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AUTOMATIC AIRCRAFT INTERCEPT CONTROL SYSTEM STUDY

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AUTOMATIC AIRCRAFT INTERCEPT CONTROL SYSTEM STUDY

Sebastian Riccobono

August 30, 1948

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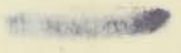
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ABSTRACT

The advent of high-speed jet aircraft created the need for automatization of intercept control and direction. Basic considerations involved are discussed and assumptions to be used as a basis for further work are stated.

PROBLEM STATUS

This is the first progress report of a study being conducted at the Laboratory under Problem R07-25R.

AUTHORIZATION

- Ref. (a) CNO ltr OP-413-C63/fic, FS-367 Ser No. 1397P413 to ONR, BuAer, BuShips, BuOrd, dated 4 Sept 1947 directing initiation of development plans.
- (b) ONR ltr to NRL, EXOS:ONR:N461:EOW, ser 52, dated 19 Jan 1948. Request for establishment of project at NRL to conduct studies of Automatic Aircraft Intercept Control System as stated in correspondence from CNO, BuAer, and BuShips.
- (c) NRL ltr C-115-23/48 (042813) to ONR dated 4 Feb 1948 confirming establishment of Problem R07-25R.

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AUTOMATIC AIRCRAFT INTERCEPT CONTROL SYSTEM STUDY

INTRODUCTION

Statement of Problem

The Automatic Aircraft Intercept Control System (AAICS) problem was established at the Naval Research Laboratory as a part of the Combat Command Electronic System project, for the purpose of conducting a study which will result in specific recommendations on the technical characteristics of an Automatic Aircraft Intercept Control System.

The overall objective of the proposed system is to provide a means of automatic determination of correct intercept plane control order from the control station, with instantaneous indication of this order in the interceptor plane. Functionally the system is required:

- (1) To determine automatically, from information on own plane and target, furnished by an appropriate control station facility the proper course, speed, and altitude order for the interceptor plane, and to provide any other necessary information for interception.
- (2) To provide for transmission of this information to intercept planes. Selective channeling devices should make possible selective transmission and direct automatic reception.
- (3) To insure reception and indication of these control orders in the plane in such a manner that the pilot is essentially free to effect contact with the target visually or by means of his airborne intercept devices.

Additional functional requirements are that the system operate universally with both Air Forces and Navy planes. Further, it is desirable that inter-linkage, or combination with the poor-visibility-approach-and-landing systems, be provided. The intercept control facility will be primarily shipborne, but consideration must be given to possible air-borne adaptation in the near future.

The AAICS study program at NRL has been divided into three main phases, as follows:

- PHASE I - The study and coordination of the military and functional requirements of the system.
- PHASE II - The study of applicable techniques and developments in the field of electronics to meet the requirements as determined under Phase I.

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PHASE III - The submission of a proposal for an AAICS which will meet the future needs of the Fleet and which can be integrated with the overall Combat Command System.

The time schedule specified by reference (a) (CNO tentative Military Characteristics) requires that development plans for an AAICS be completed by the fiscal year 1950 and that prototype equipment be made available by fiscal year 1953. Plans for production of equipments will probably be made subsequent to 1953.

Two closely related steps are involved in the completion of Phase I; (a) the establishment of performance characteristics for the system based on military considerations as interpreted by military personnel, and (b) the technical interpretations of these military characteristics based on knowledge of what is technically feasible by present techniques and by anticipated developments during the next five years.

It is clear that in order to define the problem adequately, steps (a) and (b) of the preceding paragraph must first be taken. Before work can progress much further, assumptions must be made on such questions as fleet disposition regarding maximum anticipated separation between the radar pickets and main units of a task force, characteristics of future aircraft, aircraft weapons of the future (fixed guns, turrets, rockets, missiles), vulnerability of future bombers and probabilities of successful kill for certain tactics of aircraft duels. It has become clear that answers to such questions are not presently available, but there are several studies and experimental projects in progress which when completed are expected to clarify the situation considerably, especially the study being conducted by OEG as a part of the Navy Air Defense Committee's program.

Therefore, the Laboratory is stating what are considered reasonable assumptions for these important factors at this time in order that Phase II of the program may be prosecuted. It should be pointed out that these assumptions are based on carefully considered information gathered by NRL from various sources, particularly from OEG and CNO. Since it is realized that the final results of studies and experimental projects now being pursued may make it necessary in the future to alter materially some of these assumptions, it is the intent of the Laboratory to review periodically the accuracy and practicability of the assumptions in the light of new data as it becomes available, and to make any necessary changes.

Related Facilities

It should also be pointed out that the most perfect system of aircraft intercept control cannot be successfully used unless it is integrated with other functions and facilities associated with a Combat Command Center. For instance, the early-warning radar system finally adopted must also supply information to many other functions; the establishment and operation of a reliable and adequate system of data relay among the surface ships of the task force must be considered a very important and needed link in the aircraft intercept direction system; the manner and adequacy of utilizing and displaying various types of combat information is closely related to the success of such a system. This requirement for integration is being kept in mind by personnel assigned to the intercept problem, and every effort is being made to keep abreast of developments and thinking in these associated fields.

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DISCUSSION OF THE PROBLEM

Surveillance

The mission of naval task forces is primarily offensive, and secondarily defensive. The defensive part can be subdivided into two parts; i.e., defense of an area and defense of its own elements from enemy attacks. Since the most stable part of a task force still consists of surface ships, the defensive system must of necessity be designed so that the main control and command can be exercised from the surface ships. In the past such control has been largely centered in CIC, but in the foreseeable future will most likely be centered in the Combat Command Center.

In the absence of more definite information, it will be assumed that future task forces will disperse their ships in a pattern that will have considerable similarity to patterns used in the past; the large ships (battleships, carriers, and cruisers) will be concentrated over a relatively small area, with a tight screen of destroyers and submarines around them and a vanguard of small ships patrolling at some distance ahead. It will be further assumed that hostile aircraft must be intercepted at a distance greater than 30 miles from force center.

The geographical disposition of task force elements is dependent on several factors, such as the nature of mission, the size of task force, and the direction of possible enemy threats. If the disposition of a very large task force and possible enemy air threat from all directions is considered, it will then be possible to state the maximum requirements.

By 1953, military aircraft approaching maximum sub-sonic speeds are expected to become a reality. This will impose severe surveillance requirements on the Fleet and probably require, in the case of the large task force, surface surveillance up to a radius of 300 miles from the force center, and up to an altitude of 50,000 feet. The economic, operational, and technical implications involved in devising and operating a system to accomplish this are tremendous. However, studies of basic principles involved indicate that surveillance of such a large volume of space can be maintained without actually probing all of it at all times. In order to discuss the problem further, it will be assumed that the surface elements of the task force are dispersed, as shown in Figure 1.

The radar surveillance coverage of a sector is shown in Figure 2. The ship at the extreme right represents the center of the task force and uses a long-range 360° search radar. At the left are shown two picket destroyers, which form a part of the circular radar screen, each using a relatively shorter range 360° search radar. The elliptical radar pattern represents the low altitude radar coverage below line-of-sight obtained from an AEW airplane flying a grid pattern in the vicinity of the radar picket screen.

Aircraft Characteristics

Information available at present indicates that by 1953 combat-type jet-intercept and bomber aircraft will be in use. Table I contains a list of expected performance characteristics compiled by the Design Research Division of the Bureau of Aeronautics. It should be emphasized that these are A set of performance characteristics - not necessarily what is desired nor what can be attained but what will probably be evolved from our present aircraft and our present system of attacking the problem of aircraft development. It can be seen from the table that speeds of 550 and 500 nautical miles per hour for interceptors and bombers, respectively, can be expected five years hence. Since fuel consumption, and consequently the endurance of jet aircraft, is better at high altitudes, it must be assumed that most interceptions will be made at high altitudes, probably up to 40,000 feet. Climb

