# PROJECT RAND

SPECIAL MEMORANDUM

VULNERABILITY OF U. S. STRATEGIC AIR POWER
TO A SURPRISE ENEMY ATTACK IN 1956

15 April 1953

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Assigned to ______________________

The RAND Corporation
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SUMMARY

This report presents estimates of the effect of a surprise Soviet attack on the combat potential of SAC. The effectiveness and cost of several defensive measures are discussed, and certain relatively low-cost measures are recommended.

This paper is a progress report of a continuing study of the vulnerability of the U.S. Strategic Striking Complex. It confines its attention to the effect of a 1956 surprise enemy attack on SAC capability to mount its first strike. Extension of the first strike into a campaign is presently being undertaken.

Three qualitatively different types of attack are considered. The first involves submarine-launched, manned aircraft. In the second, TU-4's penetrate the radar warning net at low altitude. The third type of attack is more conventional in that TU-4's penetrate at high altitude. A-bombs of 40 and 100 KT yield are assumed to be used by the Soviets, one bomb being dispatched to each occupied SAC bomber base and depot.

Measurement of SAC vulnerability to these attacks is based on an extrapolation of RAND's estimate of present SAC operating practices to 1956, and on an assumption that 1956 U.S. programmed objectives will be met.

The model describing the interaction between an attacking enemy force, ADC, and SAC involves the detection of the attack by the radar net, an attempt by area and local defenses to inflict attrition, and transmission of warning to SAC. Upon receipt of warning at SAC bases, it is assumed that evacuation is ordered. The physical damage on any given SAC base is then determined by the chance that a carrier reaches the base, the degree of evacuation, and the physical effects of the bomb. The overall physical damage to SAC is then the aggregate of the damage at the individual bases.

An interpretation of the aggregate physical damage to SAC in terms of its effect on SAC's first strike potential is next undertaken. This is a difficult problem, and what is reported in this paper represents a fairly crude first cut at the problem.

For example, the likely delays imposed on SAC due to base denial, damage assessment and control, strike replanning, etc., need further serious study. The availability of such critical inputs to SAC as bombs, MATS aircraft, and en route bases has not yet been examined; consequently, these items are assumed available for the first strike. AMC support has been considered, but appears to be of little importance for the first strike.

The work reported here is based almost entirely on data already available at RAND. Moreover, in some cases, such as those mentioned above, we have not yet been able, to date, to interpret available pieces of data in operationally meaningful terms. Nevertheless, even under these limitations a number of important conclusions can be drawn regarding the vulnerability of programmed 1956 SAC.

Summary of Conclusions*

1. Using the submarine-launched or low-altitude TU-4 surprise attack, the enemy can destroy a major part of SAC potential at relatively small cost in A-bombs and aircraft. With no more than 50 aircraft and bombs, two-thirds or more of SAC bomber and reconnaissance aircraft could be destroyed.

The high altitude strategy is substantially more costly to the enemy in terms of aircraft (but not in bombs), and produces less destruction than the submarine-launched and low-altitude strategies.

2. The degree to which the enemy succeeds in making an effective attack depends upon his capability to mount an attack and reach the radar network without giving enough advance warning to allow full-scale execution of SAC's

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* See Part IV for a more complete listing of the conclusions of this report.

evacuation plan, and also his capability to minimize penetration times thru the radar network. While this study has concerned itself principally with an investigation of this latter capability and its implications, an examination of the former capability has not been neglected and work designed to furnish a better estimate of this capability is now in progress. It is apparent from the results that a substantial reduction in vulnerability would result from advance indications of enemy activity provided these could be translated into sufficiently unambiguous states of alert, but from the limited data now available at RAND, the probability of such action appears to be small.

So far as warning supplied by the radar network is concerned, against enemy attacks designed to maximize tactical surprise the programmed 1956 radar network does not provide enough warning at most SAC bases for either evacuation to occur or for fighter defenses to be effectively brought to bear.

Indeed, most of the SAC aircraft and bases which survive do so owing to the failure of the enemy carrier to reach the target because of operational difficulties and the range limitation imposed on the sub-launched aircraft. The situation is especially bad in overseas areas, where two-way TU-4 missions of relatively short duration are possible and warning times are quite short.

3. Since SAC survival is due mainly to failure of an enemy carrier to reach the base (rather than to evacuation or to incomplete bomb coverage), the part of SAC surviving is mostly in the form of intact units. In the absence of the implementation of an enemy strategy designed to produce overseas base denial, the surviving SAC units could mount a strike after relatively short delays for reorganization and reassignment. Preliminary investigation shows that more serious delays would occur in case the enemy employed a strategy which produced overseas base denial, such as, for example, those involving a ground-burst A-bomb attack, an H-bomb attack, a paratroop drop, or an amphibious landing. These delays may, in fact, be so serious that SAC

will be forced to adopt a different operating concept. Investigation of the effects of base denial is a subject of the continuing study.

A complete defense program for the preservation of SAC combat potential must await a thorough analysis of the cost and effectiveness of various defense strategies (carefully selected sets of defense measures). This is clearly beyond the scope of the present preliminary report. In this report we present a fairly complete listing of defense measures which have been discussed in the course of the study. The relative effects and costs of several expensive defense measures are discussed, but no preference for any one of them is expressed at this time. Certain measures which are of relatively low cost are, however, recommended either for immediate implementation or for further study. In some areas the study revealed a definite need for improvement but no preferred remedial measure can be recommended at present; in these areas recommended performance goals are listed.

Summary of Recommendations*

A. Recommended for immediate action.

1. Relocation to interior areas of all programmed ZI SAC bases now planned for areas with little warning and not yet under construction.

2. Placement of an adequate storage of POL which is relatively invulnerable to enemy attack at all overseas SAC bases.

3. Storage of flyaway kit spares off base.

4. Dispersal of SAC units on rotation overseas to squadron level.

5. Stronger passive defense.

a. Where SAC base facilities permit, a plan for rapid emergency ground dispersal of aircraft to the perimeter or off base.

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* See Part IV for a detailed description of these recommendations.

b. Personnel shelters or slit trenches at all SAC bases.

c. Plans for the effective assessment of damage and rapid communication of that information to higher headquarters.

d. Storage of damage control and base decontamination equipment off base.

6. Joint exercises with other commands (especially ADC) of SAC evacuation and base defense plans, including takeoff of SAC aircraft to test command relations, warning and control network, and SAC combat capability subsequent to evacuation. These should include practice in damage assessment and communication of damage assessment information to the appropriate SAC headquarters.

7. Determination of stocks of aircraft parts and equipment on the best available estimates that can be made for expected wartime consumption, rather than peacetime consumption. This includes making allowances for battle and ground damage.

8. Filling of gaps in the low-altitude warning net in the southern states.

B. Recommended for Further Study.

1. Exchange of bases in the ZI between SAC and other commands.

2. Reducing the number of SAC units on rotation, or else giving these units the mission and means for very quick retaliation.

3. Measures which confuse the enemy as to probable future SAC deployment overseas.

4. Towing or taxiing aircraft off base.

5. Storage of a ready reserve of aircraft.

6. Peripheral low-altitude radar.

7. Reporting of all aircraft sightings by ships traveling northern Atlantic and Pacific routes.

C. Recommended performance goals.

1. Provision of substantially more warning at ZI SAC bases coupled with a corresponding reduction in SAC evacuation times.

2. Reduction of the time spent by SAC on its forward bases before the first strike to a minimum. Investigation of the desirability of mounting AEW aircraft and standing air patrols overseas during SAC occupancy.

3. A clear cut and relatively unambiguous set of ground rules for translating indications of enemy activity into corresponding states of U.S. alert.

4. Establishment of procedures to permit SAC to make more effective use of alert states bases on the imminence of hostilities.

## PART I - STATEMENT OF THE PROBLEM

### 1. Introduction

This paper presents a progress report of a study of the vulnerability of SAC. Circumstances prevented an extensive field trip to collect basic empirical data for the study, and the work was undertaken in advance of such a trip. The work reported here is therefore based almost entirely on extrapolations of data which have been available at RAND for some time. In many areas where no data were available, assumptions had to be made. A small amount of field data, obtained shortly after completion of this portion of the study, substantiated many of these assumptions.

Although only a small portion of the problem has been examined, and despite the limited data available, certain valid conclusions can nevertheless be drawn concerning the vulnerability of SAC and the effectiveness of selected defense measures. (These are presented in Part IV of this report.)

The results presented are based on the work of H. I. Ansoff, W. W. Baldwin, R. L. Belzer, E. Boehm, J. C. DeHaven, C. B. Dougherty, R. H. Frick, W. H. Fleming, Colonel T. A. Holdiman, H. S. Rowen, Jr., F. M. Sallagar, J. T. Schneider, Mrs. A. L. Skogstad, R. L. Stewart, Jr., and C. V. Sturdevant, III.

### 2. General Problem

The complete scope of the problem of vulnerability of the Strategic Striking Complex of the United States is described in detail elsewhere.* Three major aspects of the vulnerability problem, however, which are relevant to the present formulation of the study, are set forth below.

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*Vulnerability of the Strategic Striking Complex, H. I. Ansoff, RAND Corp., Special Memorandum, 17 November 1952, SECRET.

A. A study of the vulnerability of SAC should include simultaneous consideration of the following elements:

(1) Type and weight of enemy attack.

(2) Effectiveness of existing local and area defenses.

(3) Behaviour of SAC under conditions of impending enemy attack.

(4) Physical damage resulting from attack.

(5) Recuperability of SAC after enemy attack.

(6) Concept of operations under wartime conditions.

The interaction of these factors should be studied within the framework of SAC as a complete base-weapon system. The combined effect of these factors on the time-phased capability of SAC to maintain combat operations under wartime conditions is a proper measure of the vulnerability of SAC.

B. SAC is the recipient of many inputs from AEC, AMC, ADC, Hq. USAF and parts of civilian economy which are vital to the performance of SAC combat mission. Consequently, a study of SAC vulnerability must include consideration of the capability of these organizations to produce the required inputs under conditions of enemy attack.

C. The enemy has, at his disposal, a number of qualitatively and quantitatively different strategies which he can employ in an effort to reduce the SAC combat potential. Consequently, an examination of vulnerability of SAC must be performed under a range of probable strategies rather than in the light of some most probable one.

3. <u>First Phase of the Study</u>

The object of the present phase of the study is to measure, under a number of restrictive assumptions, the reduction of SAC's first strike combat sortie capability which may result from a number of different types of enemy attack and to investigate the effectiveness of a number of measures designed to mitigate this effect.

The second phase of the study will remove several of these restrictive assumptions and will extend the scope of the problem beyond the first strike into a campaign. The first and second phases should conclude the study of vulnerability of SAC.

The third phase will be a study of the defense of SAC combat potential. This will involve a study of the effectiveness of combinations of the defense measures (defense strategies) investigated in the vulnerability problem with the aim of recommending some of these combinations for implementation by the Air Force.

The first phase of the study is being conducted under the following assumptions:

A. The interaction between SAC and Soviet forces is examined in the context of a surprise enemy attack in 1956 and the subsequent SAC capability to retaliate.

SAC Capability

B. The D-day deployment of the force studied in this paper is based on the programmed SAC base utilization. The force consists of seven heavy bomber wings (B-36), thirty medium bomber wings (B-47), four heavy reconnaissance wings, six medium reconnaissance wings, ten fighter wings, and six hundred supporting tankers. The following deployment is in effect on D-day*:

| ZI | | | | | Overseas | | |
|---|---|---|---|---|---|---|---|
| Depots | MB wings/bases | MR wings/bases | HR wings/bases | HB | MB | MR | Depots |
| 4 | 22/15 | 5/3 | 4/4 | 7/7 | 8/8 | 1/1 | 6 |

*The numbers in the table are: No. of wings/ No. of bases. Fighter wings are not included in the indicated SAC deployment, nor have they thus far been taken into account in the SAC damage patterns and combat sortie potential as described in later sections of this paper.

The overseas base structure available for bomber, tanker, and reconnaissance aircraft operations is as follows:

| Area | Number of Bases<br>Operating & Staging | Staging |
|---|---|---|
| Alaska | 2 | 0 |
| North East | 6 | 1 |
| French Morocco & Portugal | 6 | 0 |
| Mediterranean | 0 | 11 |
| U.K. and Western Europe | 14 | 6 |
| Middle East | 0 | 14 |
| Pacific | 4 | 2 |
| | 32 | 34 |

C. With the exception of the inputs to SAC provided by AMC and ADC, all other inputs (by MATS, AEC, etc.) are assumed to be available to SAC in required quantities. The effectiveness of AMC and ADC in providing the required support to SAC is examined.

Enemy Capability

D. It is assumed that SAC has the highest priority on the enemy strategic target list. Consequently, it is assumed that the enemy is willing to allocate to SAC from his stockpile of A-bombs and aircraft a force which, in his opinion, is sufficient to deliver a serious blow to SAC's combat capability. It is assumed that on the initial blow the enemy will send one A-bomb to each of SAC bases occupied by bomber aircraft (both ZI and OS) and one bomb to each SAC depot. With a small additional expenditure of bombs the enemy could also attack reconnaissance bases.

The following strategies are considered for enemy's delivery of this blow:

I. An attack launched from long-range submarines positioned around the periphery of the ZI and near the overseas bases, employing F-86 type manned aircraft and using low-altitude penetration whenever possible.

II. An attack employing refueled low-altitude TU-4's.

III. A high-altitude mass attack which may be directed either specifically against SAC or against a larger ZI target complex which includes SAC.

(In addition to these, a strategy will be considered which employs a feint surprise attack against a few ZI targets intended to provoke SAC into redeploying into its overseas positions. This is followed by a heavy raid on SAC on its overseas bases at the time of maximum concentration of SAC aircraft. Strategies involving mixtures of I, II and III will also be considered.)

SUSAC will attempt to carry out all of these initial attacks under the conditions of maximum possible surprise.

E. At the outbreak of hostilities the size of the total enemy A-bomb stockpile is no less than 150 and no greater than 600 with a most probable value of 300, 40 to 100 KT bombs. The enemy has the capability of using some of the fissile material to produce H-bombs.*

F. The enemy bomber stockpile is 1000 TU-4's, 225 medium turbo-jet bombers of the B-47 type, 175 TU-75 aircraft (with a 2-way capability against some ZI targets), and it is assumed that as many as 950 IL-28 type aircraft will be available for strategic use in deep penetration missions overseas. The enemy will also have 100 turbo-jet sub-launched fighters (F-86 type). The enemy is assumed to have a 40 KT bomb small enough to be carried by this type aircraft.

G. In addition to the A-weapons the enemy will probably employ HE against forward operating bases within 2-way range of his bombers.

H. In this phase of the study we explicitly exclude consideration of BW, CW, as well as the covert delivery of these and atomic weapons.

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* It will be seen that, because of the small scale of the initial attacks, the A-bomb and aircraft stockpile assumptions have no effect on the results presented in this paper.

## 4. Structure of the Problem*

This study considers a period of time which starts with the mounting of the first enemy strike and terminates when SAC mounts its first retaliatory strike. This section outlines the structure of the problem for this initial period.

A. The relevant independent variables of the problem are grouped into four classes:

(1) Variables which are controlled** by the enemy, such as the set of targets to be attacked, the type of carrier, the yield of bomb employed, and the number of bombs per target.

(2) Variables which are controlled** by the U.S., such as the number of SAC bases, the physical layout of the bases, the concept of SAC operations, the warning network, the area defense network, and the materiel support for SAC.

(3) Exogenous variables which are either external factors controlled by neither the enemy nor the U. S., or those variables for which the nature of the control is obscure. Examples of such variables are weather conditions, and the amount of advance warning of an impending enemy attack.

(4) State variables, which describe the performance and effectiveness of various elements in the interactions among the above three classes of variables, such as performance characteristics of enemy bombing and navigation systems, performance characteristics of the warning network, and physical damage criteria (critical over-pressures for various levels of damage, etc.).

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*See Appendix A for a more complete description of the mathematical structure of the problem.

**By controlled variables are meant those whose values can be varied with choice of policy, plans, programs, strategy, operational procedure, etc. The "control" is not complete and may be subject to such constraints as budgetary limitations, time lags, and random

B. The following chronological sequence of events will illustrate the interactions between these basic variables:

(1) As enemy aircraft approach the defense network, they are detected by radar, identified as hostile, and attacked by area defenses. The raid is assessed and warning of attack is transmitted to SAC and other agencies. The interactions of the variables involved determine:

(a) The probability that a particular enemy bomb carrier does not abort and survives the area and local defenses to reach the target; and

(b) The net warning time available at SAC bases.

The results of the interactions will differ depending on whether advance warning of enemy attack is received before radar detection.

(2) Upon receipt of warning at SAC bases, evacuation is ordered by the base commander. The various interactions present determine:

(a) The degree of evacuation of the base or dispersal on the base which is achieved before the expected time of bomber arrival.

(b) The extent of destruction of the various physical components on the base if the bomb is dropped.

(3) The results of (1) and (2) are combined to determine:

(a) The aggregate physical damage to the entire SAC force as the sum of damage to all SAC bases bombed.

(4) After the initial enemy attack, recuperation begins and SAC prepares to mount its first strike.

The damage by the enemy attack is assessed, plans are revised, and units are reformed. The SAC commander then deploys his reconstituted force for the first strike in accordance with the concept of operations, modified to take into account various constraints, such as time delays, destruction of essential logistics support, limitations in base availability caused by the damage situation, etc. The interactions of the variables determine:

(a) The strength, type, and deployment of surviving and reconstituted SAC units; and

(b) The sortie potential as a function of time after the initial enemy attack.

## PART II - MEASUREMENT OF VULNERABILITY

In determining the effect of the initial enemy attack on SAC capability we have assigned the 1956 program objectives to the US-controlled variables, and used the best available estimates for the SU-controlled variables. The SAC operations concept is based on extrapolation of the present concept adjusted to take account of the expanded force.

While the results presented below deal exclusively with the effect of the enemy's first attack, it will be seen from the results that the levels of damage to be expected are very high and that without substantial defense measures, SAC may, in fact, have practically no combat capability for sustained operations after the first enemy attack.

### 1. Enemy Strategies

It is assumed that the Soviets will attempt to neutralize SAC at the very beginning of the war and will make every effort to maximize the surprise of the first attack, which takes place at 0630 PST, Sunday morning, in the summer of 1956. In this initial strike, occupied SAC bomber bases and depots are attacked with air-burst A-bombs. There are approximately 50 targets in this category; they are listed in Appendix C.

Three primary types of attack strategies designed to achieve a maximum of surprise are considered. All aircraft are scheduled to penetrate the warning network at approximately the same time. It is assumed that the Soviets have complete knowledge of the D-day geographic deployment of SAC and ADC units, depots, and radar sites.

While, to date, the effects of the three strategies have been examined separately, there is no reason to exclude the possibility of the enemy's using some combination of these 3 basic strategies together with an attack on industry or population targets.

a. Strategy I

In this strategy, manned aircraft, similar to the F-86, are launched from submarines in coastal waters. Each aircraft carries a 40 KT bomb and one aircraft is dispatched to each occupied SAC bomber base or SAC depot, both in the ZI and overseas. The range of such an aircraft is taken as approximately 700 n. mi. when flying at 400 knots at 35,000 ft. altitude*. (However, it appears that only a slight increase in aircraft size would be required to achieve ranges of the order of 1200 n. mi.). These aircraft fly at low altitude to coastal targets and at high altitude to targets near the limit of their range. The altitude of approach to the target is assumed to be about 5000 ft.; if weather permits, the aircraft may climb to high altitude and deliver the bomb by dive-bombing, otherwise, the aircraft may approach at this altitude and employ a toss-bombing technique. Due to its small size (which reduces the radar detection distance) and its high speed (which decreases the warning time available to SAC and the chance of interception,) this weapon has a high probability of surviving to bomb.

The positions of the submarines and the attack routes to ZI bases are shown in Fig. 2a.

b. Strategy II

In this strategy <u>single TU-4's</u>, each carrying a 100-KT bomb, are dispatched to each of the occupied SAC bomber bases and depots. These aircraft are employed on one-way missions and most of them require a single target-bound refueling. Take-off areas are Vladivostok, Tenni, Katakoa, Magadan, Markovo, Murmansk (Vayenga), Berlin, Rumania and Bulgaria. All aircraft penetrate the warning network at <u>minimum altitudes</u>, 2000 ft. or less. For altitudes such as these there are gaps in our radar network, particularly in the

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* Based on a proposal from an aircraft manufacturer to the USN, BuAer. The container for this aircraft is <u>smaller</u> than that for the Regulus missile.

south, as shown in Fig. 2b. These aircraft are assumed to fly at approximately 2000 ft. altitude most of the way to the target, and to approach the target at about 5000 ft. altitude. If weather permits, it is assumed that just prior to reaching the target these planes execute a sharp climb to approximately 20,000 **feet, with consequent** considerable loss in speed, and that the bomb is delivered from high altitude with level-bombing techniques. If weather is poor, radar bombing from high altitude is employed.

In this strategy (and in Strategy III) the "end-run" type of attack is utilized to minimize the warning time. The "end-run" consists of attacking many of our southern-central targets from the south. The attack routes to the ZI and to overseas base areas are shown in Fig. 1.

c. Strategy III

This strategy is similar to Strategy II except that a cell of 10 aircraft are dispatched to each aiming point, and the warning network is penetrated at high altitude (approx. 30,000 ft.). As in Strategy II, one 100-KT bomb is assigned to each target. The routes for this attack are for the most part the same as for Strategy II, however, since the detection distances are different than those at low altitude, there is a slight change of routes to the ZI as shown in Fig. 2c. The routes for overseas attacks are the same as those of Strategy II. (See Fig. 1) These aircraft are assumed to remain at high altitude and to employ either visual or radar bombing techniques depending on the weather over target.

If more than one bomb per cell were carried, the remaining aircraft after reaching their primary target (SAC bases and depots) could attack population or industry targets.

The carrier has been considered to be the TU-4 operating on a one-way mission with refueling. However, with the TU-75, refueled, certain of the targets are within round-trip range. The take-off areas for this strategy are the same as for Strategy II

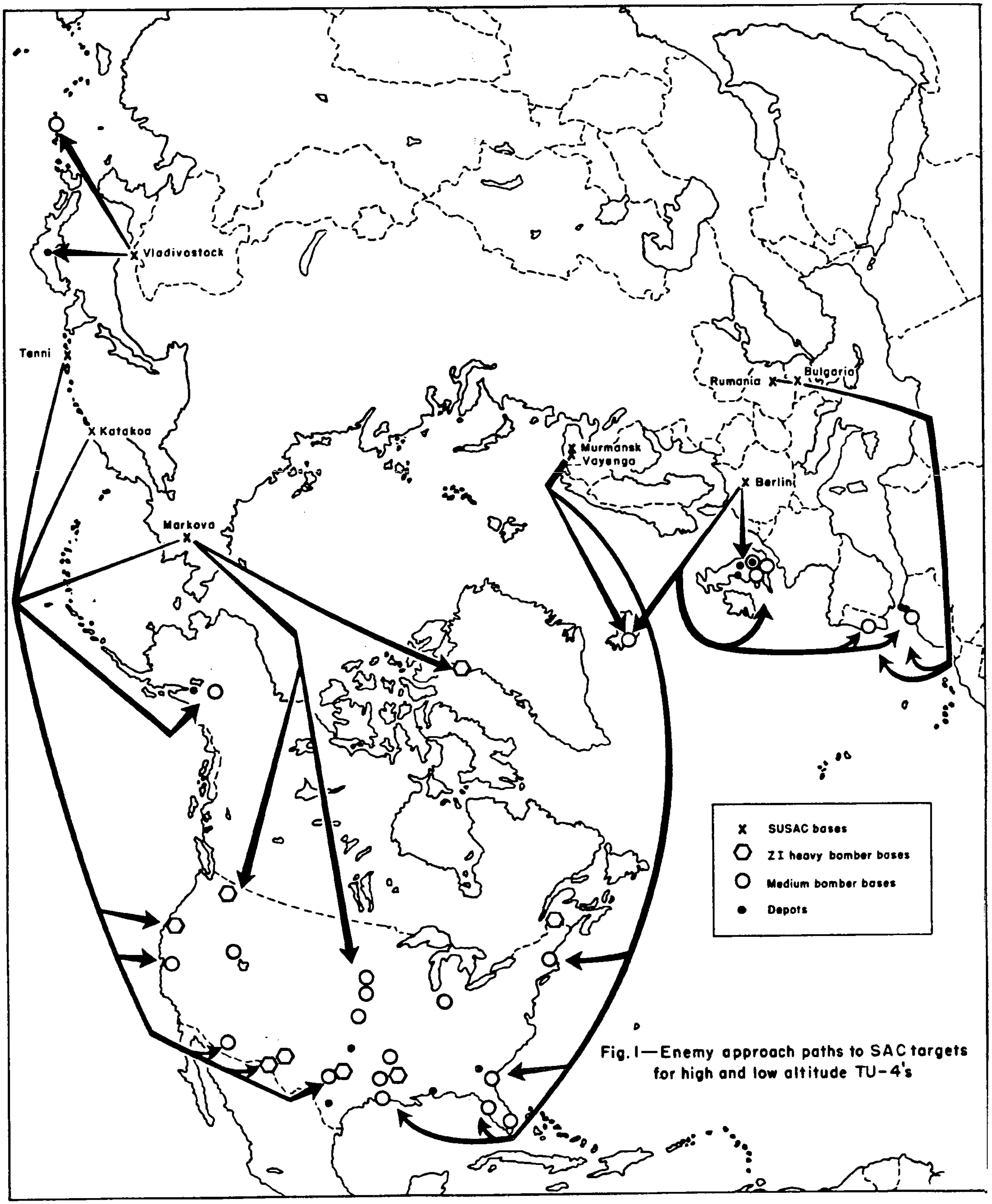


Fig. 1—Enemy approach paths to SAC targets for high and low altitude TU-4's

/Another basic strategy, employing a "one-two" punch technique is currently under consideration in this study. In this strategy, the initial Soviet attack is delivered in two phases: the first of these phases is designed to decoy SAC into a vulnerable position, and the second to deliver the actual blow.

In Phase I, the SAC units and depots overseas, and certain "easy" targets (population or industry) in the ZI which can be bombed by single aircraft without encountering appreciable attrition are attacked with A-or H-bombs.

Phase II begins when, as presently scheduled, the remaining SAC units are deployed to their operating bases in the U.K., French Morocco, Thule, Iceland, Alaska, Okinawa, Japan, Spain, and Newfoundland. These base areas are attacked after they are occupied by SAC, but before the units there are able to mount their first strike.

In this strategy, much of the element of initial surprise is lost. On the other hand, most of the operating bases can be attacked in force utilizing round-trip unrefueled TU-4's. In addition, the enemy can expect to catch a greater portion of SAC on the ground since the detection and warning times at forward operating bases are considerably less than those at the home bases.

