NCSP TL-114-55/01

SECRET

HEADQUARTERS
AIR RESEARCH AND DEVELOPMENT COMMAND
Post Office Box 1395
Baltimore 3, Maryland

CANCELLATION OF TECHNICAL REQUIREMENT

Cancellation of
TR No. 3
17 January 1955

1. The following Technical Requirement is cancelled effective this date:

TR No.	Title	Date
3	(SECRET TITLE) Development of Ladybird(S) Vehicle	13 Aug 1954

2. Security classification of the above document remains unchanged. (U)

3. TR No. 3 is superseded by Amendment No. 1 to TR No. 54 (U).

4. Title in paragraph 1 is classified SECRET, paragraphs 2, 3 and 4 are unclassified. Reference Paragraph 23c AFR 205-1.

BY ORDER OF THE COMMANDER:

UNITED STATES AIR FORCE
HEADQUARTERS AIR RESEARCH AND DEVELOPMENT COMMAND
OFFICIAL | AUTHENTICATION 2/6

John R. V. Dickson, Col

DON R. OSTRANDER
Brigadier General, USAF
Director of Development
Deputy Commander/Technical Operations

W. J. THOMAS
Colonel, USAF
Chief, Technical Programming Office

DISTRIBUTION:

APGC	3
HQ ARDC	25
AEDC	2
AFAC	2
AFCRC	1
AFFTC	2
AFMTC	1
AFTRC	1
AFSWC	5
[redacted]	[redacted]
WADC	20

This document is classified SECRET in accordance with par 23c, AFR 205-1.

[redacted] 53-40001

55WC5-
04

IV. GUIDANCE

The contractor, A.V. Roe, Ltd., should be guided into the study of the major problem areas. These include, but are not limited to, the air bearing, engine development, and aerodynamic stability. All new technical possibilities should be exploited. (Uncl)

V. OTHER INFORMATION

(a) The Defence Research Board of the government of Canada will be informed through channels of the actions taken with respect to the Canadian Contractor. (Uncl)

(b) Any contract with A.V. Roe will require that sufficient copies of all reports will be forwarded to the Defence Research Board for their use and for the use of the Royal Canadian Air Force. (Uncl)

(c) This project will be established as Development Plan 1794, BPSN 1-1794 which is funded in the amount 2,494M in FY '55. (Uncl)

(d) Development Plan is required by 15 September 1954. (Uncl)

BY ORDER OF THE COMMANDER:

Paul F. Nay

PAUL F. NAY
Colonel, USAF
Actg Chief, Aeronautics & Propulsion Div.
Deputy Commander/Technical Operations

UNITED STATES AIR FORCE
HEADQUARTERS AIR RESEARCH & DEVELOPMENT COMMAND
OFFICIAL | AUTHENTICATION 313

W. J. THOMAS
Colonel, USAF
Chief, Technical Programming Office
Deputy Commander/Technical Operations

This document is classified SECRET in accordance with paragraph 23c of AFR 205-1.

SECURITY CLASSIFICATION S. CNET

ARDC RESEARCH AND DEVELOPMENT PROJECT PLAN

REPORTS CONTROL SYMBOL: ARDC D4

DATE: 15 September 1954

1. TITLE (Secret Title) AVRO Vertical Take-off Aircraft Code Name Ladybird (Secret)	2. ☒ INITIAL 3. CHANGE	4. PROJECT NUMBER: 1794	
5. TASKS	6. PROJECT SUPPORTS SYSTEM (s): None	7. FORMER PROJECT NUMBER: N/A	
8. RESPONSIBLE CENTER: WADC	9. SUPPORTING CENTER: AAFTC, AEDC	10. BUDGET SEQUENCE NUMBER: 1-1794	
11. FUNCTIONAL AREA: Technical Development	12. DIRECTIVE: Technical Requirement #3, 13 Aug 54	13. PRIORITY: 1A	14. SECURITY: Secret
15. ESTIMATED COMPLETION DATE: 1960			
16. OP RDY DATE: N/A	17. DATE INITIATED: 15 September 1954	18. USAF PRECEDENCE: I-3	19. ARDC PRECEDENCE
20. ARDC HQ: RDTDP			
21. PROJECT OFFICER: William E. Lamar, WCSB, Ext. 31324	22. CONTRACTOR: A. V. Roe Canada Ltd., Malton, Ontario	23. USE: N/A	24. CATEGORY: A-1

25. COORDINATION

COORDINATING AGENCY	NAME	ORGANIZATION
WADC	Col McKee	WCLS, Aircraft Lab.
WADC	Col Appold	WCLP, Power Plant Lab.
AEDC		
AAFTC		
NACA		

