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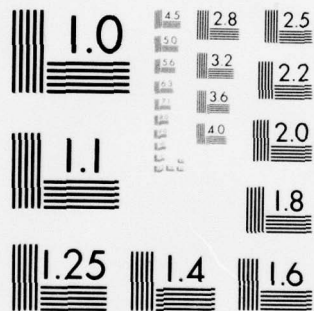
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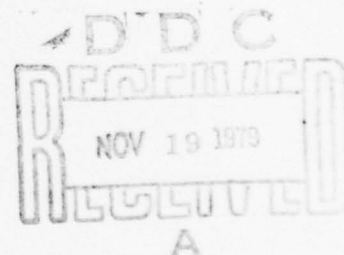
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THE DETERMINATION OF THE
ACCESSIBILITY OF POST-ATTACK
LAUNCH WINDOWS

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

LSSR 20-79B



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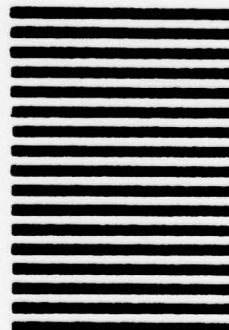
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This study examined the availability and accessibility of post-attack launch windows using simulation. The basis for the study was the research and development of the Rand Corporation's Airbase Damage Assessment Model. Prior to this study, damage assessment 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.

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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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September 1979

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Captain Dennis F. Ballog

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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


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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

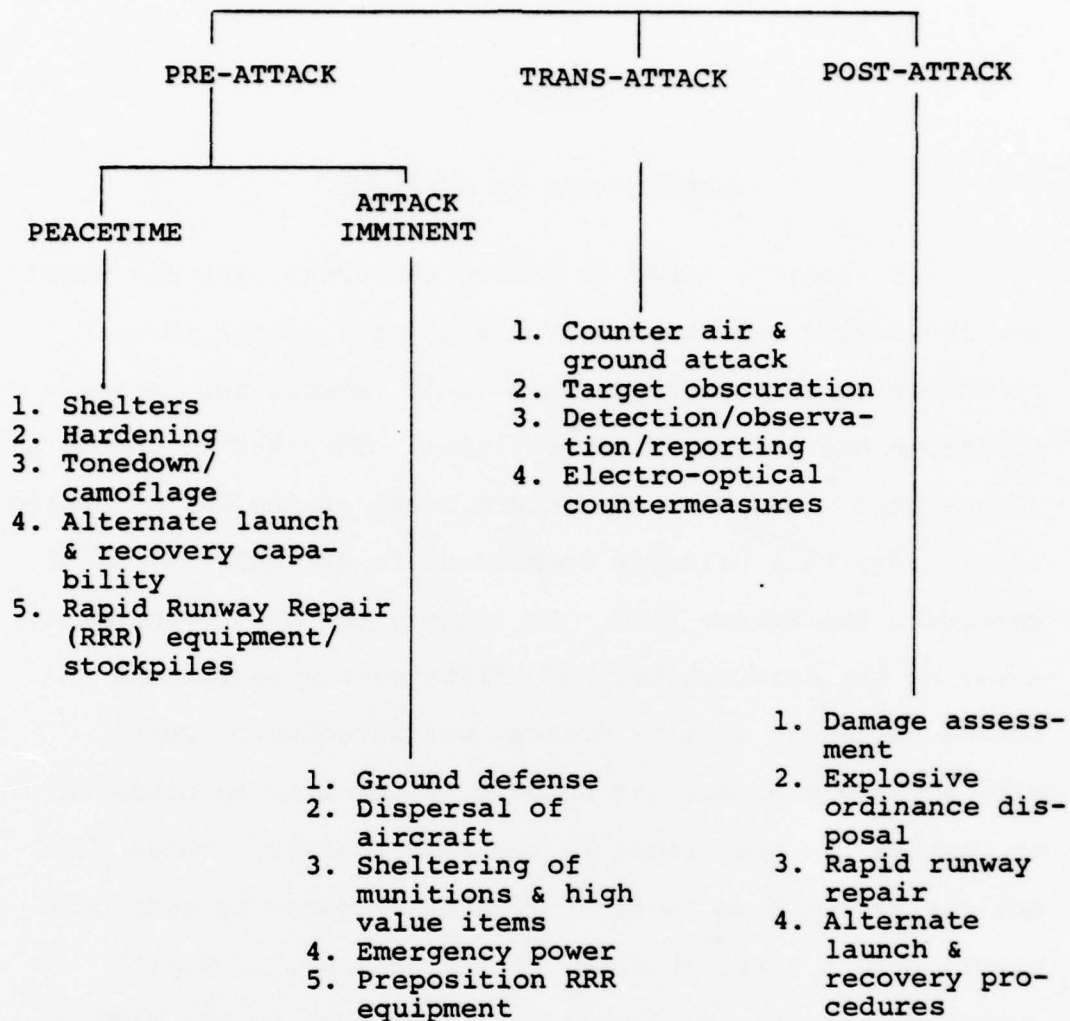


Fig. 1-1. Airbase Survivability Efforts (1)

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

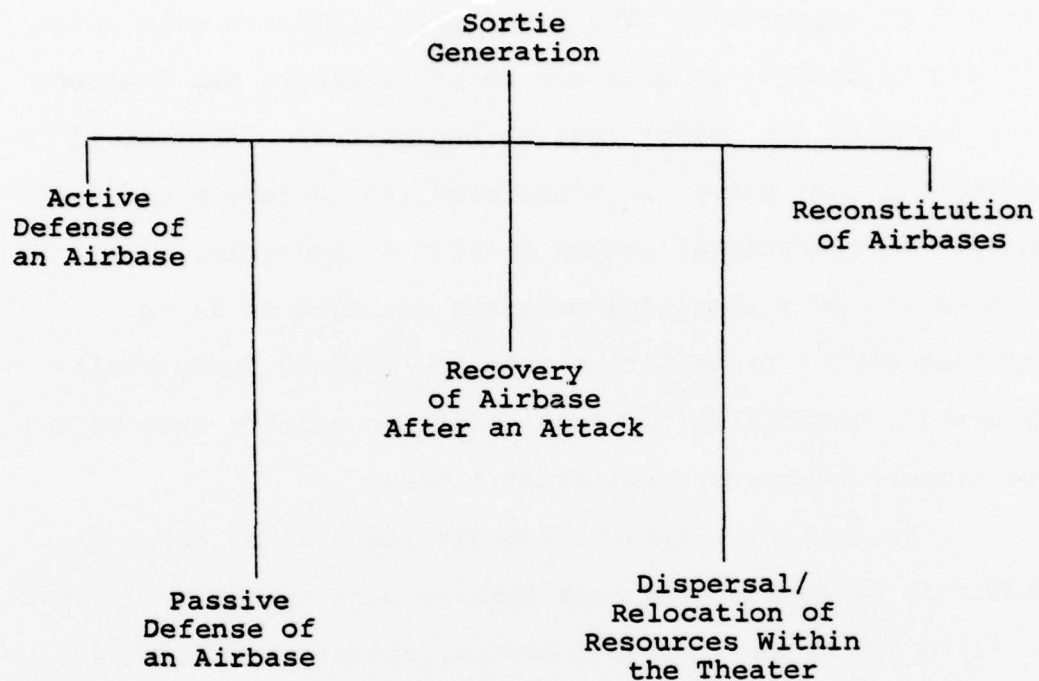


Fig. 1-2. Categorization of Candidate Programs to Increase the Survivability of NATO Air Operations (2)

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

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

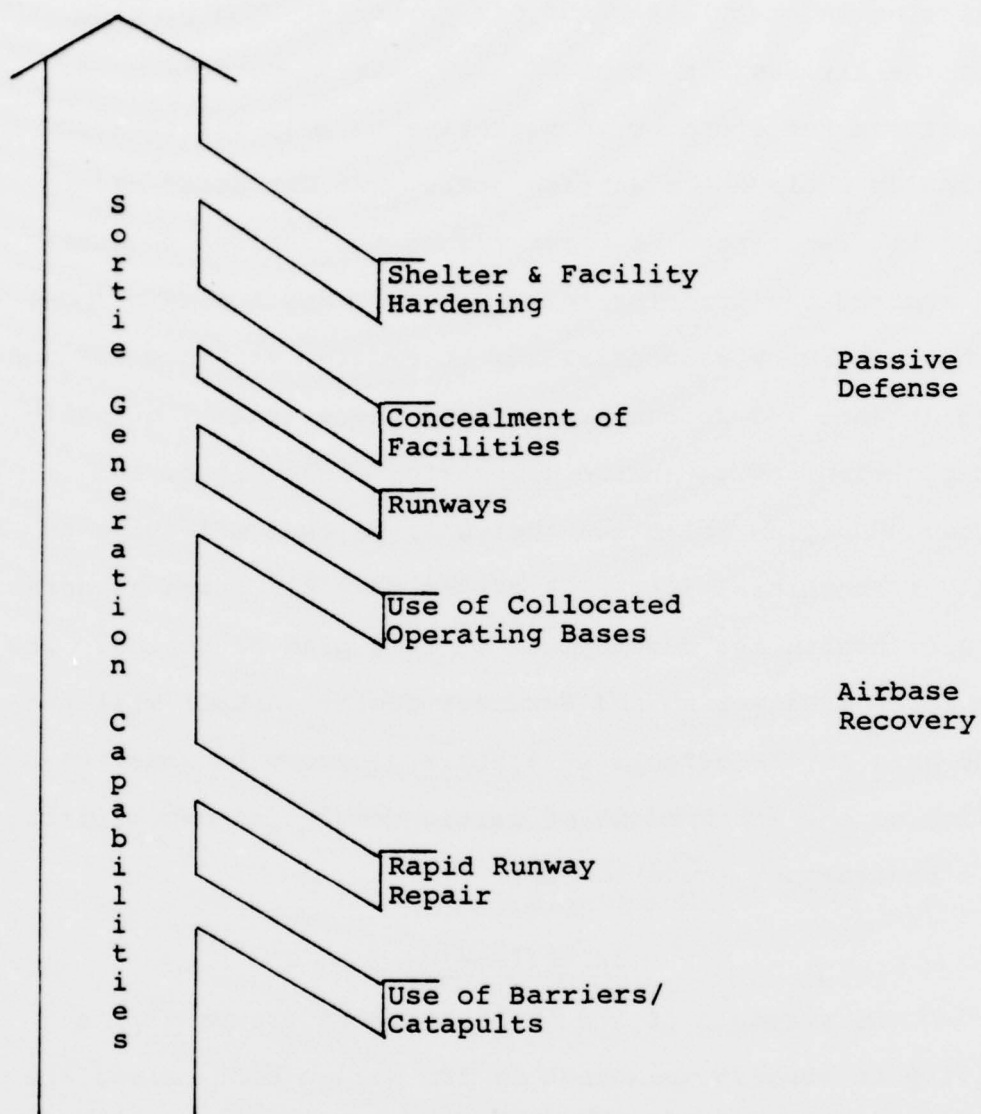


Fig. 1-3. Airbase Survivability Enhancements (1)