The success of this strategy depends upon the intelligence available to the enemy since the enemy must have accurate knowledge of the times of arrival of SAC units at the forward operations bases./

2. Enemy Operational Assumptions

a. In order to maximize surprise to the warning network, Soviet simultaneous ETA's for ZI targets are made good with an accuracy of approximately + 15 minutes and - 0 minutes*. This condition requires the use of select crews, proper training and planning for the mission, a planned loiter at the I.P. or before, and sufficient fuel reserves. The "end-run" targets are the

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* This is a critical assumption in this study. It will be investigated further in the course of the continuing work.

critical areas as regards this assumption. Aircraft scheduled to these areas will have to carry extra fuel (in many instances through the use of stripping the aircraft and/or by the use of overload refueling) to be able to meet these ETA's within the specified tolerance. It appears that the TU-4 has the capability for accomplishing this.

b. Bombing Accuracy

Visual CEP = 1500 ft. - (visual bombing is assumed to occur when the cloud cover is less than .3 at bombing altitude)

Radar CEP = 4000 ft.

c. Bombing Altitude

Strategy I = approximately 5000 ft.

Strategy II = approximately 5000 ft.

Strategy III = approximately 30,000 ft.

Strategy IV = 5,000 to 30,000 ft.

d. Altitude of Burst

All strategies - chosen so as to maximize the ground area sustaining 8 psi overpressure.

e. Probabilities of an Abort

Sub-launched aircraft = .05

TU-4's and TU-75's = .10 for ranges less than or equal to 2200 n.mi.

.15 for ranges between 2200 and 4500 n.mi.

.20 for ranges greater than 4500 n.mi.

f. Gross Errors

Strategies I & II = 0

Strategy III = 0.05

g. **Probabilities of Refueling Aborts**

Rendezvous = 0 (Subs with beacons establish the rendezvous areas)

Hook-Up = 0

h. Bombing and Navigational Equipment

TU-4's and TU-75's = Q-13 or equivalent

Sub-launched aircraft = AN/APN-81 doppler radar and type A-1 computer or equivalent plus radio compass.

In addition there is a high probability that CAA omnirange and commercial broadcast stations, and Marine markers and radio marker beacons will be on the air at the time of the initial attack.

The results of this study are sensitive to assumptions a, e, f, g. The remaining assumptions in this section have no appreciable effect on the conclusions.

3. Warning and Evacuation

Figures 2a, 2b, and 2c indicate the ZI radar coverages provided for in the 1956 USAF program. These figures also indicate warning time contours which enclose regions in which the gross warning time available to SAC bases is one hour and two hours, respectively; these contours were obtained by considering the radar coverage and possible minimum-distance paths of enemy penetration by TU-4's and fighter aircraft. Since the time interval $t^o$, required for identification of the enemy and transmission of warning from ADC to SAC was assumed to be 15 minutes, the contour on these charts also represent net warning time of 45 minutes, and 105 minutes, respectively. (This estimate of the transmission time $t^o$* is based upon very limited data and is very probably optimistic.)

Since these contours are based upon minimum enemy penetration distances, they represent minimum warning times: if the enemy employs non-optimum paths

* A complete list of the symbols used in this report is shown on pp. 91-94.

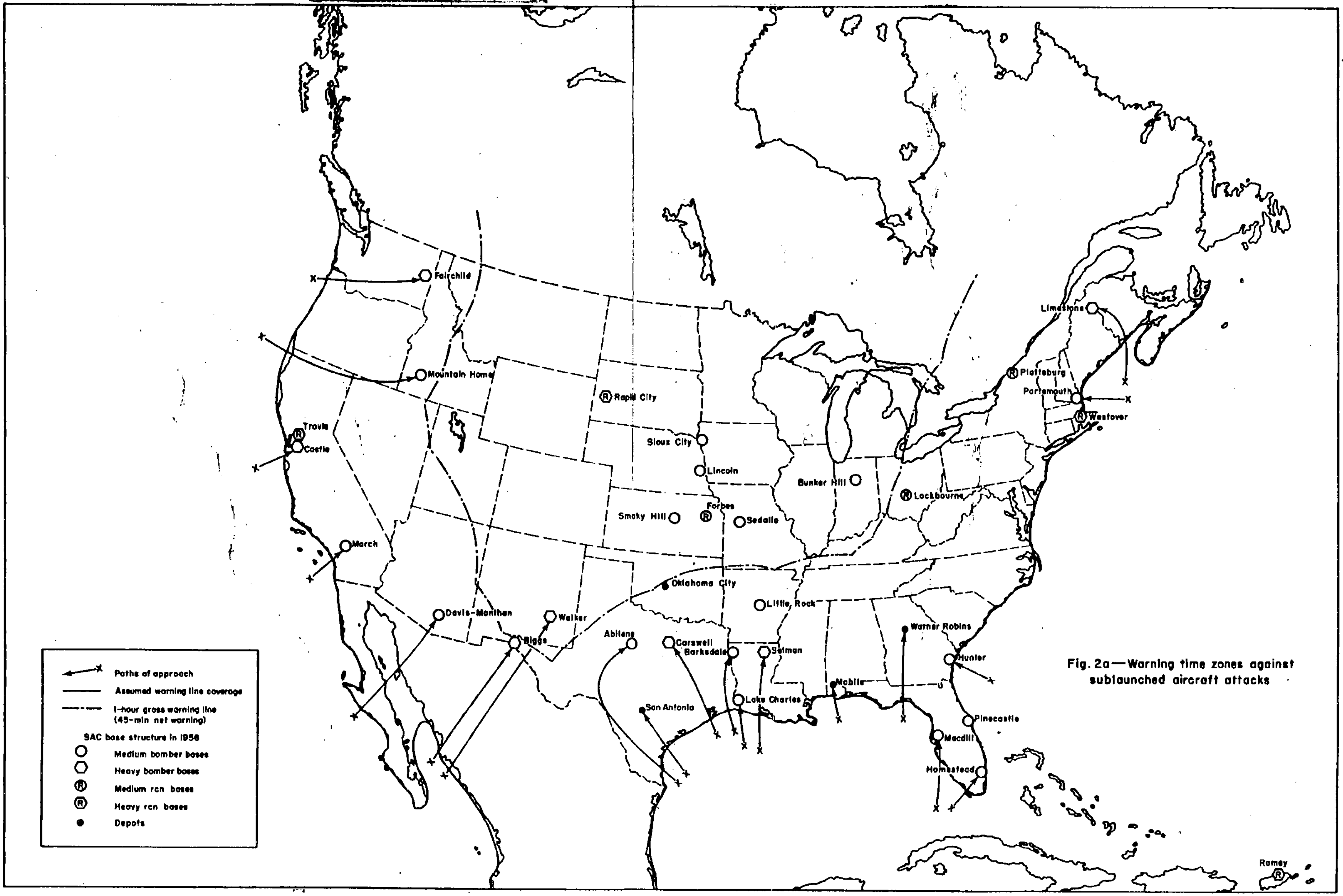


Fig. 2a—Warning time zones against sublaunched aircraft attacks

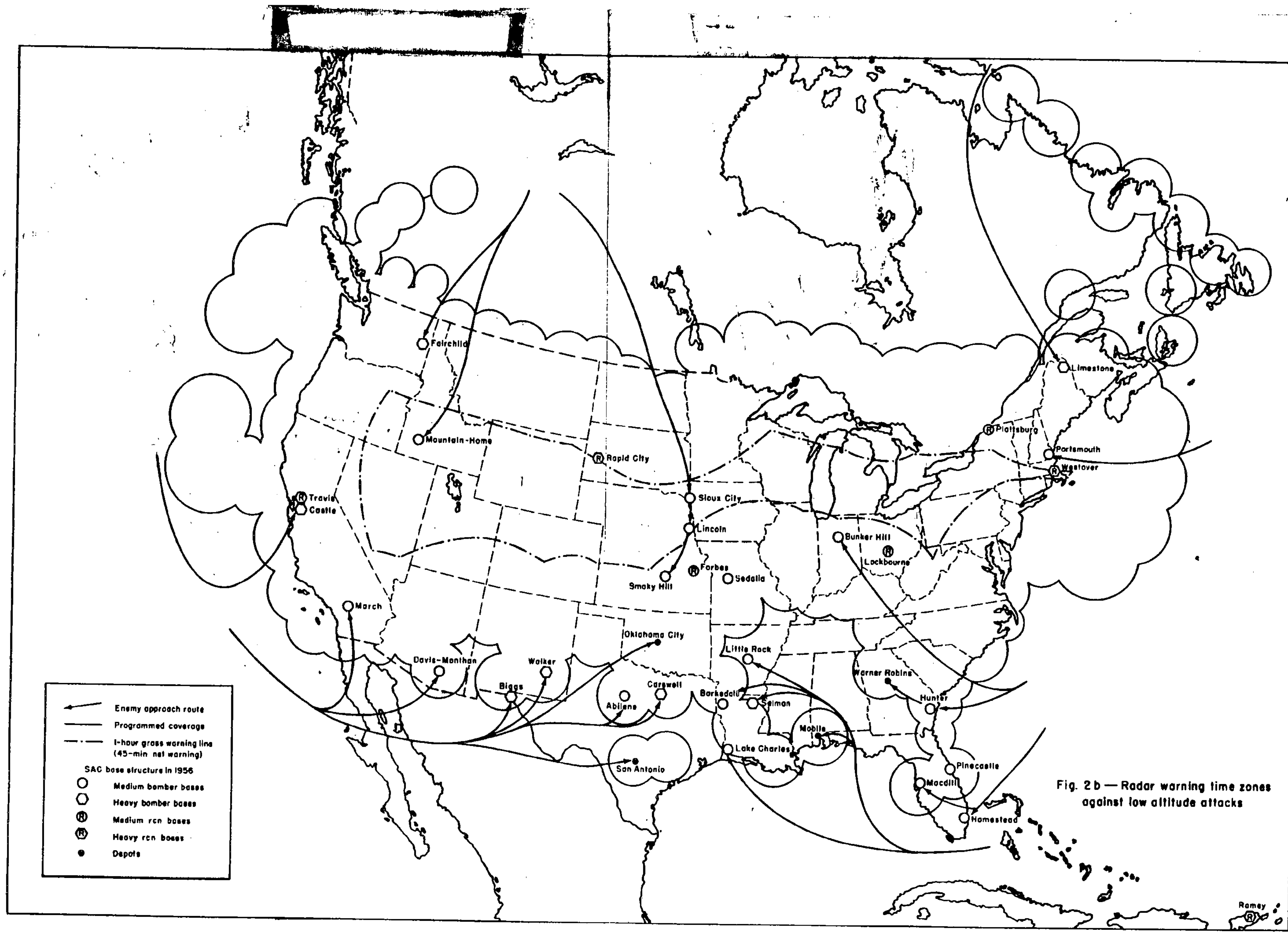


Fig. 2b — Radar warning time zones against low altitude attacks

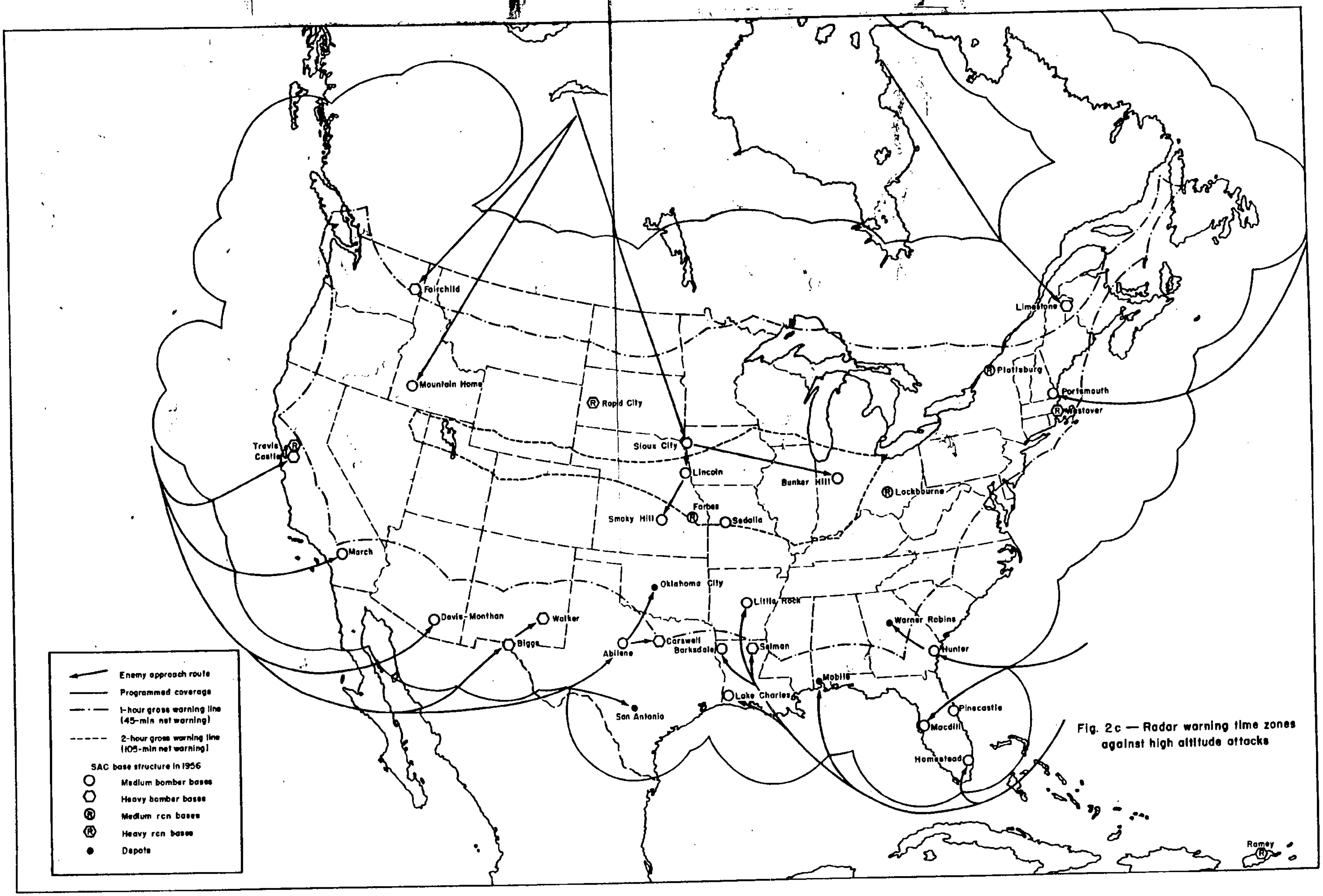


Fig. 2c — Radar warning time zones against high altitude attacks through the warning network the actual warning times developed could be greater than these contours indicate.

The charts show that, for a high-altitude TU-4 attack (Fig. 2c), the 105-minute net-warning (two-hour gross-warning) zone includes a relatively small central section of the country. There is no three-hour gross-warning zone. Against a low-altitude TU-4 attack (Fig. 2b) the coverage is considerably worse: there is no two-hour gross-warning zone. For the sub-launched attack (Fig. 2a) the radar coverage is still worse because submarines surface and launch their aircraft <u>within</u> the radar network, and because of the small size and high speed of the aircraft. For this type of attack it is assumed that the aircraft are detected at the coast, that bases within 15 minutes, (100 miles) of the coast receive no net warning, and that bases 500 miles inland receive an hour's net warning.

The enemy tracks actually assumed in the study are superimposed on the maps of radar coverage. These show the paths of approach to and penetration of the radar warning net, and the subsequent courses to the targets. The approach paths are based on the assumption that the enemy has complete knowledge of the locations and general knowledge of the operating characteristics of the radar warning stations.

The values, actually used in this study for the net warning times at SAC bases are listed in Appendix C. It will be noted that these warning times differ somewhat from values which might be inferred from the warning-zone contour lines. The reasons for this are, first, that the enemy paths shown do <u>not</u> necessarily minimize the penetration distance and, second, the warning times listed are based upon an aggregation of bases by geographic area.*

Figure 3 shows the distribution of the net available warning time at SAC ZI bases for different enemy strategies. It is seen that in the case of a submarine-launched attack, SAC gets virtually no warning. This is due to the combination of the low altitude, small size, and the high-speed capability of the attacking airplane. On the other hand, the limited range of the aircraft (about 700 mi.) places five occupied and one unoccupied bomber bases, one depot and two occupied reconnaissance bases out of range. The high-altitude raid, as expected, provides the best warning pattern.

It is assumed that upon notification from ADC that an enemy attack is under way (with no prior "equivocal warning"**), all SAC units will attempt to evacuate the bases. In Figures 4a and 4b the form of the evacuation pattern of a base has been combined with the effectiveness of the A-bomb to produce an overall picture of aircraft destruction as a function of the net warning time at the base. Most aircraft which are not destroyed suffer major damage.

From time 0 to time $t^1$ is the period of assembly of personnel, warming-up, and check-out which is required before aircraft can begin taking off. This period is estimated as approximately one hour. If attacked during this interval, all aircraft are caught on the ground. Between $t^1$ and $t^2$ is the take-off period. Its length varies depending on the type and number of wings stationed on the base. For a 2-wing medium bomber base, it is seen to be of the

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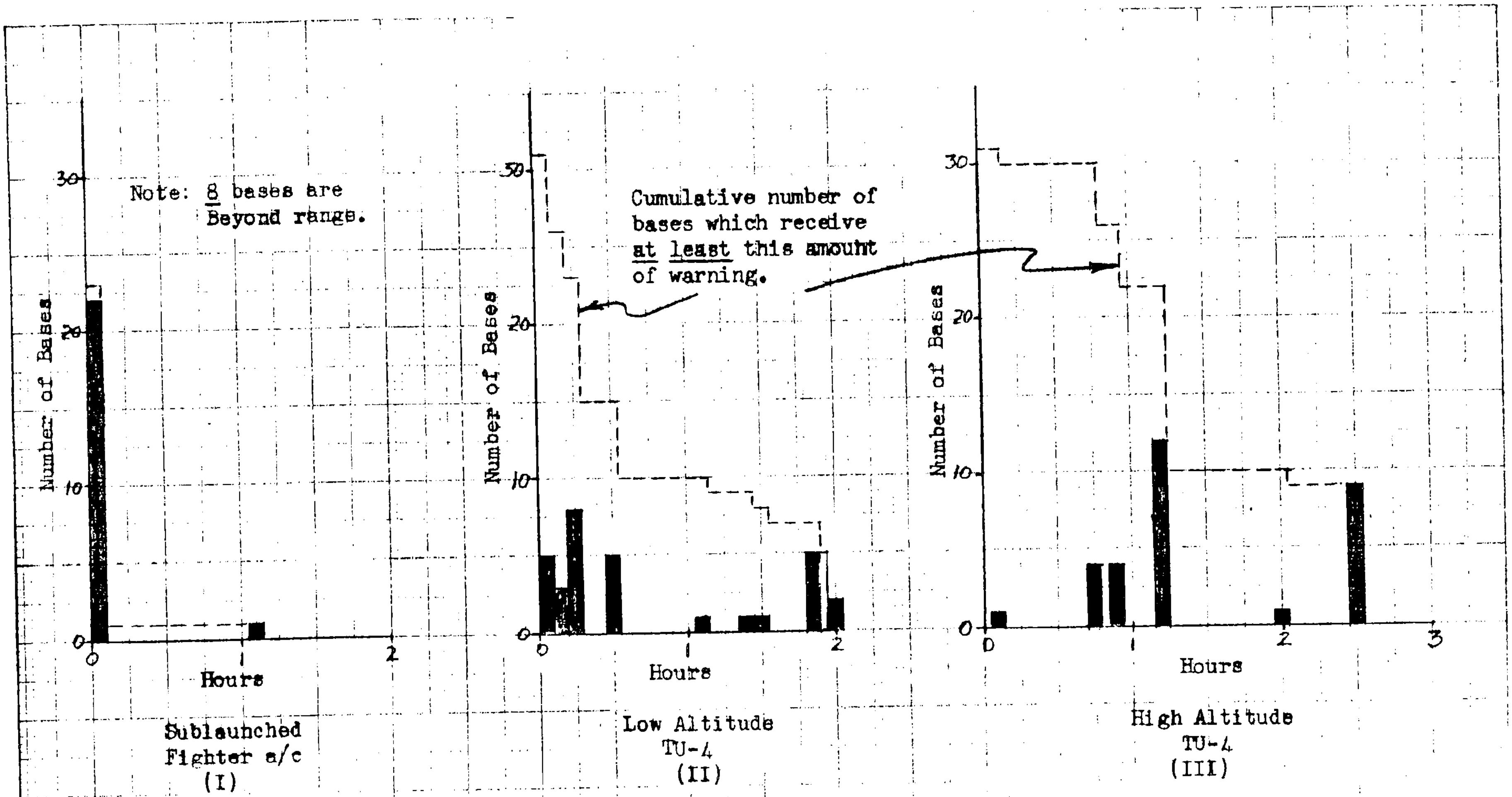
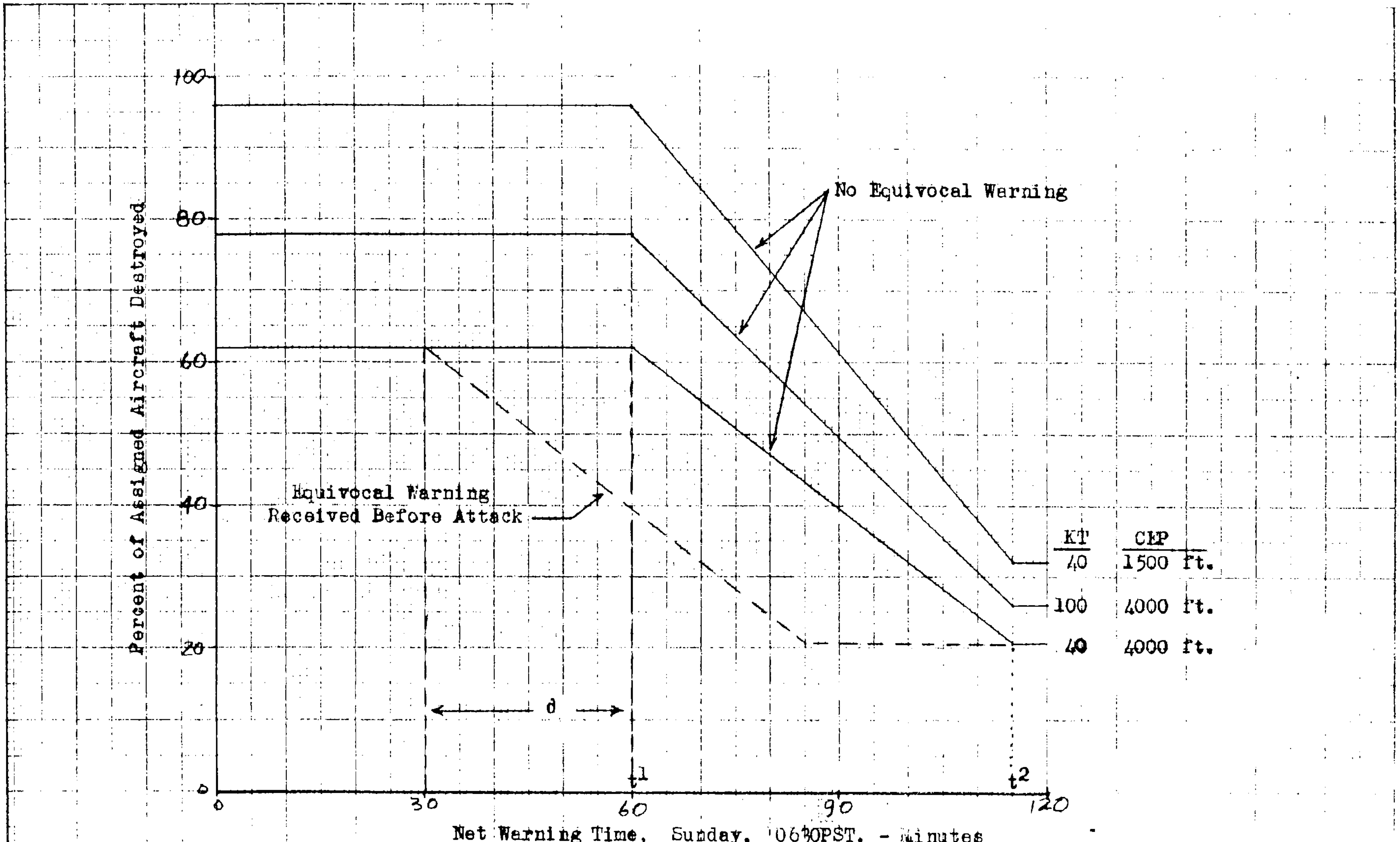
* In Figure 2b, it would appear as though enemy planes pass undetected through the Alabama gap in the radar net, thereby giving little or no warning to the bases thus attacked. Actually, the radar coverage circles shown are for 90% probability of detection; outside these circles there is still a substantial probability of detection. Moreover, because of navigational problems, the enemy will have difficulty in executing an optimum path through this gap. For these reasons it is assumed that the enemy aircraft are detected at the narrow point in the gap.

** In this study the term "equivocal warning" is used to designate an advance warning of the possible imminence of an enemy attack.




