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NRL REPORT NO. R-3164

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PRELIMINARY STUDY OF AN AIRBORNE COMMAND SYSTEM

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PRELIMINARY STUDY OF AN AIRBORNE COMMAND SYSTEM

J. J. MacGregor, S. Riccobono, W. W. Balwanz
G. F. Wall, K. L. Huntley, J. F. Plunkert

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Approved by:

Dr. R. M. Page, Superintendent, Radio Division III

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ABSTRACT

The authors of this report profess a firm belief that a fleet of Naval aircraft on a mission can and should be commanded by well informed officers located aboard a plane or planes engaged in the assigned mission. This report intends to show that future air warfare will necessitate the airborne command system operating independently of surface administration. It advocates the assignment of an airplane to each fleet of aircraft for the sole purpose of accommodating the officers issuing the necessary commands. To perform this task the senior airborne officer must be equipped with complete combat information and must have the facilities to collect and disseminate this information to any or all units of the fleet practically instantaneously.

The report further endeavors to outline the electronic facilities required for the command plane in order to attain these objectives and show how these facilities should be used for dissemination of information to all fleet units.

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PRELIMINARY STUDY
OF AN
AIRBORNE COMMAND SYSTEM

INTRODUCTION

One of our most urgent needs is the development of new military tactics and weapons in order to bolster our ability to conduct a successful future war should the need arise. From a preliminary study, it is evident that the offensive and defensive capabilities of Naval aircraft can be increased many fold, if facilities are developed to permit actual direction of Naval movements and combat actions from the air. At present the information obtainable in the air is insufficient. Consequently, the system must be changed to permit more flexible combat operations.

A plan is proposed here to direct the efforts of scientific and military personnel toward the development of the essential facilities for a system of airborne command. It is intended that the system provide, in the air, all of the necessary facilities presently used in shipboard CIC in addition to many other facilities which are peculiar to an airborne system of command. This should not be interpreted to mean that miniature replicas of shipboard CIC facilities be designed for airborne use. Each facility must be critically examined in the light of anticipated future instruments of warfare.

The detailed design of equipment for airborne control will depend upon the character of future air operations. It is difficult to foresee just what this character will be. One possible form would be a Navy task force arrangement in which the present day escorted bomber operation is elaborated upon to a marked extent. On the assumption that escort fighters can always be provided with the ability to engage defending fighters on equal terms, the chief hazard to such future aircraft can be expected to be from anti-aircraft fire composed of homing or ground directed self-propelled missiles.

In attempting to analyze the electronic requirements for an airborne command system many questions arise concerning the functions, size, range, and dispersion of the fleet. The first part of this report discusses these factors and makes certain assumptions, while the latter part is devoted to the actual electronic requirements based on these assumptions.

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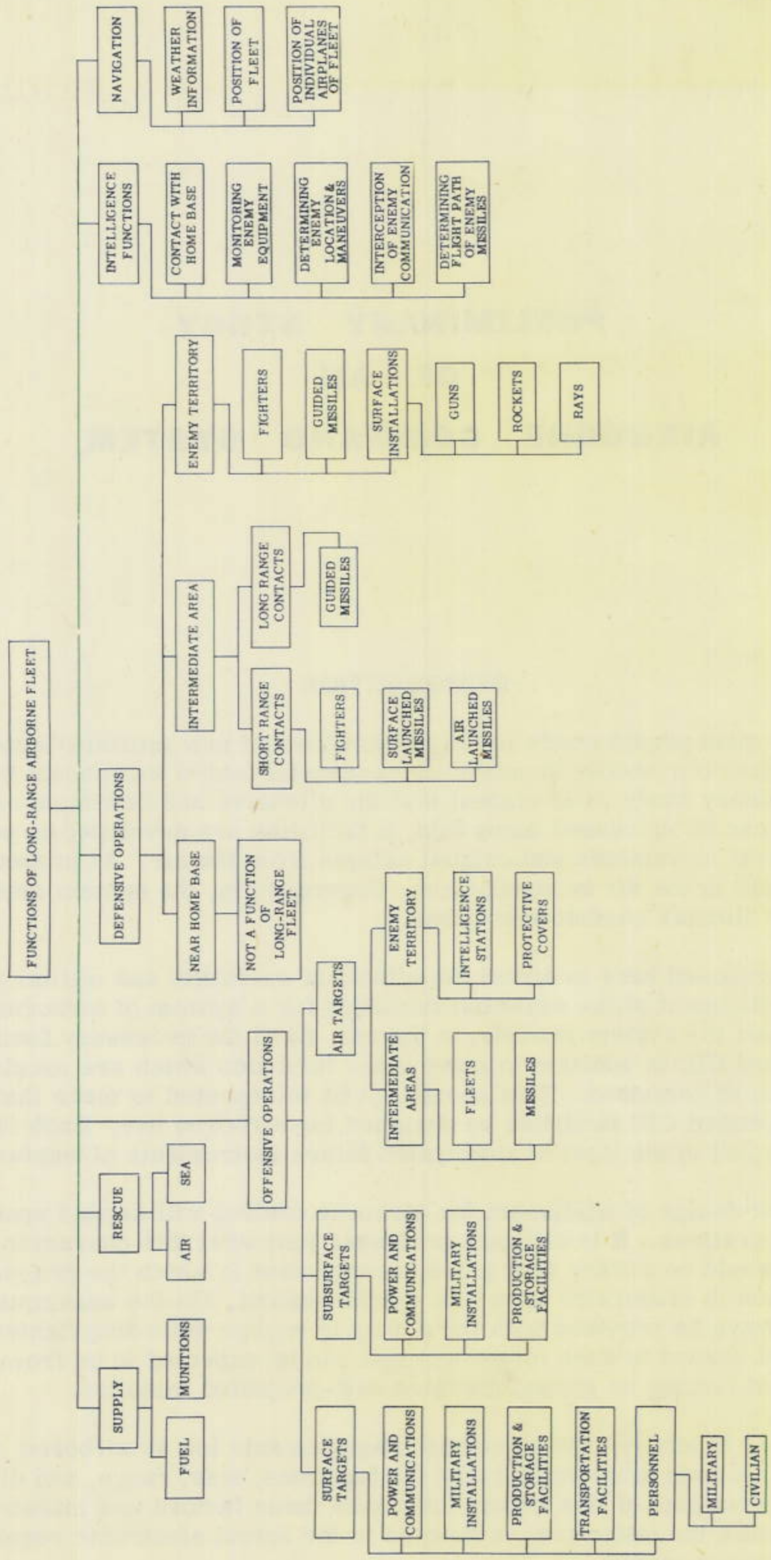