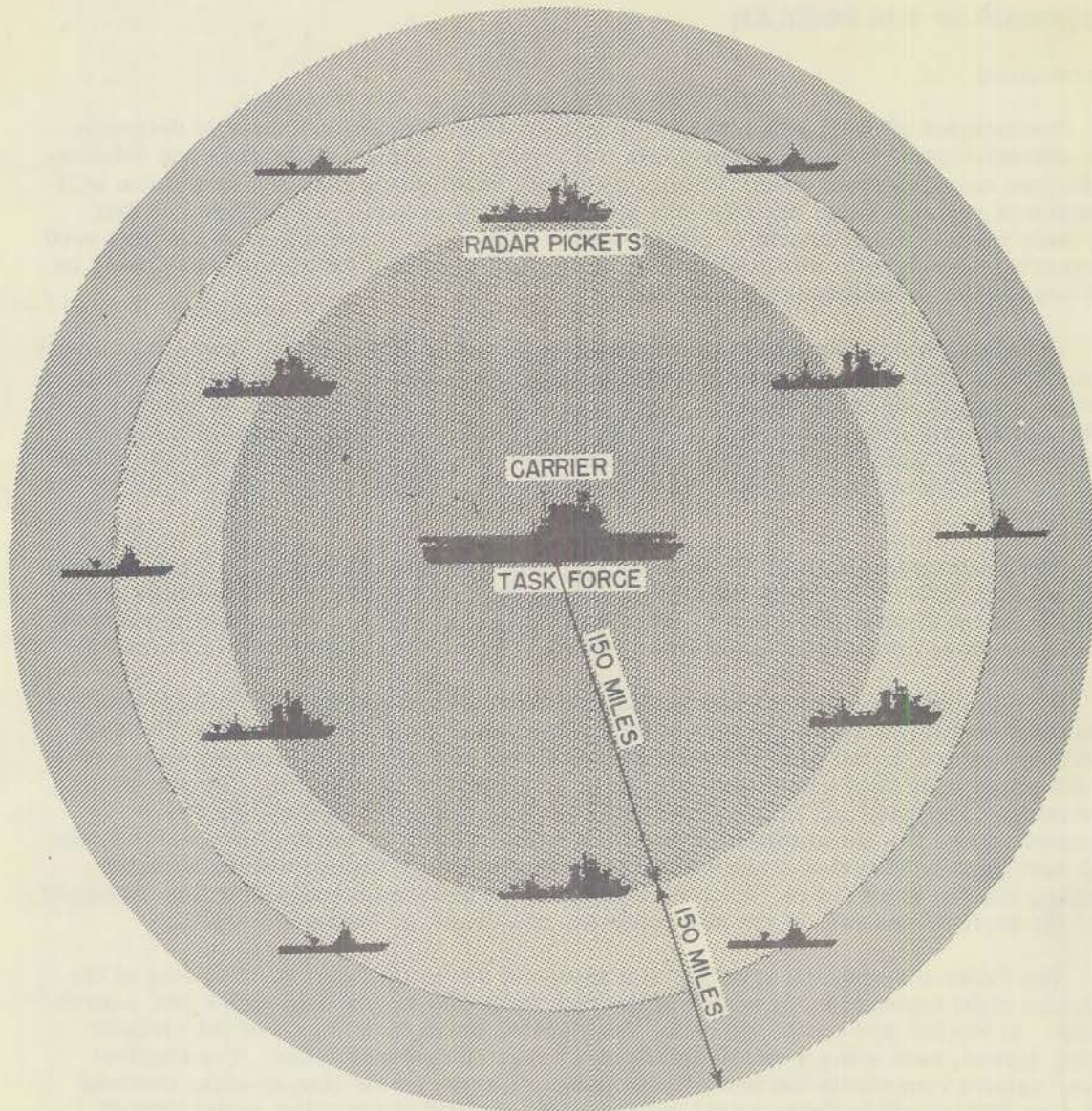


Fig. 1 - Ship Dispersion Pattern of a Large Task Force

time for 1953 interceptors will be between 4 and 7 minutes. They will be held in readiness on carrier decks for immediate take-off without the necessity of turning the carrier and its flotilla into the wind.

Aircraft Holding Area and CAP

The next logical consideration is to determine the intercept aircraft "holding area." The most flexible solution would be to maintain a combat air patrol in the vicinity of the destroyers. However, with the advent of jet aircraft, the use of CAP employing this type of plane within the next five years appears questionable because of their limited endurance.

A CAP of modern conventional type aircraft can be used with very limited application because of the speed disadvantage. Such speed disadvantage is not serious if air-to-air weapon developments make possible a single-shot high-kill-probability weapon that can be employed in a head-on collision type of intercept course.

If it is assumed that only jet intercept aircraft will be used and that such aircraft will be held in readiness on the carrier deck, it is necessary to consider where the carrier should be located; (a) near the picket destroyers?, or (b) with the main task force? In the former case, the risk involved in locating carriers near the picket destroyers is very great since they would then become main targets for the enemy; this would, however, permit a more favorable choice of locating the desired intercept area. In the latter case, the carriers would enjoy a higher degree of security from enemy attacks, but a restrictive limit on the location of the desired intercept area with respect to the main task force would be imposed owing to the longer distance aircraft would have to fly to meet a raid. The obvious conclusion is that the carriers should be assigned positions with the main task force and a reliable communication facility maintained between the destroyers and the carriers.

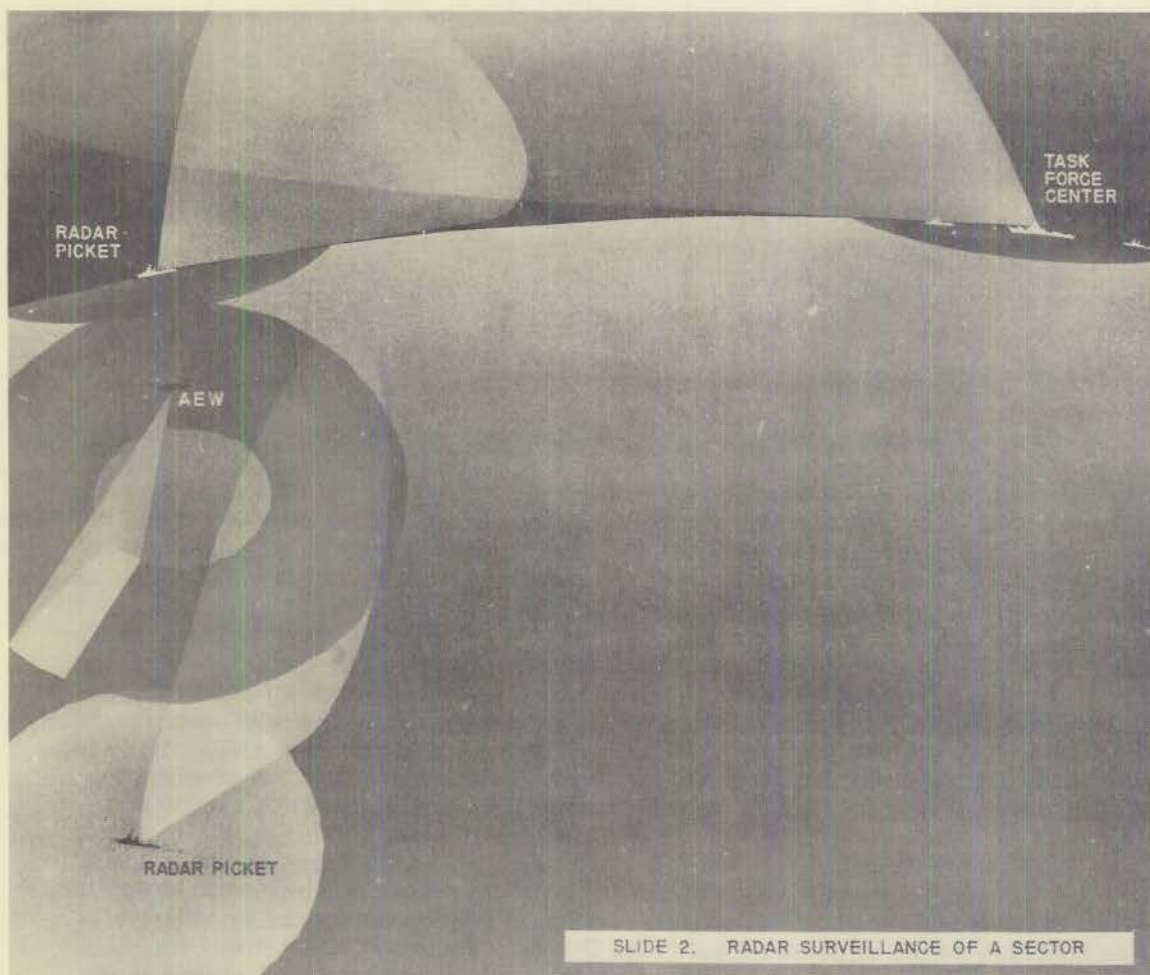


Fig. 2 - Radar Surveillance of a Sector

TABLE I
A SET OF PERFORMANCE CHARACTERISTICS OF AIRPLANES (5 years hence)

