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SECRET

U.S. ARMY REQUIREMENT
FOR
A NEW FAMILY OF AIR VEHICLES

DEVELOPMENT PROGRAM REPORT No. 4

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SALES DEPARTMENT

AVRO AIRCRAFT LIMITED

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INTRODUCTION

In December 1955 Brig. Gen. Hutton, Commander U.S. Army Aviation Center, Fort Rucker, Ala., in an article in Aviation Week magazine, challenged the aircraft industry to develop and produce a new family of aerial fighting vehicles to meet the requirements imposed by modern concepts of warfare.

The U.S. Army conducted a design competition during which a number of proposals were evaluated and development contracts to design and build "aerial jeep" research vehicles were awarded to Chrysler Corporation, Aerophysics Development Corporation and Piasecki Aircraft Corporation. It has also been reported that Hiller and Fletch-Aire have carried on with similar company sponsored programs.

It has long been recognized that the design concept investigated under P.V. 704, Project 1794 and System 606A holds great promise for application to a variety of weapon systems over a wide performance range. To those familiar with the Avro VTOL design, it is apparent that this concept can provide the family of vehicles called for by General Hutton.

Representatives of the U.S. Army visited Avro on 26 and 27 September 1957 for a briefing on 606A/704. These representatives expressed great interest in the program and invited Avro personnel to visit U.S. Army Headquarters for further technical discussions. This visit was made on 30 October 1957 and an informal briefing on the results of a preliminary study by the Special Projects Group of a design to satisfy the Army need was given. At the request of the U.S. Army a briefing for General Gavin and his staff is scheduled to be given in the Pentagon on 29 November 1957.

This report is prepared to inform Management of the Army requirements for aerial fighting vehicles, of the efforts of competitors and of the progress made by Avro to satisfy this requirement.

REQUIREMENT

In general terms, the U.S. Army desires to perform the traditional cavalry missions of reconnaissance, counter-reconnaissance, pursuit, harrassment etc., by means suitable to modern warfare. More specifically they require a vehicle which will carry a payload of 1,000 lbs. consisting of a crew of two, weapons and cargo. This payload must be carried under certain specified conditions. A minimum range of 25 N. miles is required. The vehicle must be capable of hovering both in the ground cushion and in free air and to obtain a forward speed of at least 25 knots. An endurance in normal flight of not less than 30 minutes is required; in hover minimum endurance is specified as 10 minutes.

Offensive Capability

It is required that this vehicle have offensive capability, survivability and versatility. Mobility is essential to offensive capability, hence the vehicle must be independent of terrain, i.e. it must be unhampered by swamps, rivers, forests and mountains. The ability of the system to gather and process intelligence data is provided by a human crew. Communication is achieved by a 2-way radio and fire power is provided by installation of a recoilless rifle and/or rockets.

Survivability

To actually realize the offensive capability of the vehicle, it is necessary that it also possess the ability to survive within the battlefield environment. Survivability is provided by avoiding detection or, failing this, through escape. It is the Army intention to take advantage of natural concealment of terrain by flying very close to the ground. It is specified that the vehicle have a minimum silhouette and that it create a minimum of disturbance to its environment i.e. it must not produce smoke, create dust clouds etc. It must operate as quietly as possible and lend itself to camouflage or other means of disguise. Although a great deal of its service life will be spent at low speed and low altitude, it must be designed to employ speed, maneouverability and deception in the event escape becomes necessary.

Versatility

Furthermore, it is required that this vehicle possesses versatility. It is desired that it be possible to ship four of them in a C.130 aircraft. The vehicle must accommodate a varied payload, tolerate a wide shift in center of gravity and be capable of hovering in free air at 6,000 ft. on a 90°F day.

SIGNIFICANCE OF REQUIREMENTS TO VEHICLE DESIGN

The requirements laid down by the U.S. Army, as discussed in the preceeding section, have rather important significance as far as the design of the vehicle is concerned. Particular problems are presented in development of suitable propulsion and control systems.

