and causation of the vehicle to start its processes
- Recause of LMSGE if appropriate

Subroutines and Functions Called

NETWRK = To move LMSGE to its next process

COMUN = To compute communications delay

RANDM = To test if vehicle/site is down for maintenance

DRAW = To compute time to recover from malfunction

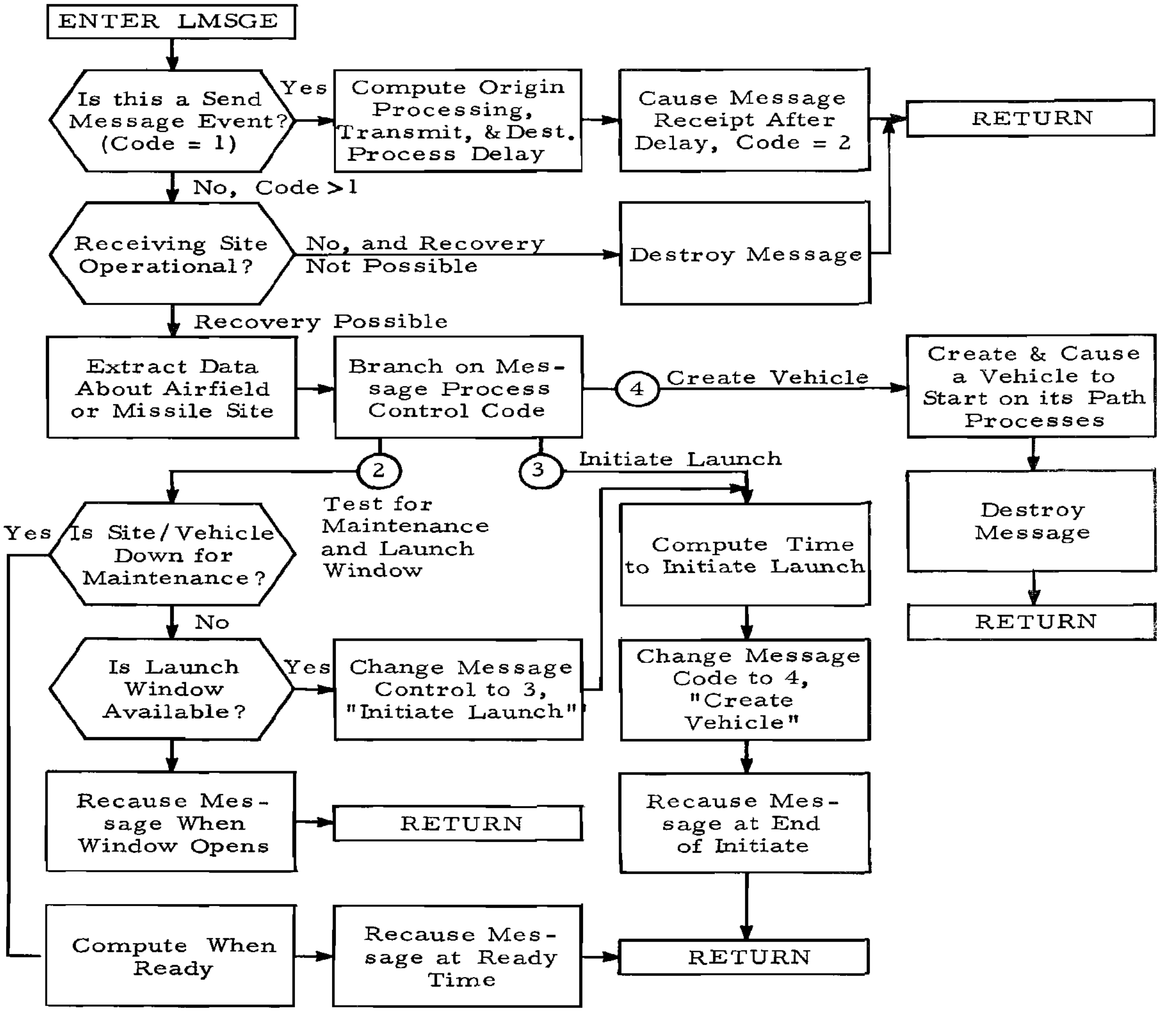
REMOVE = To remove entity records from memory

TRANS = For ABM and SAM launches, compute azimuth, elevation, and (slant) range of threat relative to launch site

ENDOGENOUS EVENT LMSGE (Continued)

Methodology

LMSGE is an event that simulates processes of a launch message. First, a communications delay is computed according to origin-destination site attributes as parameters to a random process. The message is re-caused after the computed delay time. If and when the launch site passes tests of readiness, operability, and launch window acceptability, a launch is initiated. After the initiation time a vehicle is created and started on its path movement processes.



ENDOGENOUS EVENT — LMSGE

SUBROUTINE MDEFND(II,JJ,IS,IC)
Missile DEFeND Logic

Discussion of Usage

This subroutine contains the logic concerning the employment of defensive missile systems against targets that are identified by sensing systems. For more complete discussion, see Part III of this volume.

The logic includes keeping of rank-ordered lists and associated data concerned with:

- Threats, available defensive forces and battle space
- Target values
- Assignments of defensive missiles to the observed threats
- The initiation of orders to launch defensive missiles against designated targets

Input Arguments

II = Index of the command site making defense decisions

JJ = Address of an observed threat record (OBSER)

IS = Type of sensing "event"

1 — Threat acquisition
2 — Threat designation
3 — Threat track
4 — Intercept track
5 — Discrimination

IC = Code for condition initiating defense decisions

1 — New threat object
2 — Defensive missile launch
3 — Threat intercepted

The program uses a threat list, and threat targeted list in a ranked set of command data. Each entry contains the following:

PCOMM = Address of the predecessor threat

SCOMM = Address of the successor threat

For Threats Not Targeted

CMEMB = Identification of threat (address of observation record)

CRANK = Latest possible launch time

SUBROUTINE MDEFND (Continued)

CPATH = Index of launch site

CPAR2 = Time threat pierces defended volume

CPAR3 = Value of threat as seen by defense

CPAR4 = Number of defensive missiles currently assigned to the target from the indicated launch site (CPATH above). The "10's" place of the number in CPAR4 is used to indicate if the launch site is ineligible for further intercept actions.

For Threats That Have Been Targeted (Launch Orders Have Been Sent)

An additional record is established with the following entries:

CMEMB = Index of command membership for this record

CRANK = Time of flight of ABM

CPATH = Address of original target record

CPAR2 = Longitude of intercept point

CPAR3 = Latitude of intercept point

CPAR4 = Altitude of intercept point

Output

- The ranking of the array of candidate-defensive-weapons against a specified target is adjusted according to conditions at decisionmaking time
- Candidates are removed from the list if it is too late to react
- A command record for the threat is created and filed (in time ranked order) in the threat list at each cognizant command site
- Messages for launch of antiballistic or surface-to-air missiles are created and sent at the instant of command decision; the message contains:

  MORIG = Command site index

  MDEST = Launch site index

  MCLAS = 301—Launch orders

SUBROUTINE MDEFND (Continued)

MTYPE = Type of message to launch (used here to indicate type of missile to launch: SAM or ABM)

MPAR1 = Launch site index

MPAR2 = Address of threat record (OBSER)

MPAR3 = Number of rounds (in salvo) to be launched against the target

MPAR4 = Time of launch to reach a threat at the designated time

MCOMM = Address of record for command membership

- Command records are created for targeted threats
- Missile launch or command site data are adjusted as follows:
    - Time of present update of threat list is inserted in the decisionmaking command site
    - Marginal value is adjusted to represent value of each planned defensive response to a threat
    - Number of rounds remaining under the command site and at launch site is computed
    - Operational status of each launch site is adjusted to Code = 1 (site inoperable) when available rounds are exhausted
- Sensor (radar) site data are adjusted to indicate the number of available tracking channels; decreased when defensive missile is assigned, increased when interception occurs

Subroutines and Functions Called

VOLUME = Predicts points and times for threat track entrance and exit of defensive battle spaces

KINEM = Computes position of a threat object at any time

TOF = Computes time of flight from launch point to threat intercept point for a specified missile type

TREE = Finds a defensive missile site in a command hierarchy structure

SUBROUTINE MDEFND (Continued)

Methodology

(U) This routine contains the algorithm for assigning an interceptor from a particular defensive missile site to engage a particular threat. The algorithm may be exercised (i.e., a decision cycle initiated) at the time of occurrence of any of the following critical events:

- each time a threat object is sensed
- interceptor launch
- intercept completion

Secondarily, a cycle is also initiated by the inability to meet the specified launch time or the loss of an interceptor in flight due to system failure or killing effects by nearby bursts. Each decision cycle is permitted only one assignment against each threat object. Multiple assignments either on a look-shoot-shoot or a look-shoot-look-shoot basis are automatically determined in the subroutine. User control in the multiplicity of assignments on an given threat object is exercised through a user-input decision variable threshold value and the specification of interceptor P_k. Non-unity input values of P_k will permit both doctrines to be simulated. A value of unity will permit multiple assignments on a look-shoot-look basis only.

(U) The data structure of the algorithm is built around records denoting threat object/missile site pairings. These records are kept in one of three sets: active (assignment possible), blocked (assignment temporarily inhibited) and inactive (assignment no longer physically possible). Whenever a new threat object is tracked by the sensors, records are created and filed in the active set pairing the object with each missile site capable of intercepting the threat. These records include the time remaining before the last possible launch against the threat. The time remaining is updated on each decision cycle and when no time remains, the records are removed to the inactive set.

(U) Whenever a particular record is chosen for an assignment, all records involving the threat object are moved from the active set to the blocked set. The records will remain blocked until an event occurs that will change their status. For example, an interceptor launch event would make the threat eligible for reassignment if a shoot-shoot doctrine is used, or an intercept event if a shoot-look-shoot doctrine is used.

(U) The assignment selection portion of the algorithm operates only on those records (pairings) in the active set. For each record an expected "marginal value saved" (MVS) variable is computed based on consideration of:

- time urgency of the threat object with respect to each candidate site
- compound survivability of the threat object
- relative inventory of interceptors
- value threatened by the object as assessed by the defense
- expected probability of killing the object

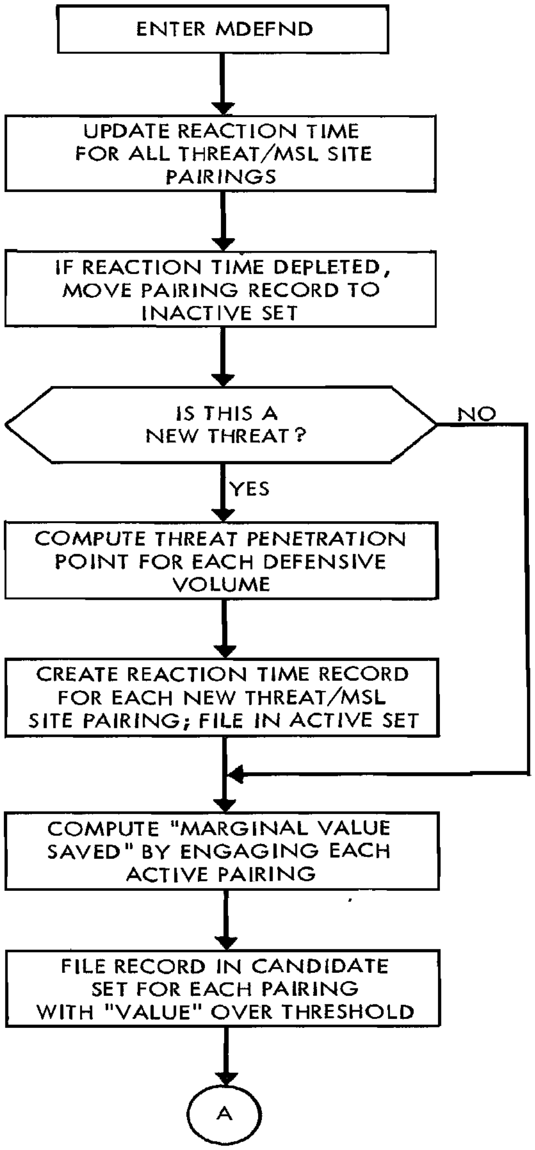
provided the missile site has uncommitted inventory and the associated guidance radar(s) are not saturated. A new, temporary set is constructed from which assignments are made beginning with the highest MVS value. The MVS ranking of candidate pairings may be overriden by a user specified preference for one defensive missile system ahead of another which would force the choice of a missile system with a lower MVS value. Once the missile site/object pairing has been selected, the launch time, intercpet time and intercept point are computed.

(U) Each type defensive missile system may be associated with a zone in which intercepts are not permitted except for self-defense. If such a zone has been defined and is in effect at the time of intercept but the object is threatening one or more elements of the defense (i.e., the object is predicted to impact within a user defined self-defense area), then the zone is ignored. For planned intercepts within the zone that do not threaten the defensive system, an attempt is made to reschedule the intercept at a time when the zone is not imposed. If this is not feasible, then the pairing is dropped, resulting in the choice of a less favorable pairing or no assignment at all.

(U) Once a planned assignment has satisfied all of the constraints, it is implemented by the issuance of a launch message to the selected missile site at the specified launch time. All records for this threat are shifted to the blocked set of candidate pairings to prevent further assignments on this cycle. Subsequent cycles may make additional assignments depending on the firing doctrine.

(U) Another aspect of the missile defense algorithm, as described above, is the command and control structure. All defensive assignments are made by one or more command sites as designated by the user's input data. If a single site is designated, then an integrated, full netted system is represented. If more than one command site is designated, then they will make decisions independently, with the possible result of multiple assignments against the same threat object.

(U) The SAM logic is currently configured for rank-ordering of threat object/site pairings on a time urgency (battle space available) basis only. A threshold value comparison is not made; assignments are made for the highest ranking pairings of a computation cycle, N-on-one.



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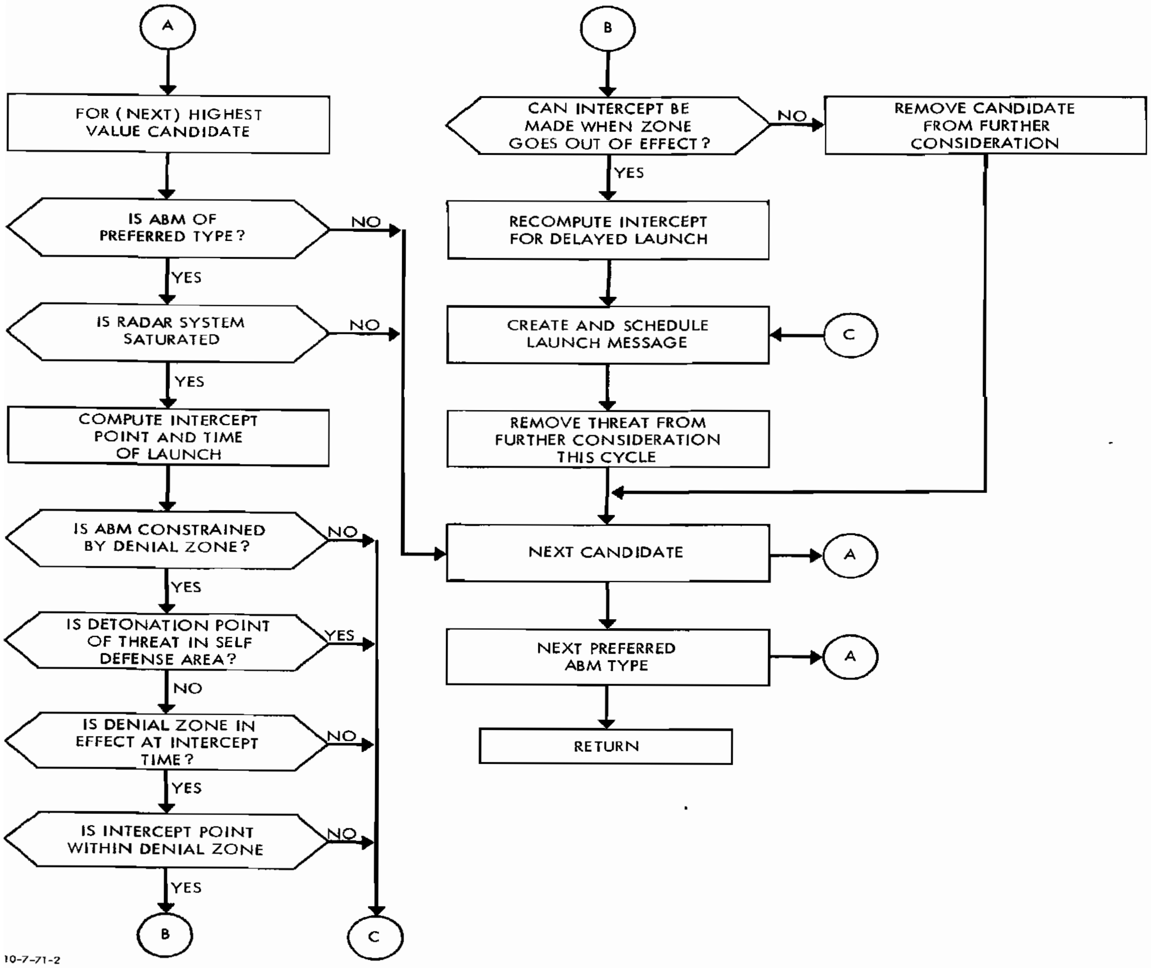
SUBROUTINE - MDEFND



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SUBROUTINE - MDEFND

ENDOGENOUS EVENT MVHCL
Missile VeHiCLe Processes

Discussion of Usage

This event occurs at the end of a path segment process for a missile. It also signifies the start of the missiles next process. The processes are:

1. Launch initiation
2. Boost phase
3. Free flight
4. Reentry
5. Create subsidiaries
6. Create burst

Input Arguments

Vehicle Event Record

VPATH = Address of current path segment record
VTYPE = Type of vehicle
VCLAS = Class of vehicle
VORIG = Address of originating site of vehicle
VCOMM = Address of record for command membership

Vehicle Specification

Probability of successful operation (used at launch initiation).

Path Record

PPROC = Code for type of process (see above)
PDURA = Time duration of path process
$\left.\begin{array}{l}\text{PLOCX}\\\text{PLOCY}\\\text{PLOCZ}\end{array}\right\}$ = Location: longitude, latitude, and altitude at end of path segment

Output

- Vehicle location adjusted
- New path segment data found (if any)

ENDOGENOUS EVENT MVHCL (Continued)

- Vehicle removed (if specified)
- Next vehicle process event caused
- Command records reranked and filed

Subroutines and Functions Called

NPATH = To search out next path segment data and create subsidiaries

EFFECT = To predict nuclear interactions (lingering) for this vehicle

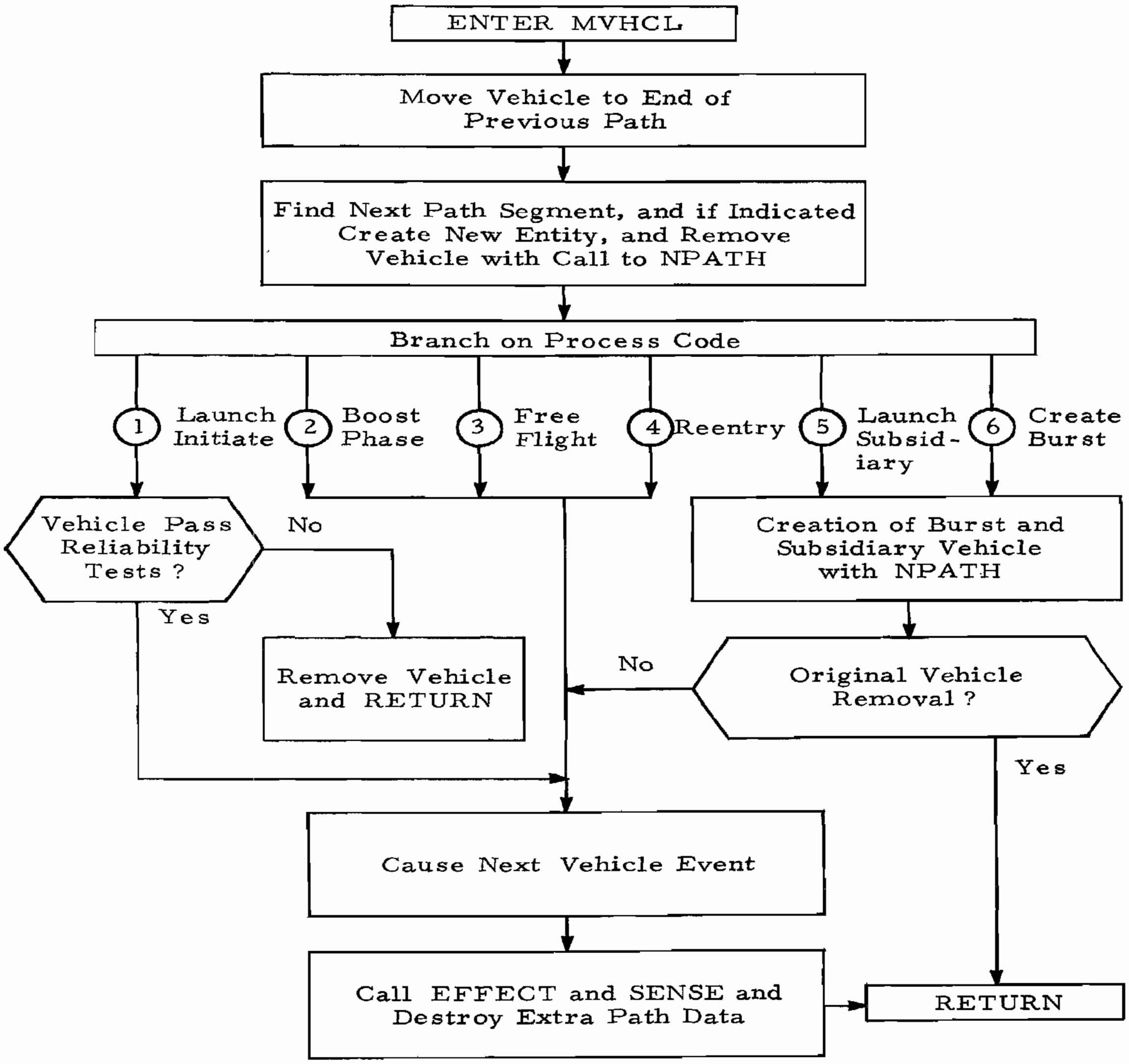
SENSE = To predict possible sensing of vehicle during the next path process

RFCRD = Rerank and file the command membership records

Methodology

The logic of the program is in three Sections:

- Section A—Logic pertaining to previous path segment
- Section B—Logic pertaining to finding the next process-path-segment
- Section C—Logic pertaining to the next path processes



ENDOGENOUS EVENT — MVHCL

SUBROUTINE NETWRK(II,JJ,KK)
NETWoRK Control of Next Process

Discussion of Usage

Subroutine NETWRK determines the next applicable process for a message or observation.