Figure 1

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PART I

ORGANIZATION AND PURPOSE OF THE AIRBORNE FLEET

FUNCTIONS OF THE AIRBORNE FLEET

In order to analyze carefully the electronic requirements of a long-range fleet, the functions of such a fleet must be determined. It is realized that such functions are determined by the highest echelons of military tacticians, and that their decisions are based upon the availability and the technical performance of equipment and personnel, and upon the urgent requirements that are dictated by the rapid changes of modern warfare.

For the purpose of determining the electronic requirements however, we can achieve some degree of success by starting with the basic ideas of offense, defense, navigation, supply, etc. By use of considerable imagination, we can build from these fundamentals and obtain a functional diagram which will contain elements of probability and possibility. Continuing along this line, we will then obtain a set of requirements for the electronic equipment. With this approach, a preliminary functional chart, Figure 1, is presented.

AIRBORNE COMMAND WEAPONS

The following brief summary of existing and possible future weapons can be used as a guide in planning the airborne command system.

Airborne weapons may be classified under four general classes:

(A) Explosive
(B) Incendiary
(C) Chemical
(D) Electronic

This is shown in Figure 2 which also lists the active agent, type of ordnance, method of control, and type of detonation of each weapon.

Numerous explosive, incendiary and chemical weapons were used in World War II. However, very few electronic weapons were available for use. It is entirely possible that ingenious electronic devices may be developed in the future.

The control classification of these various airborne weapons normally falls in one or more of the following categories:

(A) Free Fall
(B) Pre-Flight Trajectory Control
(C) Full Automatic Control
(D) Full Manual
(E) Semiautomatic

The higher speeds of aircraft, missiles and rockets make it necessary for the control of weapons to become automatic. Briefly the automatic controls may be

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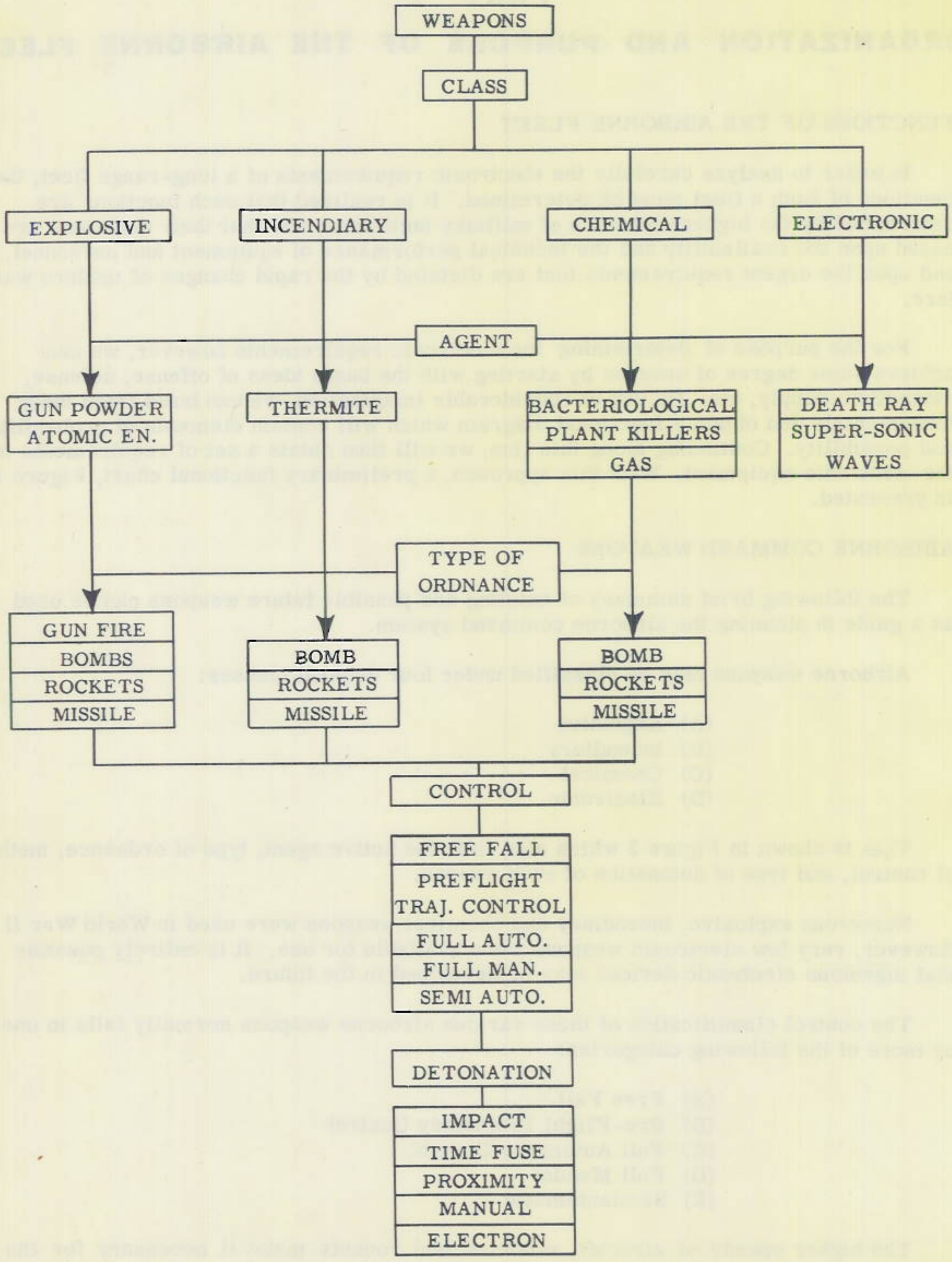


