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PROGRAM PLANNING REPORT
AVRO V.T.O.L. PROJECT P.V. 704

AVRO AIRCRAFT LIMITED

PROGRAM PLANNING REPORT

AVRO V. T. O. L. PROJECT P. V. 704

Issued by:

Avro Aircraft Limited
Malton, Ontario, Canada

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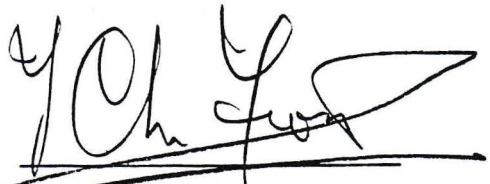

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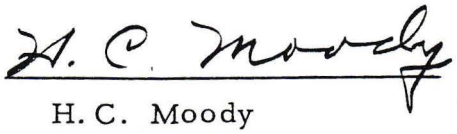

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The number of pages in this brochure, including Frontispiece, Title Page, Table of Contents, Illustrations and charts is 40.

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INTRODUCTION

The research and development facilities built up by the Company since the formation of A.V. Roe Canada Limited in 1945 have been largely devoted to the design and development of long range, all-weather aircraft suited to the unique defence needs of Canada. Its success in this task manifests the ability of the Company's engineering resources.

However, it became apparent that development of conventional type aircraft would not always suffice to offset the increasing potential of the enemy threat. Time was not on our side. A design breakthrough was required, the goal being a long range aircraft with speed, altitude and manoeuvrability capabilities which would eclipse the performance of any known aircraft.

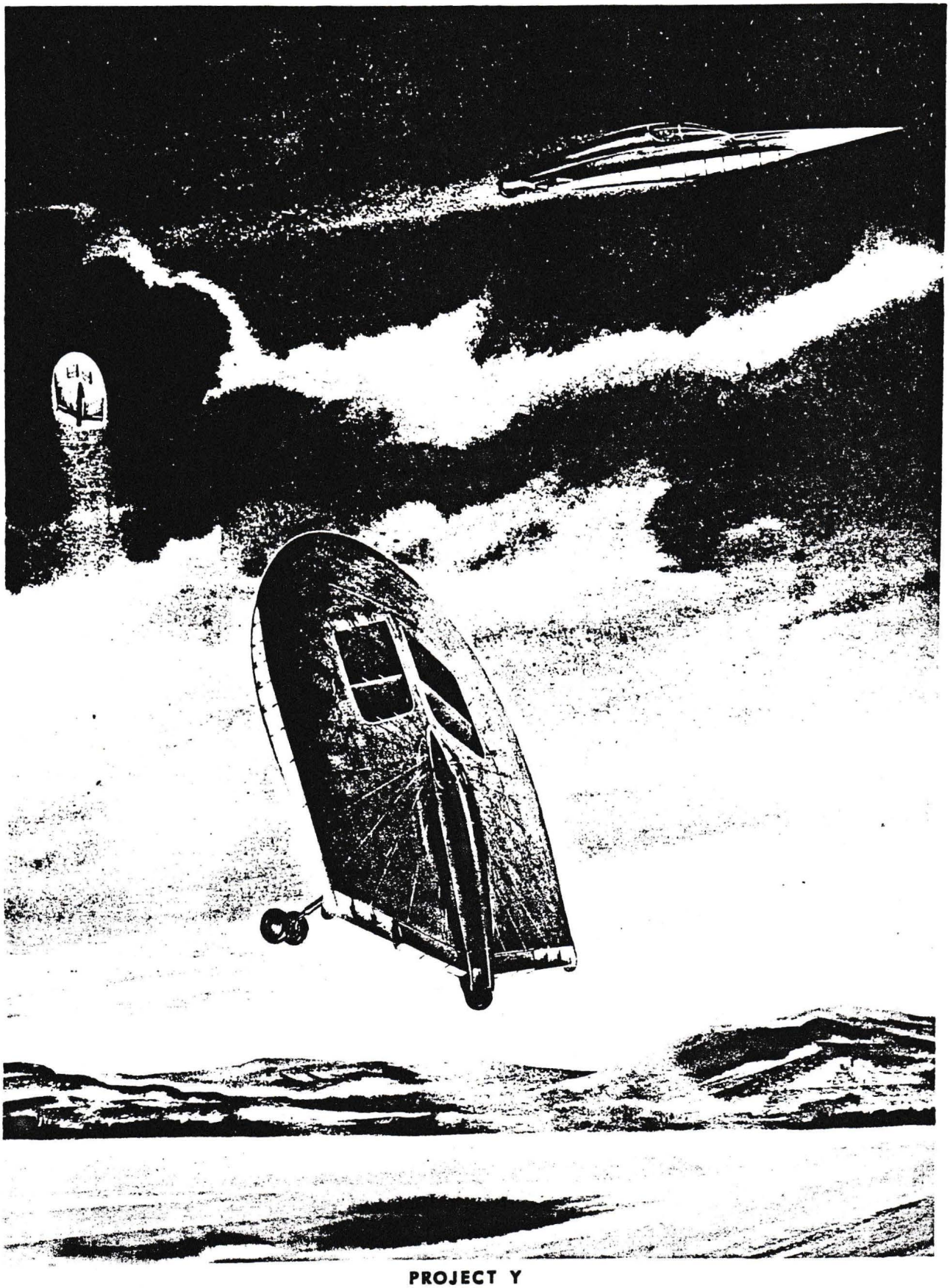
Accordingly, during the fall of 1951 the Company embarked upon a program of investigation to determine the feasibility of such an aircraft having the added capability of V.T.O.L.