DISTRIBUTION OF NET WARNING TIME AT SAC BOMBER AND RECONNAISSANCE BASES IN THE Z.I.
1956 USAF RADAR PROGRAM

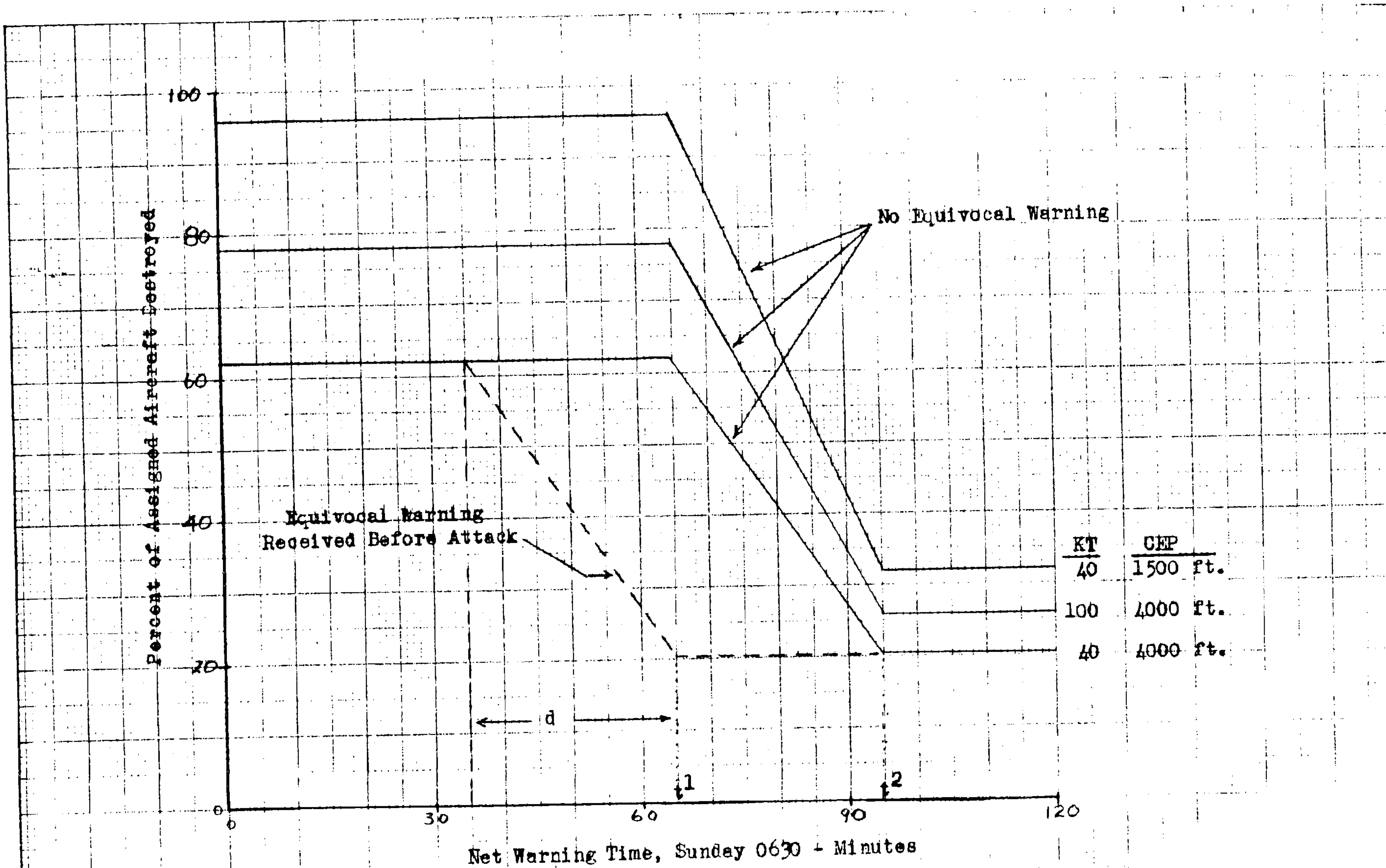
Figure 3




AIRCRAFT DESTRUCTION AS A FUNCTION OF NET WARNING TIME, 1956

ZI MEDIUM BOMBER BASES (2 wings per base)

Figure 4a




AIRCRAFT DESTRUCTION AS A FUNCTION OF NET WARNING TIME, 1956

ZI HEAVY BOMBER BASES (1 wing per base)

order of 55 minutes (this includes take-off of tankers) and for a 1-wing heavy bomber base it is 30 minutes. If the bomb is released during this interval only part of serviceable aircraft is caught. Finally, after $t^2$, only unserviceable aircraft remain at the base. Similar curves can be used to describe the personnel casualties and the percent destruction of materiel which is scheduled for evacuation from the base*.

The effect of equivocal warning is illusted in the shift d of the beginning of the evacuation period to an earlier time. This corresponds to the assumption that white alert is called at the base some time prior to the attack. This puts minimum crews on a standby basis and reduces the assembly period entirely to warm-up and check-out of aircraft. The take-off period cannot be reduced any further since the aircraft are taking off at the maximum rate.

It can be seen from the graphs that the effect of equivocal warning, if utilized for evacuation purposes, is to reduce the total required evacuation period by 25% to 30%. The usefulness of this reduction is determined by comparison of the time required for maximum evacuation $t^2$ with the time actually available $t^w$ at the various bases.

Since Figures 4a and 4b show that in the case of surprise attack with no equivocal warning the assembly period is at least one hour, then at the scheduled time of bomb release** the following percentages of bomber bases in the ZI have all of their aircraft on the ground: 22% for the high altitude

* The results of a SAC-wide alert test in 1952 appear to indicate that the level of evacuation capability assumed in this study is optimistic. In the alert test, at the end of one hour 64% of all SAC aircraft were flyable (some below "In-Commission" standards), and of these only 7% were equipped with complete combat crews and flyaway kits. At the end of 6½ hours 75% of the aircraft were flyable but only 36% were completely equipped.

** Not all enemy carriers meet the schedule; some abort or are shot down on the way.

attack, 73% for the low-altitude TU-4 attack, and 73% for the submarine-launched attack.

If equivocal warning is available to SAC prior to the attack, measures can be taken to reduce the assembly period, (Figs. 4a and 4b). In this case the corresponding percentages become: 0% for the high-altitude attack, 73% for the low-altitude TU-4, and 73% for the sub-launched attack respectively.

If we further take into account partial evacuation, we get the following table:

| Enemy Strategy | Percent (%) of ZI-based bomber aircraft on the ground at instant of bomb release | | | |
|---|---|---|---|---|
| | NO PRIOR EQUIVOCAL WARNING | | WITH EQUIVOCAL WARNING | |
| | Heavy Bombers | Medium Bombers | Heavy Bombers | Medium Bombers |
| I Sub-launched a/c | 100 | 76 | 100 | 73 |
| II Low-Altitude TU-4 | 100 | 82 | 100 | 72 |
| III High-Altitude TU-4 | 90 | 64 | 43* | 42 |

It is seen that with the existing base structure and radar network, equivocal warning has a significant effect on SAC vulnerability only with the high-altitude attacks. The picture is not substantially changed if reconnaissance bases are included. This indicates that the gains for the bombers from a possible redistribution of bomber and reconnaissance aircraft among the programmed SAC bases would be small.

The general conclusion to be drawn from these considerations is that the present <u>ZI radar network and the SAC base location do not seem to be properly matched and, unless a very high attrition level can be inflicted on the enemy, heavy damage is to be expected from enemy attacks</u>. Furthermore, since

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* The discrepancy between these numbers and 0% above is due largely to the fact that for high-altitude raids a large fraction of bases have enough time only for a partial evacuation (see Fig. 3c).

Figs. 4a and 4b present a very optimistic evacuation pattern f(t), the evacuation times assumed in this paper represent an upper limit to what SAC can be expected to do. Consequently, while improvement in SAC evacuation procedures is certainly desirable, any real improvement in the evacuation picture would have to come through increase of the net warning time $t^W$ provided to SAC.

So far the warning situation has been discussed for the ZI base complex. On the overseas bases the picture is considerably worse. It is estimated that all areas except the UK will get virtually no warning against the submarine-launched and low-altitude attacks, and about 30 minutes against the high-altitude attacks. In the U.K., recent defense exercises give estimates of 30 minutes for high-altitude attacks.

It can therefore be concluded that all wings on rotation overseas will be caught on the ground.

4. Damage to Aircraft

The computation of damage to SAC bombers as a result of enemy attack takes into account the combined effects of attrition to attacking aircraft, warning and evacuation, SAC deployment on D-day, geometric configuration of the bases, physical vulnerability of the bombers*, size of bomb, bombing accuracy, and the weight of attack brought to bear.

The mathematical structure of the computational model is developed in Appendix A. In order to take account of varying weather conditions and of the unequal carrier survival probabilities for different target areas, random sampling is employed. The following figures show representative samples in which the total number of bases attacked approximates the expected number within 6%. Small differences in results may be due to sample variance.

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* The value of the overpressure for complete destruction of aircraft has been taken as 8 psi, and for severe damage to air craft as 4 psi.

Figure 5 shows the world-wide damage pattern to SAC bombers as a result of the first surprise enemy attack. It is seen that the percentage of bombers surviving undamaged for each strategy is around 27% for submarine-launched, 35% for low-altitude attack, and around 53% for the high-altitude attack.

The graph shows that among the damaged aircraft a majority are destroyed or suffer heavy damage. In fact, only the submarine-launched attack produces an appreciable number of undamaged and lightly damaged aircraft. This is due to the fact that the 40 KT bombs employed in this case produce incomplete coverage against some of the large overseas bases.

The cost to the enemy of mounting the attacks illustrated in Figure 5 is as follows:

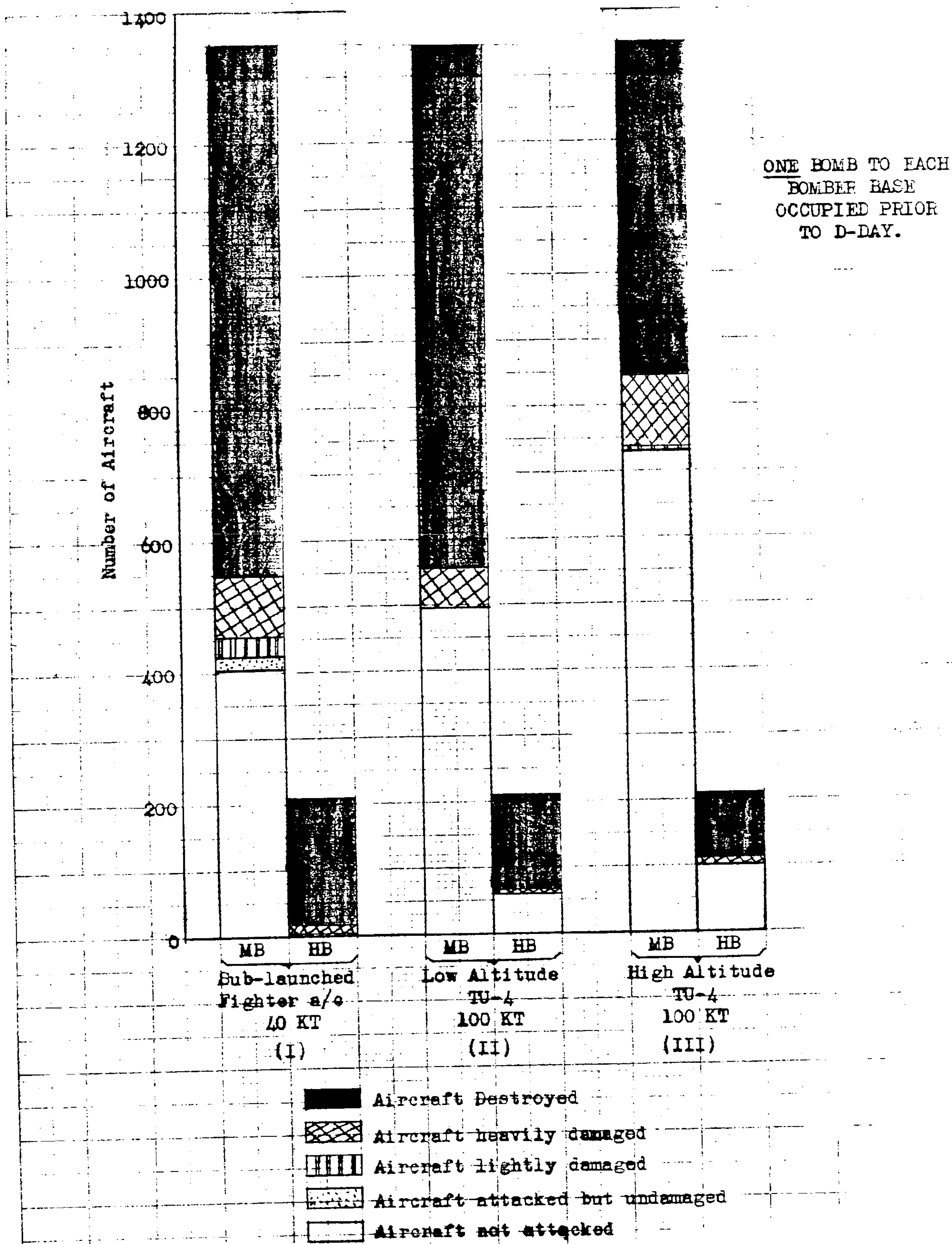
| Enemy Strategy* | Aircraft | | | Bombs | | |
|---|---|---|---|---|---|---|
| | Type | Sent (number) | Lost (number) | KT | Sent (number) | Used (number) |
| I Submarine-launched | F-86 | 35 | 35 | 40 | 35 | 35 |
| II Low-altitude | TU-4 | 41 | 21 | 100 | 41 | 35 |
| III High-altitude | TU-75<br>TU-4 | 410 | 226 | 100 | 41 | 35 |

* This table is computed under the assumption that all attacks against the ZI are one-way. For strategies II and III the attacks against the overseas areas are two-way.

One important conclusion is evident from comparison of Figure 5 with the above table:

From the enemy point of view the high-altitude strategy is both much more costly (in terms of aircraft lost) and much less productive than either the submarine-launched or the low-altitude strategy*. However, the bomb requirements for all three types of attack are comparable.

* In the present problem this does not mean that the high-altitude strategy can be dismissed from further consideration on the grounds of "dominance". For one thing, this strategy may be employed by the enemy as a sub-strategy in mass attacks against the ZI.




AIRCRAFT DAMAGE AT SAC OCCUPIED BOMBER BASES BY A SINGLE STRIKE SURPRISE ATTACK WORLDWIDE

Figure 5

Figure 6 shows separately the damage patterns to the bombers in the ZI and to the wings on rotation overseas. The survival pattern is further illustrated in the following table:

| Enemy Strategy | Surviving Bombers ZI | Surviving Bombers Overseas |
|---|---|---|
| | (Percent of total number in the area) | |
| Submarine Launched * | 34 | 6 |
| Low-altitude | 46 | 0 |
| High-altitude | 62 | 25 |

It is seen that all strategies are even more lucrative for the enemy against overseas bases than against bases in the ZI.

In analyzing Figure 6 it is important to separate the factors which contribute to survival of SAC bombers. The two active factors contributing to reduction of the damage are: (a) the evacuation state $f(t)$ at the time of bomb drop which determines the damage $q$ if a bomb is dropped, and (b) the combination of aborts, gross errors, and attrition which determine whether a carrier penetrates to the target to drop the bomb.

Both the attrition and the degree of evacuation increase with the penetration distance $r$ between the radar screen and the base. The combined effect is that bases which are likely to get hit because of low attrition to penetrating carriers are at the same time not likely to get adequate warning. On the other hand, the bases which are not likely to get hit will probably also get enough warning to evacuate. This is illustrated in the following table:

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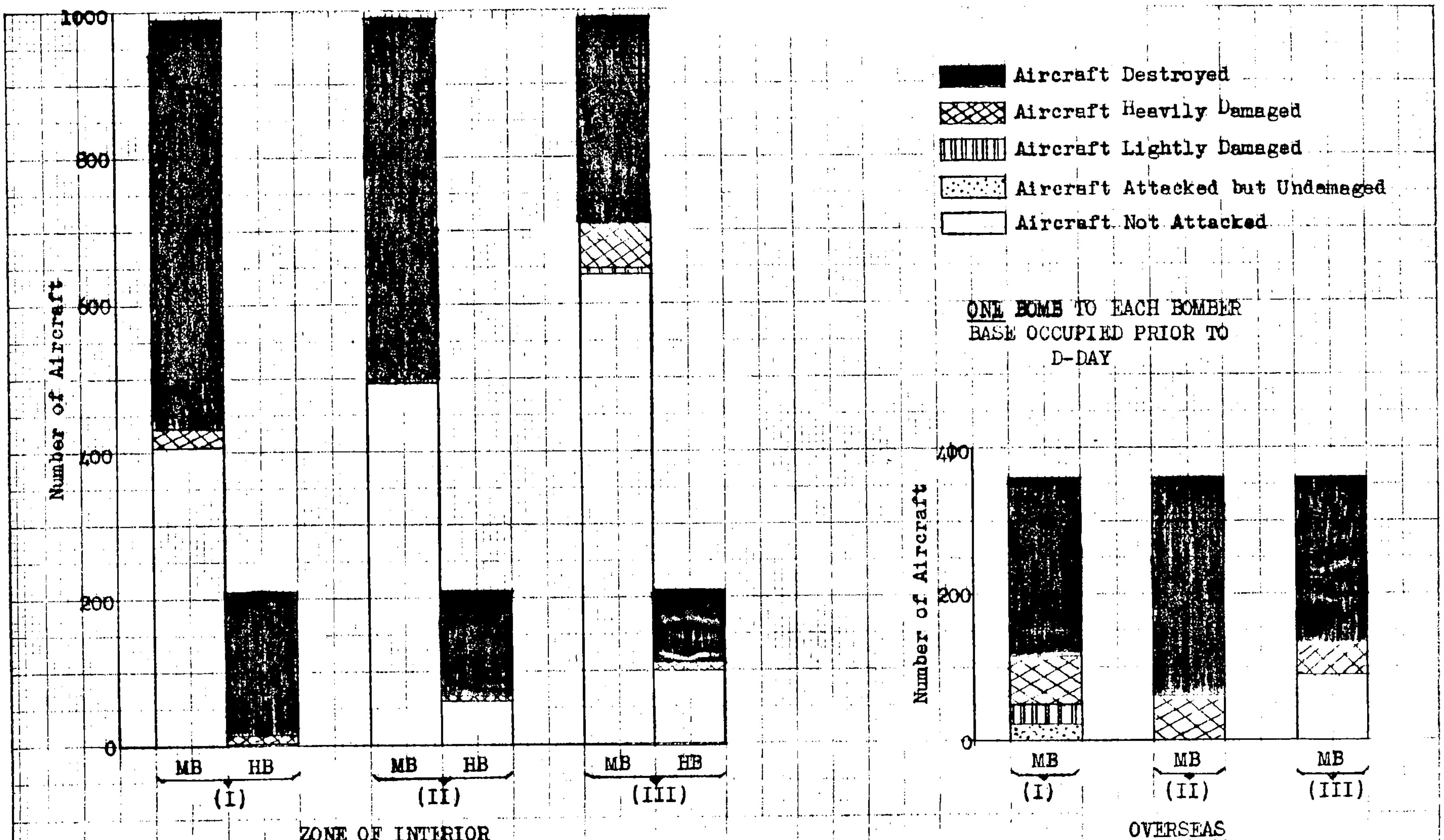
* The survival of as much as 34% of SAC bombers in the ZI is due largely to the fact that five occupied bomber bases were beyond the 700 n. m. range limit assumed for the aircraft. With a 1200 n.m. aircraft, all ZI bases could be reached.




(I) Sub-launched Fighter a/c, 40 KT bombs.
(II) Low Altitude TU-4, 100 KT bombs.
(III) High Altitude TU-4, 100 KT bombs.

AIRCRAFT DAMAGE AT SAC OCCUPIED BOMBER BASES IN THE ZI & OVERSEAS BY A SINGLE STRIKE SURPRISE ATTACK

| Enemy Strategy | Percent of Total Number of Bombers in the ZI: On bases which are not hit | | On bases which are hit | | Total surviving on all bases |
|---|---|---|---|---|---|
| | Evacuated | On the ground and surviving undamaged | Evacuated | On the ground and surviving undamaged | |
| Sub-launched | 18 | 16 | 0 | 0 | 34 |
| Low-altitude | 15 | 31 | 0 | 0 | 46 |
| High-altitude | 26 | 31 | 5 | 0 | 62 |

It is apparent that the aircraft which evacuated in the first column are doubly protected, since the base is not hit anyway.* On the other hand, the third column shows that bases which need evacuation do not get any, except in the case of high-altitude attack.

Thus if no warning were available the respective survival figures would have been 34%, 46%, and 57%, whereas if every bomber got through and warning were present the numbers would have been 18%, 15%, and 31% respectively.

5. Recuperability of Aircraft

The first step in the translation of the aircraft damage into the subsequent combat sortie capability is to determine the recuperability of the damaged aircraft.

Figure 5 shows that for the low-altitude and the high-altitude attacks there is virtually no light damage and the only surviving aircraft which can eventually be put back into commission have sustained heavy damage. In the case of the sub-launched attack, for reasons previously mentioned, there is a small number of lightly damaged aircraft, but again the majority of reparable planes is in the heavily damaged class. For convenience we summarize the pertinent numbers in the following table:

* This is not to say that evacuation should be discounted. For a larger raid or a lower defense kill potential, evacuation would look much better.

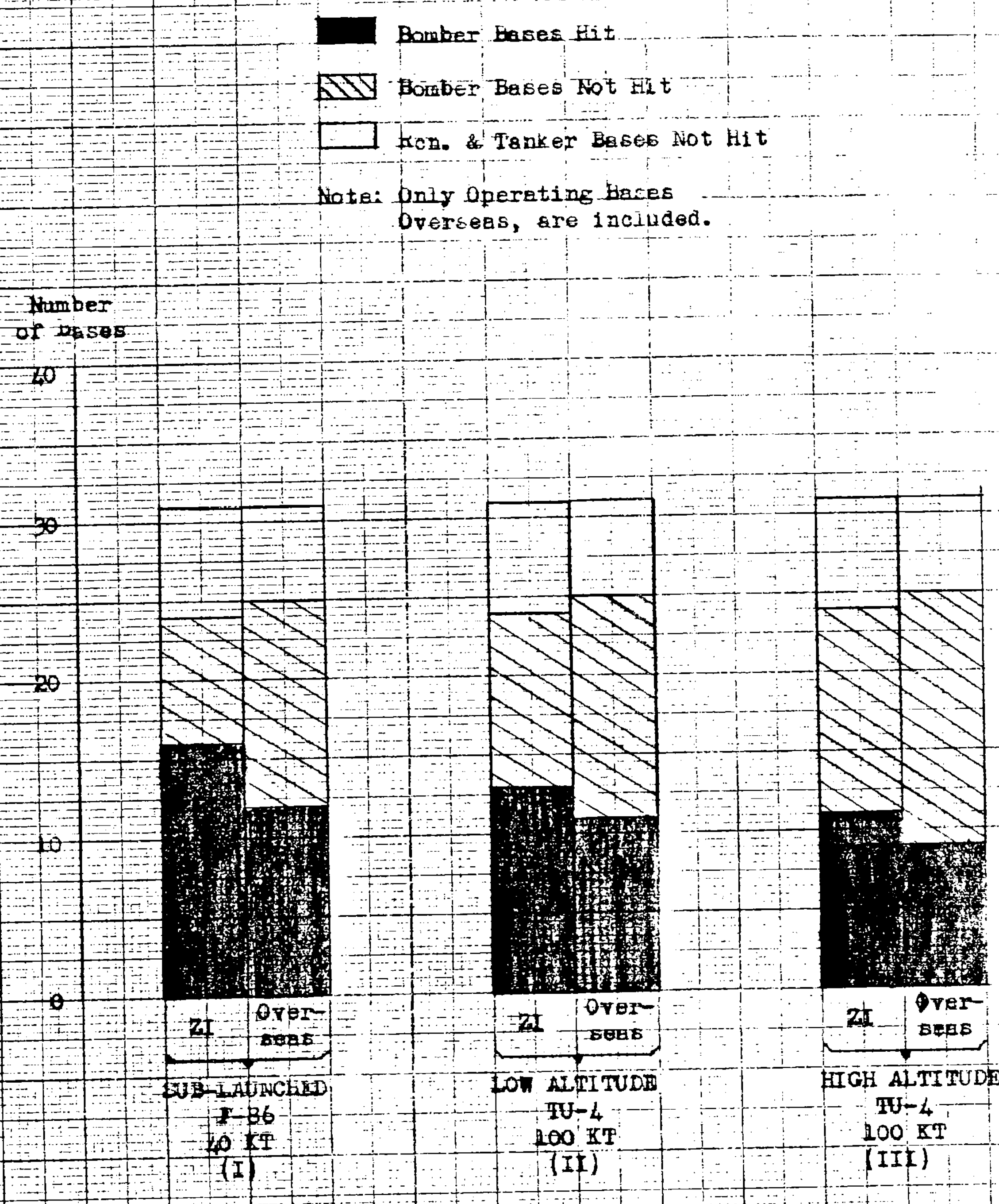
| Enemy Strategy | Number of bombers on bases hit: Undamaged | Light damage | Heavy damage |
|---|---|---|---|
| Submarine-launched | 21 | 32 | 107 |
| Low-altitude | 0 | 1 | 67 |
| High-altitude | 0 | 9 | 117 |

The availability of the repair capability depends on the pattern of destruction of depots and bases. Immediately following enemy attack, bases which have been hit will be completely inoperable for the period required for damage assessment and emergency measures such as clearing of the debris, putting out fires, restoration of minimal facilities and services, etc. After this delay period is over (which is estimated to be of the order of 3 days) repair on lightly damaged aircraft can commence almost immediately provided spare parts, minimum tools, and power are available. To be sure, the base capacity to perform light repair will be significantly degraded as compared with the undamaged condition as the result of damage to equipment and facilities and possibly personnel casualties. However, in view of the small numbers of lightly damaged aircraft shown in the above table, the moderate light repair task can be accomplished in a matter of days.

Aircraft sustaining heavy damage will need depot repair and will not be available for some months. It is concluded that repaired aircraft will not be an appreciable factor in the first strike sortie potential of the force.

6. Base Damage and Recuperability

Figure 7 illustrates the base damage pattern for the ZI and overseas. The relatively high percentage of surviving bases as compared to the aircraft survival is due to the fact that the enemy strategy consisted in each case of attacking only occupied bomber bases. Consequently, a number of unoccupied operating bases and a number of reconnaissance and tanker bases survive undamaged.




DAMAGE TO SAC BASES IN THE ZI & OVERSEAS

BY A SINGLE STRIKE SURPRISE ATTACK IN 1956

Figure 7

10 × 10 to the ½ inch, 5th lines accented. MADE IN U. S. A.

The importance of the base destruction pattern to the subsequent sortie capability must be discussed separately for the ZI and the overseas bases. In the ZI we again have to **distinguish** the medium bomber from the heavy bomber force. After enemy attack, the part of the base complex which supports the medium bomber, reconnaissance, and tanker aircraft has to provide support which is sufficient for execution of the mobility plan. To be capable of efficient operations from overseas bases, the medium force has to have its flyaway kits and the parts of unit essential equipment required at forward bases. Consequently, the effect of medium bomber base damage in the ZI on the combat sortie capability of the medium force is determined primarily by the availability of the materiel airlifted under the mobility plan since most ZI medium bomber bases are to be abandoned immediately after the outbreak of war.

In the case of the heavy bomber force the situation is considerably different. The ZI home bases of the heavy bomber and reconnaissance force will become the operating bases in wartime. Consequently the survival of a number of essential base facilities and supplies such as parking areas, maintenance equipment, runways, spare parts and other supplies, POL, etc.* is essential to continuation of efficient operation. It appears that, because of the specialized equipment required for maintenance of the heavy (B-36) units, only limited substitutability will exist in the ZI between the heavy bomber bases and the undamaged medium bomber bases. It is reasonable to expect that the net effect will be a serious degradation in the combat sortie potential if the heavy bomber bases are heavily damaged.

Similar considerations apply to the overseas bases which become operating bases for the medium force during wartime. The overall effect of the

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* It appears that, except in the Arctic climate, survival of structures is not essential to combat operations.

various shortages which may result under the damage conditions is two-fold: (a) To reduce the capacity of the base for handling the originally scheduled number of aircraft, and (b) to increase the service and maintenance time before the first strike.

It appears that base damage and recuperability are much more sensitive to the type of burst and the type of weapon employed against the base than is the level of aircraft damage.

In the case of the air-burst A-bomb, it is estimated that most of the above-ground structures on the base will be destroyed, that the runway and underground POL storage will survive essentially undamaged, that radioactive contamination of the base will be negligible; (the extent of damage to equipment on the base has not yet been adequately assessed.) It is estimated that base operations could be resumed after an initial period which is required for damage assessment and control, and restoration of minimal services. The base capacity and the serviceability of aircraft on a damaged base will, of course, be influenced by the availability of spare parts and other supplies and equipment from sources outside the base. It appears that with some minimum essential requirements such as fuel storage and transfer facilities, communication equipment, electric power, etc., overseas SAC bases can support limited first strike operations with little outside assistance. For purposes of the present computation, it has been estimated that a base damaged by an air-burst A-bomb will be inoperable for 72 hours and that for 27 days thereafter its ability to support units deployed on SAC's first strike is reduced by thirty percent.

