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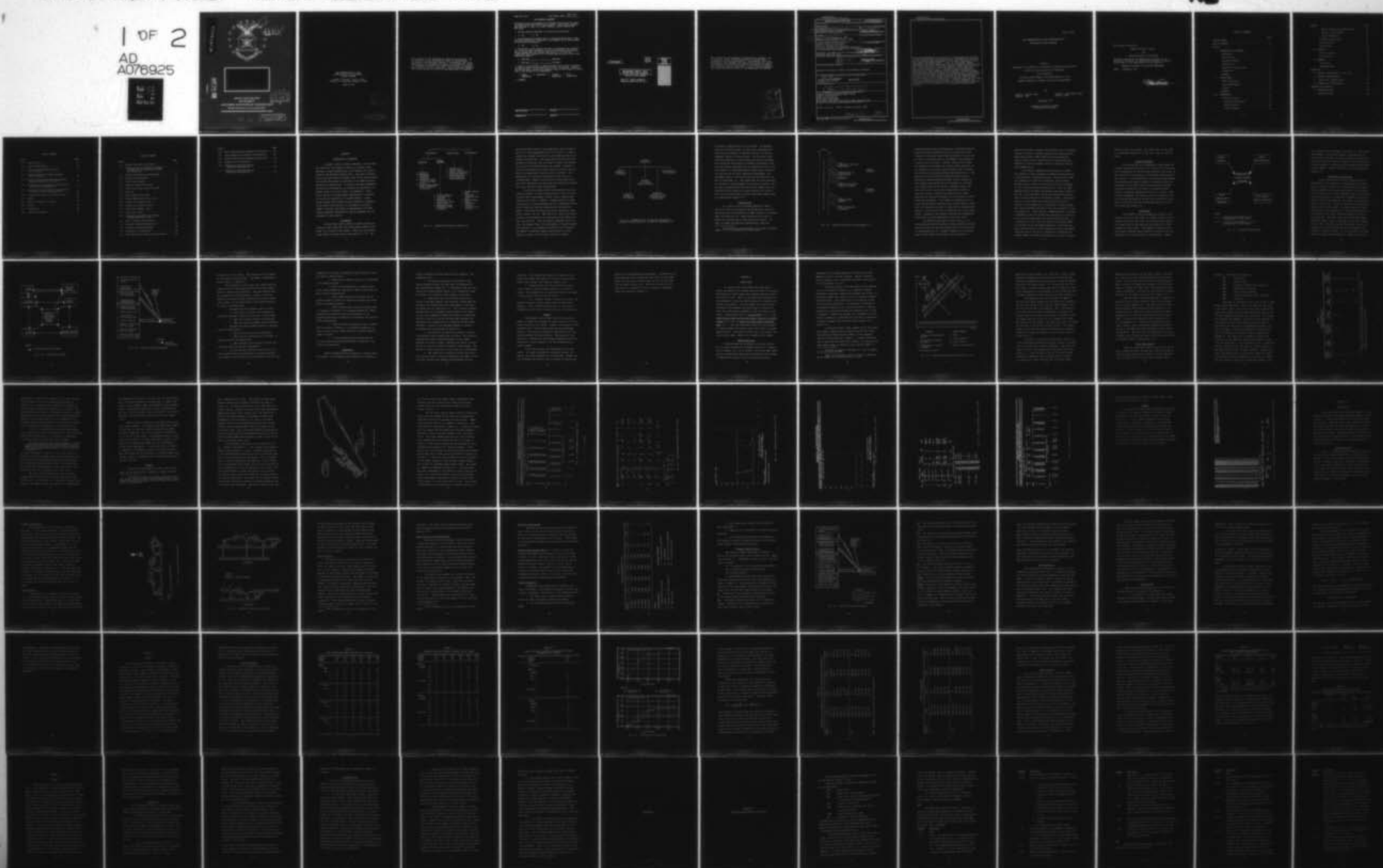

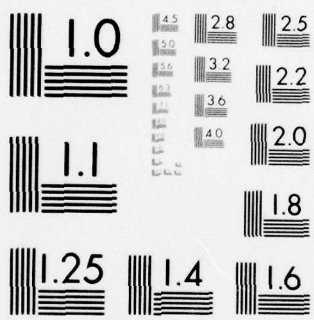
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UNITED STATES AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

THE DETERMINATION OF THE
ACCESSIBILITY OF POST-ATTACK
LAUNCH WINDOWS

Dennis F. Ballog, Captain, USAF
Darrell B. Hutchinson, Captain, USAF

LSSR 20-79B

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This study examined the availability and accessibility of post-attack launch windows using simulation. The basis for the study was the research and development of the Rand Corporation's Air-base Damage Assessment Model. Prior to this study, damage assessment has always been done from the attacker's point of view, that being how can we do the most damage, given a set resource. This study examined it from a standpoint of survivability specifically starting with a standard airbase configuration, developing the most probable attack scenario, running the model, and examining the data to develop the probability of availability for the various launch windows required by the differently configured U.S. aircraft. Manual inspection of the output allowed the development of the probability of accessibility from the ramp area to the available launch window. Finally, examining two alternate proposed runway configurations and developing their net contribution to the probabilities of accessibility and availability.

LSSR 20-79B

THE DETERMINATION OF THE ACCESSIBILITY OF POST-ATTACK LAUNCH WINDOWS

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Facilities Management

By

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Darrell B. Hutchinson, BSEE
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September 1979

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This thesis, written by

Captain Dennis F. Ballog

and

Captain Darrell B. Hutchinson

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN FACILITIES MANAGEMENT

DATE: 7 September 1979

Todd Stewart
COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION TO RESEARCH

In today's world of scarce resources, the Air Staff was faced with the problem of having to allocate those resources to many programs that would enhance the nation's offensive and defensive capabilities. They had to choose a course that would meet the future needs of the United States and satisfy this nation's commitment to our NATO allies of deterring the Warsaw Pact. To satisfy the NATO commitment, assuring the survivability of effective air operations in Europe, after an initial attack, was paramount. There were a variety of actions under consideration to preserve or restore air operations in the NATO theater. Those actions ranged from increasing point defenses to enhance a single base's survivability, to increasing the overall number of aircraft available for employment by the NATO theater commander (shortened to theater commander for the remainder of this thesis).

Background

Actions that could be taken to ensure airbase survivability were subdivided into three phases based on the stage of an attack on the airbase. They were: pre-attack, trans-attack, and post-attack (see Figure 1-1) (1). The

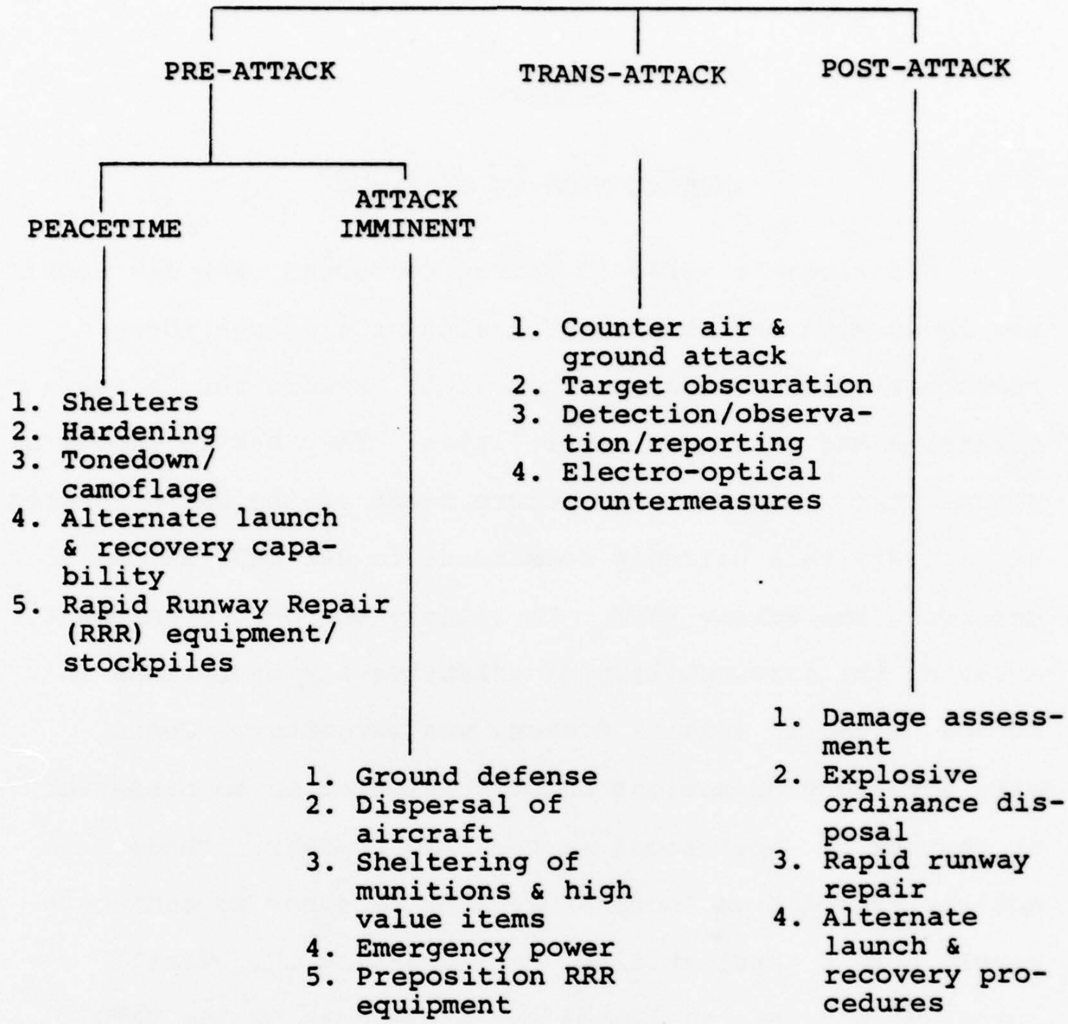


Fig. 1-1. Airbase Survivability Efforts (1)

pre-attack phase refers to the preparation and/or training that has to be accomplished prior to an attack, in order to enhance the airbase survivability and ensure wartime sortie generation capability. The trans-attack efforts were categorized as activities that are meant to lessen the destructive force of the attack against the airbase. Actions in the post-attack phase are those required to return the airbase to an operational status as soon as possible. The examination of alternative programs was done so as to increase NATO's capabilities with the limited funds available while maximizing the total positive efforts that affect the trans- and post-attack capabilities.

Prioritizing among these diverse possibilities was difficult because it required dealing with a host of uncertainties about the program's scopes, costs, capabilities, scenarios and timing. However, a common measure of effectiveness for all these programs had to be formulated before their interaction could be understood by the decision makers. The connecting threat was sortie generation capability (Figure 1-2) (2). The ability to launch and recover aircraft was considered to be the driving force behind airbase survivability. From the theater commander's point of view, the primary value of each proposal to improve airbase survivability is its probable contribution to increasing the number of effective combat sorties which he could employ or recover in the initial stages of a battle

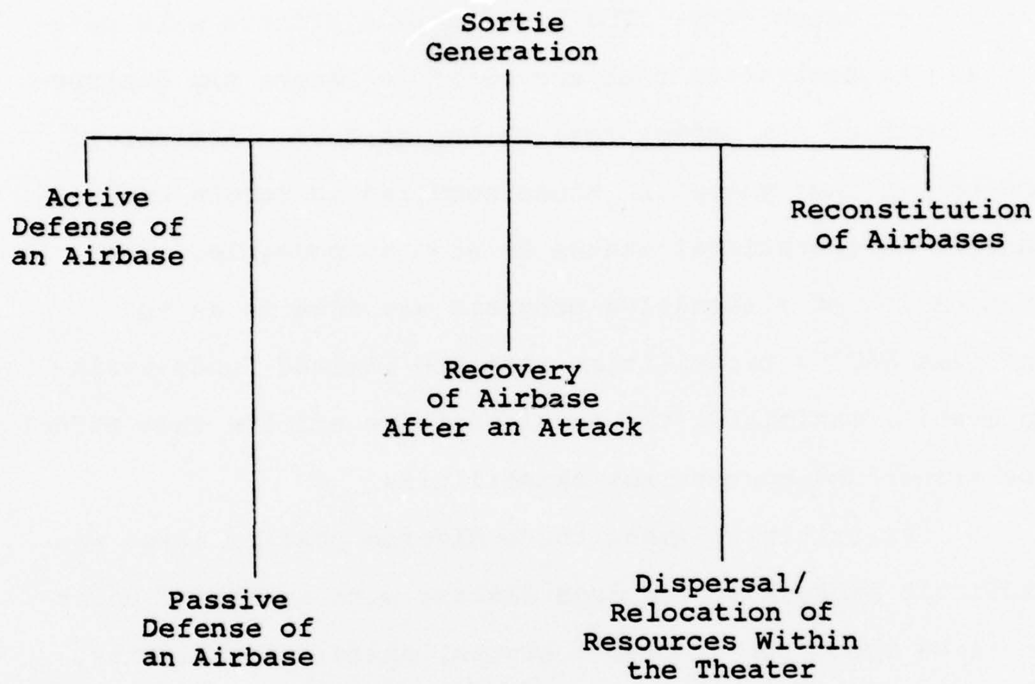


Fig. 1-2. Categorization of Candidate Programs to Increase the Survivability of NATO Air Operations (2)

following an enemy attack on his airbases. The problem, from the Air Staff's point of view, was to determine the priorities for spending in peacetime to help the theater commander achieve his wartime goal. The Air Staff recognized the importance of prioritizing the various programs and charged the Directorate of Concepts and Analysis (DCA) with the primary responsibility to examine each area of concern (Figure 1-3 delineates some of these areas), quantify its contribution to sortie generation enhancement, and recommend a plan of action that will be cost effective as well as functional (1). DCA tasked many Air Force agencies to aid them in the development of this plan of action. The Air Force Engineering and Services Center (AFESC) will provide data on the effects of airbase recovery and survivability on the enhancement of sortie generation capabilities in a post-attack scenario (2).

Justification

As a result of the increased emphasis on NATO's ability to survive an attack by the Warsaw Pact, plans are being made for the modification of NATO airbases to increase their survivability (2). Among those plans are ones to modify the configuration of the existing airfields.[1] In order to change the existing configurations, detailed

[1]Airfield shall be construed as the runway, taxiways, ramps, etc. for the remainder of this thesis.

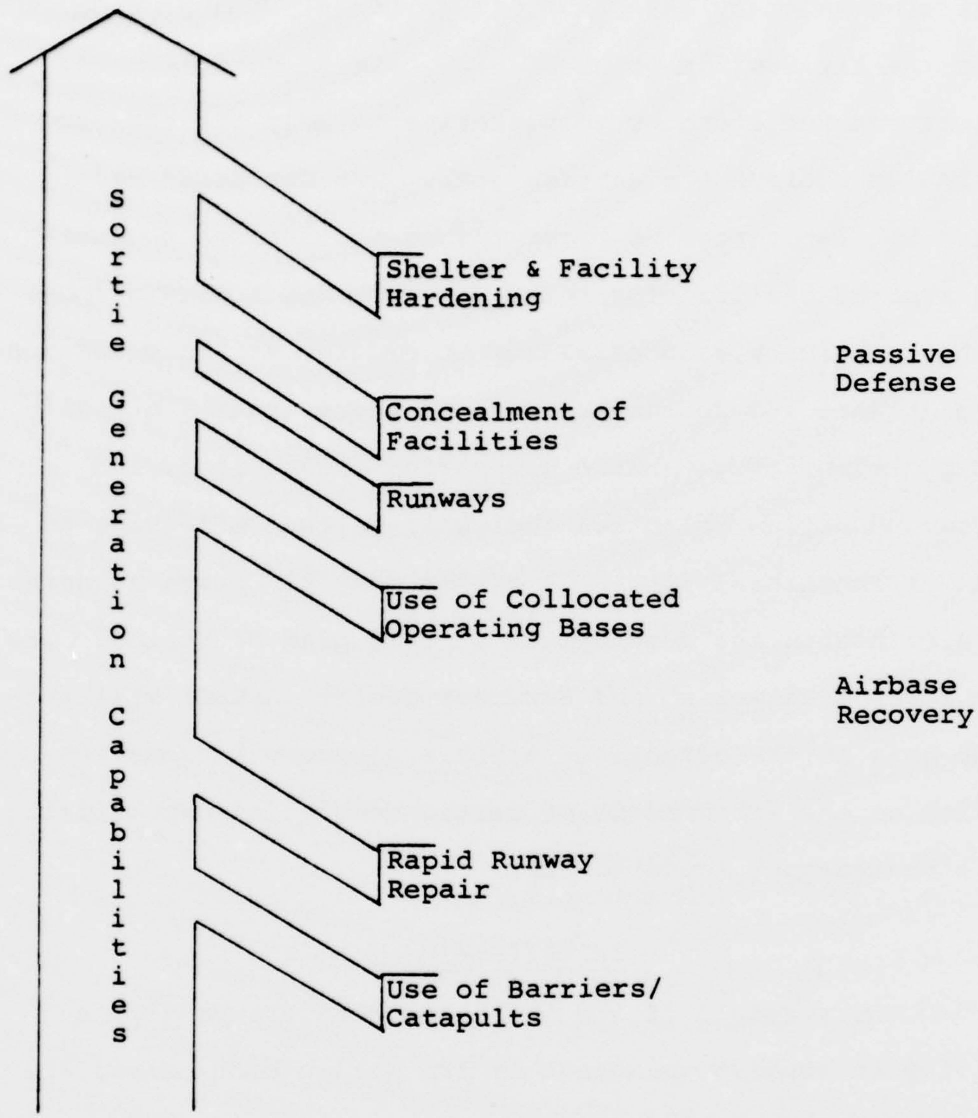


Fig. 1-3. Airbase Survivability Enhancements (1)

information about which configurations or proposed modifications could best withstand initial air attacks was vital. A number of simulation models were developed for use by the Air Force in the prediction of the damage to an airbase as a result of an air attack. However, they were only used for analyses of the effects of various attack scenarios on the probability of finding launch windows after an attack, and that only on existing airfield configurations (2). The reason for this was that the simulation models and the probability tables derived from them, used to assess airfield damage only checked for the existence of a minimum clear region (MCR) on the runways, taxiways, ramps, etc. that would allow a particularly configured aircraft to launch or recover. Neither the models nor the tables addressed the question of whether or not the MCR or launch window was accessible. The concept of accessibility of a launch window implies that any given launch window is accessible to a specific aircraft if there are no obstacles preventing it from taxiing from its parking area to the launch window. Therefore, any analyses ignoring this prospective problem has a limited usefulness in the real world.

The AFESC decided that the major thrust of its investigations would be limited to those programs that were directly related to the post-attack effort, but that could be accomplished now (9). AFESC's analyses will determine such diverse things as how severe are the effects of munitions on today's runways, how aircraft react to repaired runways, how fast a cratered runway can be repaired by the Rapid Runway Repair (RRR) teams to provide accessible launch windows and the stabilization of unpaved surfaces adjacent to existing runways in lieu of repairing the runways themselves (9).

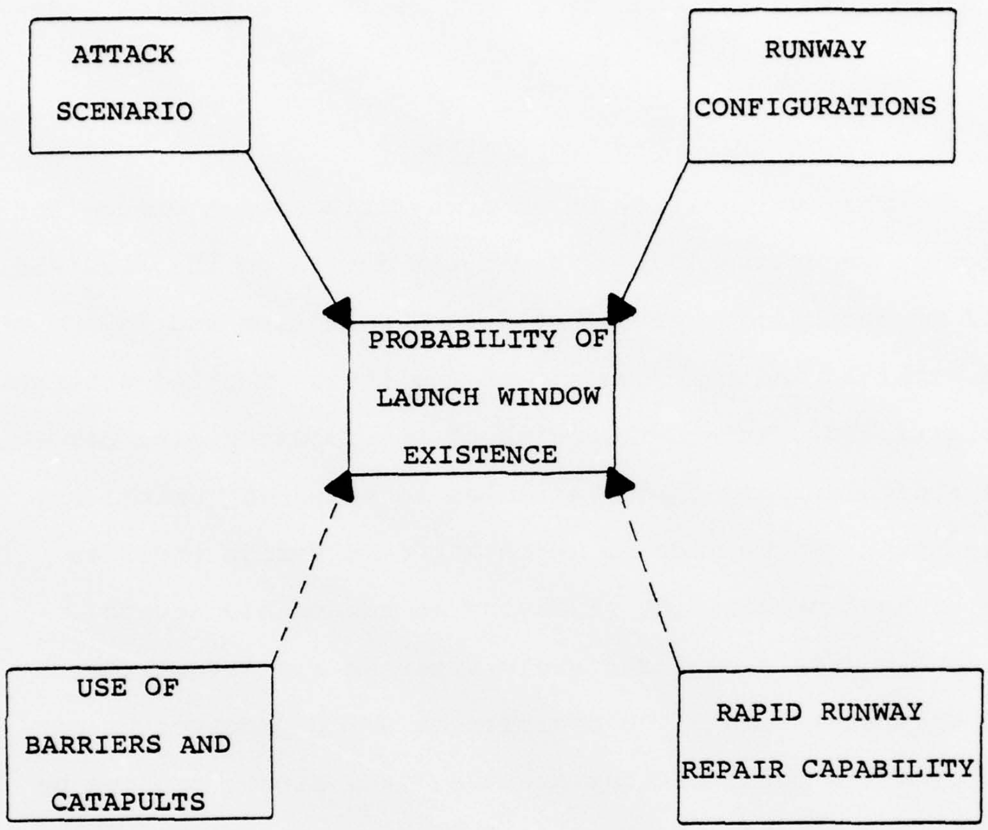
This thesis, combined with the efforts of AFESC, will enable Air Staff planners to examine the survivability of each base on a case-by-case basis. The failure to take the probability of having an accessible launch window present after an attack will severely limit the increased utility of airfield design modifications. This was amply demonstrated by the newly constructed contingency runway at Hahn AB. The contingency runway was constructed parallel and in close proximity to the existing runway. Preliminary tests on it have shown that there was no significant increase in the probability of existence of launch windows, much less accessible ones due to the close proximity of the two runways (2). There must be a combined effort to develop a methodology that will enable the optimization of survivability to be incorporated into airfield modifications. As a by-product of this, the local Base Civil Engineer (BCE) will be able to use the damage statistics to estimate how much on-hand material will be required to repair the damage resulting from an initial air attack and to estimate the average number of craters his personnel will have to repair after an initial air attack. The latter will in turn lead to a reasonable estimate of a "get well" time for the airfield.

Problem Statement

The availability of an accessible launch window for aircraft generation following an air attack on the airfield, will be determined by the pre-attack condition and layout of the airfield and the scenario of the attack mounted against the airfield. An understanding of the relationships between the aforementioned three variables is necessary before any assessment can be made of which airfield design provides the highest probability of having an accessible launch window in existence immediately after an air attack. Without this assessment, the decision on which prospective airfield design modifications are the best, either can not be made or would have had only limited applicability to the real world (see Figure 1-4).

