18 December 1956

EXHIBIT "I"

STATEMENT OF WORK

PROJECT 1794

PART 1. Engineering Program

1.1 The Contractor shall conduct studies and test programs as outlined below to supplement those previously completed under this contract and to support the AVRO P.V. 704 program. The Contractor shall also construct the test rigs, manufacture or modify the models or other test items, provide instrumentation and furnish the facilities required to accomplish this program, except for certain Government furnished test facilities as approved by the Contracting Officer, Hq AMC, when deemed necessary for the advancement of the program and to be in the best interest of the USAF.

1.1.1 The Contractor shall conduct tests of wind tunnel models to more completely define the aircraft characteristics throughout Mach number range of 1 to 4.

1.1.2 The Contractor shall conduct tests of wind tunnel models to determine aircraft characteristics in the transonic speed range.

1.1.3 The Contractor shall conduct tests of subsonic wing tunnel models. The problems of trim and balance and control shall receive particular emphasis.

1.1.4 The Contractor shall conduct tests to investigate hover and transition to forward flight. Stability and control as well as performance characteristics shall be included.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
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LANGLEY FIELD, VA.

AMES AERONAUTICAL LABORATORY
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LEWIS FLIGHT PROPULSION LABORATORY
21000 BROOKPARK ROAD, CLEVELAND 11, OHIO

November 20, 1956

To: Headquarters
Air Research and Development Command
Directorate of Systems Management
Wright-Patterson Air Force Base
Ohio

Attention: RDZSBA

Subject: Visit to Langley Laboratory

Reference: ARDC, Comdr, Detach #1, RDZSBA ltr Nov. 5, 1956

1. In response to your letter of November 5, 1956, the Committee would be pleased to have the following persons visit the Langley Laboratory on December 5 or 6, to discuss technical aspects of test programs to be conducted under USAF Project 1794 in investigating the AVRO Vertical Take-Off Aircraft.

STEPHENS, Major William R., Detachment #1, Headquarters ARDC, Wright-Patterson Air Force Base, Ohio
FROST, John C. M., AVRO Aircraft Ltd. (Canadian Citizen)
DOUGLAS, John R., AVRO Aircraft Ltd. (Canadian Citizen)
EARL, T. D., AVRO Aircraft Ltd. (British Citizen)

2. As proposed in your letter, the detailed arrangements for this visit may be made directly with the Langley Laboratory.

J. W. Crowley,
Associate Director for Research

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1.1.5 The Contractor shall conduct studies and tests to investigate the air and exhaust gas flow internal to the aircraft to include:

1.1.5.1 Intake efficiency

1.1.5.2 Diffuser efficiency

1.1.5.3 Compressor efficiency

1.1.5.4 Nozzle efficiency

1.1.5.5 Exhaust systems

1.1.5.6 Control shutter operation

1.1.5.7 Temperature profile determination

1.1.5.8 Overall propulsion system efficiency

1.1.6 The Contractor shall conduct an analysis of the propulsion system to include design point, off design point and transient operation. Operation of the propulsion system as a ramjet (in the "hot" condition) will be included, together with consideration of the effect on performance of the ducted fan system during this phase. An analysis of the propulsion control system shall be included.

1.1.7 The Contractor shall accomplish the development and test of the propulsion system components required to achieve supersonic flight.

1.1.8 The Contractor shall conduct studies and tests to determine the effect of operating temperatures, including those due to aerodynamic heating, on the thermal stresses, strength structural rigidity and aeroelastic characteristics of the aircraft. The effect of temperature on the flight control system and components shall be included.

Exhibit "I" (Cont'd)

1.1.9 The Contractor shall conduct analyses and tests to investigate the flutter and vibration characteristics of the aircraft. The effects of forced vibration due to the propulsion and duct systems on structure, equipment and personnel shall be included.

1.1.10 The Contractor shall conduct analyses and tests to investigate the effect of noise and structure, equipment and personnel.

1.1.11 The Contractor shall conduct studies, analyses and tests to further establish the stability and control characteristics of the aircraft in all phases of flight. Particular emphasis shall be placed on:

1.1.11.1 Reducing aerodynamic instability

1.1.11.2 Providing acceptable flight safety characteristics

1.1.11.3 Establishing reliability of pneumatic and/or hydraulic control systems.

1.1.11.4 Determining flight limitations due to stability and control characteristics.

1.1.11.5 Investigating stalling characteristics and post stall motions.

1.1.11.6 Control Systems for hovering, transition and forward flight.

1.1.12 An investigation shall be made to establish crew member escape systems and procedures. Escape in the event of power plant failure at high Mach numbers shall be included.

1.1.13 A study shall be made to determine ground handling requirements of the aircraft, including take-off and landing surface requirements.

Exhibit "I" (Cont'd)

1.1.14 An investigation shall be made to determine the range of fuel stowage compartment temperatures and to provide suitable stowage conditions.

1.1.15 The Contractor shall conduct investigations of the cooling and pressurization requirements of crew, equipment and structure.

1.1.16 The Contractor shall conduct studies of ground support and training equipment requirements in accordance with MIL-S-9412.