APPROVAL

26. CENTER NAME	SYMBOL	28. HQ ARDC NAME	SYMBOL
Homer A. Boushey, Col, USAF	WCS	Jewell C. Maxwell, Col USAF	WCSB
Norman C. Appold, Col, USAF	WCLPO		
Daniel D. McKee, Col, USAF	WCLS		
James H. Rothrock			

27. CENTER APPROVAL AUTHORITY: JAMES H. ROTHROCK, Colonel, USAF, DCS/Operations

29. HQ ARDC APPROVAL AUTHORITY:

30. BRIEF OF PLAN (Use Additional Sheets If Necessary)

a. No similar existing standardized equipments or techniques are known.

UNCLASSIFIED

54WCS-8492-/4

ARDC FORM 100
1 DEC 52

[redacted] SECURITY CLASSIFICATION

SECRET

b. Survey of Similar Equipment or Techniques in Process of R&D

(1) USAF

X-13 Ryan Vertical Take-off Aircraft. Tail Sitter type (lands by hooking on cable). Delta wing planform powered by Rolls Royce RA28-49 engine with 10,000# SLS thrust. Gross wt 7,019#, empty wt 5,172#. Span 21', Length 23', pitch and yaw control by swiveling tail pipe and roll control by jet nozzles on wing tip. Mockup 1 June 1954, scheduled for 1st flight middle 1955.

(2) BuAer

XFY-1 Convair vertical take-off aircraft, Tail Sitter type. Powered by YT40 type turbo propeller engine.

Has completed initial tethered and free flight tests.

XFV-1 Lockheed vertical take-off aircraft, Tail Sitter type. Powered by YT40-14 vertical turbo-prop engine. Gross wt. 14,000#.

(3) Contractor Sponsored

Bell Research VTO aircraft. Flat Riser powered by Fairchild engines (J44). Gross wt approximately 2,000#. Original test aircraft burned after engine failure. Second model being tested in tethered flight.

(4) NACA Jet and Rotor Supported Platform Craft - Stand on Type VTO "Flying Carpet" Research project.

Analytical and model test investigations of stability and control problems of VTO aircraft by Free Flight Tunnel Section LAL NACA.

NACA Reports RM L50J16
RM L51H13a
RM L54B16
RM L54C18

(5) British

Rolls Royce - "Flying Bedstead" project. A flat riser vertical take-off research device powered by 2 nene engines mounted horizontal end to end, facing in opposite directions. Tail pipes fitt with extension nozzles with 90° band to exert thrust in down ward direction. Seat and controls provided for pilot on top and near center of the machine. Controlled by jet nozzles exhausting air bleed from the engine compressors. Has been test flown in tethered and free flight (August 1954). (SECRET

Design studies of large aircraft (bombardment type) for vertical take-off. Delta planform in 100,000# class powered by numerous Rolls Royce RB-108 engines for vertical take-off and other engines for forward flight. (SECRET)

UNCLASSIFIED

[redacted]

SECRET

Short Brothers - Vertical Take-off Research aircraft using Rolls Royce engines (report received from a U.S. Contractor that British MOS has awarded Contract to Short Bros for such an aircraft). (CONF)

The above survey represents a preliminary investigation of other activity in the vertic take-off field and is intended to provide brief information regarding the scope of activity and "leads" for future more detailed consideration. Helicopter and small convertiplane activity has not been included. (CONF)

c. There are other projects under development which may satisfy the USAF requirement of reducing the length of or eliminating runways. This project, however, shows potenti advantages in vertical take-off and operational performance not yet shown by any other projects. (SECRET)

d. N/A

e. Historical Data

(1) The original concept of the contractor was to increase the aircraft thrust-frontal area ratio far in excess of that obtainable with conventional jet turbine engines by rearrangement of the powerplant for radial flow. Such increases in aircraft thrust-frontal area ratio were desired in order to improve supersonic flight performance. Development of this idea as Projects Y and Y2 by AVRO Canada, under RCAF cognizance, was extended to include application to vertical take-off aircraft when it was determined that thrust/weight ratios were sufficiently high and that use of the radial flow engines with jet exhaust at the periphery produced a ground cushion effect. Preliminary ingenious small scale model testing by AVRO Canada has demonstrated this phenomenon. (SECRET)