	Interceptor	General Purpose Fighter	Escort Fighter	Light Bomber	Medium Bomber
Combat Wing Loading	45	35	70	80	80
Combat Gross Weight	18,000	---	---	---	---
T.O. Gross Weight	25,000	25,000	50,000	45,000	100,000
Type of Armament & Wt.	50 Rockets (500 lbs.)	Fixed Guns or 50 Rockets (700 lbs.).	Streamlined nose and tail Turrets (5500 lbs.)	None	None
Bomb Wt.--lbs.	---	---	---	5,000	10,000
Rate of Climb (S.L)--ft/min.	25,000	25,000	5,000	5,000	4,000
Time to Climb/alt--min/ft.	4/50,000	7/50,000	12/35,000	12/35,000	14/35,000
Horizontal Displacement in Climbing/alt--naut.mi/ft.	0--50/50,000	0--50/50,000	50/40,000	50/40,000	50/40,000
Range/V Cruising--naut.mi/M	---	---	3000/.85M	3000/.85M	4200/.85M
Endurance	T.O. & climb + 5 min. combat at 50,000 ft. + 40 min. loiter at 40,000 ft. + 20 min. at S.L.-- Clean Condition	T.O. & climb + 3 hrs. at 40,000 ft. + 20 min. at S.L.-- Clean Condition	---	---	---
V Max/alt--(kn/ft.)	700/50,000	550/50,000	515/40,000	515/40,000	505/40,000
V Max/alt--	730/35,000	---	---	---	---
Max no. of g/speed/altitude g/kn/ft.	3/565/50,000	3/515/50,000	2.5/480/40,000	2/480/40,000	2/480/40,000

Location of AAICS Facilities

Another logical question is what should be done with the radar early-warning information gathered by the pickets? (a) Should it be utilized at the destroyers by assigning responsibility for direction of air intercepts to the destroyers? or (b) should this information be relayed to the main task force and the responsibility for direction of air intercept placed there? Placement of control at the destroyers would provide increased effectiveness and reliability of intercept direction when the raid interception area is located near the destroyer because of better radar accuracy and propagation characteristics of high-frequency radiation at short distances. Further, it would permit task forces a greater degree of flexibility on missions, since such an important function would not be centered on any one ship. In the latter case, placing control and direction of all air intercepts on one ship of the main task force makes possible its closer integration with other functions, but subjects it to saturation by mass raids; and, under conditions when raids will be intercepted at distances of about 100 miles from the main task force, the line-of-sight propagation limitations may seriously compromise the reliability of direction and control.

A more desirable solution is indicated by utilizing the advantages of both alternatives. That can be accomplished by providing AAICS facilities on one or more ships within the main task force and the picket destroyers. Primary cognizance for the employment of these facilities would, of course, rest at the Combat Command Center within the main task force. Facilities would be provided to permit the rapid transfer of control to the destroyers whenever the situation dictates it.



Early-Warning Requirements

Stated in simple terms, the AAICS is required, (a) to detect accurately the presence of a target at the greatest distance possible from the main task force, (b) to evaluate its threat, compute the optimum intercept course, and vector the intercept aircraft to close proximity of the target so the pilot can use his weapons most effectively, and (c) to maintain surveillance during the actual combat time. Early warning of sufficient range to permit successful interception must be accomplished by whatever means can be made available.

In the field of shipborne radar early warning, the only equipment at present aboard ship which gives continuous range, bearing, and altitude information is the SX. The SX gives information only every fifteen seconds, which impairs its use in the detection of high-speed jet targets. The SP equipment could be used for height-finding on more than one target simultaneously, but only with great difficulty. During height-finding operations search facilities are lost.

A long-range search set (AN/SPS-2) being developed at NRL will have coverage up to 300 miles and could be placed on the Combat Command Center ship of a task force for the purpose of maintaining surveillance of the entire theater of operations up to a radius of 300 miles. Since low-flying targets can be detected only within the radar horizon of approximately 50 miles, in the range band from 50 to 300 miles the coverage beam would be progressively higher and higher above the water, until at a range of 300 miles it would be about 70,000 feet from the surface. This would leave large gaps in the radar coverage pattern; to overcome this serious deficiency picket ships carrying so-called light-weight radar would be placed on a perimeter 100 miles or so from the primary objective of the enemy.

Auxiliary equipments to be placed aboard the picket would consist of radar adaptable to a smaller ship (DD or DE) with a range of 150 miles and altitude coverage in a cosecant-squared pattern up to 100,000 feet. Here again, however, the problem of low-flying targets presents a major issue, since the radar horizon from each picket would be approximately 50 miles, and such lack of radar surveillance at low altitudes would be an invitation to the enemy to approach in that manner in order to avoid early detection. In the interest of obtaining effective early warning, the means must be provided to fill this gap at the lower altitudes, particularly at the radar early-warning outposts.

Since the search and height-finding radar (SPS-2 and the light-weight radars) will probably cover not over 25° above the surface, the remaining volume enclosed by the 130° sector above the ship would not be illuminated by the ship's radar. At an altitude of 40,000 feet it represents a distance of 28 miles which aircraft can traverse without being "seen" by the ship's radar. Therefore, it is essential that all AAICS ships be equipped with short-range hemispheric radar such as represented by the XDK development at NRL (Figure 3).

In the province of airborne long-range radar equipment there is AEW only. Excluding mechanical and systems operational difficulties, sea return is the prime factor limiting detection results with this gear. Operational tests recently conducted by Operational Development Force (OPDEVFOR) show that if the sea return is greater than 70 miles for the desired operational altitude, detections will become so negligible as to not justify AEW operations. The maximum range of detection of a two-plane target is approximately 100 miles, and of a single plane about 80 miles. Increased target speed decreases all probability factors of detection, and once the oncoming target enters the area of sea-return, if it be airborne, detection is just about impossible with AEW.

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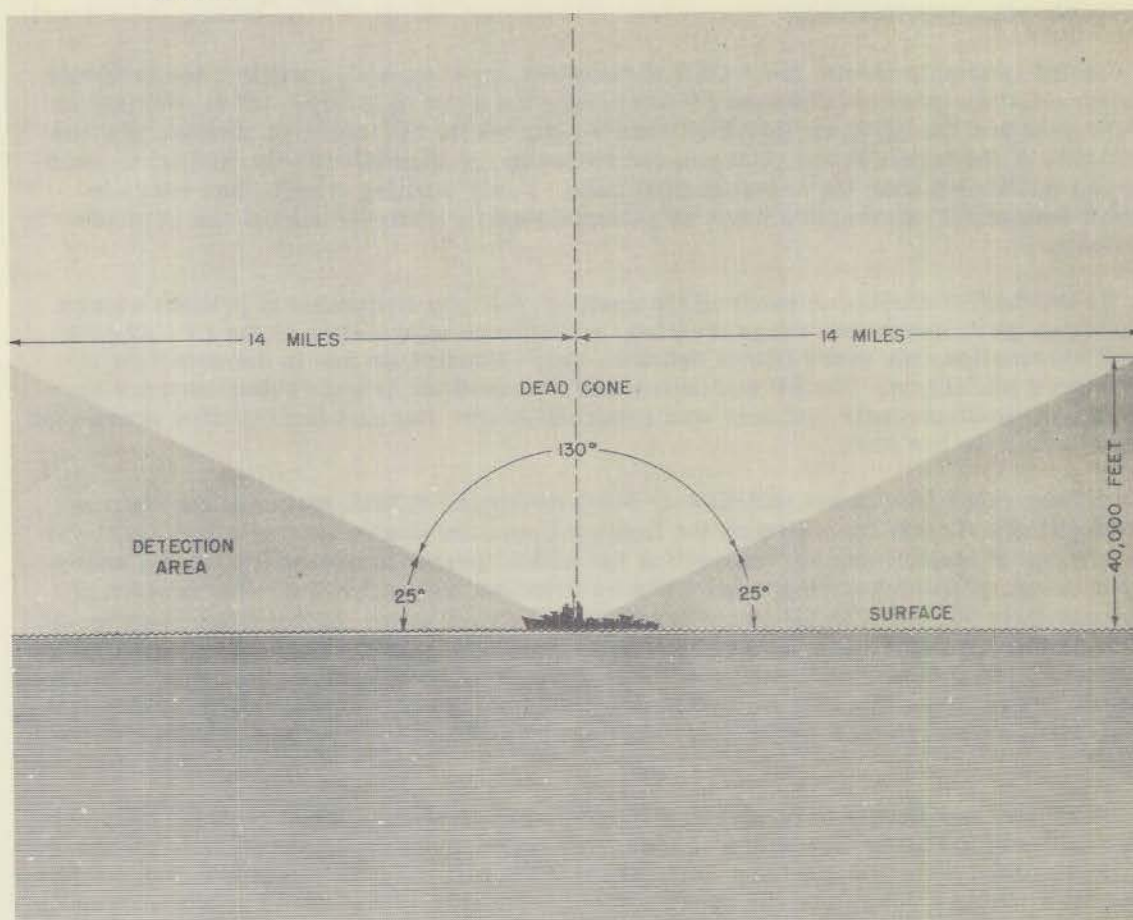


Fig. 3 - Limit of Shipborne Vertical Radar Coverage

A compromise between operational altitude and sea-return must be made in order to attain the most suitable values of range. Operation with sea-return of 50 miles on the scope is considered best for optimum operational altitude. The minimum altitude, however, must be at least 5600 feet to permit detection of low-flying targets at 100 miles. Results obtained show that with sea-return at the optimum value of 50 miles, 80% of the targets are detected.