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

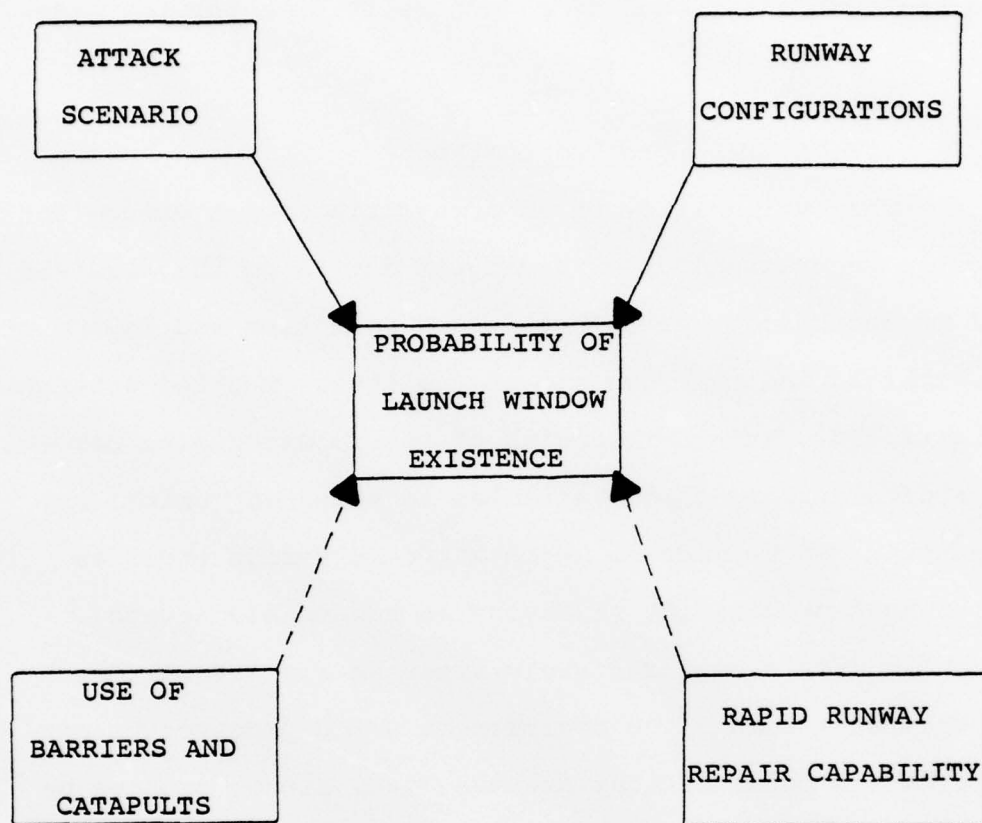
after an initial air attack. The latter will in turn lead to a reasonable estimate of a "get well" time for the airfield.

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

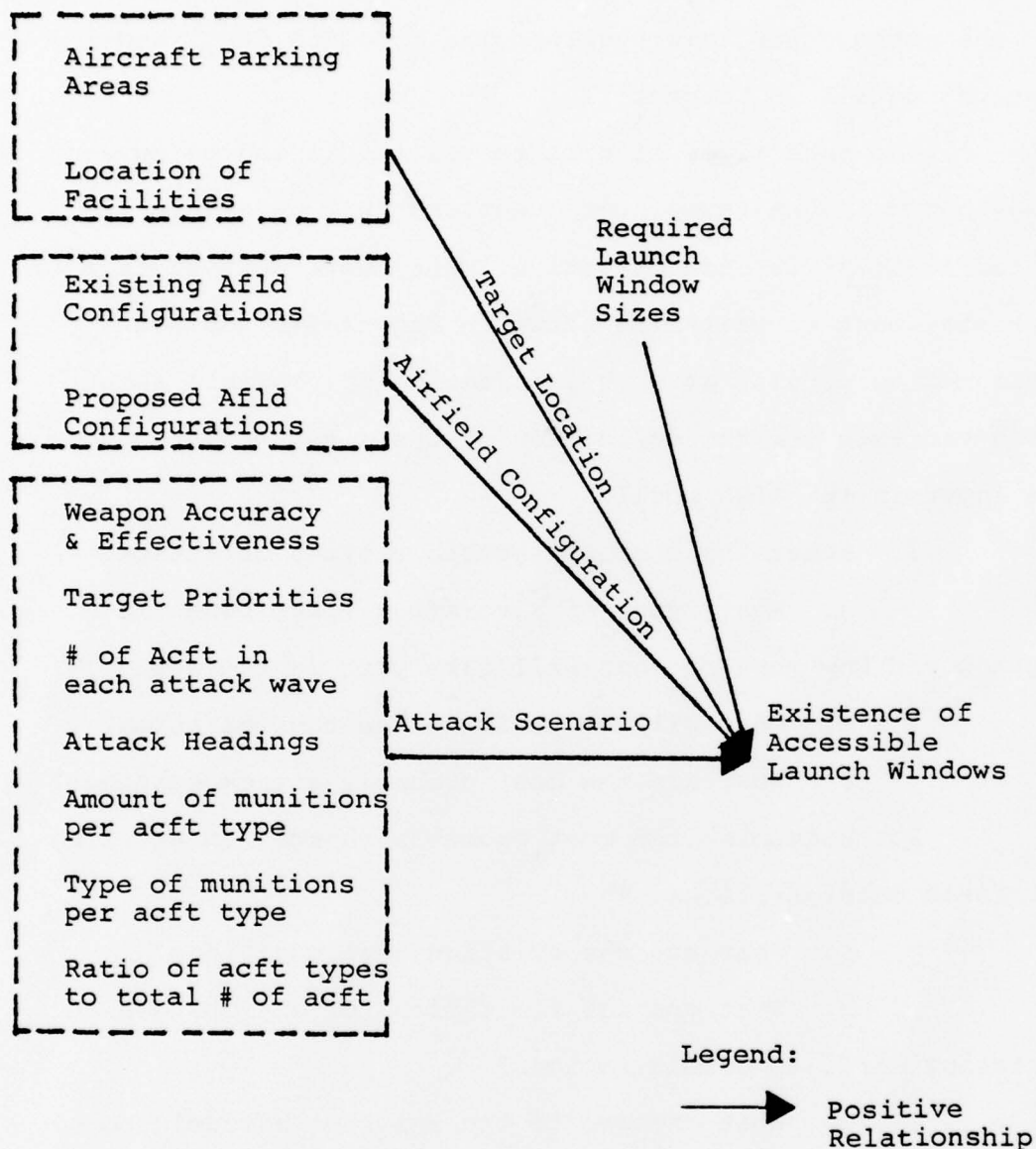


Fig. 1-6. Variable Interrelationships

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 complementary?
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

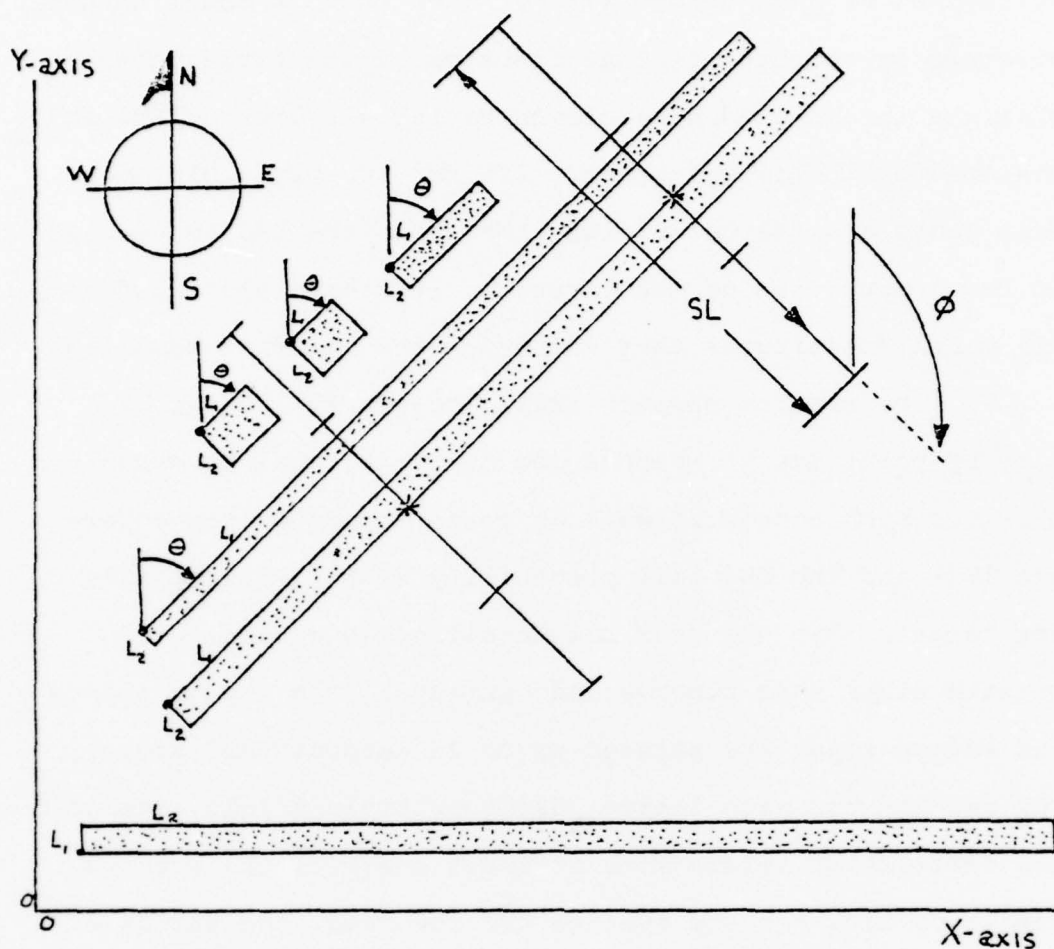
estimates of the average damage and variability of that damage for each of the many targets. Several different sets of problems can be treated by successive cases during a single computer run (7:1).

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

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

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



TARGETS	ATTACK PASSES
Reference (westernmost) corner	* DMPI
L_1 Northeasterly heading boundary	ϕ Attack heading
L_2 Southeasterly heading boundary	SL Stick length
θ Orientation angle	++ 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

^bCompact listing of hits and required repairs for runways or taxiway.^cCompact 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.