This program has aroused the interest and support of Government authorities in Canada, the U.K. and the U.S.A. The history of this support, and its implications, are reviewed in the following pages.

D. D. P. CONTRIBUTION - PROJECT "Y"

The Department of Defence Production for Canada provided limited funds in the amount of $180,325.42 within the scope of the CF-100 Jet Fighter Development Program, to permit initial studies of the Project "Y" V.T.O. concept. As a result of these studies the Defence Research Board became sufficiently interested to recommend that the Department of Defence Production sponsor a study program. By a Purchase Order dated May 3, 1954, the Department of Defence Production accepted costs incurred to March 31st, 1954 in the amount of $212,508.57 thereby formally acknowledging the Government's interest in the program. A second Purchase Order for studies in the United Kingdom accounted for an additional sum of $16,285.61 making a total contribution by the Department of Defence Production by specific Purchase Orders of $228,794.18. The total funds contributed by the Crown therefore amounted to $409,119.60.

Effective March 31st, 1954 the Department of Defence Production discontinued their financial support and indicated that, although they were not dissatisfied with the potential of the concept, funds available for the defence of Canada should be expended in further development of conventional aircraft.

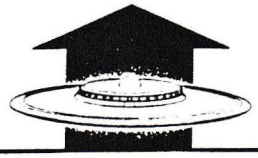


PROJECT Y

U.S.A.F. CONTRIBUTION - PROJECT 1794 STUDIES

As the interest of the Department of Defence Production decreased, the Company succeeded in developing the interest of the United States Air Force for the support of the program. During the Spring of 1954, U.S.A.F. interest increased to a point where continuation of the program under interim Company sponsorship appeared to be advisable and after establishing the nature of the contract to be anticipated from the U.S.A.F. the Company undertook commencement of the work in accordance therewith.

By Contract dated May 6, 1955, the United States Government authorized the expenditure of $784,492.29 U.S. funds, for a study program retroactive to July 1, 1954 and ending with the submission of final Technical Reports in June 1956. The study program was an investigation to determine the feasibility of the Avro Aircraft V.T.O.L. concept. The Company therefore recovered through this contract the sum of $287,000 being the amount of funds expended as anticipatory costs prior to the issuance of a formal contract.