Input Arguments

II = Address of entity

JJ = Type of entity (3—message, 4—observation)

KK = Index of previous control record, if KK is negative, the previous process is repeated

Output

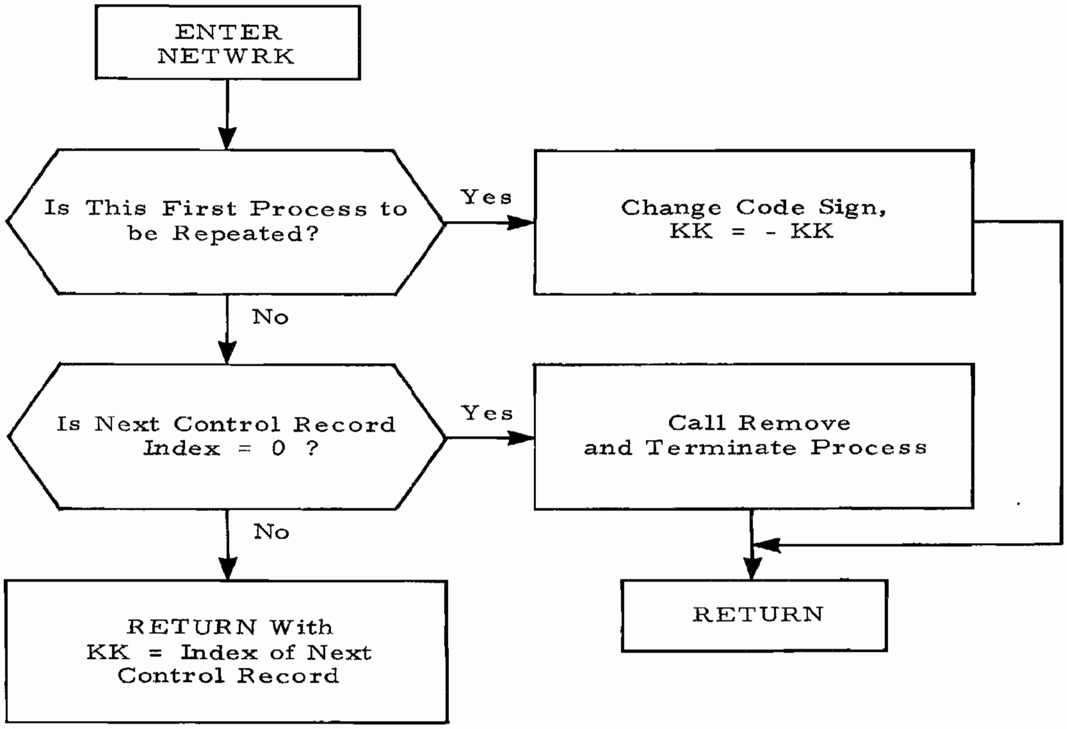
KK = Index of new control record

Subroutines and Functions Called

REMOVE = Removes the entity if there is not a next process

Methodology

Program NETWRK operates on an indexed list of control records. The first entry in the record identifies the next applicable control record (and associated process). The second entry identifies an alternate control record; this permits initiation of an alternate (or parallel) sequence of processes. If applicable, the third entry identifies the type of process appropriate to this record.



SUBROUTINE — NETWRK

FUNCTION NNEFF (II,JJ)
NonNuclear EFFects for Destruction

Discussion of Usage

Function NNEFF computes the outcome of an engagement by one vehicle against another using probabilities of kill based on 1-on-1 single pass engagement logic. This program simulates the possible destruction of an entity using nonnuclear devices; or nuclear devices with warhead too small to contribute to the nuclear environment.

Input Arguments

II = Address of interceptor vehicle
JJ = Address of target vehicle

Output

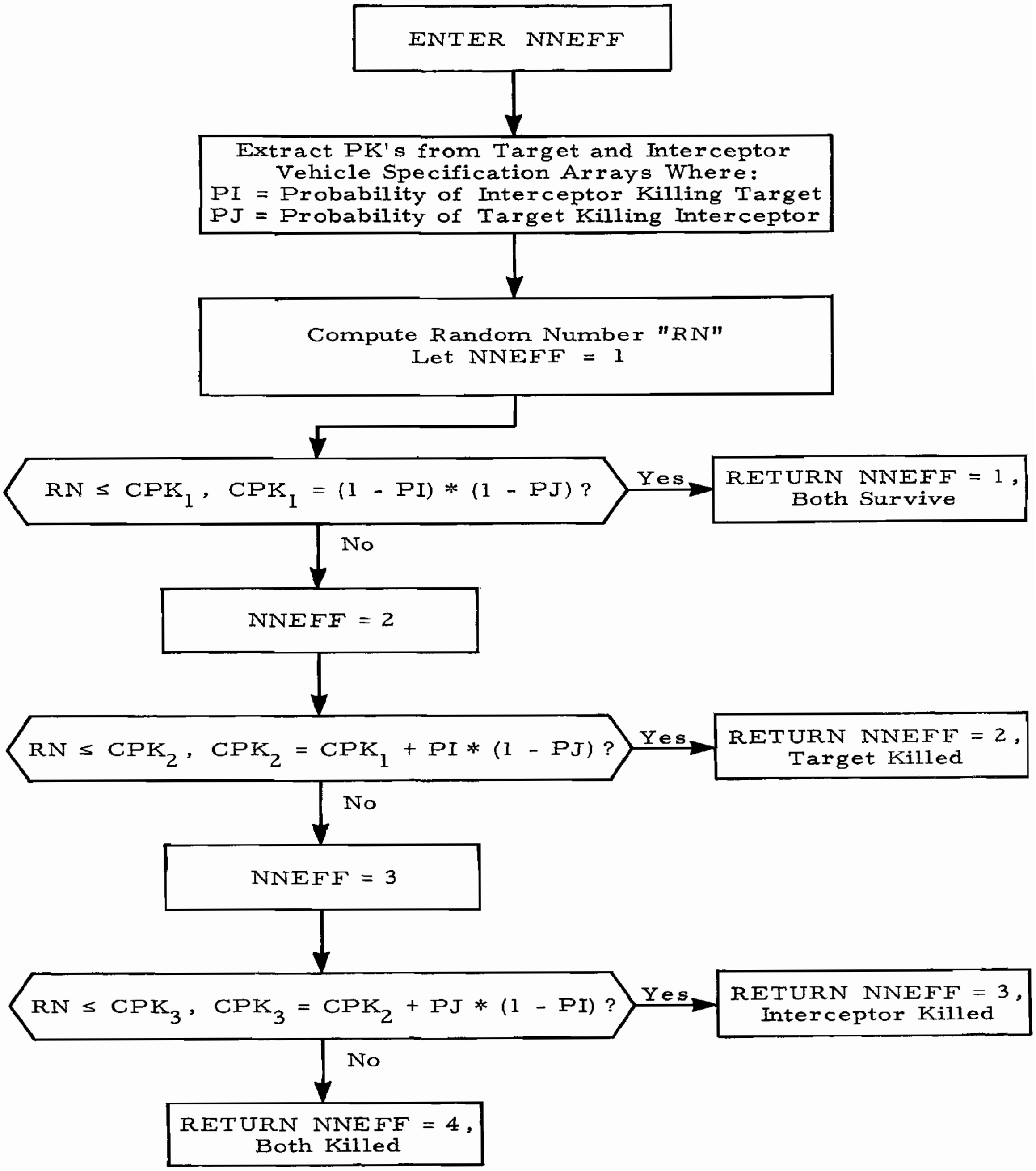
NNEFF = 1—Both vehicles survive
2—Target vehicle only killed
3—Interceptor only killed
4—Both vehicles killed

Subroutines and Functions Called

RANDM = Compute a random variable X, $0 \leq X \leq 1$.

Methodology

After extracting the probability of kill for the interceptor versus target vehicle and for the target vehicle versus the interceptor from the vehicle specifications array, a random number is computed. The random number is compared to the conditional probabilities of kill and the code for the results of the engagement is presented for output.



FUNCTION — NNEFF

FUNCTION NPATH (II,IP)
Get Next PATH Process for an Entity

Discussion of Usage

Based on input specifications, function NPATH may get the address of the next path segment record, remove an entity, create an entity, or start an entity on a path segment.

In future versions of the program, this function may be redesigned to allow storage of path data on (external) random access equipment.

Input Arguments

II = Address of an entity looking for its next path segment
IP = Address of current path segment for entity

Output

NPATH = Address of current path (if IP negative on input)
= Address of next path for entity (if IP positive)

- Vehicle or burst event notice may be created
- Vehicle or burst entity removed from memory (if there is not a next path)
- If vehicle or burst is created, it is filed in a command set

Subroutines and Functions Called

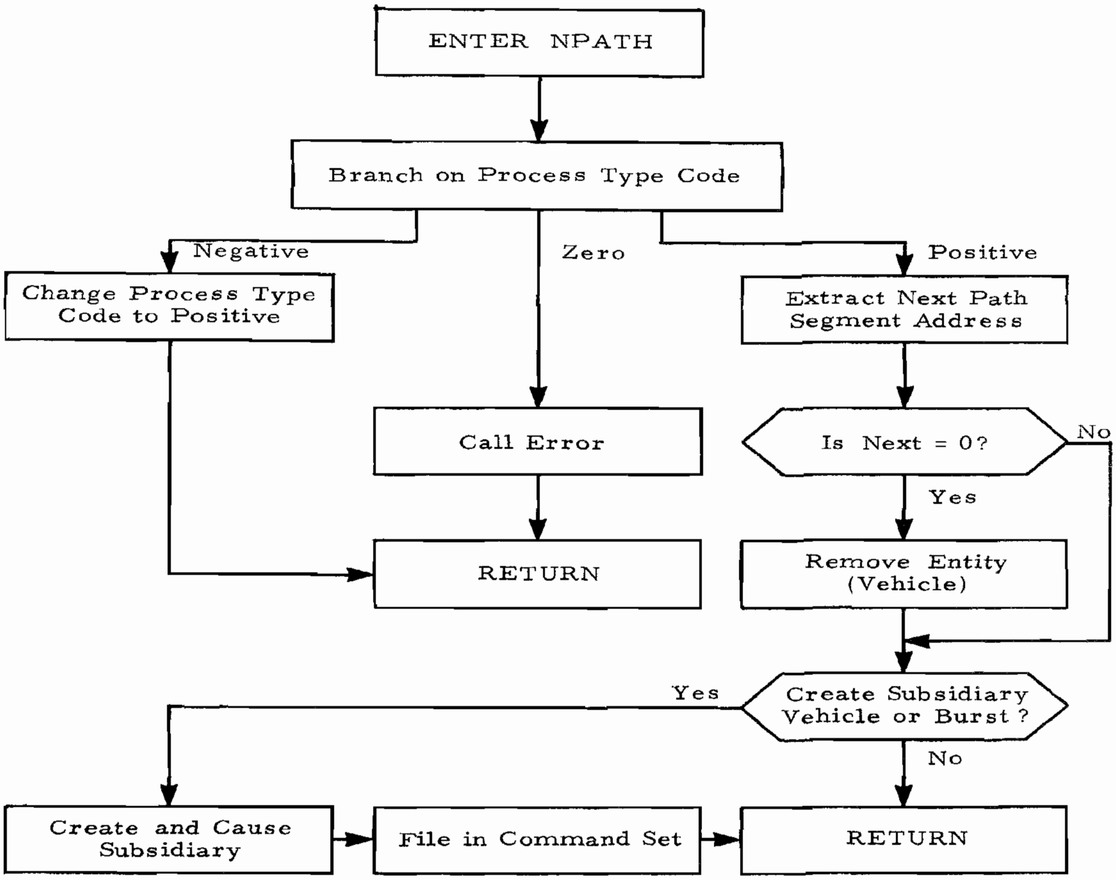
REMOVE = Remove an entity and associated records

Methodology

Interrogation of the path segment process code for the indicated segment "IP" allows branching to perform one of the following:

- Return with current path segment address
- Remove an entity and associated records
- Return with address of the next path segment that a vehicle is to follow

If indicated in the current path segment record, a vehicle or burst may be created and caused to start on its path segments. If a vehicle or burst is created, it is filed in the proper command set.



FUNCTION — NPATH

SUBROUTINE NUC(II)
NUClear Fireball Path Parameters

Discussion of Usage

This subroutine calculates the path parameters for a nuclear fireball so that the position of a fireball can be computed as a function of time in KINEM. These parameters are also used by function FIRBL to compute radius of a "fireball" as a function of time.

Input Arguments

II = Address of a fireball burst entity

- Data from the burst entity:

  BPATH = Address of path data storage of the burst
  BTYPE = 1 through 7, burst type
  BLOCZ = Altitude of burst

- According to the burst type, a specification value for the burst is:

  BSPEC( ) = Cube root of weapon yield

Output

Path Parameters

PPAR1 = RO—Initial fireball radius (n.mi.)
PPAR2 = NEO—Initial free election density
PPAR3 = RD—Fireball rebound distance (n.mi.)
PPAR4 = TEQ—Time for fireball to reach equilibrium (hrs)
PPAR5 = RTEQ—Fireball radius at equilibrium (n.mi.)
PPAR6 = TTORD—Time when toroid forms (hrs)
PPAR7 = RTORD—Radius at time of toroid (n.mi.)
PPAR8 = RMAX—Maximum radius of effects

Subroutines and Functions Called

None.

SUBROUTINE NUC (Continued)

Methodology

The following method of formulation is used to compute the fireball parameters:[1]

$$RO = Y^{1/3} * \left(\frac{HOB + 1}{10}\right)^{3/2}$$

where: Y = Yield, (KT)

HOB = Height of burst, Km (converted from nautical miles to kilometers)

$$RD = \frac{RO}{4}$$

$$TEQ = .6 * RO * (HOB + 10)^{.8571428}$$

$$TTORD = 2 * RO$$

$$RMAX = 40 * RO$$

$$NEQ = 3.16 * 10^{19} * e^{-HOB/6.97} \; ; \text{ for } HOB < 100 \text{ Km}$$

$$= 1.77 * 10^{13} \; ; \text{ for } HOB \geq 100 \text{ Km}$$

$$RTEQ = RO + .1 * TEQ^{2}$$

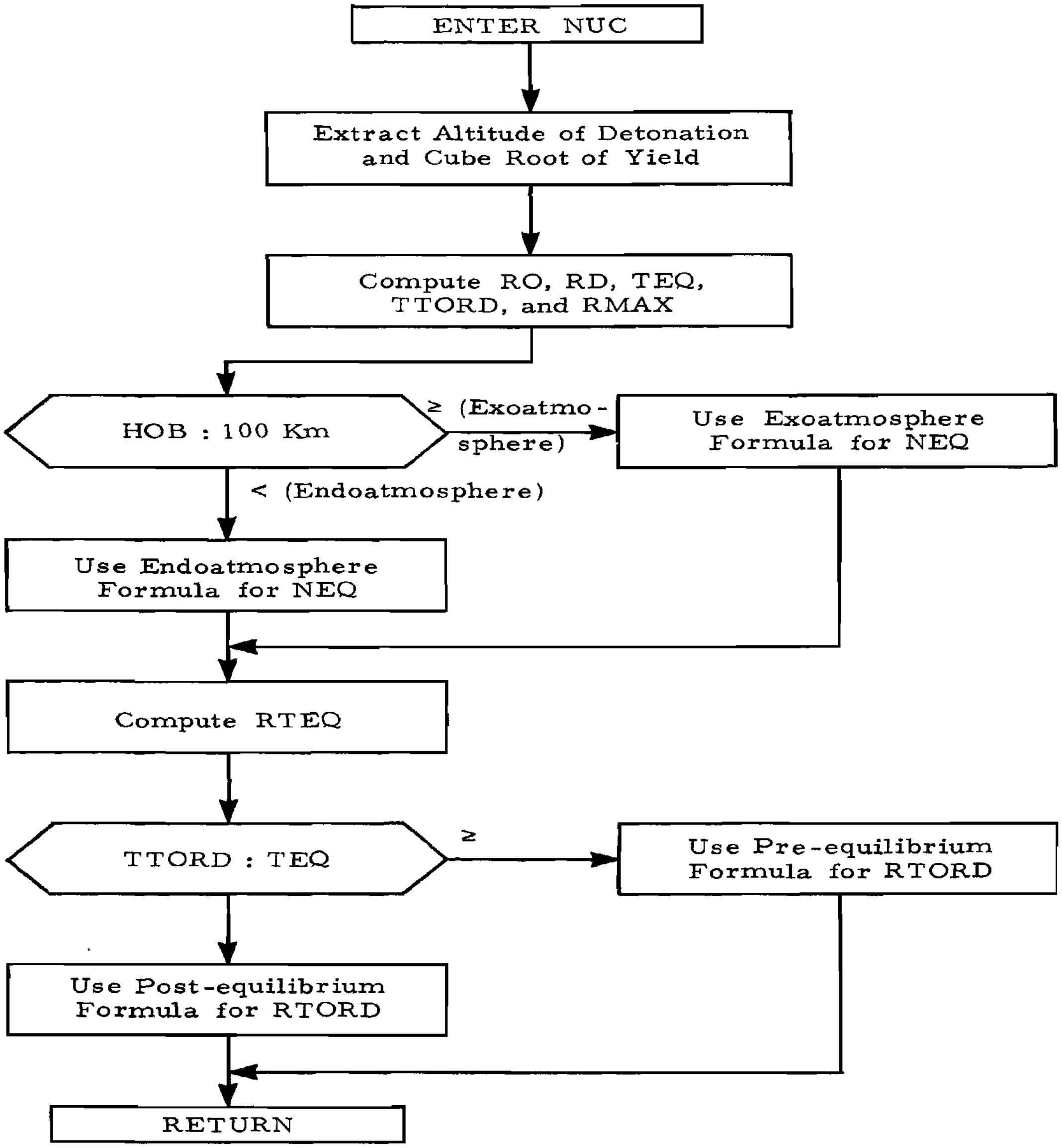
$$RTORD = RO + .1 * TTORD *^{3/2} \; ; \text{ for } TTORD < TEQ$$

$$= RO + .1 * TEQ^{3/2} + .1 * TTORD^{1/2} \; ; \text{ for } TTORD \geq TEQ$$

The computed values are then converted to units indicated for path parameters and stored as a path record.

---

[1] These unclassified values and formulas are extracted from: ABM-1 Model, Vol. V, CSM-AM-68-68, NMCSSC, 15 November 1968. The unclassified formulas included in the programs are for checkout purposes only and are not suitable for actual estimation of nuclear effects.



SUBROUTINE — NUC

ENDOGENOUS EVENT OBSER
OBSERvation of a Vehicle or Burst by Sensor

Discussion of Usage

Endogenous event OBSER represents the sighting of a vehicle or burst by a sensor. This event is caused whenever a vehicle or burst (object) is simulated to be in the following processes:

1. Entered into a sensors volume of view
2. Acquired by sensor
3. Designated (named)
4. Tracked as a threat
5. Tracked during intercept operations
6. Discriminated from other objects
7. Exit from sensor volume of view

Input Arguments

Event Notice OBSER for an Object Observed by a Sensor Site

OCLAS = Class/subclass code for observed object

OCONT = Index of current control record

SCOPY = Address of next OBSER record in copy

OCOMM = Address of record for command member

OSENS = Index of sensor site

OIDEN = Address or index of observed object

OLOCY = Location (latitude) of object at point of tracking

OLOCZ = Location (altitude) of object at point of tracking

OSTAT = Sensing status of observed object

OFACT = Factor representing signal-to-noise (S/N) for blackout threshold

ODURA = Duration of sensing function

FASGN = Address of first note about radar interference, or interceptors (manned or ABM) assigned to bombers

LASGN = Address of last member of set of assignment notes (set ASGN)

OPOST = Posting code (sensing status at command site)

OSURV = Probability of the sighted vehicle being still alive

ENDOGENOUS EVENT OBSER (Continued)

OSTAR = Start time of current sensing process
OENTR = Time of entry into sensor volume
OEXIT = Time of exit from sensor volume
OSTOP = End time of current OBSER process

Specifications of Sensor Site

- Sensor site status code (if code < 10, site inoperable)
- Class and type of site
- Type of sensor at site

Sensor Specifications

- Duration of blackout which does not interrupt sensing
- Identification of first control process record for acquisition
- Required time to track a vehicle
- Required time for designation
- Required time for intercept tracking
- Required time for discrimination

Observed Vehicle Record Data

VSTOP = Stop time for current vehicle path process

Output

- If a sensor site is killed or otherwise inoperable, the observation record is removed
- A note is created for each vehicle/burst/sensor occlusion as follows:

  NREFR = Address of the reference burst record
  NTYPE = 1—Interference of sensor due to burst
  NTIM1 = Time vehicle enters a cone of occlusion (ranking attribute)
  NTIM2 = Time a vehicle is blacked out
  NTIM5 = Time vehicle exits a burst cone of occlusion

ENDOGENOUS EVENT OBSER (Continued)

- Message events may be caused to indicate change in sensing states to command sites as follows:

  MORIG = Message origin (sensor site index)

  MDEST = Message destination (APEX of command site to which the sensor site reports)

  MCONT = IDENT of first control record for acquisition status change

  MCLAS = 302 — Class/subclass code; report of sensing object

  MPAR1 = Address of vehicle record

  MPAR2 = Address of observation record

  MPAR4 = Status code for sensing process

  2 — Acquisition
  3 — Designation
  4 — Track
  5 — Intercept tracking
  6 — Discrimination
- Entries in the observation record may be changed to reflect a new (next) observation process
- Observation processes recaused at appropriate time

Subroutines and Functions Called

VOLUME = To compute time that object enters and exits cones of possible occlusion

SEE = Time object can be seen in a nuclear environment

DISCR = Compute time that a reentry vehicle can be discriminated according to the altitude in the atmosphere at which a vehicle is significantly decelerated

Methodology

Event OBSER contains logic associated with the beginning and end of processes representing events about observation of various kinds of radar sensing functions for vehicles and bursts. There are seven such processes as described below. Whenever an observation event occurs, the status of the site containing the sensor is interrogated. If the site is dead, the observation record is removed from the game and the program exits.

The seven observation processes are described below.

Case 1—Entry into a Sensor Volume

If the vehicle or burst has entered a sensor volume of view, it is filed into the command set owned by the sensor. A search is then made of other members of the command set to find instances where a burst interferes with the radar's viewing of a vehicle. For identified interactions, the beginning and end times of the interference are computed and stored in a NOTE record. This NOTE is then filed in an ASGN set attached to the observation.

If the vehicle is computed to leave the sensing volume before it could be observed, the observation record is destroyed. If it is determined that the vehicle will be seen for a sufficient period of time, the observation record is changed to indicate a possible acquisition, and an observation event about this possible acquisition is caused to occur at the predicted time. Note that an acquisition may not result because of blackout due to bursts in the intervening time.

Case 2—Acquisition[1]

If a vehicle passes the tests of visibility to a sensor in a nuclear environment (program SEE), the process code in the observation record is changed to Case 3 (Designation) and a message regarding acquisition (code 2) is sent. The time designation would occur is predicted and the observation event for track is caused at the predicted time. If the vehicle does not pass tests of program SEE, the time for acquisition is again predicted, and the observation event for acquisition is caused.

Case 3—Designation

If the vehicle passes tests similar to those of case 2, a message (code 3) is sent and the time of "track" is predicted. The observation

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[1] If the vehicle exits the sensors volume of view in this case, or cases 3, 4, and 5, an exit event is caused and the following event is ignored.

event for track (code 4) is caused to occur at the predicted time. In addition, a dummy observation event record for discrimination is created and caused to occur at the time that a vehicle passes a "stopping" altitude. At the stopping altitude in the atmosphere, light objects such as decoys and chaff are decelerated to such a degree that they can be discerned from high ballistic coefficient warheads. If the vehicle did not pass tests defined by program SEE, the time for designation is again predicted and the observation event for designation is recaused at the predicted time.

Case 4—First Track

If the vehicle passes tests defined by program SEE for occlusion due to existence of burst entities, a "first track," message (code 4) is sent. At the time a vehicle changes course (changes to a new path process) or exits the sensor volume (whichever is first) an intercept observation track or volume exit is caused. If the vehicle did not pass tests of program SEE, the time of first track is again predicted and the observation of track event is caused.