(2) During January 1954, AVRO Canada and the Canadian Defense Research Board invited the USAF to visit AVRO and discuss Project Y, a tail sitter VTO aircraft and preliminary aspects of a new flat riser, later designated the Y2. As a result of this visit, subsequent briefings by AVRO Canada personnel to the USAF Air Council and ARDC, and receipt of an aircraft proposal by AVRO Canada, Technical Requirement #3, was issued to exploit the potential of this project. (SECRET)

f. Methodology

(1) A preliminary study was accomplished by AVRO Canada to determine feasibility and adaptability of a radical new engine and aircraft design to provide high supersonic speed performance and to solve the vertical take-off problem. These analytical and design studies were supported by a model test program, which included:

(a) Static air bearing tests

(b) Dynamic air bearing tests

(c) Thrust recovery and flow demonstrations

(d) Coanda effect tests

(e) Ground cushion demonstrations (SECRET)

UNCLASSIFIED

SECRET

(2) Initial consideration of Project Y in January 1954 by the USAF and NACA, and later review and evaluation of AVRO's proposal for Project Y2 during June and July 54 by the USAF resulted in a conclusion that although this project offered considerable potential merit, further extensive exploration was necessary in order to determine the practicability of this type of aircraft engine combination and its application to military use. Prime problem areas determinable at this time were isolated and a Phase I program to further resolve these problems and explore the potential of this project was recommended prior to actual fabrication and testing of a flight article. (SECRET)

(3) After the problem areas have been sufficiently resolved, or earlier if it is desired to take a greater development risk in order to provide possible time savings, a decision will be required to determine the specific type of aircraft to be developed. (UNCLASSIFIED)

(4) The selected type will then be designed in detail, fabricated, and tested. (UNCLASSIFIED)

g. Performance Characteristics

(1) Capabilities of the Y2 test vehicle as estimated by AVRO Canada in Brochure Number One, June 54, are as follows: (SECRET)

(a) Performance

Item		Without Reheat	With 1500-2240°F Reheat
Maximum level speed	knots Mach No.	1,490 2.6	2,000 3.48
Ceiling (max. power at mean wt.)	ft.	71,600	80,600
Time to height from hovering start for			
36,090 ft.	min.	1.76	N.A.
60,000 ft.	min.	2.66	N.A.
70,000 ft.	min.	4.2	N.A.
Still air range with allowances for take-off, climb, cruise, descent and landing	miles	620	N.A.
Take-off and landing distances	-	Nil	Nil
Maximum hovering altitude from take-off	ft.	10,000	N.A.
Maximum hovering altitude at mean wt. 26,000 lb.	ft.	18,000	N.A.
SLS Basic Thrust	lbs.	43,500	

UNCLASSIFIED

[redacted]

SECRET

b. Size

Empty Weight	21,050#
Gross Weight	29,000#
Wing Area	670 ft^2
Span (= Diameter)	29.2 ft (SECRET)

(2) Performance capabilities have not been determined for vehicles of this type having military capabilities. (SECRET)

h. Increased Capability

This project, if successful and extended to provide military capabilities, would provide the USAF with a high performance vertical take-off weapon suitable for operation from dispersed bases with minimum base installations. This would assist in overcoming the growing and possible catastrophic vulnerability of conventional air bases and aircraft concentrations. (SECRET)

i. Statement of Effects

Use of the proposed radial flow engine will introduce new supply and maintenance problems. Operation of any V.T.O. aircraft from widely dispersed bases will require major revisions in USAF organizational, maintenance, and logistic operations. Operations of this aircraft will introduce a new training problem.

The full effect and degree of change introduced by this new concept cannot be assessed at this time. (SECRET)

j. Project Acceleration

Completion date of this project can be accelerated by taking the risk of simultaneous development and fabrication and increasing scope of the program. This action would require additional funds and possibly additional facilities. The current approach provides for orderly progression of the development at a rate consistent with the need of resolving or clarifying major problems in order to better assure the fabrication of an effective flying article. (UNCLASSIFIED)

k. Other

Problem areas of this aircraft have been outlined in Box 30 r(2) 'Approach'. Solutions to each of these problems require formulation of a detailed development program. It is anticipated that at a later date, certain of these problems will be included as tasks to this project. (UNCLASSIFIED)

l. N/A

m. N/A

n. Requesting Agency

HQ USAF (UNCLASSIFIED)

SECRET

o. Participation and/or Coordination

NACA (P) No funds (UNCLASSIFIED)

Canadian Defense Research Board (C)
(Includes Royal Canadian Air Force) (UNCLASSIFIED)