COMPANY CONTRIBUTION - PROJECT P.V. 704

In view of U.S.A.F. approval of the concept the Company deemed it timely to embark upon a program to design and manufacture one research vehicle. Thus the Company would advance the state of the art and maintain its leadership in the field of high altitude, supersonic flight with an aircraft possessing V.T.O.L. and S.T.O.L. potential.

The then Vice President and General Manager of the Company issued a directive dated December 13, 1955 to invest $4,650,000 in the development and production of one flying prototype. The Contracts Department issued a Sales Order dated December 19, 1955 in the amount of $66,000 to determine the basis upon which the Company-sponsored program would proceed.

The Projects Group established the program and provided Management with a Program Planning Report defining in detail the extent of the work to be undertaken and the manner in which it would be accomplished. On September 7, 1956 the Contracts Department issued a Costing Supplement to initiate the program. The funding limitation has been periodically adjusted since issue of this Supplement by amounts reflecting fiscal funding requirements established by program review.

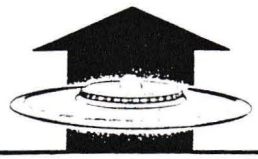
U.S.A.F. CONTRIBUTION - FURTHER STUDIES

In July 1956, the United States Air Force, impressed by the results obtained to date, notified the Company that a program of further studies would be authorized.

This program includes subsonic, transonic, supersonic, hover and transition wind tunnel tests as well as the design, development and test of the combustor and fuel systems necessary to achieve supersonic flight. A military specification for a weapons system will be prepared for the Company's choice of one of the following: interceptor, fighter-bomber, reconnaissance, tactical bomber. Additionally, a specification is at present in preparation for a U.S.A.F. research aircraft based on the Company's private venture project P.V. 704. A complete investigation and analysis of the three-component power plant is also part of the program and the U.S.A.F. have provided six A.S.V. 8 engines to support this work. The amount of U.S.A.F. funds provided for the program is $1,536,134.

The U.S.A.F. cumulative contractual commitment to date amounts to $2,297,597 plus approximately $1,200,000 for wind tunnel services and facilities, together with free issue equipment and instrumentation for the aircraft estimated to be worth $30,000. This then brings the cumulative total of U.S.A.F. contributions to the end of the current contract to a figure in excess of $3,500,000.

By virtue of U.S.A.F. participation in the development of the Combustor and Fuel Systems, which would otherwise be carried under Project P.V. 704, the Company on February 21, 1957 reduced its appropriation for P.V. 704 by approximately $500,000 to a new total of only $4,100,000. Furthermore, the fact that U.S.A.F. have provided six A.S.V. 8 engines (at a cost of $180,000) for use on the Six Viper Test Rig enabled the Company to maintain its scheduled rate of program achievement on P.V. 704 within the limitations of a reduced budget for the current fiscal year.



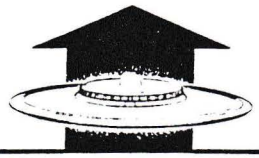
PATENTS

D. D. P. SPONSORSHIP

The design work and study program which was directed to the original Project "Y" configuration was paid for by the Crown under the original CF-100 Jet Fighter Development Agreement. The Company's Case No. 281, Gas Turbine Engined Aircraft, was conceived during the period of this Agreement and, under the terms contained therein, the patent rights were assigned to Canadian Patents and Development Limited. However, under the so-called 1/3 - 2/3 Agreement between the Company and C.P. & D. Ltd., the Company has the right to use the invention subject to the payment of royalties to be agreed upon or, failing agreement, royalties as set by the Commissioner of Patents.