In the case of a surface-burst A-bomb the damage to aircraft and structures for a given yield will be reduced by from 10 to 20 percent of that for an air burst. The probability of destruction of underground POL and of cratering of the runways is estimated to be small. The major effect on base operations in this case is the residual contamination.

The contamination pattern is very sensitive to the prevailing wind direction at the time of the bomb drop. At the very best, all of the vital base facilities may escape contamination altogether and the situation will then be equivalent to that of an air burst. At the very worst, in the absence of decontamination equipment, the base may be completely denied for a period as long as two weeks, and for a long period thereafter occupancy of the base may not be possible for long enough times to conduct combat operations. However, adequate decontamination measures can substantially reduce the period of base unusability.

In addition to the actual physical dangers of contamination, the probable effect on the morale of the personnel ordered to operate from a surface-bombed base appears to be serious. It is considered that for the first strike at least, and possibly for a considerable period thereafter, practically all of the surface-bombed bases will be denied to SAC.

As far as destruction of aircraft is concerned, the H-bomb is a weapon of overdestruction, since, as was shown in the preceding section, even a 100-KT bomb produces a very high damage level for a reasonable range of CEP. A major advantage will probably come from the effect of the H-weapon on the damage to the base. Above ground facilities would be totally destroyed. It appears that the probability of destruction of the underground POL is still small, as in the case of the air-burst and the ground-burst A-bombs. The probability of destruction or severe surface damage to the runways, however, either due to cratering, blast, or thermal effects, appears to be quite high.

For the purposes of this computation it was assumed that <u>H-bombed bases would be denied to SAC for the duration of the 3 months' campaign</u>.

The estimates presented above, while the best available at this time, are based on very incomplete data and results. A considerable amount of field data will have to be gathered before these estimates can be improved.

It is important to point out that the enemy strategies used so far in this study have been confined to attacks on occupied SAC bomber bases and supporting depots. Consequently, base denial is a by-product of these strategies. Should the enemy choose a special base denial strategy (such as wholesale HE attacks, paratroop or amphibious landing, or sabotage) the results shown on Fig. 7 would be radically changed. In fact, it appears possible for the enemy to deny SAC all of the forward operating bases for a period of time long enough to disrupt the retaliatory strike.

7. Combat Sortie Potential after Damage.

The concluding step in the analysis of vulnerability of SAC to enemy attacks is to consider the combined effect of the various levels of destruction to essential components: aircraft, crews, materiel, bases, bombs, support aircraft, etc. In general, the essential component which is in shortest supply will tend to limit the overall SAC capability after damage.

We propose to measure this capability in terms of the numbers of combat-ready aircraft. Since the timing of the first retaliatory strike may be critical to SAC's success, we also measure the time delays incurred in making these combat-ready aircraft available in forward areas.

The present chapter presents our crude initial attempt at synthesizing the effects of damage into time-phased graphs of combat-sortie potential by various geographic areas. A great amount of data remains to be collected and considerable work must be done before these schedules will begin to approach the probable state of affairs in a war in 1956.

While the following discussion is directed primarily toward the medium bomber portion of SAC, certain aspects of the discussion apply also to the heavy bomber portion. In order to assess the degradation of SAC's combat sortie potential resulting from enemy damage, it is first necessary to determine the combat sortie potential <u>before</u> damage. Before enemy attack, each SAC unit is assumed to be assigned to a particular overseas base area for wartime operation and to have undergone training oriented specifically toward operation from this area. On D-day, with the exception of a few units which are on rotation overseas at bases in their assigned geographic area, all of the units are physically located at the ZI home bases.

When the order to execute is given to SAC, units are deployed to overseas bases as rapidly as possible, consistent with the overseas area assignment of each unit and the delays required for movement, servicing, ferrying, and preparation for combat. The number of wings deployed overseas is subject to three limitations:

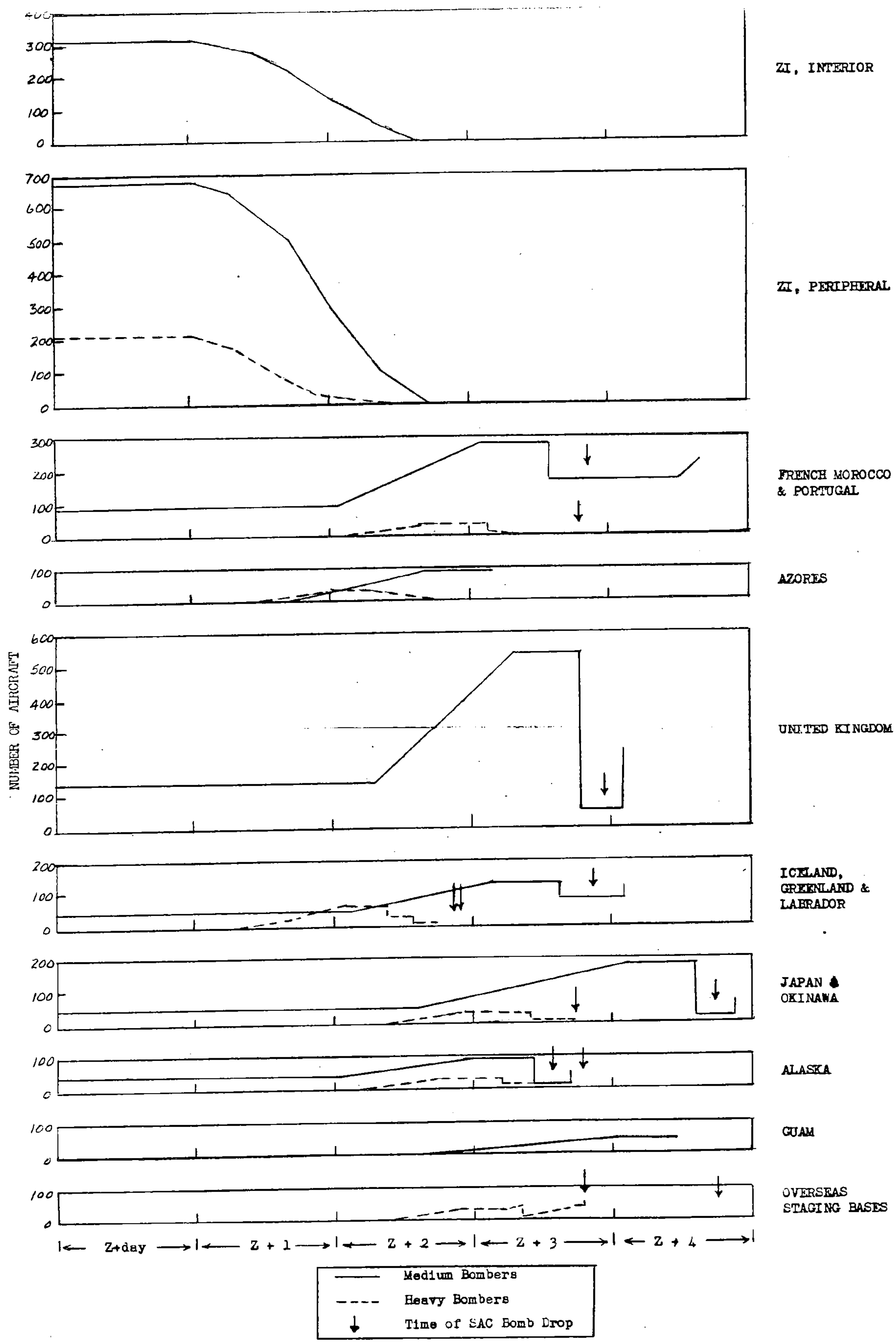
(1) a maximum allowable concentration of aircraft per base (an attempt to reduce vulnerability);

(2) the number of units assigned to combat reserve; and

(3) the availability of programmed bases in each geographic area.

Fig. 8 shows graphically the deployment of SAC units overseas in the undamaged case, with no limitations on the number of wings which may occupy an overseas base. The chart shows the number of SAC medium and heavy bombers on the ground, both in the ZI and in each of the overseas areas, as a function of time after Z-day, the day on which the SAC units begin to move into execution of the war plan. In the undamaged case, Z-day coincides with E-day, the day on which the SAC units are ordered to execute. In the damaged case, we have assumed that E-day is the day SAC is attacked; as a result of damage certain delays may be necessary or desirable, and the units do not begin to move until Z-day, h days later. Thus, in the damaged case Z = E + h.

In Fig. 8, the number of units deployed to each overseas area is proportioned roughly according to the number of targets accessible from each general direction of attack. The variation in take-off times between the overseas base




CONCEPTUAL SCHEME OF SAC DEPLOYMENT AS A FUNCTION OF TIME
(undamaged situation)

Figure 8

areas is due to the assumption that target time is the same for all target areas. Because of the greater ferrying distances involved, aircraft based in Japan and Okinawa are not available for sorties until almost 24 hours after aircraft based in other areas.

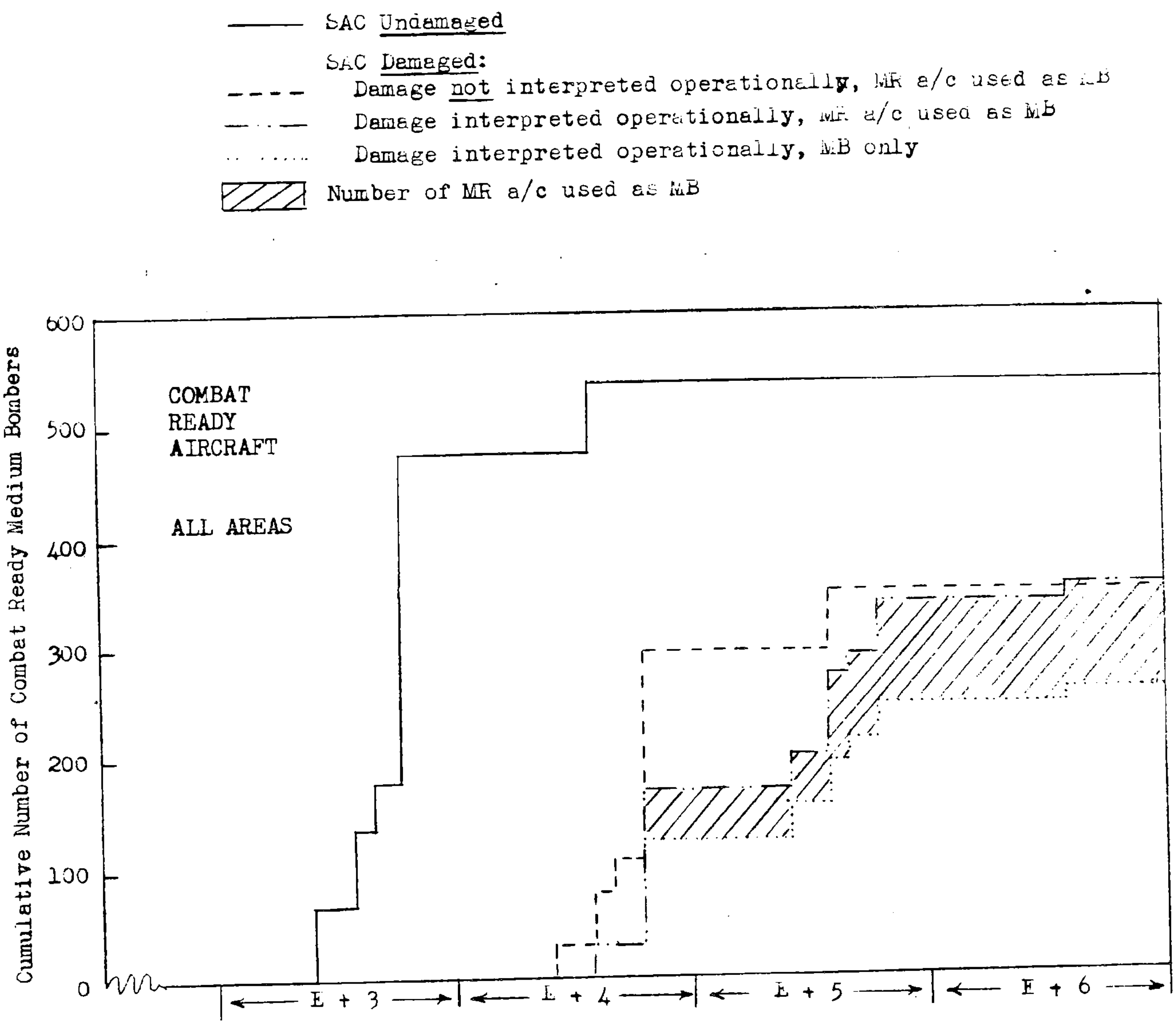
The scheme illustrated on Fig. 8 is used as the basis for all summary operations schedules presented below. Thus, if SAC is undamaged, and the overseas concentration of aircraft is limited to one wing per base, the solid lines of Fig. 9 and 10 indicate the summary schedule at which medium bomber aircraft become available for mounting the first SAC strike. In accordance with Fig. 8, the steps in the schedule occur when the aircraft in a particular geographic area become combat-ready. (It is assumed that 70% of the aircraft deployed overseas are combat-ready for the first strike.) The effect of limiting overseas base occupancy to one wing is to produce a combat reserve of 360 medium bomber aircraft (8 wings) in the ZI.

It should be pointed out that the graphs present merely a schedule of availability of combat-ready aircraft and that the first strike may be made at any time during the build-up, the size of the strike being limited by the forces on hand at that time.

After the enemy attack, the sortie potential of SAC is determined by employing the residual assets of SAC, as closely as possible, in accordance with the concept of operations for the undamaged case, within the following limitations imposed by the effects of the enemy attack.

Immediately following the enemy attack, it is assumed that there is a minimum delay of 24 hours before orders are issued to SAC units to execute the war plan. This period of time is introduced to account for initial confusion, interruption of communications, assessment of damage, replanning, and redirection of units.

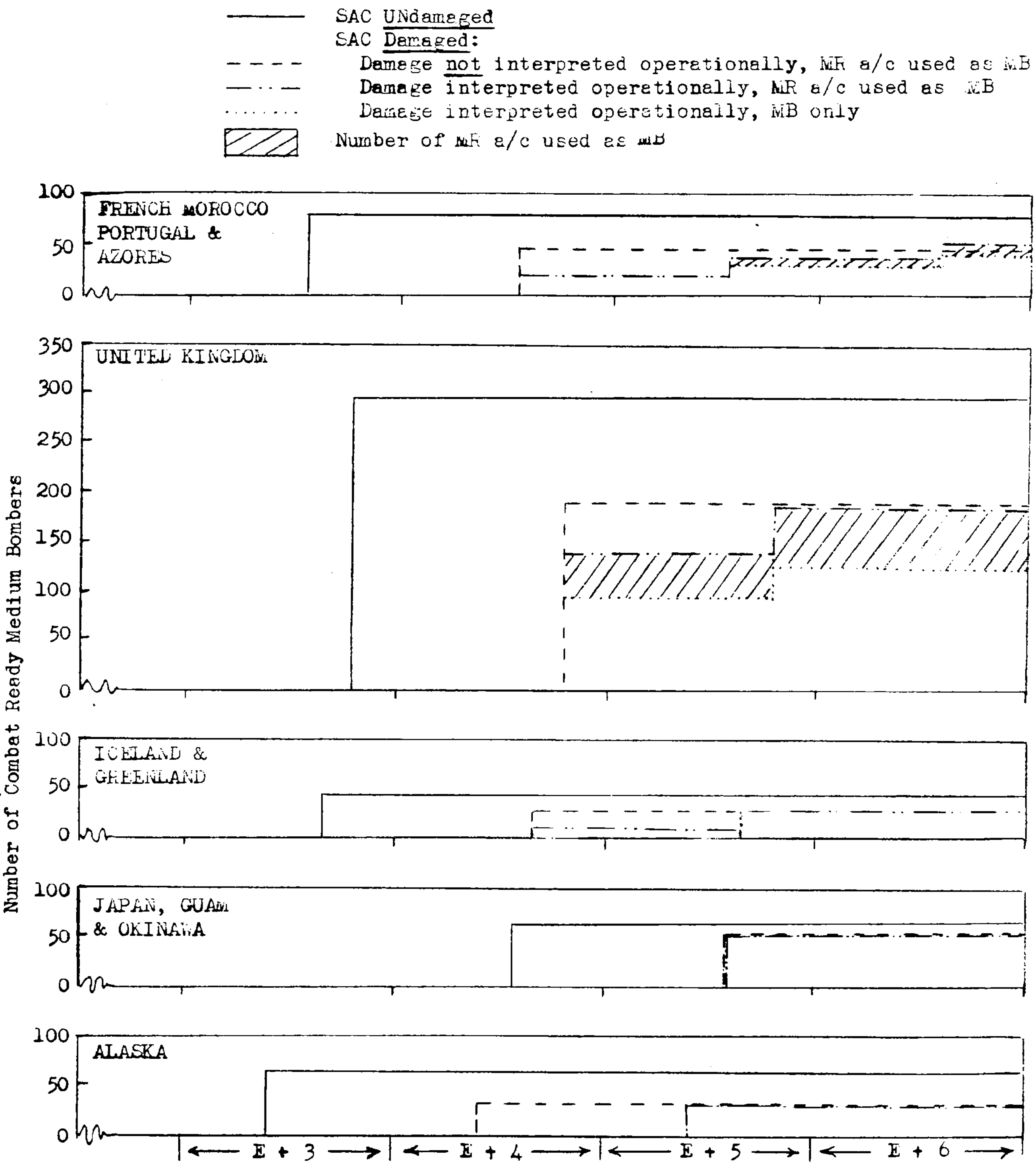
The enemy attack creates a different pattern of destruction at each SAC base. Warning times differ from base to base, and hence bases may be attacked




COMBAT READY MB AVAILABLE FOR SAC's FIRST STRIKE AS A FUNCTION OF TIME

SAC UNDAMAGED VERSUS SAC DAMAGED
BY LOW ALT. TU-4 ATTACK; 1956 USAF RADAR PROGRAM
(Maximum Overseas Concentration of a/c - 1 wing per Base)

Figure 9




COMBAT READY MB AVAILABLE FOR SAC's FIRST STRIKE AS A FUNCTION OF TIME, BY AREAS

SAC UNDAMAGED VERSUS SAC DAMAGED
BY LOW ALT. TU-4 ATTACK; 1956 USAF RADAR PROGRAM
(Maximum Overseas Concentration of a/c - 1 Wing per Base)
FIG. 10

while in various stages of evacuation. Evacuation times differ for the various elements of a base, and hence a bomb drop during evacuation might destroy much of one element, little of another. Because of failures of enemy bombers to reach targets, for one reason or another, certain bases will not be attacked, and units at these bases will survive intact.

For purposes of this study, the elements $F^j_{ik}$ of a unit necessary for the mounting of the first SAC strike are aggregated into three classes: aircraft and crews; other personnel; materiel (flyaway kits and unit essential equipment). In units which are not attacked, all of these elements survive intact, and the unit retains its organizational identity and its initial strength. Units which are attacked after evacuation is substantially completed (all flyable aircraft evacuated, 90% or more of personnel and materiel* evacuated) are treated as organizational units with reduced aircraft strength; for such units complete complementarity of surviving aircraft, personnel, and materiel is assumed**. Because of the diversity of the items in the flyaway kits, units which evacuate less than 90% of their materiel before being attacked lose their organizational identity, and the surviving elements are treated only as available for filler replacements for the remainder of the surviving organizations.

As previously mentioned in Section 6, the base capacity $U^j_k(t)$ is assumed to be 0 for 3 days following an air-burst A-bomb attack, and 70% of the undamaged capacity for 27 days thereafter. The base capacity after an H-bomb attack is assumed to be 0 for the duration of the three months' campaign.

Subject to the limitations in base capacity $\left\{ U^j_k(t) \right\}$ and various delays brought about by the damage situation, the surviving units are allocated to the overseas base areas in proportion to the target accessibility from those

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* Materiel appears to be the slowest element to be evacuated and hence the scarcest element surviving in a damaged unit.

** Data available on a recent SAC evacuation exercise suggest that this is an optimistic assumption.

areas. Even when the surviving force is much smaller than the initial force, units are deployed to all areas in which bases are available. About 40% of the force is deployed to the United Kingdom.

Crews and plans are assumed sufficiently flexible that units may operate from the areas to which assigned by the emergency war plan (undamaged SAC deployment plan) with no delays other than the initial 24-hour delay for damage assessment and redirection. Units which must be reassigned to new base areas are given an additional 48-hour delay for retraining.

Figures 9 and 10 indicate the schedule of combat-ready medium bomber aircraft available for the first SAC strike, as the result of the enemy low-altitude TU-4 attack, with the programmed 1956 ZI radar network in place.

The dashed line on Figures 9 and 10 is the schedule of combat-ready medium bombers available for the first SAC strike which could be obtained if only aircraft damage were taken into account. Under this schedule, the surviving units are deployed to the overseas operating bases without regard to base damage, and without regard to time delays incidental to the damage (such as might be required by reassignment of units to new base areas, for example). The only delays taken into account are the delays for actual movement indicated in Fig. 8 for the undamaged case, plus the initial 24-hour delay for confusion and replanning.

Since it is assumed that reconnaissance aircraft are not attacked by the enemy, reconnaissance aircraft in excess of those required to support the surviving bomber force can be used to fill bomber cells, thus increasing the effective number of bomber sorties available. The dashed line schedule of Figures 9 and 10 takes account of this use of reconnaissance aircraft.

The dashed-dot line in Figures 9 and 10 is the schedule of combat-ready medium bombers available for the first SAC strike which is obtained by taking account of <u>all effects</u> of enemy damage, delays in the use of damaged bases, degradations in the capacity of damaged bases, delays from reassignment of units to new base areas, etc. The use of reconnaissance aircraft to fill bomber cells has also been included in this schedule.

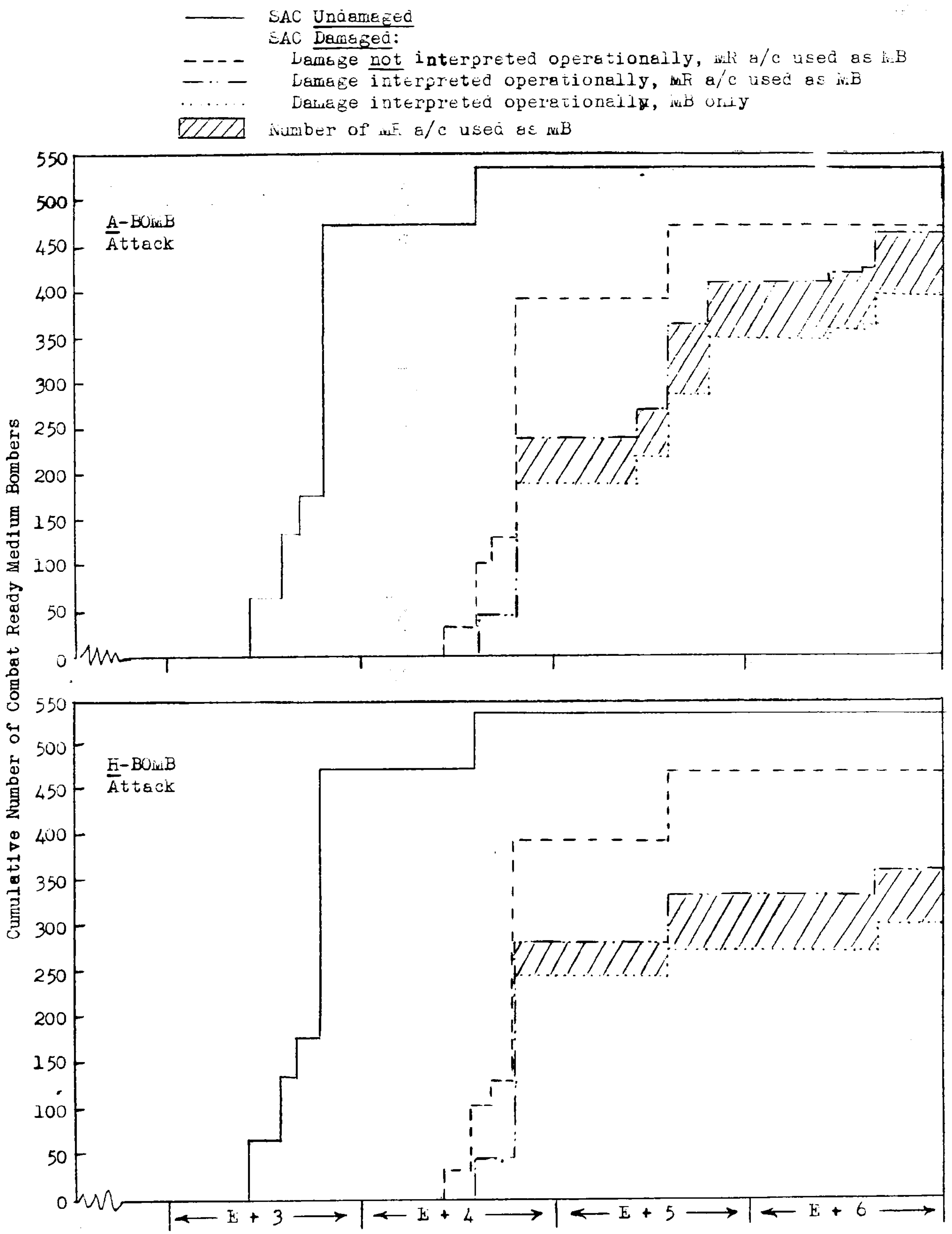
A comparison of the dashed line (no account of effects of damage other than aircraft) with the dashed-dot line (all effects taken into account) illustrates the extra delays on SAC combat readiness imposed by the system as a whole.

The <u>dotted line</u> in the figures takes all damage effects into account but makes no use of reconnaissance aircraft to fill bomber cells. This is the schedule of <u>medium bomber aircraft</u> only.

Figure 11 shows the same schedules of sortie availability for the case when a larger part of SAC survives the initial enemy attack because of better radar coverage. (The particular kind of radar augmentation assumed is discussed in Part III, Defense Measures.) This figure shows the effects of both H-bomb and air-burst A-bomb attacks, to illustrate the effects of prolonged base denial caused by the use of the H-bomb. It is seen, for example, that the maximum number of sorties which can be mounted by bombers only (dotted line) drops from about 400 in the A-bomb case to 300 in the H-bomb case.

As may be seen from Figures 9, 10, and 11, the effect of the enemy attack is twofold: to reduce the maximum number of sorties which may be mounted in the first SAC strike, and to introduce delays in the mounting of the first strike.

