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PROJECT RAND

RESEARCH MEMORANDUM

(U) IDENTIFICATION PROCEDURES FOR AIR DEFENSE

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RM-1078

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PREFACE

This is one of a series of RAND Research Memoranda which discuss aspects of the active air defense of the continental United States. The series is a part of RAND's current study of high-attrition air defense. The study will evaluate various choices in development, procurement, and deployment for several budget levels, including budgets considerably higher than current ones. The time period being studied includes operations between now and 1960; the general framework of the study is similar to that described in RAND Report R-227, Air Defense Study, October 15, 1951 (Secret), except that a wider range of questions is under consideration. In many ways the present series serves to extend, modernize, and modify R-227 and its supporting Research Memoranda.

Major conclusions, particularly those which are dependent on the putting together of the component parts of the study, will be presented in subsequent publications. The conclusions given in the present series are only those which can be drawn from the more specialized parts of the study. A list of the memoranda in this series, and the tentative contents of a second series planned for later publication, are given on the next page.

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First Series

No.	Title	Author	Date	Class.
RM-1075	Possible Offensive Capability Against the U.S.: 1953-1960	Johnston Barlow Dadant	5/1/53	Secret
RM-1076	Notes on Targets in Planning the Air Defense of the U.S.	Capron	5/1/53	Secret
RM-1077	Contiguous Radar Coverage in the U.S. Air Defense System: 1953-1960	Barlow	5/1/53	Secret
RM-1078	Identification Procedures for Air Defense	Attaway Barlow	5/1/53	Secret
RM-1079	Data Handling Systems for Air Defense	Dadant Reich	5/1/53	Secret
RM-1080	Electronic Countermeasures Against U.S. Air Defense: 1953-1960	Barlow	5/1/53	Secret
RM-1081	Examination of a Subsonic Area Defense Missile with Low Altitude Capability	Barlow White Mallett	5/1/53	Secret
RM-1082	The Use of Atomic Explosives in Air Defense	Barlow Holbrook	5/1/53	Secret*

* With AEC Restricted Data Supplement

Later Publication

Tentative contents include discussions of guns and other low-altitude weapons, interceptor and missile performance limitations (particularly at low altitudes), effectiveness of local-defense missiles, and design principles for semi-active missile guidance.

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Identification Procedures for Air Defense

I. INTRODUCTION

The objective of this memorandum is to estimate the identification capabilities of the air defense system against various threats in the time period 1953-1960, and to discuss alternative procedures which might be used. It is assumed that the enemy will be able to approach the U.S. from all azimuths and at all altitudes from 50 to 60,000 feet, with a resulting requirement for omnidirectional and omnialtitude identification capabilities. The techniques considered available are:

1. Electronic IFF.
2. Operational means now evolving in ADC (e.g., flight plan matching, multiple-corridor approaches, in-flight maneuvers, code words).
3. Recognition by natural features (e.g., altitude and speed).
4. Forced landing for inspection.
5. Statistical raid recognition.

Identification is sometimes considered completed when an aircraft is first recognized. However, the attrition operation is a time consuming one, with the result that identity must be retained up to as long as two or three hours. Two types of identification are thus practiced:

a) Perimeter identification, which is the initial recognition at the edge of the defended area or radar cover, and

b) Internal identification, which is the attempt to retain or regain the identity of an aircraft once it has been established.

II. INTERNAL IDENTIFICATION

Great progress has recently been made by ADC with perimeter identification. This progress has resulted mainly because the perimeter often can be placed in a region of sparse air traffic, thus greatly simplifying the problem. The internal identification problem has shown no such promise of solution. Rather, the trend has been towards removal of the problem by performing the perimeter identification at distances from defended and air battle areas which permit grounding of background traffic prior to bomber arrival.

A. Defense Efficiency Degradations

When such a solution is not available, the efficiency of the defense system is degraded because of the high probability of losing a bomber in the background traffic. When a bomber is so lost, its true identity is still restricted to the set of aircraft in its vicinity at the time. In the absence of some other device, interceptors must be sent to all aircraft in the set until the bomber is found again. Unless a switch in identity is known to the defense, not even this is done and the bomber is in all probability completely lost. Hence, the degradation will be reflected in a certain fraction of all available interceptors being wasted on investigatory flights, and a certain fraction of all bombers escaping interception. In the present memorandum this degradation is considered to be sufficiently serious that a detailed examination is made of the background traffic under various circumstances.

B. The 1956 Internal Identification Environment

The occurrence and degree of this degradation are dependent upon the amount of radar cover available at bomber altitude, the traffic

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capacity of the data processing system[1] and the amount of background traffic. To illustrate the problem, a concrete situation is considered here: the perimeter identification and traffic environment for 1956. The offensive threat considered is the IL-28 at low altitude, since this combination places the most stringent requirements possible upon the perimeter identification system in 1956.[2]

Three early warning situations could exist. First, intelligence indications may provide several hours of unequivocal warning, in which case internal traffic will be grounded when the bombers arrive. Secondly, an amount of equivocal warning sufficient to ground all "unessential" traffic may be available. This case is incapable of evaluation at this time, because essential traffic has not yet been adequately defined, nor is there available a complete analysis of the essential traffic to be expected on the days following the declaration of an emergency. RAND's study of identification and the problems of keeping a clear picture of the air situation have indicated that making a clear-cut rule about who shall be allowed to fly during an emergency should be a matter of great concern. It can be expected, in any event, that during daylight hours the situation will be more favorable to the defenses than the third case: no advance warning of an

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(1) The peacetime traffic exceeds the capacity of the present system and of any proposed improvements in it until the advent of the Lincoln Laboratory Transition System in the 1958 to 1960 period.

(2) With the exception of the sub-launched turbojet missile or aircraft. This is a special threat and must be considered separately.

attack until the bombers are detected by the radar or Ground Observer Corps (GOC) networks.

Figure 1 shows the geographical situation; depicted are:

a) Possible regions of the U.S. and Canada which will have sufficient low-altitude radar cover to permit interception of the IL-28. This coverage results from an assumed 300 low-altitude radars of the ASR-1 and AN/CPN-18 type available in 1956.(1) The cover is that provided against the IL-28 at 50 feet over the ocean and 200 feet over land.

b) Estimated peacetime traffic within that portion of each permanent radar site's primary area of responsibility(2) which overlaps the low-altitude cover. The traffic shown is the average total (carrier, civil, and military) number of aircraft simultaneously in the air between 3:00 and 4:00 P.M. local time on an average July day. The estimates are taken from RM-773.(3) The traffic figures may be corrected

(1) Such radars are not now part of the air defense program but they are felt to be necessary to obtain low-altitude coverage. They could be installed by 1956 if a vigorous program were instituted soon. They could be netted together by the RADATA system described in RM-1077, cited in the Preface.

(2) Primary area of responsibility: defined to be all the area within range of a TU-4 at 30,000 feet and closer to a given permanent site than to any other.

(3) L. D. Attaway, A Preliminary Estimate of Air Traffic, The RAND Corporation, Research Memorandum RM-773, 30 January 1952 (Secret).

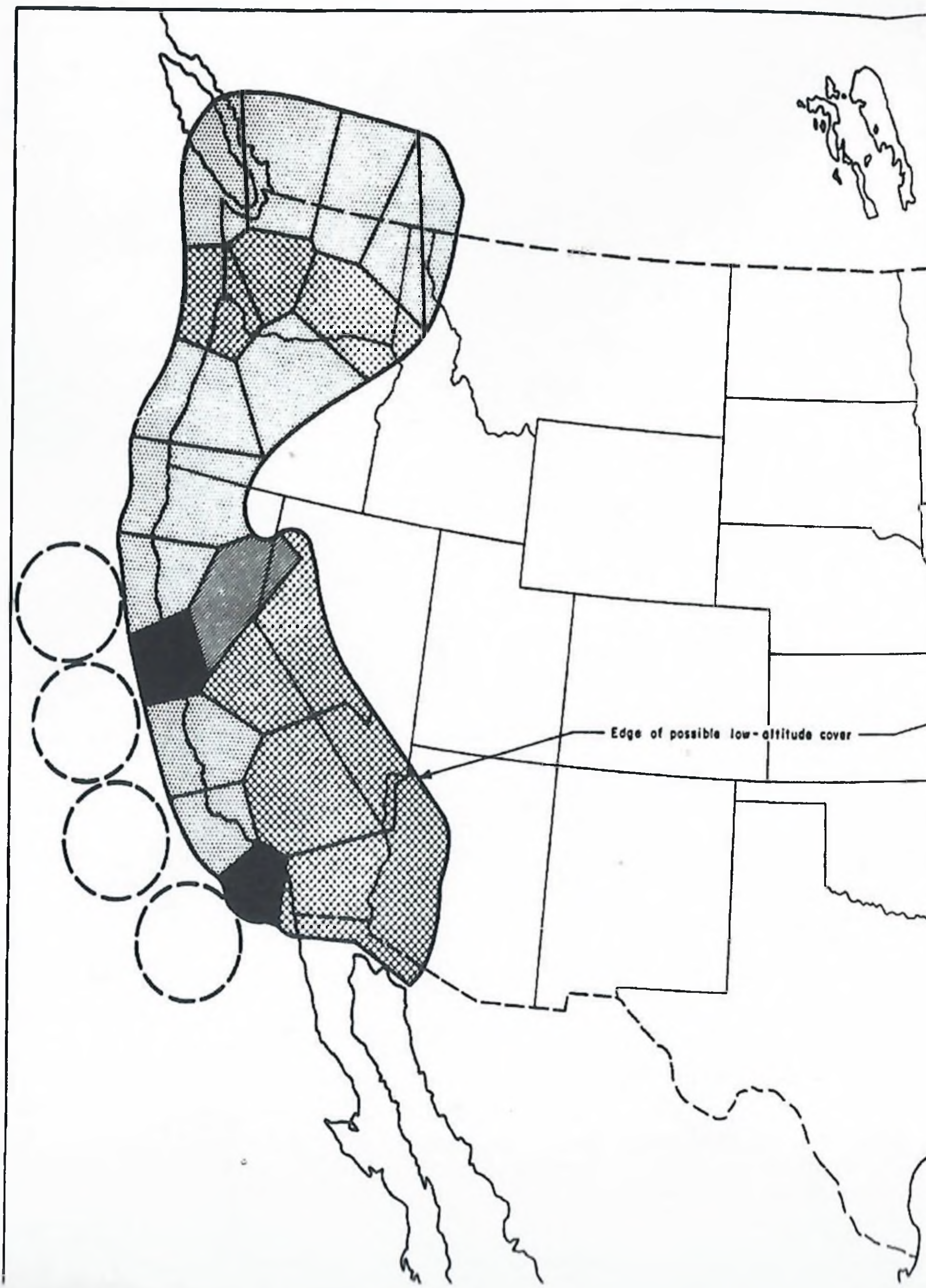
to any hour of the day by the application of the curve of Figure 2, which shows the fraction of the peak which occurs at any given time of day. These estimates were originally made for the 1951-1953 time period, but are usable as rough estimates of the 1956 situation.

c) The overwater coverage which might be achieved with AEW aircraft under certain circumstances. Against a low-altitude attack in 1956 by IL-28 aircraft the situation with respect to low-altitude cover appears to be as follows:

Picket ships may or may not be available, depending on Navy participation. Even if available their radar range against such an attack is only about 30 miles, so the coverage they could supply would be ineffective for identification purposes.