New contractual arrangements were subsequently made with the Crown to cover the cost of research and development work up to the cessation of support by the Crown and these arrangements were recited in Purchase Order 2-B-4-54 dated May 3, 1954. This purchase order did not require the assignment of rights to the Crown but merely the issuance of a royalty-free license which would allow the Government to have articles embodying the inventions manufactured in Canada. The following inventions were conceived during the period of this purchase order and applications for patent were made in the countries listed hereunder:

SUBJECT MATTER	INVENTOR	NUMBER	COUNTRY
Vertical Take-off Aircraft	J. Dubbury		
(Case No. 311)	J.C.M. Frost		
	T.D. Earl	684594	Canada
		11581/54	Great Britain
		502156	United States
Radial Flow Gas Turbine Engine Rotor Bearing	J.C.M. Frost	684595	Canada
(Case No. 327)		18039/55	Great Britain
		502155	United States
Disc Type Aircraft	J.C.M. Frost		
(Case No. 328)	T.D. Earl	685716	Canada



SUBJECT MATTER	INVENTOR	NUMBER	COUNTRY
		13789/54	Great Britain
		507098	United States
Vertical Take-off Aircraft Control	J.C.M. Frost	685717	Canada
(Case No. 335)		13579/55	Great Britain
		507099	United States
Disc Aircraft With Multiple Radially Disposed Engines	J.C.M. Frost		
(Case No. 340)	T.D. Earl	685718	Canada
		13790/54	Great Britain
		507100	United States

U.S.A.F. SPONSORSHIP

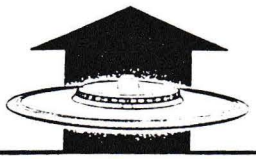
Under the terms of the Contract by which the U.S.A.F. sponsored Project 1794, the Company was required to grant to the U.S. Government a non-exclusive, royalty-free license to make, use or sell products embodying the inventions throughout the world. There was no requirement for rights nor, and this is most significant, was there any requirement for any arrangement in respect of background patents. The work performed during Project 1794 produced one invention on which the Company has already filed patent applications and the following filing information may be of interest:

SUBJECT MATTER	INVENTOR	NUMBER	COUNTRY
Disc Aircraft With Gas Turbine And Ram Jet Engines	J.C.M. Frost	19459/55	Great Britain
(Case No. 348)	C.J. Williams	710342	Canada
		595547	United States

Another invention, Case No. 382 relating to controls, which is being prepared for filing, was conceived during this period of U.S.A.F. sponsorship and a license arrangement should, therefore, be made in favour of the U.S. Government.

Supplemental contracts with the U.S.A.F. to date contain the standard clauses in respect of patents. However, the scope of the work is such that the possibility of patentable material arising from the work performed is somewhat remote.

Formal contracts with the U.S. Government require not only that inventions which have been conceived under the contract but also those which are first actually reduced to practice, shall be the subject of a royalty-free, non-exclusive license to the U.S. Government. Consequently, it is in the interest of the Company to progress the work to the greatest extent possible by the use of its own funds, since the development and construction of prototype aircraft for the U.S. Government would entail



the actual reduction to practice of the inventions on which the U.S. Government does not now enjoy any license privileges.

COMPANY SPONSORSHIP

No patent applications have been filed on inventions which have been conceived under P.V. 704. However, several disclosures have been submitted and these are under active consideration.

It may be well to note here that development of the concept has reached the stage where design changes do not affect certain basic principles. Because of this fact it is reasonably apparent that, in the future, inventions arising out of the work will not be the subjects of broad basic patents but rather a larger number of more or less limited details which will be dependent on the relatively smaller number of basic patent applications. This is the normal course of events in which the scope of the patent applications decreases as the development approaches a static configuration. Conversely, the scope of the patent applications is proportional to the advancement in the state of the art.

THE COMPANY'S PATENT POSITION

In considering the Company's patent position, the primary consideration is the extent to which the Company has been able to retain a favourable patent position despite various contractual obligations which together, at first glance, appear to derogate from this position. However, before considering this question, it should be established that whenever a contract of a research or development nature is accepted, it is a standard contractual requirement that the contractor will assign rights or grant licenses to the customer for patents which arise out of work paid for by the customer. The Company, in its contractual negotiations with the D.D.P. and the United States Government, could not, with justification, request exemption from this rule.