Propulsion System

Because of the requirement for free air hover, the thrust produced must be greater than the total weight of the vehicle and the power unit must tolerate prolonged static operation. This latter fact eliminates certain types of power plants where cooling is a particular problem. The combined requirements of endurance, range and payload dictate that the propulsion system operate economically. It must also be reliable and have a self contained starting system to give satisfactory results under battle-field conditions. To avoid disturbance to the environment, the system must have a low exhaust velocity and it must not produce smoke or other detectable exhaust products.

Control System

The usual form of control for aircraft which is dependent upon aerodynamic pressure is not suitable for this vehicle due to the requirement for hover and low speed flight. This system must be effective under all operating conditions, i.e. must be independent of forward flight speed. Furthermore it must accommodate a wide range of C.G. travel.

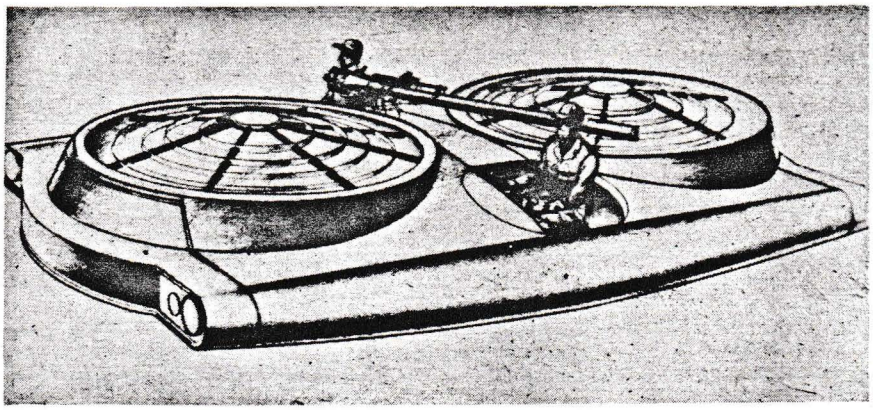
Other Factors

Although the propulsion system and the control system are of prime importance the specified requirements are also significant to other portions of the vehicle. The structural envelope must be the minimum required to accommodate payload and installed equipment and protrusions such as vertical stabilizers must be avoided to meet the silhouette requirements. The aerodynamic shape should provide a good lift/drag ratio for free air flight and at the same time provide the desired ground cushion characteristics. The production cost of these vehicles must be low, they must be easy to maintain under service conditions and actual maintenance required should be at a minimum. It is desired that operation of these vehicles be as simple and foolproof as possible so that extensive training of personnel will not be necessary.

THE COMPETITION

The U.S. Army has given development contracts totalling $1,700,000 to Chrysler, Aerophysics and Piasecki aircraft corporations. However, Army personnel have indicated that they are not satisfied with any of these designs. Discussed in the following pages are proposals submitted by Chrysler, Aerophysics, Piasecki, Goodyear and Hiller.

CHRYSLER'S PROPOSAL



FEATURES

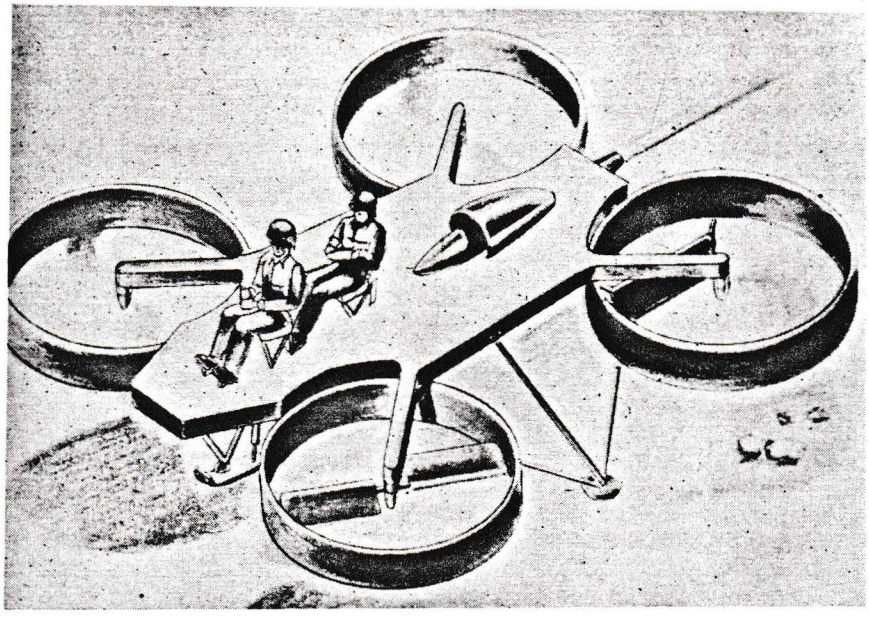
1. Ducts rotated to divert air stream
2. Small frontal area
3. Convenient to ship
4. Single engine (?)