C-121C and C-121D AEW aircraft should be available in sufficient numbers to allow four AEW stations to be operated on each coast. The performance of the AN/APS-20B radar in these aircraft against the IL-28 has been estimated[1] to be such that one aircraft cannot simultaneously supply high- and low-altitude coverage. At best, if the coverage is adjusted optimally for the altitude of the target aircraft, the

(1) See RM-1077, cited in the Preface. The 10% blip scan contour is used here.


Edge of possible low-altitude cover

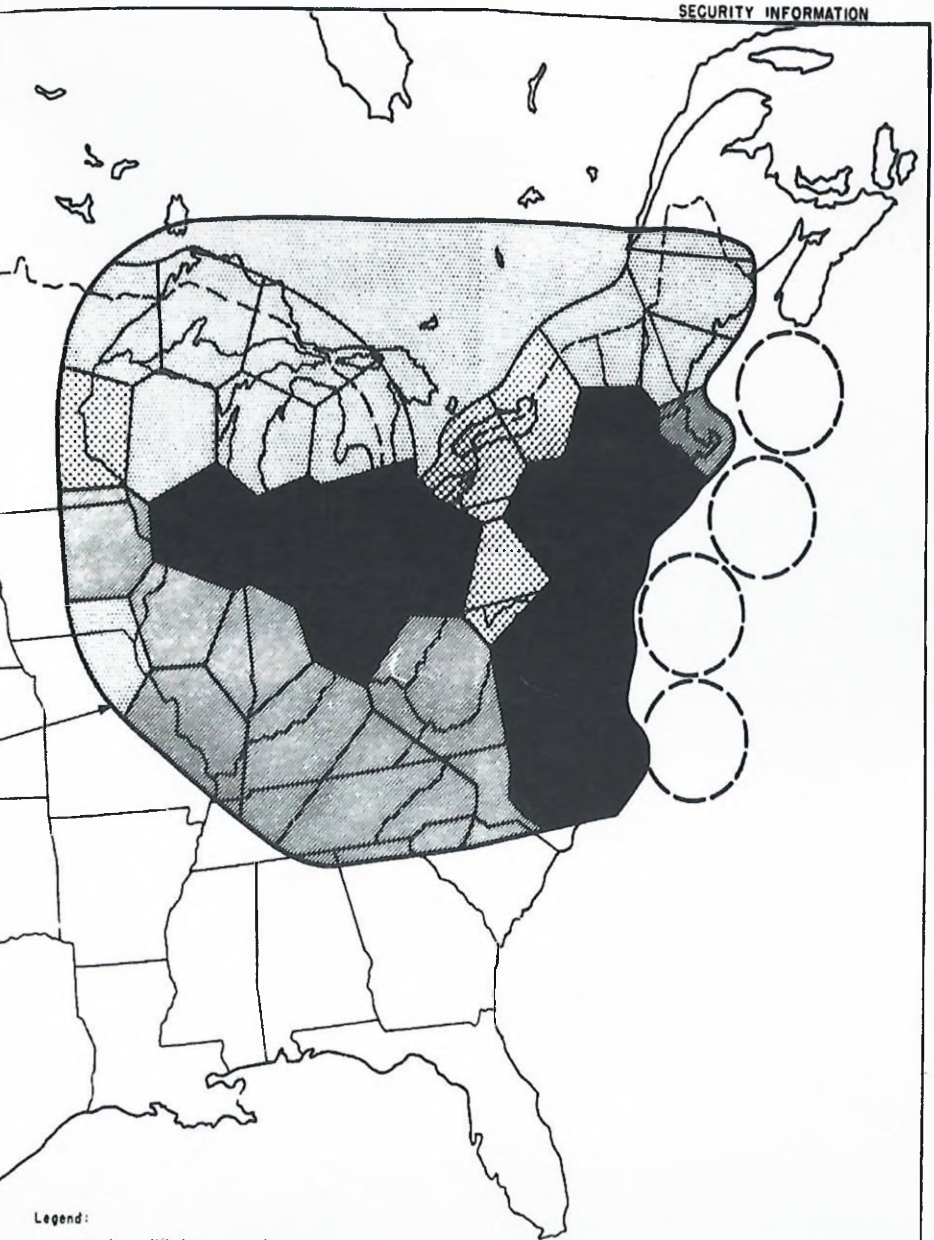


Fig. 1—Estimated low-altitude cover against the IL-28 and peak air traffic

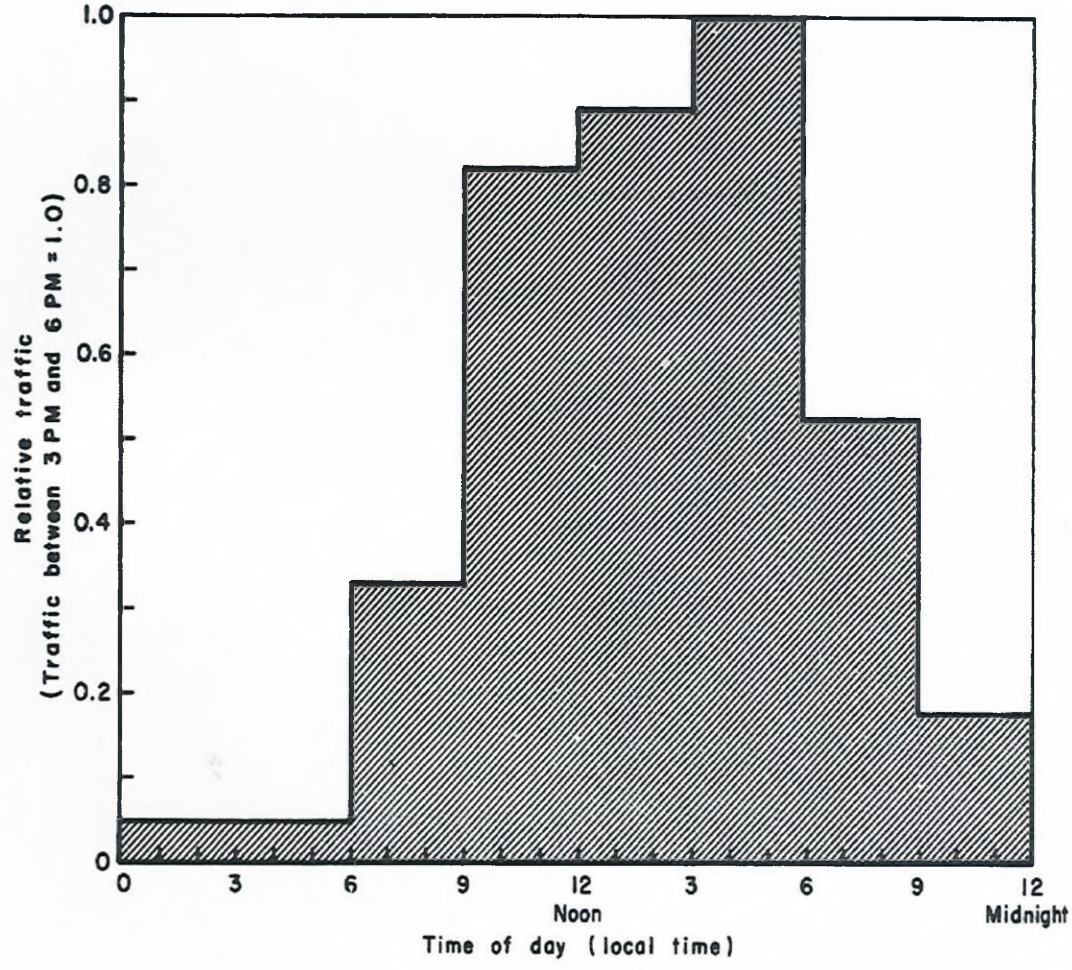


Fig. 2—Distribution of traffic throughout the day

range to be expected is about 80 miles. Hence, if the AEW radar is adjusted for low-altitude targets in the example considered here the expected coverage is as shown by the dashed circles in Figure 1. If the AEW radars are adjusted for coverage against high-altitude targets, very little coverage could be expected against low-altitude targets. A possible expedient would be to modify the antenna and feed construction to permit the radar beam to be raised and lowered a few degrees on alternate scans. Thus one scan would cover low altitudes and the next, high altitudes. If some such expedient as this were adopted, fairly satisfactory AEW radar coverage could be obtained against low- or high-altitude IL-28's, at least for identification purposes, out to radar ranges of about 80 miles from the AEW aircraft indicated previously. The AEW coverage as shown in the dashed circles on Figure 1 can be interpreted in this way. The AEW aircraft positions are those currently proposed by Air Defense Command.

Unfortunately, at best the AEW coverage does not represent an aircraft-tight band, especially if enemy aircraft determine the positions of the AEW stations and slip between them.

It is clear from Figure 1 that during appropriate daylight hours, if he can slip past the AEW coverage the enemy is free to enter the low-altitude cover at many points where he would be immediately immersed in heavy background traffic (121 to 390 simultaneous aircraft per radar area); this can occur in Connecticut, New York, New Jersey, Maryland, Virginia, North and South Carolina, and central and southern California. He can enter the perimeter in South Carolina, Kentucky, Tennessee, Missouri, Iowa, and northeastern California and find himself immersed in moderately heavy traffic (81 to 120 simultaneous aircraft per radar area). It is obvious from Figure 1 that the heaviest peacetime traffic occurs near our most highly prized target complexes. Unless additional early warning is provided, the efficiency of the defense system will probably suffer large degradations of the type discussed above.

This conclusion strengthens the conclusion reached in RM-1077 about the desirability of increasing the number of AEW stations over those now programmed.