Limitations

Since AFESC is doing the empirical testing on the capabilities of the RRR teams, no attempt was made in this research to derive the nature of the relationship between the capabilities of RRR teams and the creation of launch windows by runway repair. The probable existence of the relationship between mobile catapults and barriers and the probability of launch windows was acknowledged. However,



Legend:

________ indicates relationship to be investigated in this thesis

-------- indicates relationship not to be investigated in this thesis

Fig. 1-4. Variable Relationships

this research did not attempt to determine it. The authors acknowledged a relationship between the probability of launch window existence and sortie generation capabilities. This thesis did not, however, attempt to derive that relationship because it involved factors presently being determined by AFESC. Further limitations will be delineated in Chapter III.

Objectives and Questions

Before the objectives of this research could be determined, it was necessary to reaccomplish the system model as shown in Figure 1-4 in greater detail in order to better understand the interactions between the variables. This was done using two basic methods: causal loop diagrams and the delineation of independent, dependent and environmental variable relationships. The causal loop diagram is shown in Figure 1-5. Figure 1-6 depicts the interrelationships of the variable types. One other factor was taken into account in the derivation of the research objectives and questions: the actual simulation model to be used in this research. The model chosen was the Airbase Damage Assessment Model (AIDA) as developed by the Rand Corporation in 1975. The model allowed the modeler to define an airbase and the attack scenario, and then determine the existence of launch windows. As it was written, the model could not handle nuclear weapons or rockets as munitions

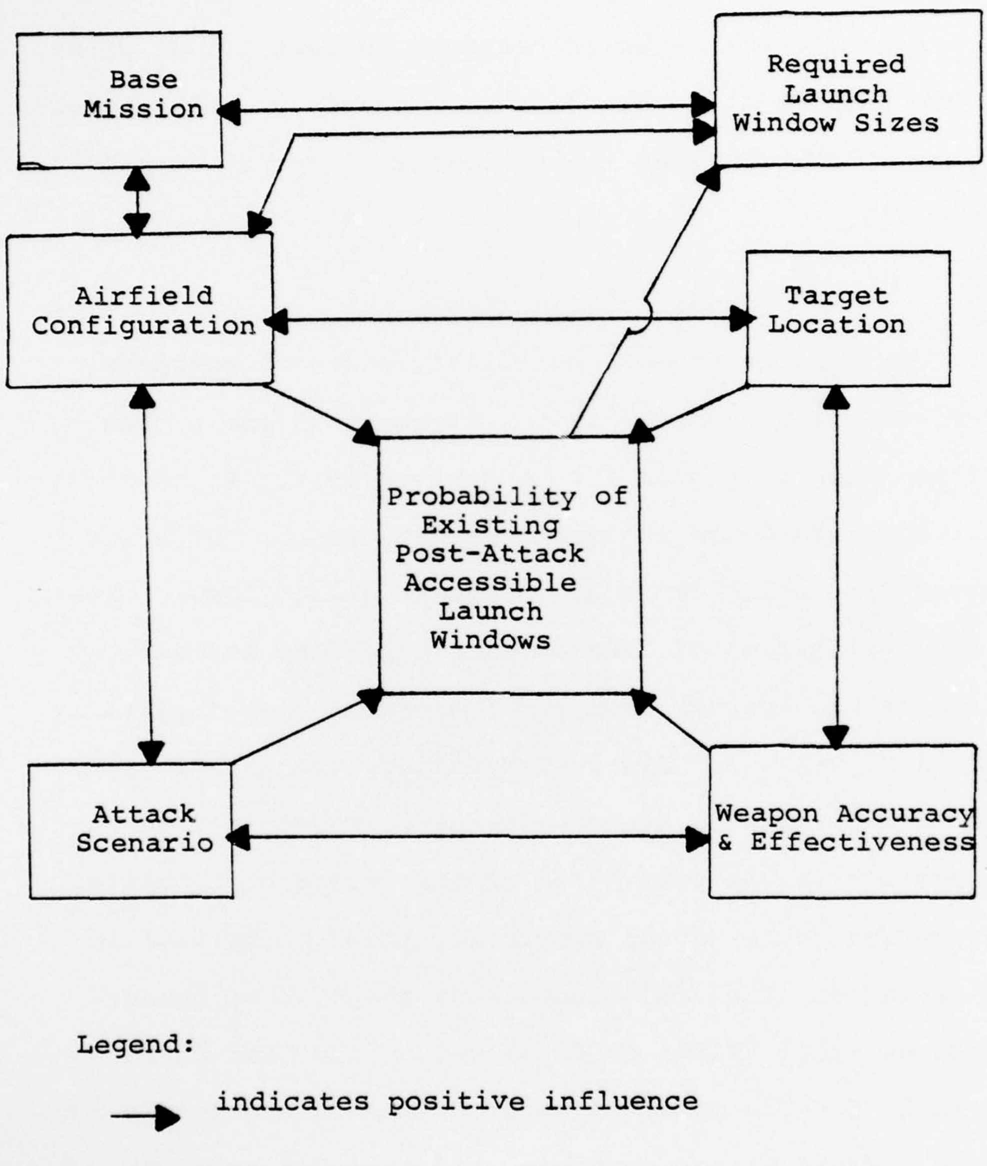


Fig. 1-5. Causal Loop Diagram

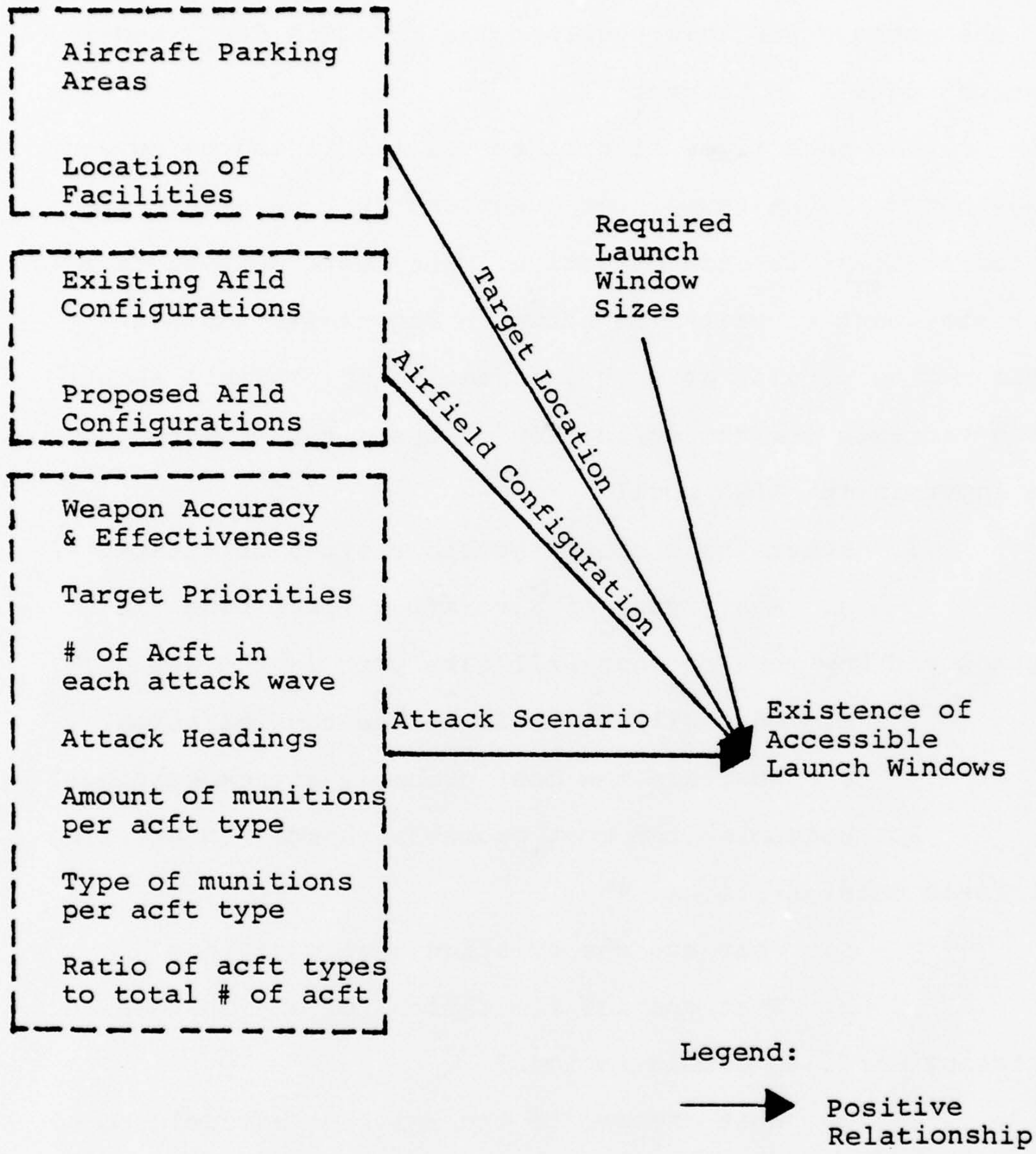


Fig. 1-6. Variable Interrelationships

delivered in an air attack. This feature was not changed by the authors for this thesis. The model is described in greater detail in Chapter II.

The objectives of this thesis are listed below and together with the associated questions that were investigated to complete each objective. They were derived from the statement of variables shown in Figure 1-6 and are designed to provide as much information as possible about each variable for the definition of the airbase system to be input in the AIDA model.

1. Determine the most probable types of attack.

a. What types of aircraft will compose the attack and how many of each will take part in the attack?

b. What will be their weapon configuration?

c. What are the most probable attack headings?

2. Determine the most probable changes in existing airfield configurations.

a. What are the existing configurations?

b. What are the limitations of any changes to existing airfield configurations?

c. What changes to the existing airfield configuration would be the most complemental?

3. For the existing airfield configuration and a given attack scenario determine the relationship between the probability of finding an existing launch window and the

probability of finding an accessible launch window for various types of USAF aircraft.

a. Which type of USAF aircraft will be deployed at each NATO airfield?

b. What is the probability of finding accessible launch windows for each type of USAF aircraft and for each airfield configuration?

c. What access routes are available for the parked aircraft to reach the runway and taxiways that could serve as secondary runways?

d. Which launch window sizes have greater than a 75 percent, 50 percent, or 25 percent probability (these probabilities represent arbitrary breakpoints in the expected probability distribution) of existence for each airfield configuration?

e. Which airfield configurations have a greater than 75 percent, 50 percent, or 25 percent probability of having a given size of launch window in existence after all types of attack?

f. Can the accessible relationship derived for the existing airfield configuration be applied to the altered configurations?

Assumptions

Several assumptions were necessary to further bound the problem. The assumptions were necessary to establish a working standard from which AIDA could be operated. The assumptions are:

1. The attack consisted of conventional, non-nuclear weapons because the AIDA model was designed for only conventional weapons (7). A secondary reason was that the use of nuclear weapons would, in all probability, make the search for accessible launch windows a moot point.

2. Since there are only two basic types of airfields in the NATO theater, the airfields in NATO were considered to be standardized and a representative airfield was chosen for this analysis (3:1). This allowed a broader application of the information determined by this thesis. In turn, this assumption reduced the number of simulations that had to be run to obtain the data base necessary for determining the probabilities of accessible launch window existence. Details of the proposed changes in airfield configurations are presented in Chapter III.

3. The base had the ability to generate aircraft if accessible launch windows were available. This basically required that those facilities/systems of the airbase designed to maintain, repair, generate and recover aircraft survive to use the available accessible launch window. The ability of these facilities to survive was not investigated.

4. The attack on an alternate airfield was concurrent with an attack on the main operating base (MOB) and the attacking aircraft were equally divided between the two

airfields. This ensured the element of surprise in the attack and allowed the number of aircraft attacking both bases to be limited, thus reducing computer time.

5. A second attack on the airfield would effectively close any launch windows present at the time of attack. This reduced the time period reviewed by the model to that directly after an initial attack.

6. U.S. aircraft, weapons, method of delivery, and probable accuracy could be substituted for Warsaw Pact weaponry. This limited background data on this type of information to the lowest possible security classification.

Summary

Considerable work has been done using simulation models to assess the existence of launch windows on an airfield following an air attack. However, the question of the accessibility of those windows never has been addressed directly. This fact has limited the applicability of the findings derived from those models. The purpose of this thesis is to address the relationship between airfield configurations, attack scenarios, and the accessibility of launch windows.

In the next chapter, the AIDA model will be presented. Its input requirements, available outputs, and some of its unique features will be discussed. Chapter III will delineate the author's plan of attack to identify and quantify the aforementioned relationship. Included will be the definition of the system that was input into the AIDA model, how the model was exercised, and the analysis plan for the model's output data. The actual analysis of the data will be in Chapter IV with the authors' recommendations and findings in Chapter V.

CHAPTER II

SYSTEM MODEL

In recent years, many models were developed to assess the damage to an airbase resulting from an air attack. The majority of those models were designed from the attacker's point of view. That is, the models were designed for the researcher to vary the attack scenarios to maximize the damage to an airbase. Of those models that could be used successfully by personnel who must repair or design the base, only three models appeared to meet the needs of this thesis. Those models were (1) Airbase Model (5:1); (2) An Effectiveness Model for Multiple Attacks Against an Airbase Complex (6:1); and (3) AIDA: An Airbase Damage Assessment Model (7:1). Only the AIDA model checks for the existence of launch windows and actually plots them (rather the bomb impact points). The others located hits on the runway, but did not print their location in a display of the runway.

Model Description

The AIDA model was developed by the Rand Corporation to permit examination of bombing attacks on a complex set of targets; e.g., on an airbase. The actual bomb impact points are obtained by Monte Carlo procedures and an attack is repeated for several trials to provide statistical estimates of the average damage and variability of that damage for each of the many targets. Several different sets of problems can be treated by successive cases during a single computer run (7:1).

The target system in the AIDA model can be composed of up to 250 separate targets; e.g., shelters, hangers, maintenance complexes, runways and taxiways (see Figure 2-1). A complete attack can consist of up to 50 distinct weapons delivery passes. Each target must be a rectangle of specific size and orientation. An attack pass is defined by the expected probability of a particular arrival, heading, aiming point, delivery accuracy and dispersion for a stick of weapons.[1] Targets are grouped into a maximum of 20 different vulnerability categories and there were a maximum of 10 types of weapons that could have been dropped in an attack (7:1).

In the basic mode of AIDA, weapons are of two types: point impact weapons (such as general purpose (GP) bombs and precision guided munitions (PGMs)) or area weapons (such as cluster bomb units (CBUs)). A weapon reliability must be specified for each kind of weapon. For each kind of point impact weapon an effective miss distance (EMD)[2] is

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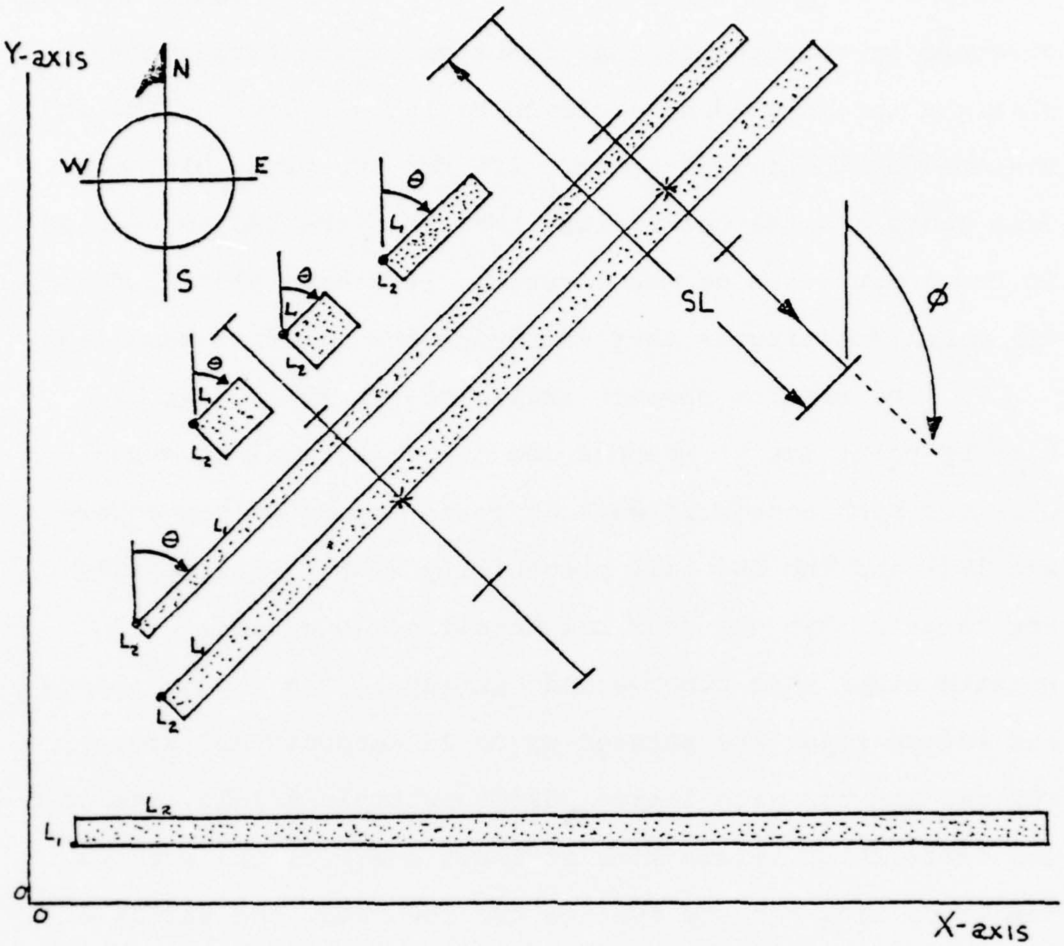
[1]A stick of weapons is defined as a rack of weapons on the attacking aircraft.

[2]That miss distance at which a weapon is effective and an impact is to be categorized as a hit.



TARGETS

- . Reference (westernmost) corner
- L_1 Northeasterly heading boundary
- L_2 Southeasterly heading boundary
- θ Orientation angle

ATTACK PASSES

- * DMPI
- Ø Attack heading
- SL Stick length
- ++ Nominal bomb impacts

Fig. 2-1. Target and Attack Layout for AIDA (7:11) specified for each target (7:2). When this is done, target coverage is computed as that fraction of the target area that was intersected by a circle having a radius of EMD and centered at the impact point. If, for any given hit, the user wants a different radius other than the EMD to be used in the computation of the coverage, it can be specified and the model substitutes that value for the value of EMD (7:3).

The results of each trial include the number of hits by point impact weapons and the fractional coverage by CBUs for each target as well as point impact weapon coverage (FC) and the CBU kill probability (PK). Additionally, for targets that the user has specified (a maximum of 20 targets other than runways and taxiways), the impact points and weapon types are printed up to 25 weapons per target. The results for each target, using multiple trials, included the fraction of trials with at least one hit, the average number of hits and the average CBU coverage, the standard deviation of those two measures, and the average values of FC and PK (7:4).

The user can also specify that certain (up to 12) of the rectangular targets are actually runways or taxiways that are suitable for aircraft operations. The model then checks to see if such operations are possible from those areas; e.g., tests are made to see if the launch window required for operations was available after an attack. In checking for runway availability, only point impact weapons are considered, and the crater radius is the EMD. Up to 250 hits can be sorted and examined for each such target. If the runway does not meet the minimum requirements, the user can request an assessment of the minimum number of craters that would need to be repaired to meet runway requirements. The user can also request an approximate plot of the impact points for each runway (7:4).

AIDA has several features designed to simplify its operation and to allow a series of cases to be analyzed during a single computer run. The first feature allows a multi-aircraft attack against the same objective to be specified easily. When two or more attacks have common parameters, e.g., heading, desired mean point of impact (DMPI), circular error probable (CEP), dispersion, or arrival probability, a single entry generates the additional attacks. Other convenience features are based on the use of the REDO card (see discussion of model input requirements). When this card is encountered it acts as a terminator card, ending the input for one case and telling the computer there is another case (7:6).

Input Requirements

There are seven basic types of cards which can be used in operating AIDA, although only three are mandatory. Four card types describe the target and attack characteristics, and the other three are used to control AIDA operation. The seven card types are:

TGT	target data
ATT	attacker data
ATT2	alternate attacker data (optional)
EMD	weapon data (optional)
CONT	control data (optional)
REDO	controls sequential cases (optional)
END	last card

There may be a maximum of 250 cards, 50 ATT or ATT2 cards, and 10 EMD cards. For a given case there can only be one control card. The order of the cards is immaterial, except that a REDO card or an END card must be used to signify the completion of input for a given case. The targets and attackers are numbered, internally by the computer, in the sequence in which their descriptions were read in. Each target can also have an alphanumeric designator; e.g., facility number. A detailed description of how the data are to be entered on each type of card is presented in Appendix A. The input data is normally printed as the first part of the output for each case and Table 2-1 outlines the output options for the results (7:8). A CONT card would be required if the user wants to take advantage of more than the most basic of AIDA's features. Without this card, AIDA examines only one Monte Carlo sample of attack and provides the actual numbers of all hits on all targets and the stored hit locations for specified targets. More

TABLE 2-1

OUTPUT CONTROL (7:8)
(for each trial)

NPRINT Control Value	All Impact Points	All Hits (and Target Corners)	Stored Hit Data	Hit Summary	Runway Results	Multiple Trial Statistics
-2	X	X	X	X	X	X
-1		X	X	X	X	X
0			X	X	X	X
1				X	X	X
2					X	X
3						X
4					X[b]	X
5				X[c]		X

[b]Compact listing of hits and required repairs for runways or taxiway.

[c]Compact listing of hits on each target.

specifically, a CONT card is required if (1) more than one trial is required, (2) an alternative output mode is desired, (3) a different mode of operation is desired, or (4) the runway availability features are to be used. The CONT card is used to specify the number of trials, the mode of operations, the output formats, the launch window size, whether or not minimum repair is to be assessed and the distances that the launch window is to be shifted laterally and longitudinally in checking for its existence (7:9).

Figure 2-1 illustrates the nature and measurement of the input data for the TGT and ATT cards. The first step when using the AIDA model is to construct a rectangular coordinate system on a plan view of the airbase.

> The target location and target orientation, as well as the attack heading and the intended DPMI, are then specified in that coordinate system, headings are measured clockwise from the Y-axis, or "north," and given in degrees [7:10].

As can be discerned in Figure 2-1, the target location is specified by the westernmost corner and the dimensions are then given for the northeasterly heading target limb and the southeasterly heading target limb. All targets must fall within the first quadrant and the sum of the X and Y coordinates must not be greater than 25,000 (7:10).

The entire attack consists of a set of distinct weapons delivery passes with each pass defined by an ATT or ATT2 card. For each pass it is necessary to specify the heading, the number and type of weapons, the intended DPMI, the probability of arrival on target, and, for the ATT card only, the aiming accuracy of the mean point of impact (the range of error probable (REP) and deflection error probable (DEP)), the ballistic dispersion in range and deflection, and, for a stick of weapons, the stick length.[3] All linear dimensions are entered using feet as the units of length (7:10).