US Navy BuAer (I)
US Marines (I)
US Army Ground Forces (I) (UNCLASSIFIED)

p. Estimated Completion Dates

Res	Jan 1957
Dev	Oct 1958
Tests	July 1960
Op Evnl.	(SECRET)

q. Requirement of Justification

See Paragraph 30h

r. Brief of Project and Objective

(1) Brief

Objective of this program is the development at the earliest possible date of a flat vertical take off supersonic aircraft which exploits the design of AVRO Canada. (SECRET)

(2) Approach

(a) Preliminary aerodynamic and power plant testing will be accomplished to insure to a reasonable degree that the configuration first fabricated will fullfil the objectives of this program - Prime emphasis will be given to the attainment of the vertical take off capability proposed by AVRO Canada. Initial power plant development effort will be directed towards the AVRO Canada radial flow engine, however, alternate means of propulsion will be investigated as a backup. (SECRET)

(b) The intense effort to be directed towards the resolution or clarification of many of the critical problem areas of this type aircraft during the first year will represent the first step of the program required for development of this aircraft. Since approximately one year will be required to yield sufficient test results to determine any appreciable change in the probability of success, or significant clarification of the development problems, it is not considered desirable to initiate actual detailed design or fabrication of the flight aircraft and engine prior to this time. Initiation of such work after the first year will still involve acceptance of a calculated risk, since many basic problems, including the radial flow engine,

SECRET

will remain unsolved and controversial for an additional year, and other problems will remain unsettled until the full scale aircraft and engine is developed and tested. (SECRET)

(c) By January 1956, test results should permit resolution of the ground cushioning effect and further clarification of the engine and control problems, although it is doubtful, that tests of the large scale air bearings and radial flow engine will be complete. A decision will be required at this time to determine whether the results available and the urgent need of this aircraft warrants the risk of full scale development before the engine problem is resolved. If so, it will be necessary to decide whether to proceed with radial flow engine aircraft or adopt an alternate configuration. A decision made at this time will have to be made on the basis of the small scale (and controversial) radial flow engine tests which will have been nearly completed. (SECRET)

(d) Results of the aerodynamic and performance tests, and completion of the military application studies should during 1956 permit a decision as to whether the initial aircraft should be purely a research or test aircraft or should provide a military capability. (SECRET)

(e) Prime problems requiring resolution are:

1. Attainment of the ground cushion effect which permits vertical take-off at much lower thrust/weight ratios than otherwise possible (SECRET)
2. Determination of the feasibility of the radial flow engine which provides the high aircraft thrust/frontal area ratio and gyro stabilization of the AVRO proposal. (SECRET)

(f) An outline of the program planned and a breakdown of the major problems to be investigated during the first phase of this program follows. This program will provide the basis for the formulation of the detailed work statement with the contractor. (UNCLASSIFIED)

1. Vertical Take-off

a. Analytical Studies and Tests will include:

1. Investigation of ground cushioning effect using peripheral jets.

2. Performance, stability and control characteristics of hovering flight.

3. Transition from horizontal to hovering flight over a desired point. (SECRET)

b. Tests will be made on as large a model as possible (commensurate with air supply) to determine static lift as a function of distance from ground for various rates of flow, forces and moments for various angles of pitch, the effect of winds, and the exit losses when utilizing an exit similar to that of the proposed aircraft. (SECRET)

SECRET

2. Radial Flow Engine Feasibility

a. Analytical Studies and designs will be made to investigate:

1. Air bearings capable of performance under the gas pressures, material stresses and high temperature distortion conditions existing in the full scale aircraft.

2. Ducting design and efficiency of air intake system. Uniformity of flow at the compressor entry. Effect of flow distortions on blade vibration and combustion fuel-air ratio.

3. Ducting of exhaust gases.

4. Aircraft-engine structural deformations and seals suitable for high temperatures and pressures resulting from use of outer skin to contain engine pressures.

5. Compressor stage seal and stator construction for adequate strength.

6. Rotor balancing requirements and means to assure acceptable vibration levels under conditions of non-uniform temperatures and pressures, and structural flexing.

7. Possible control vane flutter problem due to use of jet exhaust for control.

8. Vulnerability of the engine.

9. Manufacturing techniques, shipping, overhaul, and maintenance characteristics under field conditions.

(SECRET)

b. Tests to substantiate design studies, provide design data and resolve problems will include:

1. Small scale bearing rig tests on basis of existing rigs and preliminary tests already completed. Tests will be made on:

a. Static rig

b. Dynamic rig

c. One-tenth scale bearing rig

2. Combustion chamber tests consisting of:

a. Water flow tests of a single chamber

UNCLASSIFIED

[redacted]

SECRET

b. High altitude tunnel tests through range of operating conditions to determine flame stability limits etc.

c. Investigation of scale effects.