C. Effect of Advance Warning on Background Traffic

The minimum additional radar cover needed to alleviate the background traffic problem is an aircraft-tight perimeter about each of the defended areas of Figure 1. Such a perimeter need not be a closed curve, but if it is not, it must be of such length and position that a bomber route around its extremities has an over-all length exceeding the ranges of the possible bomber types. The distance needed between identification perimeter and solid cover depends upon the bomber speed and the time required to ground a sufficient fraction of all traffic. This time has been variously estimated between forty-five minutes and two hours. (It should be noted that the time required is not necessarily proportional to the number of airborne aircraft, since the denser areas have more airfields.)

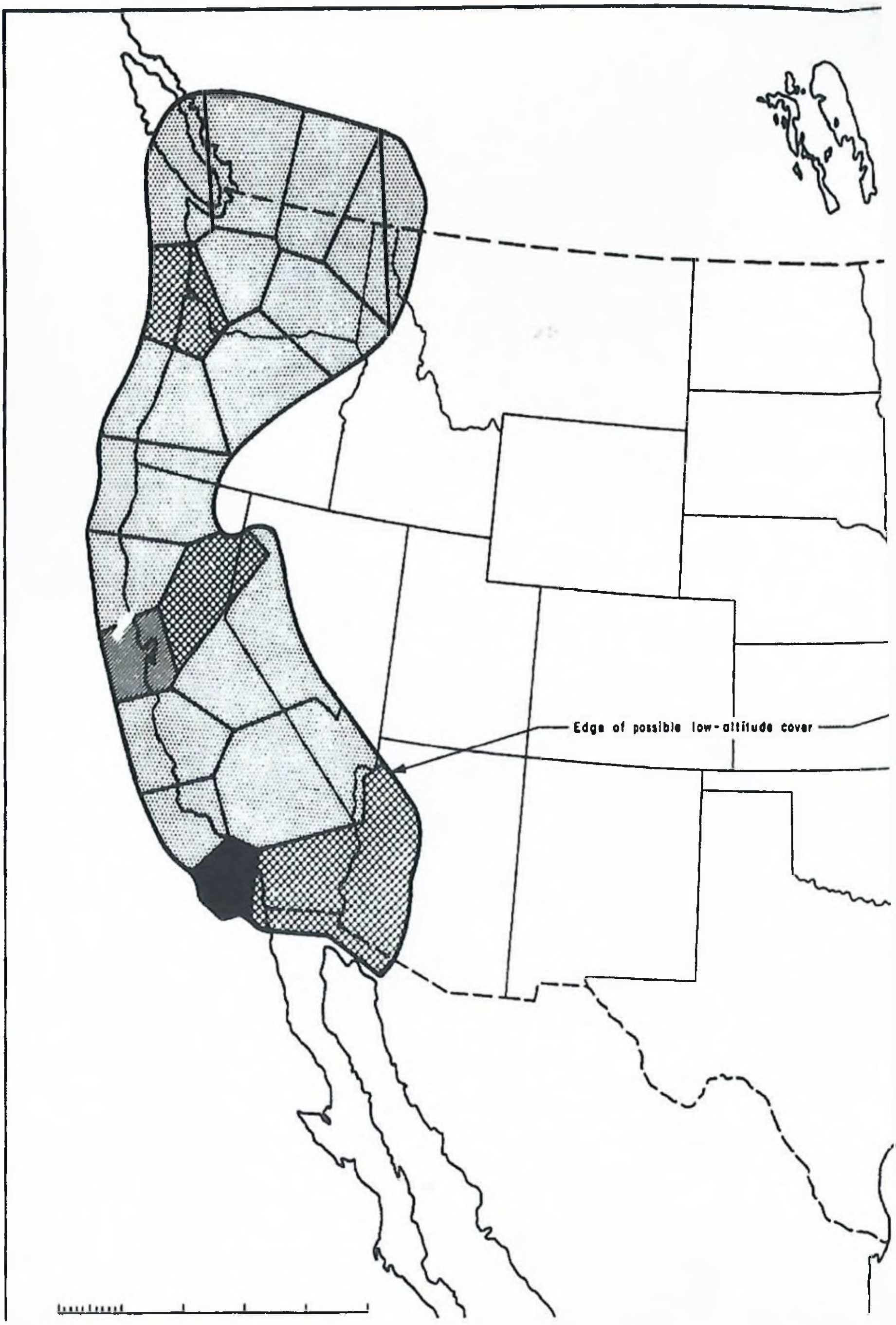
A rough estimate of the background traffic still airborne at bomber arrival time is presented in Figures 3 and 4. These figures are based on the following assumptions:

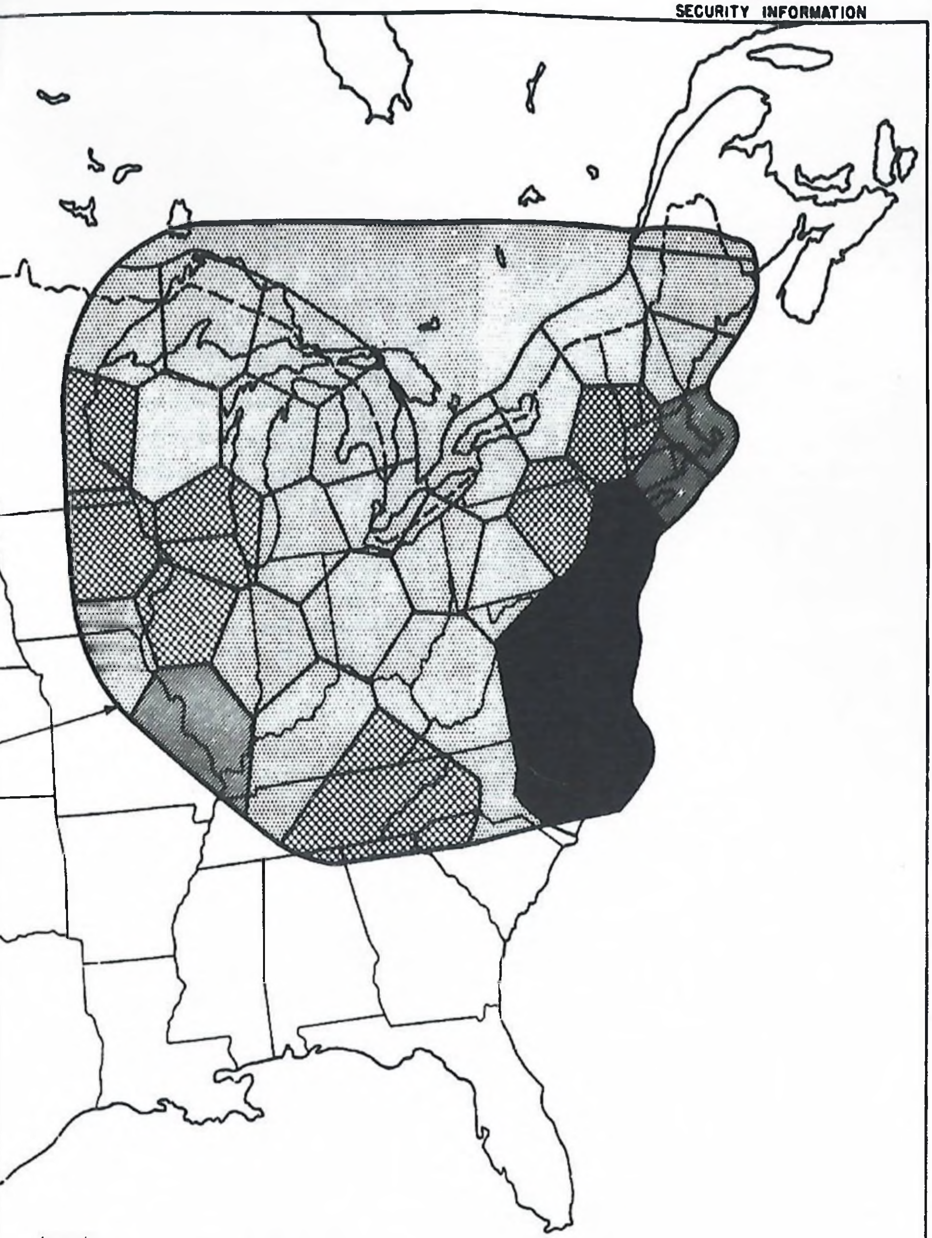
1) Sixty minutes are required to ground 95 percent of all traffic in any given radar area. For illustrative purposes, the fraction still airborne at any time after an alert is given by a simple exponential of the form e^{-ax^2}, where x is the time, a is a constant adjusted to meet the conditions of the previous sentence.

2) The bomber approaches a given area via the shortest path within the perimeter, and upon reaching the edge of the low-altitude cover begins to climb at maximum rate to combat altitude (40,000 feet) and to accelerate from low-altitude cruise speed (275 knots) to combat speed at 40,000 feet (420 knots). During the climb phase of one-half hour the bomber makes good a forward speed of 275 knots.

3) Figure 3 assumes no advance warning beyond the ground-based low-altitude cover.