Briefly reviewing the position, it will be remembered that one invention, Case No. 281, was conceived under the CF-100 Jet Fighter Development Agreement by which all rights were assigned to Canadian Patents and Development Limited. By a further agreement with Canadian Patents and Development Limited, the Company has the right to use this patent on payment of royalties. Cases Nos. 311, 327, 328, 335 and 340 were conceived as a result of work performed under Purchase Order 2-B-4-54 and the Company retains full rights to these inventions subject to the requirement to grant to the Crown a non-exclusive, royalty-free license to have articles incorporating the inventions manufactured in Canada. The United States Government has no license arrangement for the use of these inventions. Cases Nos. 348 and 382, of which 382 is still in the initial stages of preparation, arose as a result of work performed under our Project 1794 contract with the U.S.A.F. However, the Company retains full rights subject to a non-exclusive royalty-free license to the United States Government.

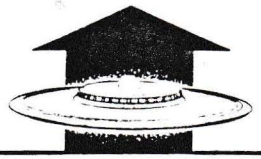
In considering this Company's patent position, it is assumed that the applications presently on file will result in valid patents and that the claims now being prosecuted will be allowed. It should be noted that rejection of some of the claims does not necessarily invalidate the latter assumption.

If the position of the D.D.P. is considered first, it will be seen that although they have rights in Case No. 281, and a license arrangement in Cases Nos. 311, 327, 328, 335 and 340, they do not have any such arrangements for the use of Cases Nos. 348 and 382. Since Case No. 348 is the first application directed to the

use of the turbine compressor configuration and since Case No. 382 covers the principles of the control system as they are applied to the P.V. 704 test vehicle, it is not conceivable that the Canadian Government could have an aircraft manufactured outside the Company without first reaching an agreement with the Company regarding patents. Furthermore, the Canadian Government has no license arrangements on P.V. 704 so that any patents which arise from this contract will further strengthen the Company's position. Lastly, Purchase Order 2-B-4-54 gave the Crown a license to have the inventions used in manufacture in Canada only and it would appear that it is reasonable to assume that the Company would be the favoured contractor.

In considering the position of the United States Government, it will be seen that they have a license arrangement with respect to Cases Nos. 348 and 382. For use of the invention as covered by the claims in Case No. 281, they would, of course, be required to negotiate with the D.D.P. For use of the other cases, namely 311, 327, 328, 335 and 340, the United States Government would be required to negotiate with the Company. These cases are considered to be very valuable in that they are directed to basic, unalterable principles essential to this V.T.O.L. concept. For example, Case No. 311 has a claim covering the ground cushion effect and Case No. 335 broadly covers the means for controlling the aircraft by the use of a system of annular nozzles and individually controlled shutters. In only one instance, Case No. 327, do the claims appear to be irrelevant to the latest configuration. In this case the claims are directed to means employing the air bearing principle for supporting the rotor on the flat, radial-flow gas turbine engine. This novel engine has of course been superseded by the turbine compressor.

The Company's position appears to be such that, if either the Canadian or United States Governments desire to have an aircraft of the Company's V.T.O.L. concept constructed by any other manufacturer they will both be required to negotiate a license agreement with this Company. It is suggested, therefore, that this places the Company in a unique and favourable position for the opportunity to participate to the fullest extent in the development and production requirements of both countries.



COMPANY INVESTMENT PHILOSOPHY

The Company's appreciation of the bargaining advantages which would accrue through the extension of its technological lead and continued control of the basic patents, together with its determination to further protect its interests, caused it to embark upon a program which will actually reduce to practice those inventions which dominate this area of aeronautical science. To this end the Company originally allocated the sum of $4,650,000.

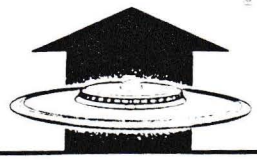
In order to obtain the maximum return on its investment, it was essential that the Company encourage U.S.A.F. participation in further studies and test programs to supplement the Project P.V. 704 program in areas which would not otherwise have been explored.

To stimulate U.S.A.F. interest and obtain contractual coverage under which U.S.A.F. financial monitorship and sub-contractor selection and control would be kept to a minimum, the Company deemed it advisable to negotiate the contract on a fixed price basis, under which it could be demonstrated that no specific element of profit was included.