Several special features are available for use with point impact weapons. If a weapon could effectively damage a target when it only falls near but outside the target outline, the EMD for a hit can be entered on the EMD card for 10 (or 20) target types. The appropriate entry in most cases is the radius of a circle whose area is equal to the mean area of effectiveness (MAE) for the corresponding target weapon combination. In the case of hits on runways or taxiways, the appropriate entry is the crater radius. When AIDA checks for the existence of a launch window, each reliable impact is assumed to have a crater radius equal to the EMD (7:12,13).

Outputs

Discussion of the outputs available from the AIDA model can be facilitated by presenting a sample problem.

---

[3]For the ATT2 cards the delivery conditions (speed dive angle, release altitude, intervalometer setting, and aiming accuracy mils) replace the stick length and accuracy inputs on the ATT card.

Such a sample was run (7:18). This sample concerns hypothetical attacks on an airbase called XYZ, as shown in Figure 2-2. The base consisted of a 150 x 8000 foot main runway, several taxiways, a parking ramp, eight maintenance support facilities, and a housing area. The attack was made by four medium bombers that dropped 25 bombs each, attempting to cut the runway at two points; two medium bombers targeted on the operations building near the main taxiway; and one medium bomber that was targeted on the electronics shop. Also, one fighter-bomber was assigned to each of the main aircraft maintenance buildings, B1 and B2, and one fighter-bomber was assigned to drop a stick of five CBUs on the housing area (7:18).

Four different cases were run to display the output. However, only Cases 1, 2, and 4 apply to the requirements of this research. In Case 1 the model was directed to use the Monte Carlo mode and to print a statistical summary of five replications of the attack. Also, no assessment of runway availability was requested. Case 2 called for a single Monte Carlo attack, but with full printout and with an examination of the availability of a 50 foot x 4000 foot launch window on either the runway or main taxiway. The focus in Case 4 was the availability of launch windows for aircraft operations. This time only the runway and main taxiway were retained as targets (for output purposes), but all attacks were considered. Twenty-five attack trials were

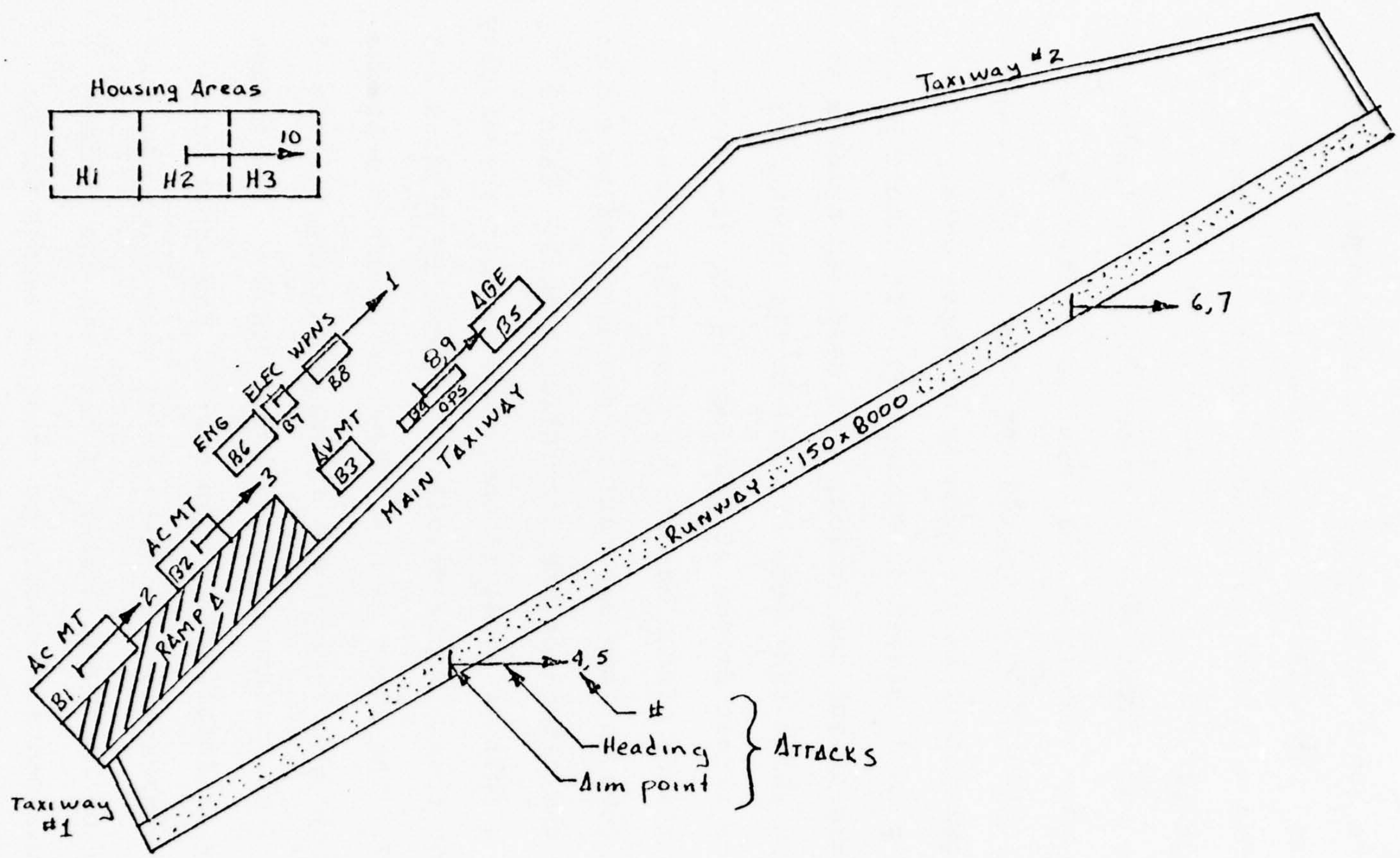


Fig. 2-2. Base XYZ (7:19)

run with the Monte Carlo mode, repair requirements were assessed, and the trial-by-trial runway results were printed along with the statistical summary for the 25 trials (7:22-23).

The very first type of output, which is listed even before the main summary of the input data, displays any trajectory calculations required for this attack. Immediately following this is the summary of input data. This relationship is displayed in Figure 2-3. It should be noted that the targets and the attacks were assigned numbers in the order in which they were located in the input deck (7:23). The target damage statistics for the five Monte Carlo repetitions of the attack for Case 1 are shown in Figure 2-4 (the various annotations are designed to aid in clarifying the nature of the statistics shown). Case 2 called for a full printout of one trial without the display of the input data. Those results are shown in Figures 2-5 through 2-7. The first results shown are the hit patterns on the runway (Figure 2-5) and the main taxiway (Figure 2-6) as well as statements about their status. The target hit summary is displayed in Figure 2-7. The input data for Case 4 represents a trial-by-trial record (top half of Figure 2-8) of the total number of hits and the minimum repair requirements necessary to create a launch window (where there is no entry there were no hits). This yields a distribution of the existence of a launch window and is

```
**********************************************************************************************************
                    *****AIDA*****     AN AIRBASE DAMAGE ASSESSMENT MODEL
                    DEVELOPED BY THE RAMSTEIN OFFICE OF THE RAND CORPORATION
**********************************************************************************************************
NO OF TRIALS   5 NPRINT  3  MODE  0  MCL       0( 250)   MCU     0( 5)   MIN REPAIR 0  PLOT HITS 0   TEST  0
**********************************************************************************************************

          *****  BASE COMPLEX NAME - BASE XYZ  *****
```

TARGET DATA

NUMBER	X-DIM	Y-DIM	NE LIMB	SE LIMB	ANGLE	TGT TYPE	STORE	BLDG NO
1	1000.	1000.	5200.	150.	60.	1.	0.	RUNWAY
2	775.	1350.	5200.	50.	45.	1.	0.	MAIN TAX
3	540.	1610.	1750.	175.	45.	3.	0.	RAMP A
4	400.	1335.	50.	375.	60.	2.	0.	TXWY #1
5	4400.	4300.	1300.	50.	70.	2.	0.	TXWY #2
6	400.	1750.	600.	250.	45.	4.	1.	AC HT #1
7	1100.	2450.	400.	200.	45.	4.	1.	AC HT #2
8	3000.	3000.	250.	150.	45.	5.	0.	AC HT #3
9	2450.	1220.	500.	80.	45.	4.	0.	OPS B4
10	2450.	3200.	400.	250.	45.	5.	0.	AGE B5
11	1425.	3075.	300.	175.	45.	4.	1.	ENG B6
12	1220.	3325.	150.	80.	45.	5.	0.	ELECT B7
13	1330.	3575.	225.	100.	45.	5.	1.	WPNS B8
14	500.	4500.	500.	500.	0.	10.	0.	H1
15	1000.	4500.	500.	500.	0.	10.	0.	H2
16	1500.	4500.	500.	500.	0.	10.	0.	H3

ATTACK DATA

NUMBER	HDG	X-DMPI	Y-DMPI	REP	DEP	R-DISP	D-DISP	NO WPNS	LENGTH	WPN TYPE	ARRIVAL
1	45.	1775.	3350.	400.	200.	50.	30.	25.	800.	1.	1.000
2	45.	650.	1350.	151.	117.	28.	23.	6.	86.	2.	1.000
3	45.	1350.	2575.	151.	117.	28.	23.	6.	86.	2.	1.000
4	30.	2750.	1300.	400.	200.	50.	30.	25.	1500.	1.	1.000
5	30.	2750.	1300.	400.	200.	50.	30.	25.	1500.	1.	1.000
6	30.	6250.	3875.	400.	200.	50.	30.	25.	1500.	1.	1.000
7	30.	6250.	3875.	400.	200.	50.	30.	25.	1500.	1.	1.000
8	45.	2600.	3400.	400.	200.	50.	30.	25.	1200.	1.	1.000
9	45.	2600.	3400.	400.	200.	50.	30.	25.	1200.	1.	1.000
10	90.	1250.	4750.	400.	200.	100.	100.	5.	2000.	3.	1.000

MISS DISTANCES ALLOWED FOR EFFECTIVE HITS
TARGET TYPES

WPN TYPE	WPN REL	1	2	3	4	5	6	7	8	9	10
1	0.950	22.	22.	22.	40.	41.	0.	0.	0.	0.	0.
		0.	0.	0.	50.000	75.000	0.	0.	0.	0.	0.
2	0.950	23.	23.	28.	50.	50.	0.	0.	0.	0.	0.
		0.	0.	0.	60.000	90.000	0.	0.	0.	0.	0.
3	0.900	500.	250.	0.	0.	0.	0.	0.	0.	0.	0.
		0.	0.	0.	0.	0.	0.	0.	0.	0.	0.250

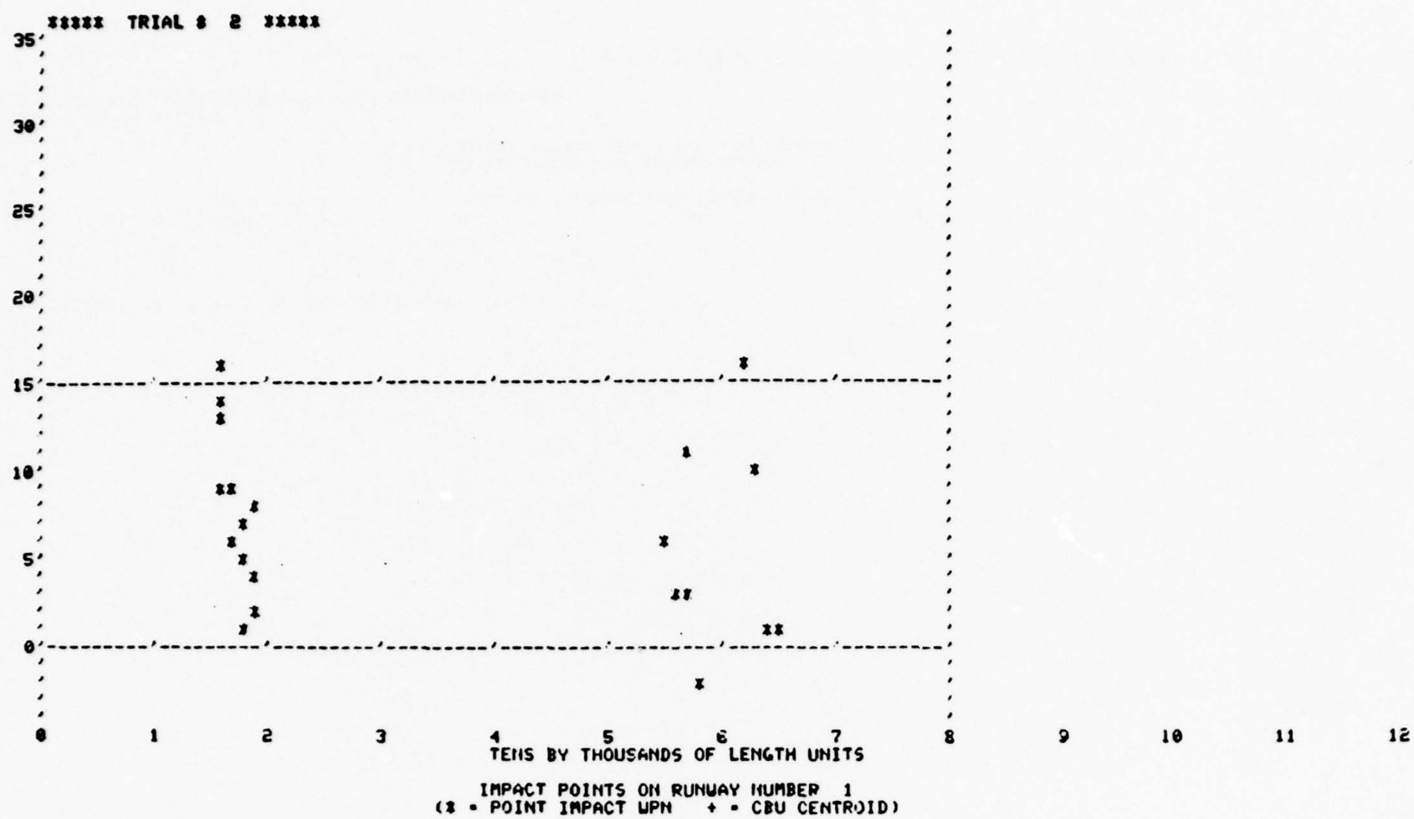
Fig. 2-3. Input Summary--All Cases (7:25)

TARGET NUMBER	PERCENT ATTACKS HIT	AVERAGE HITS PER ATTACK	STD. DEV. OF HITS	AVG. CBU COVERAGE	STD. DEV. COVERAGE	AVG. BOMB COVERAGE EMD	AVG. BOMB COVERAGE OTHER	CBU PK	BLDG NO.
	TARGET TYPE # 1								
1	100.0	18.40	3.51	0.	0.	0.019	0.	0.	RUNWAY
2	100.0	14.20	12.52	0.	0.	0.041	0.	0.	MAIN TAX
		------ 32.60		------ 0.					
	TARGET TYPE # 2								
4	0.	0.	0.	0.	0.	0.	0.	0.	TXWY #1
5	0.	0.	0.	0.	0.	0.	0.	0.	TXWY #2
		------ 0.		------ 0.					
	TARGET TYPE # 3								
3	80.0	3.62	2.88	0.	0.	0.019	0.	0.	RAMP A
		------ 3.60		------ 0.					
	TARGET TYPE # 4								
6	100.0	5.40	1.34	0.	0.	0.155	0.220	0.	AC HT #1
7	60.0	2.40	2.83	0.	0.	0.166	0.217	0.	AC HT #2
9	0.	0.	0.	0.	0.	0.	0.	0.	OPS E4
11	0.	0.	0.	0.	0.	0.	0.	0.	ENG B6
		------ 7.80		------ 0.					
	TARGET TYPE # 5								
8	40.0	2.20	3.19	0.	0.	0.114	0.271	0.	AC HT #3
10	60.0	2.40	2.53	0.	0.	0.063	0.102	0.	AGE B5
12	0.	0.	0.	0.	0.	0.	0.	0.	ELECT B7
13	0.	0.	0.	0.	0.	0.	0.	0.	WPNS E2
		------ 4.60		------ 0.					
	TARGET TYPE # 10								
14	0.	0.	0.	0.23	0.11	0.	0.	0.050	H1
15	0.	0.	0.	0.32	0.19	0.	0.	0.031	H2
16	0.	0.	0.	0.36	0.10	0.	0.	0.089	H3
		------ 0.		------ 0.91					

DAMAGE STATISTICS BY TARGET TYPE

TARGET TYPE	AVERAGE PERCENT HIT	STANDARD DEVIATION	---- COVERAGE ---- EMD	OTHER	CBU
1	100.0	0.	2.3	0.	0.
2	0.	0.	0.	0.	0.
3	80.0	44.7	1.9	0.	0.
4	40.0	13.7	11.7	16.1	0.
5	25.0	25.0	6.5	16.5	0.
10	0.	0.	0.	0.	7.7

Fig. 2-4. Target Damage Statistics, Case 1 (7:27)



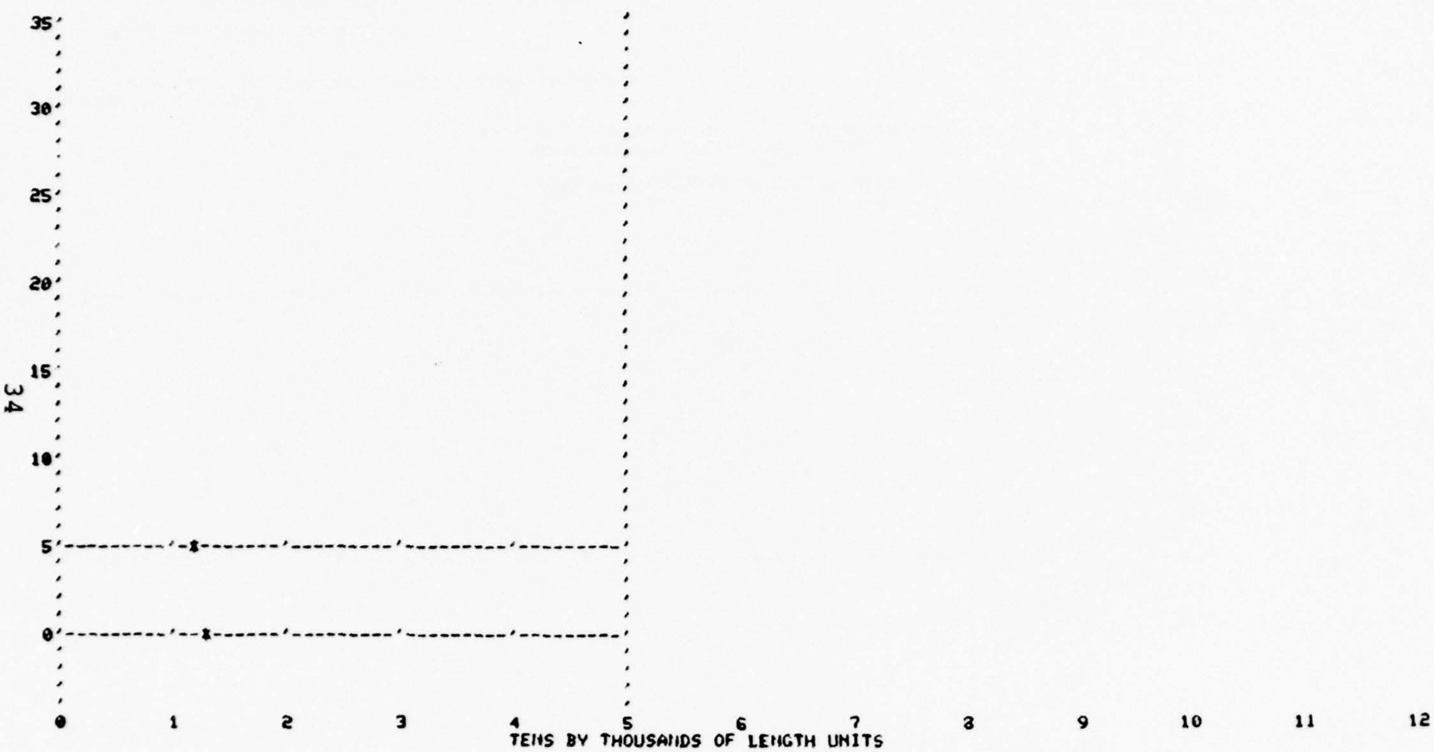
RUNWAY # 1 IS CLOSED
1 HOLES MUST BE REPAIRED TO MEET RUNWAY MINIMUMS

AT LEAST ONE RUNWAY IS AVAILABLE

Fig. 2-5. Runway Hit Patterns, Case 2 (7:26)

```
*****AIDA*****     AN AIRBASE DAMAGE ASSESSMENT MODEL
DEVELOPED BY THE RAMSTEIN OFFICE OF THE RAND CORPORATION
NO OF TRIALS   2 NPRINT  0  MODE  0  MCL   4000( 500)   MCU   50(10)   MIN REPAIR 1  PLOT HITS 2   TEST  0

***** BASE COMPLEX NAME - BASE XYZ *****
```




```
IMPACT POINTS ON RUNWAY NUMBER  2
(* = POINT IMPACT WPN    + = CBU CENTROID)

RUNWAY #  2 IS CLOSED
   2 HOLES MUST BE REPAIRED TO MEET RUNWAY MINIMUMS
```

Fig. 2-6. Taxiway Hit Patterns, Case 2 (7:28)

TARGET HIT SUMMARY TRIAL 2

TGT NO.	NO. HITS	CBU COVERAGE	BOMBS EMD	BOMBS OTHER	CBU PK	BLDG NO.
		** TARGET TYPE # 1 **				
1	22	0.	0.	0.	0.	RUNWAY
2	0	0.	0.	0.	0.	MAIN TAX
		** TARGET TYPE # 2 **				
4	0	0.	0.	0.	0.	TXWY #1
5	0	0.	0.	0.	0.	TXWY #2
		** TARGET TYPE # 3 **				
3	5	0.	0.020	0.	0.	RAMP A
		** TARGET TYPE # 4 **				
6	2	0.	0.057	0.081	0.	AC HT #1
7	1	0.	0.028	0.041	0.	AC HT #2
9	0	0.	0.	0.	0.	OPS B4
11	7	0.	0.374	0.508	0.	ENG B6
		** TARGET TYPE # 5 **				
8	0	0.	0.	0.	0.	AC HT #3
10	10	0.	0.378	0.801	0.	AGE B5
12	1	0.	0.029	0.196	0.	ELECT B7
13	6	0.	0.393	0.854	0.	WPNS B8
		** TARGET TYPE # 10 **				
14	0	0.	0.	0.	0.	H1
15	0	0.	0.	0.	0.	H2
16	0	0.	0.	0.	0.	H3