4) Figure 4 assumes thirty minutes of additional cover beyond all radar areas of Figure 1 which have more than forty airborne aircraft. The perimeter corresponding to this


Edge of possible low-altitude cover



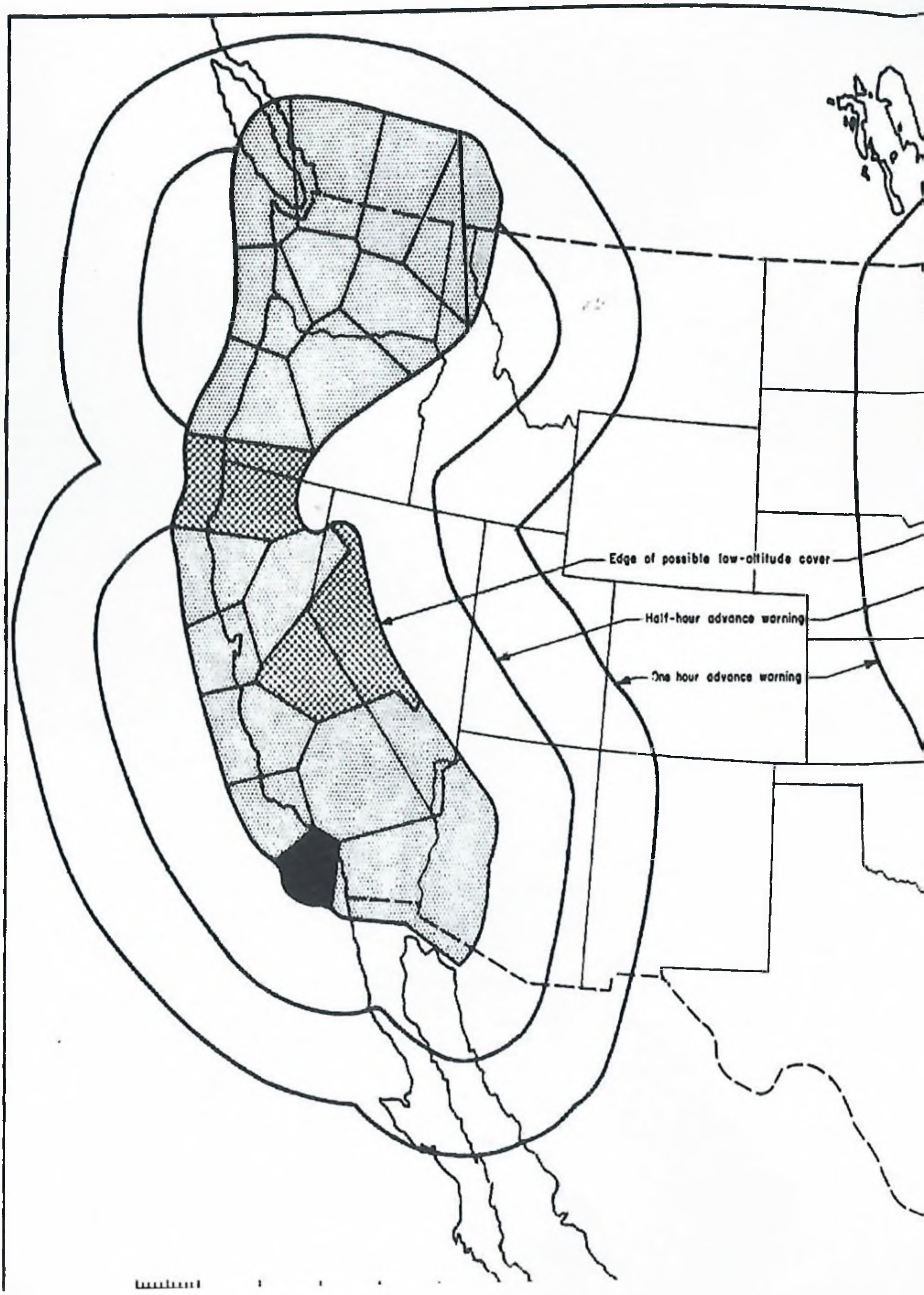
Legend:

Low altitude cover perimeter

Radar area boundaries

Coding (in numbers of aircraft):

Fig. 3—Estimated low-altitude cover against IL-28 showing peak traffic still airborne at bomber arrival time with no additional warning



Edge of possible low-altitude cover
Half-hour advance warning
One hour advance warning

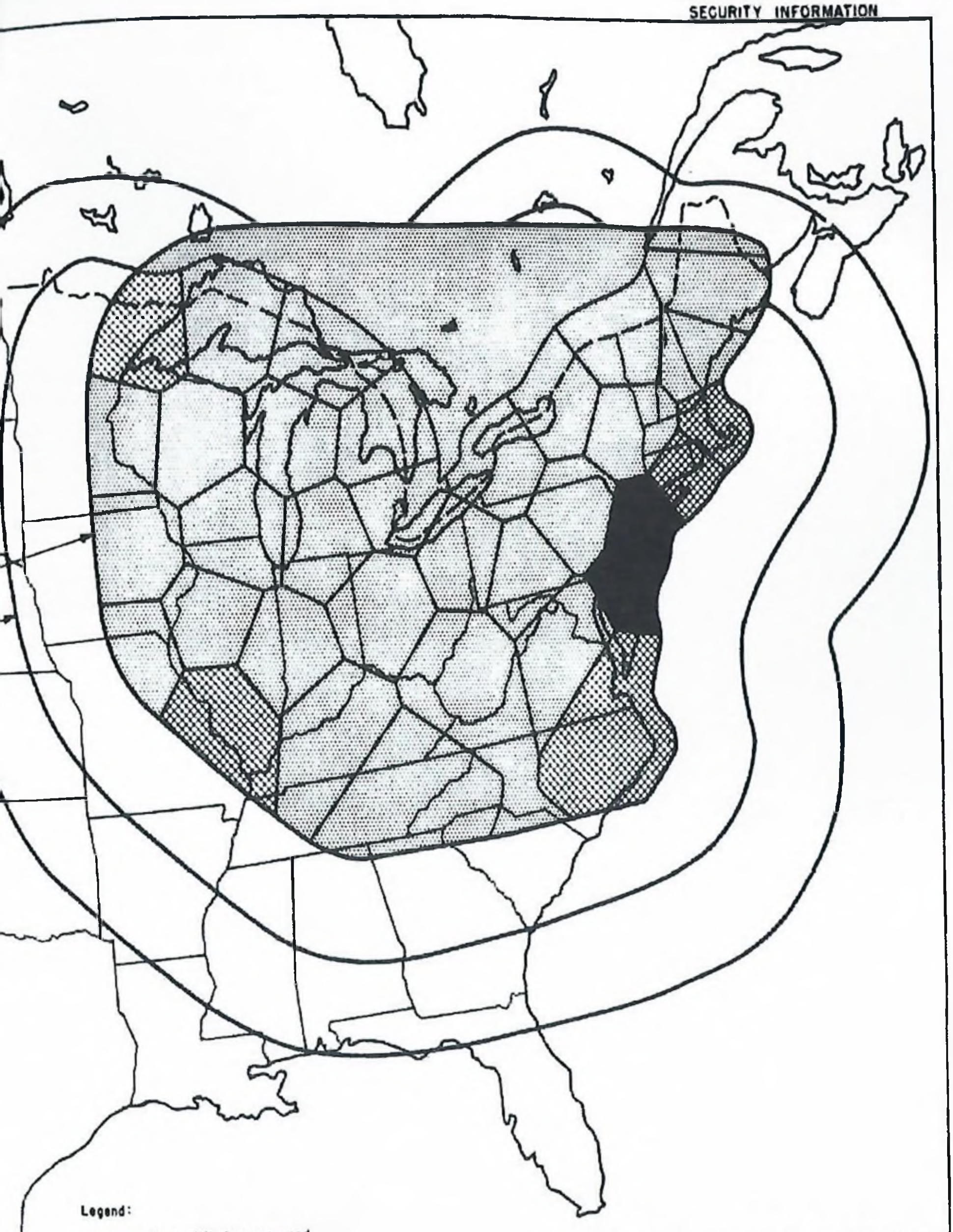


Fig. 4—Estimated low-altitude cover against IL-28 showing peak traffic still airborne at bomber arrival time with

advance warning is shown in Figure 4. The 30 minute line over the ocean corresponds roughly to the coverage which <u>might</u> be obtained from AEW radars if the enemy bombers do not choose routes midway between AEW stations and if the radar range achieved is slightly more than estimated here.

5) The assumption in both figures is that identification, and the subsequent grounding orders, are made simultaneously for all approaches. Actually, it is likely that bombers on some of the approaches would be identified before other bombers, and all traffic would then be grounded.

If the assumption about the required grounding time is correct, an hour of excess warning permits the landing of essentially all background traffic. The perimeter corresponding to this advance warning is also shown in Figure 4.

Figures 3 and 4 indicate that, subject to the grounding time assumptions, one-half hour warning is sufficient for all areas except the East Coast between Rhode Island and South Carolina, and the Los Angeles and San Francisco areas; in these regions an hour is needed. This one-half hour warning for overland attacks can most likely be achieved by means other than the closed perimeters indicated in the figures. This is so because of the limited range capabilities of Soviet bombers expected in 1956, and because the S.U. does not possess forward staging areas near our ZI. It is necessary to seek some sort of compromise deployment of low-altitude radars, both for economy and because of the difficulties in getting very many radars installed by 1956.