1.1.17 The Contractor shall conduct design studies to apply the AVRO Aircraft Vertical Take-off design concept to the following:

1.1.17.1 Reconnaissance Weapon System

1.1.17.2 Interceptor Weapon System

1.1.17.3 Tactical Bomber Weapon System

1.1.17.4 Research Aircraft

1.1.18 The Contractor shall formulate a Weapon System Development Plan for the system under Part 1.1.17.1.

1.1.19 The Contractor shall accomplish analytical studies of the effect of displacement of exhaust jets on the aerodynamic characteristics of the aircraft, will formulate test programs to investigate this phenomenon and will conduct such tests as are approved by USAF.

1.1.20 The Contractor shall conduct general studies to determine performance trade data and to determine limits on performance and physical parameters associated with the type of aircraft being investigated.

PART 2 Data

2.1 Program Planning Report

The Contractor shall prepare and submit to the Commander, Detachment No. 1, Hq Air Research and Development Command, ATTN: RDZSBA, Wright-Patterson

xhibit "I" (Cont'd)

AFB, Ohio, for approval, a Program Planning Report for the work required in Part I. The Program Planning Report shall include a description of methodology, work definition, time scheduling, and cost and manhour data by sub-parts. Ten (10) copies of the Program Planning Report shall be furnished as soon as possible, but no later than 15 March 1957.

2.2 Specifications

2.2.1 The Contractor shall submit to Hq Air Research and Development Command, ATTN: RDZSBA, for approval, detailed specifications of the tests to be accomplished under Part I. Test Specifications will provide information on test objectives, facility requirements, model characteristics, test conditions, instrumentation requirements, data collection and reduction, etc. Test specifications will be furnished in accordance with the time schedule of the approved Program Planning Report.

2.2.2 The Contractor shall submit to Hq Air Research and Development Command, ATTN: RDZSBA, for approval a General Design Specification for the propulsion system components to be developed under Part 1.1.7. MIL-E-8220 (ASG) will be used as a guide in preparing and presenting Performance Specification Data. Specific information required is:

a. Design information necessary to define the components, assemblies and systems to be developed, including drawings, weight estimates and material requirements.

b. Variations of inlet conditions (temperature, pressure, and Mach number profiles) appearing at the burner face during the more significant phases of engine operation.

Exhibit "I" (Cont'd)

c. Specific combustor performance including combustion efficiency and stability limits.

d. Engine thrust and specific fuel consumption.

e. Significant parameters to be used by the fuel control system.

This design specification will be furnished in accordance with the time schedule of the approved Program Planning Report

2.2.3 The Contractor shall submit a General Design Specification and Development Plan for the Research aircraft to be studied under Part 1.1.17.4. USAF Specification Bulletin No. 99 will apply and the development plan will include the data required by Part 2.4.2.11. Submission of performance data shall be in accordance with MIL-C-5011A. Design information as defined in MIL-D-7579 and MIL-D-17984 will be presented to include the data required by Part 2.4.2.7.1 thru 2.4.2.7.16. This report will be furnished in accordance with the time schedule of the approved Program Planning Report.

2.3 Bi-Monthly Progress Report

The Contractor shall furnish by the 20th day of the month following the reported two (2) month period, ten (10) copies of Bi-Monthly Progress Reports presenting a summary of: Work performed, percentage of task accomplished, results obtained, problems encountered and the budgetary status of the program. Bi-Monthly Progress Reports will be delivered to Hq Air Research and Development Command, ATTN: RDZSBA. The first Bi-Monthly Progress Report will be due 20 May 1957.

2.4 Technical Report

2.4.1 The Contractor shall furnish to Hq Air Research and Development Command, ATTN: RDZSBA, twenty-five (25) copies of Terminal Reports in

Exhibit "I" (Cont'd)

accordance with the time schedule of the approved Program Planning Report, but in any event not later than 1 October 1958.

2.4.2 The Technical Reports shall presents the results of the study and test programs required by Part I and shall include, but not be limited to:

2.4.2.1 A clear statement of the purpose of the study.

2.4.2.2 A description of the method of approach to solution of the problem.

2.4.2.3 A statement of assumptions made with an evaluation of validity.

2.4.2.5 An evaluation and interpretation of these results.

2.4.2.6 Performance trade data shall include the factors of speed, range, altitude, aircraft weight, aircraft size and payload, together with a discussion of limits on these factors.

2.4.2.7 Design Information and Performance Data. Submission of performance data shall be in accordance with MIL-C-5011A and design information as defined in MIL-D-8034 and MIL-D-17984 will be presented for each of the design studies required by Part 1.1.17.1 thru 1.1.17.3. If not specifically required by these specifications the following data will also be included:

2.4.2.7.1 Plot of area distribution cut at M=1

2.4.2.7.2 Tabulation of wetted area

Exhibit "I" (Cont'd)

2.4.2.7.3 Zero lift drag buildup, components and total.

2.4.2.7.4 Plot of dC_D/dC_L2 vs M

2.4.2.7.5 Plot of a.c. travel vs M

2.4.2.7.6 Plot of c.g. travel and analysis of effects.

2.4.2.7.7 Variation of $dC_L/d\alpha$ vs M

2.4.2.7.8 Low speed airplane efficiency factor "e".

2.4.2.7.9 Substantiation of drag factors and thrust.

2.4.2.7.10 Take-off, landing and transition calculations.

2.4.2.7.11 Plot of C_L vs M

2.4.2.7.12 Mission profiles showing altitudes vs distance

2.4.2.7.13 Group weight statement and weight substantiation report.

2.4.2.7.14 V-n diagram with gust considerations.

2.4.2.7.15 Three-view drawings and inboard profiles with section views. Positions of major equipment items as well as antenna, radome and armament locations should be indicated.

