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PROJECT AQUILINE

RESEARCH AND DEVELOPMENT STUDY

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TABLE OF CONTENTS

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RESEARCH AND DEVELOPMENT STUDY

I   Nature and Purpose of the Study.

This study has been prepared in response to a request by the Bureau of the Budget for the background, the history of the development and operational concepts of this important project area. The vehicle development and associated component subsystems have been organized into the total project concept under the AQUILINE cryptonym.

Project AQUILINE was initiated in response to intelligence requirements which would only be satisfied by unmanned reconnaissance systems. The need for a new level of capability encompassed not only photographic missions but also required the emplacement of collection payloads hundreds of miles into denied areas. The system concept incorporates the use of the most advanced microtechnology, e.g., microelectronics, microminiature sensors and power sources, sophisticated communications and control systems.

This study is organized into four major sections. The first presents a history of the program up through fiscal year 1967 including a description of the intelligence collection potential. The second section outlines the planned development program for fiscal year 1968 and fiscal year 1969. Section III presents a detailed description of the basic technology involved in the development cycle and a summary of the development concept. The final section presents several operational concepts and estimates program timing and costs.

II History.

A. Program Initiation.

For the past four years, DD/S&T/ORD has been considering advanced concepts by which "black box" sensors could be emplaced at strategic targets in China, Russia, North Vietnam, and other denied areas. These emplaced "black boxes" would collect a variety of ELINT, COMINT, SIGINT air sampling and other technical intelligence. The information would be stored for later read out via radio to overflight aircraft or relay satellites. A major difficulty in the emplacement concept has been the need for the "mother ship" to execute the penetration and drop at a high altitude in order to avoid detection and/or interception. Black box payloads designed for emplacement in this manner tended to be large and heavy -- a few hundred pounds not being unusual.

Discussions by ORD with other offices within the Agency (OSA, OSP, FMSAC, OSI, OEL, and other potential users within the clandestine services) gave substance to the developing AQUILINE concept. It was agreed that low altitude drops of small, lightweight, low power solid state sensors would have a high probability of surviving the emplacement. Indeed, the same qualities could decrease the probability of detection of the black box once emplaced.

Solid state and microminiaturization technologies had progressed by 1965 to the point where these black boxes could be developed. A low flying emplacement vehicle capable of long range surreptitious penetration was in its genesis in the Office of Research and Development.

B. Program Concept.

During this period ORD, internally and through conceptual studies conducted by the Naval Ordnance Test Station (NOTS), Douglas Aircraft Company, and others, was defining and developing the concept of a very small bird-like emplacement system (see Figures 1 and 2). Mission analyses and cost-effectiveness studies indicated that this approach had great promise in meeting the requirements of the advanced penetration system sought by the Agency. The studies produced a completely new concept in collection platforms. Conceptually, the platform could exist for long periods of time in target areas and would be practically undetectable. Even if detected, it would be expensive and difficult to defend against. Its low altitude and low speed characteristics added to a long loiter time capability would permit detailed examination of the target areas and permit a wide variety of intelligence missions. Further, its small size and innocuous nature would make it more politically palatable in tense situations than conventional aircraft. It would be unmanned, smaller, and cheaper, and, therefore, expendable on special missions. Because of these characteristics, it would be deployable against targets not accessible by any means at the present time. It would be long-range insurance against the loss of current vehicle assets, which will devaluate with time due to improved enemy defenses and the loss of foreign real estate. In an early stage of development, it could complement existing high altitude systems by providing more detailed examination of selected targets -- especially under cloud cover.

Concentrated study was performed on a wide range of aerodynamic lift devices including balloons, ballistic glider, powered glider and helicopter types for this application. The powered glider was selected because of the following considerations:

1. Vehicle. A small aerodynamically clean vehicle can be produced which will contain the miniature payloads and subsystems required for the missions contemplated.

2. Propulsion. A variety of propulsion systems such as two-cycle engines, four-cycle engines, fuel cell and radioisotope powered systems, are practicable for propelling the vehicle thousands of miles.