Figure 2 - Airborne Command Weapons

classified as follows:

(A) Automatic Pilots, Gyros, etc.

(B) Electronic Control
1. Manual Remote Control by Radio
2. Automatic Control
a. Radar Bombing Devices
b. Gun Directors
c. Missile and Rocket Guiding
d. Radar Beacon Homing

(C) Infrared Control
1. Homing
2. Detection

In addition many new types of weapons may have to be developed in order to be effective at supersonic speeds.

DISTANCE RANGE OF OPERATION

Range to Base: - Military requirements will probably determine the range of operation of future airborne fleets, but in order to understand the operation of this system, it is necessary to assume the possible range (in miles) that the airborne fleet will be required to travel in order to accomplish its mission. In order to simplify the issue, it is necessary to divide the missions into categories:

A. Short range aircraft missions of approximately 100-mile radius employing simple line-of-sight VHF communications.
B. Long range aircraft missions of distances in excess of 100 miles.

It will be necessary to analyze the operation of the command system under each of these conditions separately.

A. Short Range Missions: - It has been assumed that short range missions of the aircraft fleet will be limited to reliable VHF communication range. Since VHF communication range varies with the altitude of the stations involved, it becomes evident that the maximum communications range will vary with operating conditions. The design of modern and future military aircraft indicates that the operation of airborne fleets will predominate at altitudes greater than 10,000 feet, where reliable VHF operation between all air units is obtainable within a 100-mile radius of the base station.

B. Long Range Mission: - The long range missions are considered to be those which extend beyond maximum VHF communication distance. The maximum range will depend upon the aircraft design limitations. It is expected that within a five-year development period, this will approximate a 3,500-mile striking range and return.

Dispersion of Elements of the Fleet: - Since the airborne fleet will be composed of a large number of aircraft, it will become necessary to disperse the planes, depending on the military tactics employed for a particular mission. The dispersion will be limited by the maximum range of the radio and the electronic equipments with which each plane is equipped. This will probably limit the dispersion area to a 100-mile radius from the command airplane. Under most conditions this will permit plane-to-plane communication between individual planes of the air fleet. During the mission, all long range contact with bases or other air fleets will be maintained by the command airplane.

COMPOSITION OF THE FLEET

Aircraft Considerations: - In the development of an airborne command system consideration must be given to the expected types of aircraft to be used. Based on present and projected experimental aircraft, the performance of future types of military airplanes can be predicted. Some of the expected developments in various type aircraft are outlined below:

A. Future development of large bomber type aircraft:

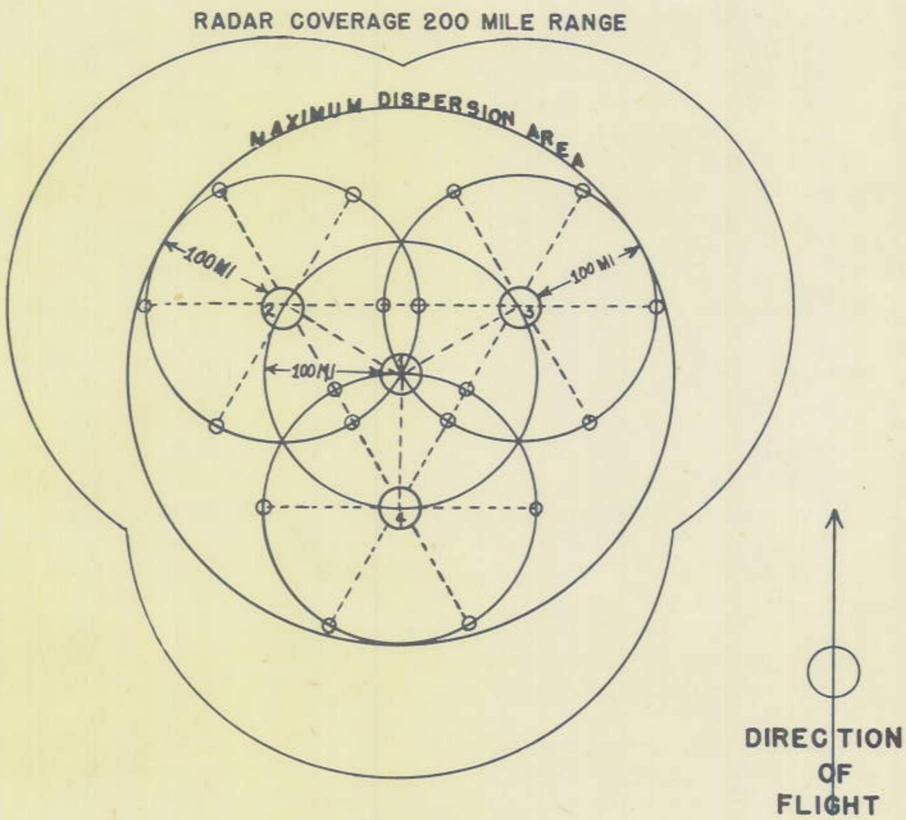
1. Conventional type: - Under present experimental flight test is the B-36 airplane, equipped with six reciprocating gasoline engines developing 19,000 h.p. This airplane weighs 140 tons, is 163 feet long, and has a 230-foot wingspread. At present there are only a few airports in the United States with runways capable of supporting the weight of such bombers. Within the next five years it is possible that advancements in jet and turbine propulsion may lead to its use on large bomber aircraft. In planning a program of airborne command for five years hence, we should be safe in assuming that the best military aircraft available for the command center will be approximately 150 tons, possibly jet propelled, and will travel at top speeds of 500-600 mph or greater. It will be capable of carrying 25 to 30 men and will travel a non-stop distance of possibly 7,000 miles. It will be equipped with adequate defense weapons whether these be guns and/or target seeking missiles.