3. Design and test of a bearing and radial flow engine at a scale commensurate with practical fabrication and efficient operation of components, and sufficiently large to produce pressures, distortions, weights, and temperatures representative of the full size engine. Sea level static tests will be made with this engine.

4. Inlet model tests in a large size supersonic wind tunnel at subsonic and supersonic speeds to provide information for the pressure recovery and flow distribution investigation of Paragraph (a)(2) above, and data regarding external drag of the inlets. (SECRET)

2. Aircraft Flight

a. Studies and test investigation will include:

1. Control effectiveness forces and response rates for stabilization, trim, and maneuver under all flight conditions under the gyroscopic stabilization and precessional moments actions of the radial flow engine, and aircraft motions throughout the flight range.

2. Provision of dynamic stability augmentation systems to: (1) augment the damping of both the snaking and mutational modes of oscillation with gyro stability, (2) provide satisfactory (Spec 1815B) handling characteristics without gyro stabilization.

3. Aerodynamic characteristics for accurate prediction of performance, determination of thrust requirements, and computation of performance on basis comparable to other USAF aircraft.

4. Pilot visibility

5. Effect of power failures and emergency means of escape. (SECRET)

b. Tests will utilize the vertical take off investigation model in so far as possible to investigate the control, trim, and maneuver under flight conditions. Subsonic and supersonic wind tunnel tests will be made to provide six component aerodynamic data.

30r(3) Subtasks

UNCLASSIFIED

See Box 30k

(4) Other Information

1. General

a. The NACA will be required to provide facilities and personnel for participation in the wind tunnel and possibly engine test programs. Extent of effort required will be determined after formulation of the detailed model test programs. (UNCLASSIFIED)

b. Hq ARDC Technical Requirement #3 Paragraph Vb indicates that any contract with AVRO Canada will require that copies of all reports be provided the Canadian Defense Research Board and Royal Canadian Air Force. (UNCLASSIFIED)

c. The US Navy (BuAer) is greatly concerned in the development of a VTO aircraft, as evidenced by Navy developments noted in Paragraph 30b, and obvious application to shipboard use. It is also considered that the US Marines and Army Ground Forces will be interested in this type vehicle. (SECRET)

2. Funds

	1955	1956	1957	1958	1959
Labor	$ 12500	$ 20000	$ 25000	$ 30000	$ 25000
Travel	2500	4000	5000	5000	5000
Contract Services	2494000	6000000	12000000	6000000	2000000
Total R & D	2509000	6024000	12030000	6035000	2030000
Materials	0	0	0	0	0
	$ 2509000	6024000	12030000	6035000	2030000
Manhours	5000	8000	10000	12000	10000

(5) Background History

See Paragraph 30r

(6) References

1. USAF Ltr dtd 26 April 54, Subject (SECRET) Project Y (A. V. Roe, Canada Ltd)

2. USAF Ltr dtd 3 July 54, Subject (SECRET) Project Ladyt (SECRET)

3. (Unclassified Title) Hq ARDC Technical Requirement #3 dtd 13 August 54 (Secret Document)

d. (Secret Title) A. V. Roe Canada Limited Development Proposal "Project Y2" (Secret Report)

e. (Secret Title) A.V. Roe Canada Limited Brochure No. 1 "Project Y2 Flat Vertical Take-off Supersonic Gyroplane" dtd June 54 (Secret Report)

UNCLASSIFIED

SECURITY CLASSIFICATION

ARDC RESEARCH AND DEVELOPMENT PROJECT SCHEDULE

☒ INITIAL ☐ CHANGE

REPORTS CONTROL SYMBOL: ARDC 105

DATE: 15 September 1954

1. TITLE: (Secret Title) AVRO Vertical Take-off Aircraft, Code Name Ladybird (Secret)			2. HEADQUARTERS ARDC	3. PROJECT NUMBER: 1794
4. RESPONSIBLE CENTER: WADC	5. PROJECT SUPPORTS SYSTEMS: None	6. ARDC TECHNICAL GROUPING: 01 Aircraft & Design Studies	7. DESIGN STUDY DIRECTIVE: Technical Reqmt #3 13 August 1954	8. FORMER PROJECT NUMBER: None
9. CONTRACTOR: A.V. Roe Canada Limited	10. DATE INITIATED: 15 September 1954	11. OP RDY	12. ESTIMATED COMPL DATE: 1960	13. SECURITY: Secret
14. PROJECT ENGINEER/SCIENTIST: William E. Lamar, Chief, New Developments, WCSB, 31324		15. FUNCTIONAL AREA: Technical Development	16. BPSN: 1-1794	17. PRIORITY: 1A