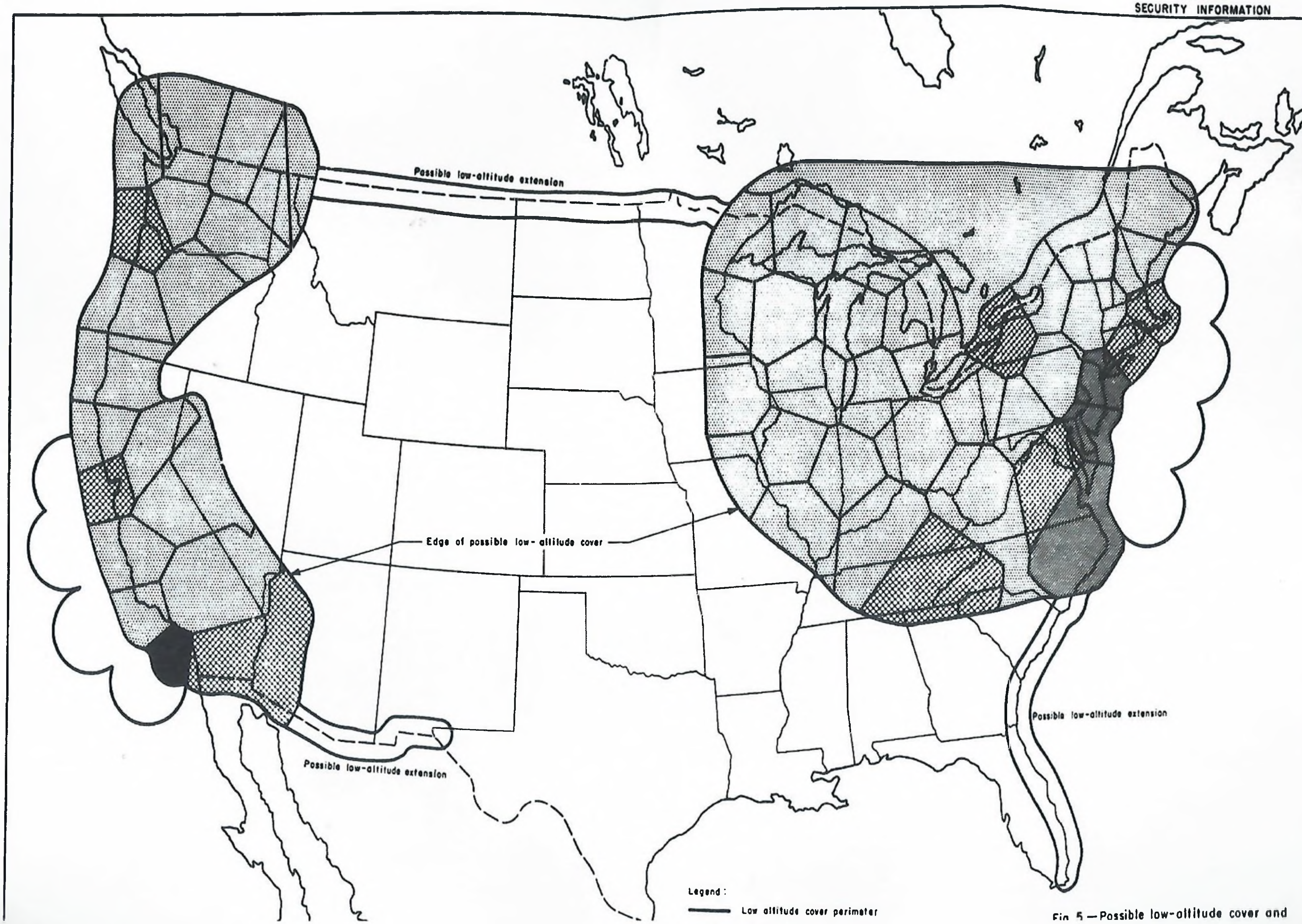


Fig. 5 — Possible low-altitude cover and

could resemble that depicted in Figure 5. The programmed AEW aircraft have been repositioned slightly to better augment the continuity of the low-altitude cover against IL-28 aircraft. Assuming that the AEW aircraft used in the plan are arranged to cover low altitudes by changing antenna tilt each scan (or by some other expedient), about a half-hour's advance warning would be supplied along most of the East Coast, for San Francisco, and for Los Angeles. More AEW aircraft would be needed to supply one hour's warning. Similarly, no advance warning is available to the San Diego-Los Angeles areas against approaches from the south because of the absence of low-altitude radars in northern Mexico. However, the extension to El Paso, Texas, would prevent a bomber from striking the Los Angeles vicinity from eastward with no warning at all provided the bomber cannot "end run" the line because of range limitations. This line of radars would provide San Francisco with the one hour of warning needed to ground all traffic for bomber routes from the south.

Inasmuch as the edge of the assumed low-altitude radar cover in southwest Arizona, northwest Montana, northeast Minnesota, and southeast North Carolina is within an hour's flight of the extended perimeter, friendly aircraft may still be airborne and attempting to cross into the defended area as the bombers are attempting to do so. Therefore, a secondary identification perimeter should be employed in each of these areas, extending an hour in depth into the ZI. Contemplated for installation before 1956 is the Canadian McGill line: a line of warning radars stretching from Prince Rupert, B.C., to Churchill, Manitoba, and thence to the Labrador radar line of the Northeastern

Air Command. If this line of radars is tied in with the contiguous cover so as to form an aircraft-tight fence, it will obviate the closing-off of the U.S.-Canadian border, and will supply much more than the requisite one to two hours of grounding time for bomber routes over Canada.

The 1956 picture was considered for illustrative purposes only. Naturally, as the regions of low-altitude cover expand, the demands for more extended perimeters will grow, at least to the point where the edge of low-altitude cover occurs an hour or more away from densely flown areas.[1] In 1958 or 1960, for example, AEW barriers may exist in the Pacific, Atlantic and Northern Canada; this may completely remove the internal identification problem. Complementary to this radar cover would be the greatly increased traffic handling capacity of the Lincoln Laboratory Transition System or some similar system.

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(1) The idea of having low-altitude perimeters is a stop-gap measure, and should be dropped as soon as solid area coverage at low-altitude can be installed. While perimeters provide a certain minimum identification capability, weapon control will generally require more extensive coverage.

III. PERIMETER IDENTIFICATION

A. Geography

There are five geographic principles which a perimeter identification system should reflect:

1) The perimeter and entry points should be within radar cover (which would see all possible threats), although not necessarily contiguous cover.

2) The perimeter and entry points should be far enough from all defense zones to permit interception before bomb release.

3) The perimeter and entry points should be sufficiently far from all areas of dense air traffic to allow either interception of the bomber or grounding of the traffic before an incoming bomber could get lost therein.

4) The routine traffic rate across the perimeter should be low enough to ensure adequate traffic handling capacity for identification purposes.

5) Insofar as is compatible with 1), 2) and 3), the perimeter and entry points should minimize the inconvenience inflicted upon routine air traffic.

The degree to which all five requirements can be met depends on the areas which can be covered and the traffic flow patterns. The only factor of 1) through 5) which is usually considered in programming radar cover is 2); it is considered because it is synonymous with the requirement that control data be provided for a distance sufficient to

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Notes on Figure 6

1. This traffic estimate was made at RAND to assist in the ADC identification study mentioned in the Conclusions. It is an extension of the results of RM-773, cited on pg. 11. In the latter a breakdown of traffic according to type (e.g., civil, military, etc.) may be found.

2. Traffic generated at military bases is not included in the coded lines.

3. International traffic other than U.S.-Canadian is not shown.

4. The first number near a military base refers to the name of the base as given in Appendix I. The second number gives the number of daily operations for:

    a) Naval Stations: Daily average for October, November, December, 1951.

    b) USAF Bases: Daily average for July, 1951.

The Naval statistics were secured from the Office of the Chief of Naval Operations, and the USAF data from the Research Division, Directorate of Research and Development, Office of the Deputy Chief of Staff, Development.

5. The average hours airborne per flight are given below:

USAF*		USN, USMC, USNR**	
Bomber	3.2	Fighter	1.6
Tanker	3.5	Attack	1.7
Fighter	1.3	Search	2.0
Reconnaissance	2.7	Patrol	3.5
Amphibious	0.9	Warning	2.5
Search and Rescue	1.2	Observation	1.5
Cargo	2.1	Transport	3.3
Trainer	0.9	Utility	2.2
Communication	0.3	Trainer	1.6
Glider	0.6	Helicopter	1.0
Aerial Target	1.2	Lighter-than-air	5.5
Total	1.3	Total	1.8

* World-wide monthly averages for March, April, May, and June, 1951. USNR and ANG over-all average was 1.4. Data from USAF Statistical Digest, January 1949-June 1951.

** Continental U.S. averages for June, 1952. (Transport category includes some trans-Atlantic and trans-Pacific flights.)

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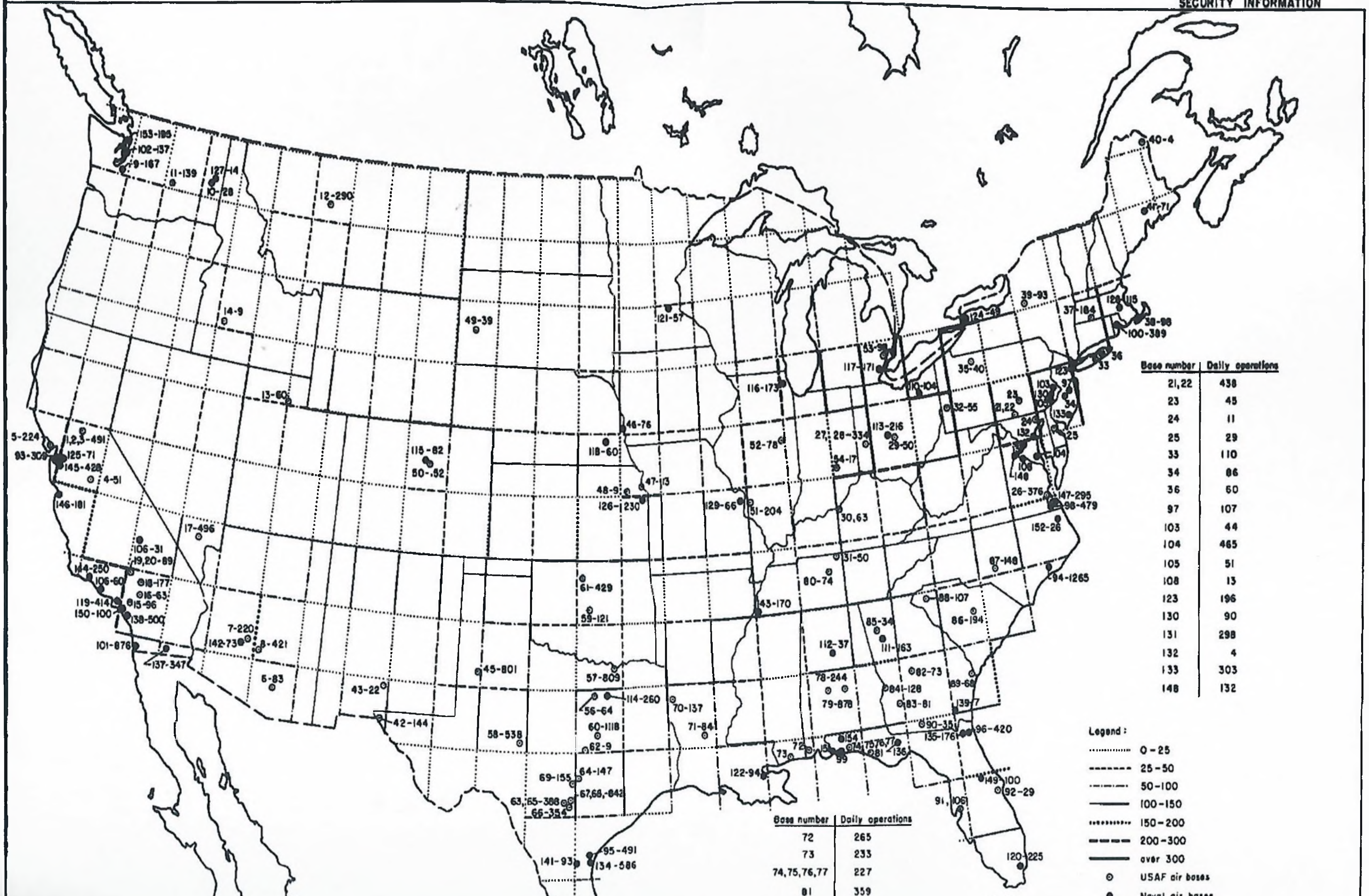

Base number	Daily operations
21,22	438
23	45
24	11
25	29
33	110
34	86
36	60
97	107
103	44
104	465
105	51
108	13
123	196
130	90
131	298
132	4
133	303
148	132

Base number	Daily operations
72	265
73	233
74,75,76,77	227
81	359

perform the air defense functions effectively. If possible, requirements 3), 4) and 5) must then be met within the restrictions of the radar net in-being and requirement 1); otherwise the radar network should be altered to meet these identification requirements.