2. Flying Wing Type: - It is also possible (in the light of present experiments) that the flying wing type of bomber will predominate in the future development of large aircraft. This design permits greater equipment, personnel and cargo capacity due to the fact that every surface of the aircraft contributes to the "lift". Large aircraft of this design may easily double the range of present day military bombers. This design definitely increases the visibility and self-protection possibilities of large aircraft due to the improved locations available for defensive armament. Many military men feel that aircraft of this design may not require fighter protection, which will become very important when planning long-range missions utilizing the airborne command system. This type plane lends itself readily to turbo-prop or jet propulsion. However, the sound barrier may limit the possible speed of this type airplane and all others. Within the next few years aircraft of this type should assume proportions suitable for use as an airborne command plane.

B. Future Development of Small Fighter and Bombing Aircraft: - The development of these aircraft beyond their present speed depends entirely upon the ability of science to conquer the sound barrier. However, for purposes of airborne command, we can assume that the fighter aircraft will increase in speed in direct proportion with the larger command type aircraft. The command type aircraft will probably remain slower in speed, but higher in range than the fighter aircraft. In the next five years, it can be expected that fighter aircraft may increase their range to approximately 3,000 miles, roundtrip.

C. Fleet Division: - The tactical formations of an airborne command will depend on the mission to be performed, and will be influenced greatly by the past experience of the military forces. For the purpose of illustration we will assume that the basic group will be the squadron which may be composed of twelve to eighteen planes. This may be sub-divided into three-plane groups, thence to individual planes. A chain of command will be formed within the squadron to accomplish an assigned mission. Several squadrons may be collectively assigned to form an air group thereby unifying the command of these squadrons. Air groups may be collectively assigned to form an air fleet. Obviously this organization is similar to that used in the recent war for air and surface craft. The airborne command may be installed at any point of this organizational breakdown to provide a flexible command for a particular force on an assigned mission.

A 325-plane air fleet is shown in Figure 3, which also indicates the command links required for this fleet composition.



1. Airborne Command
2. Air Group Command - Alternate No. 1--108 Planes
3. Air Group Command - Alternate No. 2--108 Planes
4. Air Group Command - Alternate No. 3--108 Planes

Small Circles--18 Plane Squadron
Broken Lines Direct Command Link

Figure 3 - Airborne Command for 325 Plane Fleet with 3 Alternate Commands

The commands are shown as the hub of the organization, but it must be realized that they may operate from a squadron to provide protection and security. The outer squadrons may be designated as search or protective aircraft while those disposed near the center of the pattern may be used for the control of offensive weapons such as will be used in future warfare. Four command planes are shown (Cf. Figure 3) one for each of the three 108-plane air groups and one at the center which serves the fleet commander.

The major operations, functions, weapons, planes and organization of aircraft fleets in future wars have been considered and the scope of the problem to be faced in the future indicated. Military personnel can readily forsee the confusion that would exist with present methods and tactics.

A system of electronic installations in the command plane and supporting aircraft of the air fleet operating as previously described will be discussed in Part II.

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PART II

THE AIRBORNE COMMAND SYSTEM

The system as proposed will function to serve groups of approximately 108 aircraft of the large bomber type operating at speeds of 500 mph or more with a striking range of 3,500 miles. The system will provide command, navigation, detection, and communication facilities, in fact, all but special devices connected with weapons. The advantages to be gained are coordination, greater offensive power, greater defensive power, and major reduction in the quantities of electronic equipment needed on fighter or attack type aircraft.

The general details of the proposed "Airborne Command System" are as follows:

A. The airborne command plane will have sufficient electronic equipment for gathering all necessary intelligence pertaining to communication, detection, navigation, homing, etc., to perform any missions, together with means for storing and releasing information as required.

B. The command plane will have necessary link facilities with the supporting or fighter aircraft for; communication, navigation, homing and fighter direction. This will be accomplished by means of an intelligence relay link.

C. The electronic equipment aboard the supporting aircraft may consist of communication, an intelligence relay link receiver, intercept search detection, IFF and beacon or homing equipment.

These equipments (aboard supporting aircraft) could also provide limited blind landing navigational facilities.

The electronic facilities for an airborne command system will in all probability require flexibility, that is, the components of the electronic installation may vary with the type of mission and composition of the air fleet. A discussion of the functions required of the component equipments follows.