Since the radar horizon places limitations on the detection properties of ship-based radar, dependence upon coverage at low altitudes beyond the fifty-mile radar horizon must be placed upon some method of detection akin to AEW or radar-equipped picket submarines, or both. It should be pointed out that while the demonstrated performance of AEW, as reported by OPDEVFOR, is inadequate to provide good coverage against low-flying aircraft, the possibility of overcoming this deficiency in the near future appears promising.

The AAICS radar components must supply adequate information to permit the direction of a large number of interceptions simultaneously. Determination of the maximum traffic capacity that will be needed, or that can be developed by 1953, is at present unknown.

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Airborne Facilities for the Interceptor

The pilot of the intercept plane will have to be directed to, or be provided with instruments which will take him within shooting range of the target. Surface-based facilities will vector the interceptor on towards the target, but for the closure stage of interception a higher degree of accuracy of data for direction is needed than can economically be provided from, say, 100 miles away. It is considered impractical to put the entire load of interception on the control station. A more practical approach is to supplement the surface-based facilities with short-range airborne radar equipment in the aircraft, such as the AN/APQ-35 equipment at present being developed. Preliminary studies indicate that if the intercept aircraft is provided with AI radar having a range of 10 to 15 miles with provisions to scan a minimum of 30° in azimuth and in elevation, then the surface-based control station would be able to direct the interceptor with the proper heading, to a point in space located within the confines of the error ellipse of the control-station radar. From this point the interceptor will be able to "see" the target with his AI radar and make the necessary course corrections to close in for the "kill." For flying intercept courses which will require the interceptor to make a sharp turn in order to make a rear-hemisphere or a beam approach to his target, the responsibility for designating the time to make the turn will have to rest with the control station.

Other airborne electronic facilities for the interceptor include the receiving equipment to receive orders transmitted by the control station, with its associated decoder and filter networks to separate the audio and electrical data components for aural and visual presentation; IFF-beacon-transponder; and voice-transmitting equipment. The AN/APQ-35 equipment previously mentioned includes the AI radar, gunnery radar, and tail-warning radar.

The pilot in the interceptor must have presented to him visually the generated intercept course transmitted from the control station, display of targets acquired by his AI radar, gunnery tracking of the target, tail warning, and the response to any IFF interrogations he may initiate. The presentation must be accomplished in a manner which will impose no undue hardships on him, so that he may be essentially free at all times to efficiently fly his plane and attack his target. Moreover, the presentation of the generated intercept course data and targets acquired by his AI radar must be accomplished on a common display to permit smooth transition. Considerable importance is attached to the solution of this problem, since it will play a very important part in the overall utilization of the system and will probably require a radical departure from data display practices employed heretofore. Several novel schemes have been advanced, and each will be thoroughly investigated during the next reporting period.

Intercept Courses and Airborne Weapons

While vectoring the interceptor on to the target, the control station must decide on the type of approach to be used and direct the interceptor so that when he reaches the closure stage he will be in the most favorable position to proceed for the "kill." Since there are several possible approach courses that can be flown, the desirability of favoring one or two types of intercept courses in future combat should be considered in the design of the system. Before that can be done, a careful analysis will have to be made of the aircraft's characteristics, its weapons, and accuracy of positioning of the interceptor by orders from the control station. Sufficient data to make such an analysis is not available at present. For instance, in the field of airborne weapons, there is some question as to the adequacy of fixed guns for use on a 550-knot fighter in the future. Turrets would overcome some of the limitations of fixed guns, but would impose a severe weight requirement, and some doubt exists as to the maneuverability of turrets against the wind stream at high speeds.

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The Sparrow air-to-air guided missile development and the proposal for the interceptor to fire small rockets in bunches of ten to fifty so as to bracket the target, present very interesting possibilities in the development of a single-shot high-probability weapon. Much importance is being attached to the development of such weapons since in the case of a head-on attack the closing speeds are of such magnitude that, unless such a weapon is used, the attack will be unsuccessful. The important point here is that until more definite data are known about the weapons to be used, a decision on preferable intercept courses cannot be made. Until such time, NRL will continue to incorporate features in the system that will make it versatile.

Preliminary Outline of the System

The final version of the shipboard and airborne electronic system for the automatic direction of intercept aircraft is not expected to become known until at least Phase II of the program is completed. However, a general outline of the present thinking has been presented and is summarized in block diagram form in Figures 7 and 8.