Figure 5 presents a possible low-altitude cover situation in 1956, the first year in which solid low-altitude cover of significant extent could be available. If it is reasonable to install the identification perimeters on the coasts and boundaries of the ZI, as indicated, the crossing traffic problem will be negligible. In case these extensions cannot be activated or if they are ineffective against possible aircraft (e.g., the long-range Type 31), a perimeter inside the ZI could raise a very severe traffic handling problem. A rough estimate of the flow of routine peacetime traffic across the ZI has been made and is presented in Figure 6. A comparison of Figures 5 and 6 indicates the traffic to be expected across internal perimeters in the ZI. Because of the manner in which air traffic converges in the vicinity of the important target complexes, it is clear that requirements 1) through 5) can be met simultaneously only if the radar cover extends far outside the boundaries of the target areas.

B. <u>The Threat</u>

In RM-1075, cited in the Preface, it is estimated that the U.S. defenses might be subjected to the following types of weapon carriers:

1. Manned, conventional aircraft, in particular: TU-4's, Type 31's, IL-28's and supersonic-dash bombers.

2. Manned, unconventional aircraft; e.g., submarine-launched turbojet, fighter-like aircraft.

3. Unmanned aircraft, e.g.,

   a) Long range surface-to-surface missiles of the Snark and Navajo types.

   b) Submarine-launched missiles of the V-1 and V-2 types.

C. <u>Identification Methods</u>

There are six principal types of identification which can be employed against the above threats. Five of them operate "in-the-small"; that is in individual radar areas. The sixth operates "in-the-large"; that is, it attempts to interpret nationwide events in terms of a possible air attack.

The first five of these methods are designed to work against even <u>single</u> enemy bombers, and most of the discussion of these methods is in these terms. The sixth method is designed to work against a <u>few</u> bombers, say less than ten, in a coordinated attack and to be effective even if these few bombers are spread over the whole country. This scale of attack is, of course, extremely small. When considering questions of weapons effectiveness, control capacity of the radar network, etc., simultaneous attack by <u>hundreds</u> of bombers are commonly assumed. Clearly, attacks of this magnitude present an entirely different identification problem. There is no chance of confusing such attacks with normal peacetime air traffic. The identification problem reduces to the ability to tell the difference between large scale SAC maneuvers and an actual attack. This problem is discussed below as a separate type of identification.

The identification methods effective against single bombers are discussed first, in paragraphs 1 through 5.

1. Characteristic Identification

This identification mode is an attempt to recognize an enemy as such, and consider the residue of aircraft as friendly. In order for this to be possible, the enemy must exhibit some characteristic peculiar to it and not to friendly aircraft. As an extreme example, consider the surface-to-surface ballistic rocket: it may approach the target at 15,000 knots and at an angle of 14 degrees with the vertical. Because similar U.S. missiles need never be flown so as to penetrate the ZI (reconnaissance missiles can land at forward bases), the ballistic rocket is immediately recognizable by its high speed and altitude. Similar statements may be made for the high-speed surface-to-surface missile of the Navajo variety (1,600 knots at 70,000 feet) and the submarine-launched V-2 (3,000 knots at a 45-degree incidence angle).

The recognition of characteristic "signatures" in the acoustic spectrum or doppler shift are also examples of this kind of identification. Research along these lines is promising, but field use is not very near. Another variant of this method is the sending of an interceptor aloft to visually inspect an aircraft. However, this is not considered a desirable technique because of the way in which it weakens the rules of engagement. A good goal is to so design the identification system that scrambles are essentially never made against "unknowns," but only against "enemies."

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Because of the mixture of weapon carriers in any given year, and the limitations against conventional aircraft the characteristic technique, even if successfully used on the surface-to-surface missiles and rockets, does not allow the defense to assume the aircraft residue to be entirely friendly. Therefore this mode must be used in conjunction with others.

2. Operational Identification

This mode is an attempt to recognize each aircraft as friendly; the residue not so identified are considered enemy. In order for this to be possible, the friendly aircraft must exhibit some characteristic peculiar to it and not to enemy aircraft. Because of the non-secret nature of radar and radio transmissions, and because of non-military confidants, these identifying characteristics must be capable of variation with time in an unpredictable manner.

a) Flight Plan Matching

The operational technique most widely used today is that of flight plan matching. At take-off, a penetrating aircraft files a flight plan, giving the time, place, and altitude of planned penetration of the identification perimeter. If the aircraft is within standard time and distance tolerances of this space-time point, he is admitted as a friendly. The pilot may reestimate his ETA up to fifteen minutes prior to penetration.

The identifying characteristic in this technique is the presence of the aircraft at the right place at the right time, it being assumed that an enemy cannot occupy the flight plan of a friendly aircraft or file one of its own. Flight plan matching as practiced to date gives unsatisfactorily high probabilities of mistaking friendly for enemy and vice versa for several reasons:

1) An enemy has at least a random chance of fulfilling the flight plan requirements and being sufficiently far ahead of the friendly to escape correct identification; this chance is enhanced by the fact that penetrating aircraft fly routine tracks. Since the flight plan information is transmitted unencoded to its air defense recipient, an informed enemy has an even greater than random chance of meeting the requirements or sending in a deceptive message.

2) Even at relatively low traffic levels, operational tests have shown that the system breaks down. This is reflected in two ways. First, aircraft penetrate without getting considered at all. Secondly, tracks get cross-correlated, so that a friendly becomes an unknown, and vice versa.

These shortcomings can be overcome partially by making the flight plan transmission secure, reducing the traffic load by regulation (or by moving the perimeter to sparsely flown regions), and by engineering the identification procedures followed by both aircraft and defense personnel so they can be more easily performed. Naturally, the random ability of the enemy to penetrate the defenses can be lessened, but not completely removed. The following three techniques are attempts to remove these deficiencies; they were evolved and tested by the Operations Analysis Section at ADC.

b) Entry Point Techniques

The flight plan system discussed above allows aircraft to enter the ZI at any point of its perimeter. The system evolving currently restricts entry to a relatively small number of points. This has several advantages:

1) Traffic crossing the perimeter at other points is immediately considered hostile.

2) The entry points may be placed at positions disadvantageous to the enemy (e.g., well away from critical targets, near interceptor bases).

3) The number of simultaneously entering aircraft is kept low (e.g., below the number of entry points), and hence the number of bombers attempting to deceive the identification system must also be low.

4) A centralized check may be maintained on these key points for analysis of the nationwide penetration situation.

5) Navigational and identification aids (e.g., high-power beacons, ground-to-air communications) can be concentrated at these few points and thereby enhance the probability of identifying friendlies as such.

c) Multiple-Corridor Approaches

This system improves upon flight-plan matching by replacing the distance tolerance with a corridor of specific heading, and by making the knowledge of the correct corridor secure from an enemy.

A standard set of corridors are established converging upon the entry point. All aircraft entering the ZI must be inspected for weapons at one of a set of briefing air fields exterior to the identification perimeter. At take-off from the briefing field the pilot is given a sealed envelope containing the number of the corridor down which he is to approach the entry point. The envelope is numbered on the outside, its contents being identical with those of a similarly numbered envelope in the possession of the personnel at the appropriate entry point. The envelope number is forwarded via the usual channels with the regular flight plan. Unless there is a security leak in the envelope filling and delivery, the corridor designation is secure information. Naturally, the pilot could divulge the envelope contents to an enemy, but this must be risked in any comparable system. If the aircraft arrives at the entry point in the correct corridor and within standard time tolerances it is admitted as friendly.

The probability that a given aircraft will meet its time and corridor tolerances is dependent upon their magnitudes; it is possible to vary the fraction of friendlies admitted as such by changing these magnitudes. Similarly, the probability that an enemy will be able to occupy the flight plan of a friendly aircraft is dependent upon the number of corridors, the time tolerance, the number of friendly aircraft per hour, and the time by which an enemy has to precede a friendly to accomplish deception. Since the defense will question its prior identification upon the arrival of the true friendly, the bomber has but a limited time to take advantage of its deception. The amount of time needed by the bomber is determined by its speed, the time required for interception, and the distance between the entry point and the closest of:

1) The bomb release line.
2) The inner edge of radar cover if it is a non-contiguous perimeter.
3) Dense traffic in which the bomber can get lost.

The manner in which the probabilities of friendly and enemy admittance vary as a function of these variables is considered in two reports by the Operations Analysis Office, Air Defense Command.(1), (2)

d) In-Flight Maneuvers

Using the envelope procedure outlined above, a penetrating pilot can also be assigned a secure maneuver to be performed in the vicinity of the entry point. If the aircraft is within given time tolerances of its flight plan, and successfully performs its maneuver, it is admitted as friendly. Again, the probabilities of friendly and enemy admittance depend on the type and number of maneuvers, the time tolerance, number of friendly aircraft per hour, the proximity of the

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(1) R. H. Jordan and R. H. Blythe, Jr., Technical Memorandum No. 3, A Multiple Corridor System for Identification of Aircraft Penetrating the Borders of the United States, Operations Analysis Office, Deputy for Operations, Headquarters, Air Defense Command.

(2) R. H. Jordan, Technical Memorandum No. 9, Test of the Multiple Corridor System of Aircraft Identification, Operations Analysis Office, Deputy for Operations, Headquarters, Air Defense Command.

entry point to items 1), 2) and 3) listed above, bomber speed, and time to intercept.[1]

e) Code Words

Using the same envelope procedure, a penetrating pilot is provided with a secure code word to be used in reply to a challenge at the entry point. Again, the time tolerances must be met; again, similar remarks about admittance probabilities apply. Because of the difference in radar and ground-to-air radio ranges, it is possible for one aircraft to be interrogated and another to answer. To obviate the possibility of a bomber taking advantage of this weakness, very directional radio and a means of correlating this signal with radar returns is needed.

3. Electronic Identification (IFF)

Electronic IFF, depending on the way it is used, could be considered either as an operational or a characteristic method, but here it will be treated separately. The electronic equipment required for this method will probably be installed only in military aircraft. Therefore it cannot be used alone to identify an enemy as such except in an area in which only military aircraft are known to be flying. IFF had a very low operational reliability in World War II. Unless its reliability is greatly improved, IFF should be employed as one event in a set of alternatives, any one of which would suffice as identification. In this manner the probability of correctly identifying a friendly as such is enhanced. Because of the large number of codes

(1) See the previously cited ADC memoranda.