OBVIOUS OBJECTIONS

1. Stability poor
2. 1 engine reliability (?)
3. Aerodynamically inefficient
4. Low load carrying ability

Ref: Aviation Week
August 19, 1957.

AEROPHYSICS' PROPOSAL



FEATURES

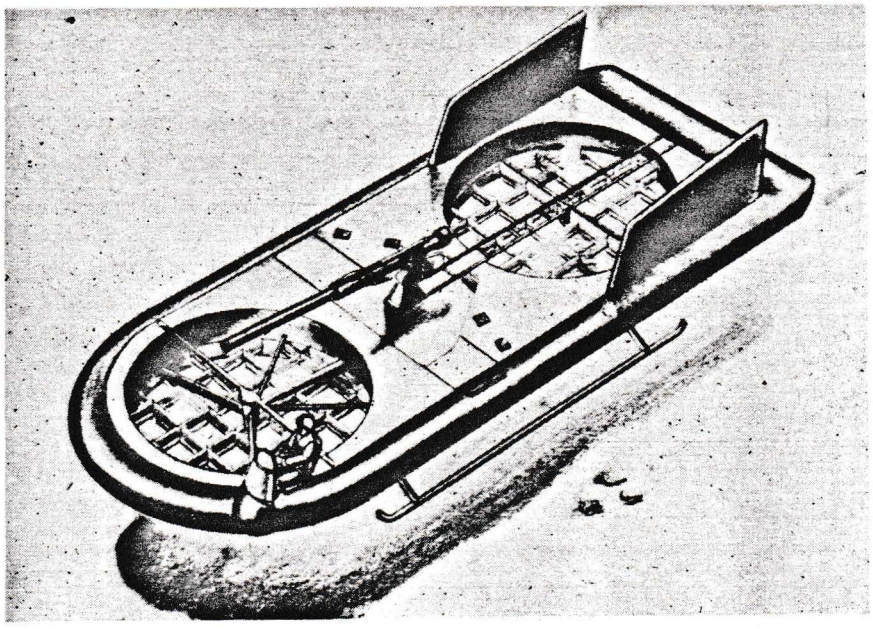
1. 4 ducted fans - for stability
2. Control by changing pitch of blades.
3. Power plant - small propjet and gear box.
4. Disassembled for shipment.

OBVIOUS OBJECTIONS

1. Negative angle of attack for forward flight.
2. Aerodynamically inefficient - poor control system.
3. Single-engine unreliability + power transmission problems.
4. No apparent armament
5. Little protection for crew

Ref: Aviation Week
August 19, 1957.