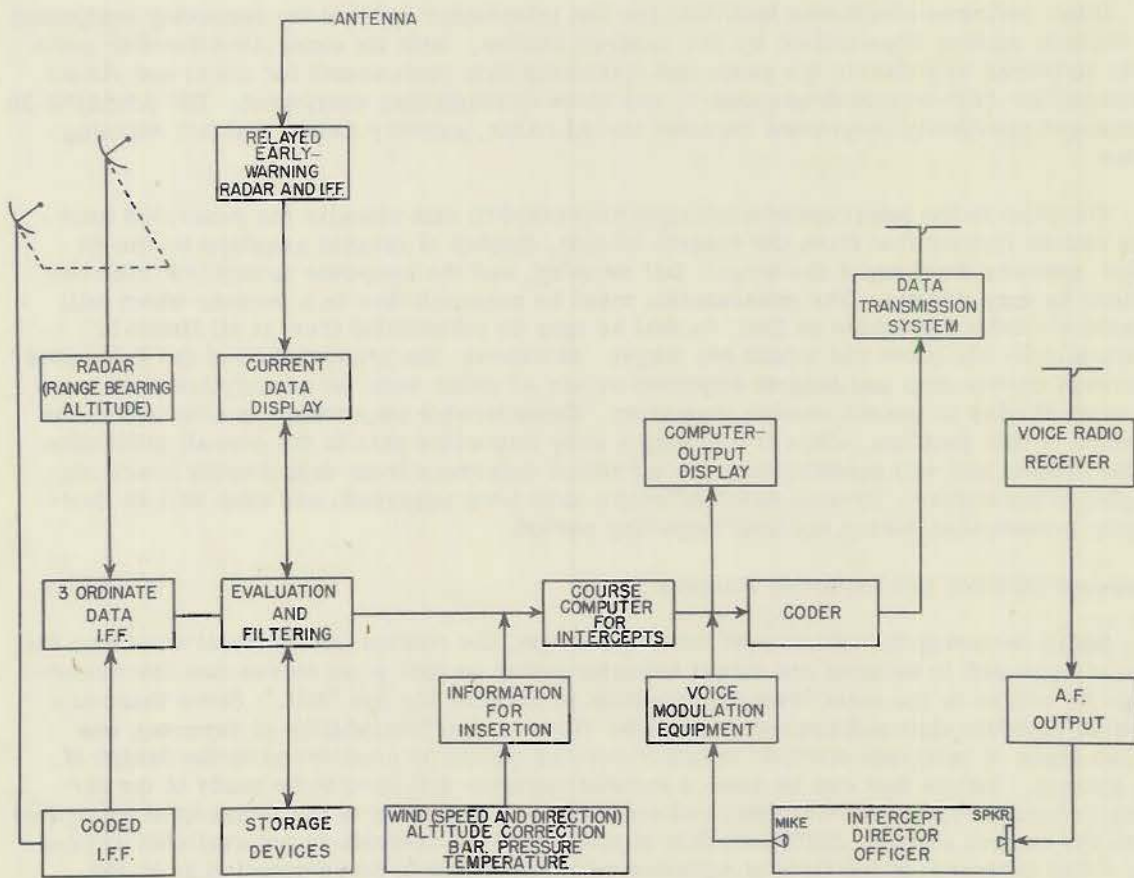


Fig. 7 - AAICS Preliminary Block Diagram of Shipboard Facilities

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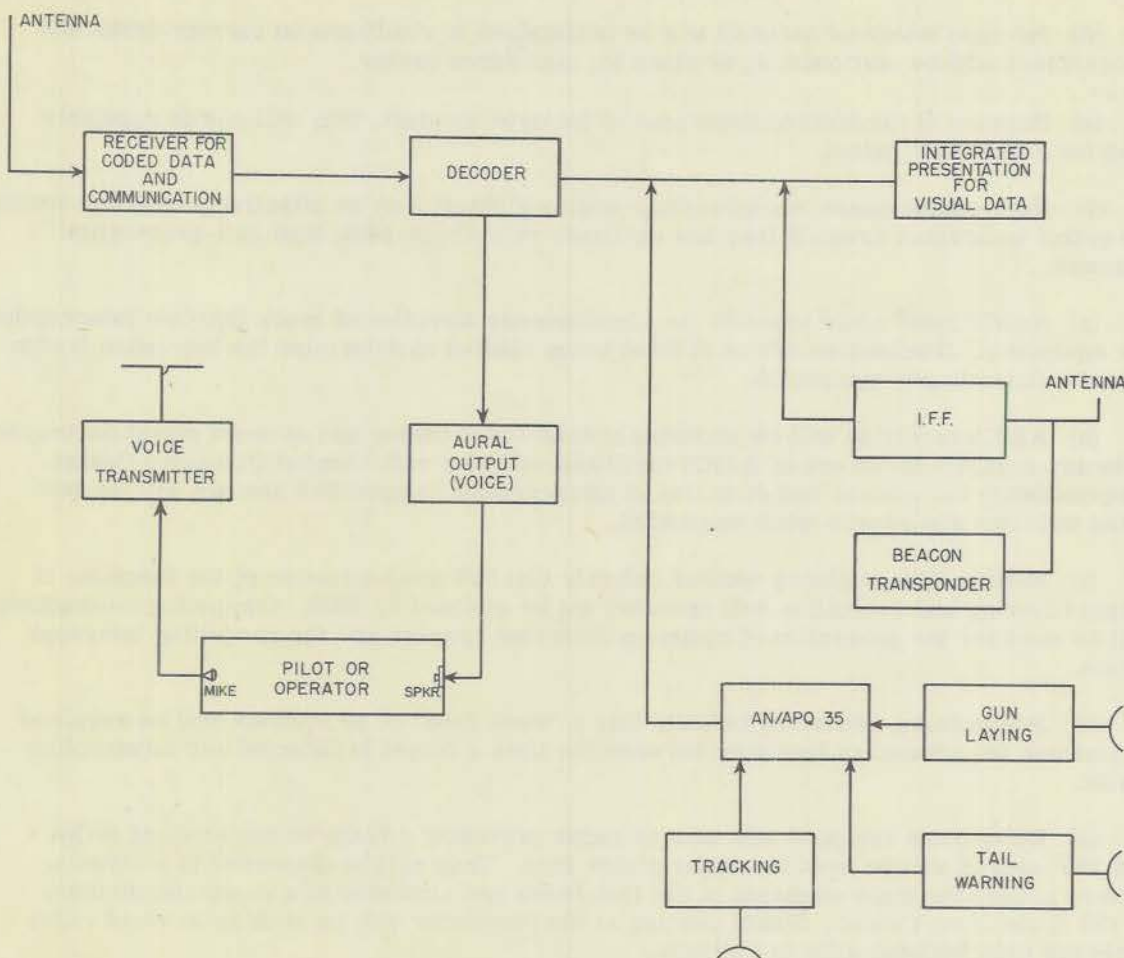


Fig. 8 - AAICS Preliminary Block Diagram of Airborne Facilities

CONCLUSIONS

A conclusion is indicated, based on the discussions herein presented, that certain assumptions of tactical and technical requirements for an automatic aircraft intercept system be made in order to form the basis for subsequent prosecution of the problem. The assumptions are as follows:

(a) Within the next five years combat-type aircraft will be in use with operating ceilings of 50,000 feet and at speeds of 550 and 500 nautical miles per hour for interceptors and bombers, respectively. The AAICS design considerations must take into account the space-time capabilities of such aircraft.

(b) The maximum requirements of large task-force operations are that radar surveillance be maintained over an area included within a circle of 300 miles radius and to an altitude up to 50,000 feet.

(c) Interception of enemy targets must be accomplished at a distance of not less than 30 miles from task-force center.

(d) Jet-type intercept aircraft will be maintained in readiness on carrier decks and the carriers will be stationed at, or close to, task-force center.

(e) Because of the limited endurance of jet-type aircraft, they will not be regularly used for combat air patrol.

(f) High-performance, reciprocating-engine aircraft may be effectively used for combat air patrol in advance areas if they are equipped with single-shot, high-kill-probability weapons.

(g) AAICS must make possible the simultaneous direction of more than one interception per equipment. Techniques are at present being studied to determine the maximum traffic capacity feasible per equipment.

(h) AAICS facilities will be provided at task-force center and on most picket destroyers. Primary cognizance for use of AAICS facilities will rest with Combat Command Center. Responsibility for control and direction of interceptions in specified sectors will be delegated to picket destroyers when warranted.

(i) Results of preliminary studies indicate that full mechanization of the functions of target filtering and evaluation will probably not be attained by 1953. Computing mechanisms will be used for the generation of optimum intercept courses and for predicting intercept points.

(j) Preliminary estimates indicate that a "dead time" of 10 minutes will be required to perform the necessary functions between the time a target is detected and interception starts.

(k) Destroyers equipped with search radar providing a range of 150 nautical miles and 360° search will be used for radar picket duty. They will be dispersed in a circular pattern around the main elements of the task force and stationed at a maximum distance of 150 miles from Center. Picket spacing at the perimeter will be such as to avoid radar coverage gaps between adjacent pickets.

(l) A long-range radar providing 360° search up to 300 nautical miles and at least up to 50,000 feet altitude will be used at task-force center.

(m) Radar early warning on enemy targets at a minimum range of 180 nautical miles is necessary.

(n) All AAICS ships will be equipped with short-range hemispheric-coverage radar in order to provide radar illumination of an approximately 130° sector above the ship.

(o) Radar coverage below line-of-sight, beyond the picket destroyer screen, will be provided by AEW aircraft and radar-equipped submarines whenever such coverage is deemed necessary.

(p) Radar and IFF data on targets must be integrated.

(q) Intermittent radar data on targets is adequate to attain the system objectives. The optimum rate of supply of such data is being investigated.

(r) The AAICS transmission facility must provide a reliable range of 100 miles.

(s) For the effective utilization of AAICS, dependence must be placed on maintenance of reliable communications and data relay links between (1) AEW aircraft and surface ships, (2) between submarine and surface ships, and (3) between surface ships. For (2) ranges up to a maximum of 50 miles will be satisfactory, but somewhat longer ranges are needed for (1) and (3).

(t) AI radar having a minimum range of 10 miles and provisions for scanning a minimum of 30° azimuth and 30° elevation must be provided in the intercept aircraft.

(u) Based on presently known information, preference to any particular aircraft-duel tactics cannot be incorporated in design considerations of AAICS, since the probability of success of any tactics is largely dependent upon future airborne weapon developments.

(v) A simple visual presentation system which will present a composite display of all data needed by the pilot and acquired by electronic equipments must be provided in the intercept aircraft.

ACKNOWLEDGMENT

During the past few months, NRL has endeavored to enlist the cooperation of the several Naval agencies (CNO, ONR, OEG, BuAer, BuShips, BuOrd, and others concerned with certain aspects of the problem) in order to exchange views and become better informed of each others' thinking, plans, and projects. The response and resulting cooperation from each agency has been excellent, with the result that considerable valuable information pertinent to the problem has been exchanged and a broader viewpoint and appreciation of many unsolved aspects of the problem have been reached.

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APPENDIX I - WORK PLANNED FOR THE NEXT REPORTING PERIOD

Work under Phase I of the AAICS Program has resulted in the establishment of assumptions for the over-all requirements of the system. The next work period, directed to Phase II, will be devoted to the studies of applicable techniques and developments in the field of electronics to meet the requirements as determined under Phase I. Such studies will include:

Radar - A detailed study of the radar facilities, conducted in order to determine characteristics of component units and techniques to effect over-all integration. This study will be confined to AAICS facilities for:

Combat Command
Radar Picket Ships
AEW Radar
Intercept Plane Radar
Submarine Radar

Some of the more important questions to be considered for all or most of the above applications are: range, height finding, beam size, scan angle and rate, pulse lengths, accuracy, peak power, tracking of multiple targets, presentation of display, integration of radar and IFF data, integration and utilization of radar data gathered from several widely separated sources, etc.

Evaluation and Computation - Study (a) of operations associated with the functions of extracting target and IFF information from the radar facilities, filtering and evaluation, and computation of intercept courses; and (b) of electronic and mechanical techniques to perform these functions with the view of replacing with automatic means as many human operations as is feasible within the time schedule established. Considerable effort will be directed to computer techniques and to specific computer requirements.

Order Transmitting Link - A comprehensive study of the AAICS order transmitting link to determine (1) what information is to be transmitted, and (2) how it can be transmitted. Methods of coding for security and selective transmission will be included.

Airborne Facilities - Study of the airborne part of the AAICS, including, among other things, techniques to be employed in receiving orders transmitted by the control station, and the integrated presentation of this information with data obtained from the airborne radar facilities. Effort will be especially directed to devising a simple method of visual presentation and the utilization of all data available to the pilot.

Experimental Systems Test - Present plans call for establishment of experimental AAICS facilities at NATC Patuxent and Chesapeake Bay Annex of NRL. At first, equipments currently obtainable will be used; later, such equipments may be modified and/or new experimental equipments be substituted in the system.