The Company's efforts were rewarded by a U.S.A.F. study contract which included $430,960 for Combustor and Fuel Systems development, and $180,000 for six A.S.M. Viper 8 engines for the Test Rig. The Company was accordingly able to reduce its funds allocation to Project P.V. 704 by the amount of approximately $550,000 and to continue the original P.V. 704 program within a reduced funds allocation of $4,100,000. By this approach, under the present contract for $1,500,000, the Company has therefore actually reduced its commitment of over $4,500,000 by more than 10% being a saving of $550,000 and has foregone an estimated profit gain calculated at 5% of the two U.S.A.F. Study Contracts in the amount of $111,500.

As a further direct result of the U.S.A.F. participation in the project the Company enjoys the benefits of the United States Armed Services Technical Information Agency (A.S.T.I.A.). This organization provides, in the form of reports, technical data relating to almost every subject. Apart from U.S. Government contractors engaged on Secret projects, the Company is the only organization outside the United States boundaries privileged to participate in this service.

A further program of supplemental studies is currently being considered by the U.S.A.F. This program will enable the Company to more effectively prepare itself to accept the lead in development and production of aircraft to satisfy the various military roles to which the U.S.A.F. may allocate them.



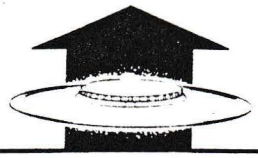
Through the retention of a control position achieved by development of superior know-how and a strong patent position, the Company has established significant sales advantages. Any other company desiring to participate in the provision of this type of aircraft to the American, United Kingdom or Canadian Governments, will first have to obtain from this Company a license to manufacture. The Company is aware that it cannot expect to receive all orders for development and manufacture; nevertheless, by skilful handling of its lead position, the Company is assured that it will be afforded its fair share of the market. By investing its own funds in the development of the aircraft, the Company is establishing itself in a position where it can justify a reasonable price under technical support and licensing contracts.

The Company's advanced position of development has placed competitive companies throughout the world in a less favourable negotiating position. The training and development time necessary to bring them abreast of this Company would be a significant factor in determining the selection of a firm to fulfill development or production orders. The early successful flight of the P.V. 704 aircraft will provide the necessary climax to the program required to justify heavy development and production spending by the United States, United Kingdom and Canada.

The United States Government and Government Agencies are necessarily bound by the terms of the "Buy American" Act. U.S. Government agencies may be unable to justify procurement from this Company, in the face of pressure from American companies, unless they are able to arm themselves with the fact that this Company has not only contributed to the development of the concept but also controls the patents necessary to carry out development and production. If these points are not available to the American Administrative Officers, their activities in support of our sales effort will be nullified by pressure from American political and industrial interests.

From the above considerations, it becomes obvious that the rate of profit which the Company will be able to justify, together with the volume of sales to be generated, will be such as to progressively return to the Company its contribution to the P.V. 704 program, with interest and profit, during the early period of fulfillment of major production orders.

Aside from the advantages related to the pursuit of the V.T.O.L. concept, the Company, as a whole, has benefited immeasurably by the wide advertisement given the Company's name in the field of aeronautical research and development.



THE CONCEPT AND THE FUTURE

A further milestone has now been reached in the development of the concept in that the U.S.A.F. has elevated the project from the exploratory and feasibility study category into the "System" category.

The designation "Project 1794" is cancelled and the project will henceforth be identified as "System 606A" which is an unclassified designation.

This is a significant decision in that the U.S.A.F. recognizes the potential the concept possesses and has placed it within U.S.A.F. funding auspices which will enable the allocation of funds for a Research and Development contract involving at least two research aircraft.

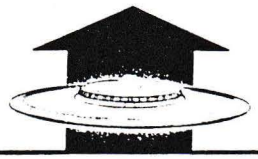
Contingent upon successful running of the Six Viper Test Rig together with favourable results from the current series of subsonic, transonic and supersonic wind tunnel tests, it is quite conceivable that negotiations for a hardware contract could take place before the end of 1957. In fact, the Company has been requested by the Project Officer, Wright Air Development Centre, to prepare and submit a specification for a U.S.A.F. research aircraft not later then December 1957.