The following table illustrates this effect:




COMBAT READY MB AVAILABLE FOR SAC's FIRST STRIKE AS A FUNCTION OF TIME, ALL AREAS

SAC UNDAMAGED VERSUS SAC DAMAGED

BY LOW ALT TU-4 ATTACK; AUGMENTED RADAR PROGRAM

Medium Bombers - Damage Interpreted Operationally

| Condition of SAC | Max. No. of A/C available for 1st strike | Date of 1st strike with max. A/C available | No. of Undeployed A/C In Units | Not in Units | Total |
|---|---|---|---|---|---|
| Undamaged | 535 | E + 4 | 360 | 0 | 360 |
| After initial low-altitude TU-4 attack | | | | | |
| a. 1956 USAF radar program | 350 | E + 6 | 0 | 0 | 0 |
| b. Augmented radar program; A-bomb | 460 | E + 6 | 0 | 75 | 75 |
| c. Augmented radar program; H-bomb | 360 | E + 6 | 180 | 75 | 255 |

The schedules of SAC combat-ready aircraft available for the first sortie represent only the limits of SAC capability. Within these limits of sortie availability, the particular schedule of SAC sorties actually mounted is a matter of command decision, and will depend upon a number of factors in the military situation. These factors represent conflicting demands on SAC, and the resulting choice of a sortie schedule is necessarily a compromise between incompatible ends. On one hand, it is desirable, for example, to mount the first SAC strike as early as possible and to mount as large a strike as possible; on the other, it is desirable to minimize the time of exposure of the forces on overseas bases prior to the first strike, to probe the enemy defenses with small forces before committing large forces, and to maintain reserves against future contingencies in the campaign. Thus, an early strike could be mounted with a relatively small period of exposure of the force prior to the attack, but necessarily with smaller forces, whereas deferring the strike for a few days would permit larger forces to be employed, but with a longer period of exposure before the attack. The schedule of SAC combat-ready aircraft availability, therefore, does not necessarily determine SAC strategy, nor the measure of its success in carrying out the mission; it does, however, have significance as a measure of the latitude of possible SAC strategies. It illustrates the range of choice open to the SAC commander in employing his force.

The results presented in Figures 9, 10, and 11 represent only a first rather crude attempt to interpret enemy damage operationally. Among others, the following items will have to be refined in later work. As mentioned previously, the availability of critical inputs I(t) (from AEC, MATS, etc.) has been arbitrarily assumed. The estimates of base capacities $U_k^j(t)$ are based on only a preliminary analysis of very limited data. Such items as JATO and oxygen are assumed available overseas, even on bases which have been attacked. A sufficient number of flyaway kits are presumed to be available and lifted overseas for the first strike. No constraint on deployment for lack or saturation of transit bases is assumed.

8. Important Limitations in the Study

In order to put the present study in a proper perspective, it is important to set down and discuss a number of internal and external limitations which have been imposed on the study. The next two sections are devoted to this purpose.

The internal limitations are due to our present inability to include certain important inputs in the model constructed for the interaction between SAC and SUSAC. This inability results in some cases from lack of necessary empirical data, and in some cases to our failure to interpret certain available facts in operationally meaningful terms.

Enemy Strategies

(a) It was assumed that all enemy attacks will be coordinated within 15 minutes so that the arrival of aircraft at the warning net is virtually simultaneous. An investigation of this assumption should improve the estimates of the net warning time available to SAC bases.

Warning and Evacuation

(a) On the basis of relatively scanty data it was assumed that it will take 15 minutes for transmission of the warning of enemy attack to SAC bases. Since net warning times were shown to be at best marginal, this assumption is critical to the success of whatever SAC evacuation can be undertaken. ADC-SAC information and control procedures will have to be investigated to improve this estimate.

(b) The pattern constructed for the SAC evacuation plan is again based on imprecise data. In particular, no information was available regarding the materiel and personnel evacuation procedures.

(c) Virtually no data could be obtained regarding the established national policies and procedures for transmittal of equivocal warning to the military establishment.

(d) The dependence of SAC evacuation on the hour and day of enemy attack should be studied further and effects due to time zone differences should be taken into account.

Damage to Aircraft

(a) Estimates of area attrition to enemy bombers were based on a simplified model. A more realistic study of the matching of the programmed ADC interceptor network to SAC bases is in order.

(b) Better data is needed on the availability and effectiveness of the overseas active defenses of SAC bases.

(c) More information is needed on the physical layout of both ZI and overseas bases. For some bomb-CEP combinations, the layout of the aircraft parking areas is important.

Base Damage and Recuperability

(a) Scant data were available on the functions performed at many types of SAC bases and on the facilities, essential equipment and stock programmed for these bases. This sort of data is a prerequisite to a better measure of base capability to support operations after damage.

(b) While the physical vulnerability of base structures can be fairly well specified, there is little information on damage expected to the contents of these structures (equipment, stocks).

(c) The model did not include consideration of the personnel casualties and its effect on subsequent combat operations.

(d) While a considerable amount of data is available on the physical effects of surface burst A-bombs, interpretation of these effects on base capacity requires further work. In particular, this involves a study of the pattern and duration of the contamination effects, and the capability of base decontamination. Only general indications were available on the effectiveness of H-bomb burst against the hard parts of bases (runways and underground storage).

(e) The integration and interpretation of all of the preceding damage effects into an overall degradation of base capacity needs further serious attention.

Combat Sortie Potential After Damage. All of the preceding limitations clearly affect combat sortie potential. In addition to these, the following need further investigation:

(a) The limitations on SAC capability imposed by denial of inputs supplied by other activities. This includes both a study of what these inputs are as well as their criticality to efficient operations.

(b) Insufficient data was available regarding the interchangeability of bases for performance of functions other than those originally scheduled (such as use of a reconnaissance base for bombing operation, or vice versa).

(c) The delays associated with damage assessment, control, and replanning required after damage must be further considered.

(d) The role of reconnaissance must be detailed and reconnaissance missions evaluated in terms of bomber sortie effectiveness.

(e) The flexibility in reassignment of crews to targets and units to base areas needs further investigation.

9. Study Context

In addition to the internal omissions and limitations discussed in the preceding section, there are a number of external limitations which must be removed before a study of SAC vulnerability can be considered in any sense complete.

(a) The SAC-Soviet interaction must be extended from the first strike into a campaign. This is being investigated now.

(b) The combat sortie potential should be related to the target destruction potential through a study of relationship of base and target areas including the effects of denial of specific base areas on the accessibility of targets. This is also a part of the present phase of the study.

(c) The study must be extended to cover other time eras. In particular, SAC-Soviet interaction in the 1953 time era involving a smaller SAC capability and a more limited enemy capability needs to be investigated, as well as SAC vulnerability in the 1958-1960 era when an important missile capability is scheduled to be phased-in.

(d) The capability of the Air Force logistics structure to contribute to the recuperation of SAC after initial attack and to support it during the campaign is presently being studied. The logistics structure itself is a possible target and the effect of damage to this structure on continued SAC operations must be considered.

(e) The study of SAC must be enlarged to include SAC fighter units, which have an offensive capability, and other members of the Strategic Striking Complex such as AEC, MATS, etc.

(f) The vulnerability of SAC to different enemy strategies and weapons such as BW, CW, sabotage, amphibious and airborne task forces, etc. must be looked at.

(g) SAC vulnerability should be studied in the light of several alternative strategic operations concepts and objectives in addition to the one already considered.

# PART III - DEFENSE MEASURES

## 1. Defense Measures and Defense Strategies

Any defense program adopted for preservation of the combat potential of SAC must fulfill a number of important requirements:

a. It must provide an all around "no-soft-spot" defense for SAC which will anticipate a number of probable enemy strategies. The entire investment may, in effect, be wasted if by implementing a defense strategy we merely force the enemy to employ a different attack strategy without making him pay appreciably for it.

b. The program must be able to survive the test of time. It must be designed so as to anticipate the developments in SAC structure and capabilities, the development in enemy capabilities, and particularly the developments in the weapons technology.

c. The program must not encumber SAC's offensive striking power to a point where SAC is "safe but impotent". (This is one of the primary reasons why, in this study, we measure vulnerability in terms of the degradation of combat potential rather than some physical destruction criterion.)

It is clear that no single defense measure is likely to fulfill these complex requirements. A combination of many measures will be needed before our strategic striking capability can attain a measure of invulnerability to a complete range of enemy strategies. However, good defensive measures are, in general, expensive to implement. Consequently, we cannot design a program for the defense of SAC by an indiscriminate aggregation of measures until we feel adequate protection will be attained. Instead, it is necessary to consider sets of carefully selected measures which avoid as much as possible, any overlap between the effects of individual measures. The effectiveness of such complete sets should be compared in the light of the overall costs which their implementation would entail.

We will refer to such sets of carefully selected defense measures as defense strategies.

It is clear from the preceding discussion that design of good defense strategies requires an understanding of the many aspects of vulnerability of SAC. Our study to date has progressed only far enough to give us an insight into one phase of SAC operations, namely, its recuperability from the effects of the initial enemy strike. In view of this, we will confine our attention in the remainder of this paper to examination of individual measures as the first step in setting the stage for a later study of defense strategies.

## 2. Classification of Measures

In order to encompass the wide range of qualitative differences between defense measures it is necessary to classify all promising defense measures according to the effect which they have on the physical characteristics of the system. In Part I, Section 4 of this paper we have listed a few of the characteristics of the vulnerability problem (a more complete listing of the characteristics is furnished in Appendix A) which are controlled* by the US, the word "controlled" being used in the sense that these characteristics (unlike, for example, the weather or the enemy stockpiles) can be modified by direct changes in US plans, programs, or operating procedures. In this section we propose to use this listing as a guide to the classification of a number of interesting defense measures. A later section of this paper will analyze the performance of a few of these measures.

Since most of our attention so far has been devoted to the effects of the first enemy strike, a majority of the measures will deal with SAC units deployed in the ZI. Measures which apply to operations after the first strike

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*For definition of "controlled", see footnote, p. 6.

will be identified as such. (The numbering of the following variables is similar to that used in Appendix A.) Following is a concise listing of all defense measures discussed so far in this study. Appendix B presents a more detailed description of the measures listed, and a discussion of the effectiveness, limitations, and other considerations affecting the implementation of these measures.

(1) Enemy variables (not within our power to "control").

(2) SAC-controlled variables.

(2.1) SAC bases; number and geographic location.

(a)* Relocation of new bases (not yet constructed) to the interior of the ZI.

(b) Relocation of all SAC bases to the interior of the ZI.

(c) Relocation of bases to the interior of the ZI in conjunction with dispersal.

(d)* Interchange of bases between SAC and other commands.

(2.2) Physical layout of bases.

(a)* Perimeter parking of aircraft.

(b)* Provision of personnel shelters and/or slit trenches.

(c)* Underground or dispersed POL storage.

(2.3) Number of units and amount of aircraft, personnel, and materiel.

(a) Increase in the total number of bases and consequent reduction of concentration of forces per base to, say, squadron level.

(b)* Storage of some base equipment and stocks in other localities. (A particular example is storage of flyaway kits off-base.)

*In this section, measures marked with an asterisk are considered "low-cost" measures, - a discussion of the implication of these measures is contained in Section 3 following.

(c)* Dispersal of a portion of organizational aircraft or aircraft from additional production to non-SAC facilities. (This differs from mothball storage since the stored aircraft are rotated and maintained in combat readiness.)

(d) Combination of dispersal with base relocation, mentioned in (2.1)(c) above.

(e)* For units on rotation overseas, deployment of not more than one squadron per base.

(f)* Modification of overseas rotation policies.

(2.4) Concept of operations.

(a) A SAC counterpart of the tactical split-wing concept under which 2/3 of each unit is deployed overseas where it conducts intensive operations, while the remaining 1/3 undergoes maintenance, training, and re-equipping in the ZI. Regular rotations of squadrons are maintained.

(b) Deployment of the bulk of the medium bomber force to the forward area, where it flies a number of intensive missions in rapid succession and then redeploys back to the ZI for maintenance and recuperation, leaving only the unflyable aircraft in the forward areas.

(c) Use of forward areas for staging only, with maximum utilization of programmed operating and staging bases to permit dispersal.

(d) Intercontinental operations by medium bomber units using aerial refueling.

*"Low-Cost" measure.

(2.5) Alert procedures upon receipt of warning.

(a)* Execution of the evacuation plan upon receipt of warning of approaching enemy aircraft, as envisaged in current SAC plans.

(b)* Execution of an emergency dispersal of aircraft on the base, and removal of personnel and materiel off the base upon receipt of warning of approaching enemy aircraft.

(c)* Conduct of training exercises in the performance of both the evacuation and the dispersal plan.

(d)* Utilization of advance warning of a likely enemy attack to prepare for (or partially execute) the evacuation or emergency dispersal plan.

(e)* Execution of the evacuation plan upon receipt of advance warning of a likely enemy attack.

(2.6) Information available to the enemy.

(a)* If plans are made to evacuate bases upon receipt of advance warning of likely enemy attack, employment of several alternate evacuation plans and selection of one at random for execution when such warning is received.

(b)* Variation of the SAC overseas rotation pattern.

(c) Reduction of the time spent by SAC bombers in the forward operating areas prior to the first SAC strike.

(d) Reduction of the time spent by SAC bombers in the forward operating area during the entire campaign, by use of one of the modified combat operations con-

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*"Low-Cost" measure.

cepts listed in (2.4) above. If permitted by the operations concept, selection of a random forward base deployment for each strike.

(e)* Activity against potential sabotage, planting of beacons or other navigational aids.

(3) Air defense and warning variables.

(3.1) Warning network.

(a) Extension of programmed radar network southward through a combined use of new ground and airborne radars.

(b)* Denial to enemy submarines of the use of the Gulf of Mexico by means of Sonar buoys, or some other blocking device.

(c)* Extension and peacetime activation of the Ground Observer Corps in the southern part of the US.

(d) Increase of radar coverage in overseas areas to permit the programmed air defense forces to be brought to bear effectively on an incoming enemy.

(e)* Utilization of NATO merchant and naval vessels for reporting of aircraft sightings to the air defense network of the US.

(f)* Development of a clear-cut and relatively unambiguous set of ground rules for translations of indications of enemy activity into corresponding states of US alert.

(3.2) Air defense.

(a) Relocation of fighter defenses in the ZI to provide more protection against attacks directed against SAC bases.

*"Low-Cost" measure.

(b) Establishment of a sufficient territorial limit off the coast of the US and concurrent patrol activity against potentially hostile submarines.

(c)* Mounting of standing air patrol above overseas bases during periods of maximum concentration of SAC aircraft on the ground.

(d)* Inspection of potentially hostile merchant and passenger ships to prevent covert delivery of A-bombs or H-bombs to coastal SAC installations.

(3.3) Channels and procedures for identification of hostile aircraft. (No specific defense measures are proposed in this area, because of ignorance of the existing channels and procedures for transmission of warning.)

(3.4) Local defenses.

(a) Allocation of a portion of the programmed 1956 Nike missile force to the defense of SAC installations.

(4) Air materiel variables.

(4.1) Maintenance support.

(a) Reduction in the concentration of facilities; at least, isolation of any additional facilities.

(4.2) Supply support at depots.

(a)* Storage of extra flyaway kits in depots, unless these items are stored in SAC units at locations away from the base.

(b) Reduction in concentration of depot stockpiles, particularly overseas. Isolation of additional stockage, at least.

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*"Low-Cost" measure.

(c)* Stockage of aircraft parts and equipment based on the best available estimates of expected wartime, rather than peacetime, consumption.

(4.3) Supply and equipment at the SAC bases.

(a) Procurement of more refueling equipment for the operating bases; additional POL facilities, underground or dispersed at off-base sites.

(b)* Provision of A-bomb damage-control equipment and personnel for all bases, accompanied by storage off base.

(c) Off-base storage of flyaway kits and duplication of UEE at off-base sites.

(d)* Stockage of medical supplies at all bases in quantities sufficient to meet the requirement generated by the enemy attack.

(5) Systems defense measures.

(5.2) Increase Self-Sufficiency and Flexibility of SAC.

(a)* Preparation of alternate war plans for various damage situations, including consideration of the possibility of denial of various operating base areas.

(b)* Provision for quick release to SAC and other military organizations of the nuclear components of A-bombs.

(c)* Auxiliary means of communications and auxiliary and immediate alternate command channels.

3. Low-cost Measures

In the list of measures enumerated in the preceding section we have used an asterisk to indicate a group which appear to have a very important common property, namely, that their implementation does not call for large increases in the budget. Such measures usually consist of changes in the existing Air Force programs, plans, and operating policies.

The requirement for a complete analysis of the vulnerability structure of SAC set forth in the first section does not, in general, apply to these measures. Most of them, since they involve only minor expenditures, can be accepted or rejected for implementation based on their individual effectiveness and their effect on the flexibility of SAC. Consequently, recommendations for implementation of certain of these measures need not await the completion of the vulnerability and defense studies. Certain low-cost measures are, in fact, recommended in Part IV of this report.

Nevertheless, the term "low-cost" that we apply to this group of measures must be carefully interpreted. Since many of them require modification in the standard operating procedures and plans of the Air Force, their implementation may result in serious repercussions on the ability of SAC to perform its assigned combat mission.

As an example of such repercussion, consider the apparently low-cost measure which calls for a modification in the combat operations concept so as to reduce the time of exposure of SAC forces in forward operating areas. If the SAC mission does indeed have the requirement for massive and simultaneous retaliatory blows against the enemy early in the war, such modification in the operations concept would conflict with the mission and would consequently be unacceptable.

While most of the measures marked with an asterisk in the preceding section do not appear to have conflicts to the extent of the example mentioned above, each of them must, nevertheless, be examined in the light of at least three considerations: (a) their potential effectiveness for the preservation of SAC combat potential, (b) their possible interference with SAC's ability to carry out its combat mission, and (c) substantial hidden and indirect costs connected with their implementation that may disqualify them for consideration as low-cost measures.

A sample approximate comparison of the effect of three of the low-cost measures is given below to illustrate that a substantial reduction in SAC vulnerability can be attained through such measures. We compare the increase in the number of surviving aircraft which results from the following measures:

a. The new bases programmed for the 1954-56 period are built inside the high-altitude two-hour gross warning line (as shown in Fig. 2c).

b. Fifty per cent of the organizational aircraft are kept at all times at non-SAC facilities.

c. Equivocal warning procedures are established and arrangements are made by SAC which permit it to execute the evacuation plan prior to enemy attack.

Low Altitude TU-4 Attack with 26 Bombs

| Defense measure | Per Cent of ZI SAC bombers surviving |
|---|---|
| Programmed SAC, 1956 | 46 |
| a. New bases (8) built inland | 68 |
| b. 50% of A/C at non-SAC facilities | 73 |
| c. Evacuation upon receipt of equivocal warning | 67 |

The indicated effectiveness of measures b. and c. is based on the assumption that the SAC bombers at facilities other than SAC bases are not attacked. This implies wide dispersal among available non-SAC airfields in case of b., and either wide dispersal or good deception by having alternate deployment plans in c. Measure c. is, of course, valid only if equivocal warning is obtained.

4. A Comparison of Dispersal, Base Location, and Radar Coverage.

In this section we compare five selected measures for decrease of SAC's vulnerability in the ZI. All five require substantial increases in the Air Force budget.

The measures affect vulnerability through a change in two of the controlled variables listed in Part I of this paper, namely, the average force concentration on the bases $F^j_{ik}$ and the relative distance, r, between the location of the bases and point of detection. The following measures are considered:

(1) Dispersal of all ZI-based bomber and reconnaissance units to squadron level. If all of the old bases are retained, then under the present SAC operations concept the following numbers of new bases are required:

14 heavy bomber bases
8 heavy reconnaissance bases
73 medium bomber bases
15 medium reconnaissance bases
110 total

The cost of the additional base construction plus added equipment and stocks comes to a total of 3.53 billion dollars. The yearly operating costs for the newly constructed bases will increase SAC budget by 0.67 billion.

It is assumed that the geographic distribution of the new bases will be the same as that of the existing base system. The effect of this measure is solely to reduce the average concentration per base of the ZI deployed forces.

(2) Dispersal with relocation. For this measure we assume that dispersal takes place down to squadron level just as in measure (1), the programmed bases are retained and all of the new bases are moved inside the high-altitude two-hour warning line shown on Figure 2c.

(3) Relocation of bases. For this measure the scheme is to abandon 25 of the programmed bases which are outside the two-hour zone and to construct a sufficient number of new bases inside the zone to permit one-wing-per-base deployment. Under this scheme six of the presently programmed bases are retained and the following numbers are constructed:

7 new heavy bomber bases

4 heavy reconnaissance bases

24 medium bomber bases

4 medium reconnaissance bases

39 total

The total cost of new construction for this case is 1.61 billion dollars and the increase in the annual SAC budget is 0.62 billion dollars.

(4) Augmentation of radar coverage. This measure increases the distance between the bases and the radar network by moving the radar coverage rather than the bases. The purpose of the sample measure considered here is primarily to close up the gaps in the low-altitude coverage and to expand protection of the southern part of the United States. The augmentation consists of:

17 AEW radar

2 GCI radars

9 picket ships

In addition, 19 Canadian GCI's are assumed to be in place. The resulting coverage pattern and the warning zones against high and low altitude TU-4 attacks are shown on Figures 12a and 12b.

The additional investment costs for installing these units is 0.39 billion dollars, and the annual operating cost is of the order of 0.17 billion dollars (on the assumption that the Canadian part of the network is paid for by Canada).

The shift in the distribution of warning times is shown on Figures 12a and 12b.

(5) Purchase of a reserve of SAC bombers. For this measure, 650 additional bombers are purchased (enough to replace the losses in the ZI shown in Fig. 6). This reserve is maintained in widely dispersed localities away from SAC bases. Enough maintenance is provided that these aircraft can be put into active