HIT LOCATION AND WPN TYPE FOR SELECTED TARGETS

	X-DIM	Y-DIM	WPN TYPE
TARGET NUMBER 6	X-DIM	Y-DIM	WPN TYPE
	716.	2042.	2
	722.	2034.	2
TARGET NUMBER 7	X-DIM	Y-DIM	WPN TYPE
	1224.	2316.	2
TARGET NUMBER 11	X-DIM	Y-DIM	WPN TYPE
	1519.	2952.	1
	1529.	2997.	1
	1578.	3036.	1
	1753.	3115.	1
	1684.	3118.	1
	1696.	3148.	1
	1704.	3145.	1
TARGET NUMBER 13	X-DIM	Y-DIM	WPN TYPE
	2061.	3541.	1
	2109.	3611.	1
	2101.	3680.	1
	2181.	3684.	1
	2100.	3733.	1
	2132.	3591.	1
TARGET NUMBER 1	X-DIM	Y-DIM	WPN TYPE
	2530.	1820.	1
	2463.	1864.	1
	2636.	1860	

Fig. 2-7. Target Hit Summary, Case 2 (7:29)

```
*****AIDA*****     AN AIRBASE DAMAGE ASSESSMENT MODEL
DEVELOPED BY THE RAMSTEIN OFFICE OF THE RAND CORPORATION
NO OF TRIALS  25 NPRINT  4  MODE  1  MCL   4000( 250)   MCU   50(10)   MIN REPAIR 1  PLOT HITS 0   TEST  0
```

***** BASE COMPLEX NAME - BASE XYZ *****

TARGET DATA

NUMBER	X-DIM	Y-DIM	NE LIMB	SE LIMB	ANGLE	TGT TYPE	STORE	BLDG NO
1	1000.	1000.	8000.	150.	60.	1.	0.	RUNWAY
2	775.	1350.	5000.	50.	45.	1.	0.	MAIN TAX

ATTACK DATA

NUMBER	HDG	X-DMPI	Y-DMPI	REP	DEP	R-DISP	D-DISP	NO WPNS	LENGTH	WPN TYPE	ARRIVAL
1	45.	1775.	3350.	400.	200.	50.	30.	25.	800.	1.	1.000
2	45.	650.	1850.	151.	117.	28.	23.	6.	86.	2.	1.000
3	45.	1350.	2575.	151.	117.	28.	23.	6.	86.	2.	1.000
4	90.	2750.	1900.	400.	200.	50.	30.	25.	1500.	1.	1.000
5	90.	2750.	1900.	400.	200.	50.	30.	25.	1500.	1.	1.000
6	90.	6250.	3875.	400.	200.	50.	30.	25.	1500.	1.	1.000
7	90.	6250.	3875.	400.	200.	50.	30.	25.	1500.	1.	1.000
8	45.	2600.	3400.	400.	200.	50.	30.	25.	1200.	1.	1.000
9	45.	2600.	3400.	400.	200.	50.	30.	25.	1200.	1.	1.000
10	90.	1250.	4750.	400.	200.	100.	100.	5.	2000.	3.	1.000

MISS DISTANCES ALLOWED FOR EFFECTIVE HITS

TARGET TYPES

WPN TYPE	WPN REL	1	2	3	4	5	6	7	8	9	10
1	0.950	22.	22.	22.	40.	41.	0.	0.	0.	0.	0.
		0.	0.	0.	50.000	75.000	0.	0.	0.	0.	0.
2	0.950	28.	28.	28.	50.	50.	0.	0.	0.	0.	0.
		0.	0.	0.	60.000	90.000	0.	0.	0.	0.	0.
3	0.900	-500.	250.	0.	0.	0.	0.	0.	0.	0.	0.
		0.	0.								

Fig. 2-8. Input Data, Case 4 (7:34)

more revealing than the statistical summary shown in the bottom half of Figure 2-9 (7:28).

Summary

This chapter has described the model that was used in answering the research questions. The model's input requirements have been delineated in detail as has its flexibility. A more in-depth discussion of the input requirements is presented in Appendix A. The available outputs from the model were developed using sample case studies. The next chapter will cover two basic items of this research: (1) the definition of the system that was input into the model and (2) the methods by which the model was exercised in order to obtain the data needed to develop the answers to the research questions in Chapter I.

TRIAL	1	TGT	1	HITS	17	REPAIRS	2
TRIAL	1	TGT	2	HITS	35	REPAIRS	35
TRIAL	2	TGT	1	HITS	20	REPAIRS	1
TRIAL	3	TGT	1	HITS	17	REPAIRS	2
TRIAL	3	TGT	2	HITS	3	REPAIRS	3
TRIAL	4	TGT	1	HITS	11	REPAIRS	0
TRIAL	5	TGT	1	HITS	17	REPAIRS	1
TRIAL	5	TGT	2	HITS	1	REPAIRS	1
TRIAL	6	TGT	1	HITS	18	REPAIRS	0
TRIAL	6	TGT	2	HITS	5	REPAIRS	5
TRIAL	7	TGT	1	HITS	16	REPAIRS	1
TRIAL	8	TGT	1	HITS	23	REPAIRS	4
TRIAL	8	TGT	2	HITS	4	REPAIRS	3
TRIAL	9	TGT	1	HITS	12	REPAIRS	0
TRIAL	9	TGT	2	HITS	5	REPAIRS	5
TRIAL	10	TGT	1	HITS	16	REPAIRS	0
TRIAL	10	TGT	2	HITS	11	REPAIRS	11
TRIAL	11	TGT	1	HITS	16	REPAIRS	1
TRIAL	12	TGT	1	HITS	16	REPAIRS	0
TRIAL	13	TGT	1	HITS	25	REPAIRS	4
TRIAL	13	TGT	2	HITS	1	REPAIRS	0
TRIAL	14	TGT	1	HITS	18	REPAIRS	1
TRIAL	14	TGT	2	HITS	15	REPAIRS	12
TRIAL	15	TGT	1	HITS	22	REPAIRS	3
TRIAL	15	TGT	2	HITS	6	REPAIRS	6
TRIAL	16	TGT	1	HITS	14	REPAIRS	0
TRIAL	16	TGT	2	HITS	7	REPAIRS	7
TRIAL	17	TGT	1	HITS	10	REPAIRS	1
TRIAL	17	TGT	2	HITS	19	REPAIRS	19
TRIAL	18	TGT	1	HITS	6	REPAIRS	0
TRIAL	19	TGT	1	HITS	17	REPAIRS	2
TRIAL	19	TGT	2	HITS	10	REPAIRS	10
TRIAL	20	TGT	1	HITS	11	REPAIRS	0
TRIAL	20	TGT	2	HITS	4	REPAIRS	2
TRIAL	21	TGT	1	HITS	15	REPAIRS	0
TRIAL	21	TGT	2	HITS	3	REPAIRS	0
TRIAL	22	TGT	1	HITS	12	REPAIRS	0
TRIAL	22	TGT	2	HITS	10	REPAIRS	8
TRIAL	23	TGT	1	HITS	14	REPAIRS	1
TRIAL	23	TGT	2	HITS	14	REPAIRS	14
TRIAL	24	TGT	1	HITS	19	REPAIRS	0
TRIAL	24	TGT	2	HITS	2	REPAIRS	2
TRIAL	25	TGT	2	HITS	5	REPAIRS	2

TARGET DAMAGE STATISTICS FOR 25 TRIALS

TARGET NUMBER	PERCENT ATTACKS HIT	AVERAGE HITS PER ATTACK	STD. DEV. OF HITS	AVG. CBU COVERAGE	STD. DEV. COVERAGE	AVG. BOMB COVERAGE EMD	AVG. BOMB COVERAGE OTHER	CBU PK	BLDG NO.
	TARGET TYPE # 1								
1	96.0	15.28	5.30	0.	0.	0.	0.	0.	RUNWAY
2	76.0	6.40	7.96	0.	0.	0.	0.	0.	MAIN TAX
		------- 21.68		------ 0.					

AT LEAST ONE MINIMUM RUNWAY SECTION WAS OPEN AFTER 64.0 PERCENT OF THE ATTACKS
WHEN ALL RUNWAYS WERE CLOSED, 1.8(0.8) HOLES REQUIRED REPAIR, ON THE AVERAGE, TO PROVIDE A MINIMUM RUNWAY
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Fig. 2-9. Trial-by-Trial Results and Target Damage Statistics, Case 4 (7:35)

CHAPTER III

METHODOLOGY

As was mentioned in the preceding chapter, a large amount of data was required to define the airbase and the attacks on it that would comprise the system which AIDA would analyze. Therefore, the initial task was to obtain this background data and define the system to be tested. The final task was to exercise the model and analyze the data output from AIDA. Reiterating then, the methodology consisted mainly of system definition, data generation and data analysis as is reflected in the research objectives listed in Chapter I.

System Definition

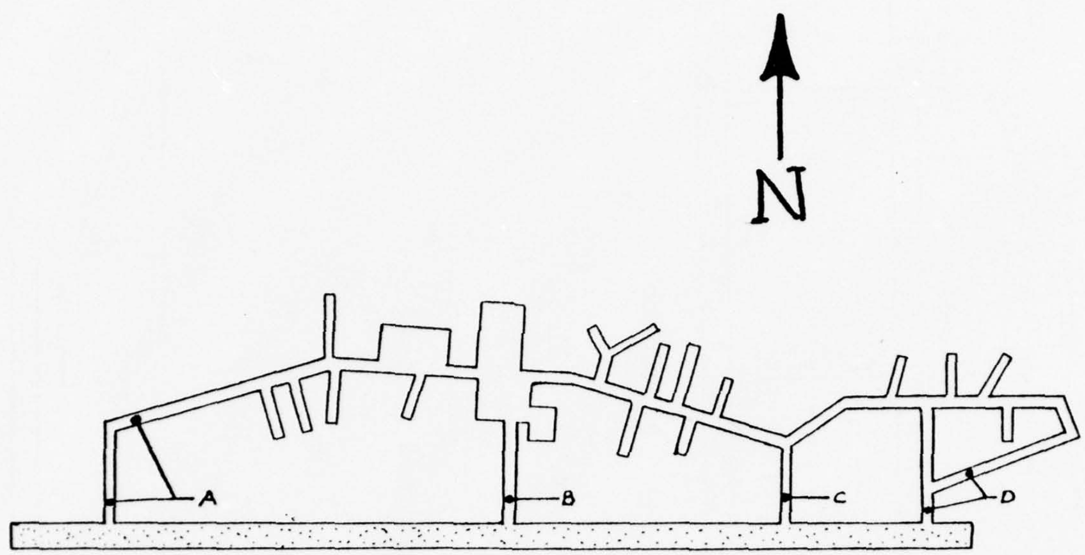
AIDA is a simulation model developed to assist in the analysis of airbase damage after a conventional air strike. The model's operation provides extensive flexibility in terms of attack level and detail of assessment. It provides specific definition of the attack scenario; e.g., number of attacking forces, level of effectiveness, targets to be attacked and the types of munitions used in the attack. As a result, the model provides a detailed damage assessment of the airbase.

Airbase Configuration

The airbase used in the system was the standard NATO MOB. It contained maintenance and operations buildings, support facilities, fuel and munitions storage areas, aircraft shelters and parking areas, and the airfield. The airfield consisted of a main runway, 150 feet by 8000 feet, and associated access taxiways. (See Figure 3-1.) Two possible modifications, as recommended by DCA, were considered to this basic airfield (3:1). They were: (1) a 100 foot by 6500 foot runway parallel to and within 1000 feet of the main runway, such that collateral damage could result from an attack on the main runway, (2) a 100 foot by 6500 foot runway separated from the main runway, such that separate targeting was required (3:1). This was construed to mean: (1) a parallel runway 900 feet away from the existing runway, and (2) a runway 715 feet away and parallel but not adjacent to the existing runway (see Figure 3-2). It is assumed that the configurations shown can in fact be made.

Target Location

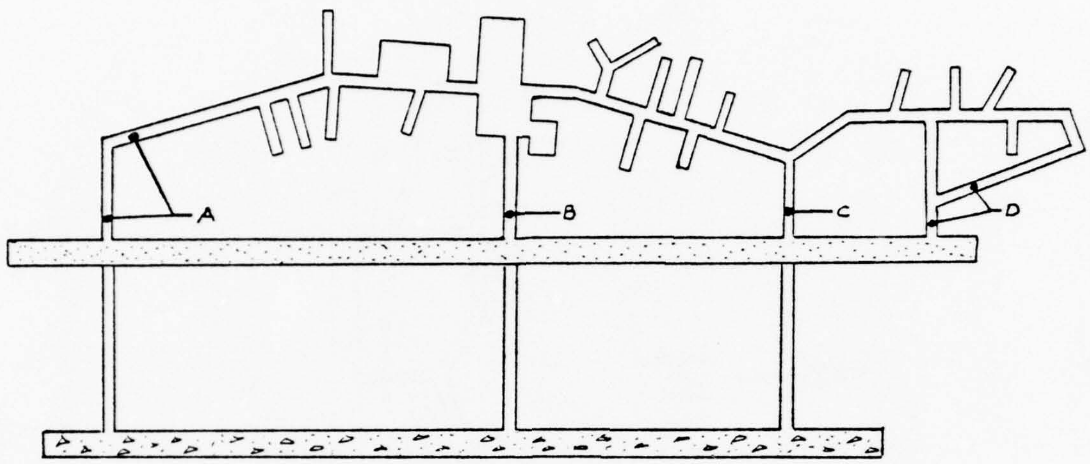
The locations of individual high priority targets (i.e., maintenance hangers, shelters, avionics shops, operations, command posts, navigational aids, etc.) were those of the standard NATO airbase. The model was exercised with varying attack scenarios, with the targeting data (including



Legend:

A, B, C, and D are Access Points.

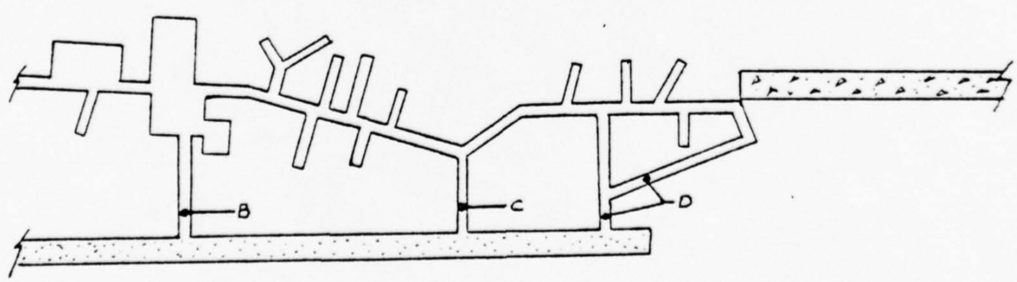
Fig. 3-1. Basic Airfield Configuration



Alternate 1

Legend:

-- Proposed Runway



Alternate 2

Fig. 3-2. Alternate Runway Configurations the pre-attack positioning of the aircraft) held constant in order to develop a zero level base from which to measure the benefits of the proposed airfield modifications. The only targets that were actually changed during this research were the airfield (the pre-attack location of the aircraft remained constant) targets. They were reconfigured to reflect the proposed airfield modifications. All other targets and their priorities, relative to the airfield targets, were held constant.

Attack Scenario

The attack scenario consisted of five basic variables: the number of aircraft in the attack, their munitions, the type of aircraft, their heading and the priorities of their targets. There were two types of aircraft employed in each attack scenario and the numbers of aircraft in each attack was held constant. The numbers of each type of attacking aircraft will be specified later in this chapter. The amount of munitions carried by each aircraft was a function of that aircraft's capabilities. Each aircraft was fully loaded with one type of conventional weapons. The delivery characteristics of the aircraft cannot be specified in this thesis but will be constant throughout.[1] The attack headings were limited to runway crossing angles (on the main runway) from 0° to 90°, in 30°

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[1]This information is not for dissemination to the public.

increments. Any other crossing angles would have duplicated information that was obtained from this range of headings (3:1).

Weapon Accuracy and Effectiveness

The Soviet aircraft and weapon accuracy and effectiveness was available to the authors. While they cannot be specified here, all those values were held constant during the research.[2] Only conventional general purpose (GP) bombs were considered as the probable weapons to be delivered against airfields. It was assumed that precision guided munitions (PGMs) would have been directed against point targets off the airfield and would therefore result in little or no collateral damage to the airfield (per direction from DCA (3:1)).

The weapons were assumed to be carried externally on the fighters and internally on the bombers. Thus, upon release, the weapons would follow a free-fall ballistic trajectory, dependent on release altitude, aircraft speed and dive angle, the release sequence of the weapons, and the ejection characteristics of the weapon racks themselves (5:7). Those values were held constant for a particular matching of aircraft and weapons and were contained in DCA guidance (3:1).

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[2]This information is not for dissemination to the public.

Aircraft Launch Window

The model was exercised using seven basic USAF aircraft (either on the ground at the time of the attack or due to be recovered as soon as possible after the attack) in four mission configurations for recovery. (NOTE: There is no relationship between these aircraft and the attacking aircraft.)

Launch Window Decision Matrix. The data on launch and recovery requirements were grouped into the matrix shown in Table 3-1 (3:2). The matrix shows the size of launch window required by each of the seven aircraft and the configurations those aircraft could be in at the time of launch or recovery. See Appendix B for detailed data on the mission configurations for each of the launch and recovery conditions in Table 3-1, as well as the aircraft configurations under each mission configuration.

System Assumptions

Assumptions were placed upon the system to constrain the number of replications necessary to utilize statistical techniques in the analysis. The assumptions were:

1. Two basic type of aircraft were studied as attack aircraft, those being fighters and bombers.

2. All the attacking aircraft were carrying GP bombs.

TABLE 3-1

LAUNCH WINDOW MATRIX (3:2)

Window	F-4	F-15	F-16	A-10	C-130	C-141	C-5
50'x1500'	L_2(R)	L_3(R)	L_3(R)	L_2R_2	LR	--	--
50'x2500'	L_3(R)	L_3R_1	L_3R_1	L_3R_2	LR	--	--
50'x3500'	L_3R_2	L_3R_1	L_3R_2	L_3R_2	LR	--	--
50'x4500'	L_3R_2	L_3R_2	L_3R_2	L_3R_2	LR	--	--
100'x4500'	L_3R_2	L_3R_2	L_3R_2	L_3R_2	LR	LR	--
150'x5500'	L_3R_2	L_3R_2	L_3R_2	L_3R_2	LR	LR	LR

Legend:

<u>Launch Condition</u>

L - Only condition possible

L_1 - Bugout

L_2 - Max wt. for 1500' groundroll

L_3 - Basic attack

<u>Recovery Condition</u>

R - Only condition possible

R_1 - Lightweight

R_2 - Max wt. for 1500' groundroll

(R) - Using mobile barrier

3. The ordinance was limited to MK-82 bombs or their equivalent.

4. PGMs were not considered for reasons previously discussed.

5. The attacking aircraft under consideration were employed at points of opportunity such as the maintenance hangers, munitions and fuel depots.

Variable Identification

The problem statement mentioned in Chapter I defined the variables used in this research as (DV - dependent variable; IV - independent variable; and EV - environmental variable):

DV = Probability of an accessible launch window

IV1 = Pre-attack airfield configuration

IV2 = Attack scenario

To provide better system definition, these variables were broken down into their specific components as shown in Figure 3-3. This redefinition allowed the determination of the environmental variables which was not provided for in the original identification of variables.

DV. Probability of an accessible launch window for each of the launch window sizes previously mentioned.

EV1. Pre-attack airfield configuration as it presently exists. Attacks on this configuration will provide the base level (control) data for this thesis.

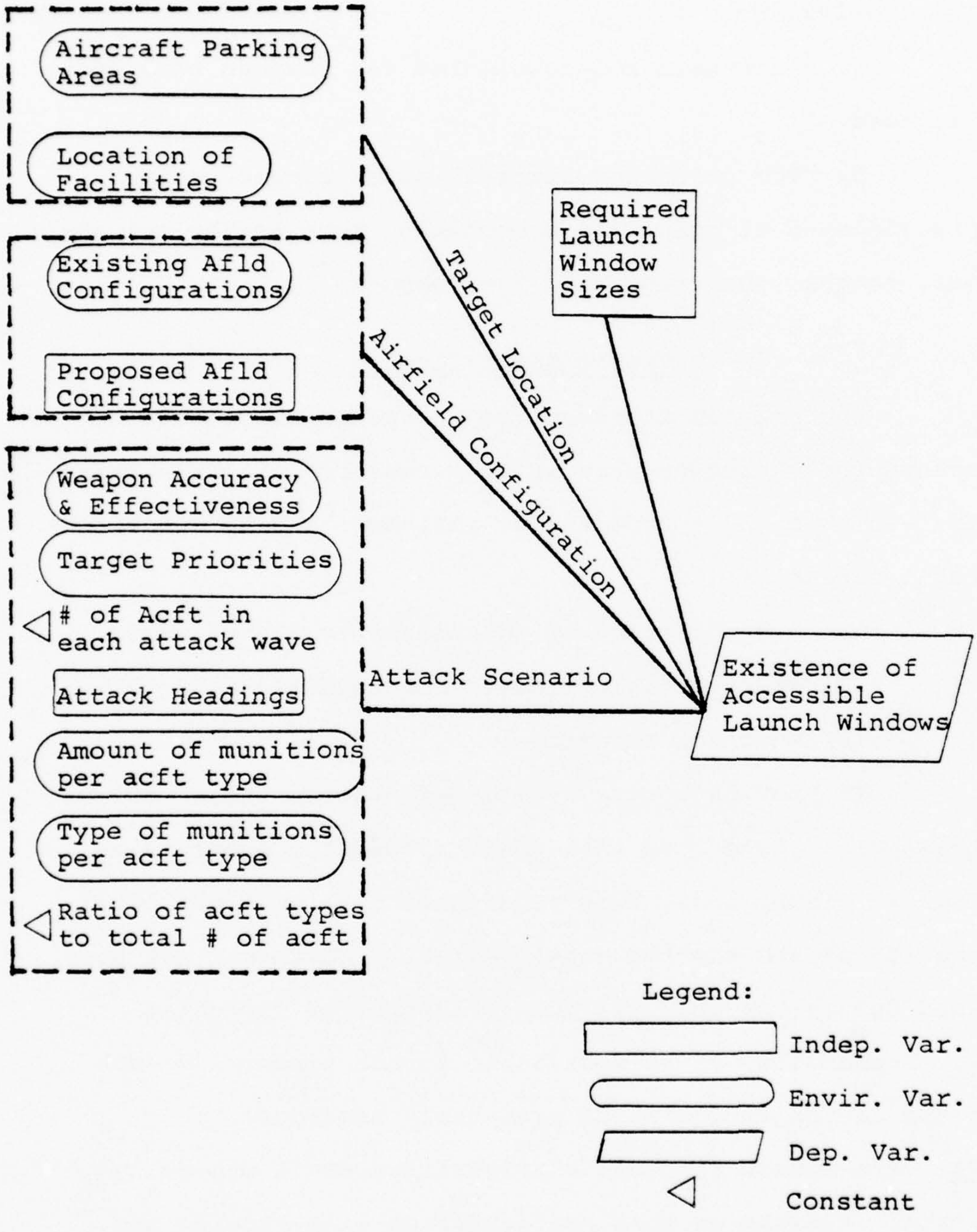


Fig. 3-3. Variable Interrelationships

IV1. The proposed modifications to the basic airfield configuration as mentioned previously (two possible configurations).