18. SCHEDULE AND PROGRESS FOR TOTAL PROJECT ▽ SCHEDULE DATE ○ REQUIRED DATE — A, B, C, [redacted], I, J, K, L

19. TASKS FOR PROJECT — FISCAL YEARS

TITLE	NUMBER	X/O	PREVIOUS	1955	1956	1957	1958	TO COMPLETE

20. RESOURCES REQUIRED BY FISCAL YEARS

	PREVIOUS	1955	1956	1957	1958	TO COMPLETE
A. MANHOURS (ARDC Pers Only)		5,000	8,000	10,000	15,000	10,000
B. CONTRACT DOLLARS - 600 FUNDS		$2,494,000	$6,000,000	$12,000,000	$6,000,000	$2,000,000

54-WAS-8424

ARDC FORM 101
1 DEC 52

UNCLASSIFIED

[redacted]

606 A

SECURITY CLASSIFICATION: **SECRET**

RDB PROJECT CARD	TYPE OF REPORT: New Project Report	REPORTS CONTROL SYMBOL: ARDC-D4

1. PROJECT TITLE	2. SECURITY	3. PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	SECRET	1794
	4. INDEX NUMBER	5. REPORT DATE: 10 October 1954

6. BASIC FIELD OR SUBJECT	7. SUBFIELD OR SUBJECT SUBGROUP	7A. TECH OBJ
Technical Development	Aircraft & Engines (01)	SRJ

8. COGNIZANT AGENCY	12. CONTRACTOR AND/OR LABORATORY	CONTRACT/W.O. NO.
Air Research and Development Command	A.V. Roe Canada Ltd. Malton, Ontario	
9. DIRECTING AGENCY: Wright Air Development Center		
OFFICE SYMBOL: RDTDP / TELEPHONE: 263		

10. REQUESTING AGENCY	13. RELATED PROJECTS	17. EST COMPL DATES
Headquarters, USAF	X-13 (USAF) VTO (Short Bros) XFY-1 (BuAer) XFV-1 (BuAer) VTO (Bell) VTO (Rolls Royce)	RES. Jan 1957 DEV. Oct 1958 TEST July 1960 OP. EVAL.
11. PARTICIPATION, COORDINATION, INTEREST NACA (P) No Funds Canadian Defense Rsch Bd (C) (Includes Royal Canadian AF) US Navy BuAer (I) US Marines (I) US Army Ground Forces (I)	14. DATE APPROVED: 3 July 1954 15. PRIORITY: 1-A 16.	18. FY / FISCAL ESTS (M$): 55 — 2,494 56 — 6,000 57 — 12,000 58 — 6,000 59 — 2,000

19. No prior report

20. REQUIREMENT AND/OR JUSTIFICATION

This project is directed by Headquarters USAF letter dated 3 July 1954 subject, "Project Ladybird (S)" and Technical Program Requirement 1-2 dated 7 October 1954.

21. a. Brief

Objective of this program is the development at the earliest possible date of a flat vertical take off supersonic aircraft which exploits the design of AVRO Canada. (SECRET)

b. Approach

(1) Preliminary aerodynamic and power plant testing will be accomplished to insure to a reasonable degree that the configuration first fabricated will fulfill the objectives of this program - Prime emphasis will be given to the attainment of the vertical take off capability proposed by AVRO Canada. Initial power plant development efforts will be directed towards the AVRO Canada radial flow engine; however, alternate means of propulsion will be investigated as a backup. (SECRET)

UNCLASSIFIED

22. RDB	SN	CN	ICAP	X.	I.	C.

DD FORM 1 JAN 52 613 REPLACES RDB FORM 1A, 1 APR 47. WHICH MAY BE USED.

[redacted]

PAGE 1 OF 9 PAGES

C4-22032

SECURITY CLASSIFICATION

578 574

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. b. (continued) ---

(2) The intense effort to be directed towards the resolution or clarification of many of the critical problem areas of this type aircraft during the first year will represent the first step of the program required for development of this aircraft. Since approximately one year will be required to yield sufficient test results to determine any appreciable change in the probability of success, or significant clarification of the development problems it is not considered desirable to initiate actual detailed design or fabrication of the flight aircraft and engine prior to this time. Initiation of such work after the first year will still involve acceptance of a calculated risk, since many basic problems, including the radial flow engine, will remain unsolved and controversial for an additional year, and other problems will remain unsettled until the full scale aircraft and engine is developed and tested. (SECRET)