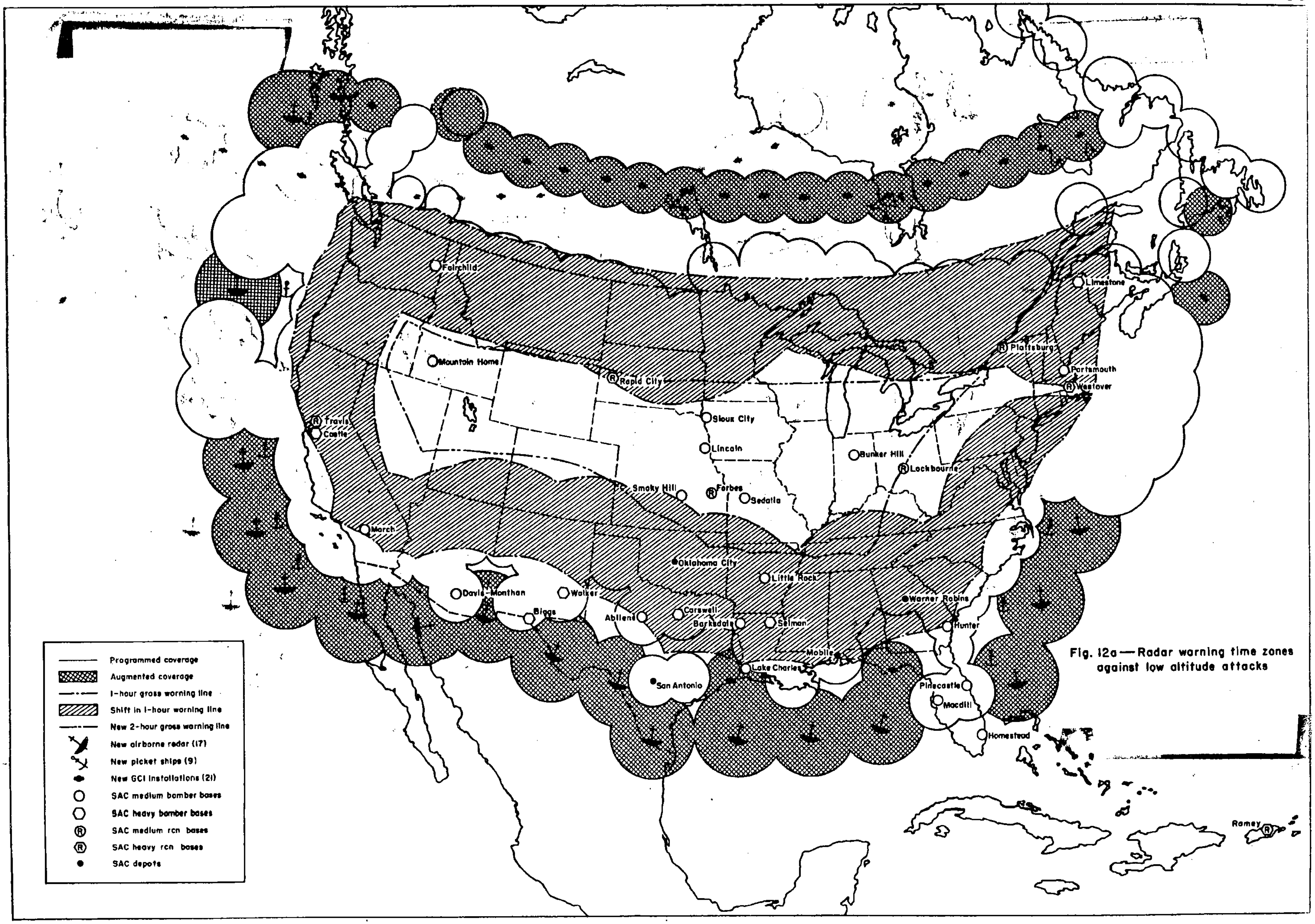



Fig. 12a — Radar warning time zones against low altitude attacks

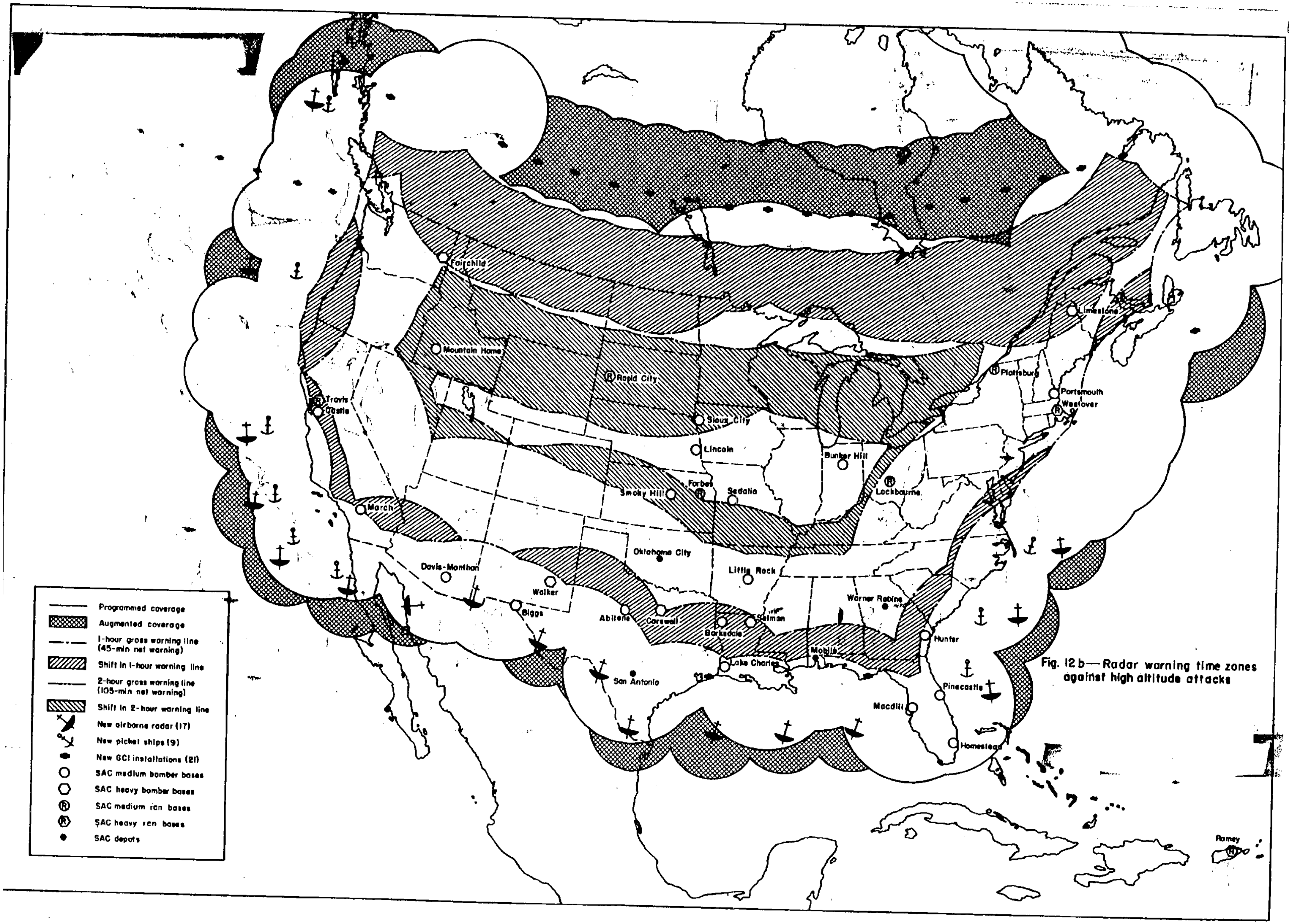


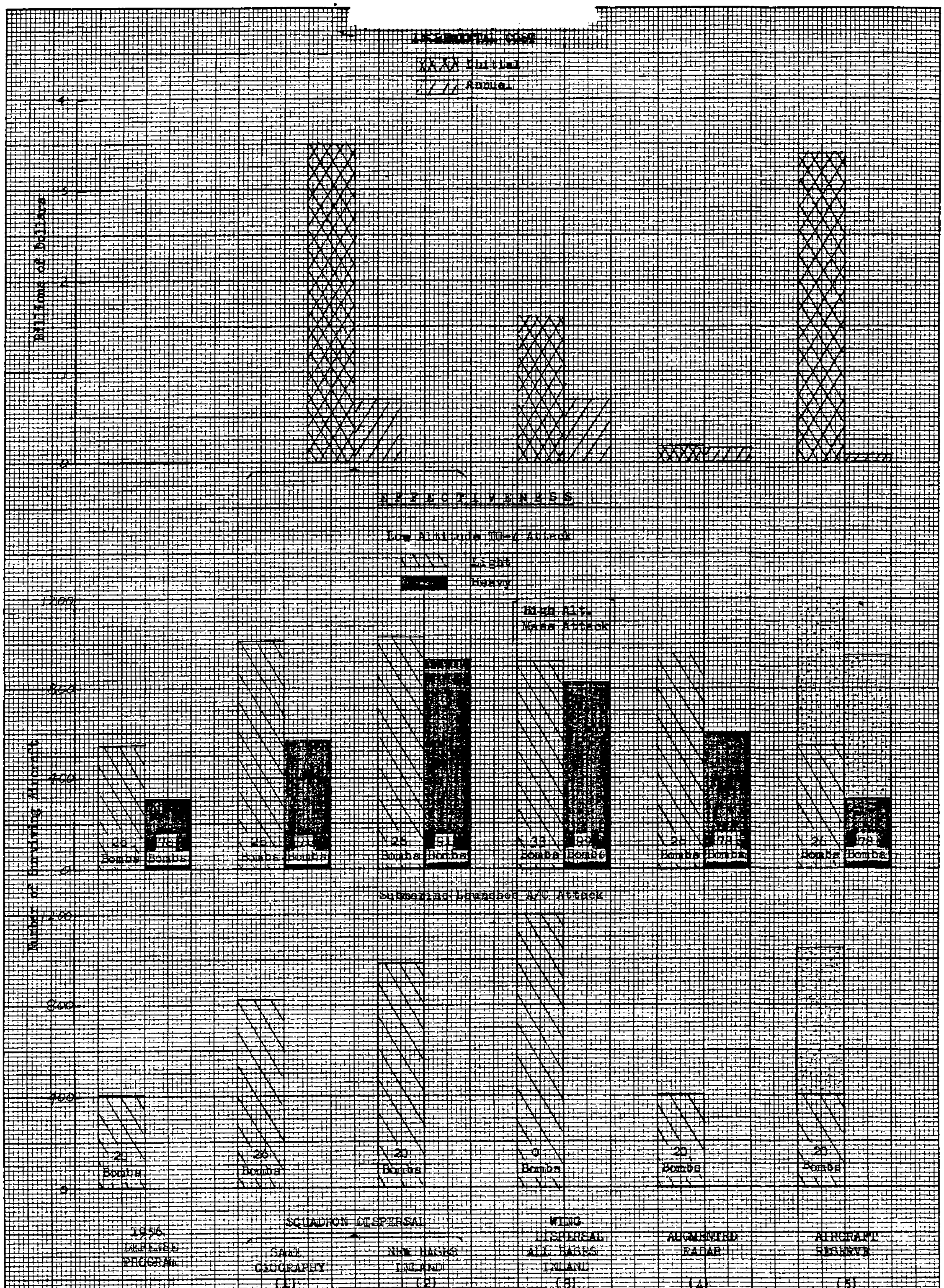

Fig. 12 b — Radar warning time zones against high altitude attacks service on short notice. The initial cost is 3.4 billion and the annual cost is 0.1 billion.

Measures (1) through (5) provide roughly the same protection in the case of the strategy which appears to have the highest probability of employment, namely, the low-altitude TU-4 attack. This is seen in Fig. 13 from the first bar in each set of the middle row. The investment and annual costs are shown in the top row of Fig. 13. It is seen that for this type of attack the augmented radar measure provides a fair dominance. It is important to note, however, that the success of this defense measure depends primarily on the increase in the kill probability against the incoming bombers which results from the longer combat time now available to the defense fighters and not from any substantial increase in the evacuation pattern. In fact, to gain appreciably by evacuation, the proposed radar augmentation should be coupled with an equivocal warning state.

One remark is in order regarding measure (3). The relocation of bases to the interior, in fact, forces the enemy to abandon the low-altitude attack which is no longer profitable and to shift to a high-altitude attack. This implies that in this case while spending approximately the same number of A-bombs as for the other measures, the enemy is forced to increase the total force of his aircraft committed to attack ZI targets from 26 to about 200.

We next consider the effect of an increased level of enemy attack still employing the low-altitude strategy (middle row of Fig. 13).

It is seen that the dispersal scheme which pays no attention to the geography of the new bases is a poor method of dispersal. In this case, by tripling his level of attack, if the effects of the possible loss of surprise with the larger attack is ignored, the enemy would succeed in producing roughly the same pattern of destruction as he did before dispersal. The radar




COMPARISON OF COST & EFFECTIVENESS OF SELECTED ZI DEFENSE MEASURES FOR SAC AGAINST SINGLE STRIKE SURPRISE ATTACKS, 1956

Figure 13

augmentation measure is likewise degraded. The other three, however, are not degraded appreciably. This points up the relative insensitiveness of losses to the size of attack for these measures. In case of measures (2) and (3) this is due, in large part, to the fact that most flyable aircraft have time to evacuate. In case of measure (5), a large fraction of the aircraft inventory is dispersed to localities not attacked.

We next consider the effect of a shift in enemy strategy to a submarine-launched attack. This is demonstrated in the bottom row of Fig. 13. We see that augmentation of radar has practically no effect on the submarine-launched strategy. The reason for this is that submarines surface off the coast inside the radar cover and are thus not hampered by extension of radar except insofar as AEW stations may pick up the surfaced submarines. (We take no account of this possibility in this computation.) Measure (3) does extremely well because the bases have all now been located outside the range of the submarine-launched aircraft. Measures (1) and (2) do about equally well, with measure (2) holding a margin because some of the bases are located outside the assumed range of the submarine-launched F-86 type aircraft. In the same way, the apparent advantage of measure (3) results from this arbitrary range limitation imposed by us on the range performance of the submarine-launched F-86-type airplane. It must be assumed that if this measure were to be implemented, and information regarding the relocation would be available to the USSR, the enemy would have no serious technical difficulties in extending the range of these aircraft to penetrate to the bases. Under these conditions measure (3) would not have such an overwhelming advantage over the others.

Another point of view must be brought to bear in the comparison of the investments involved in the five measures. Measures (1), (2), (3), and (5) call for budgetary increases to be allocated exclusively to SAC. Measure (4), on the other hand, has the quality of providing warning to ADC and the rest of the

ZI. Since such warning appears to be inadequate at this time, only a part of the cost of this measure should be charged to SAC.

A comparison between measures (1), (2), and (3) alone suggests that measure (2) is certainly preferable to measure (1) and that measure (3), in turn, is a much cheaper and more desirable one. It must be recalled, however, that measure (3) relies on evacuation of aircraft for a considerable part of its success. Under the present combat operations concept, medium bombers are redeployed overseas shortly after D-day; consequently the effectiveness of all measures is primarily concentrated during the first enemy strike. Should the operations concept be revised to hold a large percentage of the bomber force in the ZI and to operate from the ZI with forward staging, it is highly probable that it will be impossible to execute the evacuation plan repeatedly and still continue normal combat operations. Under these conditions it would appear that the lower concentration of aircraft provided by measure (2) would begin to justify the investment.

As a final remark it should be pointed out that measure (3), which calls for abandonment of a large segment of SAC base structure, would face grave political repercussions.

At this point, the comparison of the five measures is primarily useful for suggestion of directions of inquiry to be pursued. These areas follow:

(a) The desirability of a SAC-ZI dispersal scheme is closely tied in with the SAC operations concept.

(b) Augmentation of radar promises to provide relatively inexpensive and substantial protection. Investigation of other possible augmentation schemes and of the "joint-cost problem" with the remainder of the ZI should be pursued.

(c) On the other hand, radar augmentation, if used alone, would leave a gap in the defense against submarine-launched attacks.

## PART IV - CONCLUSIONS AND RECOMMENDATIONS

### CONCLUSIONS

This report is preliminary in nature: it deals only with a limited portion of the problem of SAC vulnerability, namely, the effect on SAC first strike sortie potential of a surprise 1956 enemy attack on SAC units in the ZI and overseas on rotation. For this reason, the list of conclusions that are based on the present limited scope of the study is incomplete and will be modified as work progresses.

The conclusions presented here are predicated upon the programmed 1956 SAC composition and deployment, upon the programmed warning and defense network, and on a projection to 1956 of current SAC operating procedures, as we understand them. Thus, the conclusions may be sensitive to major changes in programs or operating procedures between now and 1956.

The following four conclusions are concerned with the description and measurement of the effect of the initial enemy attack upon SAC first strike potential.

1. With the programmed SAC deployment and programmed 1956 warning and defense network, the enemy will have the capability of destroying a major part of SAC potential in a surprise attack at relatively small cost in bombs and aircraft. Employing a low-altitude attack with TU-4's or sub-launched aircraft the enemy could destroy two-thirds or more of SAC bomber and reconnaissance aircraft at a cost of 50 or fewer bombs and aircraft. The fraction of SAC personnel surviving is likely to be greater than that for aircraft; the fraction of flyaway kits surviving is likely to be smaller.

The degree to which the enemy succeeds in making an effective attack depends upon his capability to mount an attack and reach the radar network without giving enough advance warning to allow premature execution of SAC's evacuation plan, and also his capability to minimize penetration times thru the radar network. While this study has concerned itself with the examination of the second factor, it is apparent from the results that a substantial reduction in vulnerability would result from advance indications of enemy activity provided these could be translated into sufficiently unambiguous states of alert. From the limited data available at RAND, the probability of obtaining such warning and translating it into concrete SAC action appears to be small.

2. In addition to the delay in mounting the first strike caused by the physical destruction of aircraft, materiel, and personnel, a surprise enemy attack will disrupt the normal functioning of SAC and thereby effect certain delays in SAC deployment for damage assessment, and reorganization and reassignment of surviving units, personnel, and materiel. More serious delays due to overseas base denial would occur if the enemy chose to attack unoccupied as well as occupied overseas bases with ground-burst A-bombs or H-bombs.

3. An end-run enemy attack, penetrating the ZI warning and defense network from the south, is operationally feasible with TU-4 aircraft executing one-way refueled missions. Such routes would take the enemy bombers through the weakest section of the ZI warning and defense net. The submarine-launched aircraft or low-altitude TU-4 types of attack are much less costly in terms of aircraft lost and much more effective in terms of damage to SAC than the high-altitude TU-4 attack. The particular intensities of attack examined in the study are intended to illustrate relatively low-cost enemy strategies: for the low-altitude attacks, the cost to the enemy is 50 or fewer bombs and aircraft; for the high-altitude attack, the cost to the enemy is approximately 50 bombs and 300 aircraft. If the enemy launches a higher-cost attack, the results will be even more damaging to SAC. For example, an attack on both occupied and unoccupied SAC overseas bases, employing approximately 30 H-bombs, could possibly compel SAC to adopt a new operating procedure, such as mounting all of its strikes intercontinentally using aerial refueling.

4. With the present aircraft parking layouts most of the parked aircraft at a bombed base will be destroyed or seriously damaged, if the enemy employs A-bombs of 40 KT or greater yield, delivered with a circular error of less than 4000 ft.*, set for either ground-burst or air-burst**. Damage to the base, however, and the recuperability of the base, depend to a considerable extent upon the type of weapon and type of burst employed. The advantage to the enemy of employing bombs larger than 40 KT would accrue, not from additional aircraft destruction (since most of the aircraft are destroyed or seriously damaged by the smaller bomb), but from additional damage to the structures and facilities of the base. The advantage to the enemy of employing a ground burst would accrue from the increase in the period of base denial due to radioactive contamination.

a. Destruction of only the structures and facilities of the ZI bases of SAC medium bomber units does not reduce the SAC combat potential, at least for the first few SAC sorties, since, under the present employment concept, those bases serve medium bombardment units only until they can be deployed overseas. However, the accompanying destruction of personnel and materiel essential to the execution of the mobility plan does reduce SAC capability.

The following set of conclusions may be drawn concerning the interrelation of the programmed elements and operating procedures of SAC, the radar warning and defense network, and their effectiveness in defending SAC capabilities.

5. For the programmed SAC base locations and programmed SAC evacuation procedures, the warning time provided by the programmed ZI radar network is inadequate. For the majority of SAC bases the warning time will be insufficient

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* Some of the large French Moroccan bases are an exception. For these bases a 100-KT air burst is required to give almost complete coverage for a circular error of 4000 feet.

** This conclusion is sensitive in case of the ground-burst to the criterion for serious aircraft damage assumed. For this study, this was 4 psi. If, say, 6 psi were used, then coverage with a ground-burst 40-KT bomb delivered with 4000 feet circular error is likely to be only partial.

for SAC to evacuate or for fighter defenses to be brought to bear effectively, should the enemy attack with sub-launched aircraft or low-altitude TU-4's.

a. The warning time for ZI peripheral bases is inadequate and for interior bases is marginal at best. Peripheral bases such as March, for example, could receive as little as 10 minutes warning of an approaching enemy force; interior bases such as Forbes (Kansas) would receive at best about 2 hours warning*.

b. Radar coverage in the southern portion of the US is especially poor; bases in these areas would receive very little warning of an end-run low-altitude or sub-launched attack.

c. In view of the inadequate warning time provided by the programmed radar network, and the consequent inability of SAC to evacuate its bases, the portion of SAC which survives the initial attack does so largely because not all enemy weapons are delivered, due to operational difficulties, such as aborts, gross errors, and assumed limited range of sub-launched aircraft. Fighter defenses destroy only a small fraction of the enemy force before they reach the targets. With the programmed radar network, even doubling the interceptor effectiveness, for example, would increase SAC survival only slightly.

6. Unless the enemy chooses poor paths of approach to overseas bases, the warning times at such bases would be so short that evacuation of the majority of aircraft from these bases could not even be initiated.

7. Repaired aircraft will not contribute materially to the first strike sortie potential of SAC. The number of seriously damaged aircraft is small - most of the aircraft exposed to attack are destroyed (for the bomb sizes and CEP's considered). However, even this small number cannot be repaired and returned to service within the first month, because of the limited depot repair capability and the time delays involved.

* The estimates of net warning times clearly vary with the assumptions as to time delays from detection to receipt of warning by SAC, ability of the enemy to coordinate, and carrier speed. These factors are discussed in Conclusion 8.

In this study, a number of defense measures have been examined for their contribution to SAC survival. No preference can be expressed at this time for any particular defense measures (except for certain "low-cost" measures to be presented in the next section.) However, conclusions can be drawn regarding the effects and limitations of the several major defense measures, and these are set forth below.

8. In order to provide interior ZI bases (see Fig. 12a) with a two-hour warning of low-altitude TU-4 attacks, the gaps in the southern ZI radar screen must be eliminated, and the ZI radar coverage extended outward at least 200 to 300 miles; this augmentation would provide about one hour or less warning to peripheral bases. To provide a two-hour warning to peripheral bases as well would require a further extension of approximately 300 miles.

a. If AEW stations were used to achieve either of the above low-altitude radar extensions, the resulting high-altitude coverage would be approximately the same as the low-altitude coverage. It should be noted, however, that the presently programmed AN/APS-20B radar, carried in C-121 aircraft, is limited in high-altitude capability and has essentially no coverage above 40,000 ft. altitude.

b. The actual amount of warning available to SAC bases depends also upon the total time elapsed from the moment of detection of the enemy aircraft to the moment the order is given to SAC bases to evacuate; this period includes the time for identification of the aircraft as hostile, transmission of information to ADC Headquarters, decision by ADC Headquarters, transmission to SAC Headquarters, decision by SAC Headquarters, transmission of warning to SAC bases, and decision by the SAC base commander to order evacuation. In this study, the total time required for this transmission process was assumed to be 15 minutes. If this transmission process should turn out in practice to require more than 15 minutes, the radar coverage must be extended accordingly, at the rate of approximately 75 miles for each additional 15 minutes of TU-4 flight.

c. For this report, enemy attacks were assumed to be closely coordinated. It would appear at this time that the enemy has enough reserve range capability to delay the penetrations of early arrivals. Late arrivals might have to penetrate the warning net after the alert was already sounded; in this case bases attacked by such aircraft would get some extra warning.

d. If the enemy employs aircraft of greater speed than TU-4's, the warning time is decreased accordingly; two hours of warning provided against TU-4 attack would be reduced to about $1\frac{1}{2}$ hours if aircraft of about 450 knots speed were employed.

e. In addition to increasing the capability of SAC to evacuate, extension of ZI radar coverage by distances up to 300 to 500 miles increases the fighter defense capabilities by providing a longer time period in which to attack enemy bombers. With programmed fighter defenses, a two-hour warning time would assure that single TU-4 low-altitude enemy penetrations would have a fairly low probability of surviving to reach an interior target.

9. An outward extension of the ZI radar coverage would not increase the protection against enemy attacks by sub-launched aircraft or sub-launched missiles since submarines can penetrate the radar net and surface well inside before being detected. To protect against this contingency, the extension of radar coverage should be supplemented by anti-submarine detection measures.

10. Improvements in the accomplishment of SAC evacuation must come largely through increase of the net warning time available to SAC. With the programmed SAC base locations and programmed radar warning network, the net warning time for most bases, after allowance for the time to transmit the warning to SAC bases, is considerably less than one hour. Even with substantial improvement in SAC evacuation procedures, it appears highly unlikely that SAC evacuation

times can be reduced to this level. Even if SAC personnel were recalled to base upon receiving advance warning of a possible enemy attack, and maintained on standby status, it appears that evacuation would still require about $1\frac{1}{2}$ hours for a 2-wing base, and about an hour for a 1-wing base.

11. Dispersal of SAC units by replication of bases, with consequent lower concentration of aircraft, personnel, and materiel per target has the advantage of materially reducing the damage to SAC for a given weight of enemy attack. On the other hand, the effectiveness of dispersal is determined primarily by the relationship between the degree of dispersal and the size of enemy weapon stockpile. (A secondary effect of compelling the enemy to employ larger force sizes is the decrease in his effectiveness because of the loss of surprise, since the appearance of large numbers of unidentified aircraft on the radar scopes would be quickly interpreted as an enemy attack.) Furthermore, dispersal is very expensive and, at this time, (See Part III, Section 4, and Appendix B) there appears to be a number of other less expensive measures of comparable effectiveness.

a. <u>If dispersal is to be used, the most effective location for the additional bases required for dispersal is in the interior of the ZI</u>. Location of new bases in this area in addition to the pure dispersal effects noted above, has the further effect of decreasing enemy damage by permitting more complete evacuation in the event of attack.

12. <u>Under the current SAC operations concept, base dispersal of SAC medium bombardment units in the ZI affords protection only to SAC capability and only against the first enemy strike</u>, since these units are deployed overseas soon after D-day. On the other hand, increased ZI fighter defenses and increased ZI radar coverage protect not only SAC facilities but concurrently, other installations in the ZI against the initial enemy strike. Moreover, after SAC units have moved overseas, these measures can be used to continue

providing defense of the ZI against subsequent enemy attacks.

RECOMMENDATIONS

Only a partial list of recommendations can be presented at this stage of the study. The recommendations are divided into three types: first, certain low cost measures which appear to be clearly desirable are recommended for immediate implementation; second, further study is recommended for certain promising measures which nevertheless require additional investigation before implementation is undertaken; and finally, in certain areas where a definite need for improvement is evident but no preferred defense measure can be suggested at this time, a recommended performance goal is listed.

A. Recommended for immediate action.

The following measures can be recommended for immediate implementation on the basis of the results to date. These measures are all of relatively low cost, involving no major increases in the Air Force budget.

1. All programmed ZI SAC bases now planned for areas with little warning and not yet under construction should be relocated to interior areas which have maximum available warning.

2. All overseas bases should be provided with an adequate operating storage of POL which is relatively invulnerable to enemy attack. This means either storage underground or dispersal at off-base sites.

3. Flyaway kit spares should be stored at off-base sites. Storage off-base of a reserve of particularly vulnerable and specialized items of equipment, such as electronic test equipment, is also desirable.

4. In view of the high vulnerability of SAC units on rotation overseas, these units should be dispersed to at least squadron level in all overseas base areas where there is an adequate number of bases.

5. More effort should be devoted to passive defense against air attack at both ZI and overseas SAC bases.

a. Wherever base facilities permit, there should be a plan for rapid emergency dispersal of aircraft to the perimeter of the base and for surface evacuation of materiel and personnel. Taxiing aircraft off base if insufficient time were available for takeoff should also be considered.

b. Protection for personnel in the form of shelters or slit trenches should be provided at all SAC bases.

c. Plans should be formulated and tested for the effective assessment of damage and rapid communication of that information to the proper headquarters of SAC.

d. Measures for control of damage and base decontamination should be given more emphasis. All stocks of equipment and supplies maintained for this purpose should be stored off base. This is particularly important in base areas far from population centers (e.g., French Moroccan bases), since in such areas there would be little chance of acquiring the proper equipment from outside sources.

6. SAC should inject as much realism as possible into tests of its evacuation and base defense plans by conducting these tests jointly with ADC, and on occasion other commands. As an example, Flying-Training Air Force could send some aircraft simulating enemy bombers through the ADC network to SAC bases, using likely Soviet routes and tactics. ADC would then notify SAC that enemy bombers were on the way and give them an ETA. SAC would then implement either its evacuation or dispersal plan in a manner deemed advisable by the circumstances. The Flying-Training Air Force aircraft could simulate actual bomb runs on SAC bases. By locating the GZ, SAC plans for damage assessment and control could be tested as a part of the exercise. The exercise should include takeoff of aircraft and should be carried through to the communication of the damage assessment information to the appropriate headquarters,

and, perhaps, practice in revising current war plans to fit the damage situation.

7. Stocks of aircraft parts and equipment should be based on the best available estimates of expected wartime, rather than peacetime, consumption. Two particular examples are allowances for battle damage and ground damage. For instance, such items as hatches, bomb bay doors, and window panels most easily damaged by A-bomb blast are almost certain to be in demand above present stock levels.

8. The gaps in the low altitude warning net cover in the southern states should be filled.

a. In particular, 4 additional radar sites should be located in Texas, 2 in Florida, and 1 in the southwest portion of Arizona.

b. In addition, GOC stations should be formed in the southern peripheral states.

B. Recommended for further study.

The following measures appear promising but require further investigation before implementation is undertaken. In some instances, these measures will be studied as a part of the present study at RAND. In others, however, there are operational questions involved which cannot be effectively dealt with without active participation by SAC.

Except where otherwise indicated, the measures listed below are of relatively low cost, and so each can be judged individually solely on the basis of its effectiveness vs. its effect on SAC's ability to perform its assigned combat mission.

1. The possibility of exchanging bases between SAC and other commands in the ZI so that SAC bombers are as much as possible to the interior should be seriously considered by the USAF.

2. Overseas rotation policies should be reviewed with the aim of either

reducing the number of SAC units on rotation overseas to the minimum consistent with the constraints of national policy and the proper training of SAC units, or giving these units the mission and the means for very quick retaliation against an enemy attack.

3. Serious attention should be given to measures which confuse the enemy as to the probable future deployment of SAC units on rotation and likely wartime deployment. Examples of such measures are: removal of peacetime markings, frequent movement from base to base of units on rotation, and variation of the bases to which units deploy on rotation both within a given overseas base area and among base areas.

4. The feasibility of towing or taxiing aircraft off base via access roads in case there is insufficient time to evacuate should be investigated. The number of access roads might also be increased in this connection.

5. The storage of a ready reserve of aircraft should be studied. In this type of storage, the reserve aircraft would be located and maintained in combat-ready condition in widely dispersed localities. The stored aircraft could be either a part of programmed TO&E of SAC wings or additional production.*

6. Provision of peripheral low-altitude radar cover to protect against very low-altitude penetrations should be considered. This measure is somewhat out of the low-cost category. All anti-submarine detection measures which show promise should be carefully considered.

7. Reporting of all aircraft sightings by ships traveling northern Atlantic and Pacific routes should be considered. This program could be undertaken on an experimental basis using U.S. government vessels only, for the purposes of establishing its effectiveness, data handling procedures, and alarm procedures. The feasibility of the program would then determine whether an attempt to extend it to all NATO flag ships should be undertaken.

* The storage costs are believed to be small. The cost of buying additional aircraft is, of course, not.

C. Recommended Performance Goals.

Thre are many areas in which a definite need for improvement has appeared, but for which no preferred remedial measure can be recommended at this time. The direction and degree which improvement should take are listed below for some of the more important of these areas.