COMMUNICATIONS

One of the most important facilities required for airborne command and the air fleet is an adequate radio communication system. The communication system will be required to perform essentially three distinct functions as follows:

A. Long range communication; that is, beyond line-of-sight
B. Medium range communication; within line-of-sight
C. Very short range communications; up to 25 miles, such as between planes in a formation.

Long range communication: - Long range communication facilities will be required by the command plane for communicating with the base or with other distant Naval elements when the air fleet is on a long-range mission. There are two ways of accomplishing this: 1) by use of relatively low frequencies and high power; and 2) by VHF or microwave automatic relay system.

In the first instance, operation at low frequencies involve the use of relatively high power, large antennas, and susceptibility to atmospheric static. Some transmitter power economy can be affected by selection of operating frequencies to take advantage of prevailing propagation characteristics for the time of day and the distance to be covered.

In the second instance an effective relay system can be established by installing radio repeater equipment in pilot-operated or remote controlled airplanes spaced at intervals between the air fleet and the home base. Neither system is ideal, but in the interest of flexibility, it appears desirable to provide both systems and for each specific mission select the one best suited.

Medium Range Communication: - Medium range communication will be required in the airborne command plane and all elements of the air fleet in order to provide rapid and direct communication. Since such communication will always be within line-of-sight range the highest possible frequencies should be used consistant with technical requirements, propagation characteristics, and developed techniques. The use of microwaves appears most desirable since antenna structures are small and efficient.

Very short range communication: - Very short range communication will be required in all planes of the air fleet in order to permit communication between planes in a formation without interfering with the overall fleet communication. The range of communications should be limited to 25 miles or less in order to assure a high degree of security against enemy interceptions or warning. Recent developments indicate that this can be accomplished by using certain portions of the microwave frequency spectrum (60,000 Mc) where the signal absorption by the oxygen in the atmosphere is appreciable.

Miscellaneous Considerations: - An airborne command communication system designed to obtain maximum performance efficiency from a large air fleet will require a large number of voice circuits plus picture and facsimile circuits. This is particularly true for the medium range communication equipment. The multiplicity of channels required does not necessarily mean the use of separate RF carrier for each channel. A sound basis for affecting considerable economy of spectrum is indicated by exercising ingenuity in applying the modulation principles of pulse time modulation, pulse amplitude modulation, frequency modulated pulse modulation, pulse repetition frequency modulation, pulse separation modulation, and combinations thereof. If microwaves are used, directive transmission with station selection by gating methods would also be desirable.

In view of the many communication circuits that will be used in the airborne command plane, it is apparent that some system of intelligence integration must be used if the maximum benefits are to be derived from these facilities. Such a system should make it possible for a person to select, for example, one or all of the incoming intelligence circuits by the simple manipulation of one or two controls. Further it should be possible for him to make permanent recordings or have the transmission repeated on a short memory circuit.

Integration of the communication facilities with all other equipments and functions in all planes of the air fleet and particularly in the command plane, must be exploited to the fullest extent. Consideration should be directed towards elimination or reduction of human effort wherever possible by the development of fast, automatic means of channel selection, switching, transmission of coded picture symbols which indicate predetermined orders, etc.

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NAVIGATION

It is proposed in this system that primary navigation will be accomplished in the command plane and/or alternate command planes. Detailed navigational information will be relayed from the command plane to accompanying aircraft via the intelligence relay link. Information concerning latitude, longitude, magnetic course, wind direction, wind velocity, and tracking course may be disseminated in this manner. The accompanying aircraft may keep a course plot to use in case of emergency; this should provide current information thereby enabling the plane to return to its base.

The command plane will carry the master navigator for the combined fleet. Alternate planes being similarly equipped will also have competent navigators aboard. The functions of these navigators will be to determine all necessary information and display it on the plotting board for relay to accompanying aircraft. Equipment must be provided to enable the navigators to determine position fixes quickly and accurately; probably this will be done by electronic means in order to make all weather, day or night operations possible. The range of the combined navigating devices must extend to the maximum striking range of the fleet.

Development of automatic navigational devices will aid materially in the dissemination of accurate navigational data with a minimum of equipment in the individual planes. Considerable effort is now directed towards development of continuous reading ground speed indicators and ground position indicators, which will enable navigators to provide necessary information.

Optical means of securing navigational data are disregarded primarily due to the time required to determine a position fix. Future planes flying at high altitudes above overcast may use an automatic optical tracking indicator thereby providing a continuous position reading. Other devices which may be utilized include distance measuring equipment, Loran, radar or other beacon systems. However, all of these systems lack suitable range, security or accuracy for all weather, day and night operations; therefore, considerable effort must be expended to provide adequate devices.

IDENTIFICATION

In order to provide a satisfactory universal identification system for the airborne fleet, several functions must of necessity be performed as listed below:

A. System must enable each aircraft in the fleet to identify every other aircraft in the fleet at any time. Personalized identification of fighters or bombers for ease of command would be desirable. Self-identification for indicating position on a relayed radar map will be necessary.

B. Visual display of identification should be provided.

C. Adequate security measures should be incorporated, such as possibility of rapidly changing frequency, signal coding and power output. Antennas should be arranged to give very narrow beaming and 360° azimuth coverage.

D. Provision should be made for installing the interrogating equipment in the command plane and connecting the system so that the information will be applied to the command plane plotting board.

E. Equipment should be designed so that the major equipment will be contained in the command plane. Only visual display circuits and transponders should be located in the individual squadron aircraft.

F. The displayed identification signals should be positive and foolproof, easily read by pilots, and not requiring visual concentration. Introduction of a color discrimination method would be highly desirable.