(3) By January 1956, test results should permit resolution of the ground cushioning effect and further clarification of the engine and control problems, although it is doubtful, that tests of the large scale air bearings and radial flow engine will be complete. A decision will be required at this time to determine whether the results available and the urgent need of this aircraft warrants the risk of full scale development before the engine problem is resolved. If so, it will be necessary to decide whether to proceed with radial flow engine aircraft or adopt an alternate configuration. A decision made at this time will have to be made on the basis of the small scale (and controversial) radial flow engine tests which will have been nearly completed. (SECRET)

(4) Results of the aerodynamic and performance tests, and completion of the military application studies should during 1956 permit a decision as to whether the initial aircraft should be purely a research or test aircraft or should provide a military capability. (SECRET)

(5) Prime problems requiring resolution are:

UNCLASSIFIED

C4-22032

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. b. (continued)

(a) Attainment of the ground cushion effect which permits vertical take-off at much lower thrust/weight ratios than otherwise possible. (SECRET)

(b) Determination of the feasibility of the radial flow engine which provides the high aircraft thrust/frontal area ratio and gyro stabilization of the AVRO proposal. (SECRET)

(6) An outline of the program planned and a breakdown of the major problems to be investigated during the first phase of this program follows. This program will provide the basis for the formulation of the detailed work statement with the contractor. (UNCLASSIFIED)

(a) Vertical Take-Off

1. Analytical Studies and Tests will include:

a. Investigation of ground cushioning effect using peripheral jets.

b. Performance, stability and control characteristics of hovering flight.

c. Transition from horizontal to hovering flight over a desired point. (SECRET)

2. Tests will be made on as large a model as possible (commensurate with air supply) to determine static lift as a function of distance from ground for various rates of flow, forces and moments for various angles of pitch, the effect of winds, and the exit losses when utilizing an exit similar to that of the proposed aircraft.

(b) Radial Flow Engine Feasibility

1. Analytical Studies and designs will be made to investigate:

a. Air bearings capable of performance under the gas pressures, material

UNCLASSIFIED

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. b. (continued)

stresses and high temperature distortion conditions existing in the full scale aircraft.

b. Ducting design and efficiency of air intake system. Uniformity of flow at the compressor entry. Effect of flow distortions on blade vibration and combustion fuel-air ratio.

c. Ducting of exhaust gases.

d. Aircraft-engine structural deformations and seals suitable for high temperatures and pressures resulting from use of outer skin to contain engine pressures.

e. Compressor stage seal and stator construction for adequate strength.

f. Rotor balancing requirements and means to assure acceptable vibration levels under conditions of non-uniform temperatures and pressures, and structural flexing.

g. Possible control vane flutter problem due to use of jet exhaust for control.

h. Vulnerability of the engine.

i. Manufacturing techniques, shipping. overhaul, and maintenance characteristics under field conditions. (SECRET)

2. Tests to substantiate design studies, provide design data and resolve problems will include:

a. Small scale bearing rig tests on basis of existing rigs and preliminary tests already completed. Tests will be made on:

UNCLASSIFIED

f. Static rig

64-22032

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. b. (continued)

2. Dynamic rig

3. One-tenth scale bearing rig

b. Combustion chamber tests consisting of

1. Water flow tests of a single chamber.

2. High altitude tunnel tests through range of operating conditions to determine flame stability limits etc.

3. Investigation of scale effects.

c. Design and test of a bearing and radial flow engine at a scale commensurate with practical fabrication and efficient operation of components, and sufficiently large to produce pressures, distortions, weights, and temperatures representative of the full size engine. Sea level static tests will be made with this engine.

d. Inlet model tests in a large size supersonic wind tunnel at subsonic and supersonic speeds to provide information for the pressure recovery and flow distribution investigation of Paragraph (1)b above, and data regarding external drag of the inlets. (SECRET)

(c) Aircraft Flight

1. Studies and test investigation will include:

a. Control effectiveness forces and response rates for stabilization, trim, and maneuver under all flight conditions under the gyroscopic stabilization and precessional moments action of the radial flow engine, and aircraft motions throughout the flight range.

