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AD NUMBER
ADB816663
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AUTHORITY
88 CS/SCOKIF (FOIA) ltr dtd 12 May 2016

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AD NUMBER
ADB816663
CLASSIFICATION CHANGES
TO: unclassified
FROM: secret
AUTHORITY
DoDD 5200.10, 29 Jun 1960

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DEPARTMENT OF ENGINEERING RESEARCH
UNIVERSITY OF MICHIGAN • ANN ARBOR

SECRET

PROJECT "WIZARD"

PROGRESS REPORT NO.1

June 1, 1946

SECRET

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UNIVERSITY OF MICHIGAN

AAF CONTRACT W33-038 ac-14222
Project MX-794

GROUND-TO-AIR PILOTLESS AIRCRAFT
RESEARCH PROGRAM

PROJECT "WIZARD"

PROGRESS REPORT NO. 1

June 1, 1946

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PROJECT "WIZARD"

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SECRET

INTRODUCTION

The University of Michigan contracted with the Army Air Forces (Air Materiel Command) on 3 April 1946 for an investigation of guidance, propulsion, launching, and supersonic aerodynamics leading to the design of a ground-to-air pilotless aircraft capable of intercepting and destroying hostile aircraft operating at altitudes up to 500,000 feet, at speeds up to 4,000 mph, and at ranges sufficient to prevent damage to the defended area.

Progress reports summarizing the status of this work are being prepared every two months by the University of Michigan under the terms of the contract. This report is the first of the series.

In addition, a separate program of basic research and engineering evaluations will be conducted in fields pertinent to the design of pilotless aircraft, such as guidance techniques, propulsion methods, supersonic aerodynamics, servo mechanisms, fuel chemistry, launching procedures, fusing and missile performance. These investigations will provide a body of information for possible future improvements of pilotless aircraft. Their extent will be determined by practical limitations of personnel and equipment.

The project bears the classification "SECRET," with the exception of general data which does not pertain to performance and design of the missiles being designed, which may be classified "CONFIDENTIAL" or lower.

GENERAL PROGRAM

Severe performance requirements of this missile necessitate that all fields involved be exploited to their utmost, especially propulsion and guidance. The initial approach on this project is therefore to become thoroughly familiar with currently available components and systems, and to determine the limiting factors in all of the various fields. This will guide work on preliminary designs and subsequent investigations.

ORGANIZATION

The project is being handled for the University of Michigan by the Department of Engineering Research. Specific responsibility rests with Prof. Emerson W. Conlon, Chairman of the Department of Aeronautical Engineering. Prof. Conlon also acts as chairman of an Advisory Board whose individual members are responsible for technical progress in the various fields.

Technical coordination and project administration will be under Prof. Wilbur R. Nelson, Project Engineer, and

Mr. Robert F. May, Administrative Engineer. Advisors for the various phases of work are:

Aerodynamics - Dr. Arnold M. Kuethe

Design - Prof. Franklin L. Everett

Guidance - Prof. William G. Dow

Launching - Prof. Jesse Ormondroyd

Mathematics - Prof. Ruel V. Churchill

Propulsion - Prof. Edward T. Vincent

Research techniques and flight test - Dr. M. H. Nichols

Full-time research employees, plus various faculty members, graduate students and under-graduate students doing part-time work, all under the supervision of the above persons, complete the project personnel.

Locations on the University of Michigan campus and space at the Willow Run airport, recently acquired by the University, will be used for research and testing.

SUMMARY OF THIS REPORT

This report gives a summary digest of progress on the project between the date of contract, 3 April 1946, and 1 June 1946. Most of the work during this period has been in setting up the organization and in determining the lines of attack for the research program, together with collecting a picture of existing information on the field.

Inasmuch as the project is still in its initial stages, with final personnel and space assignments not yet completed, this report deals with the kinds of problems being considered in the various phases of the work. Subsequent progress reports will deal more completely with technical progress and more final thinking along specific lines.

AERODYNAMICS

The problems of drag, stability, maneuverability, and surface temperature appear to be the most important for the aerodynamic design. All of these are intimately tied in with the other features of the design. For instance, a system of propulsion involving rocket—ram jet—rocket may be feasible provided a clean configuration can be found which will not increase the drag unduly over a pure rocket system. Various proposals will be examined from the standpoint of drag.