3. Observability. Tests of mock-up models demonstrate that such a vehicle and its subsystems

could have low enough observability (visual, acoustic, radar and IR) to immerse itself in the indigenous signal environment of the target area, loitering unobtrusively while performing its mission.

4. Guidance and Navigation. Several guidance and navigation systems such as CHECKROTE, radio direction finding, transit satellites and Loran or Omega could direct this vehicle to within a few miles of the distant target.

5. TV Eye. A subminiature TV Eye is practical, both in the visible and IR, to assist in guidance and navigation as well as perform surveillance duties.

6. Communications Link. Secure communications for data transmission and vehicle control are achievable at line-of-sight ranges and feasible over the longer ranges by using relays such as a small vehicle of the same type, satellites or CHECKROTE.

7. Payloads. Photographic, IR, ELINT, audio, air sampling, and droppable black box payloads being developed by various ORD divisions point up the diversified potential of the system.

8. Mobility and Flexibility. Because of its size, weight, and speed, the vehicle can be launched from a small boat or aircraft, or a simple portable launcher.

9. Range. The range of the IOC version will be [redacted]; however, four-cycle internal combustion engines or fuel cells will provide ranges to thousands of miles. Radioisotope engine versions would have unlimited range (30-day flight duration -- 36,000 mi.).

10. Operations Research. Computer programs for vehicle configuration, systems integration, systems vulnerability and mission analysis have all been studied and can be developed further to insure the effectiveness of operational systems. Eventually this could be done in the IPRD facility of ORD.

C. FY 1967 Development Program.

During the fiscal year 1967, development of an emplacement/collection system configured as a small powered glider (AQUILINE) began with a budget of [redacted] dollars. During the year, the development concept of the AQUILINE system was refined and improved with:

1. The initiation of an IOC* prototype development program.

2. The continuation of advanced system studies by Douglas Aircraft (System Contractor).

3. Institution of development programs in the subsystem areas of aerodynamics, propulsion, navigation,

*IOC - Initial Operational Capability. This term is used to designate the first generation vehicle and associated subsystem.

communications, antennas, survivability studies, intelligence collecting payloads, and ground control equipment.

A flight test range was established and instrumented to allow flight tests of the airframe, its subsystems, as well as developing payloads. The flight of the fully instrumented IOC system is scheduled for October 1967. This system will include remotely controlled autopilot, navigation and communications equipment (including a slow-scan TV camera and associated radio transmitter) and will be equipped to carry test payloads up to five pounds to a range of [redacted]

III Program Objectives.

A. <u>Overall Objective</u>.

The AQUILINE development program has been designed to provide an evolutionary series of aerial collection systems capabilities. The program will require advancements in the state-of-the-art in the areas of aerodynamics, propulsion, navigation, communication and payload instrumentation. <u>A major goal is for the program to provide the capability of defining the optimum collection system available from the development program at any time which may be used against specific intelligence targets to satisfy specific requirements.</u> (Figure 3 -- Development Plan.) A more detailed description of this aspect of the program is contained in Section IV below.

By late fiscal year 1968, the Initial Operational Vehicle will be capable of flying [redacted] missions at altitudes up to 10,000 feet, carrying a payload of five pounds. The system will have achieved prototype hardware capable of positioning and controlling the vehicle to within a CEP of 70 feet at distances to [redacted]. These capabilities are sufficient to perform intelligence collection missions against typical peripheral targets in China, Cuba, and the USSR. When interrogated, the AQUILINE computers will be capable of supplying the detail design information on a specific embodiment of the IOC prototype which would be optimized to these objectives. In addition, the computer will calculate the probability of success for the mission.