³For 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

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

TARGET NUMBER	PERCENT ATTACKS HIT	AVERAGE HITS PER ATTACK	STD. DEV. OF HITS	AUG. CBU STD. DEV. COVERAGE	AUG. BOMB COVERAGE (CBU OTHER)	BLDG NO.
1	120.0	18.43	3.51	0.	0.019	0.
2	120.0	14.23	12.52	0.	0.041	0.
		32.60		0.		0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
		0.		0.		0.
3	80.0	3.62	2.88	0.	0.019	0.
		3.60		0.		0.
6	120.0	5.40	1.34	0.	0.155	0.
7	20.0	2.40	2.23	0.	0.166	0.
9	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.
		7.60		0.		0.
8	40.0	2.20	3.13	0.	0.114	0.
10	20.0	2.40	2.53	0.	0.023	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
		4.60		0.		0.
14	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
		0.		0.		0.

DAMAGE STATISTICS BY TARGET TYPE

TARGET TYPE	AVERAGE PERCENT HIT	STANDARD DEVIATION	END	OTHER	CBU
1	120.0	0.	2.3	0.	0.
2	0.	0.	0.	0.	0.
3	20.0	44.7	1.3	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)

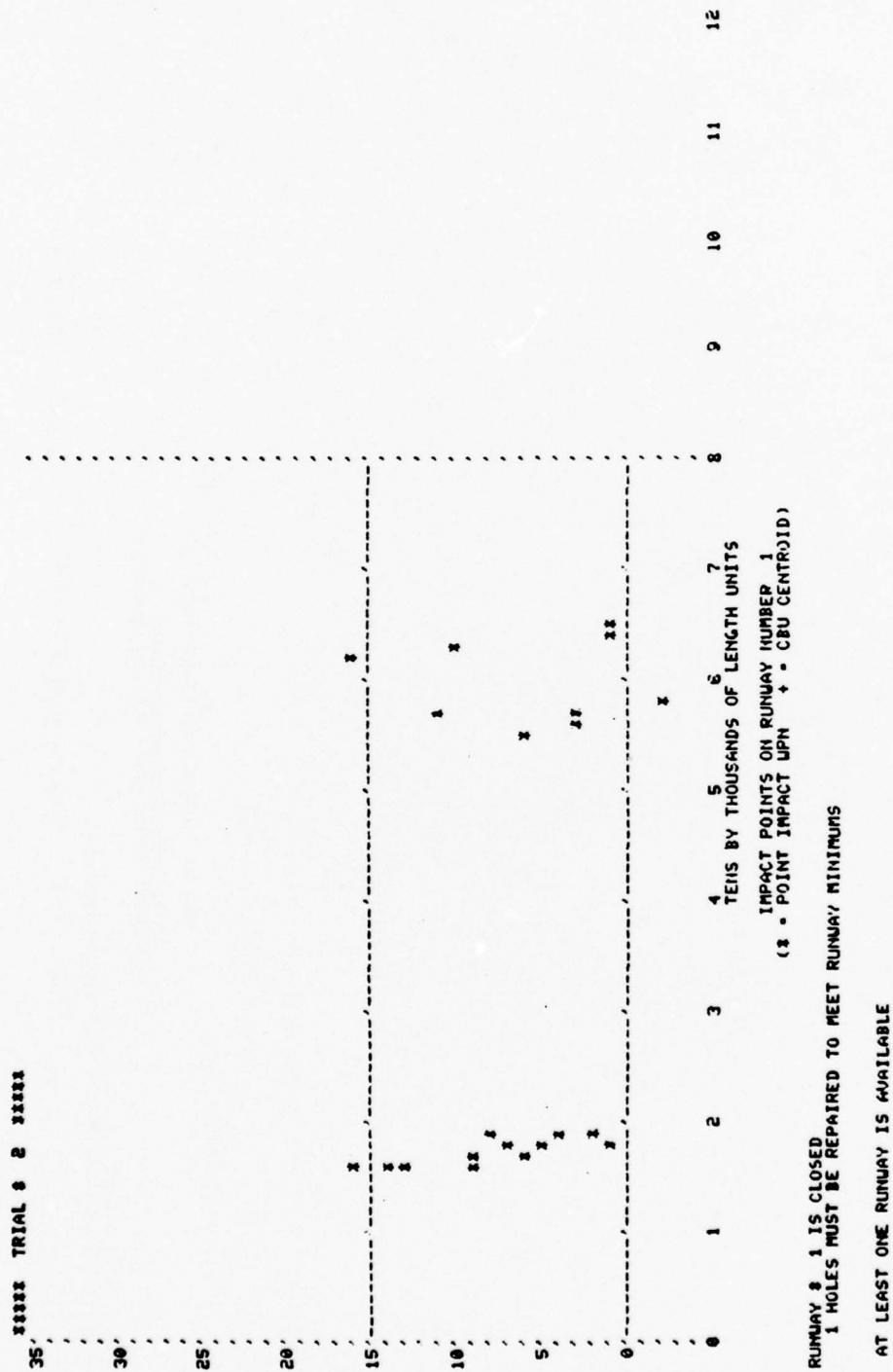
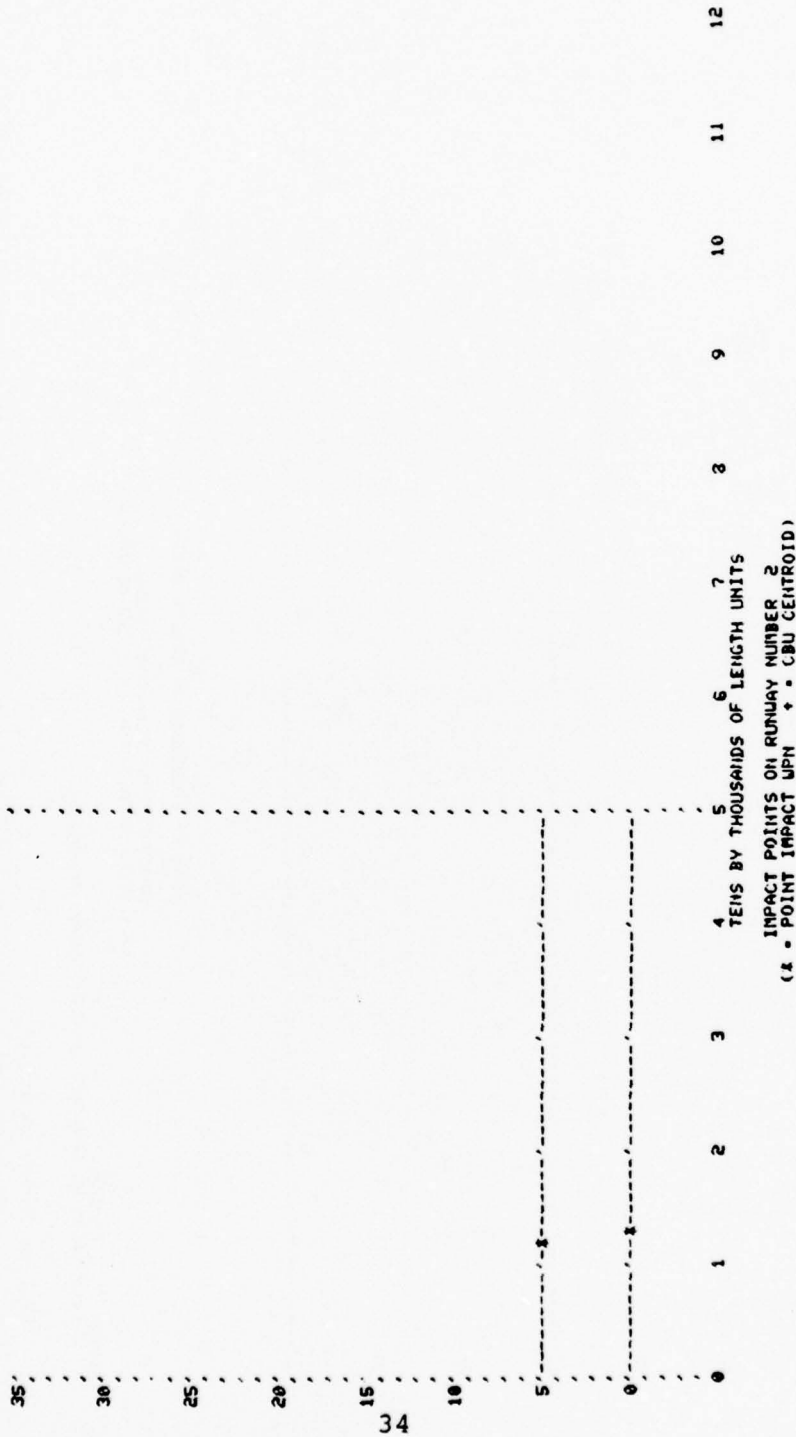


Fig. 2-5. Runway Hit Patterns, Case 2 (7:26)

AN AIRBASE DAMAGE ASSESSMENT MODEL
 DEVELOPED BY THE RANDSTEIN 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



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

HIT LOCATION AND UPN TYPE FOR SELECTED TARGETS

TARGET NUMBER 6	1-DIM	Y-DIM	UPN TYPE
	716.	2042.	2
TARGET NUMBER 7	1-DIM	Y-DIM	UPN TYPE
	722.	2034.	2
TARGET NUMBER 11	1-DIM	Y-DIM	UPN TYPE
	1224.	2316.	2
	1519.	2552.	1
	1529.	2597.	1
	1578.	3036.	1
	1753.	3115.	1
	1684.	3118.	1
	1636.	3148.	1
	1704.	3145.	1
TARGET NUMBER 13	1-DIM	Y-DIM	UPN TYPE
	2061.	3541.	1
	2109.	3611.	1
	2101.	3680.	1
	2181.	3684.	1
	2100.	3723.	1
	2122.	3501.	1
TARGET NUMBER 1	1-DIM	Y-DIM	UPN TYPE
	2530.	1820.	1
	2463.	1864.	1
	2636.	1860.	1

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

```

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

```

XXXXX	BASE	COMPLEX	NAME	-	BASE	XYZ	XXXXX
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10
11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12
13	13	13	13	13	13	13	13
14	14	14	14	14	14	14	14
15	15	15	15	15	15	15	15
16	16	16	16	16	16	16	16
17	17	17	17	17	17	17	17
18	18	18	18	18	18	18	18
19	19	19	19	19	19	19	19
20	20	20	20	20	20	20	20
21	21	21	21	21	21	21	21
22	22	22	22	22	22	22	22
23	23	23	23	23	23	23	23
24	24	24	24	24	24	24	24
25	25	25	25	25	25	25	25
26	26	26	26	26	26	26	26
27	27	27	27	27	27	27	27
28	28	28	28	28	28	28	28
29	29	29	29	29	29	29	29
30	30	30	30	30	30	30	30
31	31	31	31	31	31	31	31
32	32	32	32	32	32	32	32
33	33	33	33	33	33	33	33
34	34	34	34	34	34	34	34
35	35	35	35	35	35	35	35
36	36	36	36	36	36	36	36
37	37	37	37	37	37	37	37
38	38	38	38	38	38	38	38
39	39	39	39	39	39	39	39
40	40	40	40	40	40	40	40
41	41	41	41	41	41	41	41
42	42	42	42	42	42	42	42
43	43	43	43	43	43	43	43
44	44	44	44	44	44	44	44
45	45	45	45	45	45	45	45
46	46	46	46	46	46	46	46
47	47	47	47	47	47	47	47
48	48	48	48	48	48	48	48
49	49	49	49	49	49	49	49
50	50	50	50	50	50	50	50
51	51	51	51	51	51	51	51
52	52	52	52	52	52	52	52
53	53	53	53	53	53	53	53
54	54	54	54	54	54	54	54
55	55	55	55	55	55	55	55
56	56	56	56	56	56	56	56
57	57	57	57	57	57	57	57
58	58	58	58	58</			