EV2. The target priorities were held constant except where necessitated by the proposed modifications of the airfield configuration.

EV3. The quantity and type of munitions, per aircraft type, were held constant. The type of aircraft used in the attack defined a range of available munitions and their possible quantities. The actual types of munitions per aircraft type and their quantities were determined prior to this research (3:Atch 1).

IV2. The attack headings were varied from 0° to 90° in 30° intervals. This range provided adequate information about the results of the different *crossing angles* (3:1). This yielded a total of four possible variable states.

CONST1. The size of the attacking group was 18 aircraft which was considered to be squadron strength.

CONST2. The ratio of the number of aircraft attacking the airfield, compared to the total number of aircraft attacking the airbase, was held constant (40:60). Also, the ratio of bombers to fighters was held constant (30:70) for each attacking group. These ratios are based on the best available information at the time of this thesis and the experience of the authors.

IV3. The required launch/recovery window sizes were based on the information presented earlier in this chapter. There were a total of six possible variable states.

EV6. Weapon accuracy and effectiveness was based on the type of munitions employed and their launching platforms (aircraft). Since these were held constant, then accuracy and effectiveness was constant for the research.

Using the system definition just developed, the research questions from objectives one and two were answered. The next two sections will discuss the data generated by the AIDA model and how that data was analyzed.

Data Generation

The standard base configuration chosen for this research was provided by DCA (4:1). It had been developed for recent studies by the Rand Corporation using the AIDA model. A map of the base is shown in Figure 3-1 and the computer code for the base itself is included in Appendix C. The target priorities were those chosen by the Rand Corporation in the above study (4:1). The computer code representing the attacks on each specific target is listed in Appendix C. The printout options chosen were those that provided plots of the bomb hits on the main runway, alternate runways, and taxiways as well as the summary statistics for each run of the model.

Previous sample studies have attempted to draw conclusions on launch window existence from data derived from only 25 repetitions of a particular attack scenario and have failed (7:24). This research used 50 repetitions to develop the data to be analyzed. This number was large enough to allow data to approach normality and still be manageable for the necessary manual work (described in the next section). Each time an independent variable was modified the model was exercised 50 times (hereafter referred to as one run) to get the appropriate data. Individual plots of each trial in a run were used to determine the probability of having an accessible launch window present for all variable combinations on the existing airfield configuration and only for the 0° attack heading runs on the other two airfield configurations. The computer's probability of the existence of launch windows was the only data created for the other variable combinations of the proposed airfield configurations.

Data Analysis

There are two major constraints on the model that affected the way this research was conducted:

1. In its search for launch windows on runways, taxiways, and parking ramps, the AIDA model does not take into account launch windows on a diagonal to the runway

centerline. Thus, eliminating a number of possible solutions to the launch window problem.

2. The model does not evaluate the accessibility of the launch windows it finds; thereby necessitating a manual inspection of the computer plots and calculation of the accessibility of each launch window for each variation of the independent variables.

As stated in Chapter I the authors felt that the problem created by number 2 above was the most significant and will be investigated in this thesis. Problem one was therefore determined to be insignificant for the purposes of this thesis.

As mentioned previously, manual inspection of all the computer plots was necessary to determine the accessibility of any launch window. The manual inspection only occurred on those plots where the computer indicated a launch window present in its summary analysis. The inspection consisted of a visual analysis by the authors which determined if a parked aircraft (parking areas are indicated in Figure 3-1) had a wide enough path to taxi to either a taxiway or the runway where the launch window occurred. The required paths were determined to be 25 feet wide for fighter aircraft and 75 feet wide for the cargo aircraft. The paths for the cargo aircraft were considered to start at the recovery window and run to an off-loading ramp (indicated on Figure 3-1).

For the development of the probabilities of accessible launch/recovery windows, the concept of accessibility was considered a 0-1 variable, where 1 denoted accessibility. The probability of having an accessible launch/recovery window was determined by dividing the number of occurrences of accessible windows per run by the total number of possible windows (50) per run. This was accomplished for each combination of independent variables as mentioned earlier. The computer determined the probabilities of finding launch/recovery windows (without regard to accessibility) for each run. The means of each of these probabilities (accessible and existence of launch/recovery windows) were compared using Scheffe's test statistic, at a 95 percent confidence interval.

$$(u_1-u_2) = (X_1-X_2) \pm t_{.025}\, S_p \sqrt{1/n_1 + 1/n_2}$$

For those combinations of independent variables where there was a statistical difference between the computer's findings and those of the author's, the function

accessibility = f(existence)

was derived. This was then applied to the 0° attack heading variable combination of each of the proposed runway configurations. The means of the resultant distributions were then compared against the means derived by hand for the same variable combinations using Scheffe's test statistic. A zero statistical difference was then considered to be adequate validation of the applicability of the derived accessibility function. These results were used to determine the answers to the questions in objective 3 (Chapter I).

CHAPTER IV

ANALYSIS

Before the actual analysis is presented, a short discussion of a few of the problems the authors encountered with AIDA is apropos. The question of accessibility necessitated that a large number of taxiways be investigated for accessibility to the main runway after an attack. The model as written limited the number of runway surfaces to five (5), which in turn limited the number of surfaces for which plots showing the bomb points could be printed to five also. This problem was eliminated by redimensioning variables NRW and HITR in the model to reflect the capability of checking twelve runway surfaces and changing some of the logic to allow the increased quantity of surfaces. The second problem was a little easier to correct. In the generation, it was necessary to obtain plots on runway surfaces that were in fact narrower than the launch window being searched for. When this situation was encountered by the model, it printed an error message and shut itself down entirely. The correction for this was to reroute the program back into itself at a point just after the section where the error was determined. Therefore, not only did the model output an error message as a reminder, but it also plotted the bomb impact points as was required for determining accessibility. These two basic changes allowed the data to be generated in a format that was congruent with the previously stated analysis procedure.

Initial Analysis

The first step in the analysis was to reduce the reams of computer output obtained in the generation phase to a form that was readily applicable to the stated analysis program. This was accomplished through manual inspection of all the output data to obtain the frequencies of closure of the important runway and taxiway surfaces. The results of this reduction can be found in Table 4-1, Table 4-2, and Table 4-3. The data in the tables depict the number of runway or taxiway closures per run. The run values were then divided by the number of trials per run and subtracted from 1.0 to get a probability of availability. The access taxiway values were treated differently in that they were divided by the number of times that taxiways could have been open when the runway was open and then subtracted from 1.0 to obtain the probability of accessibility. The probability of finding an accessible launch window was then the product of these two values. The probabilities per launch window size were graphed as shown in Figure 4-1 (this figure is a sample, the remainder of the graphs are located in Appendix D). The top graph reflects the probability of finding a

TABLE 4-1

HAND CALCULATED RUNWAY CLOSINGS FOR 50 TRIALS

Launch Window Sizes		1500 X 50	2500 X 50	3500 X 50	4500 X 50	4500 X 50	5500 X 50
BASIC							
0° RWY.		0	0	0	3	16	46
TWY.	1	14	13	15	16	22	NA
	6	14	13	13	16	19	2
	7	25	28	26	26	23	NA
	9	0	0	0	0	0	0
30° RWY.		0	0	0	2	18	37
TWY.	1	17	14	33	26	18	NA
	6	18	19	13	10	12	6
	7	22	24	34	25	17	NA
	9	0	0	0	0	0	0
60° RWY.		0	0	0	4	14	41
TWY.	1	22	20	22	21	18	NA
	6	6	6	5	7	5	6
	7	18	17	15	11	4	NA
	9	0	0	0	0	0	0
90° RWY.		0	0	0	2	9	35
TWY.	1	23	29	21	20	19	NA
	6	7	6	8	7	9	8
	7	8	10	14	9	9	NA
	9	0	0	0	0	0	0

TABLE 4-2

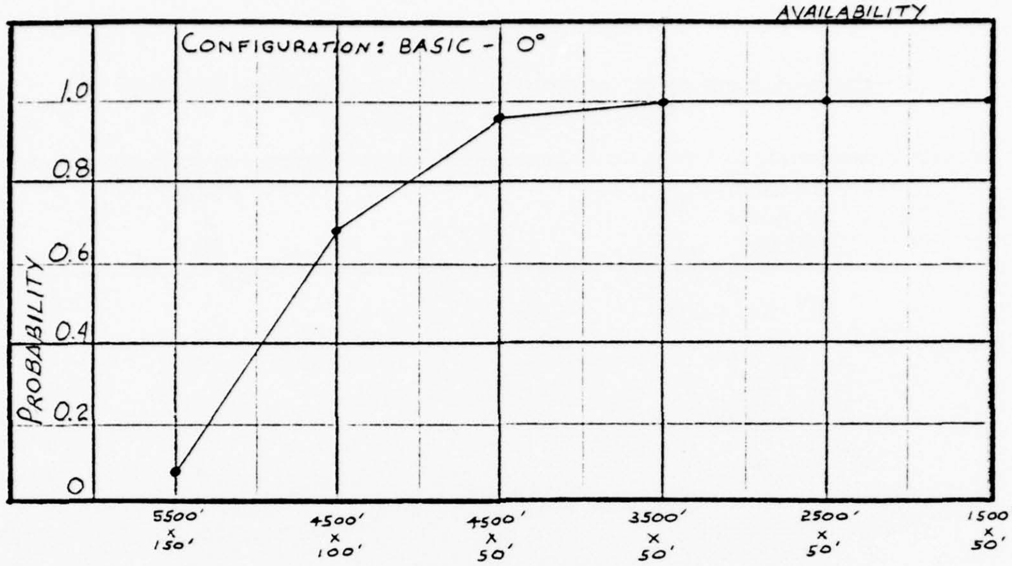
COMPUTER CALCULATED RUNWAY CLOSINGS FOR 50 TRIALS

Launch Window Sizes		1500 X 50	2500 X 50	3500 X 50	4500 X 50	4500 X 100	5500 X 150
ALT. 1							
RUNWAY	0°	0	0	2	3	23	40
	30°	0	0	2	4	18	40
	60°	0	0	0	1	13	42
	90°	0	0	0	0	10	40
ALT. RWY.	0°	0	0	0	0	1	14
	30°	0	0	0	0	1	11
	60°	0	0	0	0	2	18
	90°	0	0	0	0	0	15
ALT. 2							
RUNWAY	0°	0	0	2	3	22	41
	30°	0	0	2	4	20	39
	60°	0	0	0	1	10	41
	90°	0	0	0	0	9	40
ALT. RWY.	0°	0	0	0	0	0	0
	30°	0	0	0	0	0	0
	60°	0	0	0	0	0	0
	90°	0	0	0	0	0	0

TABLE 4-3

HAND CALCULATED ALTERNATE CONFIGURATION RUNWAY CLOSINGS FOR 50 TRIALS

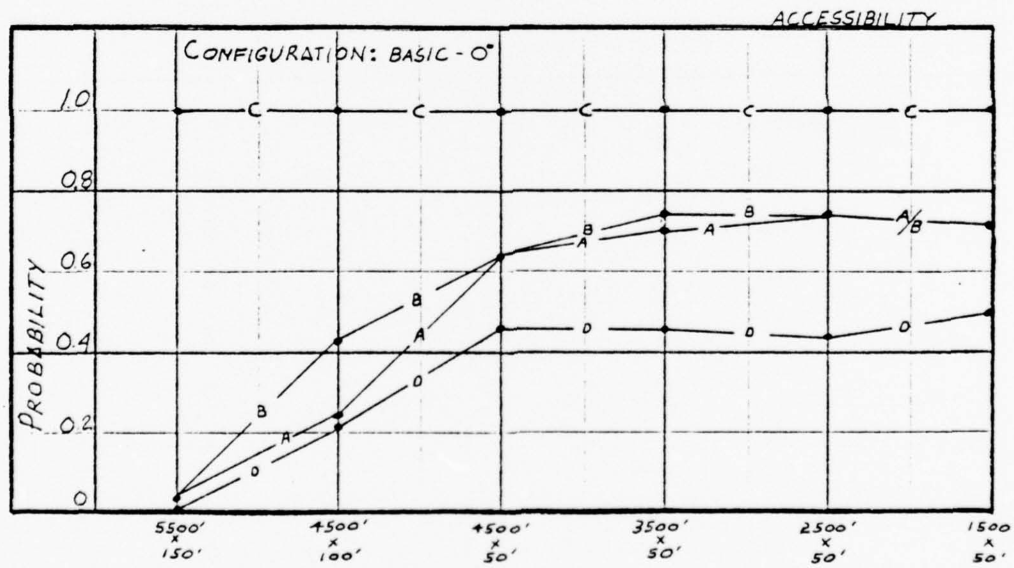
Launch Window Size	3500 X 50
0° Heading	
<u>ALT. 1</u>	
RUNWAY	0
ALT. 1	0
TWY. 1	15
6	0
7	0
ALT. TWY. 1	14
2	10
3	10
<u>ALT. 2</u>	
RUNWAY	0
ALT. 1	0
TWY. 1	14
6	0
7	0
ALT. TWY. 1	4
2	7
3	0



Launch Window

Legend:

A - access pt. A
B - access pt. B
C - access pt. C
D - access pt. D



Launch Window

Fig. 4-1. Probability Distributions

launch window in existence for a specified configuration and attack heading while the bottom graph depicts the probability of an accessible launch window for the same configuration and attack heading. The data points were connected to accentuate the changes in probabilities from one launch window size to another. If the horizontal scale was measured in square feet, the data would, in fact, be continuous; but as they are presented, the data are discrete.

After the distributions for availability and accessibility were plotted, it was necessary to determine if there really was a significant statistical difference between them. This was done using the difference of means of two populations with unknown variances method (Scheffe's statistic for a single comparison). The pooled sample variance was calculated from:

$$S_p^2 = \frac{1}{n_1-n_2-2}\left(\sum^{n_1}(X_1-\bar{X}_1)^2 + \sum^{n_2}(X_2-\bar{X}_2)^2\right).$$

The confidence intervals resulting from the difference of means calculations between the availability and the accessibility from a given point are displayed in Table 4-4. Calculations for access point C are not shown because this taxiway was never closed in all the trial runs. The access point with the highest incidence of no statistical significance between availability and accessibility was access

TABLE 4-4

VALIDATION OF THE CONCEPT OF ACCESSIBILITY FOR THE BASIC CONFIGURATION

Heading	MCR	$U_x - U_A$	$U_x - U_B$	$U_x - U_D$
0°	5500 X 150	NA	.04±.368	NA
	4500 X 100	.44±.22	.38±.25	.46±.22
	4500 X 50	.32±.167	.32±.167	.52±.172
	3500 X 50	.30±.143	.26±.143	.52±.155
	2500 X 50	.26±.143	.26±.143	.56±.157
	1500 X 50	.28±.14	.28±.14	.50±.156
30°	5500 X 150	NA	.12±.524	NA
	4500 X 100	.36±.248	.24±.251	.34±.249
	4500 X 50	.52±.167	.20±.141	.50±.169
	3500 X 50	.34±.178	.74±.202	.32±.183
	2500 X 50	.72±.205	.62±.179	.52±.167
	1500 X 50	.66±.188	.64±.183	.56±.17

NOTE: Underlining indicates statistical nonsignificance.

TABLE 4-4--Continued

Heading	MCR	$U_x - U_A$	$U_x - U_B$	$U_x - U_D$
60°	5500 X 150	NA	.15±.334	NA
	4500 X 100	.36±.231	.10±.211	.08±.207
	4500 X 50	.40±.179	.14±.144	.26±.162
	3500 X 50	.44±.155	.12±.093	.36±.144
	2500 X 50	.40±.152	.13±.101	.32±.148
	1500 X 50	.44±.155	.12±.101	.28±.152
90°	5500 X 150	NA	.14±.319	NA
	4500 X 100	.38±.206	.16±.189	.18±.189
	4500 X 50	.40±.166	.12±.126	.18±.137
	3500 X 50	.42±.153	.15±.114	.30±.14
	2500 X 50	.60±.153	.14±.101	.21±.125
	1500 X 50	.52±.152	.18±.109	.22±.115

point B. By studying the dimensions of these two taxiways (as listed in Appendix C) the reason behind this occurrence became clear: when the width of the taxiway was greater than 75 feet, the taxiway was less likely to be closed by only one or two bombs and therefore less likely to affect the accessibility of a given launch window.

Final Analysis

One of the research questions that this thesis wanted to answer was whether or not an accessibility function could be derived that would be applicable to all airfield configurations. In order to validate the use of such an accessibility function derived from attacks on the basic airfield configuration or alternate airfield configurations, it was first necessary to derive the accessibility distributions for the alternate airfield configurations. Only a limited amount of data was collected due to time constraints on the access to the use of the computer. The model was run for a launch window of 3500 feet X 50 feet with an attack heading of 0°. The 3500 foot X 50 foot launch window was chosen because it represented the largest MCR that had 100 percent availability at all attack headings. The 0° attack heading was chosen because the difference of means for a 3500 foot X 50 foot launch window (.26±.143) was close to the mean difference in all the attack headings given that size launch window. Those results were displayed previously in Table 4-3. Prior to comparing the accessibility distribution of the basic configuration with the probability distributions of the alternate configurations, by way of the accessibility function, it was first necessary to determine if accessibility of the alternate configurations was statistically significant. The statistical significance of each of the accessibility distributions (derived by hand) for the alternate configurations was determined using Scheffe's statistic. The results are shown in Table 4-5. For the most part, accessibility was only a problem for the new taxiways created to connect the old taxiways to the new runways. Only for access point A, was there a statistical difference between availability of a launch window on the existing runway and accessibility to that window for both alternate configurations. However, accessibility through access point B was statistically significant from availability of launch windows on the alternate runways in both alternate configurations.

To validate the application of the accessibility function derived previously, a combination of variables common to both the basic and alternate configuration distributions had to be chosen. It was accessibility from point A to a 3500 X 50 foot launch window on both runways in each alternate configuration and an attack heading of 0°. While this was only a limited validation, it was all

TABLE 4-5

VALIDATION OF THE CONCEPT OF ACCESSIBILITY FOR THE ALTERNATE CONFIGURATIONS

Heading	MCR	U_x-U_A	U_x-U_B	U_x-U_D
0				
<u>ALT. 1</u>				
RUNWAY	3500 X 50	.30±.143	<u>0±0</u>	<u>0±0</u>
ALT. RWY. 1	3500 X 50	.28±.140	.20±.125	<u>0±0</u>
<u>ALT. 2</u>				
RUNWAY	3500 x 50	.28±.140	<u>0±0</u>	<u>0±0</u>
ALT. RWY. 2	3500 X 50	<u>.08±.085</u>	.14±.108	<u>0±0</u>

NOTE: Underlining indicates statistical non-significance.

that was possible during the limited time available. To properly test this function, the same type of comparisons discussed later in this paragraph must be conducted for each MCR size, each attack heading and for each configuration. Therefore, the function or point of the function became P = .7E; where P was the probability of having an accessible window and E was the probability of having an available window. For the two alternate configurations, the actual hand calculated values of E and P were:

	ALT. 1	ALT. 2
A to Basic Runway:	E=1.0 P=.7	E=1,0 P=.72
A to Alternate Runway:	E=1.0 P=.72	E=1.0 P=.92

Comparing these values of P with the projected values of P yielded a difference of means as shown in Table 4-6. There was no statistical difference between the projected and the actual probability of accessibility for alternate configuration 1 (basic or alternate runway). However, for alternate configuration 2 the function could only be applied to the existing runway and not the alternate runway.

TABLE 4-6

ACCESSIBILITY FUNCTION VALIDATION DATA

	Projected $\bar{P}_A$	Actual $\bar{P}_A$	S^2_{P-A}	U_P-U_A
ALT. 1				
RUNWAY	.7	.7	.214	0.0±.202
ALT. 1	.7	.72	.210	-.02±.20
ALT. 2				
RUNWAY	.7	.72	.210	-.02±.200
ALT. 2	.7	.92	.145	-.22±.166

NOTE: Underlining indicates statistical significance.

CHAPTER V

SUMMARY

Before presenting the conclusions and recommendations, it is necessary to review the basic motives and the justifications that were initially set when this study began. First, it was necessary to define the basic runway configuration that was to be used as the basis for this investigation, from which two alternative runway configurations could be examined for their contributions to providing accessible launch windows. Since the study was to be used in the NATO environment, the initial airfield configuration was similar to those currently in the European theater. Next, it was necessary to select the types and size of attack that the airfield would probably be subjected to. During an initial surprise attack, a squadron strength group consisting of fighters and bombers would attack the airfield and would concentrate its efforts on closing the runways, or denying their use by closing the taxiways, so that an air offense could not be launched against the attacking force. Upon defining the airfield configuration, and the type and size of the attacking force, it was necessary to run the model, varying the attack heading, to provide a broad data base for investigation.

The results would serve as a base line in the investigation of the two alternative proposals. The data on the basic configuration allowed the derivation of an accessibility function that would predict the probability of accessibility, given the probability of availability of a launch window. This function was applied to the probabilities of availability for the two alternate configurations to see if it would predict accurately for either airfield configurations.

Conclusions

The aforementioned analysis program yielded three basic conclusions about the airfield configuration-attack scenario system that was input in the AIDA model.

1. Accessibility was the key factor in determining whether or not a runway was actually open in more cases than was availability. This conclusion was based on the data presented in Table 4-4 (Chapter IV). In 53 of the 64 cases, accessibility was the determining factor (i.e., accessibility was statistically significant from availability) while only 11 of the 64 revealed availability to be key.

2. The derived accessibility function, P = .7E, was a statistically significant predictor of the accessibility of launch windows on the main runway in both alternative configurations. However, it was a

statistically significant predictor of the accessibility of launch windows on only one of the two alternate runways. That one being parallel and in close proximity to the main runway. The basis for this statement was in Table 4-6 (Chapter IV) and in the fact that alternative runway 1 used the same access routes as the main runway while alternate survey 2 used what could be considered entirely new access routes. Thus the accessibility function, as it stands, can only be applied to possible alternative runways if they use the same access routes.

3. The alternate parallel runway in close proximity to the main runway did not provide an open runway in as many cases as did the other alternate runway. Using Table 4-2 (Chapter IV) as a basis, the authors noted that in 301 of 2400 trials, for alternate runway 1 (parallel and close proximity to the main runway), the runway was closed, while alternate runway 2 was only closed 234 of 2400 trials. This yielded a probability of availability of .9025 for alternate 2 and .8746 for alternate 1. The difference of means test described in Chapter IV revealed that the difference between these probabilities was statistically significant (.0279±.0198).

These conclusions must be qualified by saying that any major changes to the type of airfield system, or attack scenario (the type of aircraft and their assigned targets) input into the AIDA model may invalidate the above conclusions.