B. <u>FY 1968 Goals</u>.

During fiscal year 1968, an Advanced Operational Capability (AOC) will be researched. This program will consider four-cycle internal combustion engine designs, advanced subsystem elements, and payload instrumentation resulting from current microelectronics R&D efforts. The initial AOC* goal will be [redacted] round-trip missions against coastal areas in Cuba, the Barents Sea, China, and Vietnam. Reconnaissance and ferret-type missions could provide low altitude imagery, ELINT and SIGINT. Feasibility of these objectives were studied in a simulated operational test against Tallinn.

C. <u>FY 1969 Goals</u>.

The range of objectives for fiscal year 1969 will be expanded by the results of advance four-cycle engine development which will extend the range of these systems to [redacted] Emerging navigational technolgies, such as the [redacted] OMEGA** will provide the capability of using these vehicles in one-way missions against Lop Nor, Shuang-ch'eng-tzu and Sary Shagan. Typical objectives for fiscal year 1969 will be the development of a black box emplacement capability within a CEP of 1/2 n.m. These missions have intelligence capabilities against missile telemetry, nuclear staging and yield.

*AOC - Advanced Operational Capability.

**A navigation concept which utilizes the long range Navy OMEGA radio transmissions, retransmitted through a synchronous satellite to the ground station for commutation and position location.

D. Ultimate Goals.

During fiscal year 1970 and beyond, program objectives are to develop capabilities for collecting intelligence from any remote area through the development of radioisotope-powered vehicles having [redacted] ranges and unlimited loiter times. Land and sea launch capabilities against any target in the USSR and China are current goals. Improved sensors and intelligence processing payloads will be adaptive to mission variations as determined by specific requirements.

IV Program Plan.

A. <u>Approach</u>.

The program plan used for development of an AQUILINE system during fiscal year 1967 will be replaced by an overall system's program in fiscal year 1968. This is necessary for a variety of reasons. During fiscal year 1967, there were three program areas:

1. IOC prototype development
2. Interface (conceptual development)
3. Subsystem development

Three vehicles, each with increasing capability, were designed and constructed under the IOC prototype development program [redacted] If in fiscal year 1968 we were to follow this same schedule of building increasingly refined test vehicles, we would quickly exceed fiscal year 1968 funding of [redacted] In addition, our increased understanding of the various subsystem requirements, and a better estimate of the costs involved in achieving these requirements has placed ever increasing strain on our limited funds.

Further, mission analysis studies revealed that in order to achieve acceptable probabilities of success against any particular target, a specially designed vehicle system should be constructed and deployed. In an environment of continually changing intelligence requirements, it becomes extremely difficult and prohibitively expensive to predict the mission requirement and the operation schedule. To plan for an AQUILINE development which provides as milestones an increasing inventory of vehicle systems designed for general purpose missions seems to us to be an inappropriate and expensive approach to the Agency's particular problem. None of these vehicle systems, in all probability, would be the optimum vehicle required to perform an intelligence mission when the need arose. To adjust the AQUILINE development plan to the available funds and to the specific capability needs of the Agency, a new plan has been formulated and put into effect.

B. Development Plan.

As shown in Figure 3, the program emphasis is now being put on developing a capability in terms of the developing state-of-knowledge which can be assessed on command by management. This is done by establishing the two computer programs shown. The scheme works as follows: For fiscal year 1968 the control of the program is vested in the Advanced Conceptual Development team (Douglas Aircraft working under the direction of the COTR). The information library for the program is a computer endowed in its subroutines with all of the known or estimated (temporarily) characteristics of the IOC AQUILINE vehicle system. At the periphery of this information base are the various subsystem project engineers (Douglas) who are charged with generating requirements, subsystem development and updating and refining the information stored in that particular subsystem computer subroutine. The computer can at any time be instructed to read out the current capability of the IOC family of vehicles under development. This information, for instance, would include the range, payload capability and "signature," (i.e., IR, radar, visual and acoustic signal) emanating from the vehicle system.