NUMBER	X-DIM	TARGET DATA			ANGLE	TGT TYPE	STORE	BLDG NO	
		Y-DIM	NE LIMB	SE LIMB					
1	1002.	1000.	8000.	150.	50.	1.	0.	RUNWAY	
2	775.	1350.	5000.	50.	45.	1.	0.	MAIN TAX	

NUMBER	HDG	ATTACK DATA			DEP	R-DISP	D-DISP	NO UPNS	LENGTH	UPN TYPE	ARRIVAL
		X-DMPI	Y-DMPI	REP							
1	45.	1775.	3350.	400.	200.	50.	29.	25.	800.	1.	1.000
2	45.	650.	1350.	151.	117.	28.	23.	6.	26.	2.	1.000
3	45.	1350.	2575.	151.	117.	50.	23.	6.	86.	2.	1.000
4	90.	2750.	1900.	400.	200.	28.	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

36

MISS DISTANCES ALLOWED FOR EFFECTIVE HITS

[illegible]

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.

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
 ***** END OF FILE *****

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

TARGET DAMAGE STATISTICS FOR 25 TRIALS

TARGET NUMBER	PERCENT ATTACKS HIT	AVERAGE HITS PER ATTACK	STD. DEV. OF HITS	AUG. CBU STD. DEV. COVERAGE	AUG. BOMB COVERAGE END	CBU PY.	BLDG NO.	RUNWAY MAIN TAX
1	96.0	15.28	5.30	0.	0.	0.	0.	0.
2	76.0	6.40	7.96	0.	0.	0.	0.	0.
		-----	-----	-----	-----	-----	-----	-----
		21.68		0.				

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

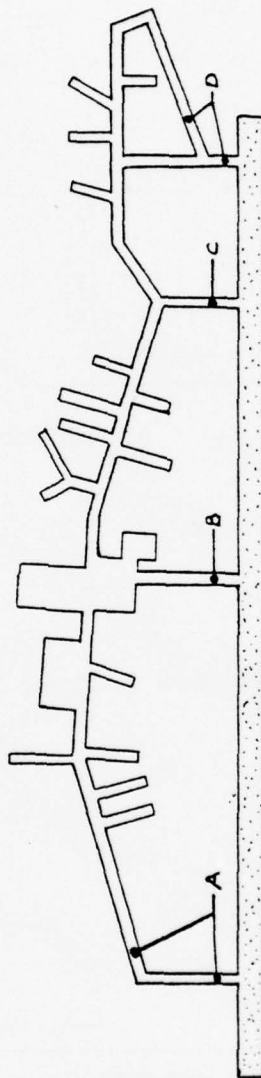
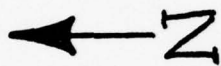
AIDA is a simulation model developed to assist in the analysis of airbase damage after a conventional air strike. The model's operation provides extensive flexibility in terms of attack level and detail of assessment. It provides specific definition of the attack scenario; e.g., number of attacking forces,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

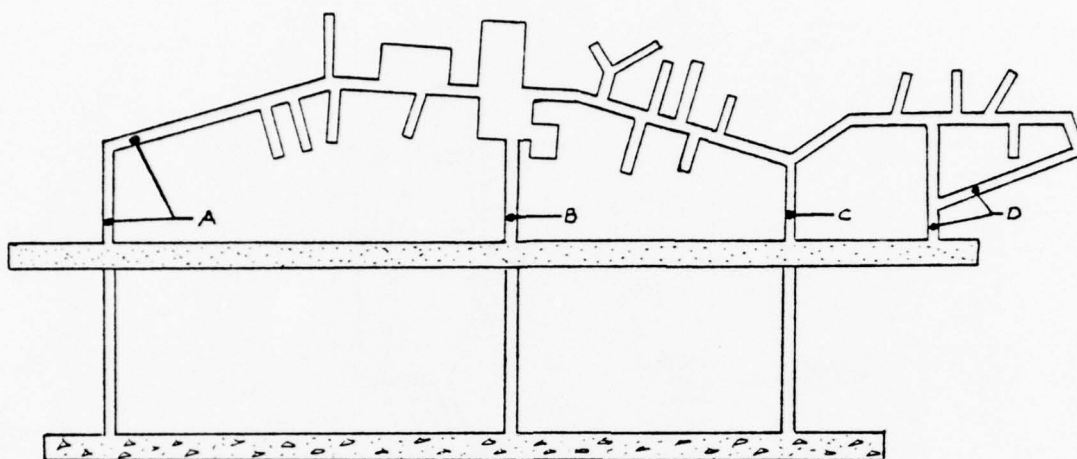
The locations of individual high priority targets (i.e., maintenance hangers, shelters, avionics shops, operations, command posts, navigational aids, etc.) were those of the standard NATO airbase. The model was exercised with varying attack scenarios, with the targeting data (including



Legend:

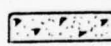
A, B, C, and D are Access Points.

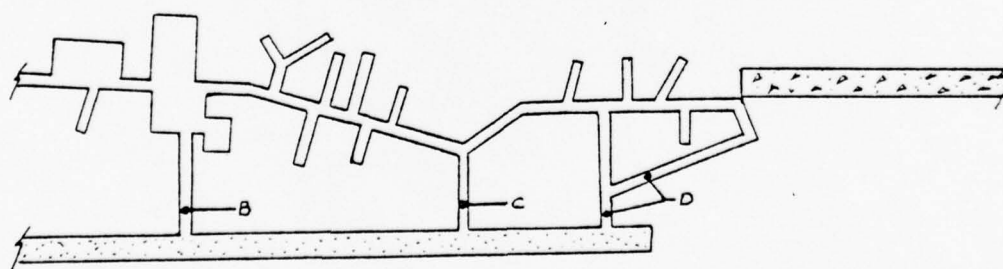
Fig. 3-1. Basic Airfield Configuration



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°

¹This 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).

²This 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 ₂ R ₂	LR	--	--
50'x2500'	L ₃ (R)	L ₃ R ₁	L ₃ R ₁	L ₃ R ₂	LR	--	--
50'x3500'	L ₃ R ₂	L ₃ R ₁	L ₃ R ₂	L ₃ R ₂	LR	--	--
50'x4500'	L ₃ R ₂	L ₃ R ₂	L ₃ R ₂	L ₃ R ₂	LR	--	--
100'x4500'	L ₃ R ₂	L ₃ R ₂	L ₃ R ₂	L ₃ R ₂	LR	LR	--
150'x5500'	L ₃ R ₂	L ₃ R ₂	L ₃ R ₂	L ₃ R ₂	LR	LR	LR

Legend:

Launch Condition

L - Only condition possible

L₁ - BugoutL₂ - Max wt. for 1500' groundrollL₃ - Basic attackRecovery Condition

R - Only condition possible

R₁ - LightweightR₂ - 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.

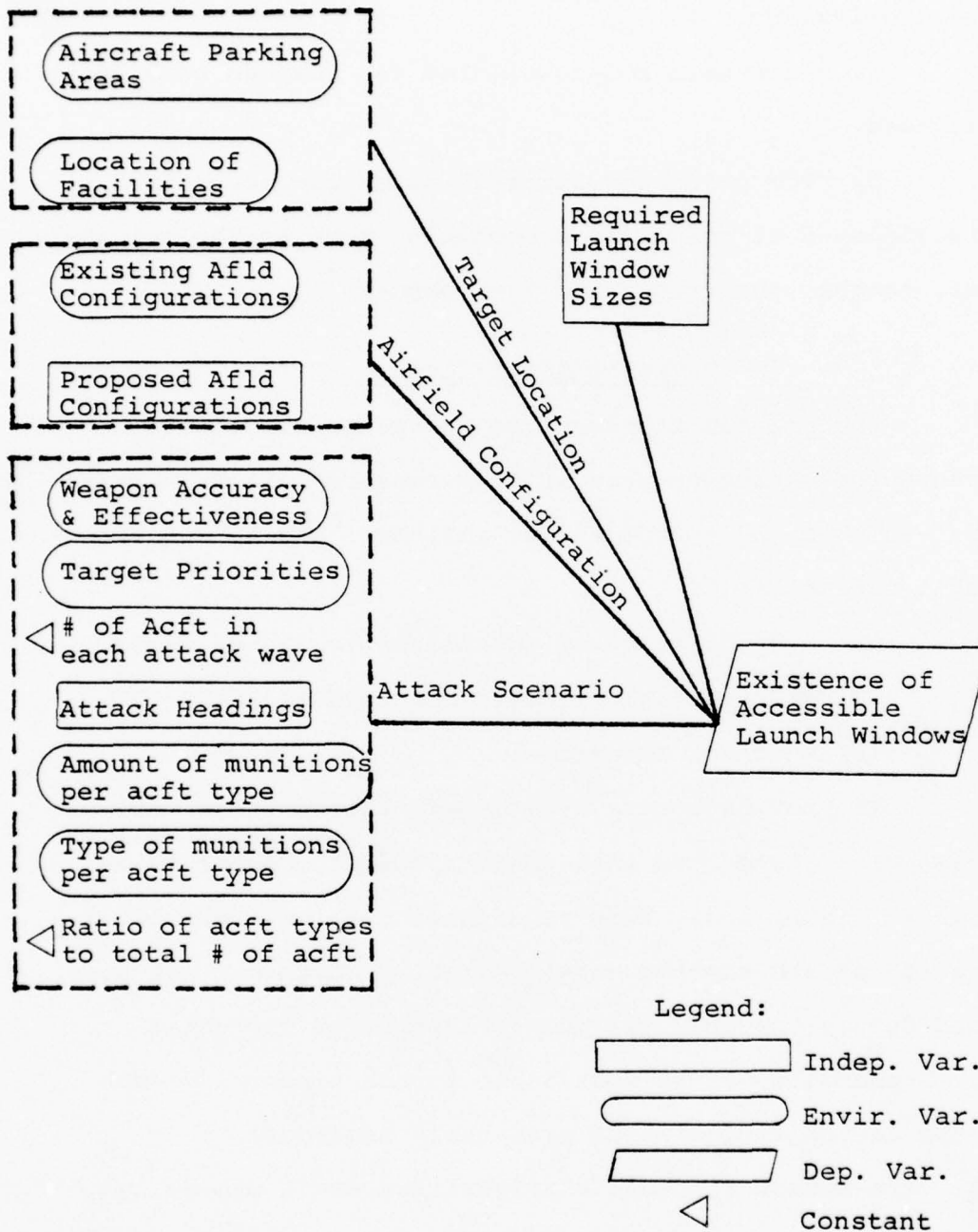


Fig. 3-3. Variable Interrelationships

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

$$\text{accessibility} = f(\text{existence})$$

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
<u>BASIC</u>						
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