1. It appears that in order to give SAC units in the ZI a fair chance of survival via evacuation, additional warning should be provided at most ZI SAC bases. This must be accomplished by some combination of additional radar, relocation of SAC bases, and decreasing time lags from detection to receipt of warning at SAC bases. Radar augmentations must be accompanied by anti-submarine detection measures in order to insure all-around protection.

Such improvements in the warning picture should be accompanied by improved SAC evacuation procedures. Certainly whatever reduction in SAC warning time requirements can be achieved is to the good, in view of the substantial amounts of such costly measures as new base construction and radar coverage needed to buy SAC extra warning time. A reasonable goal for the warning network would appear to be to furnish at least 1-1/2 hours warning at all SAC bases in the ZI. Correspondingly, the maximum time for SAC to evacuate its bases in condition Able (i.e., aircraft in minimum flyable condition) after receipt of warning would be reduced to 1-1/2 hours.

2. From the information presently available at RAND it appears that under present SAC plans and with programmed SAC overseas facilities, SAC units will have to spend at least 24 to 36 hours at overseas bases before mounting the first strike. It appears that during this length of time the enemy will have little difficulty in obtaining good information concerning SAC's whereabouts and mounting a strike against the occupied overseas bases. In view of the high probability of such an attack, the time spent by SAC on its forward bases

before the first strike should be kept at a minimum. Such measures as provision of more refueling equipment and use of ferrying crews may be required to achieve this. The desirability of mounting AEW aircraft and standing air patrols in overseas areas during SAC occupancy should also be studied in this connection.

3. There ought to be a clear-cut and relatively unambiguous set of ground rules for translating indications of enemy activity (equivocal warning) into corresponding states of U.S. alert. The scanty information available at RAND suggests that, while trigger agencies are assigned the mission of this translation, the corresponding ground rules do not seem to be clearly formulated.

The circumstances attending Pearl Harbor and the initiation of the Korean war show that the mere existence of indicators of enemy activity does not necessarily guarantee that these will be translated into adequate states of national alert.

4. Procedures should be established and arrangements made which will permit SAC to make more effective use of alert states based on the imminence of hostilities. For those SAC bases where the warning provided by ADC is likely to be very short, any evacuation would have to be undertaken before receipt of warning that an attack is actually underway. An example of a measure which could be undertaken in the event of advance alert is a dispersal of SAC units in short-warning zones to other USAF airfields and civil airports. Actions of this sort would, of course, have to be worked out in advance. On the other hand, in areas where the times provided by the warning net are marginal or better (for example, one hour or more), less disruptive procedures, such as maintaining standby crews and generally bringing all units to a high state of readiness, are likely to be of substantial value.

## APPENDIX A

## MATHEMATICAL STRUCTURE OF THE PROBLEM

In describing the interaction between the basic independent variables, a type of mathematical symbolism is used. This symbolism is used merely to provide a concise form for indicating the relationships among the variables and is not meant to imply that the variables involved are defined in precise mathematical form. For those readers who may prefer to avoid the symbolism, the interactions are also described by a listing of the relevant variables in each case.

(1) The enemy controls* the following variables:

(1.1) $\{T_k\}$ - Set of targets to be attacked.

(1.2) $\alpha$ - Type of carrier assigned to the attack.

(1.3) - Bombs; including

(a) KT - Bomb yield

(b) $\{W_k\}$ - number per target.

(1.4) $\mu$ - Tactic variables which describe all cell sizes, paths of approach to defenses, and flight profile (speeds and altitudes).

(1.5) $\tau$ - Time of attack.

Items (1.2) through (1.5) will, in general, vary from target to target. The set of items (1.1) through (1.5) describe an <u>enemy strategy</u>.

We use superscript $j$ to designate types of aircraft at SAC bases ($j = 1$ for MB; $j = 2$ for HB, etc.), the subscript $k$ to designate particular SAC bases and facilities, and the subscript $i$ to designate the vulnerable

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* For definition of "control", see footnote, p. 6.

components of a given facility (such as a/c, personnel, flyaway kits, POL, etc.)

The U. S. Controls* the following variables:

(2) SAC variables.

(2.1) $\{B_k\}$ - SAC bases; number and geographic location.

(2.2) $\{G_k\}$ - Physical layouts of bases.

(2.3) $\{F_k^j\}$ - SAC units; strength, type, and deployment. $F_{ik}^j$ denotes the amount of the ith component of a jth type unit located on base $B_k$.

(2.4) C - Concept of operations together with specific ground rules for strategic bombing in case of war. This includes base utilization pattern, size and timing of missions and tactics.

* For definition of "control", see footnote, p. 6.

(2.5) Alert procedures to be followed on receipt of warning of probable enemy raids.

(2.6) The information available to the enemy regarding time-phased distribution of SAC aircraft on its bases.

(3) Air defense and warning variables which affect the vulnerability of SAC.

(3.1) R - Warning network including location, type, number, and operations concept of the radar network, Ground Observer Corps, and other warning devices.

(3.2) A - Area defense including location, type, number, and operations concept of the interceptor network.

(3.3) - Channels and procedures for identification of hostile aircraft and transmission of warning to SAC.

(3.4) L - Local defenses, including location, type, number, and operations concept.

(4) Air Materiel variables which affect the vulnerability of SAC:

(4.1) - Maintenance support for SAC

(4.2) - Supply support available to SAC.

(4.3) - Materiel and personnel prestocked at overseas bases.

(5) Certain critical inputs to SAC which are required for normal combat operations are controlled by other Air Force and civilian agencies such as AEC (bombs), MATS (airlift), CAA (flight control), Hq. USAF (warning and command), ADC (warning and air defense), AMC (maintenance and supply support), civilian economy (electric power, etc.), and so on. With the exception of the role of ADC and AMC (see 3 and 4 above,) these have not yet been properly investigated in the present phase of the study. We lump all of them under the generic symbol I.

(6) The following important variables are exogenous to the problem:

(6.1) - Weather conditions over SAC bases at time of enemy attack. Probability of good weather is denoted by $p^W$.

(6.2) - The amount of equivocal (pre-D-day) warning available. We treat this variable as exogenous because of the lack of information on the mechanism and controls set up to obtain such advance warning.

(6.3) - The information available to SAC for planning purposes regarding the information pattern at SUSAC's disposal.

(7) The following state variables are of importance to the problem:

(7.1) - Performance characteristics of enemy bombing and navigation systems including:

(a) $p^a$ - The probability that the bomb carrier aborts.

(b) $p^g$ - The probability that the bomb carrier makes a gross error.

(c) CEP - This is influenced by the weather conditions at the time of attack and the bombing altitude.

(7.2) $\hat{R}$ - Performance characteristics of the warning network

(7.3) $\hat{A}$ - Performance characteristics of the area defenses.

(7.4) $\hat{L}$ - Performance characteristics of the local defenses.

(7.5) $\dot{x}$ - Physical damage criteria (critical over-pressures for various levels of damage and so on).

For simplicity of notation, dependences on the subscripts i, j, k will not be explicitly shown in items 8 through 10, but will be indicated in the text.

The interaction between the basic variables proceeds as follows:

(8) As enemy aircraft approach the defense network, they are spotted by radar, identified as hostile, and attacked by area defenses. The raid is

assessed and warning of attack is transmitted to SAC and other agencies. This interaction determines:

(8.1) $p^A$ - The conditional probability of a particular enemy carrier en route to a base B being killed by area defenses. This is determined by the variables (1.2), (1.4), (2.1), (3.1), (3.2), (7.1), (7.2), (7.3). Thus:

$$p^A = p^A(\alpha, \mu, B, \gamma(1-p^a), r, A, \hat{A}) \qquad (1)$$

where

$\gamma$ = size of cell dispatched, and

$r = r(B, \Pi, R, \hat{R})$

is the distance between point of detection by the warning net R and the base B to be attacked, and $\Pi$ is the path of approach to the warning and defense net. (The abort probability $p^a$ influences the cell size penetrating area defenses, and hence influences $p^A$).

(8.2) $p^L$ - The conditional probability of a particular enemy carrier being killed by local defenses. This is determined by (1.2), (1.4), (3.4), (7.1), (7.4), (8.1). Thus:

$$p^L = p^L(\alpha, \mu, \gamma(1-p^a)(1-p^A), L, \hat{L}). \qquad (2)$$

(8.3) $t^w$ - The net warning time available at SAC bases. The variables are (1.4), (2.1), (3.1), (3.3), (6.2), (7.2).

$$t^w = \frac{r}{\sigma} - t^o,$$

where

$\sigma$ is the speed of the carrier and $t^o$ is the time for transmission of warning to SAC. $t^o$ depends on (3.3) as well as the equivocal warning received by ADC prior to the time of attack.

(9) Upon receipt of warning at SAC bases, evacuation is ordered by the base commander. Items (1.5), (2.3), and (2.5) then determine:

(9.1) $f(t)$ - The fraction of a given component (aircraft, personnel, or or materiel) exposed on a SAC base at time $t$ after receipt of warning. The concentration at instant of enemy bomb release is then $f(t^w)$. The evacuation curve $f(t)$ is different for different components i, and also varies with the size of the force stationed on a base and the time $\tau$ of enemy attack. In case of equivocal warning, $f(t)$ is replaced by $f(t - d)$, where $d$ represents a shift (which in general varies from component to component) in the time at which evacuation begins due to more rapid assembly of personnel and equipment.

(10.) The level of physical destruction to a SAC facility is determined by (1.3)(a), (2.2), (7.1)(c), (7.5), (8.3), (9.1). Given a bomb drop,

(10.1) $q(x)$ - The fraction of a particular vulnerable component on a particular base suffering damage at or above level x (x being in psi, cal/cm$^2$, etc.) is given by:

$$q(x) = f(t^w)q(x, G, KT, CEP). \tag{4}$$

(11.) The damage to the entire SAC force and base system is determined by (1.1), (1.3)(b), (2.3), (7.1)(a)(b), (8.1), (8.2), and (10.1). To make dependences on the subscripts i, j, k clear when aggregating the various damages, these subscripts are now included. Thus:

(11.1) $\left\{D_{ik}^j\right\}$ - The overall damage pattern for the ith component on bases housing jth type units is given by:

$$\left\{D_{ik}^j\right\} = D\left[\left\{T_k\right\}, \left\{W_k\right\}, \left\{p_k^s\right\}, \left\{q_{ik}^j(x)\right\}, \left\{F_{ik}^j\right\}\right] \tag{5}$$

where

$$p_k^s = (1-p_k^a)(1-p^g)(1-p_k^A)(1-p_k^L)$$

is the probability that a particular bomb carrier successfully arrives over the target and releases the bomb and x has values corresponding to the various damage levels specified (destruction, major damage, etc.)

(12) After the initial enemy attack, recuperation begins and SAC prepares to mount its first strike. At this point SAC must no longer be considered to be a set of physical entities (bases, aircraft, etc.) rather, SAC together with the supporting members of the Strategic Striking Complex should be regarded as a set of <u>activities</u> whose combined output is combat sorties.

After enemy attack, damage assessment is made, plans are revised and units are reformed. The SAC commander deploys his reconstituted force for the first strike in accordance with the concept of operations C, modified to take into account the various constraints, such as time delays and limitations in base availability, brought about by the damage situation. The variables are (2.3), (2.4), (4), (5), (11.1).

(12.1) $\left\{F_k^j(t)\right\}$ - Strength, type, and deployment of surviving and reconstituted SAC units at time t is given by:

$$\left\{F_k^j(t)\right\} = F\left[\left\{D_{ik}^j\right\}, \left\{F_{ik}^j\right\}, M, C, Q_k^j \left\{U_k^j(E+h)\right\}, \left\{\bar{t}\right\}, t\right] \quad (6)$$

where

M is a measure of base and depot capability to repair damaged aircraft,

(12.2) $U_k^j(t)$ - is a measure of the capacity of the kth base to support operations of type j units,

$Q_k^j$ is a measure of the maximum allowable concentration of SAC forces on overseas bases, and

(12.3) $\left\{\bar{t}\right\}$ - is a set of time delays due to confusion, strike replanning, reassigning crews to targets, and so on.

(13) The first strike sortie capability as a function of time after enemy attack is then determined by (2.4), (5), (12.1), (12.2), (12.3).

(13.1) S(t) - the sortie potential at time t is given by:

$$S(t) = S\left[C, \left\{F_k^j(t)\right\}, Q_k^j \left\{U_k^j(t)\right\}, I(t), \left\{\bar{t}\right\}, t\right] \quad (7)$$

where

I(t) is a measure of the availability of critical inputs (e.g. A-bombs) required by SAC.

## SUMMARY OF SYMBOLS USED

Enemy Variables - (Greek Letters)

$\alpha$ - Type of enemy carrier assigned to the attack.

$\gamma$ - Size of cell dispatched.

$\mu$ - Tactic variableswhich describe all cell-sizes, paths of approach to defense, and flight profiles (speeds and altitudes).

$\pi$ - Path of approach of enemy aircraft to the warning and defense net.

$\sigma$ - Speed of the carrier.

$\tau$ - Time of the attack.

U.S. Variables - (Roman Letters)

A - Area defense including location, type, number and operation concept of the interceptor network.

$\hat{A}$ - Performance characteristics of the area defenses.

$\{B_k\}$ - The set of SAC bases; their number and geographic location.

C - Concept of SAC operations together with specific ground rules for strategic bombing in case of war. This includes base utilization pattern, size and timing of missions, and tactics.

CEP - Circular probable error of the enemy's bombing system, - a measure of the amount of possible variation in actual bomb fall about the aiming point.

$\{D^j_{ik}\}$ - The overall damage to the i-th component at all bases housing j-th type units.

d - The amount of shift in the time at which evacuation begins, due to pre-planning after equivocal warning.

E - The day on which hostilities begin (for the undamaged case, the day on which SAC is ordered to attack the enemy; for the damaged case, the day on which SAC is attacked).

$F^j_{ik}$ - Amount of the i-th component of a j-th type unit located on base $B_k$.

$\{F^j_k\}$ - This set of SAC units; their strength, type and deployment.

f(t) - The fraction of a given component (aircraft, personnel, or materiel) exposed on a SAC base at time t after receipt of warning.

$f(t^w)$ - The fraction of a given component exposed on a SAC base at instant of enemy bomb release.

f(t-d) - The fraction of a given component on a SAC base at time t after receipt of warning, when prior equivocal warning has been received and pre-planning for evacuation executed.

$\{G_k\}$ - The physical layouts of the SAC bases.

h - The number of days delay after the initial enemy attack before SAC units are ordered to execute the war plan.

I(t) - A measure of the availability of critical inputs (e.g., bombs, airlift, maintenance and supply support, etc.) required by SAC.

i - Subscript designation of a vulnerable component of a SAC facility (e.g., aircraft symbolized by i = 1, personnel by i = 2, etc.)

j - Superscript designation of a type of SAC aircraft (e.g., MB denoted by j = 1, HB by j = 2, etc.)

k - Subscript designation of a particular SAC base (e.g., Abilene denoted by k = 1, Barksdale by k = 2, etc.)

KT - Bomb yield, in kilotons of high explosive.

L - Local defenses, including location, type, number and operations concept.

$\hat{L}$ - Performance characteristics of the local defenses.

M - A measure of base and depot capability to repair damaged aircraft.

$p^A$ - The conditional probability that a particular enemy carrier en route to a base B is killed by area defenses before reaching the target.

$p^a$ - The probability that the bomb carrier aborts.

$p^g$ - The probability that the bomb carrier makes a gross error.

$p^L$ - The conditional probability that a particular enemy carrier is killed by local defenses before reaching the target.

$p_k^s$ - The probability that a particular bomb carrier successfully arrives over the target and releases the bomb.

$p^w$ - The probability of good weather over SAC bases at the time of the enemy attack.

$Q_k^j$ - A measure of the maximum allowable concentration of SAC forces on overseas bases prior to the first strike.

q(x) - The fraction of a particular vulnerable component on a particular base which suffers damage from the enemy bomb, when the criterion for such damage is x or greater (x being in psi, cal/cm$^2$, etc.)

R - Warning network, including location, type, number, and operations concept of the radar network, Ground Observer Corps., and other warning devices.

$\hat{R}$ - Performance characteristics of the warning network.

r - The distance between the point of detection by the warning net R and the base B to be attacked.

$S(t)$ - The SAC first strike sortie potential at time $t$.

$\{T_k\}$ - The set of SAC targets to be attacked by the enemy.

$t$ - A point of time after the receipt of warning at a SAC base.

$\bar{t}$ - A set of time delays after theenemy attack caused by confusion, strike replanning, reassigning crews to targets, etc.

$t^o$ - The interval of time required for transmission of warning from ADC to SAC.

$t^w$ - The net warning time interval available at a SAC base.

$U_k^j(t)$ - A measure of the capacity of the K-th base to support operations of j type units.

$\{W_k\}$ - The number of bombs per target which the enemy employs.

$x$ - Physical damage criteria (critical overpressures for various levels of damage, etc.).

## APPENDIX B

## CLASSIFICATION AND DISCUSSION OF DEFENSE MEASURES

In this Appendix the list of U.S.-controlled* characteristics of the vulnerability problem (as set forth in Appendix A) is used as a format for the classification of defense measures. Following each such listed characteristic are shown the defense measures related to it. The effect of each such defense measure on SAC combat potential is discussed.

Since most of our attention so far has been devoted to the effects of the first enemy strike, a majority of the measures will deal with SAC units deployed in the ZI. Measures that apply to operations after the first strike will be singled out as such. (The numbering of characteristics of the vulnerability problem used below is similar to that used in Appendix A.)

(1) Enemy Variables (not within our power to "control")

(2) SAC Controlled Variables

(2.1) SAC bases; number and geographic location.

Both the area defense kill probability and the warning time available to a base increase with the penetration distance, r, between the point of detection and identification and the base. Because of this dual effect, defense measures which increase r can be expected to be particularly effective. One way to increase it is to relocate bases to the interior. The following relocation variants can be considered:

(a) Relocation of new bases which have been programmed but not yet constructed. Since the ZI base program calls for the construction of only a small number of new bases by 1956, this measure will have a relatively small effect. On the

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* For definition of "control", see footnote, p. 6.

other hand, it involves no increase in SAC budget.

(b) Relocation of all SAC bases which have insufficient r. This, in effect, would call for abandonment of all but six of SAC bases programmed for 1956 and for construction of a set of new bases in the interior of the U.S. This and the preceding measure will be discussed further in the next section.

(c) Relocation in conjunction with dispersal (see (2.3)(d) below). This is a "combination" measure which would reduce average concentration of SAC forces and at the same time provide a larger r for the new bases.

(2.2) Physical Layout of Bases, $G_k$.

The physical layout of bases affects vulnerability in two ways; through the geometric distribution of the vulnerable components on the base, and through the protection provided by the structures on the base to these components. Changes in each of these factors affect the coverage $q_i$.

The reduction in the damage level that might result from modification of the physical layout of a base is quite sensitive to the KT of the bomb and CEP. With the efficiency of A and H-bombs rapidly increasing with time, modifications of the physical layout of the base effective against bombs of present yields may become ineffective for higher-yield bombs.

To date we have done very little work on measures dealing with modification of the physical layout of bases. However, the results available indicate that at least the following measures deserve serious attention.

(a) It appears that perimeter parking of aircraft increases somewhat the probability of their survival for moderate sizes (40 to 100 KT) of A-bombs and HE attack.

(b) Provision of personnel shelters and/or slit trenches is an effective and relatively inexpensive means for protecting personnel over a large range of bomb sizes.

(c) Storage of POL underground or at dispersed off-base sites, particularly in overseas areas.

(2.3) Number of units and amount of aircraft, personnel, and materiel $F^j_{ik}$.

The size of the enemy's set of selected targets $T_k$ and hence his total bomb $W_k$ and aircraft requirements for a given level of destruction are determined by the number of aiming points presented by SAC. Permanent pre-D-day dispersal which reduces $F^j_{ik}$ at each base is a means for increasing this requirement. Specific measures in this class are:

(a) An increase in the total number of bases and a consequent <u>reduction of</u> $F^j_{ik}$ <u>per base, say, to squadron level</u>. The idea is to disperse the force in "balanced packages" (in the same proportion for all vulnerable parts in each package as in the rest of the wing). We shall refer to this type of measure as "<u>balanced dispersal</u>".

(b) <u>The storage of some base equipment and stocks in other localities</u> (e.g. small equipment, reserve stocks). The idea behind this "<u>component dispersal</u>" is that some components of the wing are more vulnerable than others (for example, aircraft may get enough warning to evacuate, while materiel will be left behind and destroyed). The aim of component dispersal is to provide a balanced combination of surviving resources after damage (or an unbalanced combination which can recuperate quickly). An example of such a measure is storage of flyaway kits off SAC bases.

(c) A measure identical in effect to the preceding which is an example of an unbalanced but highly recuperable component dispersal is to keep at all times, say, 50% of organizational aircraft dispersed at non-SAC facilities. (This is different from mothball storage since the dispersed aircraft are rotated and maintained in combat readiness.)

(d) Combination of dispersal with relocation mentioned above in (2.1)(c). Under this measure $F^j_{ik}$ is reduced to, say, one squadron per base and all of the new bases are built in areas with r as large as possible.

(e) For units on rotation overseas dispersal can be attained by a policy of deploying not more than one squadron per base. The present SAC base development program may make this possible for the number of units scheduled for rotation.

(f) Review of overseas rotation policies with the aim of either reducing the number of SAC units on rotation overseas to the minimum consistent with the constraints of national policy and the proper training of SAC units, or giving these units the mission and the means for very quick retaliation against an enemy attack.

(2.4) Concept of Operations.

The concept of combat operations, C, determines, in part, the SAC base utilization pattern after D-day, as well as the size and frequency of SAC strikes to be mounted from each base. Since the enemy capability for mounting attacks against different SAC base areas varies considerably, the base utilization pattern will importantly affect the vulnerability of SAC units to this attack. The planned timing and size of SAC missions will further affect the degree of SAC dispersal in the various base areas: if a large number of sorties is to be flown simultaneously from a given base area, it may become necessary to deploy as much as one or two wings per base, thus presenting an attractive target to the enemy. If, on the other hand, it is decided that smaller but more frequent missions are to be flown, it will be possible to reduce the concentration of SAC bombers on bases to a much lower level.

While modification in the combat operations concept are thus seen to have a very important effect on the vulnerability of SAC units, they may be most difficult to bring about since they are a product of the over-all strategic concept for waging the war. Any modification of the concept requires information for decision at a higher level than that possessed by this team. However, to aid in the decision process several variants in the operations concept are being considered in this work.

The following major variants in SAC operations concept should be compared for their relative vulnerability and combat effectiveness:

(a) A SAC counterpart of the tactical split-wing concept under which about 2/3 of each unit is deployed overseas where it conducts intensive operations. The remaining third undergoes maintenance, training, and re-equipping in the ZI. Regular rotations of squadrons is maintained.

(b) Deployment of the bulk of the medium bomber force to forward areas, where it flies a number of intensive missions in rapid succession and then re-deploys back to the ZI for maintenance and recuperation, leaving only the unflyable aircraft in the forward areas.

(c) Use of forward areas <u>for staging</u> only, with maximum utilization of programmed operations and staging bases to permit dispersal.

(d) Intercontinental operation of all medium bomber units, with air-to-air refueling. (The relative costs of implementing the last two variants have recently been compared in another RAND study. The results of the comparison indicate that concept (c) is to be preferred to concept (d).

(2.5) Alert Procedures on Receipt of Warning

The alert procedures on receipt of warning are all aimed toward reducing that part of the force that is exposed at the instant of enemy attack. The defense measures in this category must be classified according to the type of warning available:

<u>Unequivocal Warning</u> which states with virtual certainty that enemy attack is on the way. A characteristic of unequivocal warning is the <u>short</u> interval between announcement and arrival of the attackers over target.

<u>Equivocal Warning</u> which states that there is likely to be an enemy attack at almost any moment. The general characteristic of equivocal warning is that as the probability of attack increases, the interval between announcement and attack, if it occurs, becomes shorter. Consequently, equivocal warning in general is not a "one shot" proposition; it may be <u>repeated several times</u> before a real attack occurs.

<u>Unequivocal Warning</u>

(a) A measure planned to be implemented by SAC is its flyaway plan which provides for take-off of aircraft upon receipt of warning; the aircraft orbit while attack takes place and either return to base after the attackers are gone or proceed to an alternate base if their base is hit. The work presented in Parts I and II of this paper indicates the need for a balanced evacuation to include removal of flyaway kits and other vital equipment together with the aircraft. Our work also indicates that under the programmed radar network the amount of warning available to a majority of the bases will be marginal and the probability of a successful complete evacuation is small.

(b) It appears that for areas in which adequate warning for evacuation is not likely to be available it would be well to recognize this fact and to plan accordingly. For such bases an alternate emergency dispersal plan could be prepared in addition to the evacuation plan. This plan would call for moving by towing and taxiing of as many aircraft as possible to the periphery or altogether off base, and for removal of personnel and materiel off the base. The amounts to be removed could be realistically predetermined in terms of the amount of probable available warning.

The degree to which evacuation or emergency dispersal plan (or their combination) may be implemented at any particular base depends on the net warning time available and is subject to the Commander's decision.

(c) It is impossible to over-emphasize the importance of conducting actual training exercises under conditions of simulated enemy attack. Regular SAC exercises (to completion) of the flyaway plan and of the emergency dispersal plan would contribute immeasurably to the probability of their success under attack.

Equivocal Warning

(d) SAC is different from other military commands in that it lives in a state of semi-alert. However, it is our feeling that this state, of itself, is largely ineffective in securing substantial evacuation because of the limited warning times likely to be available under sneak-attack conditions. Equivocal warning may most profitably be used to insure successful completion of either the evacuation or emergency dispersal plans. For example, under such an alert condition, all flyable aircraft could be perimeter parked, a minimum flying crew (of the order of 3) could be stationed near their aircraft, etc.

The effect of such alert on the success of the evacuation plan has been discussed in Part II. The advantage of this type of alert procedure lies in the fact that it does not lead to a major disruption of SAC operations at a time when hostilities are imminent. Also, the alert could be repeated at fairly frequent intervals without important effects on SAC combat potential.

(e) A more disrupting procedure on receipt of equivocal warning is to execute the flyaway plan. The disruption need not be all loss, e.g. this time could be spent in getting all aircraft combat ready, making simulator runs, etc. The disruption could be minimized by special arrangements such as pre-stockage in the evacuation areas. The evacuation areas might be changed each time so that they themselves will not be aiming points. In addition, it appears that the evacuation plan might be conducted at squadron level. An investigation shows that sufficient facilities exist in the ZI for this purpose. If thus executed, this measure becomes equivalent to the balanced dispersal measure discussed above, but at a considerably smaller cost.

(2.6) Information Available to the Enemy

The information pattern available to the enemy has an obvious effect on the vulnerability of SAC. The better the information, the more successfully can the enemy select the time for attacking the set of targets $\left\{T_k\right\}$ when a high concentration of SAC force is on the ground.