DETECTION

Probably, the most important electronic components of the airborne command system will be the detection equipment in the command aircraft. This detection system will be required to accomplish tasks heretofore not performed with airborne radar equipments. The functions and characteristics of the detection system necessary to gather the vital information required for air fleet operations are as follows:

A. Radar Coverage: - The radar units of this detection system will be required to search 360° in azimuth as well as give full coverage in a vertical plane and provide target altitude information. Several antennas may be necessary to provide this information especially since both surface and air targets may require simultaneous detection and tracking, a function which would be difficult with a single radar antenna. Each radar antenna must be able to operate normally regardless of the flight attitude of the command plane, which means that improved surface stabilization methods must be employed.

B. Expected Range: - The radar should be of sufficient power and sensitivity to provide 200-mile range. The operating altitude of the airborne fleet will allow this goal to be achieved from the propagation standpoint, and improvements in radar design should provide the required power and sensitivity to achieve this performance. This range can be extended by relayed detection information obtainable from other aircraft.

C. Antijamming Features: - The radar equipment used for airborne command work will be the nerve center for the fleet operations. Therefore, every known electronic jam-proofing feature must be incorporated into the system to insure continuous and reliable operation.

D. Undersea Detection: - The command plane will also require a supplemental detection equipment capable of supplying submarine detection information. Such an equipment need not be an integral part of the radar, but the information obtainable from it should be displayed on the master plotting board of the command plane.

E. Infrared Detection: - The use of infrared detection systems provides numerous additional advantages when used alone and in conjunction with normal radar detection. In the detection of guided missiles and high speed aircraft, infrared offers much promise as a possible detection device. It also may provide certain information in case the radar system is successfully jammed by the enemy. Although much remains to be investigated in this field, it appears certain that the airborne command fleet will require some infrared detection devices as the art progresses.

F. Detection Display System: - By far the greatest problem will be the complete display of all detection information on a master indicator in the command plane. It is expected that this task will require many new developments which are now in the experimental stage, such as moving target indication, multicolor cathode ray display tubes, storage tubes and various projecting systems, expanded sweeps and target blanking circuits. The goal to be achieved would be to center all detection information on a single plotting board containing the following:

1. Disposition of all fleet planes and IFF signals.
2. Disposition of enemy surface units.
3. Disposition of enemy air and undersea craft.
4. Disposition of friendly air, surface, and undersea craft.

By proper target blanking circuits, one or all of the above items could be displayed on this master plotting board and airborne command of an entire fleet could be adequately and efficiently conducted.

G. Radar System in Individual Squadron Aircraft: - As previously mentioned in this report, the use of the command system will relieve individual squadron aircraft of the task of carrying heavy radar equipments. However, individual aircraft will require some smaller radar for functions such as fire control, IFF and short range interception. Radar fire control will be necessary for firing rockets, dropping bombs, guiding missiles, etc.

INTELLIGENCE RELAY

Requirements: - The system should be capable of relaying detection, navigation and related intelligence between fleet airplanes. Two primary functions are:

A. Relay of detection intelligence from especially equipped airplanes to the command airplane, for the purpose of increasing the detection range.

B. Relay of plot-board intelligence from the command plane to the individual airplanes of the fleet. A single receiver in these airplanes will display this intelligence, thus eliminating considerable electronic equipment in combat airplanes. It is assumed that this plot-board intelligence will contain all types of stored information that is needed by the fleet, such as navigation information, location of all surface and air vessels, friendly or otherwise, IFF information, etc.

A number of channels should be provided for transmitting the composite plot board or only a section thereof, as indicated by the needs of the individual portions of the fleet. Control is needed to insert or delete various functions in the plot-board information, as desired by the command. The equipment should be integrated with the communication equipment to provide associated voice channels.

Research on relay systems has been conducted by various groups. A number of methods have been proposed which will provide at least some of the desired functions. A thorough review of this field is required before recommendations can be made on the direction of future research.

Proposed System: - The foregoing paragraphs have mentioned the desirability of an intelligence relay system to disseminate information to the air fleet. A possible system is outlined below and shown in Figures 4 and 5 (pages 14 and 15). The system would provide the functions outlined previously as being desirable for the command of an airborne fleet. It is assumed that the command plane will be equipped with the following:

A. A detection system capable of detecting air or surface targets with a high degree of resolution. This system will be composed of radar and infrared detecting equipments with monitor scope displays.