The problems of maneuverability and control are intimately connected with each other and with the other phases of the design. At the higher altitudes these factors must obviously depend upon other means than lifting surfaces and movable controls. Further, it is necessary to consider whether these other means, for instance a system of rockets distributed over the body, are adequate in the lower speed region of the trajectory.

Dynamic stability of the aircraft immediately after launching must be studied for various configurations as a function of the launching speed. The variables to be considered in this connection will be fineness ratio, area of wing and control surfaces if present, the possibilities of rocket control, configuration of rockets for stability, and so on.

Phenomena in the transonic region must be studied with a view to determining whether it is feasible to launch at less than sonic speed.

Surface temperatures, while not important in the upper regions of the atmosphere, will determine how shallow a trajectory may be expected for an oncoming missile from a given distance.

Efforts thus far have been expended on plotting approximate curves of drag versus altitude for two representative aircraft at various supersonic speeds up to 8000 ft/sec. The object of these calculations was to give a rough quantitative idea of the drag force involved for representative cases. It was assumed that the known laws of aerodynamics for skin friction, wave drag, and base drag are valid up to an altitude of 200,000 feet and that above this altitude the Newtonian law holds, i.e., the drag results entirely from impingement of the molecules against the tapering nose.

Methods for calculating the skin temperatures are being examined, especially those given in the German literature.

Information on the lift and center of pressure for bodies of revolution at angles of attack is being collected.

In order to make these investigations complete, it is necessary that microfilms of as much as possible of the German literature be investigated, and all available aerodynamic reports be studied. This will consume considerable project time during the next few months.

Basic aerodynamic research will be concentrated in the field of aerodynamics in which the mean free path of the molecules is of the same order as the thickness of the boundary layer. A considerable amount of work has been done on the characteristics of air at very low pressures (i.e., large mean free path), but the phenomena of viscosity, slip at the surface, and the like, for the pressures occurring at altitudes of a few hundred thousand feet are relatively unknown. The determination of skin temperatures, drag, and shock wave phenomena await detailed investigations in this field.

DESIGN

The design group will coordinate the activities of the various phases involved insofar as design of the missile's configurations and mechanisms is concerned. It will first, by a study of existing designs, provide a guide to the groups working on different phases of the project as to relative space limitations and weight distributions.

Design studies under way utilize various types of propulsion and launching, with the main objective of crystalizing the problems confronting the different technical groups. Several possible combinations will be modified to meet the needs of the functional components, and by a series of modifications the final design which appears to best fulfill the requirements will be determined.

Some data and reports have been collected which will form a basis for more detailed work. Effort has been directed toward associating possible component parts.

GUIDANCE

The initial work on the guidance problem will chiefly involve determining the existing electronic and related components which are available for guidance, with their various limitations. At the same time preliminary plans and designs for specific guidance systems will be started.

Thus far considerable familiarity with functioning of the V-2 rockets, and with available techniques for telemetering, remote control channel establishment, rocket guidance, and possible types of interception trajectories has been obtained. Estimates of the properties of the upper atmosphere which affect radio propagation and interception guidance fuel requirements are being made.

Numerous possibilities are apparent for early warning and tracking of the offensive missile, types of interception to accomplish destruction of the offensive missile, and guidance methods for the initial stages of flight and final interception. It is necessary to make some assumptions in order to begin any specific evaluations and designs.

It is first being assumed that the approach of an enemy missile will be indicated through an extended chain of radar early warning and tracking installations. These installations should be so located as to give approximately 10 minutes warning prior to arrival. This would permit interception to be completed perhaps 150 miles from the defensive launching site, and calls for the ability to get a missile to the proper position within a period of about 150 seconds.

The interception path may be any of the following:

A. Identical with, but opposite in direction to, that of the approaching missile.

B. Tangential to the path of the approaching missile at the point of desired interception.

C. Across the path of the enemy missile at the interception point; non-tangential.

D. Pursuit from behind along a tangential path.

The pursuit course would be more important if the enemy missile were assumed to have intelligence and the ability to take evasive action. The guidance problem will first be attacked under the following assumption: the enemy missile has no intelligence, after its initial launching, which would enable it to make a marked deviation from the early tracking trajectory.