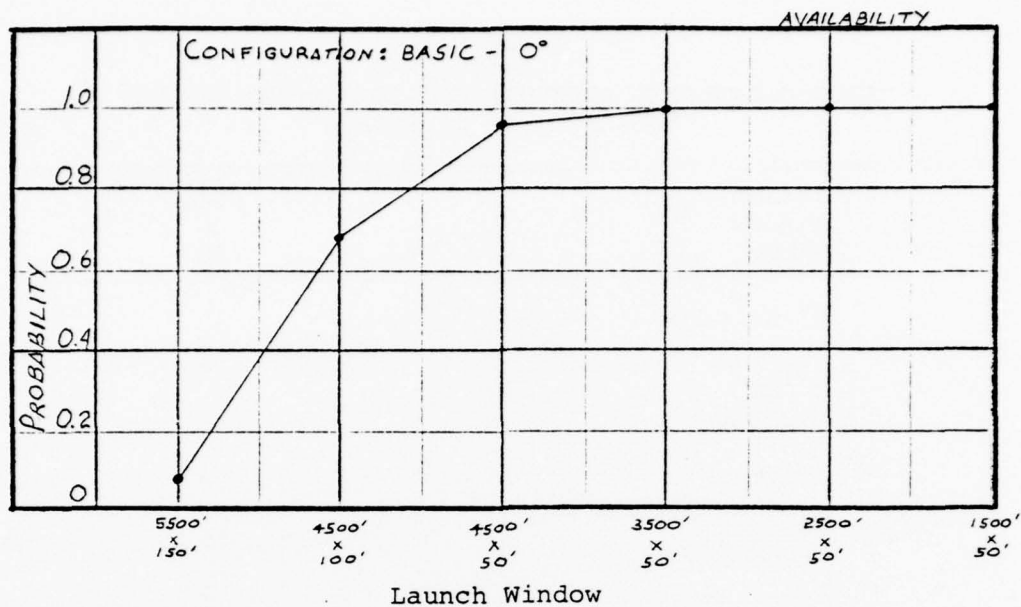
ALT. 2

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	3500
Window	X
Size	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



Legend:

A - access pt. A
B - access pt. B

C - access pt. C
D - access pt. D

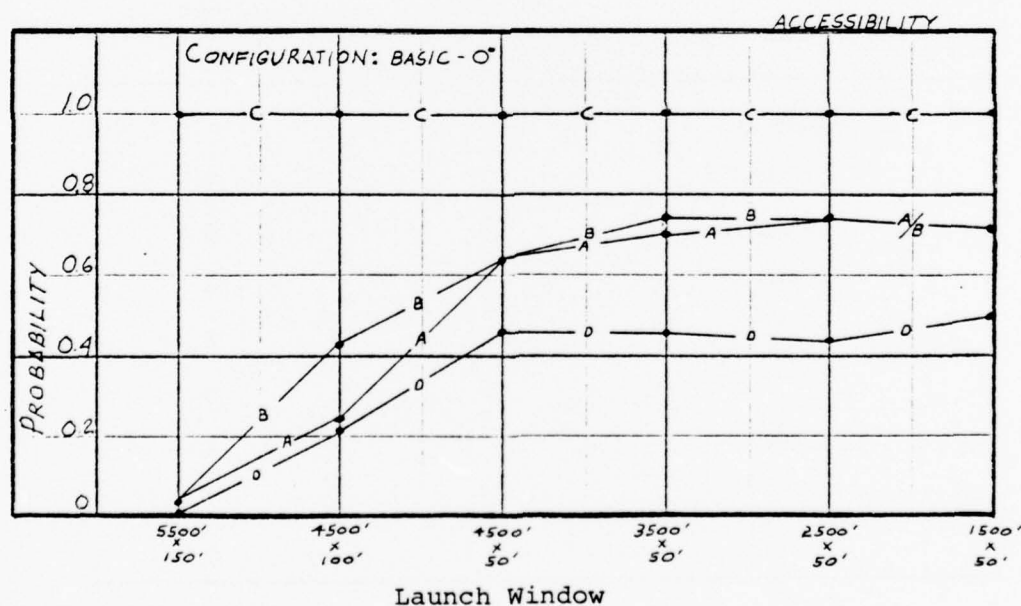


Fig. 4-1. Probability Distributions

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:

$$s_p^2 = \frac{1}{n_1 - n_2 - 2} (\sum (x_1 - \bar{x}_1)^2 + \sum (x_2 - \bar{x}_2)^2).$$

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	<u>.04±.368</u>	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	<u>.12±.524</u>	NA
	4500 X 100	.36±.248	<u>.24±.251</u>	.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:

A to Basic Runway: $\frac{\text{ALT. 1}}{E=1.0 \text{ P}=.7}$ $\frac{\text{ALT. 2}}{E=1.0 \text{ P}=.72}$

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

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 ($.0279 \pm .0198$).

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.

<u>Columns</u>	<u>Data Entry</u>
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.

<u>Columns</u>	<u>Data Entry</u>
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.)

<u>Columns</u>	<u>Data Entry</u>
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.

<u>Columns</u>	<u>Data Entry</u>
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

ColumnsData 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 alphanumeric) 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

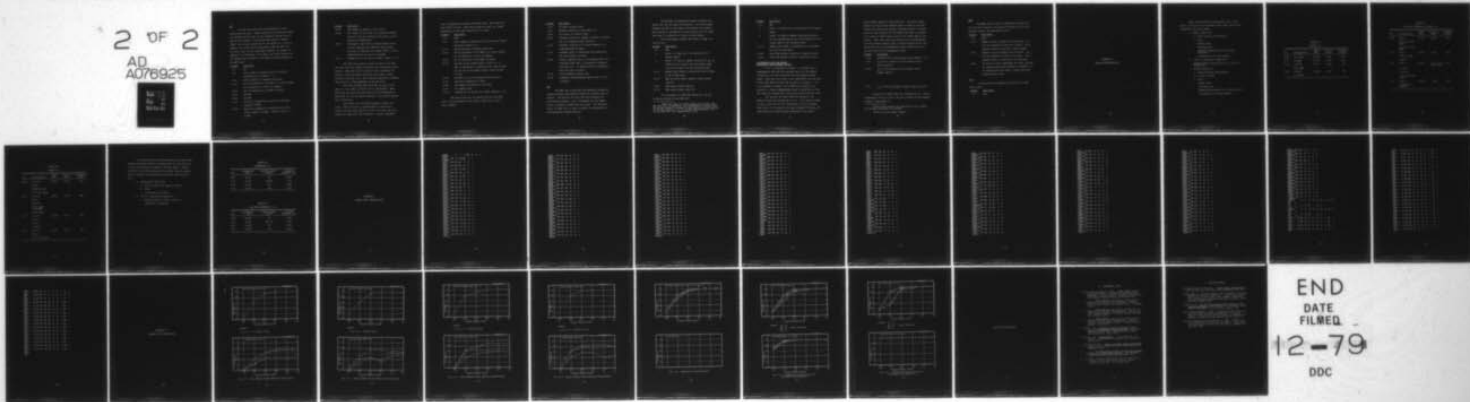
AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/6 15/7
THE DETERMINATION OF THE ACCESSIBILITY OF POST-ATTACK LAUNCH WI--ETC(U)
SEP 79 D F BALLOO , D B HUTCHINSON

UNCLASSIFIED

AFIT-LSSR-80-798

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2 OF 2
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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).

<u>Columns</u>	<u>Data Entry</u>
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.

<u>Columns</u>	<u>Data Entry</u>
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.

<u>Columns</u>	<u>Data Entry</u>
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).

<u>Columns</u>	<u>Data Entry</u>
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:

<u>Columns</u>	<u>Data Entry</u>
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.

¹When 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).

<u>Columns</u>	<u>Data Entry</u>
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 reliability 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.

<u>Columns</u>	<u>Data Entry</u>
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.

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

³Only 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.

<u>Columns</u>	<u>Data Entry</u>
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.

<u>Columns</u>	<u>Data Entry</u>
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	37,011	6,923	740
	Full ammo			
F-16	2-AIM-9	18,562	3,340	700
	Full ammo			

TABLE B-2

1500 FOOT GROUNDROLL (LAUNCH) (2)

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

TABLE B-3

ATTACK (2)

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

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	1800	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	2500	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	1700	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
2370CCA						
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
2530WC 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
2630HTC 34						
2640TGT	5635	2745	230	140	87	6
2650HNCR 35						
2660TGT	5915	2760	230	140	87	6
2670HNCR 36						
2680TGT	5570	2725	20	60	87	9
2690ELECT 37						
2700TGT	6185	2740	115	115	87	6
2710AC 41						
2720TGT	6340	3000	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
2890ENGSH81						
2900TGT	3610	2010	70	40	75	6
2910ORCL 82						
2920TGT	3965	2000	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	500	0	10
3110ORCL 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 110A						
3260TGT	8830	2615	210	25	65	9
3270SHP 110B						
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
3370HTG 145						
3380TGT	7595	2125	145	100	87	7
3390WPN 157						