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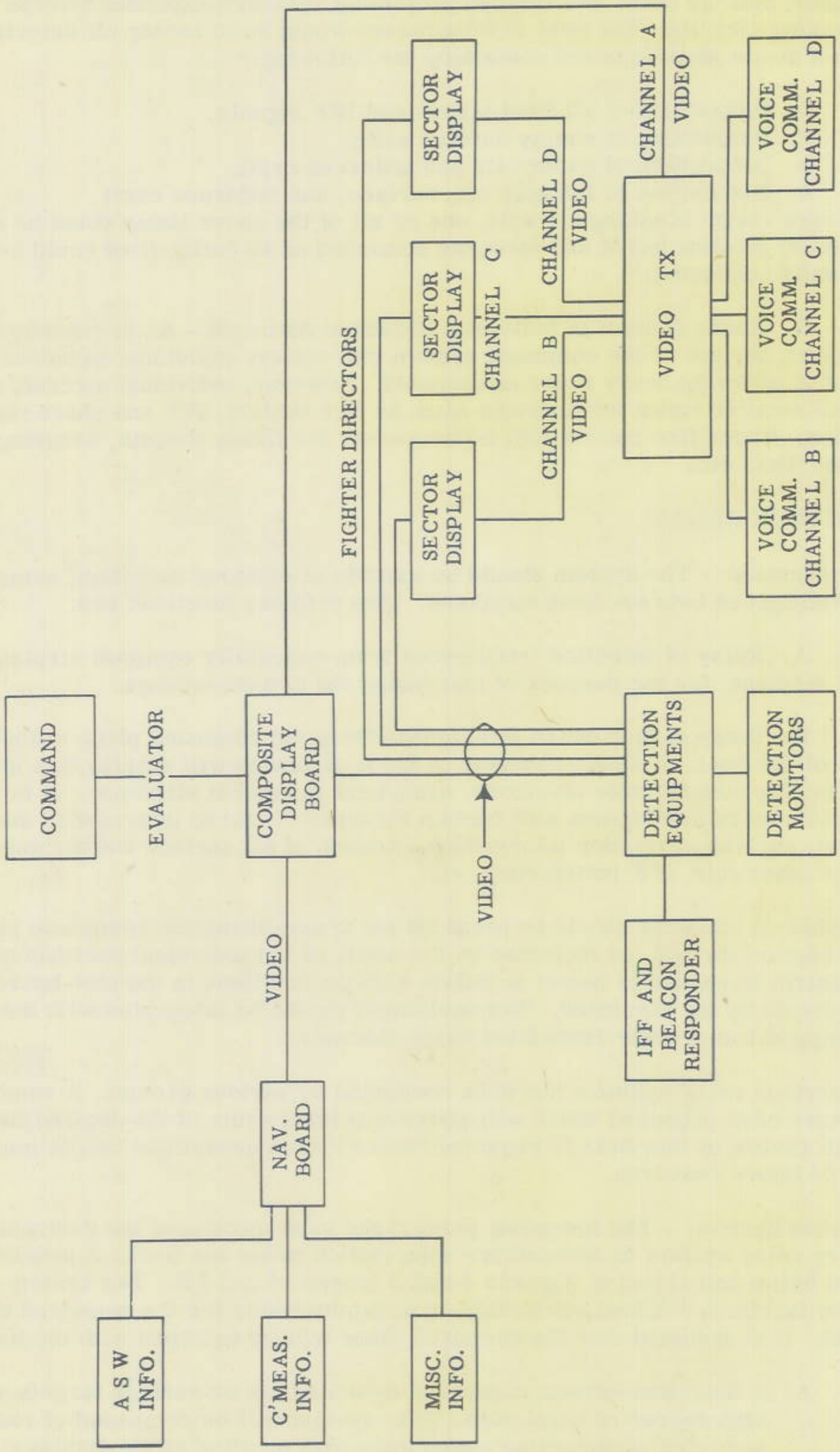

Figure 4 - Command Aircraft Intelligence Relay Components

IFF and beacon responses will be displayed on this scope in sufficient detail to identify any or all aircraft as desired. The video output from the detection system will consist of all radar, infrared, IFF and beacon information.

B. A display board should be provided where the detection and IFF video information may be presented. This may consist of a projection type of cathode-ray tube and a suitable screen. Additional information will also be projected on this screen from a navigation board. This will present a composite picture of all available information from the evaluator in the direction of the fleet. The evaluator may then study all factors such as fleet and enemy dispositions and issue directives as to the action to be taken.

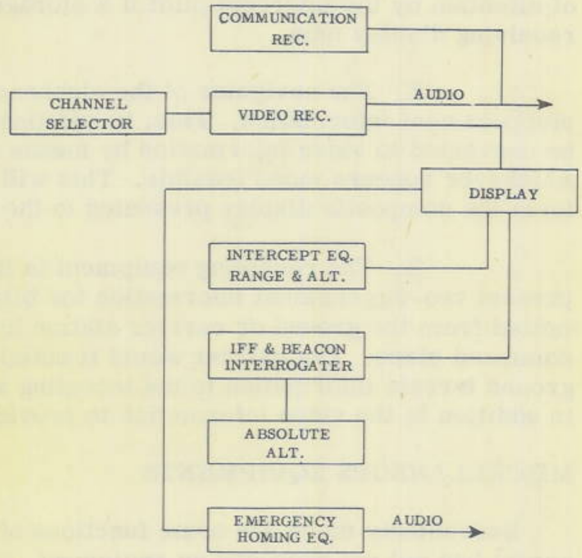

Figure 5 - Accompanying Aircraft Intelligence Relay Components

C. The video from the detection and IFF equipment may be presented on several sector displays. Three are shown on the attached block diagram, Figure 4. The sector displays will be utilized by the fighter directors in assigning an intercept course to engage an enemy or direct action against ground installations. The individual sectors may be selected from any part of the radar coverage circuit as assigned by the evaluator. A sweep display control will enable the fighter director to expand any part of the sector for greater accuracy during the interception.

D. A video transmitter will be used to relay the video information either from the composite display as viewed by the evaluator or from a sector as viewed by the fighter directors. During normal flight operations the composite display will be transmitted to all planes permitting each pilot to obtain all information concerning fleet dispersion and navigation information. Preceding enemy action, aircraft designated to intercept will be directed to switch to a secondary channel. This channel will present data from the sector as viewed by the fighter director. Intercept courses, enemy altitude and such other information as the fighter director deems pertinent may be presented on this display. General information as to means by which this may be accomplished is given later. Voice communication will be desirable for each fighter director in which case it may be transmitted by the video carrier and filtered out in the receiving plane.