Case 5—Intercept Tracking

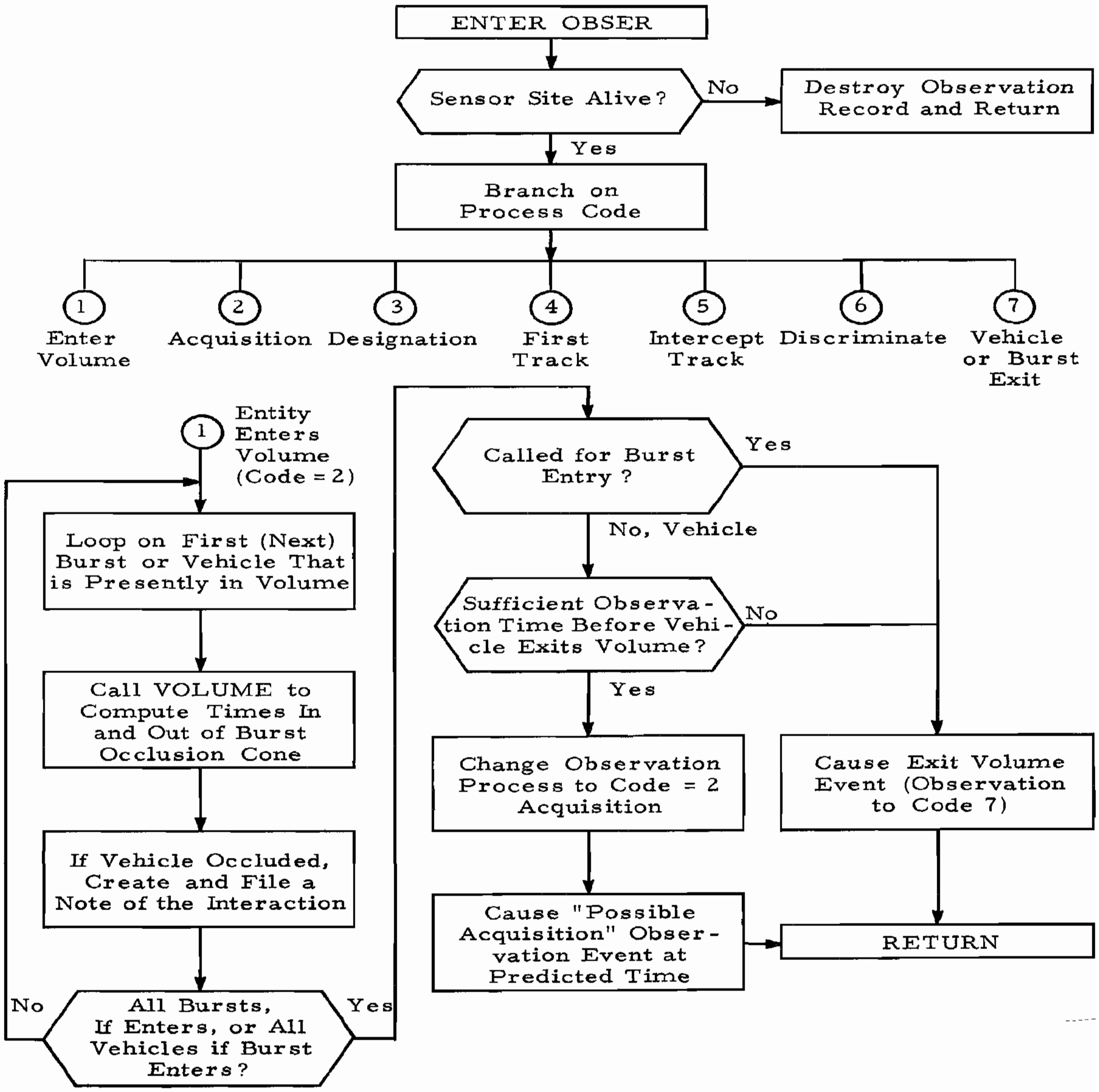
If the process code is 5, the intercept track logic is invoked. This logic is used for interception purposes. When the observation of intercept track occurs, a message (code 5) is sent. The time for next intercept track is extracted from the vehicles record as the time it changes from one path segment to another. If the vehicle exits the sensor volume of view, an exit volume event (observation process code 7) is caused, and the "dummy" discrimination record is removed from memory.

Case 6—Discrimination

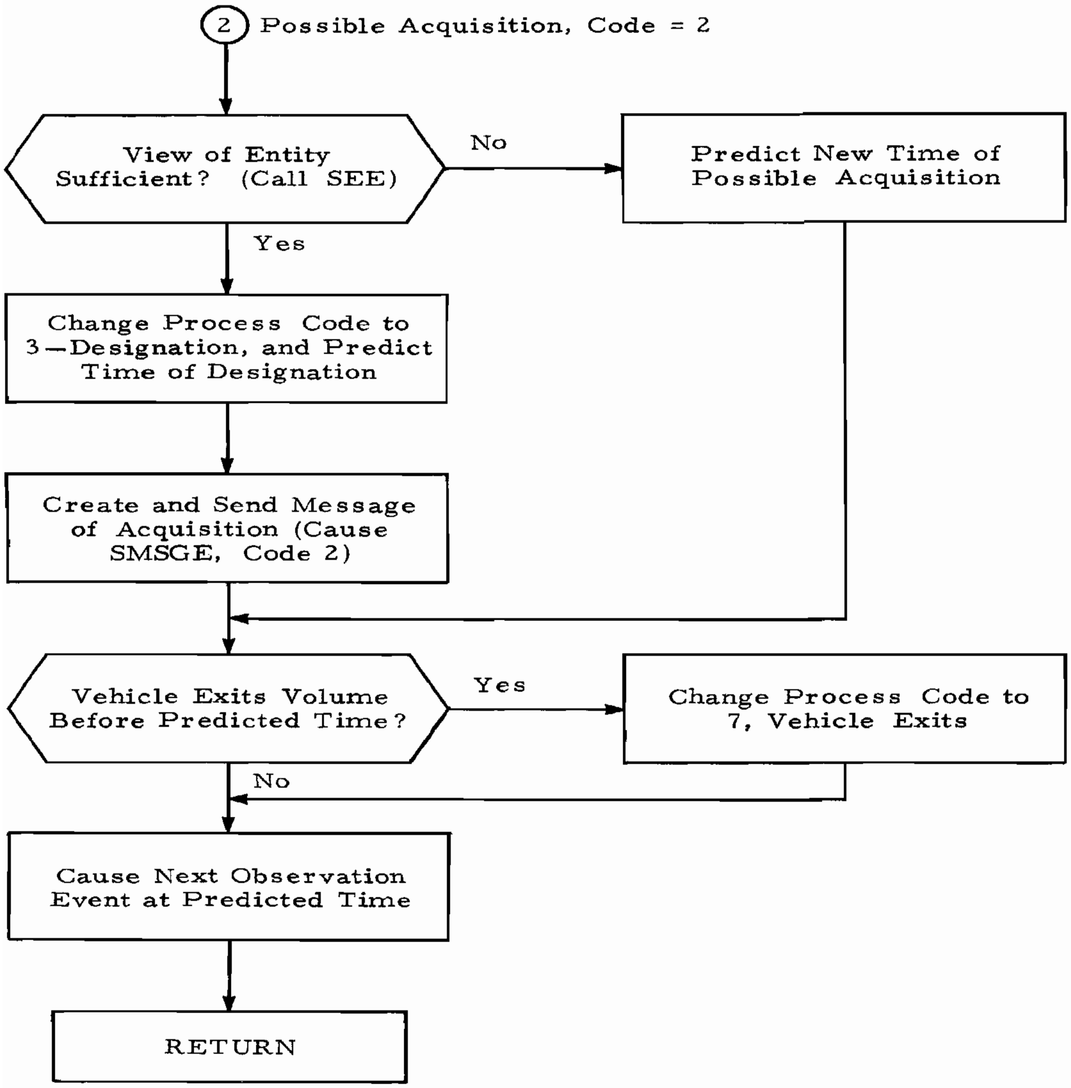
When a vehicle traverses an altitude in the atmosphere where objects of low ballistic coefficient are significantly decelerated (chaff and decoys), a possible discrimination event is caused. If the vehicle passes tests of program SEE for possible occlusion of view due to nuclear environment, a message indicating discrimination (code 5) is sent. If the vehicle does not pass the tests, a new discrimination time is computed, and the observation event process 6 is recaused.

Case 7—Exit from Volume

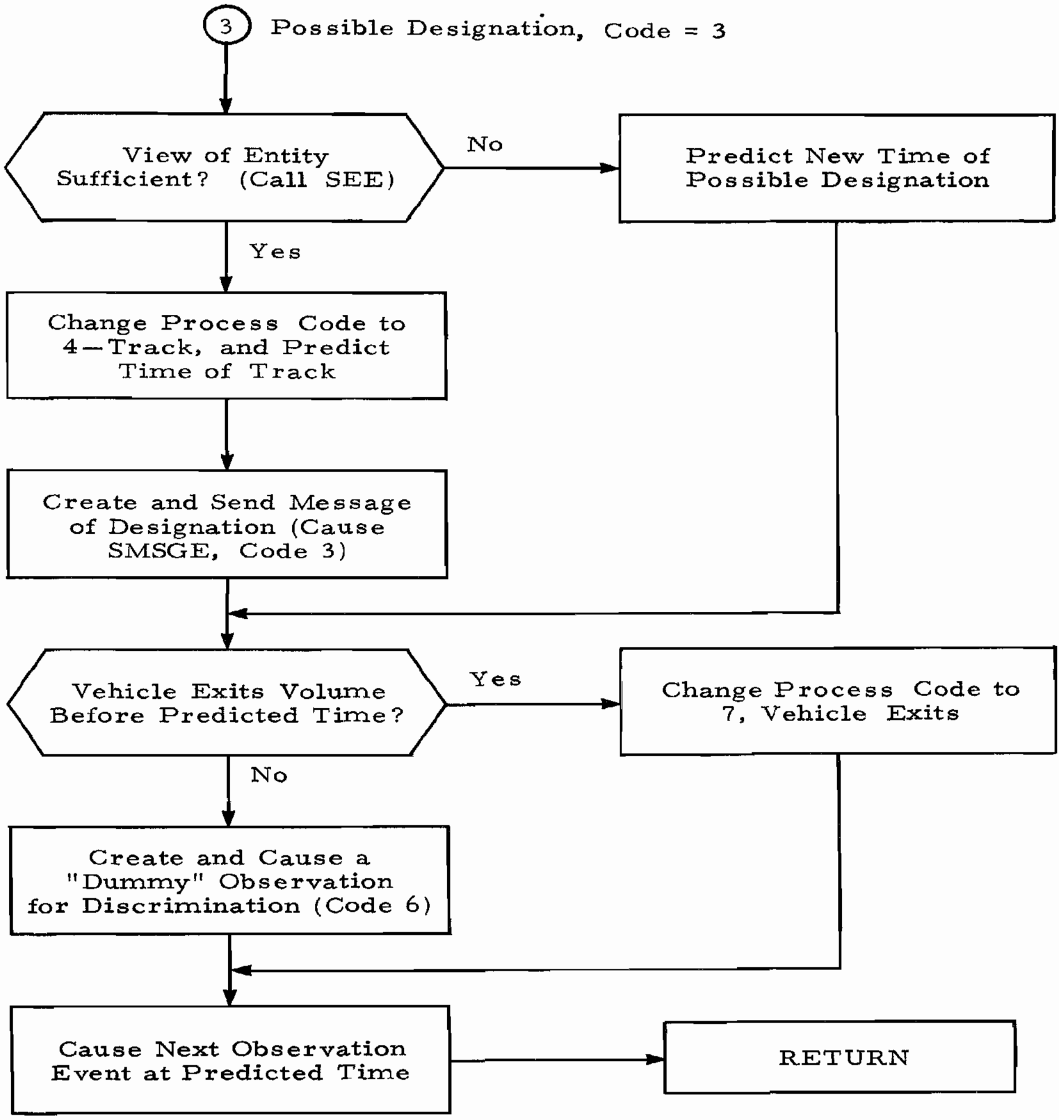
When a vehicle exits from a volume, a message of code 7—Exit is sent, the observable is removed from memory, command ownership records are erased, and notes regarding occlusions by bursts are removed.



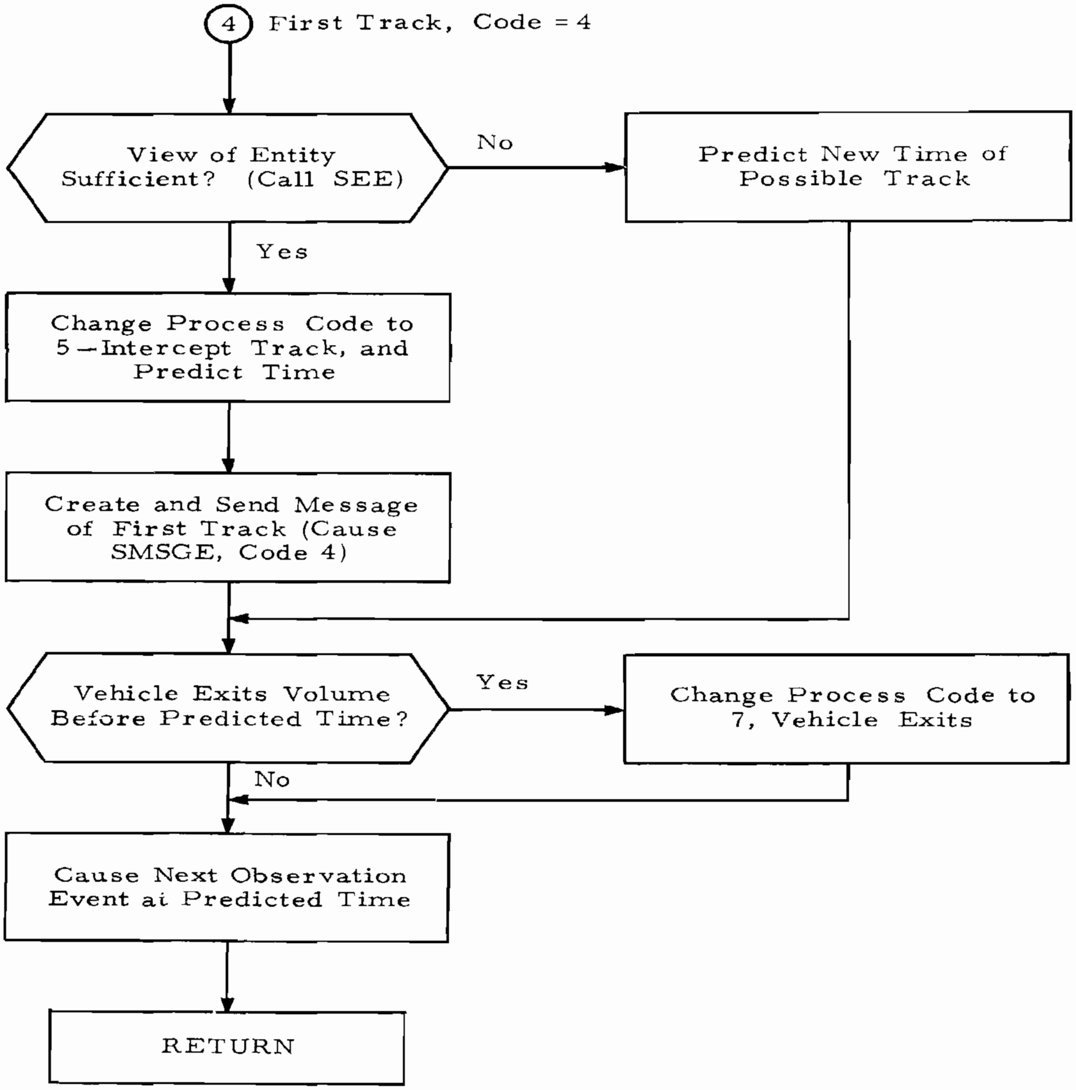
ENDOGENOUS EVENT — OBSER



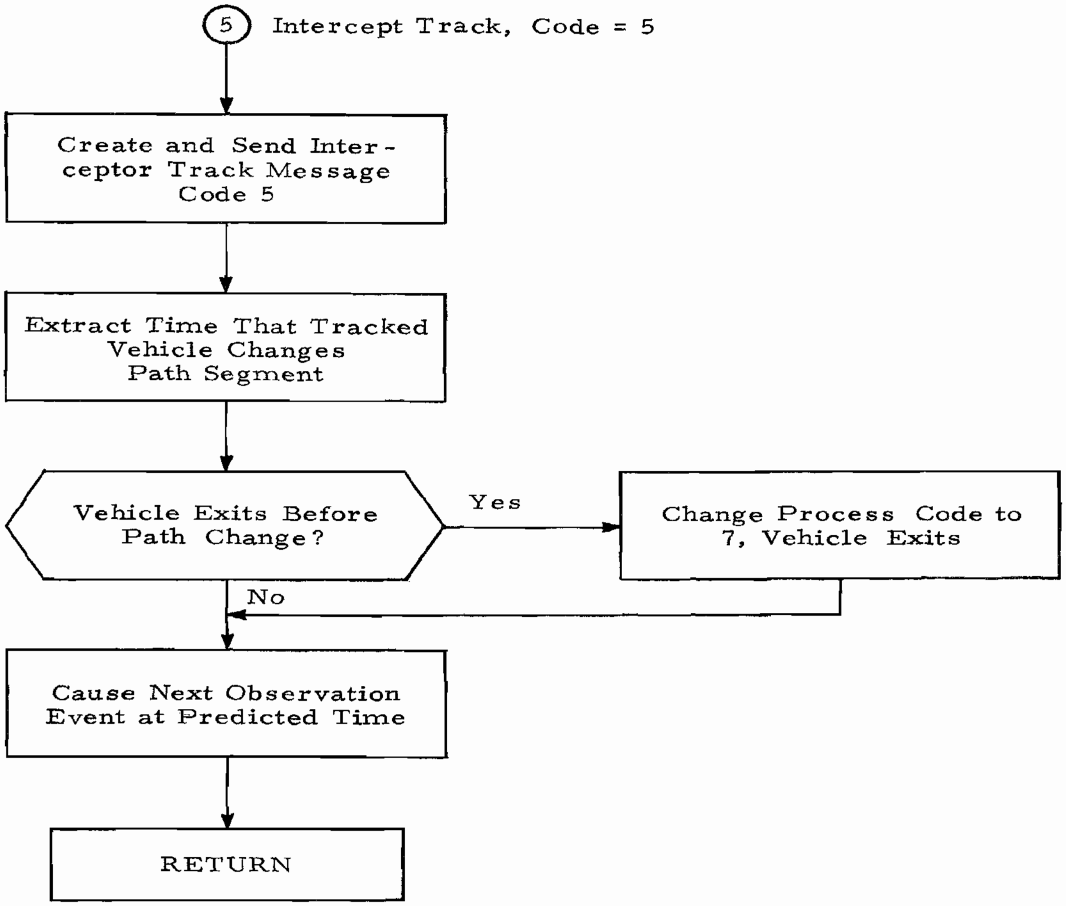
ENDOGENOUS EVENT — OBSER (Continued)



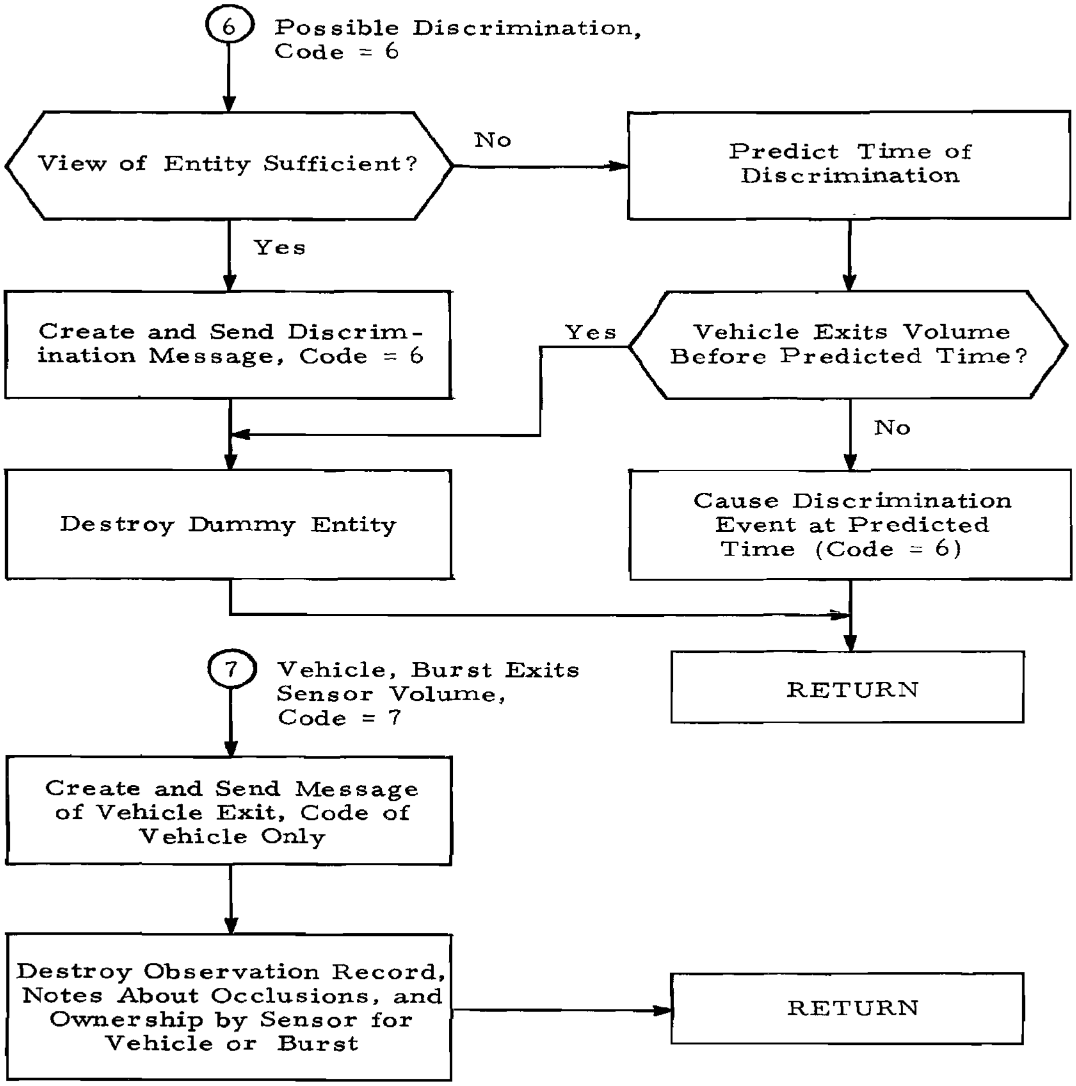
ENDOGENOUS EVENT — OBSER (Continued)



ENDOGENOUS EVENT — OBSER (Continued)



ENDOGENOUS EVENT — OBSER (Continued)



ENDOGENOUS EVENT — OBSER (Continued)

EXOGENOUS EVENT ORDER
ORDERs from Higher Headquarters

Discussion of Usage

This event causes a message to be created and transmitted for the launching of a missile or bomber. It is also used to position bombers and fighters at airfields.

Input Arguments

Event input data as follows:

- Exogenous event type (set to 001)
- Simulation hours
- Simulation minutes
- Simulation seconds

MT = Code for message subclass
MORIG = Identification (index) of originator of message
MDEST = Identification (index) of destination of message
MPAR1 = Index of launch site
MPAR2 = Index of path sent to fly
MPAR3 = Number of vehicles to create (for fighters and bombers)

Output

A message is created causing vehicle launching or positioning.

Message Parameters for Launching

MPAR1 = Index launch site
MPAR2 = Address of the first segment of a path that the vehicle is to "fly"
MPAR3 = Index of launch window (if any)
MPAR4 = Time of launch (set to zero if "launch when ready")

Message Parameters for Positioning of Fighters and Bombers

MPAR1 = Identification index of site
MPAR2 = Address of first path record
MPAR3 = Number of vehicles to position

Other Message Parameters

MCLAS = MT + 300, where
MT = 1 — Launch order
4 — Position fighter or bomber

MORIG = Index of site where message originates (input)

MDEST = Index of site where message terminates (input)

MCONT = Control record index that defines message processes

MCOMM = Address of a record showing command to which this message belongs

MTYPE = Subclass of message destination site

Subroutines and Functions Called

None.