A second computer program has been established in order to make maximum use of this information. The information for this computer is derived from reiterated survivability studies. The mission survivability computer program predicts the ability (probability) of the selected AQUILINE vehicle to penetrate undetected through the radar, visible, and acoustic defenses of a hostile country. In order to describe the radar defenses, the location and characteristics of each radar, including radar horizon and ground clutter, are read into the computer program. The visible and acoustic defenses are described by the population density distribution. A candidate mission profile and vehicle are then chosen for gathering intelligence from a selected target behind the defense system. The mission profile is described by the position-time-function of the flight path (altitude, velocity, position vs. time), the cloud cover, the background-sky contrast and the sun-aircraft relationship along the route. The candidate aircraft is described by its radar cross section (as a function of viewing angle), its physical size and the acoustic and infrared characteristics of the power plant. With these data, the computer program determines the probability of undetected penetration through the radar, visible and acoustic defenses. Should any of these probabilities prove unacceptable, a new mission profile and/or vehicle can be chosen which concentrates specifically on that aspect of penetration.

C. Flight Tests.

In order to assure that the information stored in the computer yields an accurate representation of the physical characteristics of the vehicle, two additional components of the development plan must be provided. These are the Prototype Systems Development (IOC) and Test Range Programs. Within the Prototype Systems Development Program, a number of test vehicles are designed and fabricated. (Five vehicles are planned for fiscal year 1968.) These vehicles are designed primarily to be test flown in a particular manner such as to augment or update the flight performance information stored in the computer. The vehicles are also used to carry developmental subsystems in experimental flight tests. The vehicles, then are designed to be representative of the IOC family of vehicles, modified slightly to accommodate other requirements of the program.

A test range for flight testing the developing AQUILINE system has been established at Randsburg Wash, a secure range on the Naval Ordnance Test Station at China Lake, California. The facilities and facilities support are being supplied by the Navy under a task order from the Agency. The prime contractor (Douglas) has established and maintains the instrumentation on the test range.

D. Summary of Development Concept.

In summary then, what the program attempts to provide is a developing capability in intelligence collection systems which can be assessed on command by management at any time and from which they can define the optimum AQUILINE collection system for a specific current intelligence requirement.

In essence, the program plan is to develop a series of AQUILINE subsystems (Figure 4) which will be fabricated, tested in flight, and evaluated. The characteristics of these subsystems will be permanently stored in the computer memory. Each subsystem R&D program has its own goal milestones which are calculated to be integrated with the total system capability development.

Each of the major subsystems may be expanded to indicate the long-range plans in that area. In Navigation (Figure 4, Item III-C), for example, R&D programs are being carried out or planned for all of the fundamental techniques listed. This broad approach is necessary because no one technique currently offers the potential to satisfy all of the probable requirements.

In conjunction with the subsystem capability development, mission environmental information for some of the most likely targets is being collected from other offices and stored for evaluation and collation with specific system configurations. Sociological studies in conjunction with wildlife information would aid in a determination of the probability of detection and recognition. The population distribution would be a measure of likelihood of detection while the birdlife studies would reveal the likelihood of the vehicle registering as a bird or a normally appearing object to the observer. It also is obvious that survivability is dependent on current meteorological data, geographic features and intrusion defense posture. The political situation would affect the determination for detection and reaction of recognition by local governments, thus affecting the calculated risk that may be taken.

Collation of all the subsystem data and environmentals would be an impossible task without the aid of modern computer techniques. However, the computer technique used in this program can compare all the R&D results achieved to date and provide answers to optimize the future AQUILINE development plan for any of three alternatives:

1. Most efficient use of available R&D funds.

2. Most effective pacing of subsystem developments for orderly buildup of system capability.

3. Most effective combination of platform and subsystem elements in a possible crash program to develop a particular mission-oriented system.