PIASECKI'S PROPOSAL



FEATURES

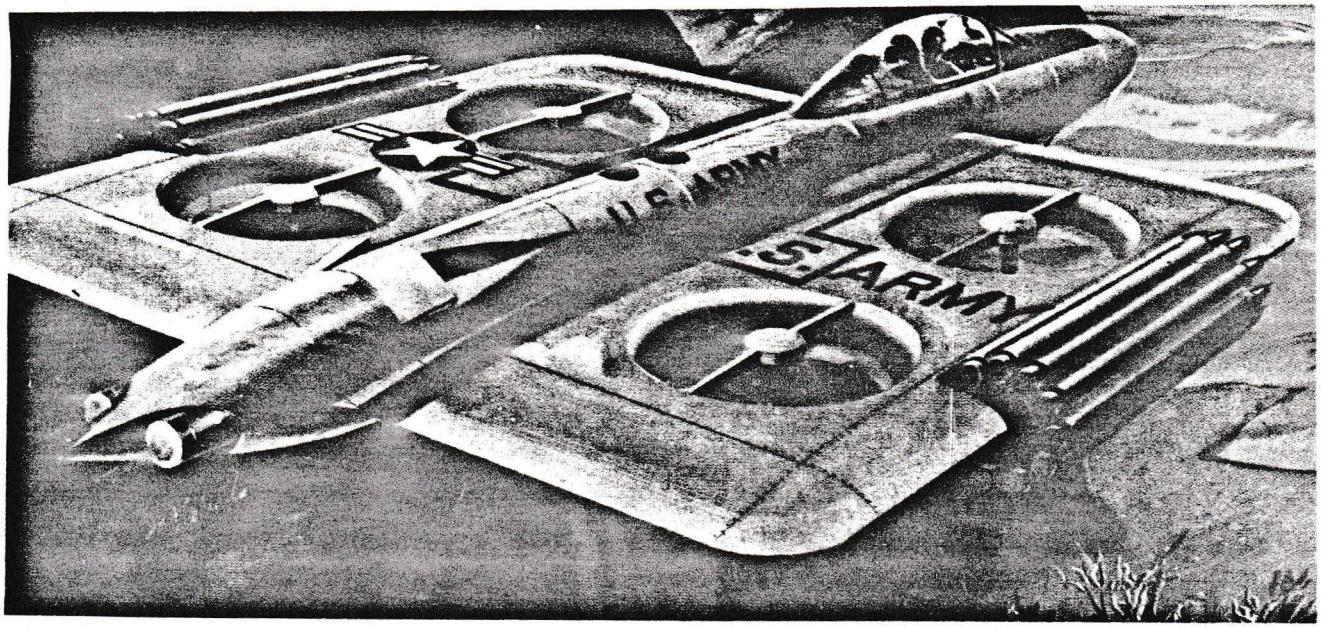
1. 2 ducted fans.
2. Deflector vanes to control pitch, yaw, etc.
3. Takes up little space - easy to ship.

OBVIOUS OBJECTIONS

1. Stability poor
2. Low load carrying ability
3. Slow speed
4. Gearing problems

Ref: Aviation Week
August 19, 1957.

HILLER'S PROPOSAL A



FEATURES

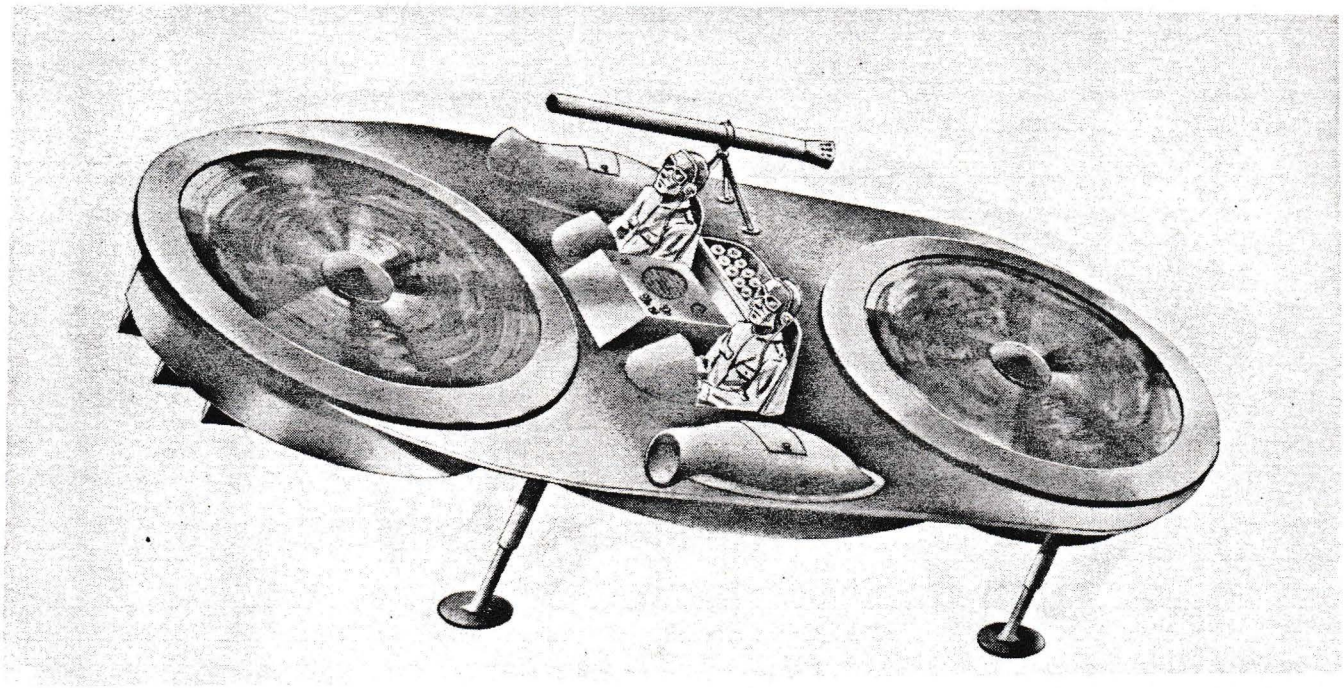
1. Effective armament - air firing capability
2. 4 ducted fan stability
3. Low frontal area
4. Fair speed indicated