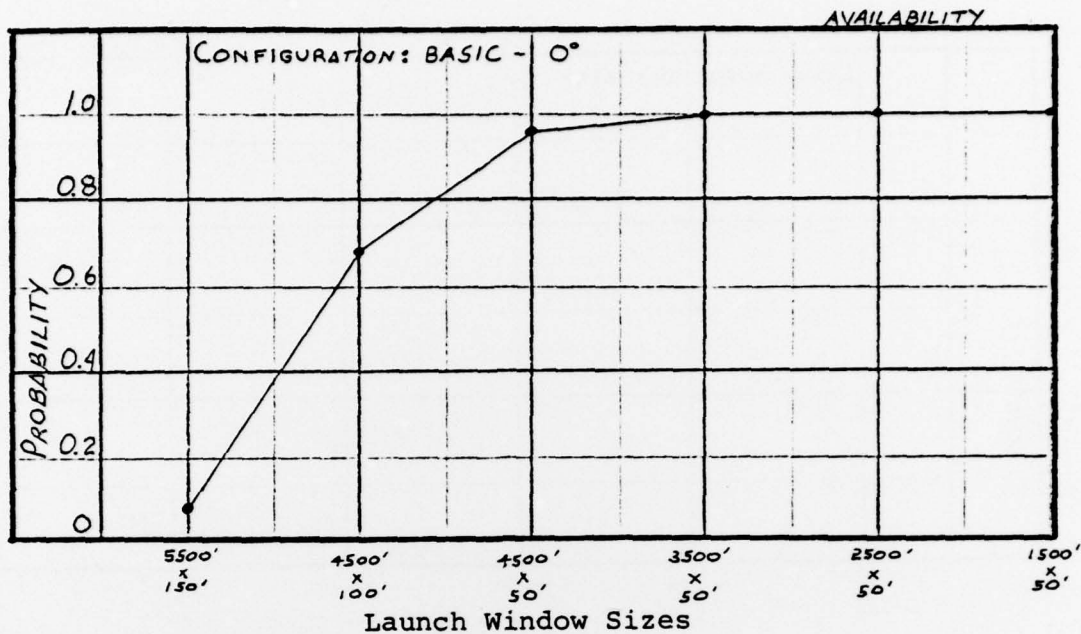
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3440TGT	7925	3025	60	195	0	10
3450ORCL 166						
3460TGT	9375	2600	50	80	0	9
3470HQ GP167						
3480TGT	8350	3375	100	35	0	9
3490REPL 168						
3500TGT	9550	3360	30	20	0	5
3510COMM 173						
3520TGT	8200	3400	60	90	0	10
3530WHSE 179						
3540TGT	7460	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	100	100	0	10
3610WHSE 199						
3620TGT	8300	2800	60	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	100	0	10
3690ORCL 257						
3700TGT	12040	2570	50	70	0	9
3710BEPV330						
3720TGT	12370	2655	30	135	0	10
3730BEPV360						
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
3810BEPV382						
3820TGT	12540	1890	72	50	50	10
3830BEPV384						
3840TGT	12670	1695	72	50	77	10
3850BEPV385						

3860TGT	12880	1680	50	72	0	10					
3870BEPV386											
3880TGT	13030	1930	50	72	0	10					
3890BEPV388											
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					
4010ICL00719											
4020TGT	3300	-760	40	60	70	8					
4030ICL00720											
4040TGT	3500	-700	40	60	70	8					
4050ICL00721											
4060TGT	3700	-640	40	60	70	8					
4070ICL00722											
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	1000	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											
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4580ATT	1	30	8130	2250	151	117	28	23	6	86	2
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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											
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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											
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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
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4920ATT	1	30	12040	2270	400	200	50	30	6	1050	1
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4940ATT	1	30	12100	1930	400	200	50	30	6	1050	1
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4980ATT	1	30	12700	1930	400	200	50	30	6	1050	1
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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
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5430END											
5440											

APPENDIX D
PROBABILITY DISTRIBUTIONS



Legend:

A, B, C, D - Access Points

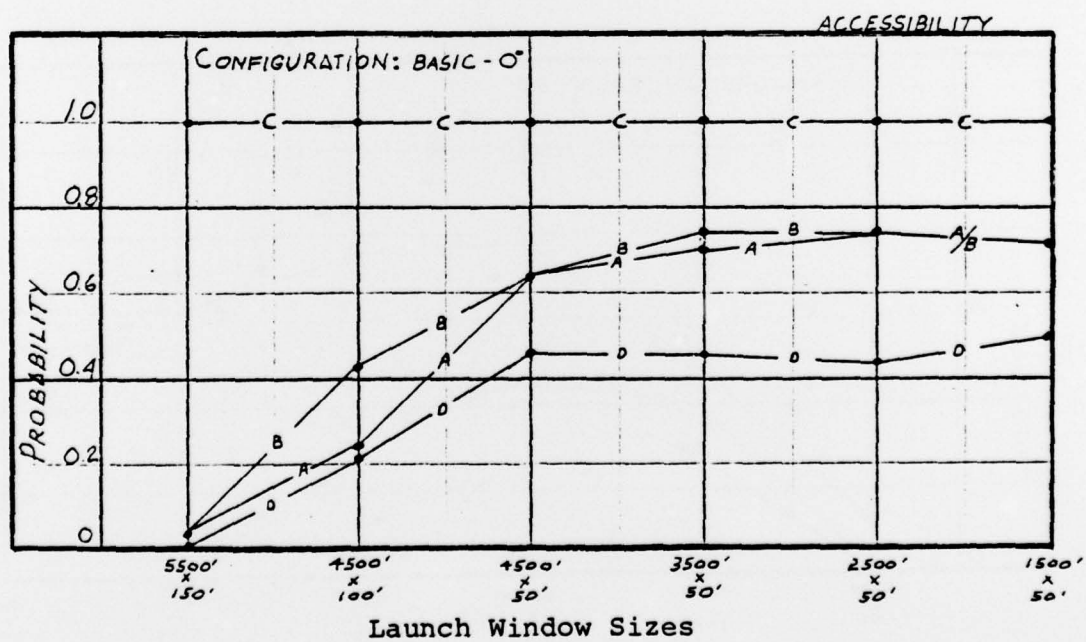
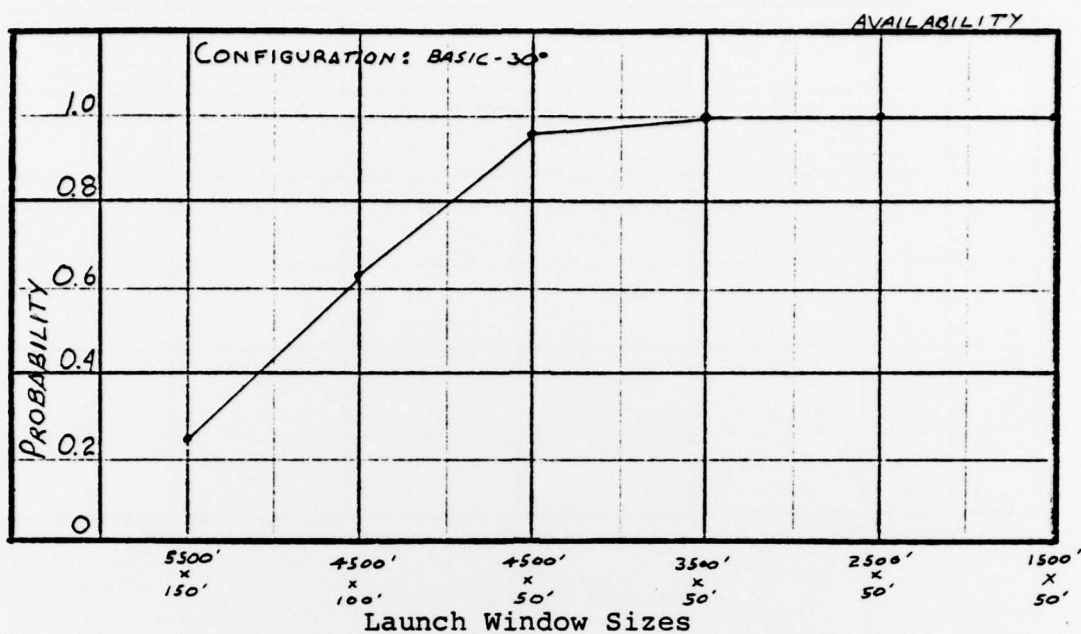


Fig. D-1. Zero Degree Attack Heading Distributions



Legend:

A, B, C, D - Access Points

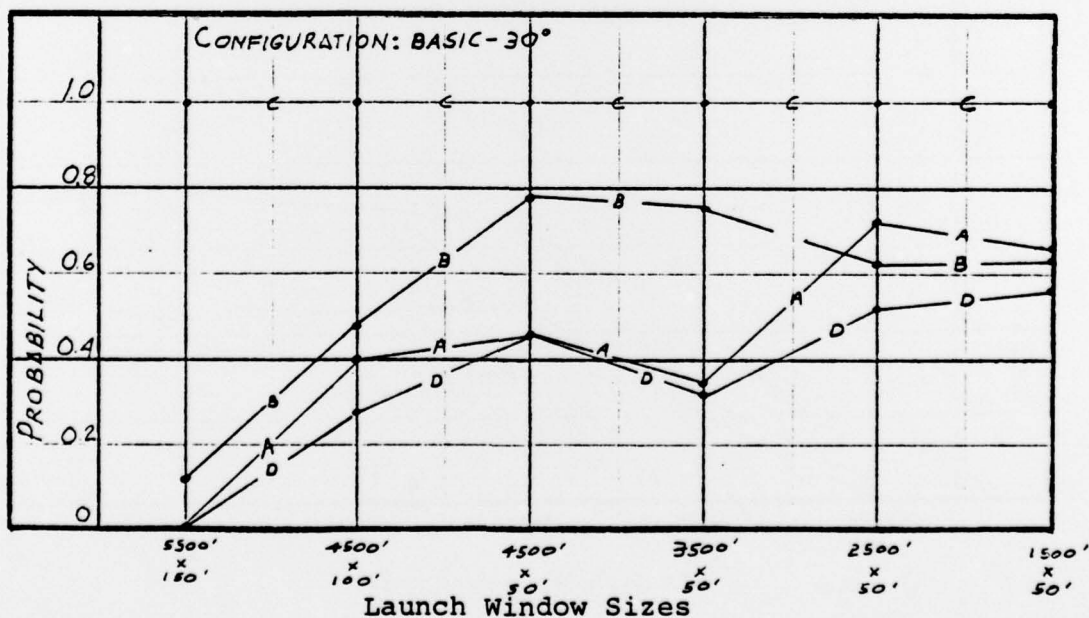
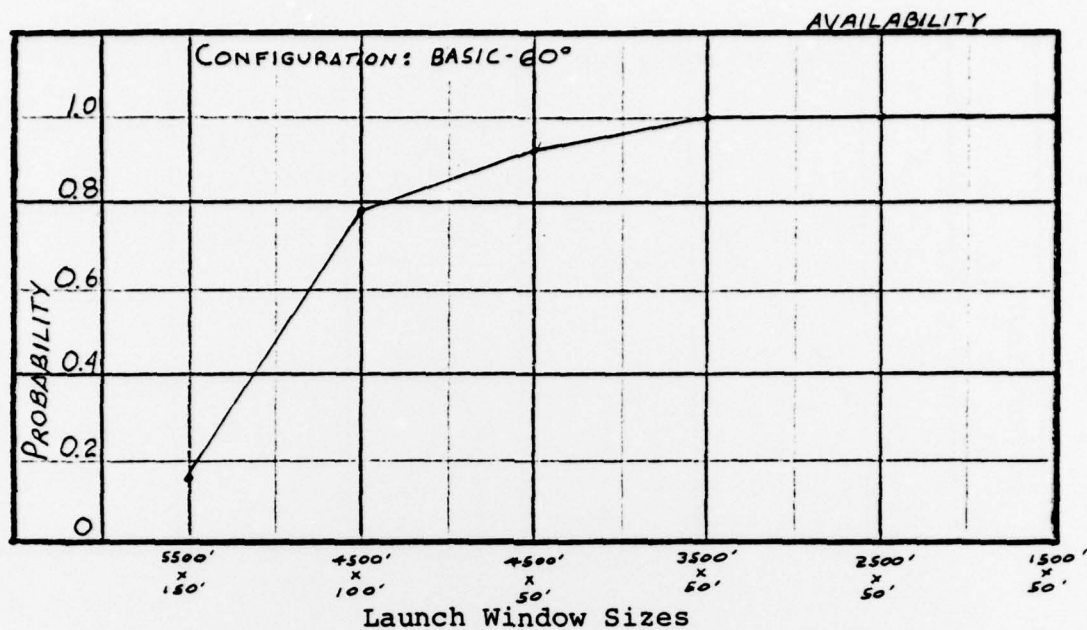