Since present thinking indicates that some sort of homing device will be needed in the final stages of flight to obtain the required accuracy of interception, the guidance accomplishments depend a great deal upon the amount of fuel which can be carried aloft and held in reserve to cause the necessary change in momentum for final interception. These fuel reserves may have to be very substantial, and will represent a major portion of the weight carried aloft.

As soon as a logical set of conditions is assumed for type of interception, useful warhead content, and weight of seeking mechanism, it will be possible to calculate the weight of fuel and motor necessary for several types of early trajectories. The result of this calculation will determine the guidance requirements.

The actual electronic guidance equipment will depend on an analysis of various possible systems. For convenience radar will be considered initially, and will probably be of major importance in the final design. Considerations of the guidance equipment depend on the type of trajectory chosen, the possibility of either vertical or directed launching, and, for the final flight path where the missile is being guided by a homing device, upon the relative merits of radar, sight, heat, or other indications in the upper atmosphere. Radar seems at present to give the most accuracy in range, but other devices may prove more practical for azimuth corrections.

LAUNCHING

It is planned to investigate all possible types of launching devices, making necessary calculations to determine the relative utility of each. Consideration will be taken of rate of fire from a given control station, mobility of the launching equipment, orientation of the missile prior to launching, and other similar factors.

The following types of launching devices are being considered, many of which can be eliminated with relatively little investigation as being impractical:

A. Simple platform with guide tower, using rocket effect of the main rocket motor for vertical launching.

B. Permanent launching mechanisms, independent of the rocket design.

   a. Mechanical springs with potential energy stored by stretch or compression.

   b. Compressed air ejection.

   c. Steam ejection.

d. Gun or mortar ejection under action of propellant gun powders, the gun powder pressure acting either directly on the missile or indirectly by compressing air which is in contact with the missile.

C. Devices forming a permanent part of the missile, but used only during launching.

a. Separate, quick-acting rocket motors.

b. Recoil motor-power generated by firing a charge of powder. (Merely a quicker variant of rocket motors.)

D. Devices temporarily attached to the missile and dropped after launching is completed.

Jet assisted take-off, with power provided by rockets properly attached to the missile until the missile's own rocket motors take over.

An off-hand evaluation of these various launching methods indicates that, first, speed is so much more important in a defensive missile than in the standard offensive types of missile, that the rocket effect of the main motors is not sufficient. Second, all but the powder ejection permanent installations would require such expensive and massive fixed installations of spring material with motorized winders, compressors, steam plants, and the like, that they do not indicate practicality; the powder ejection systems, however, provide a large amount of energy for quick release with a comparatively small volume of propellant, and offer more promise. The self-contained devices handicap the missile's performance by the added weight which would have to be carried throughout the rocket's flight; the temporarily attached devices, on the other hand, overcome this disadvantage and have the further advantage of the body of experience already existing in jet assisted airplane take-off and American experiments on V-1 launching.

Considerations of vertical launching as opposed to launching on course (controlled train and elevation) indicate that a fairly sizeable permanent installation would be required for the latter and not for vertical launching. The guidance problem ties in closely with this choice.

PROPULSION

The first part of the propulsion research program is the evaluation of the various means of propulsion, using rockets and ram-jets. This study will be broken down into considerations of liquid, solid and gaseous fuels. A review of all published data likely to be of assistance is being made. The object will be to determine the specific fuel consumptions to be expected at various speeds and altitudes, and to evaluate the total fuel loads to be carried for any given range and speed of flight.

A study of all published data relating to combustion processes is under way, and will be followed by a considerable amount of testing to determine which processes provide a maximum combustion speed and the greatest effectiveness at high speeds and at low pressures. Various fuels will be eliminated due to slowness of reaction time, and others will be further tested relative to their maintaining combustion at high speeds and low pressures.

A study of the theory and practice of supersonic diffusers has been made, in order to evaluate the performance of ram-jets versus rockets as a means of saving fuel while in the atmosphere.

A series of functions have been graphed to cover a range of flows, pressures, and temperatures likely to be encountered. These will reduce the subsequent labor of calculation considerably.