OBVIOUS OBJECTIONS

1. Gearing problems - engines to ducted fans
2. Poor manoeuverability characteristics
3. High wing loading

Ref: Newsweek
July 15, 1957.

HILLER'S PROPOSAL B



FEATURES

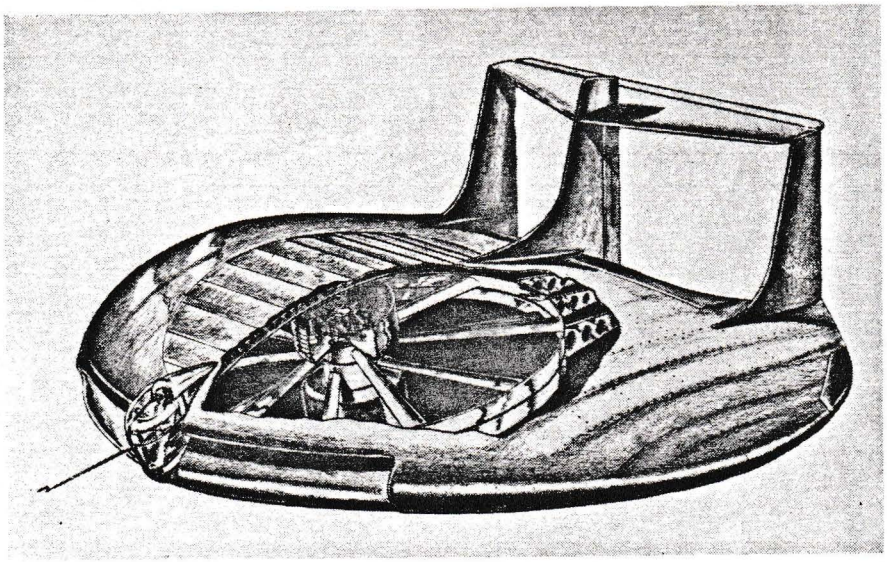
1. 2 ducted fans
2. 2 engine reliability - (interconnected)
3. Low wing loading

OBVIOUS OBJECTIONS

1. Low speed characteristics
2. Gearing problems
3. Short range - high fuel consumption

Ref: Amer. Aviation
February 11, 1957.

GOODYEAR'S PROPOSAL



FEATURES

1. Aerodynamically controllable in event of engine failure
2. Hovering attitude probably controlled by vanes
3. Good visibility.
4. Two engines (probably)

OBVIOUS DISADVANTAGES

1. Comparatively low forward speed
2. Changes in momentum accompanied by change of attitude - poor gun platform, etc.

Ref: American Aviation
September 8, 1957.

AVRO DESIGN

A brochure entitled "Avromobile, a New Family of Air Vehicles", dated November 1957, describes the design of the Avrocar, the Avrotruck and the Avrocoach. The Avrocar is designed to meet Army requirements specified herein, the Avrotruck is designed to meet the U.S. Army requirement for a vehicle having a 4 ton cargo capacity and the Avrocoach is designed to meet their requirements for a vehicle capable of transporting an infantry squad. The Avro design incorporates a number of features which give it a decided advantage over the designs proposed by competitors.