Recommendations

A review of the problems incurred during this research as well as the findings of the analysis lent itself to many possibilities for future investigations or actions. These have been reduced to the most significant.

1. In the future when AIDA is used to check for available launch windows, their accessibility should be considered, but to do so it must undergo some significant structural changes. The model must allow the searching of access taxiways to determine their openness without affecting the calculations about the availability of a launch window as is presently the case. The model must be streamlined as it is presently a significant waster of computer CPU time and memory space. Lastly, the output data provided by the model should be restructured so that the relationship between a taxiway to an available launch window is maintained (it is not now) and so that the personnel interpreting the output can tell where all available launch windows are located with regard to the open access taxiways. Consideration should be given to returning the model to the Rand Corporation or to just commissioning the development of a new more efficient and useful model.

2. Analysis of the data for this thesis seemed to point to the conclusion that taxiways of a width less than 75 feet were more susceptible to closing than those of a width greater than 75 feet. The scope of this thesis did not allow the validation of the above statement, but due to its possible significant impact on existing as well as future airfields, it should be investigated thoroughly. Validation of this possible conclusion will ensure that future airfields are designed with at least 75 foot wide taxiways and that existing airfields widen the taxiways at major choke/access points to at least 75 feet.

3. Recent emphasis by the Air Staff on airbase survival has pointed to the need for quantifying the supplies the BCE can expect to need in the first few days after an air attack to restore his base to an operational status. Models such as AIDA can provide him with a reasonable estimate of the number of craters the RRR team will have to fill to provide available launch windows and the accessibility function can correct that number to reflect repairs to provide an accessible launch window. With the results of the studies presently underway at the AFESC (9) to determine the actual time it takes a RRR team to repair a crater and the time it will take an Explosives Ordinance Disposal (EOD) team to clear the airfield for the BCE operations, a BCE will have a reasonable idea of his "get

well" time given a specific number (and size) of craters to repair.

4. The analysis done by this thesis tended to point out that the derived accessibility function was highly sensitive to changes in airfield configurations (i.e., parallel runways, oblique runways, disjointed runways). However, this could not be supported due to the limited validation. Further research is needed to determine the sensitivity of the function to airfield configuration changes. With the magnitude of the sensitivity known, the function can be corrected and used by managers to determine accessibility with existing computer models, thus saving the time and money of creating and using a more complex model.

5. To increase the applicability of the statement "accessibility is a more important factor than availability," the basic analysis that was accomplished on a particular airfield configuration in this thesis should be duplicated. This is necessitated by the limited validation possible in this thesis. The duplication should discuss not only similar airfield configurations, but different ones as well with different attacking aircraft and targeting assignments. Only if the conclusions reached in this thesis can be achieved in other situations will they affect the attack scenario-damage assessment concept as it is presently employed in the Air Force.

APPENDICES

APPENDIX A

DETAILED DESCRIPTION OF AIDA INPUT

The following pages are taken from Appendix A of the Rand Report on AIDA (7:37-50).

The basic types of input cards employed with AIDA are as noted below:

CONT	control card
TGT	target card; one per target
ATT	attack card; one per weapon delivery pass (or group of identical passes)
ATT2	alternate attack card
EMD	effective miss distance card; one for each weapon type
REDO	controls sequential cases
END	terminates overall computation

The ATT2 card is actually two cards in sequence and the EMD card may have up to three supplementary cards. A detailed description of the entries for each type of card is presented on the pages that follow.

The general arrangement of data on all basic card types is similar; the card type-name is placed (left-adjusted) in the first four columns and the data are listed in eleven 6-column fields between Columns 7 and 72. All data are read with a F6.0 format; i.e., they are to be real numbers. If a whole number is to be input, it may be entered (right-adjusted) in the field without a decimal point; the decimal point is necessary otherwise. Columns 5 and 6 on the ATT, ATT2, and EMD cards are also used, as will be described, and the name of the target complex being studied and a name for each target may be included in Columns 73 through 80 of the CONT and TGT cards, respectively; any alphanumeric names are acceptable.

All linear dimensions should be in consistent units (e.g., feet) and the target orientation and the attack heading entries should be in degrees.

CONT

The CONT card controls the mode of operation, the choice of random number generator, the number of trials (attack replications), and printout options; specifies the minimum clear length (MCL) and minimum clear width (MCW) for runway attack effectiveness calculations; and controls the runway repair assessment.

Columns	Data Entry
1-4	CONT
11-12	When 0, the seed for the random number generator is the same for all runs. If greater than 0, the seed is changed from run to run; if equal to -1, the random number generator is locked out. If equal to -2, the expected-value mode of operation replaces the Monte Carlo mode.

Columns	Data Entry
13-18	Desired number of replications. Default is 1.
23-24	Controls printout options as follows. If entry is 5 Prints multiple trial statistics plus a condensed listing of hits by trial 4 Prints multiple trial statistics plus a condensed listing of runway status by trial 3 Prints multiple trial statistics only 2 Above plus runway results for each trial 1 All above plus hit summary for each trial 0 All above plus stored hit data for each trial -1 All above plus all hits and target corners -2 All above plus all impact points
30	Controls printout of intermediate information for program test purposes; should normally be 0. If set to greater than 7, the random number generator is locked out. See the program source listing for the effect of other values.
31-36	MCL for aircraft operations. (Used to test if the runways are open.)
37-42	MCW for aircraft operations. (Used to test if the runways are open.)

Columns	Data Entry
48	When entry is 1, runway results will include the minimum number of craters to be repaired for the runway to meet the MCL and MCW criteria.
54	When the entry is 1, a plot for all impact points will be included for all closed runways (if, also, the printout option entry in Columns 23 and 24 is less than 3); when the entry is 2, impact plots are provided for each runway whether or not it is closed.
55-60	The distance that the "minimum runway rectangle" is to be shifted laterally in checking for an adequate section; the default value is 5.
61-66	The distance along the runway that the minimum runway rectangle is to be shifted in checking for an adequate section; the default value is 250.
73-80	A name can be entered here for the entire target complex and it will appear in the heading of the output listing.

TGT

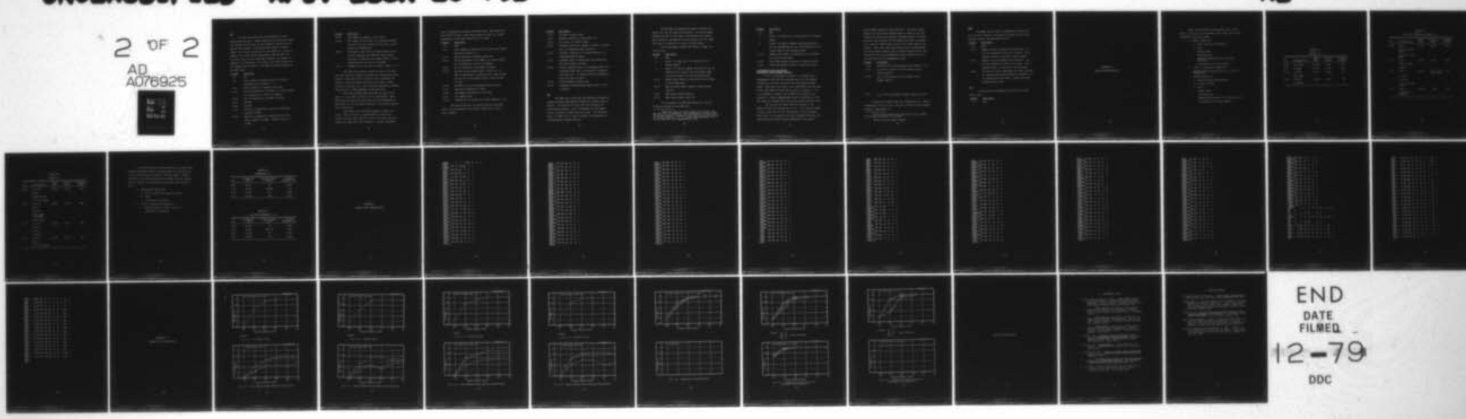
Each TGT card designates the location, size, and orientation of a rectangular target.

Columns	Data Entry
1-3	TGT
7-12	The X-coordinate of the westernmost corner of the target.
13-18	The Y-coordinate of the westernmost corner of the target. If a target boundary runs exactly north-south, the X and Y coordinates of the southwestern corner should be specified.
19-24	Target dimension along the boundary running northeast (or north) from the X and Y coordinates of the reference corner specified in the two previous fields.
25-30	Target dimension along the boundary running southeast (or east) from the reference corner.
31-36	Heading in degrees of the northeast (or north) heading boundary of the target (along the dimension specified in Columns 19 to 24). (Meaning varies for target type #21; see below.)
41-24	Target type. Targets may be grouped into up to 10 (or 20) different categories with like vulnerabilities. This entry is used in conjunction with the effective miss distance on the EMD card. Target type #1 is restricted to runways and taxiways that may be used for flight operations; there will be no more than 5 targets of this type. Entering a 21 for target

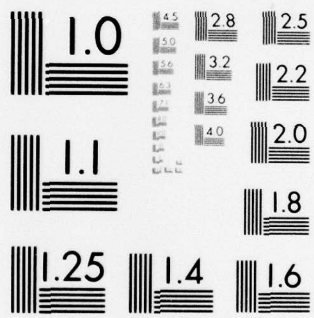
Columns	Data Entry
41-24 cont'd	type actually acts as a signal (but only in conjunction with the expected-value mode) directing that a 17 x 17 grid of hit-density values be tabulated over a square, the south-west corner of which is entered in Columns 7 to 12 and 13 to 18. In this case, entries in the third, fourth, and seventh fields have no meaning. Unless a different value is entered in Columns 31 to 36 (preferably a number divisible by 16), the default dimension of the square is 4000, for a grid increment of 250. There may be one or more target type #21 cards, and they may be intermingled with normal target cards; however, when present, one of the type #21 cards must be the last target card entered for a case.
48	If greater than 0, all hit locations will be saved (and printed when entry in Column 24 of the CONT card is 0 or less).
73-80	A name or number for the target (any alpha-numeric) may be entered here. This name as well as the sequence number that is assigned automatically will appear for target identification in the output listing.

AD-A076 925 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 15/7
THE DETERMINATION OF THE ACCESSIBILITY OF POST-ATTACK LAUNCH WI--ETC(U)
SEP 79 D F BALLOG , D B HUTCHINSON
UNCLASSIFIED AFIT-LSSR-20-79B NL

2 OF 2
AD
A076925



END
DATE
FILMED
12-79
DDC


1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

ATT

The ATT card specifies the parameters of each weapon-delivery pass. Inputs required are the attack heading (measured from north in the coordinate system used to specify the targets), the desired mean point of impact (DMPI) for a single weapon or for the middle of a stick of weapons, the aiming error expressed as REP and DEP, the ballistic error of the individual weapons, the number of weapons to be delivered in the pass, the stick length, and the weapon type (related to the effective miss distance on the EMD card).

Columns	Data Entry
1-3	ATT
5-6	Total number of passes with the following characteristics; default = 1.
10-12	Attack heading in degrees from north.
13-18	The X-coordinate of the DMPI of a single weapon or the middle of a stick of weapons.
19-24	The Y-coordinate of the DMPI as above.
25-30	The REP
31-36	The DEP
37-42	Ballistic dispersion in range of individual weapons (R-DISP).
43-48	Ballistic dispersion in deflection of individual weapons (D-DISP). Default value is R-DISP.

Columns	Data Entry
49-54	The number of weapons in the stick.
55-60	The length of the stick (the distance between the first and last weapon of the stick in the absence of dispersion).
61-66	The weapon type (used in effectiveness calculations together with EMD and target type). An entry is required (an integer from 1 to 10); otherwise hits will not be recorded.
67-72	Probability of arrival at target; default = 1.0.

The ATT2 card should be used in place of the ATT card when the user wishes assistance with trajectory calculations. When this card is used the user expresses the attack in terms of speed, altitude, dive angle, intervalometer settings, etc., and a special subroutine converts these inputs to those demanded on the ATT card.

Both ATT and ATT2 type cards may be used in the same run; the order of entry is of no importance. When ATT2 cards are used the input data will be reproduced as submitted, as well as being tabulated in the normal manner, after conversion.

Data input with the ATT2 procedure require two cards. The first card is labeled ATT2 in the first 4 columns and has input similar to that on an ATT card (all fields are read with a F6.0 format); a second unlabeled card is mandatory following each ATT2 card. The format for both cards follows. When these cards are used, all linear dimensions in the input data will be in feet.

Columns	Data Entry
1-4	ATT2
5-6	Total number of passes with the following characteristics; default = 1.
10-12	Attack heading in degrees from north.
13-18	The X-coordinate of the DMPI of a single weapon or the middle of a stick of weapons.
19-24	The Y-coordinate of the DMPI as above.
25-30	The CEP in the normal plane in mils, or, if DEP is specified, a constant which, when divided by the sin of the impact angle, gives the REP, in mils.
31-36	The DEP in mils (if omitted, CEP controls).
37-42	Ballistic dispersion in mils.
49-54	The number of weapons in the stick.
61-66	The weapon type.
67-72	Probability of arrival at target; default = 1.0.

The data format for the second card of each ATT2 pair is as noted below (this card is used with a 6F6.0, 3F6.3 format).

Columns	Data Entry
7-12	Aircraft velocity (kn).
13-18	Release altitude of last bomb (ft).
19-24	Dive angle at release (deg).
25-30	Terminal velocity of weapon (cluster) or first leg of a high-drag bomb (ft/sec).
31-36	Terminal velocity of a cluster bomblet or a high-drag bomb (ft/sec).
37-42	Probable error in estimating and correcting for wind effects (ft/sec).
43-48	Cluster opening time or fin opening time for a high-drag bomb (ms), or cluster/fin opening altitude (ft). (A decimal point is mandatory when altitude is input.)
49-54	Intervalometer setting (ms).
55-60	Dispensor intervalometer setting (ms) (0 for clusters).

EMD

The EMD card is optional and provides information regarding weapon performance against the various types of targets. The entries for this card are different for point-impact weapons, a hit is assessed for any impact within a distance of EMD from the target. For CBU munitions, the EMD card is used to specify the dimensions of the rectangular bomblet pattern.

The methods for expressing weapon coverage also differ for the two types of munitions. For point-impact weapons the EMD is also used as the weapon kill radius, and coverage is determined as that fraction of the target area that is covered by a circle of that radius.

For point-impact weapons (GP bombs or PGMs) the entries are:

Columns	Data Entry
1-3	EMD
5	Enter 1 if data are to be entered for 20 target types.[1]
6	Enter 1 if data on weapon reliability, p_k, or effective kill radius for this weapon type, are to be entered (on the following card).
11-12	Weapon type (used in conjunction with Columns 61-66 on ATT card).
13-18	EMD for point-impact weapons versus target type #1.
19-24	EMD versus target type #2.
67-72	EMD versus target type #10.

If the weapons are CBU-type munitions, use the following entries on the EMD card.

---

[1] When more than 10 target types are involved, the EMD data and, if specified, the supplementary coverage data for target types #11 through #20 are entered in ten 6-column fields from Column 13 to 72 on cards that immediately follow the EMD card (and supplementary card).

Columns	Data Entry
1-3	EMD
5	Enter 1 if data are to be entered for 20 target types.
6	Enter 1 if data on weapon reliability and/or on kill probabilities are to be entered for any target type on the following card.
11-12	Weapon type (used in conjunction with Columns 61 to 66 on ATT card).
13-18	Enter CBU pattern length as a negative entry.
19-24	Enter CBU pattern width as a positive entry.

SUPPLEMENTAL CARD FOR WEAPON RELIABILITY AND COVERAGE FACTORS

If a 1 is entered in Column 6 of an EMD card, a supplemental card must be included next with the weapon reliablity and a set of entries for the several target types. Note that this card is not identified, but one must follow each EMD card that has an entry in Column 6. If a 1 is entered in Column 5 of an EMD card, as well as in Column 6, a second supplementary card is required for target types #11 through #20; this card is the fourth of four.

All entries on these cards are optional; the default value for reliability is 1.0. If an entry is made in any of the last 10 (20) fields and it is not greater than unity, it is taken as the user estimate of the p_k for that particular weapon-target combination for either point-impact weapons or CBU munitions. For point-impact weapons, an entry that exceeds unity is taken as an additional kill radius and another coverage fraction is determined as that fraction of the target area that is covered by a circle of that radius, given a hit within EMD of the target. Thus, when there are entries on the supplemental card for certain target types, coverage fractions are computed both for the corresponding value of EMD as well as for the value on the supplemental card.

Columns	Data Entry
7-12	Reliability[2] of this weapon type; default = 1.0.
13-18	p_k or kill radius[3] for this weapon versus target type #1.
19-24	p_k or kill radius for this weapon versus target type #2.
	.
	.
	.
67-72	p_k of this type weapon versus target type #10.

Entries for target types #11 through #20 on a second supplemental card will be in the ten 6-column fields between Column 13 and Column 72.

---

[2]Since these entries are read with an F6.0 format, the decimal point must be included.

[3]Only for point impact weapons.

REDO

The REDO card is used to terminate the input for one case and initiate a new case with some or all of the previous inputs, as described earlier.

Columns	Data Entry
1-4	REDO
7-12	Number of prior targets to be retained. All will be retained if there is no entry. Use a negative entry if none are to be retained.
13-18	Number of prior attacks to be retained. All will be retained if there is no entry. Use a negative entry if none are to be retained.
19-24	An entry of unity suppresses the input listings for targets and/or for attacks and weapons if no changes have been made in these data sets from the prior case.

END

An END must be included at the end of all data entry cards.

Columns	Data Entry
1-3	END

APPENDIX B

MISSION CONFIGURATIONS

Three launch mission configurations are listed below; the fourth is no different than normal day-to-day operations and is not shown.

1. Bugout (Table B-1)

   a. Basic aircraft configuration

   b. Fuel:

      Engine start

      20 minute taxi

      Takeoff/climb/cruise for 550 miles (mil.pwr.)

      20 minutes at 10K feet reserve

2. 1500 ft. Groundroll (Table B-2)

   Maximum weight configuration for a 1500 ft. ground roll

3. Attack (Table B-3)

   a. Basic aircraft configuration

   b. Stores and ammo

   c. Fuel:

      Engine start

      20 minute taxi

      Takeoff/climb/cruise for 30 minuts @ m=.8

      20 minutes at 10K feet reserve

TABLE B-1

BUGOUT (2)

A/C	Configuration	TOGW (lbs.)	Fuel Wt. (lbs.)	Groundroll (feet)
F-4E	Full ammo	42,356	8,983	1600
A-10	No ammo	32,700	5,547	1500
F-15	4-AIM-7F Full ammo	37,011	6,923	740
F-16	2-AIM-9 Full ammo	18,562	3,340	700

TABLE B-2

1500 FOOT GROUNDROLL (LAUNCH) (2)

A/C	Configuration	TOGW (lbs.)	Fuel Wt. (lbs.)	Groundroll (feet)
F-4E	Basic +	41,270	6,898	1500
	1-600 gal tank empty			
	2-370 gal tanks empty			
A-10	Basic +	32,750	2,487	1500
	2100 lbs ammo			
	2 MK-82			
F-15	Basic +	49,500	11,635 (int) 4,327 (ext)	1500
	4 Aim-7F			
	4 Aim-9L			
	2 610 gal tanks (67%)			
F-16	Basic +	25,500	7,529	1500
	4 Aim-9L or 6 MK-82			

TABLE B-3

ATTACK (2)

A/C	Configuration	TOGW (lbs.)	Fuel Wt. (lbs.)	Groundroll (feet)
F-4E	(A to G)	49,860	8,959	2300
	Basic +			
	12-MK-82 LDGP			
	2-370 gal tanks			
A-10	(A to G)	39,900	2,654	2350
	Basic +			
	18-MK-82			
	1350 rounds 30 mm ammo			
	Flack/Chaff			
F-15	(A to A)	37,859	5,961	780
	Basic +			
	4 Aim-7F			
	4 Aim-96			
F-16	(A to A)	19,063	2,875	800
	Basic +			
	2-370 gal tanks			

Two recovery mission configurations are shown below. Normal day-to-day recovery configurations are not shown nor is the configuration for barrier recovery shown. Barrier recovery is not shown because the aircraft could be returning in a number of configurations and still take the barrier.