By such experimental facilities it is expected that the solution of some of the more difficult portions of the problem may be facilitated. Problems involving integration of facilities aboard widely separated ships can be simulated. Should an emergency arise, it will also contribute towards the procurement for the Fleet of more modern interim facilities than now exist.



MEMORANDUM FOR THE DIRECTOR, FBI

Reference is made to the report of the Special Agent in Charge, New York, dated 1/15/54, captioned as above.

The information contained in the report is being furnished to you for your information.

Very truly yours,
Special Agent in Charge

The information contained in this report is being furnished to you for your information.

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APPENDIX II - OUTLINE OF FIGHTER DIRECTION SYSTEM
USED AT PRESENT BY THE FLEET

by P. L. Wedding and M. E. Wright

It is the purpose of this appendix to review briefly, for reference purposes, the procedures of the present system of Fighter Direction. It is intended to show how Fighter Direction is handled in the present system, from detection to "kill." It will not attempt to deal with any future procedures or equipments to be used for Fighter Direction; future procedures and equipments will be dealt with in another phase of the problem.

Fighter Direction, by definition, is the tactical employment and control of fighter aircraft for the interception and destruction of attacking enemy aircraft. This definition presupposes the detection, tracking, and the threat evaluation of the enemy aircraft.

Detection will be considered first. In order to control aircraft for the interception of enemy aircraft, it is necessary to know that enemy aircraft are present, and the position as well as the number of these aircraft. Detection is usually accomplished by means of radar. SK and SP radars are most widely used for this purpose. When an aircraft is detected, its position is plotted on a plotting board giving its range, bearing, and elevation, if they can be determined. The SP, together with the SP fade charts, is generally used for elevation determination.

After detection, the target is tracked and its speed determined by means of the radar data. The tracking is necessary so that the position of the target is known at all times. Each new position of the "bogey" is plotted on the air plot. When the radar echo fades, the dead-reckoning plotter, using as reference the last-known position, general heading, and speed, will draw arcs on the board at frequent intervals to indicate the area where the target may be located. This is continued until the bogey is again detected.

All targets, as they are detected, are plotted on the main air plot. The senior Fighter Director Officer then assigns the interception of the specific raid, which he has designated by a raid number or letter, to Intercept Officers. At this point, the intercept plotter for that specific raid begins to plot the track of the bogey assigned to him. The Fighter Director Officer, after consulting the ready room and studying the air status board, assigns certain fighter divisions to an Intercept Officer for interception of the raid. The Intercept Officer then vectors his planes on an interception course. As the vectoring progresses, the Intercept Officer follows it on a precision PPI while the plotter keeps a record of the developments. If the bogey changes course, the Intercept Officer gives his pilots a corrected course. Advantage is taken of the conditions of clouds, sun, and altitude to give the intercept pilots the best possible chance for a successful interception. The Intercept Officer has control of the planes until visual or airborne radar contact is made with the bogey and then turns the responsibility over to the pilots.

From the time of detection until the interception is completed, the assistant Fighter Director Officer keeps the bridge, gunnery officers, and flag plot informed of the progress. If the raid eludes the interceptors and approaches to within gunnery range of the base, the Intercept Officer clears his planes and turns the raid over to the A. A. Gunnery Officer.

After the raid has been stopped or has infiltrated past the interceptors, the Intercept Officer turns control of the planes back over to the Fighter Director Officer for assignment to another raid or CAP.

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The following is a breakdown of the organization, functions, and duties of Fighter Direction in CIC:

I. Fighter Direction Organization

Figure 9 shows a block diagram of the Fighter Direction Organization. Its duties are as follows:

A. Receive, plot, and record information

1. Receive information from the many sources available to it (radars, communication, visual lookouts, etc.)
2. Plot information on the many plotting boards so that it is easily accessible to the cognizant personnel.

B. Issue order based on the received information.

C. Take action to:

1. Alert the force
2. Devise tactics for interception
3. Vector interception
4. Control planes while aloft
5. Provide defense against infiltration.

II. Information Received by the Fighter Directors

A. Types of Information

1. Azimuth or bearing
2. Altitude
3. Weather in operational range
4. Range
5. Identification
6. Speed
7. Number of aircraft
8. Condition of friendlies
9. Fleet condition
10. Geographical data

B. Sources of Information

1. Communications
2. Radar
3. Visual lookouts
4. IFF
5. Friendly planes
6. Fade charts
7. Experience

C. Methods of Presenting Information

1. Plotting boards
2. Status boards

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- 3. PPI's and other remote indicators
- 4. Messages

III. Duties of Fighter Direction Officers

The component elements of the organization and duties of each are as follows:

Senior Fighter Director Officer

A. Training of Fighter Director Teams

- 1. Radarmen
- 2. Plotters
- 3. Talkers
- 4. Radio Operators
- 5. Status-board Keepers

B. Delegation of Specific Duties to Officers and Personnel

- 1. Assignment of raids to intercept officers

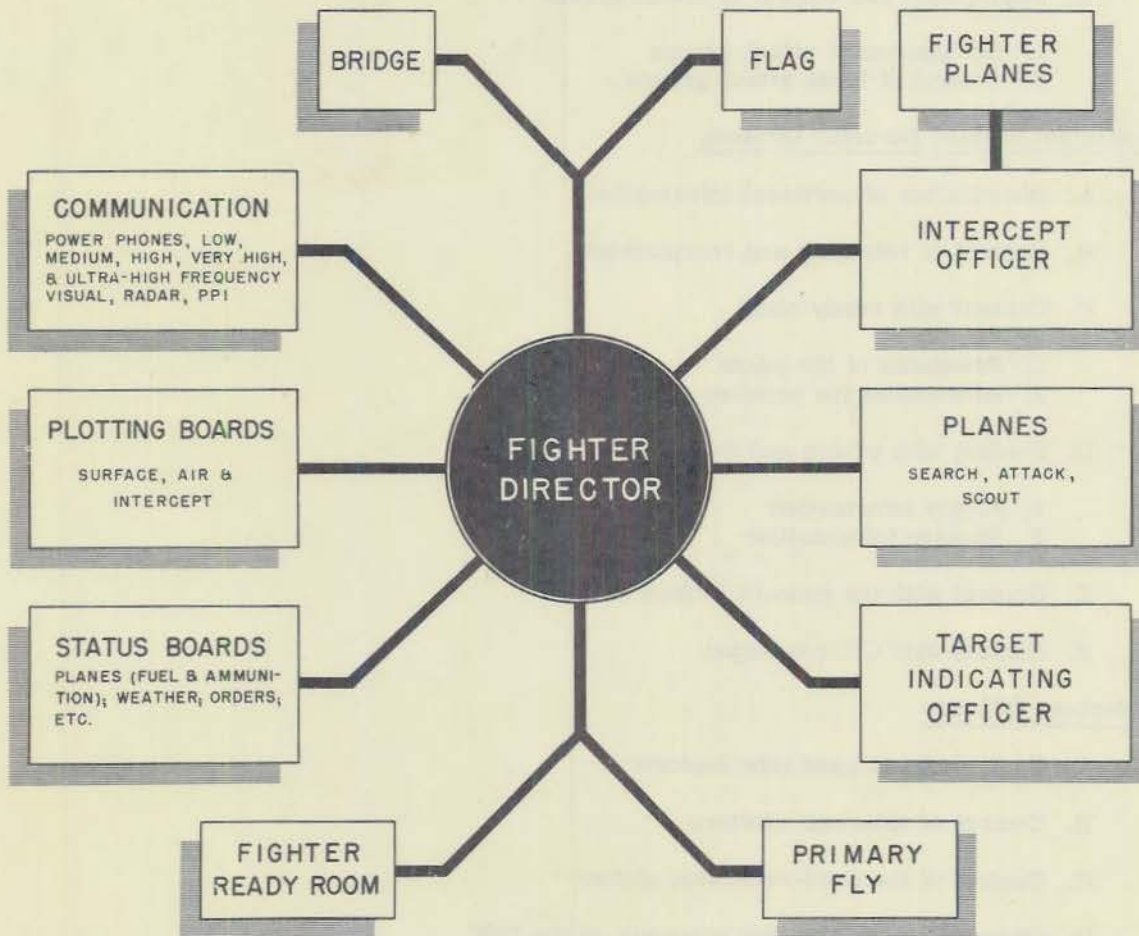


Fig. 9 - Fighter Direction System - Chain of Command and Facilities

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2. Assignment of radar operators
 3. Assignment of plotters
 4. Assignment of status-board keepers
 5. Assignment of recorders
 6. Assignment of talkers
 7. Assignment of radio operators
 8. Assignment of officers to certain specific duties
- C. Designation of specific enemy raids and the responsibility for each
1. Identity of each enemy raid
 2. Responsibility for each raid
- D. Assignment of scout and fighter search divisions
1. Assignment of scout planes
 2. Assignment of fighter search and C.A.P. divisions
- E. Deployment and control of attack groups
1. Designation of attack groups
 2. Control of these attack groups

Assistant Fighter Director Officers

- A. Distribution of pertinent information
- B. Control of refueling and rearmament
- C. Contact with ready room
1. Readiness of the pilots
 2. Information for briefing
- D. Contact with bridge and flag
1. Supply information
 2. Receive information
- E. Contact with the gunnery liaison officer
- F. Contact with CIC personnel

Intercept Officers

- A. Control of assigned interceptors
- B. Control of intercept plotters
- C. Control of the dead-reckoning plotter
- D. Observation of intercept progress on the PPI

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- A. Evaluation of main plotting board data
- B. Control of main plotting board plotters

Radar Control Officer

- A. Control of all radars and their operators
- B. Control of status boards and status plotters
- C. Control of the main display talker

Intelligence Officer

- A. Control of radio monitors
- B. Cryptography
- C. Background data

Visual Fighter Director Officer

- A. Control of all visual lookouts
- B. Contact with gunnery liaison officer
- C. Contact with Fighter Directors in CIC

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1. The first of these is the...