Propulsion

The turbo rotor propulsion system not only satisfies the performance requirements but also:-

1. Gives maximum efficiency without accepting the penalty involved when flow of the propulsive jet is external to the aircraft.

2. Uses developed and available turbo jets as the source of power.

3. Avoids transmission of prime power by means of shafts, gears, clutches etc.

4. Affords multi-engine reliability.

5. Eliminates gyroscope effects.

6. Provides forward thrust without change in vehicle attitude.

Airframe

The circular planform and peripheral exhaust flow give excellent ground cushion characteristics to provide the extremely low speed, low altitude capability desired. At the same time the body of the vehicle is a lift producing air foil that, in combination with the jet flap effect, provides efficient aerodynamic characteristics for free flight performance. The pneumatic control system has a simple and reliable means of providing adequate control under all flying conditions and by virtue of its negative static margin the vehicle is highly maneouverable.

Manufacture

Vehicles of this design are inherently economical to manufacture. Due to their symmetry, the number of different parts involved in their fabrication is greatly reduced in comparison to a conventional design. It is structurally simple and standard materials and processes are used in its fabrication. Another feature of this design is its utilization of components or assemblies in performing more than one function, i. e. the wing performs its normal aerodynamic functions, serves as a cargo compartment and as a diffuser for the propulsion system.

RELATION TO EXISTING PROGRAMS

Project 1794

What has become known as the Avro VTOL design concept has been under investigation since 1952. Active programs have been underway since early in 1955 when USAF support in the form of Project 1794 was initiated. This project extended through August 1956 at a contractual funding level of $758,000. It was designed to investigate the practicability of developing a flat VTOL supersonic aircraft. It included tests in the supersonic wind tunnel at the Massachusettes Institute of Technology, hover and low speed tests in the subsonic tunnel at the Wright Development Center and numerous rig tests and analysis at Avro. In general, the results of these tests were very favourable and in several instances they exceeded expectations.

P.V. 704

The Company sponsored program designated P.V. 704 was initiated in January 1956 to extend into 1958 at an estimated cost of about $5,000,000. The objective of this program is to design, fabricate and demonstrate in flight a test aircraft. Among the more important phases of this program are the development, test and operation of the propulsion system test rig and the control system test rigs.

System 606A

In March 1957 the USAF extended their support of the program under Research System 606A. This program extends the 1794 investigation to October 1958 at a contract cost of $1,600,000 and includes additional supersonic tests at M.I.T., transonic tests at WADC and furtherance of the subsonic program in the WADC 20 foot tunnel. It also provides for development of the combustion system required for supersonic flight and for studies to apply this design concept to operational weapon systems.

Applicability

These three programs are significant to the development of the Avromobile in that they represent an accumulation of experiences in a R & D program over the past 2 1/2 years. A great number of the wind tunnel tests which have been completed are directly applicable to the Army vehicle. Specifically, nearly 1,000 test hours (480 of them in the 20 foot tunnel) were completed at WADC under Project 1794. An additional 320 hours, including transition from hover to forward flight, are scheduled to be accomplished early in 1958 under system 606A. In addition there have been extensive ground cushion tests, involving

some 75 models, completed at the Malton facility. A similar, yet more complex, propulsion system has been designed, fabricated and is now in its initial test phases at Avro. The control system being developed and tested for the supersonic aircraft is directly applicable to the low speed vehicle.

CONCLUSIONS

A review of the designs proposed by our competitors and a comparison with that proposed by the Special Projects Group, leads to the conclusion that the Avro design is a most promising solution to the U.S. Army requirement for a new family of air vehicles having offensive capability, survivability and versatility.

As compared to the supersonic aircraft development in progress under P.V. 704/606A the Avromobile is a rather simple device. The development problems involved are strictly engineering in nature, no basic research is required.

The work accomplished under Project 1794, P.V. 704 and 606A provide an adequate background of experience, accumulation of technical data and component development to permit immediate initiation of an Avromobile hardware program.

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Date ..... Nov. 27/57 .....