1. Lightweight (Table B-4)
   a. Basic aircraft (no ammo or stores)
   b. Fuel:
      20 minutes at 10K feet
2. 1500 ft. Groundroll (Table B-5)
   a. Maximum weight at which a 1500 ft. groundroll is possible

TABLE B-4

LIGHTWEIGHT (2)

A/C	Landing Wt. (lbs.)	Landing Speed (knts)	Landing Distance (ft)
F-4E	34,517	146	2,800
A-10	25,600	100-140	1,150
F-15	28,599	125	2,588
F-16	15,379	108	2,050

TABLE B-5

1500 FOOT GROUNDROLL (2)

A/C	Landing Wt. (lbs.)	Landing Speed (knts)	Landing Distance (ft)
F-4E	40,800	157	3,300
A-10	32,750	100-140	1,400
F-15	49,500	173	4,370
F-16	25,500	140	3,200

APPENDIX C

SYSTEM INPUT COMPUTER CODE

```
0100CONT            25     2     0  3500    50     0     2
0110BASIC
0120TGT      1300   675   150 11200     0     1
0130RUNWAY
0140TGT      2350  1490  2690    50    74     1
0150TWY 1
0240TGT      4910  2250  2825    50    87     2
0250TWY 2
0260TGT      7710  2360    50  2620    17     2
0270TWY 3
0280TGT     10230  1680   850    50    55     2
0290TWY 4
0300TGT     10920  2120    50  2575     0     2
0310TWY 5
0320TGT      7020   825  1150    85     0     1
0330TWY 6
0340TGT     11900  1970    50  1280    66     1
0350TWY 7
0360TGT     12340  1095  1450    50    70     1
0370TWY 8
0380TGT     10200   825   860    75     0     1
0390TWY 9
0400TGT      2350   820   665    50     0     1
0410TWY 11
0420TGT     13430  2160    50   650    70     2
0430TWY 10
0440TGT      4175  1980    50   550    50    16
0450TWY 21
0460TGT      4450  2580    50   450    80    16
0470TWY 22
0480TGT      4880  2240   760    50     0    16
0490TWY 23
0500TGT      4880  2190    50   600    73    16
0510TWY 24
0520TGT      5100  2260   440    50    20    16
0530TWY 25
0540TGT      5090  2210    50  1015    40    16
0550TWY 26
0560TGT      5915  2260    50   500    55    16
0570TWY 27
0580TGT      8070  2570    50   300    85    16
0590TWY 28
0600TGT      7500  2900    50   650    30    16
0610TWY 29
0620TGT      8070  2575   450    50    40    16
0630TWY 30
```

```
0640TCT     7920  1990   340    50    45    16
0650TWY 31
0660TCT     8490  2165   800    50    20    16
0670TWY 32
0680TCT     8450  1550   550    50    15    16
0690TWY 33
0700TCT     8930  2030   700    50    20    16
0710TWY 34
0720TCT     9090  1500   400    50    15    16
0730TWY 35
0740TCT     9350  1900   450    50    25    16
0750TWY 36
0760TCT    11470  2165   450    50    25    16
0770TWY 37
0780TCT    12170  2150   450    50     0    16
0790TWY 38
0800TCT    12000  2050    50   550    30    16
0810TWY 39
0820TCT    12465  2170   600    50    35    16
0830TWY 40
0840TCT    12800  1720   400    50     0    16
0850TWY T42
0860TCT    13350  2035   250    50    69    16
0870TWY T41
0880TCT     5610  2590   785   300    87     3
0890RAMP 1-2
0900TCT     6715  2840   430   490    87     3
0910RAMP 3
0920TCT     7000  2300   625   350    87     3
0930RAMP 4A
0940TCT     7640  2020   310   220    87     3
0950RAMP 4B
0960TCT    11890  1970   150   130     0    16
0970RAMP R5
0980TCT     7390  2780    80    50    15     4
0990B 3027
1000TCT     7680  2600    50    80    32     4
1010B 3026
1020TCT     7600  2960    50    80    30     4
1030B 3028
1040TCT     7880  2780    80    50    30     4
1050B 3029
1060TCT     8110  2940   120    50    42     4
1070B 3030
1080TCT     8140  2560   120    50    40     4
1090B 3032
```

```
1100TGT     8170  2000    80    50    45     4
1110B 3034
1120TGT     8450  1900    80    50    15     4
1130B 3038
1140TGT     8700  2400    80    50    15     4
1150B 3037
1160TGT     8715  1840    80    50    15     4
1170B 3040
1180TGT     8910  2370    80    50    30     4
1190B 3041
1200TGT     8900  1870    50    80    15     4
1210B 3045
1220TGT     8960  1525    50    80     0     4
1230B 3046
1240TGT     9130  2170    50    80    20     4
1250B 3044
1260TGT     9265  2470    50    50     8     4
1270B 3043
1280TGT     9270  1610    80    50    12     4
1290B 3047
1300TGT     9500  2380    80    80    45     4
1310B 3049
1320TGT     9660  2090    50    50    34     4
1330B 3050
1340TGT     9645  1590    80    80    45     4
1350B 3051
1360TGT     8585  1590    50    50    84     4
1370B 3052
1380TGT    10730  1640    80    80    60     4
1390B 3053
1400TGT    10675  1890    50    80    60     4
1410B 3054
1420TGT    10910  1950    50    80    60     4
1430B 3055
1440TGT    10985  2350    50    80    86     4
1450B 3056
1460TGT    11160  1930    50    50     0     4
1470B 3057
1480TGT    11360  2350    80    50    30     4
1490B 3058
1500TGT    11650  2610    80    50    30     4
1510B 3059
1520TGT    11625  2240    80    50    30     4
1530B 3060
1540TGT    11770  1790    80    50    65     4
1550B 3061
```

```
1560TGT   11865  1615   80   50   73   4
1570B 3062
1580TGT   12000  2250   50   80    0   4
1590B 3063
1600TGT   11990  2465   50   80    4   4
1610B 3065
1620TGT   12300  2580   50  120   87   4
1630B 3067
1640TGT   12070  1930   50   80   45   4
1650B 3068
1660TGT   12410  1610   80   50    7   4
1670B 3069
1680TGT   12400  1940   50   80   45   4
1690B 3070
1700TGT   12415  2410  120   80   35   4
1710B 3071
1720TGT   12595  2685   50   80   35   4
1730B 3072
1740TGT   12830  2490   80   50   35   4
1750B 3074
1760TGT   12665  2275   50   80   35   4
1770B 3075
1780TGT   12675  1890   80   50    0   4
1790B 3076
1800TGT   12940  1790   80   50    0   4
1810B 3078
1820TGT   12920  2280   80   50   20   4
1830B 3079
1840TGT   13025  2440   80   50   30   4
1850B 3081
1860TGT   13300  2350   50   80    0   4
1870B 3082
1880TGT   13410  1880   80   50   30   4
1890B 3084
1900TGT   13640  2190   80   50   63   4
1910B 3086
1920TGT   13750  1970   80   50   33   4
1930B 3085
1940TGT    3400  1680   70  120   70   4
1950B 1
1960TGT    3330  1950  120   70   70   4
1970B 2
1980TGT    4400  1800   70  120   60   4
1990B 3
2000TGT    4400  1900  120   70   60   4
2010B 4
```

```
2020TGT      4800  1700   120    70    60     4
2030B 5
2040TGT      4350  2150   120    70     0     4
2050B 6
2060TGT      4450  2560   120    70     0     4
2070B 7
2080TGT      4700  2560   120    70     0     4
2090B 8
2100TGT      4620  2320    70   120     0     4
2110B 9
2120TGT      5000  2920    70   120     0     4
2130B 10
2140TGT      5050  2550   120    70     0     4
2150B 11
2160TGT      5300  2600   120    70    30     4
2170B 12
2180TGT      5200  1600    70   120     0     4
2190B 13
2200TGT      5300  1860    70   120    30     4
2210B 14
2220TGT      5460  2100    70   120    30     4
2230B 15
2240TGT      5800  2150    70   120    50     4
2250B 16
2260TGT      5900  1790   120    70    40     4
2270B 17
2280TGT      1450   640   200    .2     0    11
2290SW MA1A
2300TGT     12350   640   200    .2     0    11
2310NE MA1A
2320TGT      2400   640   200    .2     0    11
2330SW BAK-9
2340TGT     11090   640   200    .2     0    11
2350NE BAK-9
2360TGT      6520  1350    50    50     0    12
2370GCA
2380TGT      7300   150    20    20     0    12
2390TACAN
2400TGT      4475  2935    70    30    45     5
2410SQ OPS14
2420TGT      4600  2990   100    70    52     5
2430SQ OPS15
2440TGT      4100  2660    44    44     0    13
2450JP-4 17
2460TGT      5145  3140    35    65     0     5
2470SQ OPS18
```

```
2480TGT     5250  3965  100   35   87    5
2490COMM 19
2500TGT     5430  3285   15   80    0    5
2510CON 1020
2520TGT     5340  3025  230   40   87    5
2530WG HQ 23
2540TGT     5200  2900   30  110   47    5
2550TELE 24
2560TGT     5440  2685   68   20   15    6
2570AC SHP27
2580TGT     5670  3005   45  100   18    6
2590PRCHT 32
2600TGT     5600  2830  125   45   18    6
2610PRCHT 33
2620TGT     5710  2845   75   75   18    9
2630HTG 34
2640TGT     5635  2745  230  140   87    6
2650HNGR 35
2660TGT     5915  2760  230  140   87    6
2670HNGR 36
2680TGT     5570  2725   20   60   87    9
2690ELECT 37
2700TGT     6185  2740  115  115   87    6
2710AC 41
2720TGT     6340  3900   40  120   75    6
2730AV 43
2740TGT     6450  3020   55  130   75    7
2750AV 44
2760TGT     6355  1995   20  100    0   12
2770RAPCON45
2780TGT     6420  1910   50  200    0    5
2790BS OPS47
2800TGT     6500  2710   80   75    0    6
2810CONT 48
2820TGT     6575  2495   75   45    0   10
2830CONT 49
2840TGT     4240  2820   44   44    0   13
2850JP-4 59
2860TGT     3380  2540   40   40    0   15
2870ELECT 62
2880TGT     6340  2700   50   75   87    6
2890ENGSHP81
2900TGT     3610  2010   70   40   75    6
2910ORCL 82
2920TGT     3965  2090   70   40   75   10
2930HAZ 83
```

```
2940TGT      5420  2550    68    20    15     6
2950AC SHP86
2960TGT      5535  2610    68    20    87     6
2970AC SHP87
2980TGT      5535  2650    68    20    87     6
2990AC SHP88
3000TGT      4000  1840    70    40    75    10
3010HAZ 89
3020TGT      4560  1550    40    70    52    10
3030HAZ 91
3040TGT      4200  2200    15    40    30     9
3050POLADM92
3060TGT      6335  2760    75    50    87     7
3070WPNSHP96
3080TGT      6725  2860   140   100    87     6
3090CALIB101
3100TGT      7260  3160    90   580     0    10
3110ORGL 103
3120TGT      7970  3150    40   150     0    10
3130FOOD 105
3140TGT      8530  2790    75    75    25     5
3150SQ OP108
3160TGT      8535  2920    12    75    25     5
3170SQ OP109
3180TGT      8580  3140    90   260    60    10
3190AUTO 110
3200TGT      8790  2870    30    50    60    10
3210AUTO 111
3220TGT      9050  2695    65    30    65    10
3230BSENG115
3240TGT      8840  2840    25   200    65     9
3250SHP 118A
3260TGT      8830  2615   210    25    65     9
3270SHP 118B
3280TGT      8935  2825    30    85    65     9
3290BSENG119
3300TGT      8920  3160    85   400    65    10
3310BSENG120
3320TGT     10750  2560    60   360     0    10
3330HOSP 137
3340TGT     10320  2260    40    40    60     5
3350COMM 143
3360TGT     10180  2550    60    40     0    15
3370HTC 145
3380TGT      7595  2125   145   100    87     7
3390WPN 157
```

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3400TGT     7420  1860   30   70   87    7
3410WPN 159
3420TGT     7465  1790   70   30   87    6
3430AGE 160
3440TGT     7925  3025   60  195    0   10
3450ORCL 166
3460TGT     9375  2600   50   80    0    9
3470HQ GP167
3480TGT     8350  3375  100   35    0    9
3490REPL 168
3500TGT     9550  3360   30   20    0    5
3510COMM 173
3520TGT     8200  3400   60   90    0   10
3530WHSE 179
3540TGT     7460  1895   50   70   87    6
3550AGE 184
3560TGT     7555  1900   50   70   87    6
3570AGE 185
3580TGT     8380  2450   85   50    0    6
3590ORCL 187
3600TGT     9100  3500  180  180    0   10
3610WHSE 199
3620TGT     8300  2800   68   45   35    9
3630PWR 201
3640TGT     7730  1795  250   60   87    6
3650AGE 204
3660TGT     6880  2890   75   25   87    6
3670ORCL 206
3680TGT     6900  2975   50  180    0   10
3690ORCL 257
3700TGT    12040  2570   50   70    0    9
3710BEPAV330
3720TGT    12370  2655   30  135    0   10
3730BEPAV360
3740TGT    13340  2490  100   90    0    6
3750DOCK 364
3760TGT    11820  2650   45   45    0   15
3770WATER366
3780TGT    11715  2425   75   50   25    7
3790WPN 371
3800TGT    12525  1710   50   72    0   10
3810BEPAV382
3820TGT    12540  1890   72   50   50   10
3830BEPAV384
3840TGT    12670  1695   72   50   77   10
3850BEPAV385
```

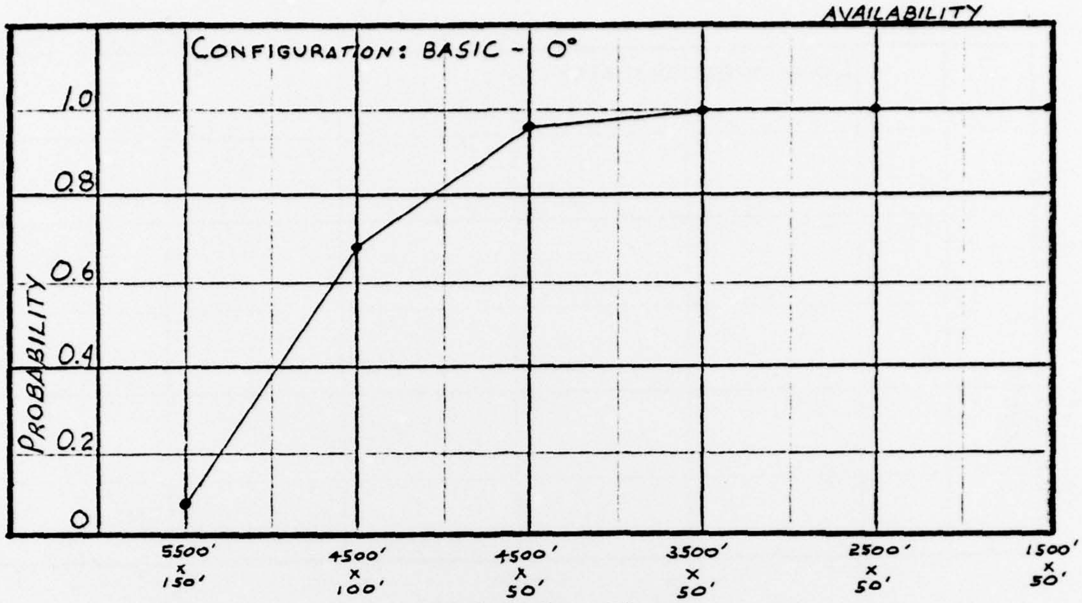
```
3860TGT    12880  1680   50    72     0     10
3870BEPAV386
3880TGT    13030  1930   50    72     0     10
3890BEPAV388
3900TGT    13175  1940   85    75     0      5
3910RDY 389
3920TGT    13300  1930  100    18     0      5
3930RDY 391
3940TGT    10620  -480   45    45     0     13
3950JP-4 620
3960TGT    10950  -360   45    45     0     13
3970JP-4 622
3980TGT     1820  -100   20    60    20      7
3990WPNS 704
4000TGT     3100  -850   40    60    70      8
4010IGLOO719
4020TGT     3300  -760   40    60    70      8
4030IGLOO720
4040TGT     3500  -700   40    60    70      8
4050IGLOO721
4060TGT     3700  -640   40    60    70      8
4070IGLOO722
4080TGT     3780  -200   30   150     0      8
4090CUBIC736
4100TGT     5400  -100   30    20     0     12
4110NAV 767
4120TGT     6100  -250   10    10     0     12
4130RADAR AN
4140EMD 11     1    25   25    50    50    70    20    60    60    80
4150
4160      .95
4170                30   30   100          60    25
4180      .95
4190EMD 11     2    25   25    50    50    70    20    60    60    80
4200
4210      .95
4220                30   30   100          60    25
4230      .95
4240ATT  1    30  2000  750   151   117    28    23     6   150     2
4250
4260ATT  1    30  2950  750   151   117    28    23     6   150     2
4270
4280ATT  1    30  6550  750   151   117    28    23     6   150     2
4290
4300ATT  1    30  7480  750   151   117    28    23     6   150     2
4310
```

```
4320ATT  1    30  9650   750  151  117   28   23   6  150   2
4330
4340ATT  1    30 10650   750  151  117   28   23   6  150   2
4350
4360ATT  1    30 11730   750  151  117   28   23   6  150   2
4370
4380ATT  1    30 12350  1030  151  117   28   23   6   86   2
4390
4400ATT  1    30 12380  1080  151  117   28   23   6   86   2
4410
4420ATT  1    30 10240  1000  151  117   28   23   6   86   2
4430
4440ATT  1    30  7070  1000  151  117   28   23   6   86   2
4450
4460ATT  1    30  7070  1830  151  117   28   23   6   86   2
4470
4480ATT  1    30  2380  1600  151  117   28   23   6   86   2
4490
4500ATT  1    30  4190  2000  151  117   28   23   6   86   2
4510
4520ATT  1    30  3320  1750  151  117   28   23   6   86   2
4530
4540ATT  1    30  4900  2230  151  117   28   23   6   86   2
4550
4560ATT  1    30  5940  2280  151  117   28   23   6   86   2
4570
4580ATT  1    30  8130  2250  151  117   28   23   6   86   2
4590
4600ATT  1    30 10230  1620  151  117   28   23   6   86   2
4610
4620ATT  1    30 11920  1970  151  117   28   23   6   86   2
4630
4640ATT  1    30  5120  2230  151  117   28   23   6   86   2
4650
4660ATT  1    30  5730  2650  151  117   28   23   6   86   2
4670
4680ATT  1    30  3030  2680  151  117   28   23   6   86   2
4690
4700ATT  1    30  3025  2670  151  117   28   23   6   86   2
4710
4720ATT  1    30  8100  2130  151  117   28   23   6   86   2
4730
4740ATT  1    30  8090  2570  151  117   28   23   6   86   2
4750
4760ATT  1    30  8580  1930  151  117   28   23   6   86   2
4770
```