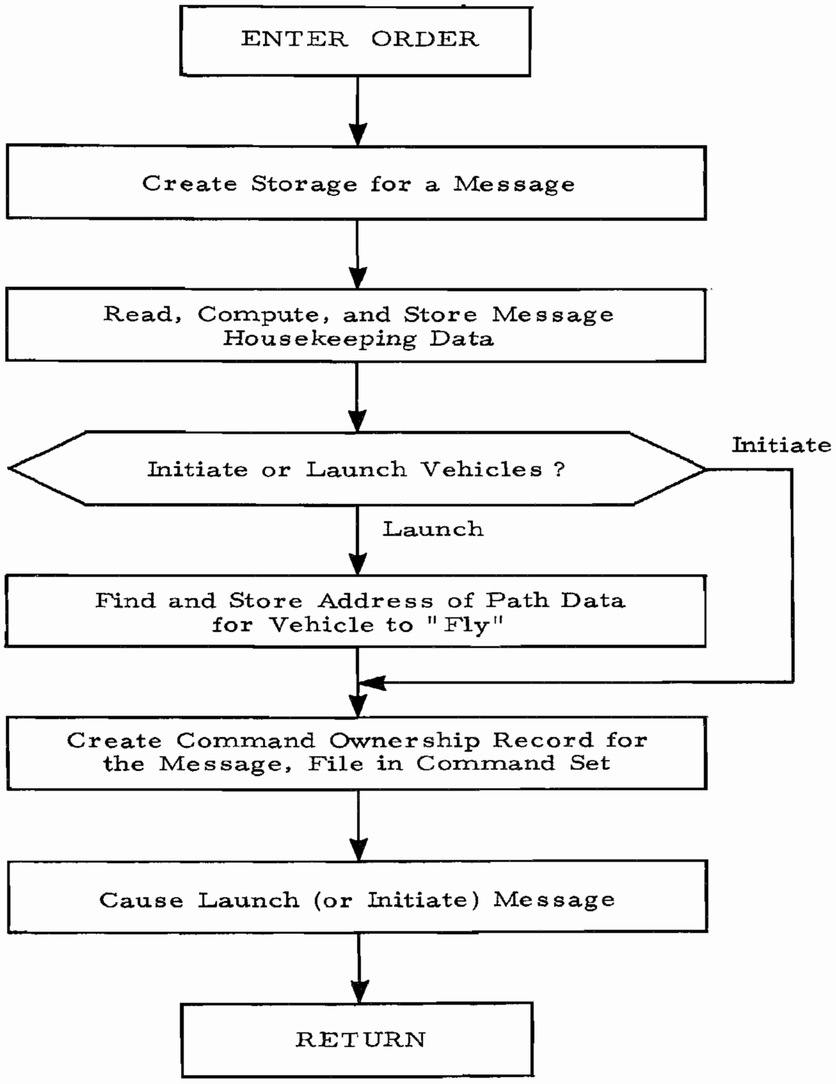
Methodology

An event "card" (or card image on magnetic storage device) is read, a message data store is created, and the data is saved for further use. The index number for control of the message is found and the program branches according to the kind of message.

If the message is for launching a vehicle, the address of path data is found, the launch site index is stored, and a record for command ownership is created.

For positioning fighters and bombers, the site index is stored, along with the number of vehicles to position and a command ownership record is created.

In both cases, the message for launch or positioning of vehicles is sent to the destination site. The message handling routines, events LMSGE and IMSGE, perform the appropriate functions for launching or positioning of vehicles.



EXOGENOUS EVENT — ORDER

EXOGENOUS EVENT PDATA
Path DATA

Discussion of Usage

This event reads and stores flight path data for all types of vehicles. A flight plan, herein called a path, may consist of up to 99 segments. The path data may also be used for movement of burst entities.

Path data is input in the form of one or more batches, where each batch contains data for the overall mission for a vehicle and all its subsidiaries. A batch consists of one header card and up to 99 groups of trailers for each path segment.

Input Arguments

Event Input Data

Exogenous event type (set to 002)
Simulation hours
Simulation minutes
Simulation seconds
Index of launch site
Class of launch site
PTYPE = Code for type of path representation (see KINEM)
PNEXT = Index of next path segment
PALTN = Index of alternate (subsidiary) path segment
PPROC = Code for type of process
PVALU = Relative value of vehicle while in this path segment
PLOCX = Location (longitude) of object at end of path segment
PLOCY = Location (latitude) of object at end of path segment
PLOCZ = Location (altitude) of object at end of path segment
PDURA = Time duration of this path segment
PPAR1 = Parameter No. 1
PPAR2 = Parameter No. 2
PPAR3 = Parameter No. 3
PPAR4 = Parameter No. 4
PPAR5 = Parameter No. 5

} See Program KINEM and Table C-13, Path Types and Parameter Meanings

EXOGENOUS EVENT PDATA (Continued)

PPAR6 = Parameter No. 6	}	See Program KINEM and Table C-13, Path Types and Parameter Meanings
PPAR7 = Parameter No. 7		
PPAR8 = Parameter No. 8		

Output

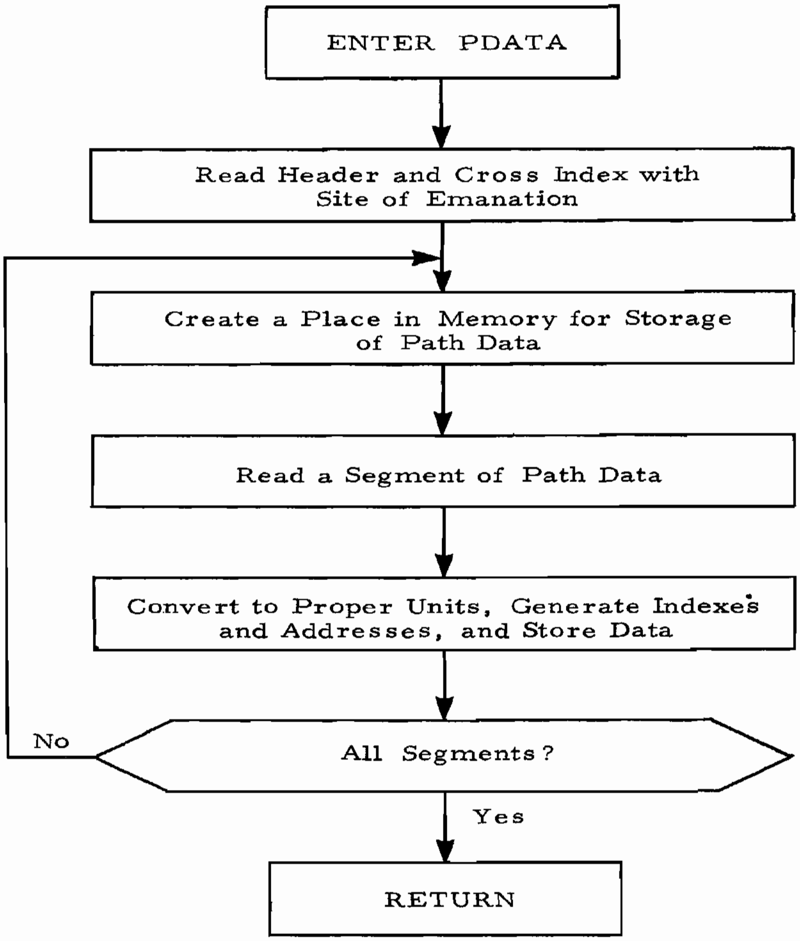
Path data are stored in memory such that the first address of a first path segment is available, and that following segments and subsidiary branches are internally addressable.

Subroutines and Functions Called

None.

Methodology

A batch of path data are read from cards or external storage devices, converted to proper units as necessary, and cross indexed to the sites from which the path emanates.



EXOGENOUS EVENT — PDATA

SUBROUTINE PROMPT (II, JJ, A, D, G, T, X)
PROMPT Nuclear Effects

Discussion of Usage

This subroutine computes the detonation-created dosage levels of prompt nuclear effects on a game entity. The dosage levels at an entity location are computed for gamma, X-ray, and neutron radiation.

Input Arguments

II = Address of burst record
JJ = Address of entity
A = Elevation of entity relative to burst
D = Distance from burst to entity

Two types of function tables are used:

- Atmosphere density (as function of altitude regime)
- Mass attenuation (for each type of radiation)

Output

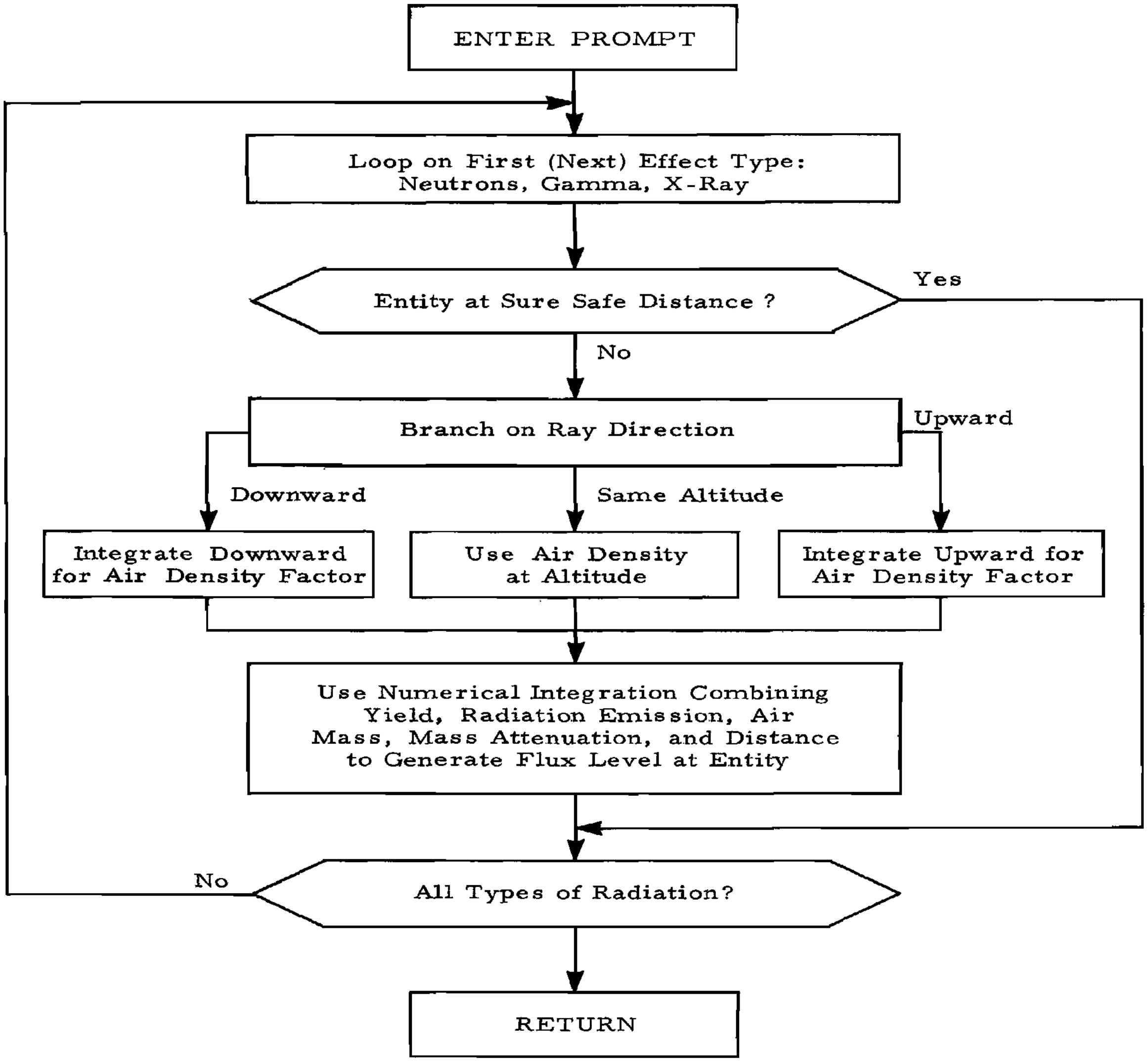
G = Neutron flux
T = Gamma flux
X = X-ray flux

Subroutines and Functions Called

INTERP = Interpolate between table entries

Methodology

Based on the altitudes of burst and an entity, the average density of air between them is computed. The density factor and the distance between burst and entity are then combined to yield mass of atmosphere that would attenuate the nuclear radiations. The yield of the weapon is then used with a mass attenuation factor and distance between burst and entity to generate the flux level of the particular kind of radiation the entity would receive. The process is used for computation of three types of radiation, using the appropriate mass attenuation function table for each type.



SUBROUTINE — PROMPT

SUBROUTINE REMOVE (II, JJ)

REMOVE Entity and Associated Records

Discussion of Usage

This subroutine removes an entity and associated records from further participation in the simulation. Indices are also adjusted as appropriate.

Input Arguments

II = Address or index of entity to be removed

JJ = Code for class of entity (see Table C-11 in code documentation)

Output

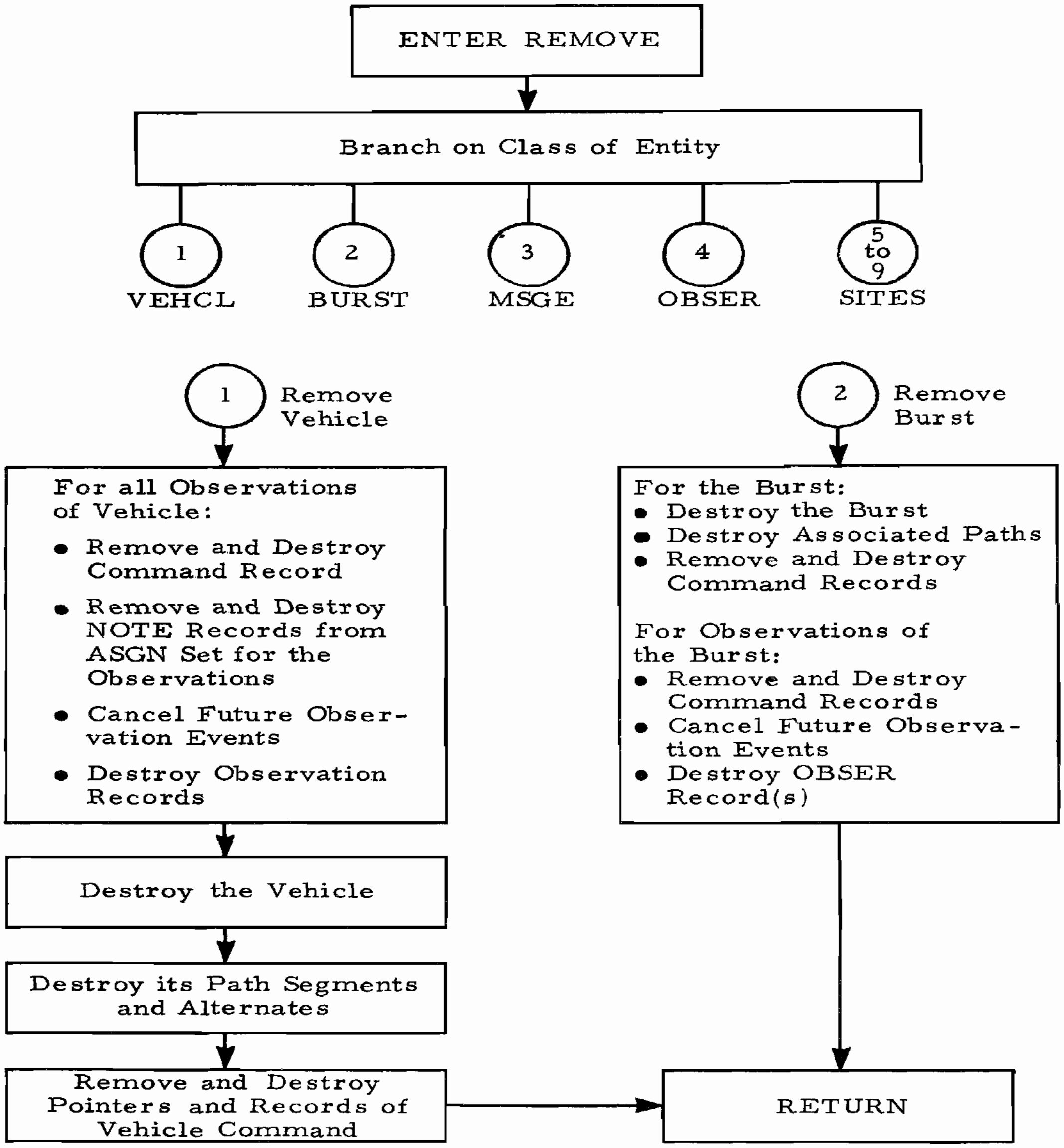
- Entity II is removed from the simulation and its storage is returned for other use
- Associated records and indices are removed and adjusted as appropriate

Subroutines and Functions Called

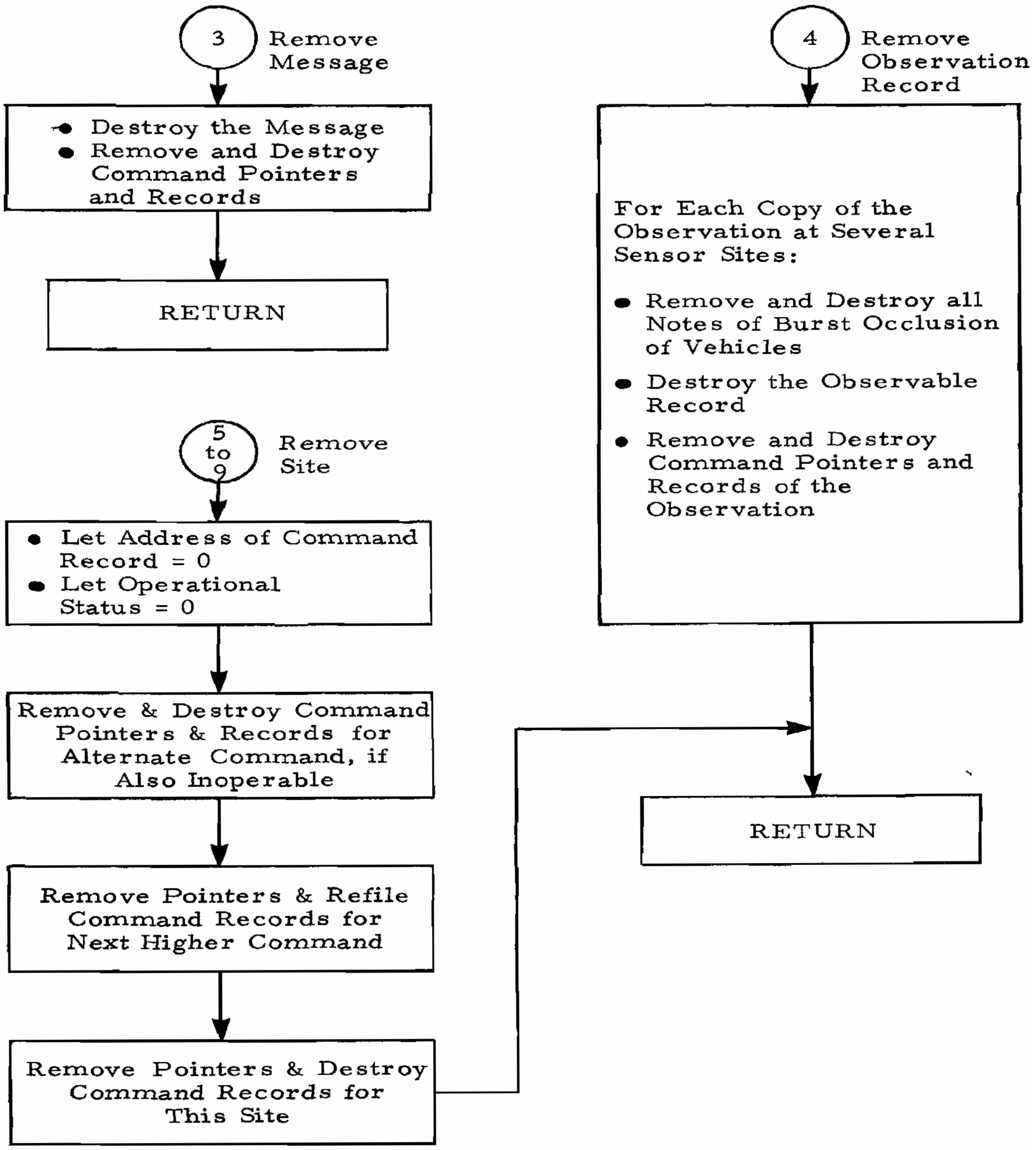
None.

Methodology

The program branches to the logic that removes the entity itself and associated records, and adjusts indices as appropriate to the class of entity. The SIMSCRIPT System verb "DESTROY" removes only one entity as specified. In this simulation, the logic of removing an entity involves associated records and indices.



SUBROUTINE — REMOVE



SUBROUTINE — REMOVE (Continued)

FUNCTION SEE(II,T,IG,ID)
Time at Which a Radar Can First SEE an Object

Discussion of Usage

This function determines the time at which an object is seen, or escapes from view (blackout) of a sensor in a nuclear environment.

Input Arguments

II = Address of an observation (OBSER) record for a vehicle that is within a sensor's range

T = Start time for search

IG = Switch to define mode of program use

1 — Find time of first sight
2 — Find time of first blackout

ID = Switch to define removal of notes about previous occlusions

1 — Destroy "old" notes
2 — Do not destroy notes

- Data from "Note" record for each sensing occlusion experienced by the vehicle observation (Notes are filed in the ASGN set)

NTIM1 = Time vehicle enters burst cone of possible occlusion In order to facilitate review of all bursts that may occlude a vehicle, the "notes" are rank-ordered by this value:

NTIM2 = Time blackout starts

NTIM4 = Time blackout ends

NTIM5 = Time out of burst cone of possible occlusion

NPAR1 = Range of vehicle at entry into cone

NPAR2 = Range at exit

NPAR3 = Indicates that note values have been previously computed

NPAR4 = Rate of change of attenuation (SLOPE) entry

NPAR5 = Range of change of attenuation (SLOPE) at exit

NTYPE = Type of note = 1, interference of a sensor sensing a object due to nuclear burst

FUNCTION SEE (Continued)

Output

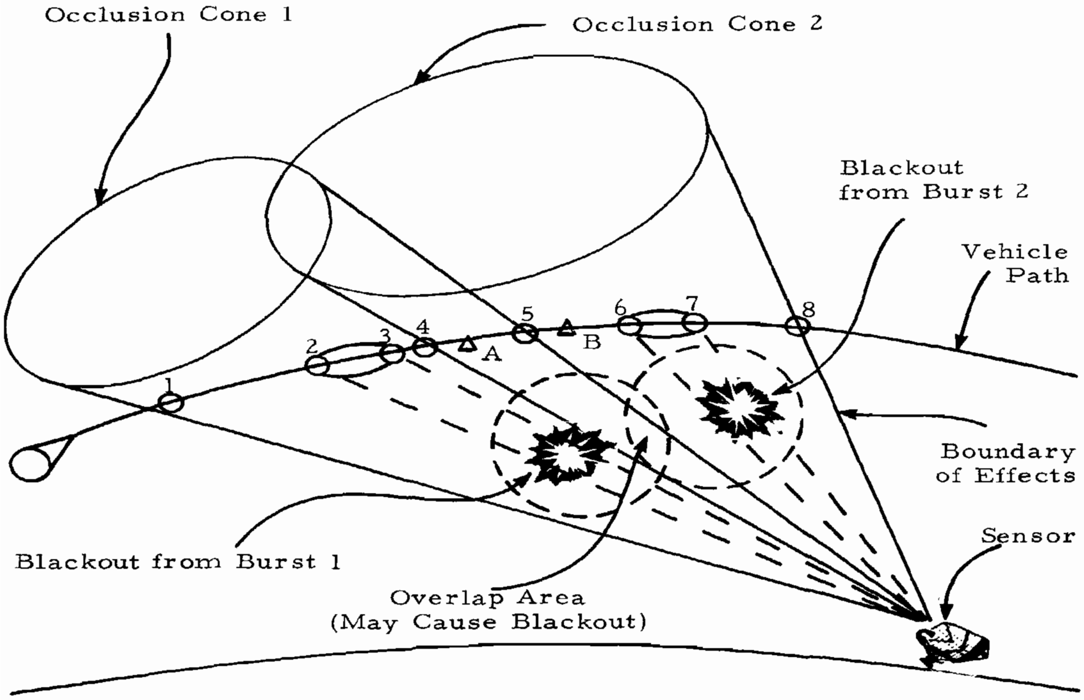
- SEE = Time of first see, or blackout
- "Old" notes destroyed (if requested)

Subroutines and Functions Called

AMOD = To determine the time interval during which a vehicle cannot be seen by a radar because of interference due to particular nuclear burst. AMOD computes the NOTE parameters described above.