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obtainable from certain versions of IFF equipment, the probability of a given code being randomly selected by an enemy can be made negligible. Subject to these conditions, IFF is considered capable of identifying as friendly the aircraft in a region where all friendly traffic has IFF equipment. It also has utility as a directional communication device like the one desired for code-word transmission; in this use it has the advantage of connecting directly with the GCI scope watcher.

There is a current program under way to install airborne and ground units of the Mark X IFF system in both the Air Force and Navy. In addition to the primary function of identification of aircraft to ground radars, the Mark X can be used for other special purpose communications jobs, including air-to-air identification and air-sea rescue. It can help the ground controller keep track of which friendly is which, although this job is best done by supplementary equipment which will be described later. A complete system description is given in AF Technical Report No. 6233,[1] from which the following excerpt was taken:

> "The Mark X uses an Interrogator-Responsor (I-R) closely interconnected with the ground radar. The I-R interrogates the airborne transponder by means of an L-band pulse transmission and receives a similar reply which is displayed on Plan Position Indicators in addition to or in place of the radar echoes. The ground-to-air

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(1) Leon J. Lader, Status of IFF Mark X, AF Technical Report No. 6233, Watson Laboratories, AMC, December 1950 (Secret).

transmission is repeated at the pulse repetition frequency (or submultiple) of the radar and consists of a pair of one-microsecond pulses separated by a three, a five, or an eight μsec interval. By prearrangement, these spacings or modes permit separating the response of various aircraft or groups on the displays. The aircraft may reply as follows:

a. IFF Mode. - A single pulse reply to the 3 μsec spacing interrogation. Operationally, all aircraft respond to the 3 μsecond mode at all times.

b. Personal Identity Mode. - A double pulse reply with 16-μsec separation to the 5-μsec spacing interrogation. Operationally, an aircraft indicates 'Personal Identity' when it is switched to this mode by the pilot on request from the ground controller.

c. Flight Leader Identity Mode. - A single pulse reply to the 8-microsecond interrogation. This mode of operation is also secured by prearrangement.

d. Emergency Reply. - A series of 4 pulses separated by 16-μsec when the pilot desires to indicate 'Emergency.' Operationally, this response appears for all modes of interrogation at the pilot's option."

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Since there is almost no security in the basic Mark X system, the Air Force has been developing supplementary equipment called SIF (Selective Identification Feature).[1] In addition to a Security Identity Mode, which may incorporate code changes every minute, SIF will provide airframe identity and also a mode which will help sort replies into categories. The Navy has a completely different supplementary security system under development. To date, efforts to settle on a joint system have not been successful.

4. Composite Techniques

The function of an identification system is to admit friendlies and deny admission to enemies. However, these two payoffs are to some extent incompatible; in most practical systems the probability of enemy admittance is proportional to that of friendly admittance. The two payoffs must therefore be balanced against one another. If two or more of the techniques discussed above are combined appropriately, a balance is more easily obtainable. It is therefore advantageous to both defenses and friendly aircraft to employ a composite system of the above identification modes. This has, in fact, been incorporated in the plans of ADC and tested at San Francisco where multiple corridors and in-flight maneuvers were combined. Results of these tests indicate that with operational experience on the part of both the defense and aircraft personnel the probabilities of friendly and enemy admittance can be brought to about 95 percent, and

(1) S. M. Beane, Status of Selective Identification Feature System, RADC Technical Report 52-25, November 1952 (Secret).

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zero to 5 percent, respectively.

It is therefore estimated that in operational use in the air defense system, these composite methods can lead to a probability of identifying a single enemy manned bomber as such of at least 95 percent, with a corresponding probability of friendly admittance of at least 95 percent also. Unmanned aircraft will be identified with an even greater reliability because of their relative inability to perform the in-flight operations required; large raids will bring on a quicker-than-average reaction, as discussed later.

5. Forced Landing for Inspection

Because of the grossness of the system just described, and the variability of flight conditions with weather, the percentage of friendlies mistaken as enemy will probably never be much lower than 5 percent. To obviate scrambling on each such friendly,[1] a "fail-safe" technique (recommended by Project CHARLES) is contemplated. In this system, no aircraft is authorized to cross the identification perimeter unless it has received permission to do so. If such permission is not forthcoming, all pilots are instructed to land at "fail-safe" airports for inspection. These airports should be within radar cover but safely removed from critical target areas.

6. Statistical Raid Recognition

Because of its statistical nature, the efficiency of the identification system may be partially expressed as the probability that a given friendly aircraft will be identified as such. When the system has reached a training and experience plateau, it may be expected that this probability will become statistically stable. For a

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(1) Or shooting at them - see Section D, p. 47 , where very strict rules of engagement are recommended.

given number of friendly aircraft, the probability of any fraction of labelled unknowns may be computed. Corresponding to the number of false alarms acceptable per year, a critical fraction of friendlies labelled enemies per given number of friendlies may be defined. When the critical value is exceeded it is assumed that something out of the ordinary is occurring (e.g., very bad flying conditions, actual air attack). Hence, if a running score is kept of all tracks penetrating the ZI, this technique may be used to detect the presence of a super-critical number of unknowns, and hence the presence of a raid. This is not considered to be a primary identification technique. Rather, it is an aid by which the posture of the defense system may be improved in the presence of certain types of raids. This technique, which is now in use, is called statistical raid recognition and is discussed in a report by the Office of Operations Analysis, ADC.(1) This type of operation could be more valuable in the future if false alarms were made much less frecuent than in current practice. This should be possible with improved primary identification methods.

7. Effect of Raid Size and Dispersion Upon Identification

The previous identification methods are effective against single bombers or few bombers. Whenever an unusually large number of aircraft simultaneously enter a given radar area they can be immediately recognized as bombers, either hostile or from SAC.(2) Hence,

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(1) R. H. Blythe, Jr., and W. F. Blaylock, Technical Memorandum No. 7, Numerical Technique for Raid Recognition, Operations Analysis Office, Deputy for Operations, Headquarters, Air Defense Command.

(2) In some cases such deceptive friendly flights may come from off-shore aircraft carriers.

the techniques discussed heretofore have to deal only with simultaneous numbers less than, say, three or four aircraft per radar area providing all SAC movements are well known. Similarly, there is a critical number of nationwide penetrations with respect to statistical raid recognition, say, five to ten. It is seen that the "local" and "nationwide" identification systems complement one another in a very important way. If the local system has a predisposition to admit single enemy aircraft, to take advantage of it the enemy must spread a given number of bombers over a wide segment of the perimeter. However, to deceive the "nationwide" system the over-all number of bombers must be kept below five to ten. The "nationwide" system thus complements the "local" system in its weakest situation of widely dispersed single penetrations and prohibits the enemy from gaining a great deal by spreading more than five to ten bombers thinly over the nation.

D. Rules of Engagement

The last and vitally important step in the identification process is the decision as to whether a specific penetrating aircraft should be attacked. This decision is governed by the rules of engagement. These rules represent a balance between fear of attacking friendly aircraft and fear of neglecting to attack enemies. Just where the balance is struck depends on the confidence the defense forces have in the reliability of the preceding identification steps, flight-plan matching, entry-point techniques, etc.

In the identification system to date, the onus of correct recognition has been upon the defense. This has resulted because the operational techniques (flight-plan matching, IFF) have operated so unreliably that the system has come to rely upon supposed characteristic features. These characteristics (from which come the "rules of engagement") are:

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1) Manifestly hostile intent.

2) Commission of an overt hostile act.

3) USSR markings, and appearance without prior arrangements, except for aircraft in obvious distress.

When an interceptor is scrambled against an unknown aircraft, that aircraft has to possess at least one of these three characteristics before the pilot can attack. Unless items 1) and 2) are very stringently redefined it is doubtful that they will ever result in recognition sufficiently early to permit a kill before bombs are dropped; reliance upon Soviet bombers being so marked is extremely unrealistic. In addition, the current shortage of all-weather interceptors forces the defense to simply overlook a significant fraction of all unknown aircraft. When and if an air attack on the ZI occurs, it would be wasteful of interceptors to use them on visual inspection missions. Rather, the identification procedures must be so designed and operated that interceptors are never used as a visual identification tool. This must certainly be the case by the time unmanned area missiles become operational, since they possess no in-flight identification capabilities.

The air defense interceptor pilot is currently faced with a very unnerving dilemma: whether to fire upon an unknown, perhaps killing a score or more fellow citizens, or to let the aircraft pass unscathed, with perhaps 100,000 lives hanging in the balance. This is hardly the psychological setting designed to elicit maximum pilot efficiency. It comes about because the pilot is called upon to recognize extremely innocuous symptoms in an adverse environment. Rather, the recognition should take place in an environment designed specifically to ensure success, before the interceptor has approached the unknown. Further, once scrambled, an interceptor pilot should have but one mission to perform: to shoot down an unknown aircraft at all costs, unless extremely rare extenuating circumstances occur (e.g., absolute visual recognition in very bad weather). Such a reorientation of pilot psychology would have two effects. First, it would reduce the probability that a pilot would fail to fire on a true enemy. Secondly, it would enhance the probability of making a correct firing pass because of his changed mental posture.

These changes in the rules of engagement can certainly never occur until the identification system achieves a reliability much greater than that currently obtaining. In view of the interrelation of the fractions of friendlies and enemies admitted, some minimum number of friendlies must be subject to possible intercept action each year. This acceptable minimum is a function of the probability of enemy attack; the public will have to be informed of the relative dangers so that an intelligent opinion can be formed. No one is in favor of shooting at friendly aircraft. Such penalties, resulting from having strict rules of engagement, must be balanced against the penalties resulting from a successfully delivered atomic bomb.

It is felt that the characteristic and operational techniques disdussed here, with a stringent application of the fail-safe principle, will reduce to a negligible number the friendlies identified as hostiles and still attempting to penetrate the perimeter. Indeed, the number of wrongly labelled friendlies still entering each year may be so low that the rules of engagement can be changed to require firing on an unidentified aircraft unless absolute visual proof of its friendly nature is very easily obtainable. Only if this condition exists can the defense forces realize a large measure of their now latent abilities.

IV. THE SUBMARINE-LAUNCHED THREATS

A. Interior Identification

In the dense traffic areas of the Atlantic and Pacific Coasts, in particular the former, heavy military traffic extends well out to sea (fifty miles or more). In order to locate the identification perimeter in a sparsely flown region it is therefore necessary to place it at sixty to one hundred miles from the coastline. The traffic-grounding problem demands an even greater off-shore distance. These off-shore locations are generally farther out than those that might be used for launching either manned or unmanned aircraft from submarines. The defense system is thus faced with the problem of enemy aircraft originating <u>inside</u> the coastal identification perimeters. Since the submarines may launch these aircraft or missiles within several miles of the shore, the background traffic problem cannot be solved by grounding procedures. No solution to this phase of the internal identification problem is currently seen, with two possible exceptions: (1) detecting and identifying the submarine, or (2) prohibiting all flying near important target areas which are within range of submarine-launched aircraft. This would be an extremely restrictive step and very difficult to implement.