2. The second is the...

Section 1

3. The third is the...

4. The fourth is the...

5. The fifth is the...

Section 2

6. The sixth is the...

7. The seventh is the...

8. The eighth is the...

Section 3

9. The ninth is the...

10. The tenth is the...

11. The eleventh is the...



Several ideas on economical ways of accomplishing this objective have been advanced and will be investigated during the next reporting period.

The question of whether the radar should supply continuous or intermittent data has been examined and there is considerable evidence in favor of intermittent data. Although continuous data is desirable under certain operational conditions, the price that would have to be paid for it in the form of complexity, size, and weight would not be justified. During a large part of the time the system will be in use, the availability of continuous data on target would contribute little or nothing to the overall effectiveness of directing interceptions. The Laboratory is at present conducting a study of data rates of information and other questions related to the radar facilities, and a report will be released shortly which will discuss the subject in detail.

After initial detection of an airborne target has been made, it will be assumed that a "dead time" of approximately 10 minutes will be required for identification, tracking, evaluation, computation, issuance of orders, etc. Assuming that the target is traveling on a straight course towards the task center at 500 knots at 40,000 feet altitude, the interceptor will require 5 minutes to climb to 40,000 feet traveling at 550 knots, and the interception must take place not closer than 30 nautical miles from task force center. Working out the problem on the basis of these assumptions, it will be found that the target must be detected at a distance of 180 nautical miles (Figure 4). If the early warning facilities of a radar picket ship stationed 100 miles out from center are utilized, the same enemy target could be intercepted at a distance of 65.5 miles from task force center (Figure 5). This indicates that unless an appreciable change in time required to perform these operations is introduced (such as reduction of "dead time"), 180 nautical miles from task force center is the absolute minimum detection range needed. In order to make allowances for possible errors and delays, the minimum detection range should not be less than 200 nautical miles.

During the five-year period being considered, it is expected that piloted combat aircraft will be flying at altitudes up to 50,000 feet, and at somewhat higher altitudes subsequent to 1953. The AAICS radar facilities must provide coverage up to 50,000 feet at a distance of at least 200 miles.

Filtering, Evaluation, and Computation

The task of extracting information on targets from the radar; of identifying, filtering and evaluating the data; and of computing vectors and predicting intercept points, represents a most important function in any system of aircraft intercept direction. Moreover, the speed with which these functions can be performed will largely influence the total "dead time" needed. Except for recent developments in the field of electronic computers, as of this date little progress has been made to improve the techniques in use at the end of World War II. The ultimate goal is to completely eliminate the human element from performing these functions and to replace it with automatic equipment. The attainment of such an ideal is not in sight at present. During the five-year period being considered, we must look forward to the continued employment of human beings for the performance of some of these functions, aided by several automatic mechanical and electronic devices, such as suitable display boards, data storage devices, electronic computers, etc.

Electronic computers to generate an intercept course quickly, must of necessity be an integral part of the system. Since all the parameters to be fed to the computer have not been determined, the type of computer needed cannot be decided. In order to generate an intercept course, three ordinate data on the target and the interceptor, the speed and course of the oncoming target, the speed and other characteristics of the interceptor, and

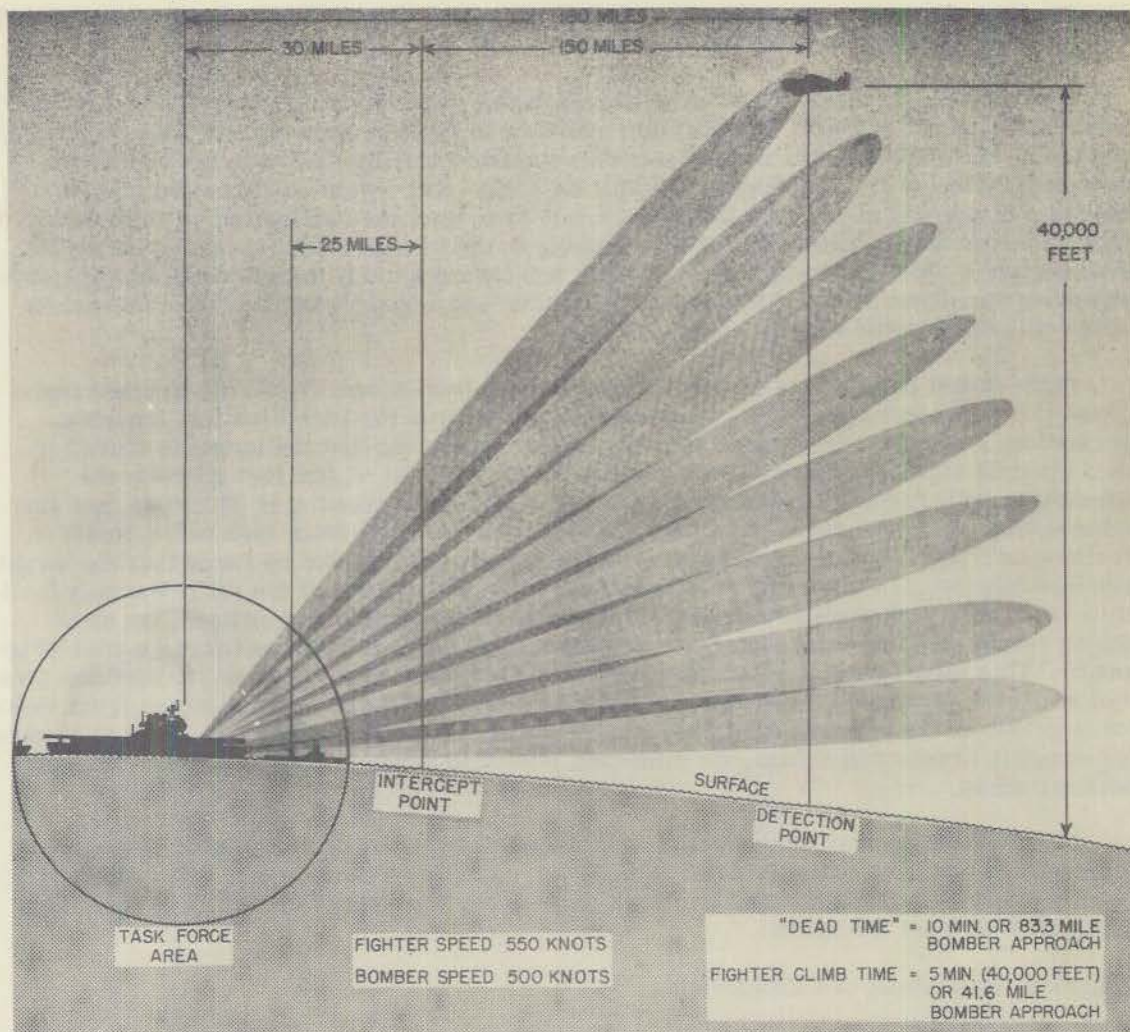


Fig. 4 - Minimum Radar Early Warning Required

aerological data on prevailing conditions in the operational area must be known. The computer output will probably have to be in electrical form to simplify the subsequent coding of the data prior to transmission.

For the simultaneous direction of more than one intercept, two general approaches to the computer problem are available, a complex computer system with provisions for time sharing among the several targets to be handled, or a battery of comparatively simple type computers connected in parallel, each computer unit handling a separate target. The maximum number of targets that can be efficiently handled simultaneously by the overall system will be investigated during the next reporting period.