Methodology

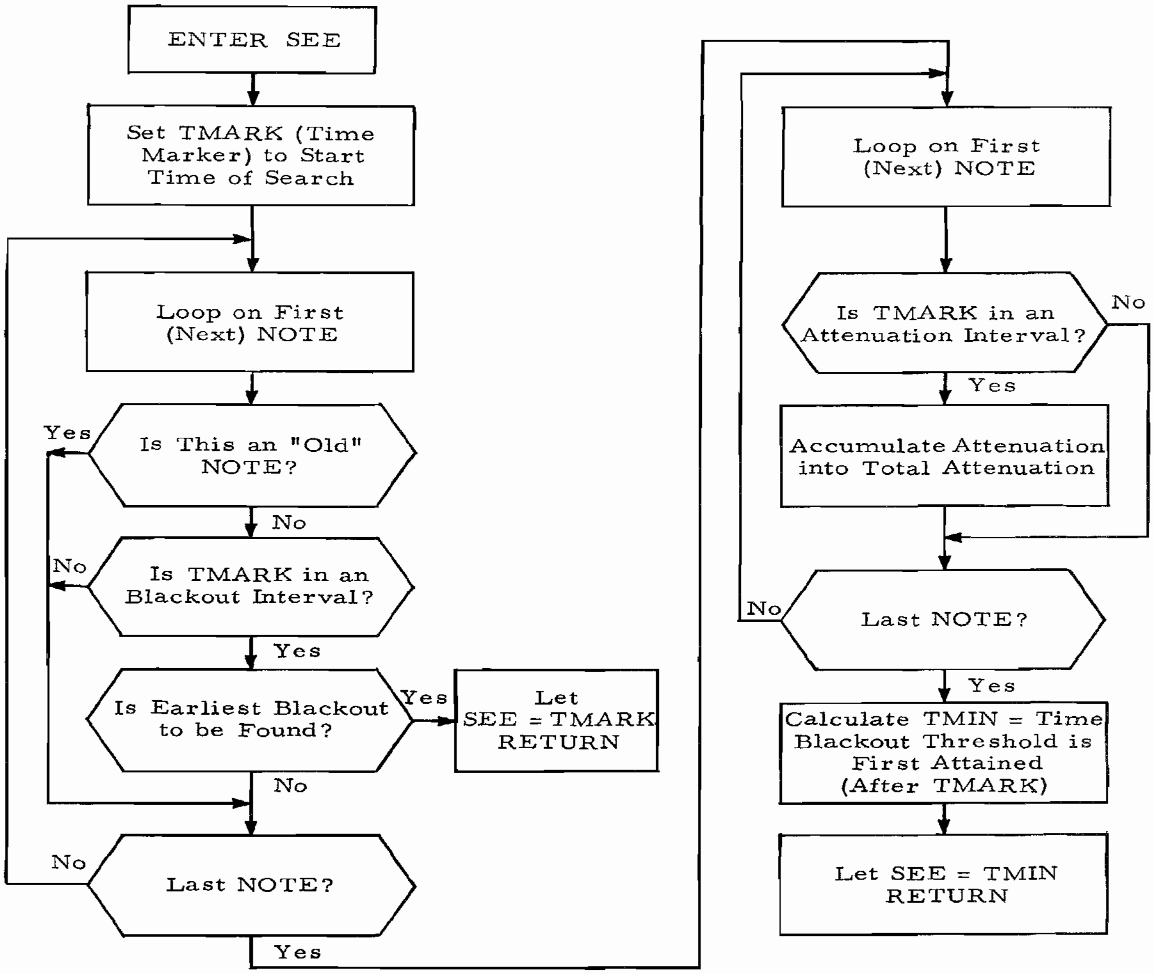
The program reviews each note of occlusion in time order along a vehicles path. If occlusion cones overlap along the path, the multiple effects of more than one burst are considered to define the blackout time along the vehicles path. The timing of an observation event is defined when the time within view is equal to or greater than a specified amount.



VEHICLE OCCLUSION FROM SENSOR VIEW

Note	Point	Description
1	1	Vehicle enters 1st cone of effects
1	2	Vehicle blacked out, burst 1 (alone)
1	3	Vehicle exits blackout region, burst 1
2	4	Vehicle enters 2nd cone of effects
1	5	Vehicle exits 1st cone of effects
2	6	Vehicle blacked out by burst 2
2	7	Vehicle exits blackout by burst 2
2	8	Vehicle exits 2nd cone of effects

Points A and B are computed as blackout regions due to multiple burst effects, time between point 3 and point A, point B and point 6 are regions of visibility. Program SEE computes these regions and sums the time within them and defines the time of observation such that the total time of visibility is equal to or greater than time required for a particular type of observation.



FUNCTION — SEE

SUBROUTINE SENSE(II,JJ)
Bursts and Vehicles That Enter Sensor (SENSE) Volumes

Discussion of Usage

This subroutine determines when a particular vehicle or burst entity enters and exits sensor volumes of view. The program is called whenever a vehicle or burst enters a new process.

If an entity enters a volume an observation notice "OBSER" is created and an event of an observable-enters-volume (OBSER event) is caused at the time of entrance. If the entity traverses more than one sensor volume during its current (next) process, additional observation records and events are created and caused.

Entities that are observed by more than one sensor are filed together in a set known as "COPY" so that the several OBSER records of a single entity may be addressed as a group.

Input Arguments

II = Address of entity being tested for entering sensor volumes

JJ = Class of entity

1 —Vehicles
2 —Bursts

Output

Observation record OBSER is created for each entrance of a vehicle or burst into a sensor volume.

OCONT = Identification of control record for the observation process

OIDEN = Address of the observed burst or vehicle

OCLAS = Class/subclass of observed object

1XX—Vehicles class/subclass
2XX—Burst class/subclass

OFACT = Signal noise threshold for blackout of vehicle

OSENS = Index of sensor site

OENTR = Time of entrance into volume

OSTOP = End of time for current observation process (also time of entrance into volume)

SUBROUTINE SENSE (Continued)

OEXIT = Time entity exits volume

SCOPY = Next observation record for this entity if seen by more than one sensor

Subroutines and Functions Called

FILT = To remove from consideration entities that could not interact

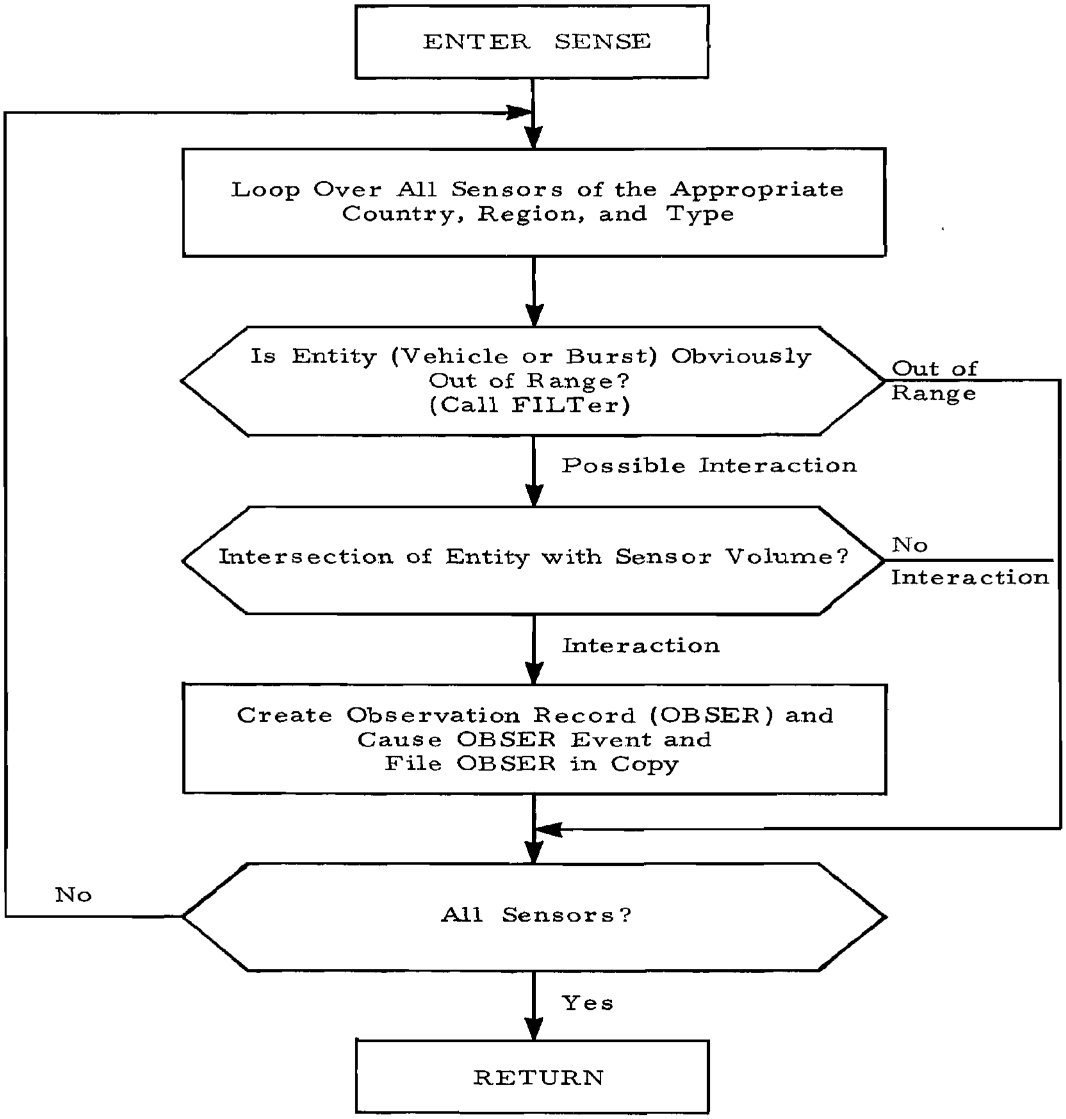
VOLUME = To compute the time and place of entrance and exit of an entity and a volume

Methodology

Program SENSE is called whenever a vehicle or burst enters a new process. The program searches out all appropriate sensor volumes and calls the geometric routine "VOLUME" to compute the time that the entity enters and exits each volume. At the instant of each entrance an observation event is caused.

This logic triggers the observation processes for simulation of the details of multisensor activity:

- Observation records for vehicles that enter more than one sensor volume of view are strung together in set COPY
- Observation records for bursts that occlude more than one sensor are also strung together in set COPY
- Knowing the index of a sensor site, all vehicles and bursts in its field of view can be addressed at any time



SUBROUTINE — SENSE

ENDOGENOUS EVENT SMSGE
Sensor MeSsaGE

Discussion of Usage

Event SMSGE contains the logic regarding the transmission delay, receipt, and processing of messages from sensors to command and control sites. Sensor messages go through two processes:

- Communications delay
- Posting of sensing status at a command site

The sensing message event is designed to simulate the transmission of messages regarding sensed objects, as viewed by sensors, to allow command and control knowledge of dynamic game events. When messages are posted, SMSGE may call manned interceptor or missile defense algorithms.

Input Arguments

Event Notice SMSGE

MARRT = Message arrival time

MCLAS = 302—Reports of radar sensing events

MCONT = Index of process control record; identifies one of the following process types:

1—Communications delay
2—Posting of change of sensing status at command site

MCOMM = Address of record for command membership

MORIG = Message origin

MDEST = Message destination

Message Parameters

MPAR1 = Address of vehicle record

MPAR2 = Address of observation record (vehicle data as observed)

MPAR4 = Sensing status code:

2—Acquisition
3—Designation
4—Threat tracking
5—Intercept tracking
6—Discrimination

ENDOGENOUS EVENT SMSGE (Continued)

Output

MCONT = Index of next process control record

MDEST = Alternate command (if original destination is dead)

OPOST = Sensing status code in observation record, OBSER (Integers x powers of 10)

Recause of SMSGE as appropriate

Subroutines and Functions Called

FDEFND = Algorithm for fighter defense

MDEFND = Algorithm for missile defense

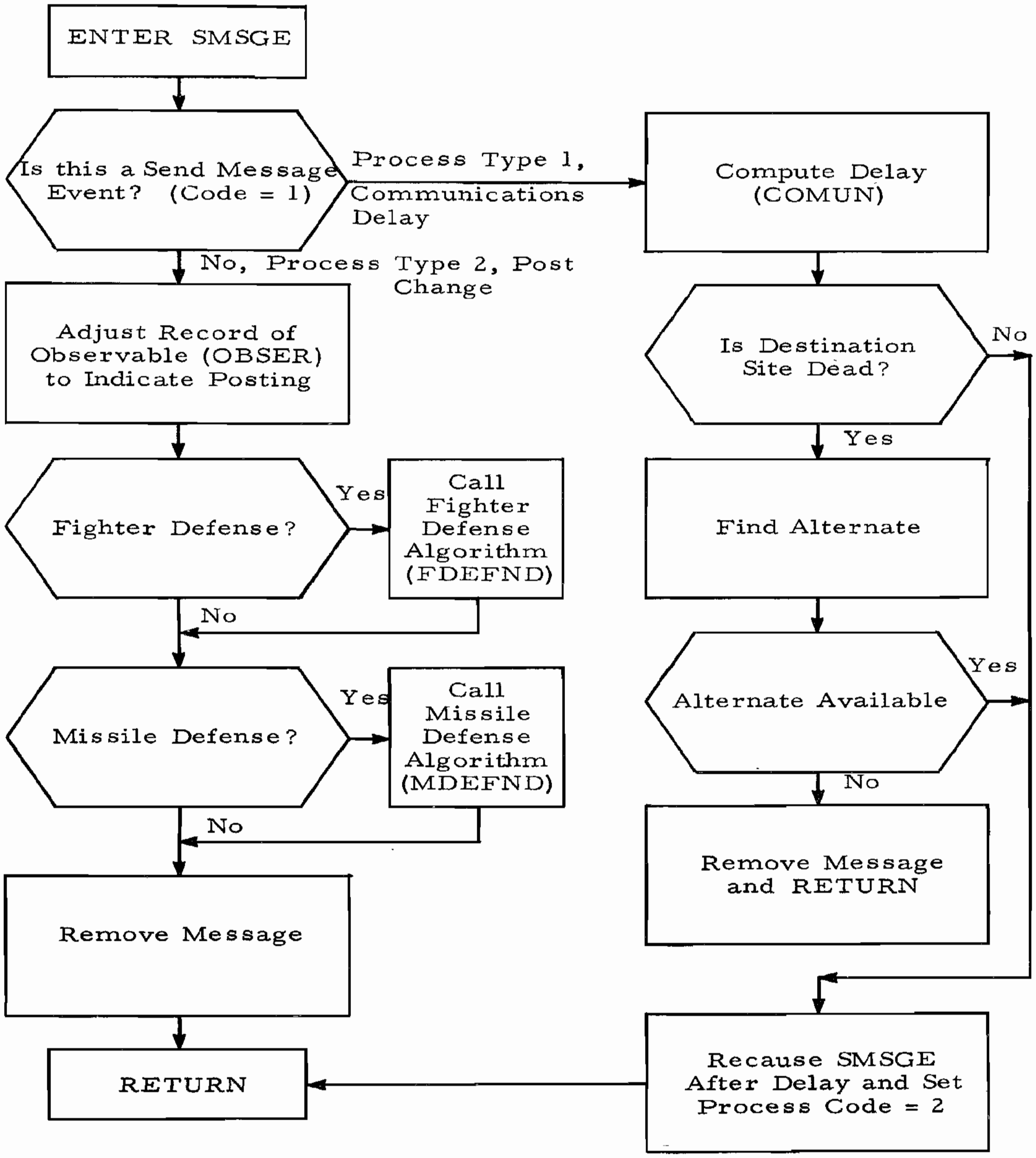
FILT = To remove from consideration entities that can not interact in a defensive manner

NETWRK = To move the sensor message to the next control process

COMUN = To compute communications delay

Methodology

SMSGE is an event that simulates the processes of a message about a sensed object. First, a communications delay is computed for sending a message to either designated command site or its alternate. When the message arrives, it is "posted" at the proper command site and defensive algorithms are invoked. A sense message may be sent for changes in acquisition, designation, tracking, or discrimination of observed objects. Each of these changes may trigger variations of defensive logic.



ENDOGENOUS EVENT — SMSGE

FUNCTION TOF(II,X,Y,Z)
Time Of Flight

Discussion of Usage

This function determines the time of flight from a defensive missile site to a designated target point for a given type of missile.

Input Arguments

II = Index of defensive missile site
X = Longitude of target point
Y = Latitude of target point
Z = Altitude of target point

From the Site II data:

- Type of missile
- Latitude, longitude, and altitude of site

Output

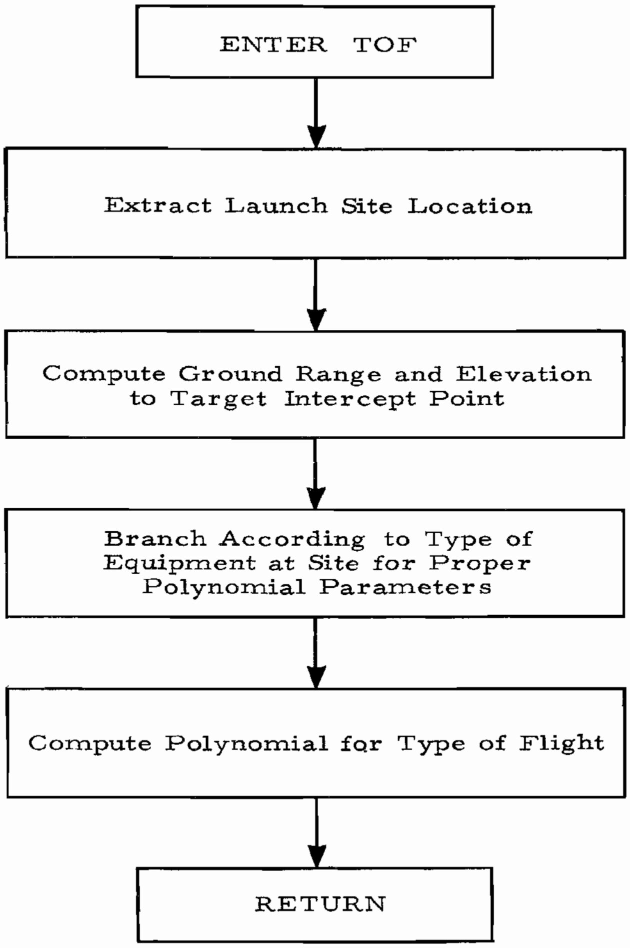
Time of flight from site (launch point) to target point.

Subroutines and Functions Called

None.

Methodology

Given the points of launch location and target intercept location, the program computes the ground range and elevation of the target. According to the type of missile, appropriate parameters of a polynominal expression are used, the polynominal is computed and the time of flight is generated.



FUNCTION — TOF

SUBROUTINE TRACE(II,JJ,LWHEN)
TRACE Events

Discussion of Usage

Subroutine TRACE may be used by any of the event routines to obtain a printout of pertinent parameters of the event. This subroutine can be used to generate a "history of events" for use by the postprocessor even though the program is principally designed for debugging purposes.

Input Arguments

II = Address of the attributes that describe a game event
JJ = The event routine number (see listing of subroutine ERROR for subroutine numbers)
IWHEN = Code for type of printout desired
0 — Output of event data at the instant preceding an event
1 — Output of data at the instant following an event

Output

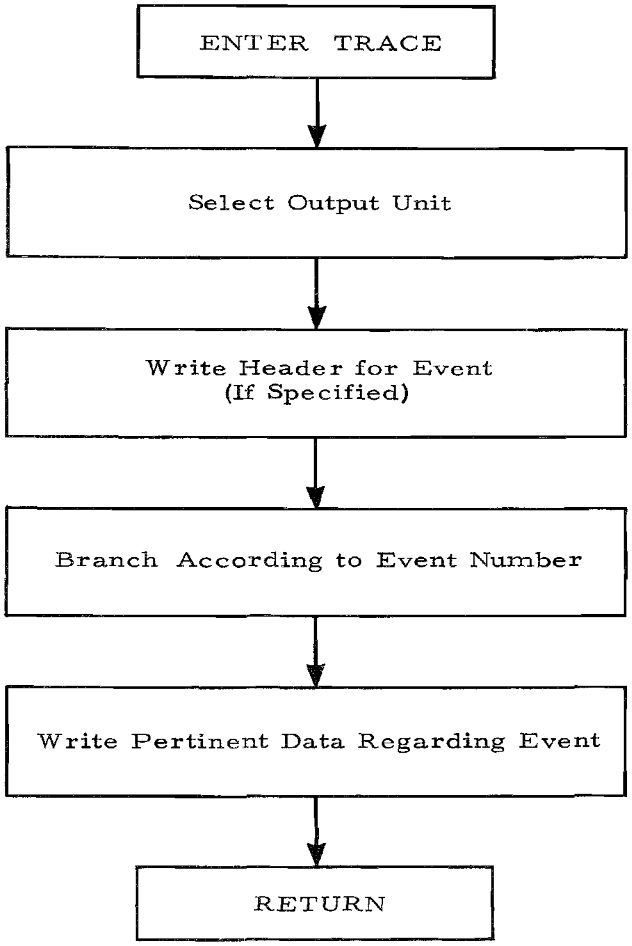
Selected event data presented to external equipment for output.

Subroutines and Functions Called

ERROR = Prints trace heading when I = 0

Methodology

The program branches according to the type of event to trace and writes out pertinent data about the event on the designated output unit.



SUBROUTINE — TRACE

SUBROUTINE TRANS(PD,PX,PY,PZ,QX,QY,QZ)
TRANSform to Local Coordinates

Discussion of Usage

Subroutine TRANS computes the azimuth, elevation, and range of a point Q relative to a point P, where P and Q are given in earth coordinates.

Input Arguments

PD = Bearing of zero azimuth (relative to north) of the local coordinate system

PX = Longitude of point P

PY = Latitude of point P

PZ = Altitude of point P (height above mean earth radius)

QX = Longitude of point Q

QY = Latitude of point Q

QZ = Altitude of point Q (height above mean earth radius)

Output

QX = Azimuth of point Q relative to bearing of principal axis of local coordinate system centered at P

QY = Elevation angle of point Q relative to local horizon

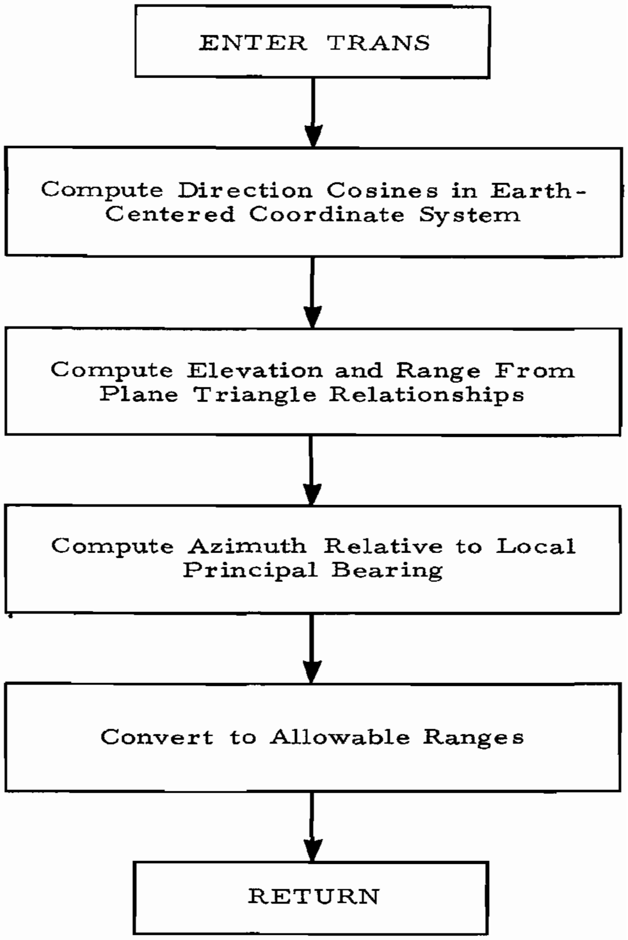
QZ = Range of point Q from point P

Subroutines and Functions Called

None.