Fig. D-2. Thirty Degree Attack Heading Distributions



Legend:

A, B, C, D - Access Points

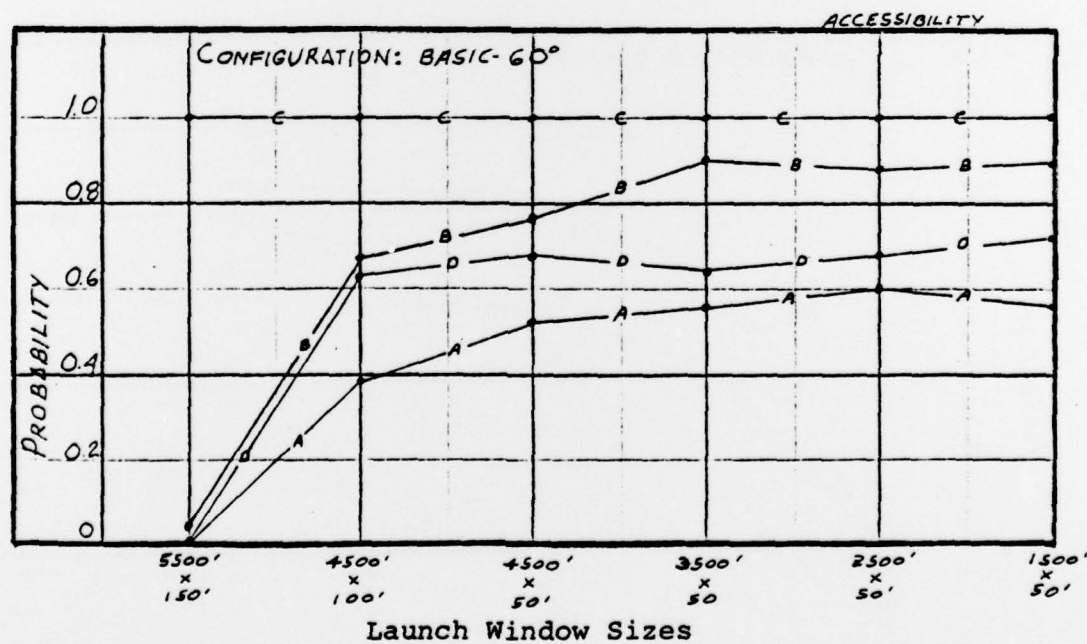
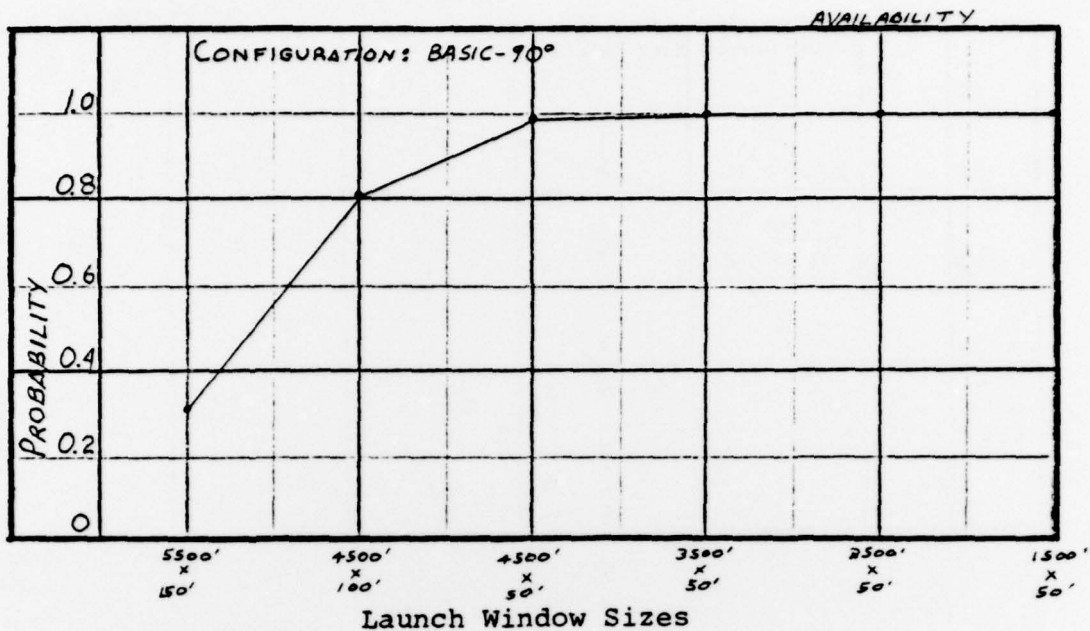


Fig. D-3. Sixty Degree Attack Heading Distributions



Legend:

A, B, C, D - Access Points

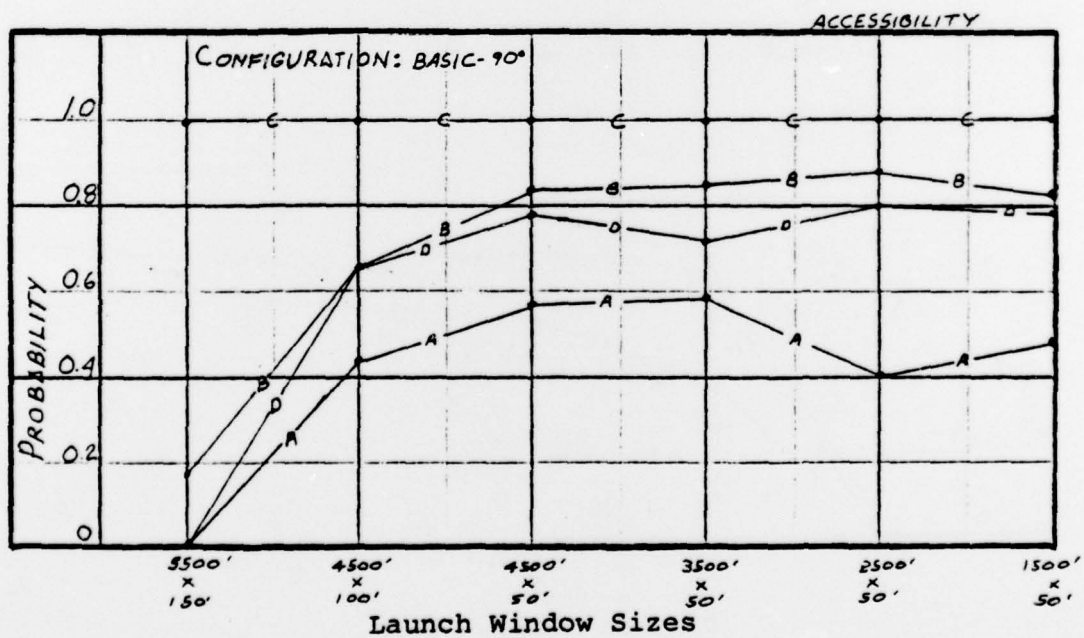


Fig. D-4. Ninety Degree Attack Heading Distributions

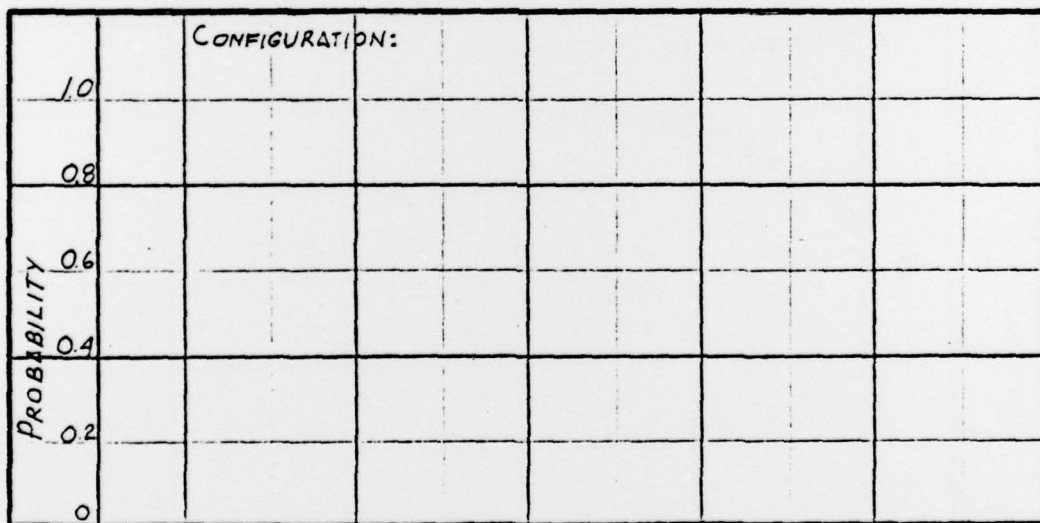
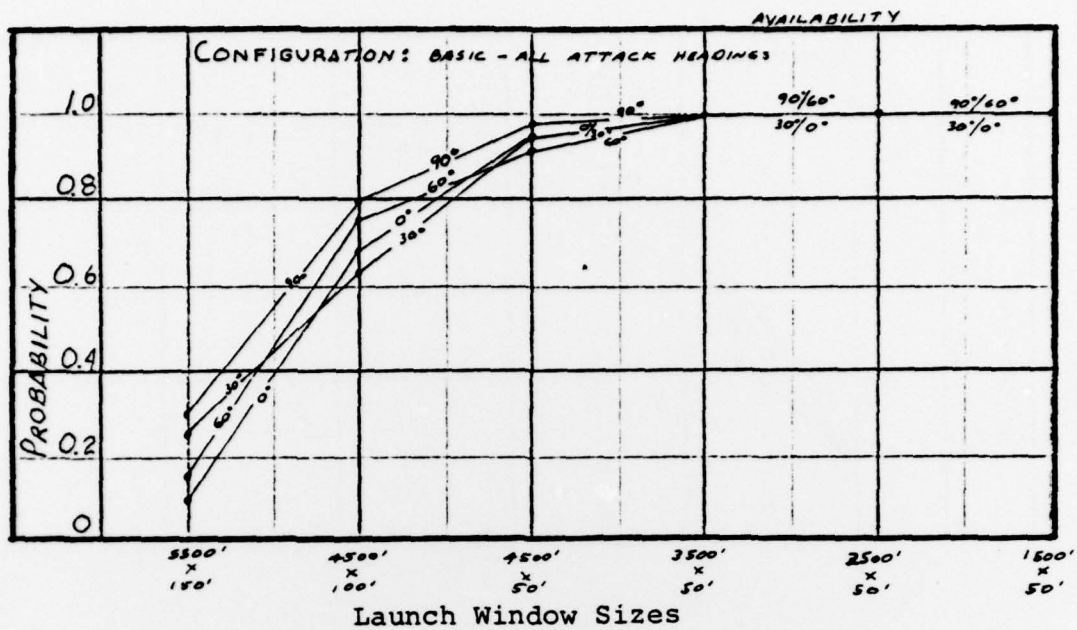