2.4.2.7.16 Basic engine development data to include, but not be limited to:

Exhibit "I" (Cont'd)

a. Compressor map

b. Experimental verification of the performance of the compressor.

c. Turbine map

d. A summary of the calculations for matching the components of the propulsion system.

e. Detail weight estimates for the components.

f. A preliminary design of the control system.

g. A discussion of the effects of non-uniform flow throughout the system including the effects of variable airflow through individual ramjet combustors due to control action.

h. A presentation of the performance at the design point, off design, and transient operation, in addition, a discussion of stall margins and control action is to be included.

2.4.2.8 Data resulting from the studies required by Part 1.1.16 shall be submitted in compliance with MIL-I-8557.

2.4.2.9 Preliminary specifications for subsystems or components to be produced by the prime contractor, by

Exhibit "I" (Cont'd)

associate contractors or furnished by the Government under provisions of AF Regulation 70-9, when existing equipment is considered inadequate. Existing equipment for subsystems such as fire control, bombing/navigation, etc., considered satisfactory by the contractor should be proposed. Subsystems are defined to include, in addition to those installed in the aircraft, ground support and training equipment deemed necessary to successful employment of the weapon system.

2.4.2.10 General specifications for new or improved materials including requirement dates and estimates of their availability.

2.4.2.11 The Weapon System Development Plan required by Part 1.1.18 shall include the following portions as specified in ARDC Manual 80-4, dated 1 September 1956.

2.4.2.11.1 General Design Specification

2.4.2.11.2 Weapon System Schedule

2.4.2.11.3 System Summary Schedule

2.4.2.11.4 Test Annex

2.4.2.11.5 Test and Test Support Aircraft Annex

2.4.2.11.6 Materiel Annex

2.4.2.11.7 Facilities Annex

2.4.2.11.8 Contract Funds

Exhibit "I" (Cont'd)

2.4.2.11.9 Test Item Annex

2.4.2.11.10 Cost Estimate Recapitulation

2.4.2.11.11 Factual data, in terms of facilities, equipment and personnel, as to the ability of AVRO Aircraft Limited to execute the Weapon System Development. The influence of other programs at AVRO Aircraft, current or contemplated, will be considered.

2.4.3 Technical Reports to be submitted are as follows. Results of work required by Part I and data required by Part 2 will be contained primarily in the reports indicated, although, when appropriate, the same data may be used in more than one report.

2.4.3.1 Summary Report - To contains (1) An introduction which includes historical background and statement of purpose or objectives, (2) Discussion of the design concept, (3) presentation of important results, (4) Evaluation and interpretation of these results, (5) Conclusions and (6) recommendations.

2.4.3.2 Design and Performance Report - To cover work required by Parts 1.1.12, 1.1.13, 1.1.14, 1.1.15, 1.1.16, 1.1.17, and 1.1.20; data required by 2.4.2.1 through 2.4.2.10.

Exhibit "I" (Cont'd)

2.4.3.3 Aerodynamics Report - To include work required by Parts 1.1.1, 1.1.2, 1.1.3, 1.1.4, and 1.1.19; data required by 2.4.2.1 through 2.4.2.5.

2.4.3.4 Propulsion Report - To cover work required by Parts 1.1.5, 1.1.6, and 1.1.7; data required by 2.4.2.1 through 2.4.2.5, and 2.4.2.7.16.

2.4.3.5 Stability and Control Report - To include applicable work required by Parts 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.8, and 1.1.11; data required by 2.4.2.1 through 2.4.2.5.

2.4.3.6 Structures Report - To cover work required by Parts 1.1.8, 1.1.9, 1.1.10; data required by 2.4.2.1 through 2.4.2.5.

2.4.3.7 Development Plan - To include work required by Part 1.1.18 and data required by Part 2.4.2.11.

2.5 The Contractor shall furnish to Hq Air Research and Development Command, ATTN: RDZSBA, one (1) 1/40 scale demonstration model of the AVRO VTOL research aircraft of Part 1.1.7.4 which may be disassembled to disclose the interior arrangement of the vehicle and which will illustrate the principles of operation.

PART 3 Project Review

The Contractor shall present a review of the status of the program to representatives of the USAF and other interested organizations approved by the USAF at six (6) month intervals during the course of this contract with locations and dates to be mutually established by the Contracting Officer and the contractor.

Exhibit "I" (Cont'd)

The purpose of the project review will be to show results accomplished, describe current status, discuss major problems encountered, and to determine direction of future effort.