E. The scanning by the radar antenna will be continuous at a rate similar to that used for PPI scans, at present approximately 24 rpm. The projection tube used for the composite display must have persistance sufficient to carry the picture between successive sweeps. The displays used by the fighter directors must be longer in persistance. It is proposed that this display tube will have characteristics such that written intelligence on the face of the tube may be converted into electrical energy. Development of a tube with such characteristics appears possible in view of recent development of the Haeff storage tube at NRL. The composite informatiom from the sector radar scan plus written intelligence by the fighter director will be transmitted to the intercept aircraft during actions involving the enemy. Information from the fighter director is instantly available to the intercept pilot. This will require a minimum of attention by the intercept pilot if a storage type cathode-ray tube is used for a receiving display tube.

F. The navigator of the airborne fleet will compile all navigational data and plot pertinent information. This, in addition to other miscellaneous information, will be converted to video information by means of a visual pick-up or Haeff storage tube, whichever appears more feasible. This will be combined with the radar-IFF video to form the composite display presented to the evaluator.

G. The receiving equipment in the accompanying aircraft may be used to present two-dimensional information for blind landings. The information would be transmitted from the ground or carrier station by equipment similar to that installed in the command plane. The carrier would transmit a composite display including radar and ground terrain information to the incoming aircraft. Elevation data could be transmitted in addition to the video information to provide third-dimensional information.

MISCELLANEOUS EQUIPMENTS

Undoubtedly there are some functions of the airborne command fleet for which this report has not yet proposed an equipment. Chief among these are: countermeasures, interphone systems, antenna array, and power supply systems.

Countermeasures: - This problem can be attacked in two ways, either all planes in the fleet can carry certain special countermeasure equipment or all countermeasure devices can be carried in one airplane and several such planes assigned to a fleet as circumstances require. The choice of either system will probably have to wait until it is known just how far our potential enemies will go in exploiting the principles of electronics. However, some advantages of both systems can be pointed out here.

A. If the countermeasures equipment is spread throughout the fleet, a greater area can be covered due to the wide dispersion of the air fleet. Each plane could alter the countermeasure equipment characteristics to best suit his own needs during the mission. Greater reliability would be provided in case one or more planes were battle casualties.

B. However, if several special planes in the fleet were devoted to countermeasures, there would be a centralized countermeasure system which could be manned by a minimum number of highly skilled countermeasure technicians. Under this sytems the countermeasure plane could work in close collaboration with the airborne command ship and provide highly reliable information concerning enemy electronic operations, and render deception and jamming services when required. The choice of either method cannot be readily made at this time.

Interphone Systems: - Considerable study and experiment will be required before a suitable interphone system can be designed for the command plane. The mental concentration required of the officers located in this plane will demand that absolutely essential talk circuits be routed to the command section of the airplane. Other methods of exhibiting audio information such as written information presented on the screens for storage tubes, high speed teletype, relayed radar and others will aid materially in curbing confusion and stimulating concentration of those officers responsible for the fleet maneuvers. All planes in the fleet will require ICS systems far better than those used today.

Antenna Problem: - With all the equipments proposed for the airborne command plane, it is evident that too many antennas would be required, if each equipment must have its own antenna. However, by using proper filters and isolation networks, several equipments may be operated from one antenna, eliminating as many as two-thirds of the antennas from the airplane. Experiments at this Laboratory indicate that operation of several microwave equipments from one antenna is possible if the RF circuits are properly integrated.

Power Supply Problem: - It is conceded that this electronics system will require power generation equipment much larger than anything now in use. However, the 28 volt d-c system is rapidly becoming inadequate and high voltage a-c systems are in development at NRL and other laboratories. By providing centralized rectifier power supplies feeding many different electronic equipments, great savings in weight and greater electrical efficiency may be attained. In this preliminary report no attempt has been made to determine the power and weight requirements. It is obvious that these items are of paramount importance for aircraft equipment, and will require considerable attention as the system is developed.

CONCLUSIONS

The previous pages of this report have attempted to set forth some ideas concerning future military aircraft operations. From the proposals contained herein, the following conclusions can be drawn.

> The present complex system of commanding aircraft operations must pass into antiquity with the advent of high speed jet-propelled aircraft.
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> The increase in speed, size and power of aircraft, together with the increased power of devastation which they bear, leaves little time for military leaders to decide the plan of battle. For this reason the large aircraft fleet becomes the most potent weapon the military can rapidly organize for war, and with a well informed military leader in a position to intelligently lead this fleet, enemy objectives can be dealt a decisive blow.
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> The opening pages of this report have outlined the functions which aircraft may be expected to perform and some of the weapons which will be available to the air fleet to help accomplish its mission. The air fleet will also protect itself from these same weapons should they be employed by the enemy.
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> In planning the airborne command system it was necessary to determine the operating characteristics of future aircraft. By careful study and investigation it was possible to predict what types of aircraft would be available for future use as a command plane as well as what may be expected for supporting aircraft. These planes will weigh approximately 250 tons and be capable of speeds of up to 500-600 mph or greater. However, the present limitation placed upon aircraft speed by the sound barrier is reflected in these predictions.
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> Having established the fact that the airborne command system was necessary and feasible, it was then possible to propose the electronic facilities necessary to provide complete information to the airborne commander and his staff. This report proposes many electronic methods of providing complete communication, navigation, detection, IFF, intelligence relay and other

miscellaneous facilities for the entire airborne command fleet.

Many of the electronic facilities proposed in this report are already developed and are immediately available for air fleet application. Some facilities, particularly the intelligence relay system, would require considerable laboratory development. The proposed communication system utilizes engineering principles and circuits already developed and experimental equipments embodying these characteristics could be built in a relatively short time. The proposed IFF and radar facilities are substantially improved compared to present day systems, but the requirements of the air fleet will demand developing these equipments to a higher degree and engineering laboratories are already engaged in many projects designed to accomplish these ends.

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