B. Perimeter Identification

The submarine-launched threats are identifiable by the means discussed heretofore: the V-2 by its high altitude and speed, the V-1 and turbojet by the operational techniques (including IFF). Since they originate within the identification perimeter, the V-1 and turbojet can only be identified if all aircraft in the off-shore regions are tracked, or a secondary perimeter is established at the coastline, or no aircraft are permitted to fly in the off-shore regions.

The distances flown after identification in the schemes considered here are usually inadequate to permit the area defenses to counter these threats; either local defenses or anti-submarine defenses are required. With respect to the latter, the Navy is pursuing a program using passive listening to low-frequency sound waves (LOFAR) which may detect submarines at ranges of several hundred miles under suitable conditions. If this program results in a reliable operational network, denying undetected submarines access to the coast, the problem becomes one of submarine identification.

The very nature of the off-shore traffic makes identification difficult. Although there is some civil traffic, most is military, and of a special local character: aircraft which will return to their point of take-off after an hour or so of off-shore gunnery, aircraft carrier approaches, etc. The time off-shore per aircraft is very variable and uncertain. Hence, any technique embracing a well-defined flight plan is probably unworkable. Some sort of short duration code system (e.g., time-varying IFF coding) is probably required. In any event, the traffic variability, habits and magnitude will present a significant problem to the identification system unless strict regulation of this flying is instigated.

C. Summary

In summary, it can be said that the submarine-launched V-2 threat is identifiable by its characteristics. The V-1 and turbojets are theoretically identifiable using operational techniques, but system loads, etc., will tend to reduce the reliability with which friendlies are called friendlies and enemies called enemies. This will occur at very inadequate distances from some targets unless all traffic in large areas is tracked. The V-1 and turbojets will have a high probability of becoming lost in background traffic during appropriate hours of the day. The anti-submarine program, if successful, promises the best means of countering the submarine-launched threats from both the interior and perimeter identification viewpoints.

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V. CONCLUSIONS

A. Interior Identification

The degree of solution of the interior identification problem is dependent upon the amount of advance warning available to the defended area in question. Assuming that an hour is sufficient to ground traffic (this may be optimistic) it appears that the warning possibly available against conventional bombers (based on identification lines matching the estimated low-altitude radar coverage in 1956) is insufficient on the Atlantic and Pacific Coasts. The defense system efficiency in these areas may suffer a degradation commensurate with 100 to 400 background aircraft still airborne in each radar area if programmed AEW coverage is ineffective. At best the programmed AEW coverage would be sufficient to reduce the background aircraft still airborne per radar area to about 60 to 100. Against submarine-launched enemy vehicles almost no advance warning is available, so the background traffic in coastal areas would be almost entirely airborne while the air battle takes place.

It is quite urgent that the various military and civil services agree on a procedure for keeping traffic to a minimum during an alert or an emergency. Priorities must be assigned and clear rules laid down about who can fly, and where and when they can fly.

B. Perimeter Identification

There are a sufficient number of identification techniques available to enable highly reliable perimeter identification. By requiring that identification take place in light-traffic regions, enemy and friendly admittance probabilities of 5 and 95 percent, respectively, can be achieved.

If a double identification perimeter is employed against the submarine-launched threats on either coast, a lower reliability than mentioned above will result against this threat because of the dense traffic occurring in the immediate vicinity of the coastline. If this reliability is too low, then off-shore traffic must be regulated. In any event the warning will be insufficient to permit area defenses to protect the targets immediately on the coast. The most hopeful solution to the submarine problem seems to be offered by the low-frequency passive listening program, if current developments are successful.

U.S. SAC flights into the ZI and Navy flights from off-shore carriers must be carefully controlled. If this is done so that large-scale enemy raids are easily identified, and if the identification techniques previously discussed are implemented, the offense cannot profitably send over two or three bombers into a radar area simultaneously in an attempt to deceive the defense. More than five to ten bombers dispersed across the nation should be sufficient to trigger a stable, well-designed statistical raid recognition system. False alarms can be much less frequent than at present.

C. Rules of Engagement

The present rules of engagement are so inadequate that they completely invalidate the preceding identification efforts and destroy the efficiency of the interceptor. It should not be the role of the interceptor pilot to make a decision between life and death of aircraft

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passengers or target city residents. The pilot should have as his sole mission the destruction of the unknown aircraft except under the rarest and most extenuating of circumstances. Such operational procedures now appear possible if the previously discussed identification modes are carefully adapted, and backed up by a fail-safe policy.

D. Present and Future Systems

Identification procedures and radar coverage must be planned together. As we get more and better radar coverage we should relocate the identification lines and modify the procedures. For example, most of the techniques discussed here could be applied immediately to traffic above 20,000 feet altitude. It would be well to do so in order:

1) To accumulate experience that would lead to a really effective system after we get coverage at low altitudes.

2) To have identification capability against a high-altitude attack, even though we may feel a low-altitude strike most likely.

Several groups within ADC have applied themselves to obtaining a workable identification system. First, the Office of Operations Analysis, ADC, has studied and tested various of the discussed techniques. Further, ADC has set up entry points on both coasts, as the first steps in an attempt to close off major portions of both coasts and the U.S.-Canadian border. Secondly, the Directorate of Plans and Requirements, ADC, has written a plan for enclosing all the major ZI target complexes into several islands surrounded by aircraft-tight perimeters. This plan is being checked and coordinated within ADC now.

It is felt that these efforts should be supported and accelerated, with the purpose of obtaining a workable identification system at the lowest possible altitude at the earliest possible date; by 1954, at the latest. Participation in this plan should be compulsory for all aircraft users operating in the areas and altitudes of implementation. Every effort must be made to so improve the efficiency of the system that the needed changes in the engagement rules can be made. Then and only then will we have a workable air defense system.

Appendix I

Air Bases Whose Rates of Operations Are Given in Figure 6

USAF Bases

1. Travis AFB
2. McClellan AFB
3. Mather AFB
4. Castle AFB
5. Hamilton AFB
6. Davis-Monthan AFB
7. Luke AFB
8. Williams AFB
9. McChord AFB
10. Fairchild AFB
11. Larson AFB
12. Great Falls AFB
13. Hill AFB
14. Mountain Home AFB
15. March AFB
16. Norton AFB
17. Nellis AFB
18. George AFB
19. 20. Edwards AFB
21. Andrews AFB
22. Bolling AFB
23. Olmsted AFB
24. Phillips Field
25. Dover AFB
26. Langley AFB
27. 28. Wright-Patterson AFB
29. Lockbourne AFB
30. Godman AFB
31. Campbell AFB
32. Gtr. Pittsburgh Apt.
33. Mitchel AFB
34. McGuire AFB
35. Stewart AFB
36. Suffolk Cty. Apt.
37. Westover AFB
38. Otis AFB
39. Griffiss AFB
40. Limestone AFB
41. Dow AFB
42. Biggs AFB

43. Holloman AFB
44. Walker AFB
45. Reese AFB
46. Offutt AFB
47. Sherman AFB
48. Forbes AFB
49. Rapid City AFB
50. Lowry AFB
51. Scott AFB
52. Chanute AFB
53. Selfridge AFB
54. Atterbury AFB
55. Oscoda AFB
56. Carswell AFB
57. Perrin AFB
58. Goodfellow AFB
59. Tinker AFB
60. Connally AFB
61. Vance AFB
62. Gray AFB
63. Kelly AFB
64. Bergstrom AFB
65. Brooks AFB
66. Ellington AFB
67.
68. Randolph AFB
69. San Marcos AFB
70. Barksdale AFB
71. Alexandria AFB
72. Brookley AFB
73. Keesler AFB
74.
75. Eglin AFB
76. Eglin Aux. Field No. 6
77. Eglin Aux. Field No. 3
78. Maxwell AFB
79. Craig AFB
80. Stewart AFB
81. Tyndall AFB
82. Robins AFB
83. Turner AFB
84. Lawson AFB
85. Dobbins AFB
86. Shaw AFB
87. Pope AFB
88. Donaldson AFB
89. Hunter AFB
90. Moody AFB
91. MacDill AFB
92. Patrick AFB

USN Stations

93. Alameda, Calif.
94. Cherry Point, N.C.
95. Corpus Christi, Tex.
96. Jacksonville, Fla.
97. Lakehurst, N.J.
98. Norfolk, Va.
99. Pensacola, Fla.
100. Quonset Point, R.I.
101. San Diego, Calif.
102. Seattle, Wash.
103. Johnsville, Pa.
104. Patuxent River, Md.
105. Philadelphia, Pa.
106. Point Mugu, Calif.
107. Chincoteague, Va.
108. Dahlgren, Va.
109. Inyokern, Calif.
110. Akron, Ohio
111. Atlanta, Ga.
112. Birmingham, Ala.
113. Columbus, Ohio
114. Dallas, Tex.
115. Denver, Colo.
116. Glenview, Ill.
117. Grosse Ile, Mich.
118. Lincoln, Neb.
119. Los Alamitos, Calif.
120. Miami, Fla.
121. Minneapolis, Minn.
122. New Orleans, La.
123. New York, N.Y.
124. Niagara Falls, N.Y.
125. Oakland, Calif.
126. Olathe, Kan.
127. Spokane, Wash.
128. Squantum, Mass.
129. St. Louis, Mo.
130. Willow Grove, Pa.
131. Anacostia, D.C.
132. Annapolis, Md.
133. Atlantic City, N.J.
134. Cabaniss Fld., Tex.
135. Cecil Fld., Fla.
136. Corry Fld., Fla.
137. El Centro, Calif.
138. El Toro, Calif.
139. Glynco, Ga.
140. Key West, Fla.
141. Kingsville, Tex.
142. Litchfield Park, Ariz.

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143. Memphis, Tenn.

144. Miramar, Calif.

145. Moffett Fld., Calif.

146. Monterey, Calif.

147. Oceana, Va.

148. Quanticc, Va.

149. Sanford, Fla.

150. Santa Ana, Calif.

151. Saufley Fld., Fla.

152. Weeksville, N.C.

153. Whidbey Is., Wash.

154. Whiting Fld., Fla.