E. Management and Funding.

During fiscal years 1966 and 1967, the program was broken down into its major components in accordance with Figure 5. During fiscal year 1967, although the funding was increased to [redacted] dollars including AQUILINE-related efforts, the program from an Agency management point of view had not progressed to the point where it was considered a system endeavor. (A system plan will be initiated in fiscal year 1968 and is discussed later.) The funding for the program was provided in a piecemeal fashion, project by project as the program areas became defined. In order to manage the many separate contract packages as an integrated program development, an AQUILINE budget sheet was used for funding control. Figure 6 is a representative copy of this budget showing the total budget funds, the office's plan to commit these funds, and the status of commitment of funds under the general program. By this means, management was kept apprised of the progress of the overall program and the effort that the new dollars committed were to fund.

The funding for AQUILINE in fiscal year 1968 is based on a master AP/ORD program with a system contractor (See Figure 3). Several individual AP/ORD support contracts with other contractors and a moderate number of AQUILINE related projects (mainly payload R&D) monitored by other divisions are funded separately in support of the program. The basic funding program supports many tasks in subsystem development, environmental studies, mission analysis, and flight testing. Individual funding of these tasks in fiscal year 1967 created unnecessary complications in contract negotiations and management as well as increasing the problems of coordinating and synchronizing the technical developments of each subsystem. A new technique will be used for fiscal year 1968 program funding and control. This plan will provide the required program development flexibility and still assure adequate control by the COTR of the rate of expenditure of funds.

A master contract will be let with the McDonnell-Douglas Company. The request for fiscal year 1968 funds to Agency management will indicate the total contract price and costs of the four major subcontract elements. This breakdown of costs will be similar to that shown in Figure 4. There are a number of major subcontracts which will be let by McDonnell-Douglas in fiscal year 1968. In fiscal year 1967 the composite fee negotiated with McDonnell-Douglas was [redacted] based on a ratio of Prime to Subcontract effort of approximately [redacted]. A new composite fee will be negotiated with the prime contractor based on the new Prime/Subcontract ratio.

In addition, the master contract will establish a funding limitation on a quarterly basis. Within this funding limitation, McDonnell-Douglas will request funds on a task basis against which costs, technical milestones and delivery schedules will be submitted to the COTR. On approval by the COTR, the contract officer will authorize funds for the task. With this mechanism both the technical and financial progress of the program will be more closely monitored. At the same time, the COTR will have the required flexibility, found necessary during early stages of the program, to adjust the direction of the total effort in accordance with the developing technology.

The preceding plan was considered more appropriate to the AQUILINE development program than a PERT COST analysis. However, PERT TIME analysis is maintained on both the advanced system development and prototype system development elements of the program.

The prime contractor has formulated a detailed fiscal year 1968 system program plan (Figure 8) for a [redacted] dollar budget. AP/ORD proposes to use this system plan by funding the highest priority tasks to a current budget ceiling of [redacted] dollars. Therefore, additional funding, if it becomes available throughout the year, can be wisely used and coordinated with the overall AQUILINE program. A summary of the projected AQUILINE costs through fiscal year 1973 is shown in Figure 9.

V Operational Development

The development of an operational AQUILINE system requires development of the aircraft system and payloads as well as ground control equipment, operations support facilities and personnel.

Although plans for fiscal year 1968 include study and parametric definition of the ground control equipment and operations support requirements, the plan is once again to develop only those components which have commonality to all possible missions.

All aspects of the problem would be researched, however, and a prototype of the basic ground control equipment would be developed. Keeping in mind that the costs of acquiring an operational capability are not funded, and that what is indicated is ORD's ability to respond technologically to a requirement for an operational system, the projected operational capability for AQUILINE is shown in Figure 7.

The development of the AQUILINE concept has required a hard look at the future of technical intelligence collection. As a result, it has been catalytic in the generation of a variety of new development projects. Although many of these new areas, i.e., small IR scanners, microminiaturization of ELINT receivers, recorders, communication and navigation equipment, etc., have application in the AQUILINE program, they also meet more general needs of the Agency. In any funding analysis it would be improper, therefore, to assess the AQUILINE program on a direct basis for the development costs in these areas. Figure 9 apportions the total costs of the program in accordance with this point of view.