A certain amount of "dead time" must elapse between the initial detection and the commencement of interceptions. This time is needed for tracking of targets, identification,

filtering, evaluation, computing vectors, predicting intercept points, issuing orders, getting crews into aircraft, and take-off. The breakdown of time required for each function has not been calculated, since the manner in which these functions will be performed has not been decided. An arbitrary figure of 10 minutes has been assumed to be reasonable for the "dead time." This includes time to get crews into aircraft and take-off, but not time to climb to altitude. It is appreciated that under combat conditions practically all aircraft will be kept aloft in order to reduce the possibility of mass destruction resulting from an enemy bomb hit on the carrier deck. Under such conditions, the dead time will be reduced somewhat.

Communications and Data Relay

One of the essential elements of the AAICS is the linkage, by radio, of the control station and the intercept aircraft in order to communicate orders and replies. It is imperative

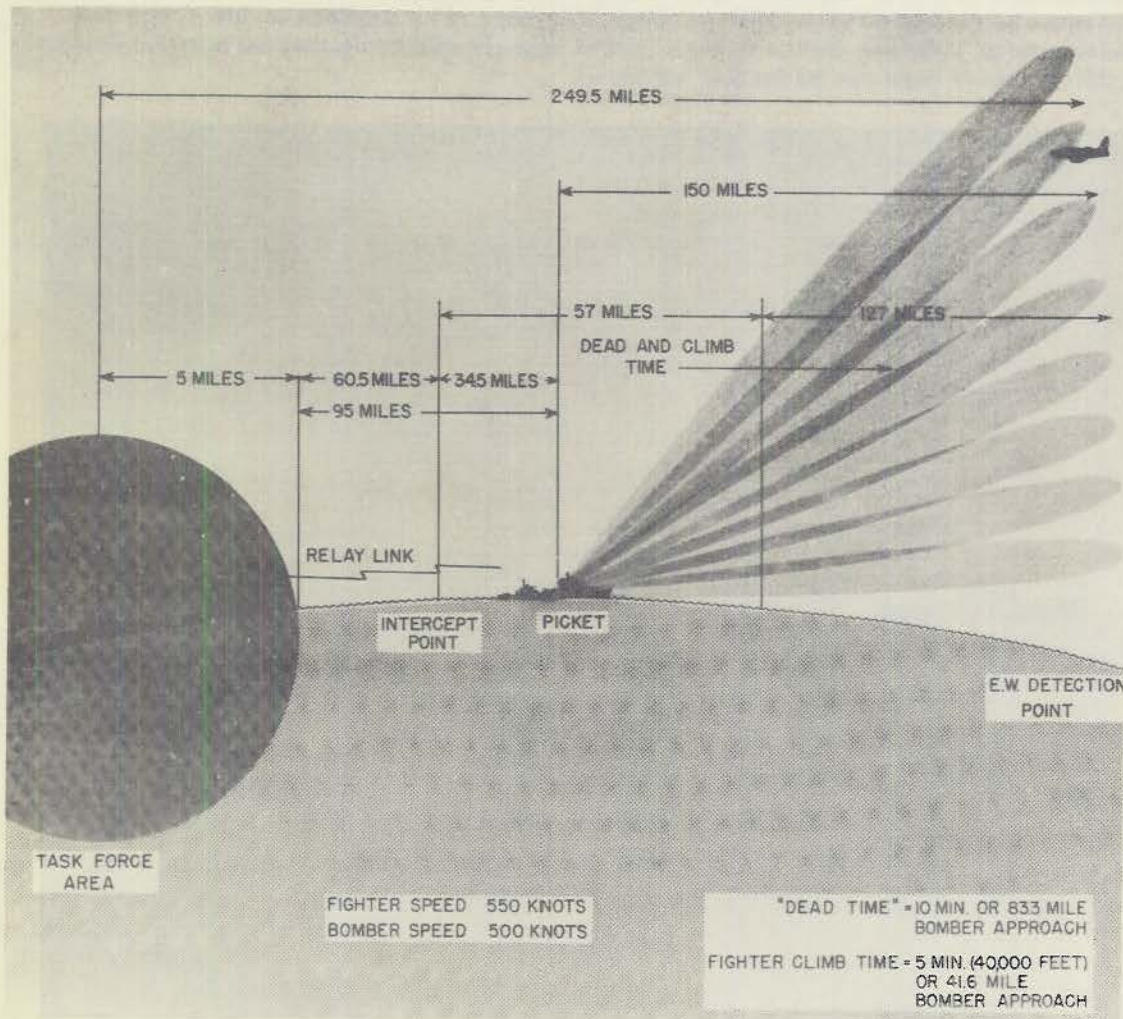


Fig. 5 - Detection Range with Early Warning from Picket

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that reliable and adequate data relay links and transmission facilities be provided between AEW airplanes and/or picket destroyers, and between surface ships in the task force. These facilities are needed in order to relay early-warning and other information between AEW and surface ships, and transmit orders and reports, relay early-warning information from pickets to the Center, and, at times when destroyers have AAICS control of one or more sectors, to relay information to Combat Command Center on the progress of the action (Figure 6). Such relay links would have to be dependable up to a distance of over 100 miles.

UHF or microwave frequencies can be used to complete the AAICS circuit between control station and intercept aircraft since these will generally be within line of sight, at a distance not expected to exceed 100 miles. The same is true of the link between AEW and surface ships. However, the problem of maintaining reliable relay links between the surface ships is more involved. With the probability of picket destroyers' being stationed as much as 150 miles away from the main task force, direct UHF or higher frequency communication cannot be depended upon owing to the propagation restrictions. Here a choice must be made between additional high-frequency relay stations or low-frequency communications. Neither choice is ideal, and it appears desirable that decision be delayed until the merits of each can be further explored.

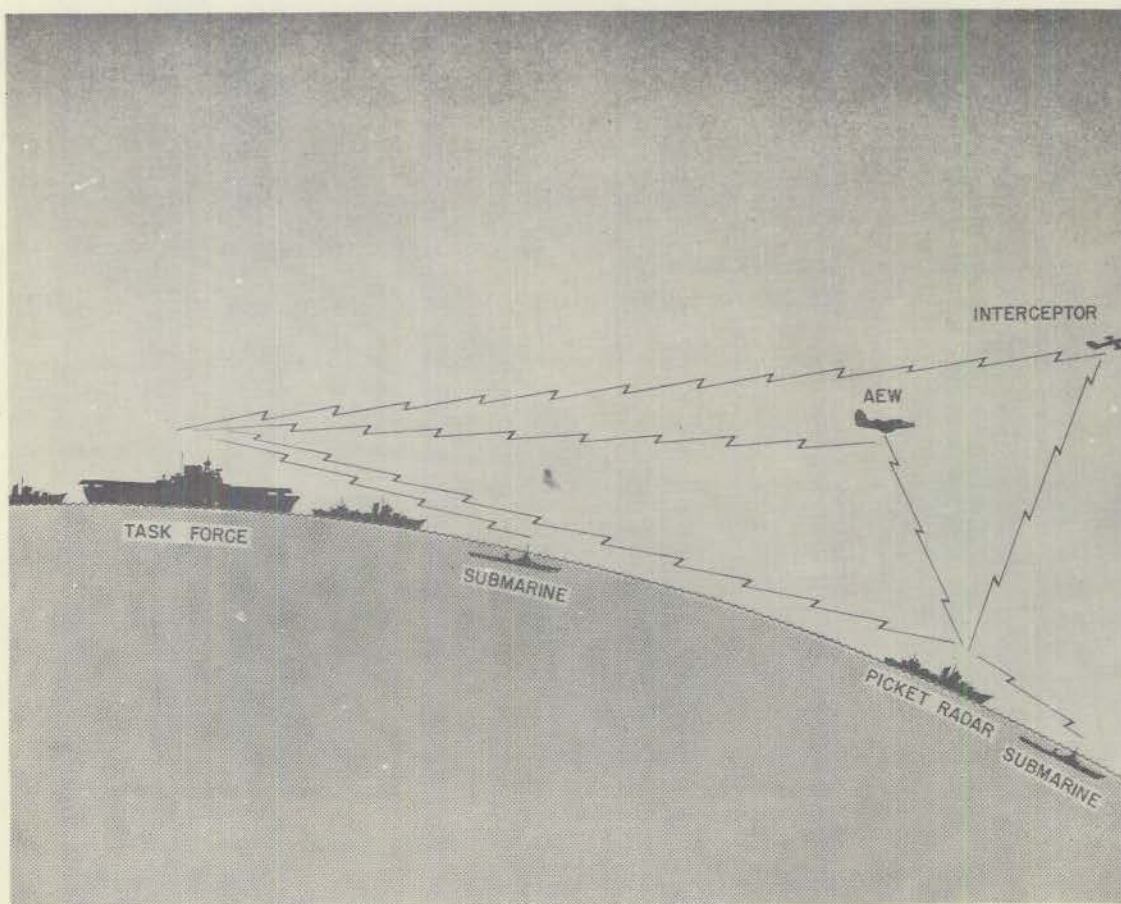


Fig. 6 - Communications Links

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