```
4780ATT  1    30 11530  2260   151   117   28   23   6    86   2
4790
4800ATT  1    30 12180  2270   151   117   28   23   6    86   2
4810
4820ATT  1    30 12250  1930   151   117   28   23   6    86   2
4830
4840ATT  1    30  8480  1930   400   200   50   30   6  1050   1
4850
4860ATT  1    30  9140  1640   400   200   50   30   6  1050   1
4870
4880ATT  1    30  9300  1640   400   200   50   30   6  1050   1
4890
4900ATT  1    30 11670  1640   400   200   50   30   6  1050   1
4910
4920ATT  1    30 12040  2270   400   200   50   30   6  1050   1
4930
4940ATT  1    30 12100  1930   400   200   50   30   6  1050   1
4950
4960ATT  1    30 12440  1930   400   200   50   30   6  1050   1
4970
4980ATT  1    30 12700  1930   400   200   50   30   6  1050   1
4990
5000ATT  1    30 12490  2430   400   200   50   30   6  1050   1
5010
5020ATT  1    30 12620  2350   400   200   50   30   6  1050   1
5030
5040ATT  1    30 12710  2270   400   200   50   30   6  1050   1
5050
5060ATT  1    30 13440  1900   400   200   50   30   6  1050   1
5070
5080ATT  1    30 13550  1930   400   200   50   30   6  1050   1
5090
5100ATT  1    30 13790  1980   400   200   50   30   6  1050   1
5105
5430END
5440
```

APPENDIX D

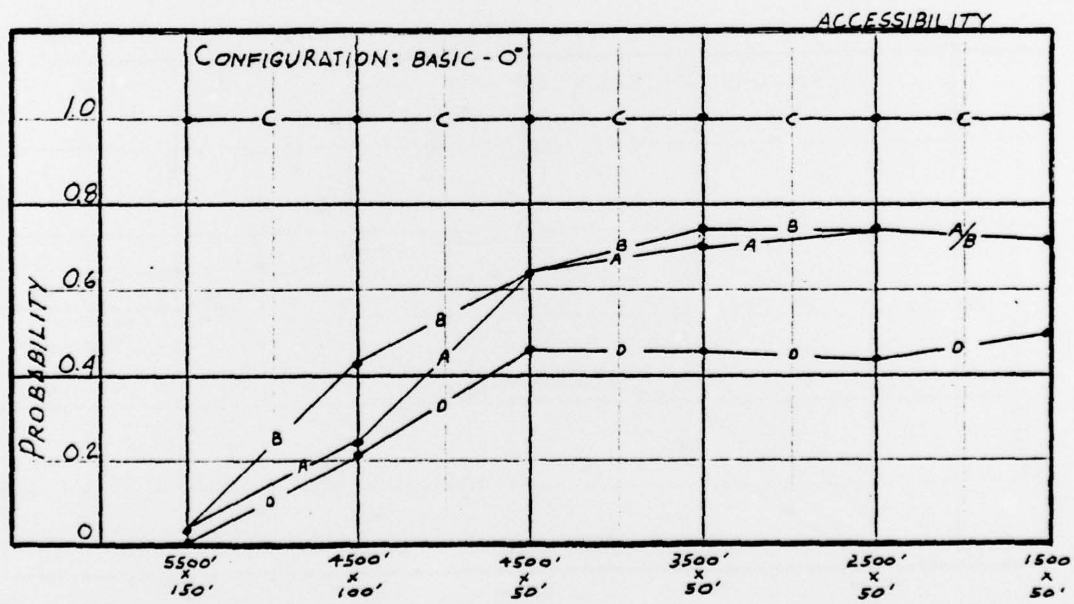
PROBABILITY DISTRIBUTIONS



Launch Window Sizes

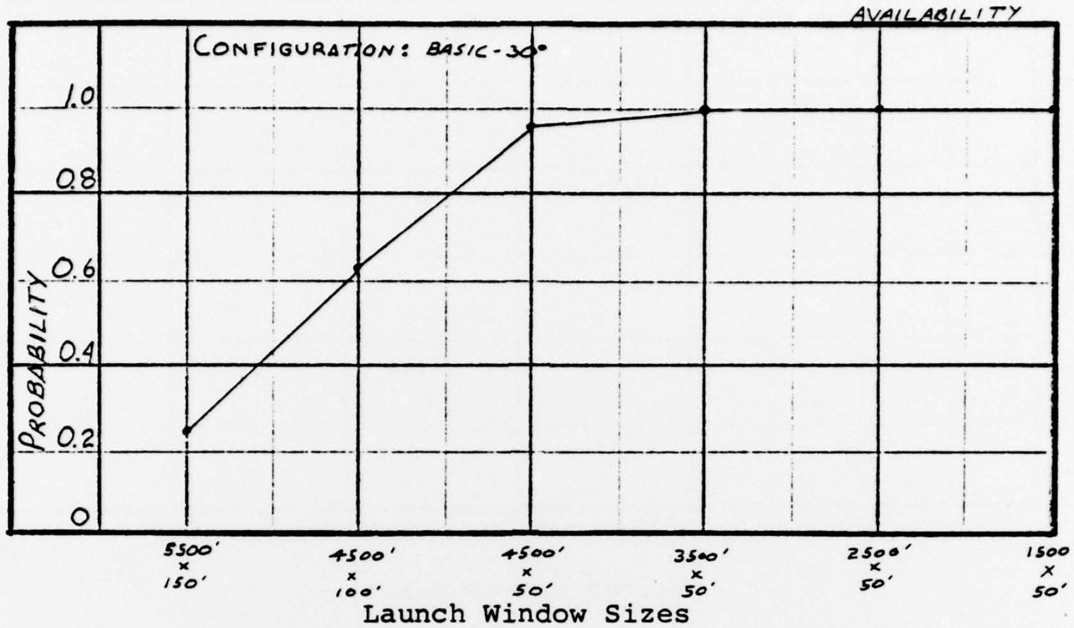
Legend:

A, B, C, D - Access Points



Launch Window Sizes

Fig. D-1. Zero Degree Attack Heading Distributions



Legend:

A, B, C, D - Access Points

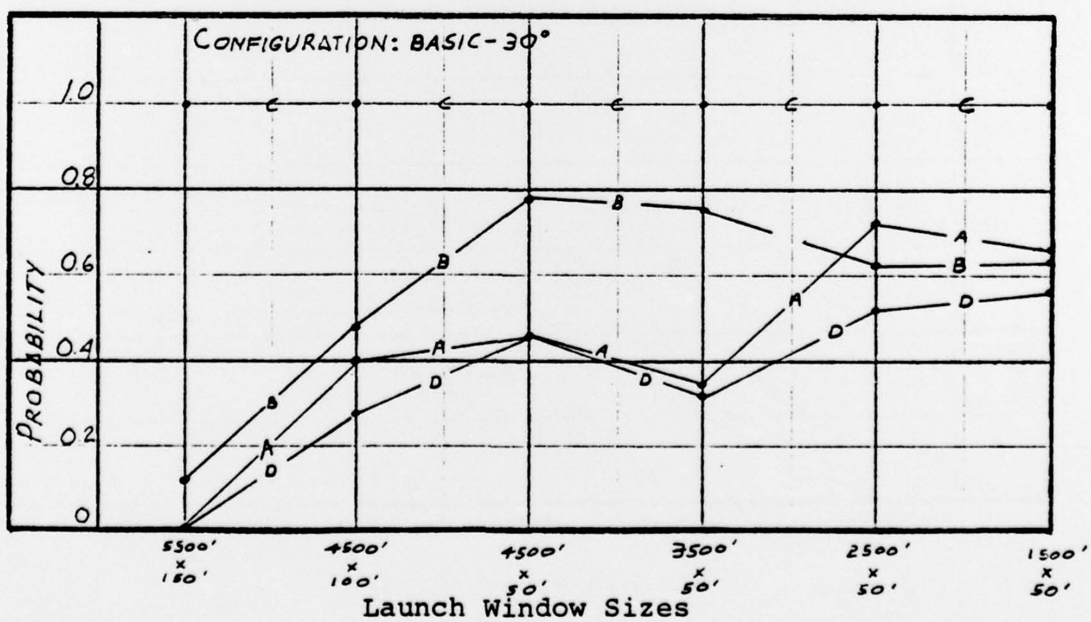
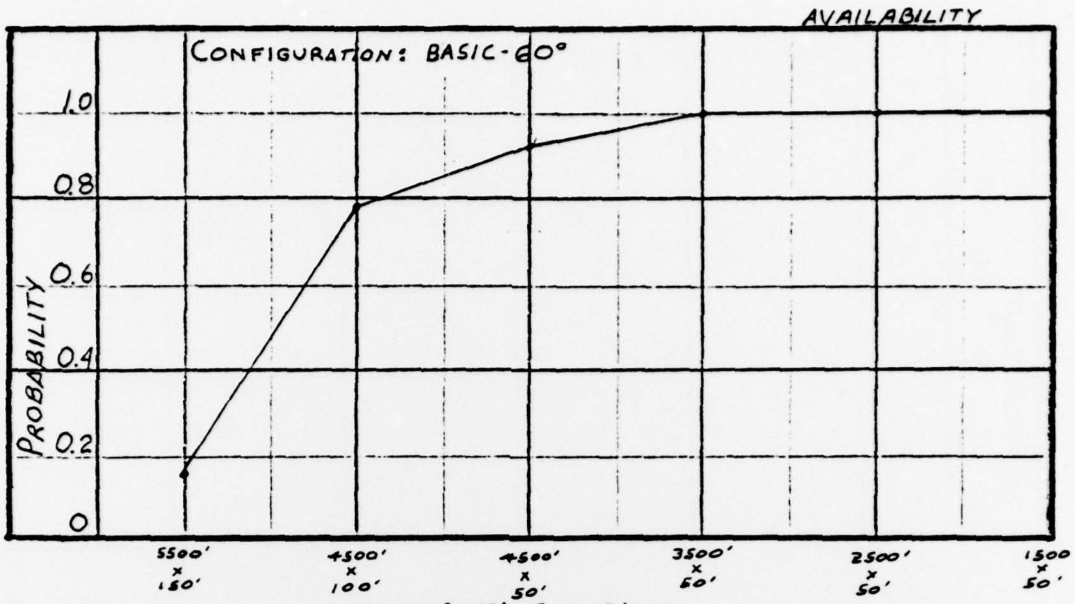


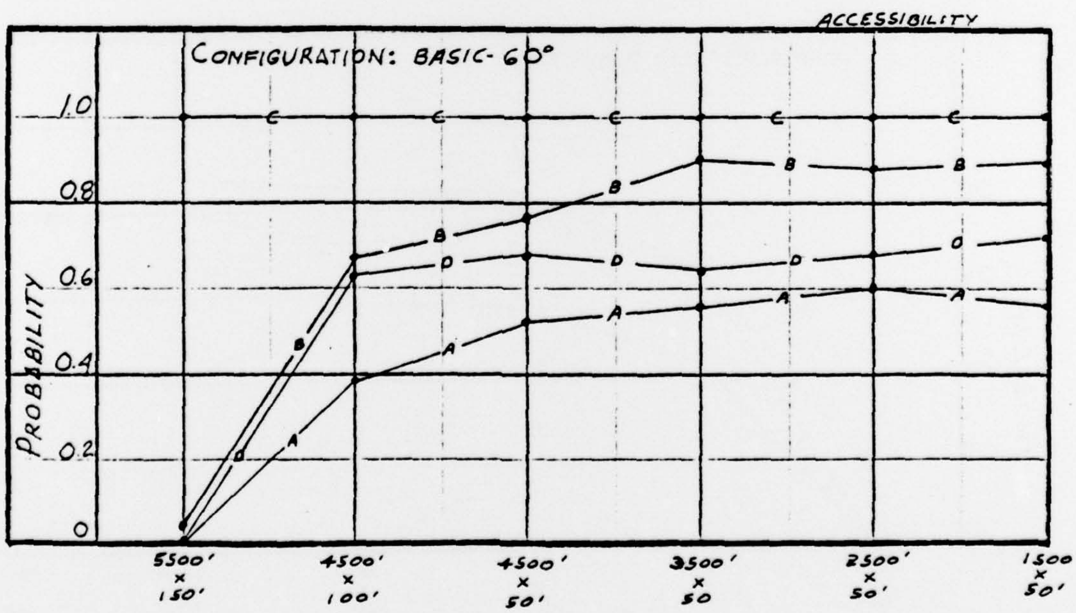
Fig. D-2. Thirty Degree Attack Heading Distributions



Launch Window Sizes

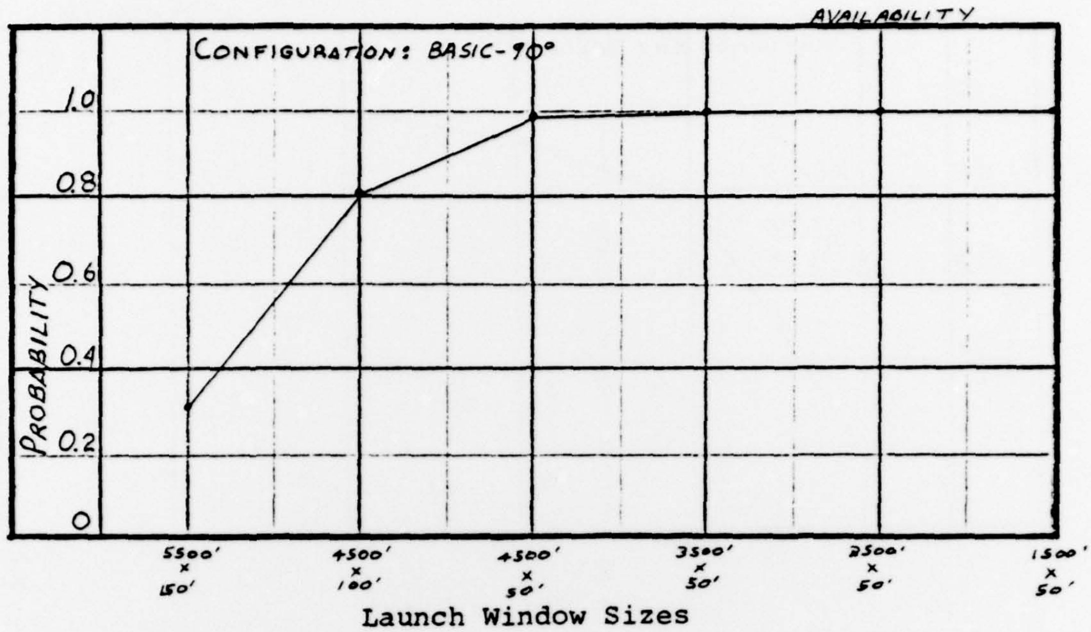
Legend:

A, B, C, D - Access Points



Launch Window Sizes

Fig. D-3. Sixty Degree Attack Heading Distributions



Legend:

A, B, C, D - Access Points

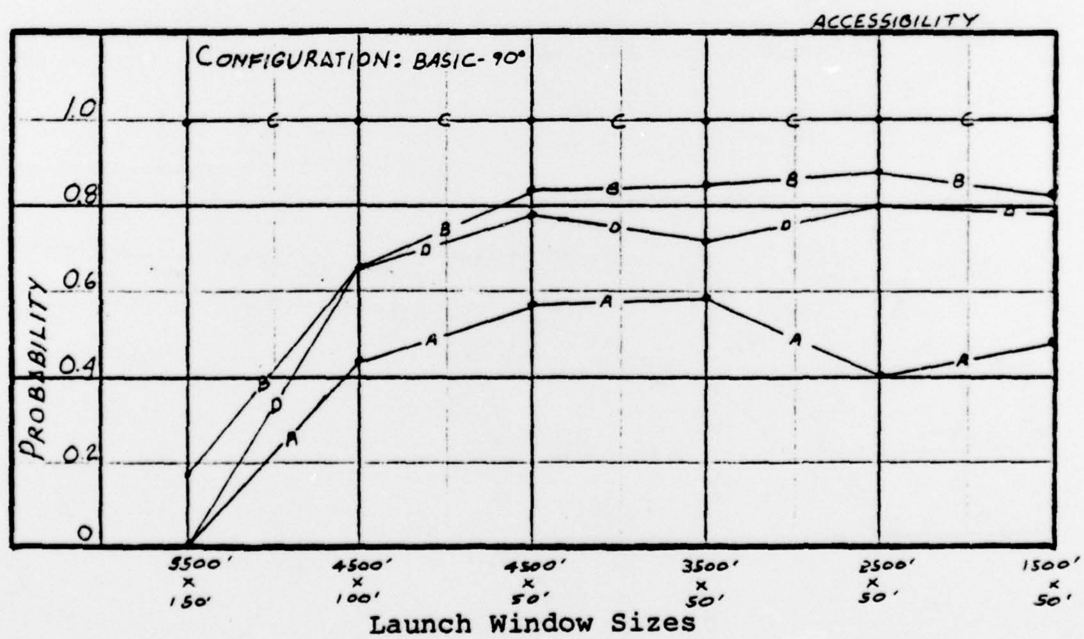
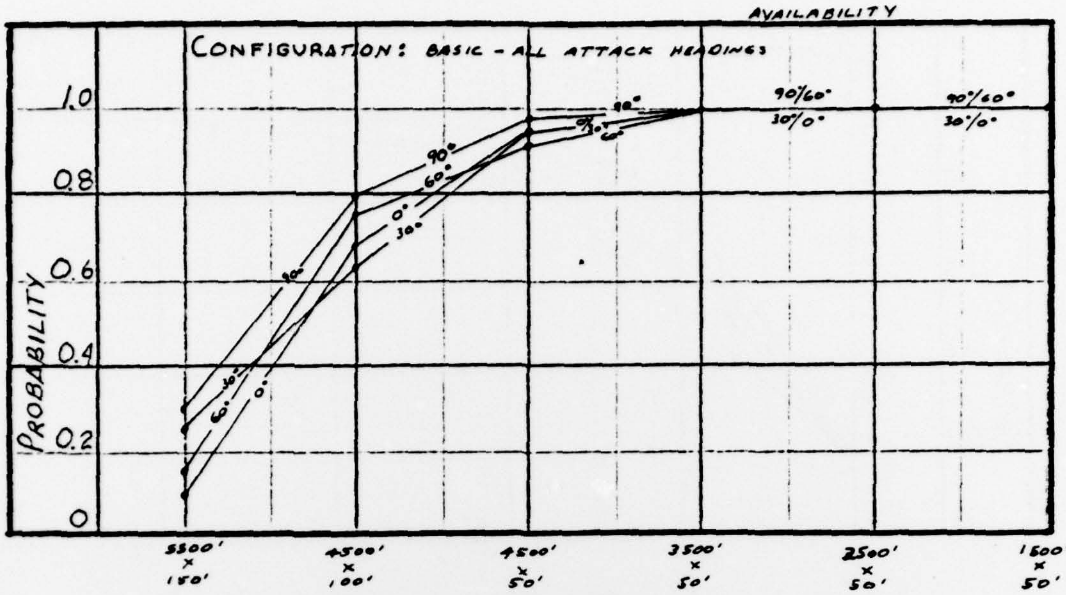


Fig. D-4. Ninety Degree Attack Heading Distributions



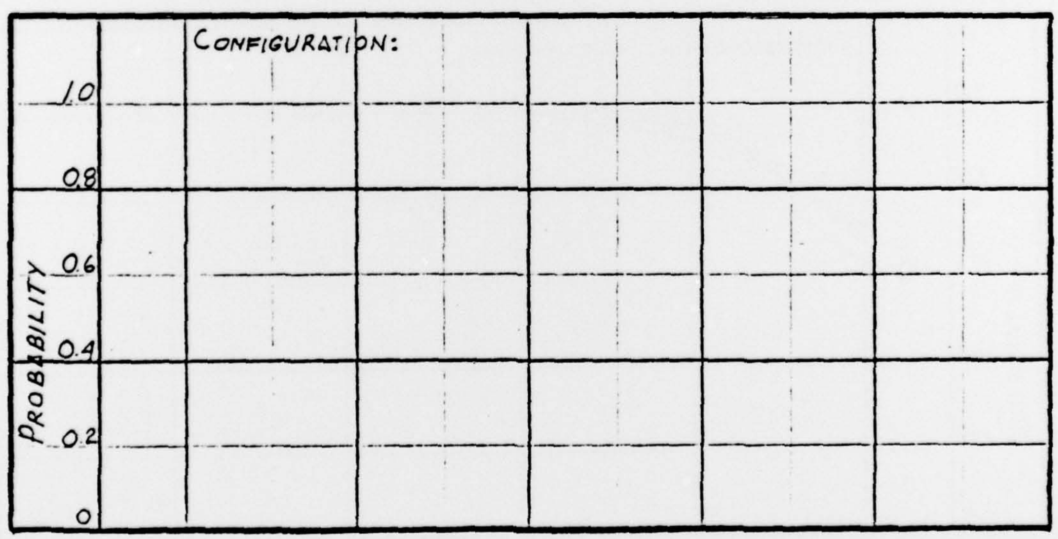
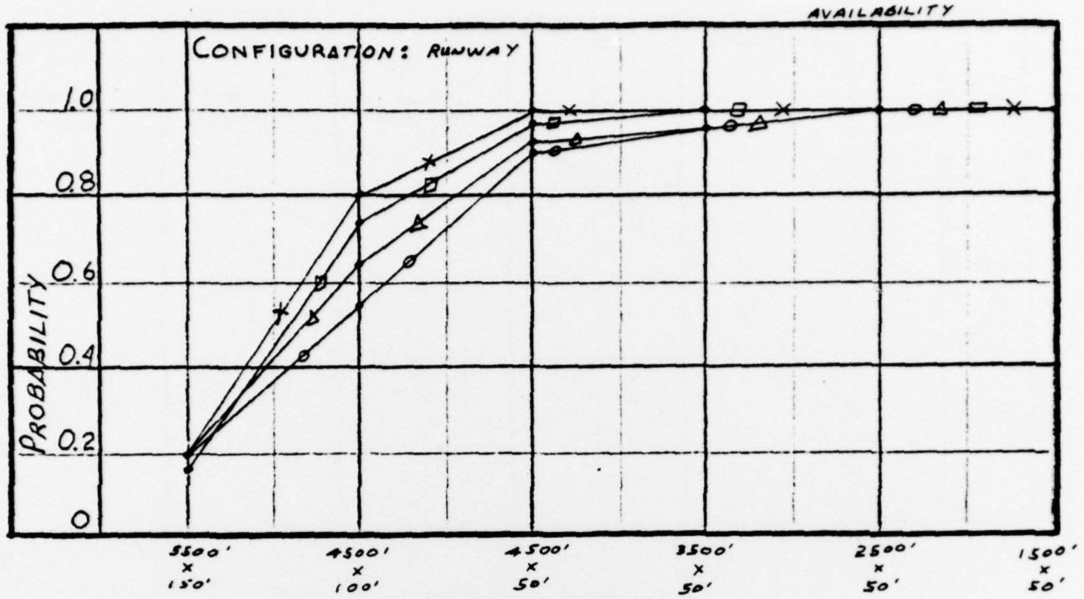
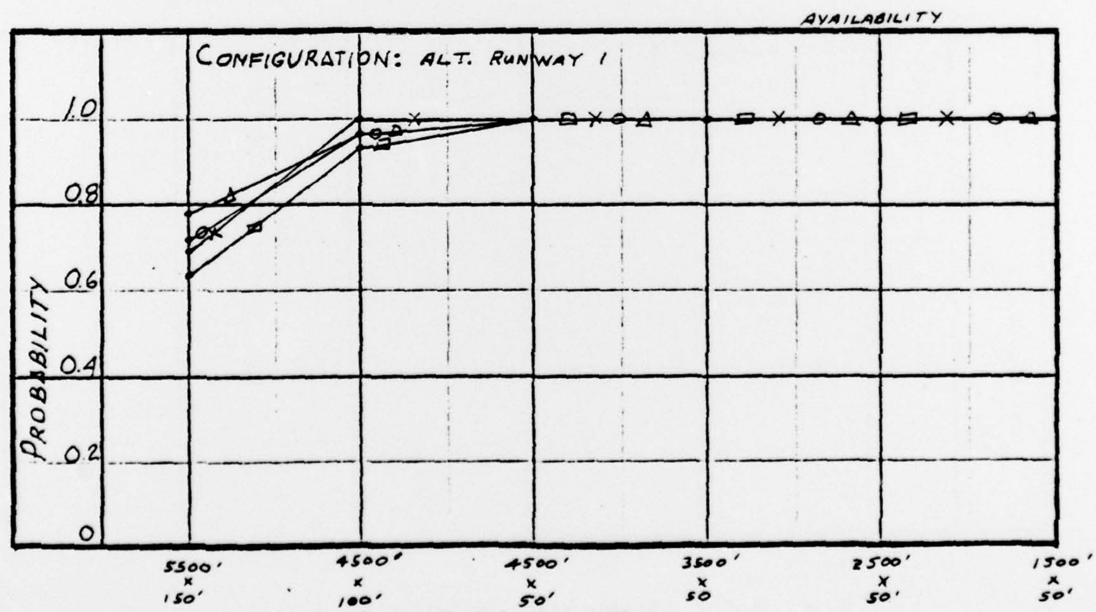


Fig. D-5. Composite of Distributions



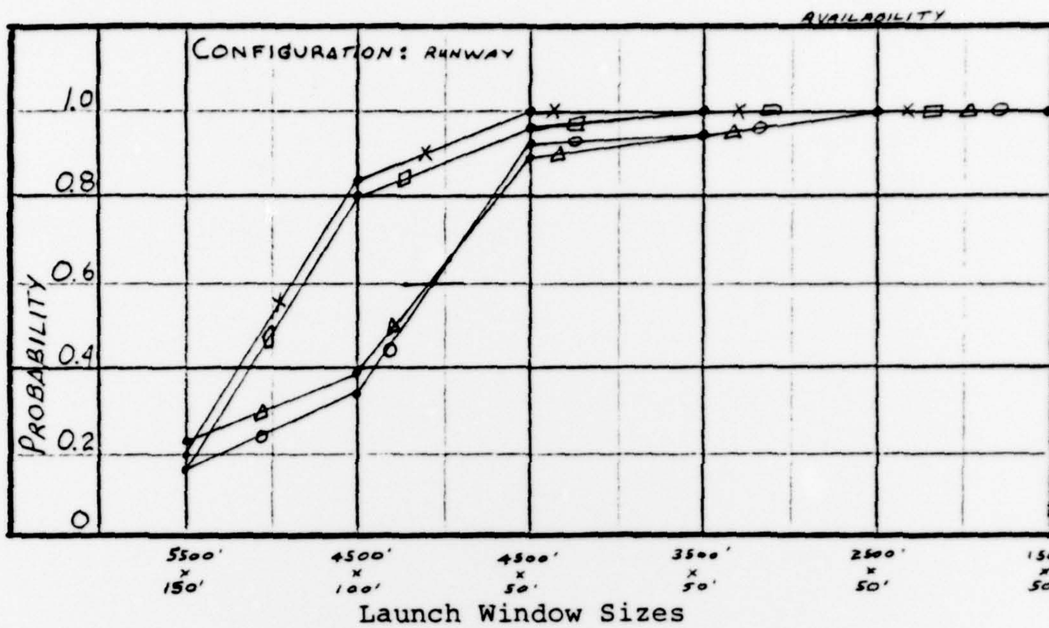
Launch Window Sizes

Legend: 0° -○
30° -△
60° -□
90° -×
Attack Headings



Launch Window Sizes

Fig. D-6. Probability Distributions for Alternate Configuration 1



Legend: 0° - ○
30° - △
60° - □ Attack Headings
90° - ×

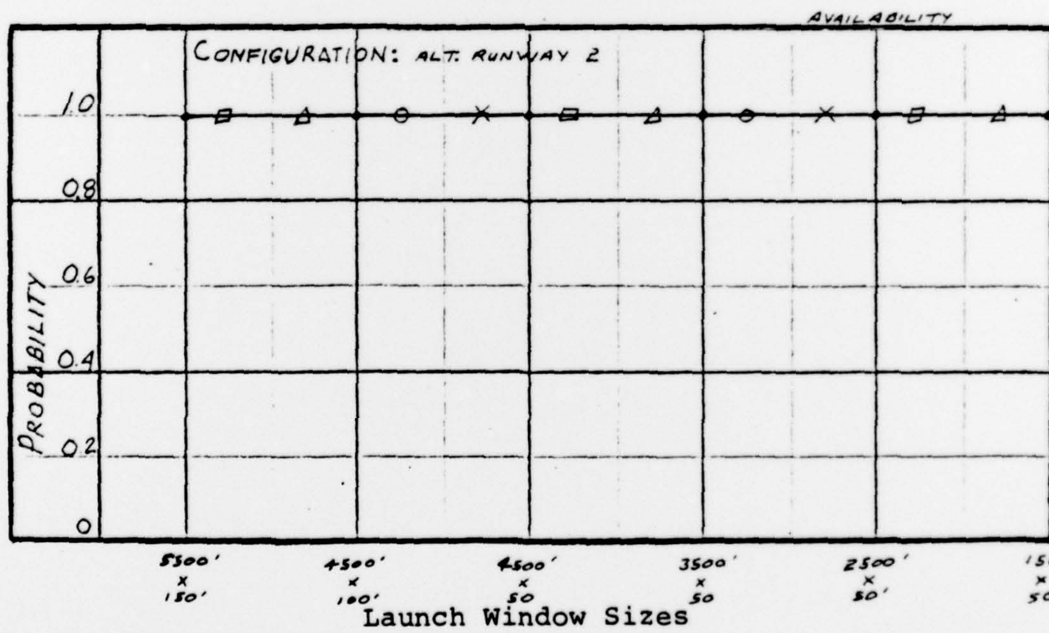


Fig. D-7. Probability Distributions for Alternate Configuration 2

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