Methodology

The earth centered direction cosines are computed and the cosine rule for plane triangles is applied to compute the range from point P to Q. The cosine rule is then applied to compute the elevation of point Q relative to point P. Napiers analogies are then used and the bearing of point Q relative to the local principal bearing emanating from point P is computed. The program considers special cases of relative azimuth, elevation angle, and range, and converts output to allowable ranges.



SUBROUTINE — TRANS

EXOGENOUS EVENT VDATA

Volume DATA

Discussion of Usage

This routine reads elevation and range points for azimuth slices to define the surface boundary of an indicated volume. These data must be read in at simulation time = 0 . Volume boundaries may be exogenously adjusted at any time.

Input Arguments

- Header Card

  Exogenous event type = 004
  Simulation hours = 0
  Simulation minutes = 0
  Simulation seconds = 0
  Index of volume to apply point data

- Trailer Cards for Each Point on the Volume Surface

  Volume slice number (index to azimuth value to which elevation and range points are applied)
  Elevation angle of point (relative to local horizon)
  Range of point relative to center of volume

- End of Volume Description

  A card with blanks in columns 1 through 4 indicates end of volume surface description

Output

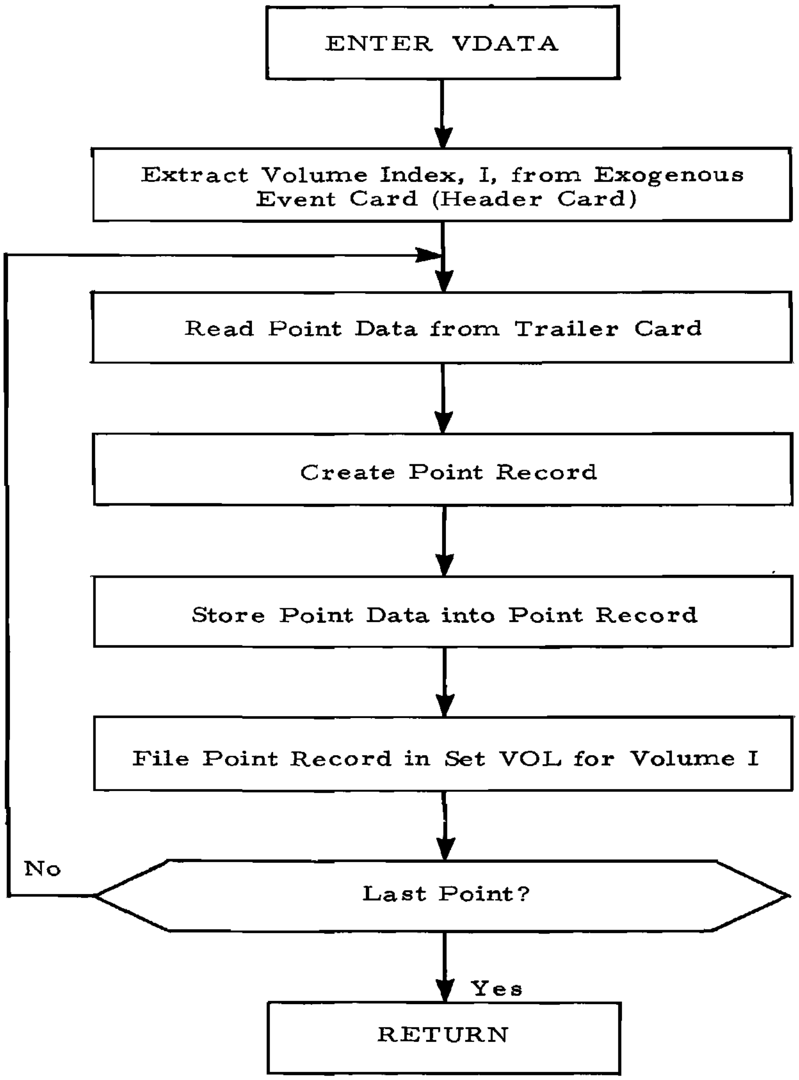
The elevation and range points are associated with each slice in the indicated volume. At least two points are needed for each volume slice.

Subroutines and Functions Called

None.

Methodology

The program reads the elevation and range data for each point on the edge of a volume azimuth slice for each slice in the indicated volume. The elevation and range data are filed in a point set known as VOL so that points, slices, and volumes are cross referenced.



EXOGENOUS EVENT — VDATA

SUBROUTINE VOLUME(II,IC,JJ,KK,VIN,VOUT,TIN,TOUT)
Enter and Exit VOLUMEs

Discussion of Usage

This subroutine determines the times and points along path segments of entry and exit of volumes by vehicles or by fireballs.

The program has three modes of operation:

- Vehicle enters/exits sensor volume of view, defensive battle space, or dust cloud
- Vehicle enters/exits "cone-of-occlusion"
- "Fireball" enters/exits a sensor volume of view; (The "fireball" entity is dimensioned to include the volume of affected air that could occlude a vehicle from a sensor.)

Input Arguments

II = Address of vehicle or fireball

IC = Mode of use:

- 1 — Compute vehicle entrance/exit of a volume, or (if KK = 4) vehicle entrance/exit of a burst occlusion cone
- 2 — Compute burst "occlusion cone" entrance/exit of volume

JJ = Index or address of entity owning volume

KK = Class of owner of volume:

- 2 — Burst (dust cloud)
- 4 — Observation record for a fireball
- 5 — Defensive missile site
- 7 — Sensor site

TIN = Switch for computation cycle; if TIN = 1 , do not compute entry point

TOUT = Switch for computation cycle; if TOUT = 1 , do not compute exit

Output

VIN = Fraction of path segment of entity as it enters a volume

VOUT = Fraction of path segment of entity as it exits a volume

TIN = Time entity enters

TOUT = Time entity exits

SUBROUTINE VOLUME (Continued)

If no entry, VIN and VOUT are set to -99 ; TIN and TOUT are set to game time.

Subroutines and Functions Called

KINEM	= To compute position of vehicle or burst as a function of time or fraction of segment
TRANS	= To compute azimuth, elevation, and range from one position to another
DIST	= To compute distance of a point to a volume surface along line-of-sight from volume coordinate center, or to compute angle out of azimuth
FIRBL	= To compute the radius of a burst entity as a function of time (used to define a cone of possible radar occlusion)

Methodology

The program branches according to the mode of computation. From the entity location and type, the program extracts the center-of-local-coordinates and volume surface data. The velocity of the penetrating entity is then extracted or computed for use in an iterative process to converge on points and times that the entity enters and exits the volume. The efficiency of the convergence of the iterative process depends on the ratio of the velocity extracted or computed over actual velocity during the path segment, and the directivity of approach toward (or away from) the "center" of the volume.

Mode 1—Vehicle Track Intersection with Sensor, Defensive Battle Space, or Burst (Dust Cloud)

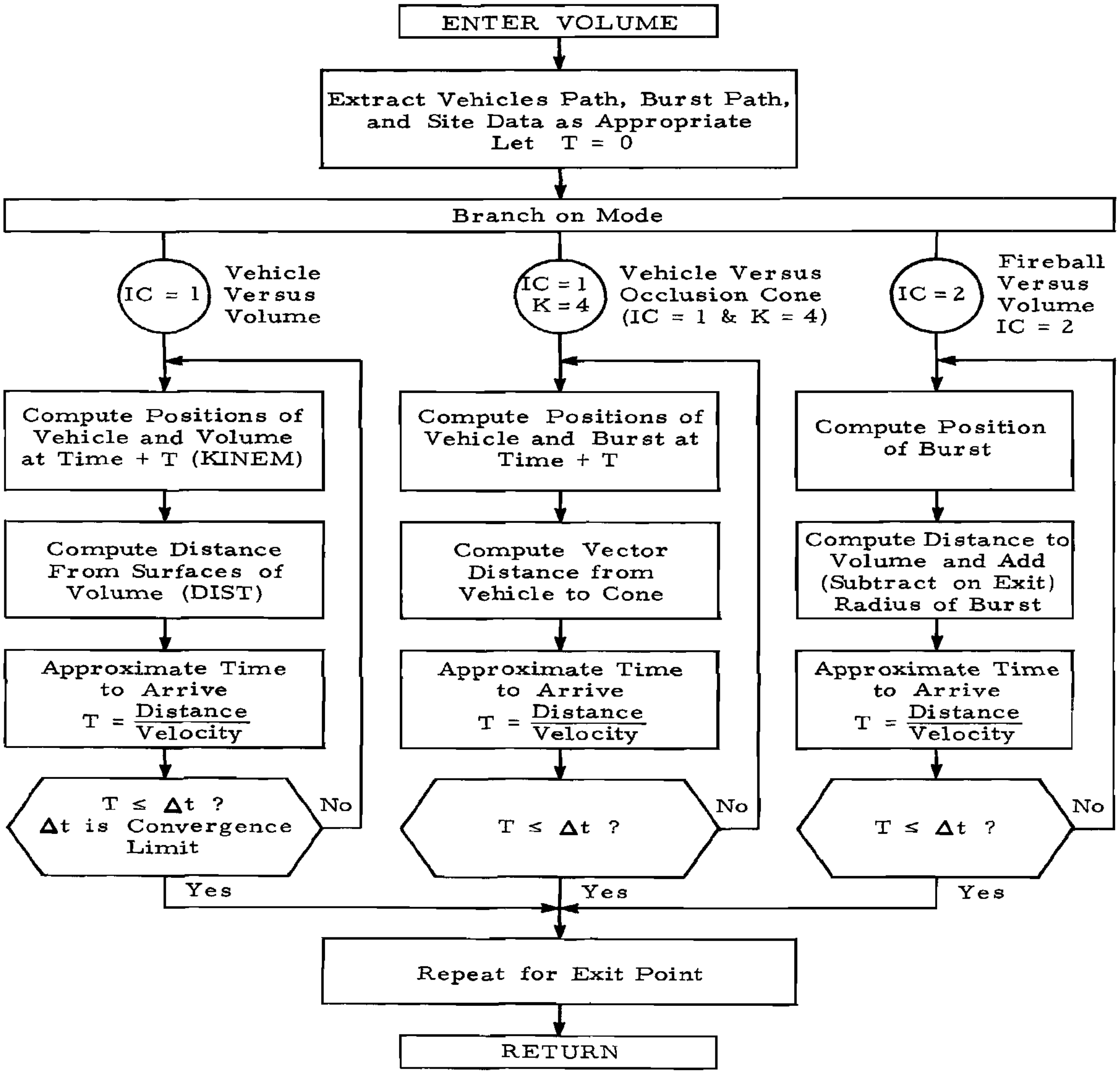
The location values of the volume "center" are extracted from a dust cloud entity, or from sensor or missile site attributes. The program computes the positions of the vehicle at time "now" and calls DIST to compute the distance of the vehicle from the surface of the volume. Using the velocity of the vehicle and the distance from the surface, a time of intersection is approximated. The distance/velocity ratio is recalculated until the time of penetration converges to within a specified limit. Note that the dust cloud movement is considered in the convergence process for the case where a vehicle enters a dust cloud. The process is then repeated for time of exit from the volume if requested.

Mode 2—Vehicle Enters and Exits Cone of Occlusion

The sensing and observation algorithms require that the times and positions of vehicles hidden by fireballs (and the associated irradiated environment in the vicinity of the fireball) be computed. In this mode of program volume, the vector to the line-of-sight (from vehicle through the burst center) along the vehicles path is computed, subtracting the effective radius of the burst cone. The program continues using a convergence algorithm based on the ratio of distance from cone surface over velocity of vehicle. The time of exit is computed in the same manner if requested. Note that the position of the cone of occlusion is "moved" and its size adjusted during the iterative process.

Mode 3—"Fireball" Enters/Exits a Sensor Field of View

The "fireball" position is computed for time "now." The distance from the fireball center to the surface of the sensor volume is computed and the fireball radius is subtracted. To find the surface-to-surface contact point, the distance over velocity ratio is computed for the moving fireball to yield approximate time of contact (or break of contact). The above process is continued until convergence to within a small time value occurs. The time of exit of the fireball is computed in the same manner as entrance time except the fireball radius is added.



SUBROUTINE — VOLUME

ENDOGENOUS EVENT WVHCL

Weapon VeHiCLe

Discussion of Usage

This event occurs at the end of a given process for a weapon vehicle such as: air-to-surface missile, free-fall bomb, antiballistic missile, and surface-to-air missile. It also signifies the start of a new process (if any) as prescribed by the path process (flight plan) data. The path processes applicable are:

- Launch initiation
- Proceed en route
- Create a burst

Input Arguments

Vehicle Event Record

VPATH = Address of current path segment record
VTYPE = Type of vehicle
VCLAS = Address of record for command membership
VORIG = Index of originating site of vehicle

Vehicle Specifications

- Probability of successful operation (used at launch initiation)
- Probability of ABM killing incoming threat

Path Record

PPROC = Type of path process (see above)
PDURA = Time duration of path process
PLOCX, PLOCY, PLOCZ = Location: longitude, latitude, and altitude at end of segment

Output

- Vehicle location adjusted
- New path process segment found (if any)
- Vehicle removed (if specified)

ENDOGENOUS EVENT WVHCL (Continued)

- Next vehicle process event caused
- Command records reranked and filed

Subroutines and Functions Called

NPATH = To search out next path segment data and create subsidiaries
EFFECT = To predict nuclear interactions for this vehicle during next path process
SENSE = To predict possible sensing of vehicle during its next path process
RFCRD = To rerank and file command membership records
MDEFND = To trigger missile defense logic

Methodology

This event logic is applied at the end of each path process. The event is divided into three sections:

- Section A—Logic applicable to end of the current path segment
- Section B—Logic applicable to determination of the next path process (if any)
- Section C—Logic associated with the next path process

Section A moves the vehicle to the end of the current process segment. Section B calls NPATH to search out the next path record and create new entities. Section C branches according to the type of next processes as follows.

Process Code 1—Launch Initiation

The program computes if vehicle passes reliability tests.

Process Code 2—Proceed En Route

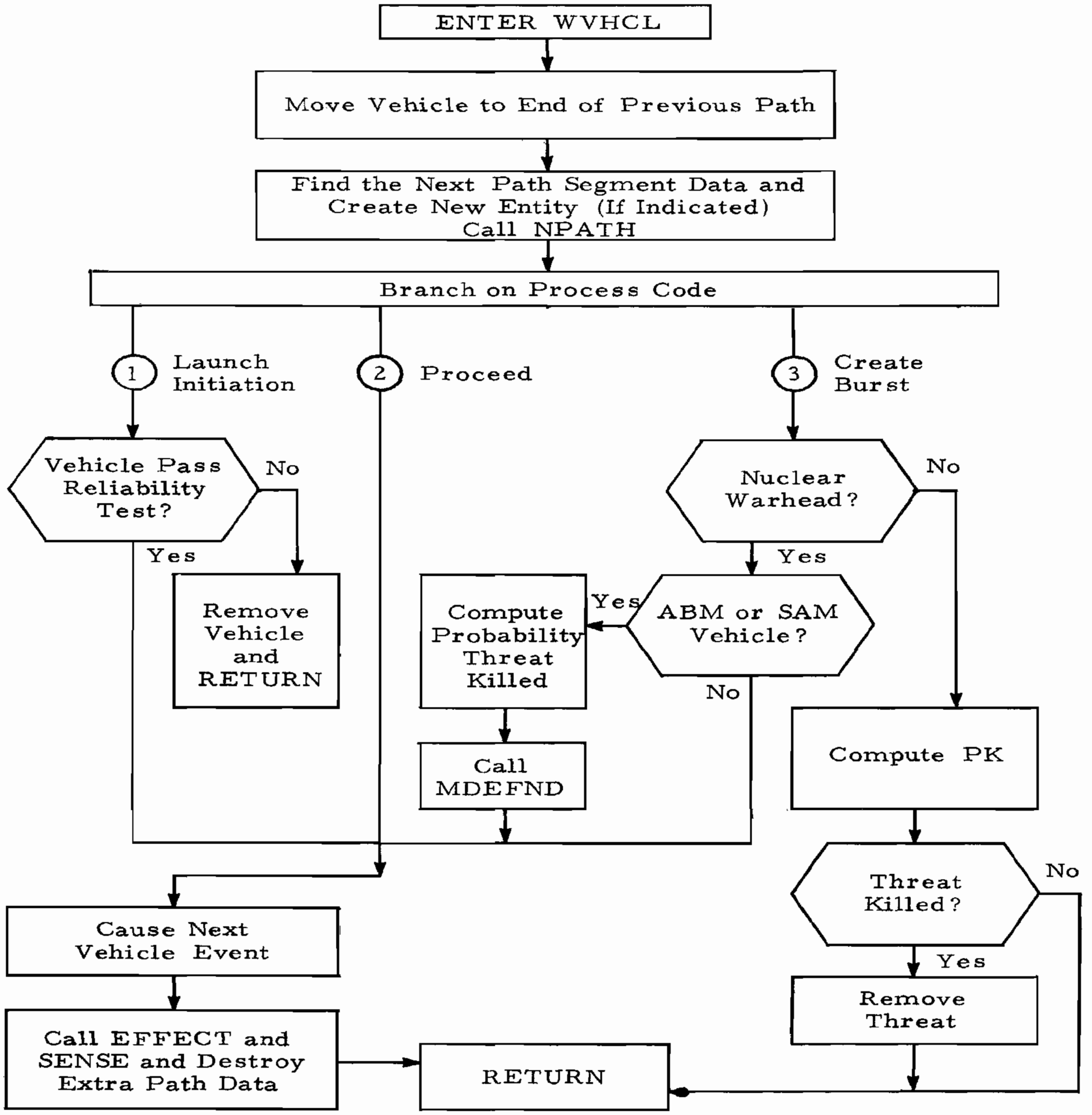
The program allows the vehicle to proceed en route.

Process Code 3—Create a Burst (or Compute Probability of Kill)

If the vehicle is an ABM, the logic computes the probability that the threat is observed as killed by the ABM, and the missile defense logic is invoked by calling MDEFND.

ENDOGENOUS EVENT WVHCL (Continued)

If required, the program completes its logic by causing the next vehicle event and predicting if the vehicle will suffer nuclear effects (lingering) or enter sensor volumes.



ENDOGENOUS EVENT — WVHCL

FUNCTION AMAX(A,B)

This function compares the values A and B and returns that one with the highest absolute value.

FUNCTION AMIN(A,B)

This function compares two values A and B and returns value with lowest absolute value.

FUNCTION ATMO(H,ID)

This function uses straight line interpolation method to find atmospheric values for a given altitude H in feet above mean sea level. Depending on value of ID; returns

2—Pressure (psi)
3—Density (grams/cm^2)
4—Mean wind velocity (ft/sec)

ENDOGENOUS EVENT BLARV

This event represents a blast front arrival at an entity or represents vehicle erosion by a dust cloud. It calls EFFECT at the instant of arrival.

FUNCTION CLAS(IC)

This function returns class code, given class/subclass code IC.

FUNCTION DENS(II,T)

This function computes density of a dust cloud II at time T .

FUNCTION DISCR(II)

This function determines the time at which a (reentry) vehicle (II) can be discriminated by atmospheric filtering (time at which a vehicle passes through atmosphere of sufficient density to decelerate low ballistic coefficient vehicle).

SUBROUTINE EVTAP(I)

This subroutine writes out entity I data in eight word records for the postprocessor.

FUNCTION FAR(II,IT,JJ,JT)

This function computes the distance between two entities II and JJ, of classes IT and JT. IT and JT are class codes as follows:

1 — Site
2 — Vehicle
3 — Path

FUNCTION FILT(IC,II,JJ,KK)

This function tests a possible interaction to see if it could occur.

FUNCTION FIRBL(IB,T,Z)

This function computes radius of "fireball" IB, which is at altitude Z, at time T.

SUBROUTINE INTERP(NN,A,F,ID)

This subroutine performs Lagrange interpolation of order ID, for function table NN, entered with argument A. F, the value of the function, is computed.

FUNCTION KCRD(MEM,RANK,IC,J)

This function creates a command record for member MEM, stores the ranking attribute RANK, and files the command record in rank order in type of command set IC, for the Jth command set.

SUBROUTINE MISS(M,S,Y,Z)

This subroutine given a missile type M and an intercept point X, Y, Z, returns a new X, Y, Z displaced from the original according to a Monte Carlo process that operates on the missile aim accuracy parameter.

SUBROUTINE REASGN(II,JJ)

This subroutine reassigns manned interceptors whenever a bomber begins a new path segment.

SUBROUTINE REPORT

See postprocessor.

SUBROUTINE RFCRD(ICRECD,RANK,IC,J)

This subroutine reranks, removes, and refiles a command record as specified.

FUNCTION SCLS(IC)

This function decodes subclass from class/subclass code, IC.

ENDOGENOUS EVENT STOP

This event calls REPORT and stops simulation as specified.

FUNCTION TABL(NN,AA)

This function performs table lookup in table NN according to argument AA, and returns the tabled value.

EXOGENOUS EVENT TFLAG

This event sets up indices for trace flags.

FUNCTION TREE(II,JJ,IS)

This function searches tree structure of command and control centers related to C&C center II. IS is the command set of interest, JJ is a search parameter.

B. Preprocessor

Discussion of Usage

The preprocessor is a series of programs that read, convert, compute trajectories, develop cross indices for simulation purposes, and develop index information for postprocessing functions. The preprocessor programs perform the basic function of converting information from the forms (described in the Volume II, User's Manual), to the more sterile formats required to feed the simulation.

Input Arguments

See forms and instructions in Volume II, User's Manual.

Output

- All of the permanent arrays needed by the simulation
- The exogenous events list
- Index information for the postprocessor

Subroutines and Functions Called

There are 20 basic function subroutines called by the master driver routine (MAIN) of the simulation preprocessor. In addition to the basic functions are several subfunctions. The basic subroutines and other subroutines are listed in Exhibit II-1, Preprocessor Routines. The simulation preprocessor accepts two kinds of data:

- Technical data (such as function tables) that are integral to computer program internal operations
- User data that specify game conditions, scenario, policy of operation of models, and events

The technical data is read first and no edit checks (except format and character compatibility in system read routines) are performed. For user supplied data, card codes are interrogated and appropriate subroutines are called to process the data. Whenever a card code (signifying end of a batch of similar data is encountered) a "wrap-up" portion of the subroutine commensurate with the previous data is called to perform output operations.

The batches of user supplied data must be in a particular sequence.

The MAIN program reads a card, tests the card code for acceptability, and branches to the appropriate subroutine. The subroutine then processes following cards until a card code(s) changes from those acceptable to the subroutine. When card code(s) that are not acceptable to a subroutine are encountered, control is returned to the master which interrogates the new code for system acceptability. If the new code is acceptable to the system, the subroutine is recalled to perform "wrap-up" operations. Upon completion of "wrap-up," the next subroutine is called. This process continues until an END card is encountered and the final "wrap-up" operation(s) are performed.