(a) If plans are made to use equivocal warning in order to execute the evacuation plan, a means of denying the enemy the information regarding the deployment of units in the evacuated position is to employ several alternate plans and to select randomly from these plans in each case of equivocal warning.

(b) Following the first enemy strike, SAC units will redeploy to forward operating bases and strike from there. The enemy will undoubtedly attempt to mount his second strike while attack bombers are preparing for take-off from forward operating areas. In order to time his strike properly, however, he will require information regarding the arrival of our units to overseas areas. His ability to act successfully on this information can be severely limited by cutting down the time spent by SAC bombers in the forward operating areas prior to their first mission.

(c) If one of the modified combat operations concepts discussed above is used, the preceding measure can be extended to the entire campaign by reducing the time spent by SAC units in these areas to a minimum. Under some of the operations concepts the total number of the available forward bases will be sufficient to permit selection of a random base deployment for each strike.

(d) An obvious and important measure directed toward curtailing information available to the enemy is increased activity against potential sabotage, planting of beacons, other navigational aids, which will alert the enemy of the presence of SAC in the area and will guide him to the targets.

(3) Air Defense and Warning Variables

(3.1) Warning Network

Under item (2.5) above we have discussed measures for improved utilization of the warning available to SAC. Here we discuss measures for increasing the available warning. As before, it is convenient to enumerate the measures under the separate headings of unequivocal and equivocal warning.

Unequivocal Warning

(a) It was shown in Part II that the radar network program for the southern part of the United States is incapable of providing sufficient warning to SAC bases against end-run and submarine-launched attacks. An extension of this radar network southward through a combined use of new ground and airborne radars could appreciably increase the available warning times. This measure is obviously expensive to implement and in particular it involves high maintenance costs. On the other hand, augmentation of the radar warning network has the fortunate property of being independent of the weight of enemy attack. In fact, if enemy chooses to launch heavier attacks the identification and warning picture benefits from the presence of a greater number of radar blips.

(b) Extension outward of radar network will not usually improve detection times against submarines, since submarines can surface inside the radar cover. A measure against potential submarine threat to SAC bases in the southern part of the United States is to deny the enemy the use of the Gulf of Mexico by means of Sonar buoys, or some other blocking device extending from the tip of Florida to Havana, Cuba and to Yucatan, Mexico.

(c) Extension and peacetime activation of the Ground Observer Corps in the southern part of the U.S. would contribute to the effectiveness of the warning network.

(d) In overseas areas radar coverage could be increased to a point where it would provide the programmed air defense forces with an opportunity to mount an effective defense against an incoming enemy. For the British Isles it appears that this can only be obtained through the use of AEW aircraft.

(e) A large number of ships of the NATO nations are at sea at all times. During periods of equivocal warning, personnel aboard these ships could be instructed to stand watch and to report through appropriate channels to the air defense network of the United States all air and sea activity within their surveillance.

Equivocal Warning

(f) An important factor in announcement of equivocal warning is the development of a clear cut and relatively unambiguous set of ground rules for translation of indications of enemy activity into corresponding states of US alert. The scanty information available to us suggests that, while the trigger agencies are assigned the mission of this translation, the corresponding ground rules do not seem to be clearly formulated. If true, this state of affairs creates a high probability of another Pearl Harbor situation.

(3.2) Area Defense

The following measures deserve attention as a mean for reducing the weight of enemy attack brought to bear against SAC installations.

(a) Relocation of fighter defenses in the ZI to provide protection against specialized attacks directed against SAC bases.

(b) Establishment of a sufficient territorial limit off the coasts of the United States and concurrent patrol activity against potentially hostile submarines.

(c) Mounting of standing air patrol on overseas bases during periods of maximum concentration of SAC aircraft.

(d) Inspection of potentially hostile merchant and passenger ships to prevent covert delivery of A-bombs and H-bombs to coastal SAC installations.

(3.3) Channels and Procedures for Identification of Hostile Aircraft.

It was shown in Part II of this paper that the time delay in transmission of warning to SAC reduces the net warning time available to SAC for defensive action. In our present state of ignorance regarding the actual channels and procedures for transmission of warning, we are not able to comment on the adequacy of the existing setup.

(3.4) Local Defenses

The potential effectiveness of the programmed local defenses at SAC installations appears to be small. The use of advanced types of local defenses could be examined. For example, the effectiveness of allocating a portion of the programmed 1956 Nike missile force to the defense of SAC installations could be investigated.

(4) Air Materiel Variables

SAC, along with the other Air Force Commands, is dependent on the Air Materiel Command for maintenance and supply support. Denial of this support can bring our strategic operations to a standstill when the stores at SAC have been consumed. It is vital, therefore, for a strategic campaign of much more than, say, 30 days, to maintain AMC functions. These functions are the following:

(4.1) Maintenance Support

(a) It appears that a reduction in the concentration of facilities would reduce the vulnerability of the maintenance function. Any additional facilities might certainly be isolated.

(b) Since it is highly probable that SAC will suffer severe A-bomb damage, the development and procurement of specialized repair equipment would insure more rapid base recuperability.

(4.2) Supply Support at Depots

(a) Storage of extra flyaway kits at depots, unless these items are stored in SAC units at locations away from the base, would increase the survival of these slow-to-evacuate items.

(b) There could be a reduction in concentration of depot stockpiles, particularly overseas. Any additional stockage could certainly be isolated.

(c) Certain aircraft parts will suffer A-bomb damage and hence there will exist a requirement for these parts which is out of proportion to the normal peacetime consumption. These items (such as hatches, window panels, bomb bay doors, etc.) could be stocked in quantities sufficient to supply the expected wartime requirement.

(4.3) Supply and Equipment at the SAC Bases

(a) In Section (2.6) it was indicated that at least for the first SAC mission, it is highly desirable to reduce the time of occupancy at the operating bases. One of the limiting items in this connection is the limited quantity of refueling equipment. More refueling equipment could be procured for the operating bases, particularly the overseas bases. In the same vein of thought, additional dispersed POL facilities, preferably underground, could be provided to insure sufficient undamaged fuel reserves, after attack, to permit wing operation for a reasonable time period out of the existing stocks.

(b) The provision of A-bomb damage control equipment and personnel at all bases in unpopulated regions would insure more rapid base recuperability. This should include heavy cranes, bulldozers, steam shovels, etc. as well as specialized fire fighting equipment, decontamination equipment, etc. Realistic exercises in the use of these equipments could be practiced.

(c) An assessment could be made of the expected wartime requirements for medical supplies and these supplies stocked accordingly at all bases.

(5) In addition to the above, there are various systems defense measures. These are concerned with the "no soft-spot" concept and the concept of increased self-sufficiency and flexibility of the Strategic Striking Complex.

(5.1) No Soft-Spot Concept

Since certain parts of the aircraft-personnel-materiel-base system complement one another, a way to increase enemy force requirement to produce a given degradation in SAC combat potential is eliminate soft-spots in the system by strengthening the weakest components. For example, an air base, a depot and a bomb storage site all complement one another in the sense that all three are required for production of combat sorties. If it appears that by destruction of 4 ZI supply depots the enemy can effectively reduce the sortie potential, the depot system could be dispersed to a point where this reduction in sortie potential would require the same enemy effort against any part of the system. In many of the measures discussed previously, an attempt has been made, qualitatively, to eliminate obvious soft-spots.

(5.2) Increase Self-Sufficiency and Flexibility of SSC.

Consideration could be given to all means which increase the self-sufficiency and flexibility of the strategic striking complex, e.g.

(a) Alternate war plans could be written for various damage situations and might include the denial of various operating base areas. In conjunction with this, damage assessment teams could be formed so that the extent of the damage might be determined rapidly for command decisions.

(b) SAC units on rotation overseas could be given the mission and the means (including nuclear components of A-bombs) for very quick retaliation to an enemy attack.

(c) Auxiliary means of communication and auxiliary and immediate alternate command channels could be established, also duplication of command channels where feasible.

APPENDIX C: BASIC DATA FOR THE FIRST SUSAC ATTACK ON SAC

STRATEGIES:

I Submarine launched - one aircraft per target.
II Low Altitude TU-4, 1956 radar program, one aircraft per target.
II' Low Altitude TU-4, Augmented radar program, one aircraft per target.
III High Altitude TU-4, 10 aircraft per target.

| BASES AND DEPOTS ( ) Number of targets | DEPLOYMENT ON D-DAY Wings (number) | Aircraft (number) | SURVIVAL TO AREA DEFENSES $(1-p^A)$ I | II | II' | III | PROB. OF ABORTS $(p^a)$ I | II, II', III | PROB. OF REACHING TARGET $(1-p^A)(1-p^a)(1-p^L)(1-p^g)$ I[c] | II[d] | II'[d] | III[e] | PROB. OF WEAT[illegible] FOR VIS. BOMB[illegible] I, II, II' | II[illegible] | [illegible]T WARNING TIME $(t^W)$ [illegible] | II | II' | III |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | - - minutes | - - - | - - - | - - - |
| ZI & OVERSEAS TARGETS (41) | | | 34.80 | 36.18 | 25.40 | 26.8 | 1.75 | 6.25 | 33.06 | 29.97 | 21.52 | 21.68 | 31.73 | 26.[illegible] | | | | |
| ZI TARGETS (26) | | | 19.80 | 21.18 | 10.40 | 13.3 | 1.00 | 4.75 | 18.81 | 16.47 | 8.02 | 10.13 | 20.71 | 17.[illegible] | | | | |
| HB (7) | 7 | 210 | 6.97 | 6.60 | 3.00 | 4.2 | .35 | 1.25 | 6.62 | 4.80 | 2.23 | 3.28 | 5.47 | 4.[illegible] | | | | |
| Biggs | 1 | 30 | 1.0 | 1.0 | .95 | .6 | .05 | .20 | .95 | .80 | .76 | .46 | .84 | [illegible] | 0 | 0 | 15 | 72 |
| Castle[L] | 1 | 30 | 1.0 | 1.0 | .30 | .6 | .05 | .15 | .95 | .68 | .20 | .48 | .95 | [illegible] | 0 | 6 | 55 | 45 |
| Carswell[L] | 1 | 30 | 1.0 | 1.0 | .30 | .6 | .05 | .20 | .95 | .64 | .19 | .46 | .84 | [illegible] | 0 | 15 | 55 | 72 |
| Fairchild[L] | 1 | 30 | .97 | .8 | .25 | .6 | .05 | .15 | .92 | .54 | .17 | .48 | .68 | [illegible] | 0 | 30 | 65 | 45 |
| Limestone[L] | 1 | 30 | 1.0 | .8 | .40 | .6 | .05 | .15 | .95 | .54 | .27 | .48 | .48 | [illegible] | 0 | 30 | 50 | 55 |
| Selman | 1 | 30 | 1.0 | 1.0 | .20 | .6 | .05 | .20 | .95 | .80 | .16 | .46 | .84 | [illegible] | 0 | 15 | 65 | 72 |
| Walker | 1 | 30 | 1.0 | 1.0 | .60 | .6 | .05 | .20 | .95 | .80 | .48 | .46 | .84 | [illegible] | 0 | 15 | 35 | 72 |
| HR | 4 | 120 | | | | | | | | | | | | | | | | |
| Rapid City[La] | 1 | 30 | - | .35 | .10 | .3 | - | .15 | - | .24 | .06 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| Ramey, P. R.[a] | 1 | 30 | 1.0 | 1.0 | 1.0 | 1.0 | .05 | .20 | .95 | .80 | .80 | .76 | .68 | [illegible] | 0 | 0 | 0 | 0 |
| Travis[La] | 1 | 30 | 1.0 | 1.0 | .30 | .6 | .05 | .15 | .95 | .68 | .20 | .48 | .95 | [illegible] | 0 | 6 | 55 | 45 |
| Westover[a] | 1 | 30 | 1.0 | .73 | .45 | .6 | .05 | .15 | .95 | .63 | .38 | .48 | .68 | [illegible] | 0 | 30 | 45 | 55 |
| MB (15) | 22 | 990[b] | 9.83 | 10.58 | 6.16 | 7.0 | .50 | 2.70 | 9.34 | 8.47 | 4.75 | 5.24 | 12.20 | 10.[illegible] | | | | |
| Abilene | 1 | 45 | 1.0 | 1.0 | .50 | .6 | .05 | .20 | .95 | .80 | .40 | .46 | .84 | [illegible] | 0 | 15 | 45 | 72 |
| Barksdale | 2 | 90 | 1.0 | 1.0 | .15 | .6 | .05 | .20 | .95 | .80 | .12 | .46 | .68 | [illegible] | 0 | 15 | 85 | 72 |
| Bunker Hill | 1 | 45 | - | .2 | .05 | .2 | - | .20 | - | .16 | .04 | .15 | .84 | [illegible] | - | 120 | 150 | 150 |
| Davis-Monthan | 1 | 45 | 1.0 | 1.0 | .80 | .6 | .05 | .20 | .95 | .80 | .64 | .46 | .84 | [illegible] | 0 | 15 | 25 | 72 |
| Homestead, Fla. | 2 | 90 | 1.0 | 1.0 | 1.00 | .6 | .05 | .20 | .95 | .80 | .80 | .46 | .68 | [illegible] | 0 | 0 | 0 | 72 |
| Hunter | 2 | 90 | 1.0 | 1.0 | .60 | .6 | .05 | .20 | .95 | .80 | .48 | .46 | .68 | [illegible] | 0 | 15 | 45 | 72 |
| Lake Charles | 1 | 45 | 1.0 | 1.0 | .50 | .6 | .05 | .20 | .95 | .80 | .40 | .46 | .68 | [illegible] | 0 | 15 | 45 | 72 |
| Lincoln | 1 | 45 | - | .35 | .10 | .2 | - | .15 | - | .30 | .09 | .16 | .95 | [illegible] | - | 65 | 95 | 150 |
| Little Rock | 2 | 90 | - | .30 | .10 | .2 | - | .20 | - | .24 | .08 | .15 | .84 | [illegible] | - | 85 | 135 | 150 |
| MacDill | 1 | 45 | 1.0 | 1.0 | 1.0 | .6 | .05 | .20 | .95 | .80 | .80 | .46 | .68 | [illegible] | 0 | 0 | 15 | 72 |
| March[L] | 1 | 45 | 1.0 | 1.0 | .45 | .6 | .05 | .15 | .95 | .68 | .31 | .48 | .95 | [illegible] | 0 | 6 | 45 | 45 |
| Mountain Home | 2 | 90 | .83 | .30 | .20 | .4 | .05 | .15 | .79 | .26 | .03 | .32 | .95 | [illegible] | [illegible] | 90 | 115 | 115 |
| Portsmouth | 2 | 90 | 1.0 | .73 | .45 | .6 | .05 | .15 | .95 | .63 | .38 | .48 | .68 | [illegible] | 0 | 30 | 45 | 55 |
| Sioux City | 1 | 45 | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| Smoky Hill | 2 | 90 | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| Pinecastle[a] | - | - | 1.0 | 1.0 | 1.0 | .6 | .05 | .20 | .95 | .80 | .80 | .46 | .68 | [illegible] | 0 | 0 | 0 | 72 |
| Sedalia[a] | - | - | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| MR | 5 | 225[b] | | | | | | | | | | | | | | | | |
| Forbes[a] | 1 | 45 | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| Lockbourne[a] | 2 | 90 | .97 | .2 | .05 | .2 | .05 | .20 | .92 | .16 | .04 | .15 | .84 | [illegible] | 0 | 120 | 135 | 150 |
| Plattsburg[a] | 2 | 90 | .97 | .77 | | .6 | .05 | .15 | .92 | .65 | .34 | .48 | .48 | [illegible] | 0 | 30 | 85 | 55 |
| Depots (4) | | | 3.0 | 4.0 | 1.30 | 2.1 | .15 | .80 | 2.85 | 3.20 | 1.04 | 1.61 | 3.04 | 2.[illegible] | | | | |
| Mobile | | | 1.0 | 1.0 | .30 | .6 | .05 | .20 | .95 | .80 | .24 | .46 | .68 | [illegible] | 0 | 15 | 65 | 72 |
| Oklahoma City | | | - | 1.0 | .20 | .3 | - | .20 | - | .80 | .16 | .23 | .84 | [illegible] | - | 15 | 85 | 150 |
| San Antonio | | | 1.0 | 1.0 | .50 | .6 | .05 | .20 | .95 | .80 | .40 | .46 | .84 | [illegible] | 0 | 15 | 45 | 72 |
| Warner Robins | | | 1.0 | 1.0 | .30 | .6 | .05 | .20 | .95 | .80 | .24 | .46 | .68 | [illegible] | 0 | 15 | 55 | 72 |
| OVERSEAS AREAS MB / MR[a] | 8 / 1 | 360[b] / 45[b] | 15.0 | 15.0 | 15.0 | 13.5 | .75 | 1.50 | 14.25 | 13.50 | 13.50 | 11.55 | 11.02 | 9.[illegible] | | | | |
| Alaska (2) | MB-1 | 45 | 1.0 | 1.0 | 1.0 | .9 | .05 | .10 | .95 | .90 | .90 | .77 | .48 | [illegible] | 0 | 0 | 0 | 30 |
| N.E. (2) | MB-2 | 90 | | | | | | | | | | | .48 | [illegible] | | | | |
| Fr. Morocco & Portugal (4) | MB-1 | 45 | | | | | | | | | | | .95 | [illegible] | | | | |
| U.K. (5) | MB-3 | 135 | | | | | | | | | | | .68 | [illegible] | | | | |
| Pacific (2) | MB-1 / MR-1 | 45 / 45 | | | | | | | | | | | .95 | [illegible] | | | | |

APPENDIX C: BASIC DATA FOR THE FIRST SUSAC ATTACK ON SAC

STRATEGIES:

I Submarine launched - one aircraft per target.
II Low Altitude TU-4, 1956 radar program, one aircraft per target.
II' Low Altitude TU-4, Augmented radar program, one aircraft per target.
III High Altitude TU-4, 10 aircraft per target.

| [illegible] D-DAY [illegible]rcraft | SURVIVAL TO AREA DEFENSES $(1-p^A)$ I | II | II' | III | PROB. OF ABORTS $(p^a)$ I | II, II', III | PROB. OF REACHING TARGET $(1-p^A)(1-p^a)(1-p^L)(1-p^g)$ I[c] | II[d] | II'[d] | III[e] | PROB. OF WEAT[illegible] FOR VIS. BOMB I, II, II' | II[illegible] | [illegible] WARNING TIME ($t^W$) [illegible] | II | II' | III |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | - - minutes | - - - - - | | |
| | 34.80 | 36.18 | 25.40 | 26.8 | 1.75 | 6.25 | 33.06 | 29.97 | 21.52 | 21.68 | 31.73 | 26.[illegible] | | | | |
| | 19.80 | 21.18 | 10.40 | 13.3 | 1.00 | 4.75 | 18.81 | 16.47 | 8.02 | 10.13 | 20.71 | 17.[illegible] | | | | |
| 210 | 6.97 | 6.60 | 3.00 | 4.2 | .35 | 1.25 | 6.62 | 4.80 | 2.23 | 3.28 | 5.47 | 4.[illegible] | | | | |
| 30 | 1.0 | 1.0 | .95 | .6 | .05 | .20 | .95 | .80 | .76 | .46 | .84 | [illegible] | 0 | 0 | 15 | 72 |
| 30 | 1.0 | 1.0 | .30 | .6 | .05 | .15 | .95 | .68 | .20 | .48 | .95 | [illegible] | 0 | 6 | 55 | 45 |
| 30 | 1.0 | 1.0 | .30 | .6 | .05 | .20 | .95 | .64 | .19 | .46 | .84 | [illegible] | 0 | 15 | 55 | 72 |
| 30 | .97 | .8 | .25 | .6 | .05 | .15 | .92 | .54 | .17 | .48 | .68 | [illegible] | 0 | 30 | 65 | 45 |
| 30 | 1.0 | .8 | .40 | .6 | .05 | .15 | .95 | .54 | .27 | .48 | .48 | [illegible] | 0 | 30 | 50 | 55 |
| 30 | 1.0 | 1.0 | .20 | .6 | .05 | .20 | .95 | .80 | .16 | .46 | .84 | [illegible] | 0 | 15 | 65 | 72 |
| 30 | 1.0 | 1.0 | .60 | .6 | .05 | .20 | .95 | .80 | .48 | .46 | .84 | [illegible] | 0 | 15 | 35 | 72 |
| 120 | | | | | | | | | | | | | | | | |
| 30 | - | .35 | .10 | .3 | - | .15 | - | .24 | .06 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| 30 | 1.0 | 1.0 | 1.0 | 1.0 | .05 | .20 | .95 | .80 | .80 | .76 | .68 | [illegible] | 0 | 0 | 0 | 0 |
| 30 | 1.0 | 1.0 | .30 | .6 | .05 | .15 | .95 | .68 | .20 | .48 | .95 | [illegible] | 0 | 6 | 55 | 45 |
| 30 | 1.0 | .73 | .45 | .6 | .05 | .15 | .95 | .63 | .38 | .48 | .68 | [illegible] | 0 | 30 | 45 | 55 |
| 990[b] | 9.83 | 10.58 | 6.10 | 7.0 | .50 | 2.70 | 9.34 | 8.47 | 4.75 | 5.24 | 12.20 | 10.[illegible] | | | | |
| 45 | 1.0 | 1.0 | .50 | .6 | .05 | .20 | .95 | .80 | .40 | .46 | .84 | [illegible] | 0 | 15 | 45 | 72 |
| 90 | 1.0 | 1.0 | .15 | .6 | .05 | .20 | .95 | .80 | .12 | .46 | .68 | [illegible] | 0 | 15 | 85 | 72 |
| 45 | - | .2 | .05 | .2 | - | .20 | - | .16 | .04 | .15 | .84 | [illegible] | - | 120 | 150 | 150 |
| 45 | 1.0 | 1.0 | .80 | .6 | .05 | .20 | .95 | .80 | .64 | .46 | .84 | [illegible] | 0 | 15 | 25 | 72 |
| 90 | 1.0 | 1.0 | 1.00 | .6 | .05 | .20 | .95 | .80 | .80 | .46 | .68 | .55 | 0 | 0 | 0 | 72 |
| 90 | 1.0 | 1.0 | .60 | .6 | .05 | .20 | .95 | .80 | .48 | .16 | .68 | .55 | 0 | 15 | 45 | 72 |
| 45 | 1.0 | 1.0 | .50 | .6 | .05 | .20 | .95 | .80 | .40 | .46 | .68 | .55 | 0 | 15 | 45 | 72 |
| 45 | - | .35 | .10 | .2 | - | .15 | - | .30 | .09 | .16 | .95 | [illegible] | - | 65 | 95 | 150 |
| 90 | - | .30 | .10 | .2 | - | .20 | - | .24 | .08 | .15 | .84 | [illegible] | - | 85 | 135 | 150 |
| 45 | 1.0 | 1.0 | 1.0 | .6 | .05 | .20 | .95 | .80 | .80 | .46 | .68 | [illegible] | 0 | 0 | 15 | 72 |
| 45 | 1.0 | 1.0 | .45 | .6 | .05 | .15 | .95 | .68 | .31 | .48 | .95 | [illegible] | 0 | 6 | 45 | 45 |
| 90 | .83 | .30 | .20 | .4 | .05 | .15 | .79 | .26 | .03 | .32 | .95 | [illegible] | 6 | 90 | 115 | 115 |
| 90 | 1.0 | .73 | .45 | .6 | .05 | .15 | .95 | .63 | .38 | .48 | .68 | .55 | 0 | 30 | 45 | 55 |
| 45 | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| 90 | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| - | 1.0 | 1.0 | 1.0 | .6 | .05 | .20 | .95 | .80 | .80 | .46 | .68 | .55 | 0 | 0 | 0 | 72 |
| - | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| 225[b] | | | | | | | | | | | | | | | | |
| 45 | - | .35 | .10 | .3 | - | .15 | - | .30 | .09 | .24 | .95 | [illegible] | - | 109 | 135 | 150 |
| 90 | .97 | .2 | .05 | .2 | .05 | .20 | .92 | .16 | .04 | .15 | .84 | .68 | 0 | 120 | 135 | 150 |
| 90 | .97 | .77 | | .6 | .05 | .15 | .92 | .65 | .34 | .48 | .48 | .39 | 0 | 30 | 85 | 55 |
| | 3.0 | 4.0 | 1.30 | 2.1 | .15 | .80 | 2.85 | 3.20 | 1.04 | 1.61 | 3.04 | 2.46 | | | | |
| | 1.0 | 1.0 | .30 | .6 | .05 | .20 | .95 | .80 | .24 | .46 | .68 | .55 | 0 | 15 | 65 | 72 |
| | - | 1.0 | .20 | .3 | - | .20 | - | .80 | .16 | .23 | .84 | .68 | - | 15 | 85 | 150 |
| | 1.0 | 1.0 | .50 | .6 | .05 | .20 | .95 | .80 | .40 | .46 | .84 | .68 | 0 | 15 | 45 | 72 |
| | 1.0 | 1.0 | .30 | .6 | .05 | .20 | .95 | .80 | .24 | .46 | .68 | [illegible] | 0 | 15 | 55 | 72 |
| 360[b] | 15.0 | 15.0 | 15.0 | 13.5 | .75 | 1.50 | 14.25 | 13.50 | 13.50 | 11.55 | 11.02 | 9.[illegible] | | | | |
| 45[b] | | | | | | | | | | | | | | | | |
| 45, 90, 45, 135, 45, 45 | 1.0 | 1.0 | 1.0 | .9 | .05 | .10 | .95 | .90 | .90 | .77 | .48, .48, .95, .68, .95 | .39, .39, .90, .55, .90 | 0 | 0 | 0 | 30 |

a. Not included in the totals.

b. Plus 20 tankers for every wing.

c. For all targets $p^g = 0$; for bases with local defense systems $p^L = 0$.

d. For all targets $p^g = 0$; for bases with local defense systems $p^L = .20$.

e. For all targets $p^g = .05$; for bases with local defense systems $p^L = 0$.

L. With local defense systems.

AIRCRAFT DAMAGE FUNCTIONS

| | 40 KT Bomb 1500' CEP | 40 KT Bomb 4000' CEP | 100 KT Bomb 1500' CEP | 100 KT Bomb 4000' CEP |
|---|---|---|---|---|
| ZI Bases* | | | | |
| % destroyed[1] | 95 | 60 | 100 | 85 |
| % major damage[2] | 5 | 25 | - | 15 |
| % light damage[3] | - | 10 | - | - |
| UK Bases** | | | | |
| % destroyed[1] | 90 | 50 | 95 | 70 |
| % major damage[2] | 10 | 25 | 5 | 30 |
| % light damage[3] | - | 10 | - | - |
| Moroccan Bases*** | | | | |
| % destroyed[1] | 45 | 30 | 65 | 60 |
| % major damage[2] | 30 | 35 | 30 | 30 |
| % light damage[3] | 15 | 15 | 5 | 10 |

* Assumed similar to Bergstrom
** Assumed largely similar to Bergstrom, but with certain modifications.
*** Assumed similar to Ben Guerir

1 Criterion: over 8 psi overpressure
2 Criterion: 4-8 psi overpressure
3 Criterion: 3-4 psi overpressure

## APPENDIX D

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