Fig. D-5. Composite of Distributions

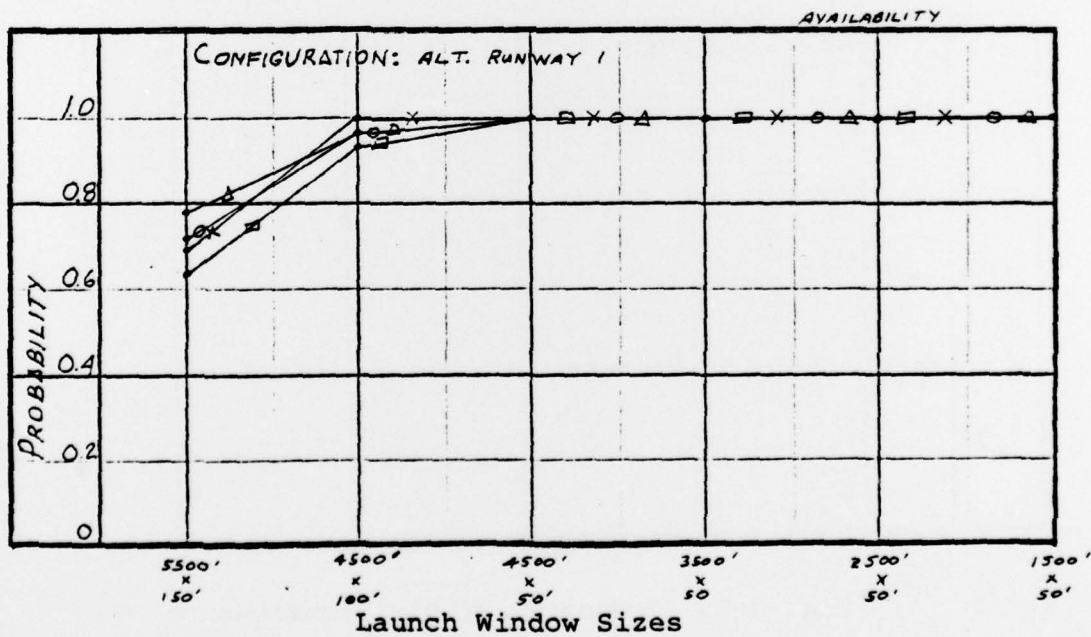
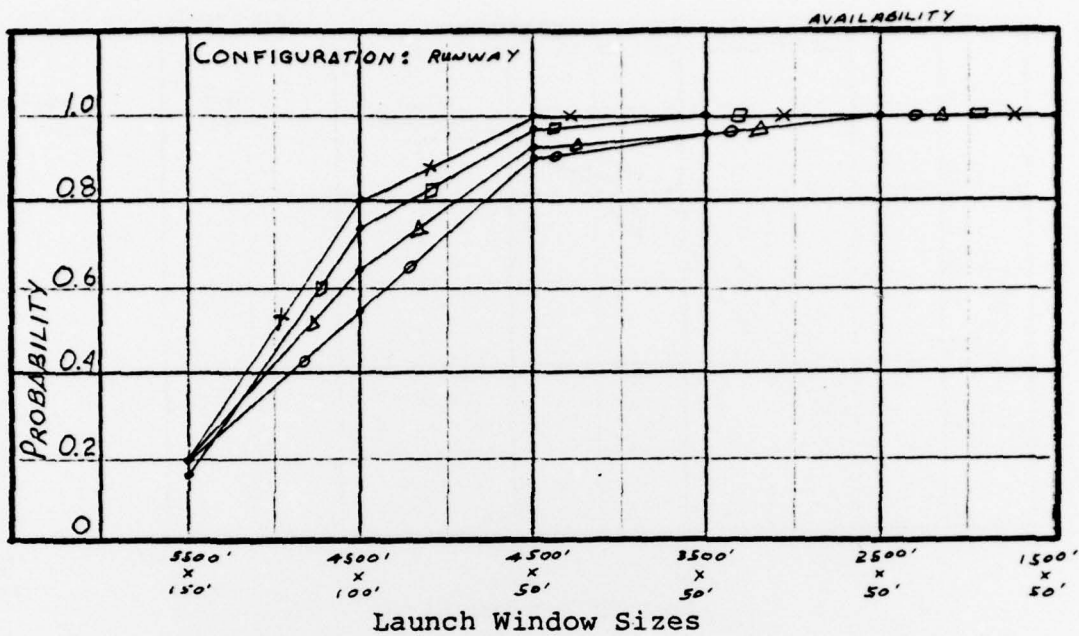


Fig. D-6. Probability Distributions for Alternate Configuration 1

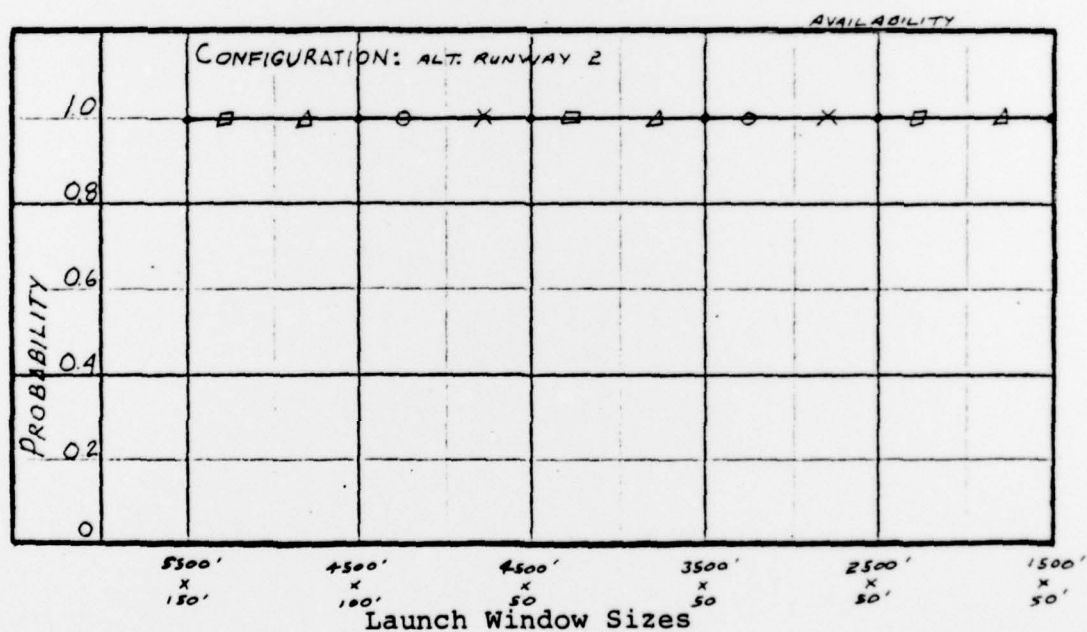
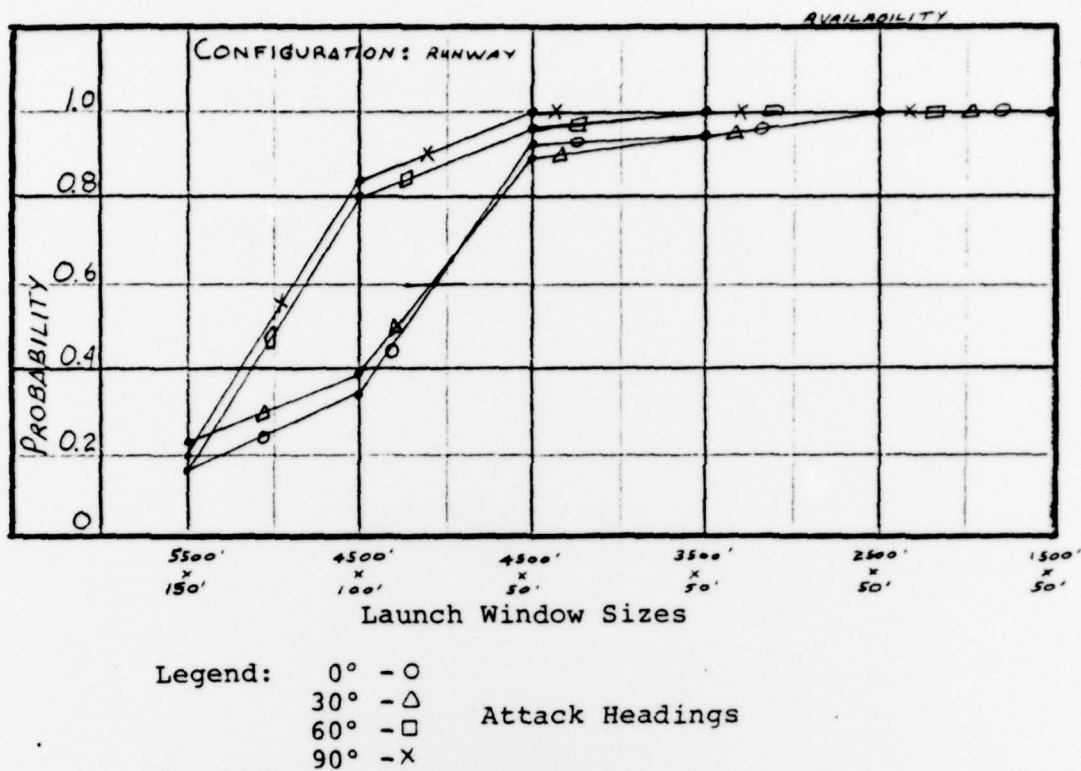


Fig. D-7. Probability Distributions for Alternate Configuration 2

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