Other functions and subroutines used in preprocessing are as follows:

- Functions

  AZ = Compute azimuth

  DRAW = Random draw for a probability distribution

- Subroutines

  IMAGE = Writes card IMAGE on tape

  VERT = ConVERTs degrees into radians for longitude, latitude, azimuth, and elevation

  CAGZ = Computes Actual Ground Zero given desired ground zero and probable miss distance

  TRANS = TRANSforms point Q given earth coordinates (latitude, longitude, and altitude) to local coordinates of azimuth, elevation, and range relative to a point P ; where point P is also given in earth coordinates

  KINEM = Determines position of an entity that is moving along a path as a function of time, or fraction of path traversed

  TRAJ = Constructs path segment parameters of missile and MIRV, and decoy trajectories for boost, free flight, and segments of reentry

EXHIBIT II-1 PREPROCESSOR ROUTINES

No.	Subroutine Name	Subroutine Title	No.	Form	Data Description
N/A	MAIN	Preprocessor master	1	FIRS	Signifies start of data
1	THRU	THRoUghput	2	---	Throughput data (no card type code)
2	OPTNS	OPTioN Switch and parameter settings	3	OP	Option switch and parameter data to control simulation option and policy
3	VOLSL	VOLume SLice and point data	4	C	Azimuth, elevation, and range of points on volume surfaces
4	BURST	Warhead BURST specifications	5	WS	Specification for each type of nuclear warhead
5	SENSR	SENSoR type specifications	6	SS	Specifications for each type of sensor
			7	NR	Nuclear vulnerabilities of sensor types
6	MSITE	Missile SITE specifications	8	MS	Specifications for each type of missile site
			9	NM	Nuclear vulnerabilities of each type of missile site
7	AIRFD	AIRFielD type specifications	10	AS	Specifications for each type of airfield
			11	NA	Nuclear vulnerabilities for each type of airfield

EXHIBIT II-1 (CONTINUED)

No.	Subroutine Name	Subroutine Title	No.	Form	Data Description
8	COMMD	COMMand site specifications	12	S	Specifications for each type of command site
			13	NC	Nuclear vulnerabilities for each type of command site
9	VSPEC	Vehicle type SPECifications	14	V1	Specifications for each type of booster, reentry object, and decoy
			15	V2	Specifications for each type of manned interceptor
			16	V3	Specifications for each type of bomber, ASM, and gravity bomb
			17	V4	Specifications for each type of ABM and SAM
			18	NV	Nuclear vulnerabilities for each type of vehicle
10	GREFT	Game REFerence Times	19	R	Reference times for bombers and missiles; L-hour, E-hour, H-hour
11	WNDWS	WiNDoWS for bomber and missile attacks	20	W	H-hour windows for bombers
			21	D	Launch window times for missiles
12	SVALD	Site VALue Data	22	SV	Values of individual sites

EXHIBIT II-1 (CONTINUED)

No.	Subroutine Name	Subroutine Title	No.	Form	Data Description
13	SITES	SITE data for all sites and command Structure	23	A	Data for each physical site in game
			24	A1	Command structure connections (ownership, membership)
14	BMISS	Bomber MISSions	25	T	Mission data for bombers
15	BSORT	Bomber SORTies	26	B1	Sortie segment data for bombers
			27	B2	Sortie path legs for bombers
16	MMISS	Missile MISSions	28	E	Missile mission data
17	MPATH	Missile PATHs	29	P	Missile path data
18	LOITR	LOITeR (strategic orbit points) for manned interceptors	30	L1	Airfields of origination
			31	L2	Loiter point locations
19	TFLAGS	Trace and error FLAGS	32	TF	Flag data for trace of programs and events
20	FINI	FINIsh tape write operations	-,-	END	No data needed

C. Postprocessor

Discussion of Usage

The postprocessor prepares output data and prepares reports.

Input Arguments

Data for the postprocessor comes from three sources:

- The preprocessor—provides index data so that user codes can be related to game entities
- The simulation program—SIMETTE program EVTAP produces eight word records for simulated events
- User supplied—options for country and timing of reports

Output

This produces a summary tabulation of results of a simulation run for specified game time intervals.

Subroutines and Functions Called

See Exhibit II-2.

Methodology

The program MAIN of the postprocessor reads a country code from user input, reads the preprocessor provided indexing data for weapon systems and weapon codes (with call to TABLD), and then reads a user supplied report option card that defines the time to produce a summary report. The program then processes eight word records supplied by the simulation. According to the type of event, the MAIN routine branches to logic associated with vehicle, nuclear detonation, or message events.

Reports are produced at the user specified game times, and when a user card with blanks in columns 0-9 is encountered, the program exits.

EXHIBIT II-2 POSTPROCESSOR ROUTINES

Name	Subroutine Title	Function
TABLD	cross index TABLe Definitions	Reads data supplied by preprocessor, for correlation of user indices to game indices
TIMIN	TIMe INput data is output for report	Reads the game time that a user specifies for production of a summary report
RECIN	RECord INput read	Reads an eight character record from magnetic tape
VLOG	Vehicle event processing LOGic	If the vehicle has been launched, VLOG associates vehicle data with preprocessor provided indices and calls STOUT to prepare output arrays
BLOG	Burst event processing LOGic	Associates burst event data with other data and calls STOUT to prepare output arrays
MLOG	Message event processing LOGic	Processes damage messages by associating the message data with appropriate sites, vehicles, and nuclear bursts; calls STOUT for preparation of output arrays
SCLS	SubCLaSs extractor	Extracts subclass code from an entity record for table indexing
FIND	FIND weapon system and weapon tail numbers	FIND searches the weapon system index tables (produced by TABLD) to relate preprocessor supplied identification numbers to weapon systems and weapons
SUBTL	SUBTaiL number extractor	Extracts the tail number for a weapon associated with a weapon system for indexing purposes

EXHIBIT II-2 (CONTINUED)

Subroutine Name	Title	Function
RSITE	Read SITE data	Reads site data produced by the simulator
ALLIW	Associates aLL Initial Weapon entities with carriers	When a weapons carrier vehicle is destroyed, this program finds all of the associated (unlaunched) weapons assigned to the carrier
STOUT	STore for OUTput	Sets up arrays for output of a summary report
CHECK	CHECK for time to report	Checks time of current simulation event record for triggering a report production
HEADNG	HEADiNG preparation	Prepares and prints header information for printed report
REPIT	REPorts Information and Totals	At the indicated report time, summarizes stored data and prepares a simulation report to user

III. MISSILE DEFENSE METHODOLOGY

A. Introduction

This part addresses the methodology which is the basis for the MDEFND subroutine of SIMETTE. This subroutine and the associated methodology contain the necessary logic concerning the employment of defensive missile systems against the air-breathing threat as well as against threat objects which originate from ballistic missile delivery systems.

SAM (Surface-to-Air-Missile) and ABM defense logic was designed to functionally share a common logic process because of various fundamentally common factors attributable to both system classes. Thus, irrespective of the differing nature of the threat each system characteristically is designed to counter, they share the common purpose of maximizing effective utilization of defense resources to the extent that perceived information concerning the visible threat allows. This latter purpose is the driving principle in the logic for employment of missile defense forces in SIMETTE.

In addition to the common principle of maximum utilization of resources a combined logic process for SAM and ABM defense was developed because of similarities in

- Equipment
- Some command network and decision factors
- Engagement geometry considerations
- Flight path considerations

and to eventually accept dual-capability systems readily.

However, in several important areas particularly related to decision assignment factors and threat characteristics, significant differences in employment of the two systems exist. Because of this, a discussion of the models on which the ABM and SAM defense logic are based will occupy separate sections of this part, with the intent of focusing on the logic-related differences between the systems.

B. Background

WSEG Report 125, Scope of the Multi-System Interaction Problem, recommended, in part, development of a large global simulation model, together with associated data management system and war plan generator for use as a tool in solving the multi-system interaction problem in general nuclear war. In concurring in this recommendation, the JCS further directed the Weapons System Evaluation Group to develop

- A preliminary design
- Requirement specifications
- Costs in terms of manpower and time and equipments

for a set of simulation procedures required to simulate all critical elements in a general nuclear war. The resultant study, WSEG Report 149, SIMulation EXchange—SIMEX, recommended development of a prototype of the simulation portion of the set of procedures, known as SIMETTE, the principal subject of this report. It was to have all basic elements of the SIMEX design, particularly in its ability to demonstrate the monitoring of multisystem interactions.

In view of the fact that the initial impetus to the multisystem interaction problem from the viewpoint of simulation methods for its solution was derived from the impact on offensive forces of a deployed ABM system, the modeling of defensive engagements and ABM in particular received considerable effort and attention in the SIMETTE prototype. This prototype effort does not include all factors identified as potentially critical in ABM engagements. However, the model takes these into account in its design, so that eventual inclusion of additional factors can be made. Circumstances allowed for the principal decision factors to be coded in together with the basic interaction-scan technique.

The discussion which follows is a general description of the rationale on which the MDEFND subroutine is based, followed by specific discussion of the principal decision factors which comprise interceptor commitment procedures. A description of subroutine program flow from an analytic viewpoint ends the discussion. Finally, SAM engagement logic is discussed separately.

C. Discussion—ABM Interceptor Response Determination

1. General

The design is neither necessarily associated with specific ABM (or SAM) systems nor conventional ballistic threat objects. Provided that flyout contours for interceptors and flight paths for threat objects can be characterized, and the command tree structure defined, the model is capable of simulating their engagement.

The ABM and SAM assignment logic employ the same basic philosophy. That is, at each computation cycle, the numerical value of a decision variable (DV) is computed for each possible pairing of threat object-interceptor fire unit. The value of DV gives the relative value for a particular pairing. Interceptor assignments are then made so as to maximize the sum of DV over the possible assignments in that computational cycle. The process is then repeated cycle after cycle until the engagement is over.

Selected critical events initiate a decision cycle.[1] For reasons which should become clearer later in this discussion, the criteria for selection of the type events which initiate a decision cycle is any event which logically warrants reevaluation of the visible threat with the possible intent of making an additional or revised interceptor commitment. The SIMETTE MDEFND subroutine for ABM's is configured for call (but not limited to) whenever one of the following events occurs:

- "Arrival" of a new threat object
- Interceptor launch from a previous decision cycle
- Intercept completion from a previous decision cycle

2. Elements of the Model

At any given time in the course of a game, any given ABM site could be faced with many threat objects from which a subset must

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[1] The phrases "computational cycle" and "decision cycle" will be used interchangeably throughout this part.

be systematically selected which represent the most threatening objects as well as being capable of interception. To be capable of interception, a threat object must, at the very least, come within the performance range capability of an ABM site somewhere on its course. A simple filter which checks to see if the projected path of the RV intersects a hemisphere of dimensions conforming to ABM performance range is employed for this purpose.

Of the set of threat objects selected as possible candidates for interception, elements of the set are more or less threatening, depending on the amount of defended value they threaten and their relative urgency from the viewpoint of time available to intercept. If for any given threat object, more than one ABM site is a possible candidate for commitment of an interceptor, ABM inventory level remaining and current comparative tracking capacity level influence the selection of a particular pairing. Comparative kill probability is additionally a factor if alternative sites have characteristically different equipment. Values for these factors combine in multiplicative fashion for a given slice in game time and enter a matrix where columns represent the candidate sites and rows the selected threat objects.

A computational cycle is initiated whenever a threat object satisfies the requisite attributes of a "Track for Missile Intercept event" (TMI) and ends with the selection of a site/object pairing for which the computed combined value noted above is a maximum and exceeds a predefined limit.[1] No more than one selection for any row or column is made in any computation cycle.

The routine continuously recycles as more TMI events are designated, ending for a given site with the loss of its command site or sites, depletion of ABM inventory, or no further arrivals of threat objects, whichever occurs first.

The interceptor response determination has the following characteristics:

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[1] This predefined limit is a threshold value employed to control interceptor expenditures. It is further discussed later in this part.

- Determines the type ABM to be used against a visible threat (as applicable where more than one type is included in a local deployment)
- Controls how much defense missile resources are to be used against the visible threat and how much should be held in reserve for that part of the attack yet to come
- Determines the number of interceptors to be fired at each threat object
- Determines which firing unit should engage a particular object, because in some cases it is to be expected that two or more batteries can successfully engage an object
- Determines the location and time of each intercept for eventual minimization of the effect of fratricide (friendly offensive and defensive, and radar blackout)

The program has been designed to emulate the following set of defense-related radar events.

A threat ensemble would first enter the coverage of long-range early warning radars which may have some capability for determining trajectory (ballistic or orbiting) and of impact point. This data may be sent to higher level defense command centers and distributed to regional command centers in the form of early attack warning data and disseminated throughout the active defense system.

The threat ensemble would next enter the coverage of a long-range missile defense radar, intersecting the viewing volume of the radar as shown in Exhibit III-1. Following detection and after the filtering process, which is intended to reject possible meteors, aircraft, known satellites, etc., a verification pulse would be sent out to determine that the return was from an object and not caused by noise. The target would then be acquired and tracked in the track identification interval (TID). During the TID interval, information would be gathered to allow calculation of the trajectory the object is on, the impact point (and thus the intended target), and the origin of launch.

The next interval of the long-range missile defense radar is TMI, arbitrarily divided into three subintervals to indicate potentially

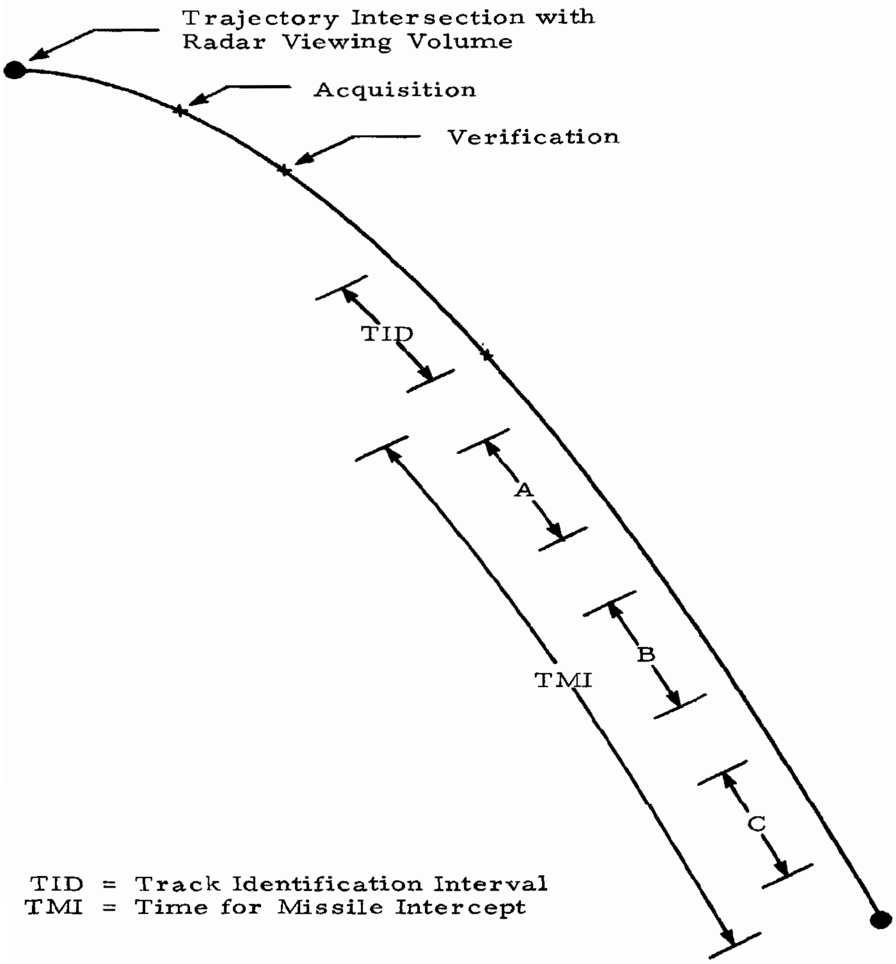

EXHIBIT III-1 CROSS-SECTION OF ABM RADAR TRACKING VOLUME improved information on threat object characteristics. (TMI in SIMETTE is currently treated as one interval at present.) At the end of TMI enough accurate data have been obtained to select an intercept point so that an interceptor could be sent to that point with a high probability of kill.

In the MDEFND subroutine, an object completing the event of TMI, intersecting this bound, constitutes a track for intercept event for the purposes of a potentially immediate ABM commitment, subject only to delays because of normal readiness times, track channel capacity limitations, or blackout considerations.

The cited radar events are simulated in the SENSE subroutine for eventual call of MDEFND. Delays due to blackout caused by nearby bursts (intercepts) from previous engagements, or due to exceeded tracking capacity, could be imposed in a given cycle, leading to a delay in game time before TMI occurs.

3. Interceptor Assignment - Computation of DV

The decision variable, DV, represents the weighted expected value saved if a given interceptor (fire unit or farm) is paired now with a given threat object. It is an appropriate decision variable since the defense is trying to maximize expected value saved over the entire engagement. This is subject to various constraints of a tactical or phenomenological nature. For example, the defense may

- Incorrectly assess an object as threat based on perceived information (radar data) and waste a round
- Be forced to hold off intercept of a warhead judged to be heading at a relatively high value threat because of high risk to friendly outgoing rounds by the resultant defensive burst
- Waste a round due to blackout interruption of the tracking sequence
- Waste a round on an undiscriminated decoy

MDEFND is subject completely to the quality of threat data fed by SENSE. Nonambient environments can therefore be simulated and their influence on defense effectiveness properly allowed to take effect. Thus, the logic developed for the MDEFND ABM Engagement

Subroutine operates on the assumption that the defense, to the extent that perceived information through the command/control network allows, will utilize resources so as to maximize defended value saved subject to the applicable constraints.

The principal factors which enter the computation of the DV value for a possible firing unit/threat object pairing are:

- The relative value of the target perceived as being threatened by an enemy warhead
- The assessed probability that a threat object is a live warhead
- The expected kill probability of the enemy RV by a particular interceptor (fire unit)
- The relative time urgency of a threat object
- The relative resources remaining at candidate fire units
- The guidance channel status at candidate fire units

These are structured in normalized form and capable of being set up as power functions to enable the user to emphasize any combination of the factors that he desires.

The program furthermore employs a threshold value to be compared with the computed DV values as a means of controlling the rate of utilization of defense resources. It is conceived as dynamically varying—an exponentially increasing function of threat density and resources remaining, thus allowing for conservation of interceptor resources as the battle progresses for the attack yet to come.

Each of the above factors is separately discussed below.

4. Relative Time Urgency

The rationale for the determination of time urgency factors is based on the fact that, other things being equal, the closer in a threat object is to the defended complex the more urgent it is to engage it. Thus, it should be given a higher priority than a target further out. To arrive at a numerical measure of this time urgency factor, a precise definition of the phrase "closer in" is required. Since these numerical measures will be used only to rank-order the relative urgencies of the possible site/threat object pairings, their relative values only and not their absolute values are important. This means that although the phrase "closer in" must be defined precisely, the definition may be made in any way that accurately reflects the relative time urgency situation. This term is quantified as follows.

Each candidate object at the game time of the computation cycle, (TIME), is projected forward to the point at which it impacts or exits the ABM site performance bound (TOUT). Inasmuch as the input or exit position represents the last possible intercept point, the elapsed time to this point,

$$\{\text{TOUT} - \text{TIME}\} \qquad (1)$$

represents the elapsed time available to complete an intercept. These differences serve as a rough rank-ordering of the time urgency of the threat objects. Alone, however, they do not serve to rank-order the possible ABM site/threat object pairings.

To do this, the elapsed time required to complete the last possible intercept is determined for each possible pairing (TOF). A time parameter,

$$\text{TAUP} = \text{TIME} + \text{TOF}(M_1 X_1 Y_1 Z) - \text{TOUT} \qquad (2)$$

is then computed for each pairing (pairings having positive TAUP values are impossible intercepts). This variable, TAUP, represents the elapsed time before exiting a given site's performance bound that an intercept can be effected.[1] It represents, in effect, the elapsed delay time that can be borne before an interceptor is committed.

For one site and many threat objects, the threat object closest in should be engaged. That is, TAUP should be minimized. On the other

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[1] Actually, the negative of TAUP is equivalent to the elapsed time before exiting a given site's performance bound that an intercept can be effected. The form of equation (2) is convenient for computational purposes.

hand, for one threat object and several overlapping sites, the ABM site selected should be that one which will intercept the threat object as far out as possible. That is, TAUP should be maximized.

As used in the program, TAUP represents the remaining available time to latest initiation of launch, i.e., launch to the performance contour exit point or,

$$\begin{aligned} \text{TAUP} &= \text{TIME} + \text{MSPEC}(13,\ \text{ISITE}(9,\text{M})) \\ &\quad + \text{TOF}(\text{M},\text{X},\text{Y},\text{Z}) - \text{TOUT} \end{aligned} \tag{3}$$

where,

MSPEC(13, ISITE(9,M)) = Minimum time from command launch decision to end of launch sequence

These numbers will range from arbitrary negative values to zero. The conversion to positive, normalized values suitable for use as multipliers in the computation of the decision variable the maximum and minimum values of TAUP are selected from the array of candidate sites and threat objects at TIME. The normalized multiplier, $\mathbf{T}$, $(1 \leq \mathbf{T} \leq 2.0)$ for the most relatively time urgent threat objects in descending order of priority is given bythe function,

$$\mathbf{T} = 1.0 + (\text{CRANK(MEM)} - \text{TMIN})/\text{DELT} \tag{4}$$

where,

TAUP(MAX) = The maximum value of TAUP of current active entries in the decision cycle

TAUP(MIN) = The minimum value of TAUP of current active entries in the decision cycle

DELT = $\{\text{TAUP(MAX)} - \text{TAUP(MIN)}\}$

CRANK(MEM) $\equiv$ TAUP

TMIN $\equiv$ TAUP(MIN)

5. Relative Interceptor Availability Factor

If, at the time of a computation cycle, a threat object can be engaged by several interceptor sites, it is reasonable to assume that the favored pairing should comprise that site which is relatively richer in interceptor resources remaining. This can be reflected in the decision variable as a factor less than one, where relatively greater resources remaining for a given candidate site.

The factor consists of, for any given site and computation cycle, the ratio of interceptors remaining (IR) (at the end of the previous cycle) to the sum total of remaining interceptors of all sites common to the threat object (ΣIR). In the program, this factor (IR/ΣIR) is given by:

$$\text{ISITE}(16,\text{L})/\text{INUM} \qquad (5)$$

6. Expected Threatened Value Saved as a Decision Variable for ABM Commitment

a. Objective Function

This section addresses that factor relating to expected value saved as a basis for selection of an ABM site/threat object pairing. The underlying assumption is that the primary objective of the defense is to commit defense resources at any given time in the game so as to maximize the expected damage saved in a defended complex threatened by ballistic missile attack. Developed in the discussion which follows is the probability expression to be employed as the objective function for the expected value formulation; target value representations for the classes of targets of interest; adaptations in SIMETTE; and alternative value functions.

The algorithm for determining expected value saved is based on the following expression (described in the appendix to this part):

$$MVS_j = V(Y) \bullet P(I) \prod_{i=1}^{j-1} \Big(1 - P(I)\Big)_i \tag{6}$$

where,

MVS_j = The marginal value saved for j committed interceptors

$P(I)$ = Probability an enemy warhead is killed by a single round of interceptor type, I , committed by the defense

$V(Y)$ = The amount of expected value threatened by an enemy warhead of yield, Y .

b. Defended Value Threatened

The program allows for timed step decreases of threatened target value as described in Volume II, Section III (Users Manual) of this report. An initial site value is assigned to conform with game start time and decreased in timed steps by assigning new values at selected points in time after the start of the game. Defended offensive elements are decreased in accordance with their associated offensive launch plans. These target values are taken as fractional values threatened and input in normalized form. Rather than maintain a dynamic update of defense resource expenditure, their respective rate of decrease was arbitrarily allowed to roughly parallel offensive element expenditures which they defend.