RESEARCH TECHNIQUES AND FLIGHT TESTING

Electronic research and instrumentation design, essential to the successful development and testing of a ground-to-air pilotless aircraft, will be in progress soon. Information about upper atmosphere characteristics will be studied for their effect on aerodynamic and propagation problems. Instrumentation required by the other groups in their laboratory and research work will be developed. Basic research techniques and evaluations within the various fields will be studied and developed.

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ATI- 671	[redacted]
REVISION	(None) [redacted]
ORIG. AGENCY NO.	UMR-[redacted]
PUBLISHING AGENCY NO.	(Same)

(OVER) U

TITLE: Project Wizard -- Progress Report No. 1, June 1, 1946

AUTHOR(S): (Not known)
ORIGINATING AGENCY: Univ. of Michigan, Ann Arbor, Mich.
PUBLISHED BY: (Same)

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
June '46	[redacted]	U.S.	English	16	table

ABSTRACT:

P 16/4.1

The document is the first progress report on an investigation of guidance, propulsion, launching, and supersonic aerodynamics leading to the design of a ground-to-air guided missile, capable of intercepting and destroying hostile aircraft operating at altitudes up to 500,000 feet, at speeds up to 4,000 mph, and at ranges sufficient to prevent damage to the defended area. The report deals with the kinds of problems being considered in the various phases of the work.

A Surface to air missiles, A Antiaircraft missiles

DISTRIBUTION: Copies of this report obtainable from Central Air Documents Office; Attn: MCIDXD

DIVISION: Guided Missiles ~~(1)~~ 2
SECTION: Design and Description ~~(12)~~

SUBJECT HEADINGS: Missiles, Guided - Design (62909)

ATI SHEET NO.: S-1-12-95

W33-038-ac-14222

Air Documents Division, Intelligence Department
Air Materiel Command

AIR TECHNICAL INDEX

Wright-Patterson Air Force Base
Dayton, Ohio

[redacted]

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U SCP-4, AUTH: DOD DIR 5200.10, 29 June 6

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12 May 2016

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Defense Technical Information Center
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Dear Mr. Stokes

This concerns the following Technical Reports:

The following records have been cleared for public release by HQ AFMC/PAX on 13 June 2007. The reviews were performed by the following Air Force organization: HQ AFMC/PAX. Therefore, the following records are now fully releasable to the public. See attachment 1.

Technical Report number: ADB816663
Technical Report Title: Project "Wizard" Progress Report No. 1
Technical Report Date: June 1, 1946
Previous classification/distribution code: Unclassified

Technical Report number: ADB816741
Technical Report Title: Project "Wizard" Progress Report No. 5
Technical Report Date: 1 December 1946 – 1 February 1947
Previous classification/distribution code: Unclassified

Subsequent to WPAFB FOIA Control Number 2016-02428-F, AFMC-2016-0019, the following record has been cleared for public release by HQ AFMC/PA on 4 April 2016. The review was performed by the following Air Force organization: HQ AFMC/HO. Therefore, the following record is now fully releasable to the public. See attachment 2.

Technical Report number: ADB817886
Technical Report Title: Project "Wizard" Progress Report No. 4
Technical Report Date: October 1 – December 1, 1946
Previous classification/distribution code: Unclassified

The following record is publicly available at the University of Michigan Library at the following link: https://deepblue.lib.umich.edu/bitstream/handle/2027.42/4989/bad5904.0001.001.txt?sequence=4&IsAllowed=y.

Technical Report number: ADB804022
Technical Report Title: External Memorandum Report No. 7, A Simplified Method of Calculating Ram-Jet Performance Applicable To High Mach Numbers
Technical Report Date: July 23, 1947
Previous classification/distribution code: Unclassified

Please let my point of contact know when the record is available to the public. Ms. Janet M. Caddell is the point of contact for this request and she can be reached at (937) 904-0884, e-mail Janet.Caddell@us.af.mil or the FOIA Office Main Line (937) 522-3095, e-mail wpafb.foia@us.af.mil.

Sincerely

DARRIN BOOHER, Civ, DAF
Freedom of Information Act Manager
Base Information Management Section
Knowledge Operations

Attachements:
1. AFMC/HO Memorandum, dated 11 June 2007
2. SAFPAOSP E-mail, dated 4 April 2016