UNCLASSIFIED

C4-22032

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. b. (continued)

b. Provision of dynamic stability augmentation systems to: (1) augment the damping of both the snaking and nutational modes of oscillation with gyro stability, (2) provide satisfactory (Spec 1815B) handling characteristics without gyro stabilization.

c. Aerodynamic characteristics for accurate prediction of performance, determination of thrust requirements, and computation of performance on basis comparable to other USAF aircraft.

d. Pilot visibility

e. Effect of power failures and emergency means of escape. (Secret)

2. Tests will utilize the vertical take off investigation model in so far as possible to investigate the control trim, and maneuver under flight conditions. Subsonic and supersonic wind tunnel tests will be made to provide six component aerodynamic data. (Secret)

c. Tasks

(1) Problem areas of this aircraft have been outlined in Box 21.b. Approach. Solutions to each of these problems require formulation of a detailed development program. It is anticipated that at a later date, certain of these problems will be included as tasks to this project. (Unclassified)

d. Other Information

(1) General

(a) The NACA may be required to provide facilities and personnel for participation in the wind tunnel and possible engine test programs. Extent of effort required will be determined after formulation of the detailed model test programs. (Unclassified)

UNCLASSIFIED

C4-22032

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. d. (continued)

(b) Hq ARDC Technical requirement No. 3 paragraph Vb indicates that any contract with AVRO Canada will require that copies of all reports be provided the Canadian Defense Research Board and Royal Canadian Air Force. (Unclass.)

(c) The US Navy (BuAer) is greatly concerned in the development of a VTO aircraft, as evidenced by Navy developments noted in Box No.13 and obvious application to shipboard use. It is also considered that the US Marines and Army Ground Forces will be interested in this type vehicle. (Secret)

(2) Funds

	1955	1956	1957	1958	1959
Labor	12,500	20,000	25,000	30,000	25,000
Travel	2,500	4,000	5,000	5,000	5,000
Contract Services	2,494,000	6,000,000	12,000,000	6,000,000	2,000,000
Total R&D	2,509,000	6,024,000	12,030,000	6,035,000	2,030,000
Materials	0	0	0	0	0
	$2,509,000	$6,024,000	$12,030,000	$6,035,000	$2,030,000
Manhours	5,000	8,000	10,000	12,000	10,000

e. Background History

(1) The original concept of the contractor was to increase the aircraft thrust-frontal area ratio far in excess of that obtainable with conventional jet turbine engines by rearrangement of the powerplant for radial flow. Such increases in aircraft thrust-frontal area ratio were desired in order to improve supersonic flight performance. Development of this idea as Projects Y and Y2 by AVRO Canada, under RCAF cognizance, was extended to include application to vertical take-off aircraft when it was determined that thrust/weight

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. e. (continued)

ratios were sufficiently high and that use of the radial flow engines with jet exhaust at the periphery produced a ground cushion effect. Preliminary ingenious small scale model testing by AVRO Canada has demonstrated this phenomenon. (Secret)

(2) During January 1954, AVRO Canada and the Canadian Defense Research Board invited the USAF to visit AVRO and discuss Project Y, a tail sitter VTO aircraft and preliminary aspects of a new flat riser, later designated the Y2. As a result of this visit, subsequent briefings by AVRO Canada personnel to the USAF Air Council and ARDC, and receipt of an aircraft proposal by AVRO Canada, Technical Requirement No.3, was issued to exploit the potential of this project. (Secret)

f. Future Plans

(1) After the problem areas have been sufficiently resolved, or earlier if it is desired to take a greater development risk in order to provide possible time savings, a decision will be required to determine the specific type of aircraft to be developed. (Unclassified)

g. References

(1) USAF Ltr dtd 26 April 54, Subject (Secret) Project Y (A. V. Rose, Canada Ltd)

(2) USAF Ltr dtd 3 July 54, Subject (Secret) Project Ladybird (Secret)

(3) (Unclassified Title) Hq ARDC Technical Requirement No. 3 dtd 13 August 54 (Secret Document)

(4) Hq USAF Technical Program Requirement 1-2 dated 7 October 54.

UNCLASSIFIED

C4-22032

PROJECT TITLE	PROJECT NUMBER
(Secret Title) AVRO Vertical Take-Off Aircraft Code Name Ladybird (Secret)	1794
	REPORT DATE 10 October 1954
	COGNIZANT AGENCY ARDC

21. g. (continued)

(5) (Secret Title) A. V. Roe Canada Limited Development Proposal "Project Y2" (Secret Report)

(6) (Secret Title) A. V. Roe Canada Limited Brochure No. 1 "Project Y2 Flat Vertical Take-Off Supersonic Gyroplane" dtd June 54 (Secret Report) (SECRET)

This document is classified Secret in accordance with par 23C of AFR 205-1.

UNITED STATES AIR FORCE
HEADQUARTERS AIR RESEARCH & DEVELOPMENT COMMAND
OFFICIAL
AUTHENTICATION

UNCLASSIFIED

C4-22032