The program is structured so that alternative value functions may be applied, or numerical values input which are suitably normalized, maintained constant or decreasing as the user desires.

The appendix to this part develops a method for expressing threatened target value for various classes of targets, where extensive dynamism in bookkeeping of defended value is desired. The approach allows for the inclusion of weighting factors which potential users can utilize for emphasizing the relative worth of given target classes.

c. Probability an Object is a Warhead

Discrimination is played in SIMETTE as a user input elapsed time after game time, an event which can (or cannot) occur at specified times within the threat acquisition through track for intercept intervals to time on target. In effect, time to discriminate acts as a delay imposed on the game time at which MDEFND is called to evaluate a threat object. (If discrimination time is scheduled to occur after the track for intercept event, the former rather than the latter event triggers MDEFND.) If the object is assessed as a warhead, the appropriate DV factors and variable is computed for all possible site/object pairings. If assessed as a decoy, it is removed from consideration by MDEFND (but not necessarily from the game, since it may have incorrectly assessed a decoy).

Future improvements to SIMETTE anticipate the more desirable representation of associating progressively increasing discrimination probabilities with threat objects as they interact with SENSE or OBSER functions. Equation (6) would then be modified to:

$$MVS_j = V(Y) \cdot P_D \cdot P(I) \prod_{i=1}^{j-1} \left(1 - P(I)\right)_i \qquad (7)$$

where,

P_D = Probability a threat object is a warhead (a function of track interval time or other suitable variable)

7. Guidance Channel Status (Radar Power Budgeting)

Other things being equal, it is desirable to engage a target using a fire unit whose radar capabilities are being used the least.

For inclusion of this concept in the calculation of DV, another weighting term must be defined.

Each radar in general will be performing a search function, tracking nonengaged targets, and conducting engagements. Its projected energy expenditure out to the time of completion of all its present engagements can therefore be estimated. The energy it has available for new assignments out to this time can be then estimated and called A_2 If this particular fire unit is paired with a given target, the energy required to conduct this engagement can be estimated and called A_1 . If

A_1/A_2 is small, it means the new assignment would not overburden the fire unit radarwise and therefore lends weight to the use of the fire unit. A function of A_1/A_2 , $f(A_1/A_2)$, can therefore be chosen as a weighting factor in the DV computation. This function could be simply A_1/A_2 raised to a suitable power. As a rough indicator of energy allocation, the function could be the ratio of ongoing intercepts to the limit possible for a given type firing unit.

The inclusion of this radar power consideration will tend to cause the lightly burdened radars to be used but not exclude the possibility that for other considerations (value threatened or time urgency), a new engagement may be given to a heavily burdened radar even at the expense of infringing on its search function for some time.

In this initial development effort, this is treated as a limiting rather than a dynamically varying factor.

8. Projected Computer Workload at a Fire Unit

A weighting factor for this consideration has not been defined as yet and does not appear in the calculation of DV. It is not clear that this consideration must be included separately from the radar power weighting factor. Computer utilization is tied very closely to radar power expenditure and a consideration of the one probably makes consideration of the other redundant. Presumably, computer capability would be adequate to support full radar utilization.

9. Pair Selection Criteria

a. Decision Factor Combination

The several terms and weighting factors discussed above are combined to form an expression for DV which is:

$$DV = [f(V_T, P, P_D)]^A \; [f(\mathbf{T})]^B \; [f \left(\frac{A_1}{A_2}\right)^C] [f(IR/\Sigma \; IR)]^E \; . \qquad (8)$$

This first bracketed quantity is simply expected value saved, the simplified computation of MVS.

The second bracketed quantity is the time urgency factor and may simply be T^B .

The third bracketed quantity is the projected radar utilization factor and may simply be $(A_1/A_2)^C$.

The fourth bracketed quantity is the remaining stockpile factor and may simply be $[(IR)/\Sigma (IR)]^E$.

The exponents A , B , C , and E may be assigned different values to emphasize one consideration or another for simulation purposes; the results can then be studied for the purpose of optimal value selection or varied to respond to different tactical conditions.

For a given computational cycle the DV for each possible fire unit-threat object pairing is computed. It is convenient to conceptualize these as entries in a continually updated array of currently active firing units as the rows and designated threat objects as the columns. In overlap situations DV entries for some threat objects are multiple entries with a selection required of the most capable fire unit. Pair selection requires two functions to be exercised. For any cycle the row maximum is found for all active sites. In cases of overlap that site with maximum DV on a common threat object is selected and unfavored sites paired with an alternative next highest DV assignment. All selections in a given cycle are then compared to a threshold value. DV entries which exceed this value are given interception commitments. Those entries which do not exceed the threshold DV are set to zero and (temporarily) removed from consideration.

b. Threshold Values

To exert partial control of the quantity of interceptor resources utilized, a threshold DV value which must be equaled or exceeded for selections to be made, is useful. Matrix entries which are less than the arbitrarily selected value of the TDV are set to zero and removed from consideration. Entries which are several times the TDV may result in several shots per salvo if practicable. Use of the TDV is thus a means for controlling salvo requirements for a given engagement on a shoot-shoot-shoot basis.

The value used for TDV enables the defense to control not the actual but the expected number of interceptors used in an engagement. It may be set very low so as to allow, say, two shots at most objects and three or even more at very threatening objects, or it may be set higher to allow an average of one shot per object with possibly two at very threatening objects. It may be set higher still to permit shooting at only the most threatening objects.

TDV settings at a given site at a given time may be adjusted to reflect the ABM stockpile still remaining at the site, the damage already sustained at the site or areas it defends, and estimates of the expected attack size yet to appear at the site. Thus, it may be set high to permit shooting at only the most threatening objects during periods of low attack density, and set lower to permit engagements of more objects during periods of high attack density.

If a threshold controlling value were not used, sites would continuously fire ABM's at threat objects subject only to physical constraints. ABM's would be needlessly wasted in periods of low attack density or against relatively low-threat objects.

A fixed threshold value associated with each site will alleviate somewhat uncontrolled utilization of resources. Much better is the use of a dynamically varying threshold value.

An important consideration in defense is the maintaining of a reserve in anticipation of the unexpected (e.g., a greater than anticipated threat level). Thus, threshold value can be made an exponentially (or a power function) or linearly increasing function of resources remaining at a given site. Testing would indicate which might be preferable. Thus, as the battle progressed, the threshold value of DV to be exceeded for given sites would increase as the stockpile at a given site decreases as a result of combat losses or utilization. This form of dynamism would permit an equal value assigned to all sites at the beginning of the game; and variations occurring to different degrees permitted by lending different weight to the functions depending on the relative worth defended by a given site.

An alternative method of dynamically varying the threshold value is according to the threat density. Thus, the more dense the threat the higher will be the threshold value; only the most threatening object(s) will be committed to. Conversely, the lower the threat density the lower is the threshold value, permitting more intercepts to occur. As with the variation on resources remaining, the variation can be linearly or exponentially increasing or increasing according to a power function, as desired, or as indicated through testing. Flexibility is allowed in altering the degree of variation to reflect different valued targets defended by the use of parameter variations in the relationships.

And finally, a combined relationship of varying threshold value as a function of the product of the above noted factors is also a possibility.

c. Overlap Considerations

Defense site overlap is of two types. These are the overlap of two dissimilar type fire units (area over terminal) and overlap of similar type fire units (area over area, or terminal over terminal). The latter condition is resolved in pair selection merely by comparison of DV entries for sites having under consideration a common threat object, and selecting the greater of the multiple entries. The former type presents a problem from the viewpoint of defense doctrinal considerations.

An ABM doctrinal constraint which required consideration in SIMETTE concerns the favored commitment of one type interceptor over another whenever an area ABM defense overlaps one or more terminal interceptor sites.

Several ways of implementing this doctrinal constraint were considered. One is to insert in the logic a preference rule in the controlling routine which maintains the DV array. Thus, if an area site is selected for commitment (based on maximum value of DV for the computation cycle), it is where possible subtended by a capable terminal defense site.

Another way is through control of a threshold DV value assigned to all type sites. Thus, any given area site which overlaps one or more terminal sites can be assigned a threshold DV value several times higher than values assigned to terminal sites. This has the effect of tending to favor terminal interceptor commitments, in contrast to area ABM commitments which would only result for extremely high DV values (very threatening objects). A related benefit of this approach is the fact that a small degree of dynamism is introduced in the model in contrast to the first alternative and its use of rigid rules. A disadvantage of the approach is the likelihood that sensitivity tests would likely be required in order to establish the extent to which the threshold values should be set in order to establish suitable demonstration of the constraint.

The approach employed in the current version of SIMETTE is the former (as an option), i.e., the use of a preference rule. The latter alternative is always available to the user under any condition.

10. Additional Features

a. Interceptor Divert

Interceptor divert prior to launch for intercept is allowed in the program. It is implemented automatically whenever the DV of a "new" threat object exceeds the DV of a pairing of a previous decision cycle, provided that the physical constraints (sufficient track data and ready time for launch, etc.) are satisfied. Moreover, the threat object from which a ready interceptor was diverted is automatically considered for a subsequent interceptor commitment.

In-flight divert is not currently allowed in SIMETTE. However, there is nothing in the MDEFND subroutine which would preclude its consideration, given the necessary flight path representation algorithm for KINEM were available.[1]

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[1] A function relating remaining time of flight and performance contour properly configured around the azimuth of the "new" flight path would also be required to simulate in-flight divert. SIMETTE currently allows a single performance contour for a type interceptor.

b. Loiter Mode Commitment

Insofar as loiter mode commitments can be interpreted to represent launches committed before nominal intercept track data processing is complete (i.e., on course track data only) this can be simulated in SIMETTE through judicious choice of values for elapsed times for track intervals.

Flight path representation algorithms of the nature of those discussed in the previous section would be necessary additions to SIMETTE if launch to intermediate thrust idle spatial positions and eventual divert to a threat were required to simulate loiter mode commitments.

c. Command Network and Local Defense

The command structure for defense resource commitment is a conventional tree structure consisting of varying levels of command sites (and their alternates) and fire units which may or may not be collocated. Defense command sites make interceptor assignments. SIMETTE allows multiple fire units to be associated with a command site, and one or more command sites associated with a higher level command site, etc.

The highest level surviving command site (capable of making assignments) makes interceptor commitment decisions. Loss of a command site (and its alternate, if applicable) causes decision control to pass to an alternate command site (if one exists) or to the next lower ordered command site(s). If none exist because of battle damage or otherwise, fire units in that tree branch are incapable of commitment.

Fire units in the branch are capable of commitment if lower ordered command sites exist. However, whereas physical overlap of fire unit performance contours are still in effect, effective overlap from the viewpoint of coordination between surviving lower level command sites is not, since the higher level command site represented coordination as well as command. The effect of this when physically overlapping fire units under uncoordinated command sites have a common threat object is that it can be doubly intercepted (as may be the case in actual battle conditions).

Local defense is thus capable of simulation in SIMETTE with the requisite decision authority shifts accounted for. Part III of the User's Manual expands on this issue.

11. MDEFND Program Flow

a. From SENSE, a threat object intersects one or more defense radar viewing volumes and is successively acquired, designated, and identified in game times and positions according to existing blackout conditions. Its track is established and at designation it is examined as to whether or not it will intersect active defense coverage.

b. MDEFND is called at the event of:

- Threat object discrimination or
- Threat object intercept track

whichever occurs last, or:

- Intercept launch in a previous cycle
- Interception as a result of interceptor commitment and launch in a previous cycle

whichever occurs earliest.

c. The positions of all active entities (threat objects and in-flight interceptors of previous decision cycles are updated).

d. Checks are made for:

- Fire unit survival
- Fire unit saturation

e. Based on assessed intended target, interceptor kill probability (compounded for previous shots, if any) and the marginal value saved is computed for all possible fire unit/threat object pairings. Active object/unit pairings are reevaluated.

f. The relative time urgency of all active pairings are reevaluated.

g. The relative resources remaining factor for all active pairings is computed.

h. A preference rule for type interceptor use is invoked if and where applicable.

i. DV values are computed for remaining active pairings.

j. All DV entries are compared against a relevant threshold DV value. Those which do not exceed the threshold DV are set to zero for this cycle.

k. Threat objects are checked for maximum DV for command site entries.

l. A check is made to see if two or more command sites have a maximum DV value when paired with a common threat object. Sites having nonmaximum values are paired with threat objects having next highest DV value in the cycle.

m. Interceptor launches in accordance with the above selections are scheduled.

D. Discussion—SAM Interceptor Response Determination

The logic which governs SAM employment is, in principle, similar to that in the ABM battle. Thus, other things being equal, the closer in a threat object is to the defended complex the more urgent it is. Likewise, if two SAM sites were each capable of intercepting a threat object, that site closest to the threat object is the preferred site for engagement. In several important respects, however, the analogy between SAM and ABM logic ends as a result of significant differences in comparative interceptor performance and deployment and threat object characteristics.

The computation of the term, value saved, is by contrast with the ABM subroutine somewhat problematical. This is partly due to the limited computational facilities available to current and near-future time-frame SAM systems compared to that projected to exist for ABM systems. Mainly, however, it is due to the uncertainties with regard to value threatened. For ballistic missiles, once track is established, its future trajectory is rigorously established, lending high confidence to predicted impact point and value threatened. For the manned bomber threat there is a great deal of uncertainty as to the future course since the target vehicle may turn. Compounding this problem is the fact the manned bombers "give birth" to new threat objects (gravity bombs or ASM's while in battle space and which themselves may represent engageable threat objects). Their direction (course) may certainly, for the most part, differ from that of the vehicle from which they originated.

The situation concerning value threatened is, at the same time, more complex than the ABM case, but lends itself to computational simplification.

SAM systems through the near-future timeframe are by the nature of their deployment and performance, terminal defense systems. As a result, overlapping sites defend a common target complex, and thus a common threatened value. For this relatively narrow view of SAM defenses, threatened value as a distinguishing parameter is not required. When and if it becomes necessary to consider it otherwise, the necessary program changes can be made easily because of the commonality of the subroutine.

As a result of these considerations fewer variables apply in the case of SAM decision factors compared to those treated in ABM engagements. In general, time urgency will be considered the only explicit governing factor in SAM commitment for SIMETTE. Value threatened, comparative site interceptor availability and guidance capacity status are excluded as explicit factors in SAM commitment decisions. The nature of the SAM systems (terminal) considered in SIMETTE obviates the need for explicit consideration of target value in SIMETTE. The comparatively greatly reduced automaticity of current and near-future timeframe SAM systems realistically excludes comparative site interceptor availability as a factor. The expected low density of penetrators and reduced automaticity of expected deployments renders guidance capacity not a factor. Absolute interceptor availability is, of course, considered.

For at least this initial development period, only intercepts at the maximum performance and mid-range contours of a site are allowed in the algorithm. Multiple shots in a salvo are declaratively specified, and as in the ABM case, divert prior to launch is allowed, whereas divert of in-flight missiles is not.

Future additions should center on allowing in-flight divert as well as additional criteria for subroutine recycle. For example, weapons launched from aircraft are "new" threat objects in point of fact and conceivably capable of being intercepted by advanced systems or with low success probability with current and near-future timeframe systems, thereby constituting the basis for a decision cycle evaluation. Likewise, course changes in some respects represent a "new" threat insofar as this bears on the requirement for a reevaluation of time urgency factors.

Finally, long range SAM's having significant area coverage may be of interest for exercise in SIMETTE or SIMEX. This may force to some extent the requirement for some scheme of predictivity of intended target. A possible technique readily adaptable to SIMETTE is to base intended target prediction (which in turn allows evaluation of threatened value) on flight path extrapolation to obtain closest approach measures. Intended targets would then be ranked in decreasing order of closest approach distances. Decision cycle calls and DV reevaluations would be made whenever course changes on threat objects were detected. SAM commitment doctrine would then substantially parallel that currently employed for ABM.

APPENDIX

EXPECTED VALUE SAVED AS A DECISION VARIABLE FOR ABM COMMITMENT

A. The Objective Function

Let V(Y) be the amount of expected value threatened by an enemy warhead of yield (Y). If interceptor effectiveness (product of the estimated interceptor reliability and SSKP) is given by P(I), then the expected amount of value threatened by an enemy warhead given that j defense rounds are committed is:

$$S(I)^j \; V(Y) \tag{1}$$

where

S(I) = 1 - P(I) = probability that an enemy warhead survives a single round committed by the defense.

The marginal value saved (MSV) by any given committed interceptor is given by:

$$MVS = V(Y) \bullet [S(I)^j - S(I)^{j+1}] \tag{2}$$

which is equivalent to

$$MVS = V(Y) \bullet \left(1 - S(I)\right) \prod_{i=1}^{j-1} S(I)_i \tag{3}$$

Replacing S(I) by (1 - P(I)) leads to:

$$MVS_j = V(Y) \cdot P(I) \prod_{i=1}^{j-1} \left(1 - P(I)\right)_i \tag{4}$$

B. Defended Value Threatened

For V(Y) to be treated as an expected value threatened, then the algorithm for V(Y) would require characteristics of the estimated intended target including type, disposition, vulnerability measure (VN or other) and a suitable damage function. Estimates would be required of the probable yield and optimum burst height of the enemy warhead as well as for the calculation of expected target damage. However, by taking for V(Y), the estimated actual rather than expected value threatened, the above computational burden in SIMETTE can be avoided. (In this context, the actual value threatened is the expected value threatened with kill probability 1.0.) For arithmetic convenience, estimated value threatened should be taken as the fractional value threatened. Thus, for example, the estimated value threatened by an enemy warhead whose aim point has been predicted to be an ICBM site of a set of N ICBM's in a defended complex, k, is $1/N(k)$.

Expressions for normalized value threatened as a function of elements remaining are presented in the following sections of this appendix for each of six classes of targets that may come under the defensive umbrella of ABM defense. Considered are:

- Offensive ICBM sites
- Long range aircraft (LRA) bases
- MI bases
- ABM defensive elements
  - Radars
  - Fire units
- Other military
- U/I

C. Defended ICBM's as Targets

If V(Y) is to be updated dynamically (that is, take into account departed defended elements), the following expression for fractional value threatened can apply:

$$V(Y) = 1/[N + A(N - NR)] \qquad (5)$$

where,

NR = The estimated number of ICBM's in the defended complex estimated to remain at the time of the jth cycle.

A = A weighting factor (> 0) attributing some value to empty holes.

Note that the effect of the term A(N - NR) is to always give some weight, however small, to a defended ICBM complex, even though all offensive rounds have been scheduled to depart. This measure of implied worth to scheduled empty silos serves to offer some defense of the friendly ICBM's that may have temporarily malfunctioned and thereby not met their scheduled departure. The greater the value input for A the smaller will be the value of V(Y) for any given NR , thus giving relatively small weight to empty silos. Conversely, relatively low values for A has the effect of giving relatively greater weight to defense of empty silos.

D. LRA Bases

The consideration noted above is even more significant where the defended element is an airfield. Thus at any time after scheduled departure of aircraft, some number may remain because of temporary malfunctions. But more significantly, an airfield represents an important reusable military resource. (b)(1) For airfields which are primarily tanker and/or bomber bases, the expression for value threatened takes the form:

$$V(Y) = [NR + 1]/[N + A(N - NR) + 1] \qquad (6)$$

In general, for airfields, the fractional value threatened is that fraction of the complement remaining at the time of the jth cycle. Aircraft being soft (about 5 psi) and their radius of disposition on the ground being small compared to the 5 psi weapon radius of a nominal one MT burst, the assumptions on value threatened appear reasonable. The "+ 1" in the numerator is employed to assure nonzero values for $V(Y)$. (It is counterbalanced by a "+ 1" in the denominator for the case of $NR = N$, i.e., prior to any scheduled departures.)

E. MI Bases

For airfields which are primarily bases for air defense manned interceptors, the full value associated with prewar (or planned trans-war) complement should represent the value threatened at any time in the game. That is,

$$V(Y) = N/N = 1.0 \qquad (7)$$

This represents a worth measure to the defending ABM sites which is conservative. However, although at any given time of the game only part of the complement might be expected to be on the base, the base is at all times required for recovery and recycle of MI's that are airborne. The assumption of the threatened value to be the value associated with the full normal complement thus appears to be reasonable. To reflect proportionate threatened value among airfields with unequal normal complements of aircraft, the value of any given air defense airfield is given by:

$$V(Y) = N_k/MAX\left\{N_{all\ k}\right\} \qquad (8)$$

F. ABM Defense Elements as Targets

For initial considerations, the targetable elements of the ABM defense system itself comprise the main guidance radars/command center (assuming they are collocated) and the fire units. Addressing the fire units first, the expression for value threatened is:

$$V(Y) = (NR + 1)/(N + 1)\,, \quad \text{given } k\,. \qquad (9)$$

where,

NR = The number of interceptors remaining at the kth site at the time of the jth computation cycle

N = The planned inventory of interceptors at the kth site at game start time

Note that the "+ 1" in the numerator is to assure that V(Y) will have some small positive value even when interceptors are exhausted. The "+ 1" in the denominator enables the expression to take the value of 1.0 at the time of the first engagement.

Inasmuch as fire units will likely be represented as a set of clusters of interceptors, each cluster comprising perhaps five, ten (or more) interceptors in close enough proximity to be considered as point targets, NR and N are <u>numbers</u> of <u>clusters</u> of interceptors comprising a kth site.

G. <u>Radars/Command Centers</u>

An ABM guidance radar/command center is the Achilles' heel of an ABM network. In the absence of an extended coverage capability,[1] loss of this element in effect constitutes loss of all elements under its control or defense including objective targets (defended ICBM complexes, (b)(1).

Accordingly, when a guidance radar/command center is estimated to be the aim point of an enemy RV, the threatened value is the sum total of all value remaining over which that center has coverage. That is,

$$V(Y) = \left[\left(\sum^{\ell_k} VR(Y)\right) + 1\right] \Big/ \left[\left(\sum^{\ell_k} V(Y)\right) + 1\right] \qquad (10)$$

The numerator is the sum of all value remaining (VR(Y)) of all ℓth targetable and defendable elements under coverage by the kth ABM·

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[1] An extended coverage capability exists where a defensive command element can take over and effectively control some or all of the operating elements of an adjoining defense command element in the event the latter is lost as a result of enemy action, malfunction, or whatever.

site; the denominator is the sum of threatened value of the time the game commences. As before, the formulation is set up so that a small residual positive value always remains.

Where a center exercises its extended coverage capability (if existent) it of course immediately adds on to its former value the value of those elements to which coverage was extended.

H. Other Military as Defended Targets

ABM defense sites can reasonably be expected to be aware of the planned launch schedules of offensive military elements, ICBM's, and SAC bombers/tankers and employ these schedules as a basis for developing threatened value criteria. As a result, a reasonable basis for assessing the relative urgency of the enemy threat at any given time is afforded in the absence of a real-time battle management or damage assessment capability. (It should be noted that the formulation presented to this point would not be inconsistent with the existence of a damage assessment capability, information from which would presumably provide actual rather than estimated value threatened, with no change in the basic premise of the formulation.) In the case of Ml airfields, the adoption of conservative assumptions of value threatened in the absence of a damage assessment capability would, of course, continue to influence the commitment of interceptors to their defense in spite of the possibility that an enemy RV may have leaked through and killed it. An artifact to control this somewhat is to reduce the value of a target by a factor, F $(0 < F < 1)$, whenever an RV aimed at such target was assessed as retaining structural integrity after the last possible interception. This problem presents itself in the case of the target classes, "other military" and (b)(1) In either case then the threatened value at any jth computation cycle is

$$V_j(Y) = \exp -F\left(\sum i_j\right) \cdot V(Y) \qquad (11)$$

where $\sum i_j$ is the sum of all missed intercepts on objects aimed at the ℓth "other military" o(b)(1) $V(Y)$ is the starting value, and F is in effect the probability that a leaking RV is still alive.