A recent letter from the Commander, Detachment No. 1, W.A.D.C. invites the Company to submit a proposal for additional study work which, at first glance, will supplement the current program by about $1,000,000.

This invitation covers studies and specifications for three weapon systems, namely, Reconnaissance, Interceptor and Fighter-Bomber, in addition to other studies involving Performance, Ground Support Equipment, Training Equipment, Full Scale Nozzle Tests, Weapon System Development Plans, and Supersonic Tests which necessitate the design and manufacture of two new wind tunnel models.

Reviewing the numerous uses to which this concept may be adapted, it appears that a most interesting possibility is that of a ground to ground or ground to air missile. It is being recommended in our proposal that a study of one of these applications be included in the new extension to the U.S.A.F. study program.

It is not unreasonable to assume that, with the increasing interest shown by the U.S.A.F., contracts for additional aircraft will be forthcoming. This possibility is further enhanced by virtue of the fact that recent information from Washington indicates that only three aircraft weapon systems are currently on the drawing board in the whole of the aircraft industry in the United States. It may be argued that this is because of funds reduction necessitated by economic and political pressure. While this may be partly the cause, the most significant reason is the fact that designers have failed to offer sufficient design gain in new aircraft weapon systems concepts



which will meet the future requirements of the U.S.A.F., from a standpoint of Design Cost, Performance and Economy of Manufacture.

The concept being reviewed here possesses many, if not all, of the potentialities which when developed should keep the Company in the Aircraft business for years to come. This statement is based upon performance figures of speed and altitude, plus vertical take-off and landing capabilities as well as the simplicity of design which allows the aircraft to be tooled and manufactured at a fraction of the cost and time required for conventional aircraft.

The extent to which the United States Government will be prepared to place production orders in Canada is a serious matter for the Company, principally because of opposition from American political and industrial interests. It must be assumed that pressure would be brought to bear upon the Company to enter into license and technical support agreements with large American firms, which would soon benefit by the use of the Company's trained technical personnel to instruct their personnel in the methods of production and development to a point where they may effectively compete with and perhaps eclipse the Company's effort in both the production and development fields.

The Company should endeavour to maintain its lead position in the area of development and should resist to the greatest extent possible all attempts of other aircraft companies to break into the field of production.

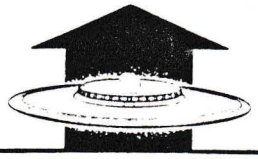
This can be done most effectively if initial production orders are maintained under the Company's control for as long as possible.

Informal recommendations offered by the U.S.A.F. make it clear that the Company would be well advised to consider setting up its own facilities within the boundaries of the United States. Such action would definitely remove the political and administrative problems now being encountered because of the policy established under the "Buy American" Act.

The relocation of the nucleus of trained personnel to a facility located in the United States would obviously be more profitable than losing the use of these personnel to competitive American companies under technical support and licensing agreements.

The results to be anticipated from the Company's investment in the P.V. 704 program will establish it as being the company presently most able to undertake fulfillment of the urgent defence requirements of the United States Government. The requirement for early establishment of extensive capital facilities to enable the Company to fulfill this need will warrant the provision of capital assistance to the Company by the United States Government to such an extent that the monetary advantages to the Company will totally eclipse the initial outlay of $4,100,000 in its private venture program. It is not considered that Company funds beyond the $4,100,000 will be required, since there is reason to believe that the United States Government will want to sponsor continued tests and refinement of the P.V. 704 aircraft.

Upon completion of one or more flights by the P.V. 704 aircraft, the Company-sponsored program will have fulfilled its primary requirement. The related patents will have been actually reduced to practice and secured within Company control and it will have been demonstrated conclusively that aircraft based upon this concept can be flown successfully. Further expenditures, or retention of title to the vehicle,



will no longer be required for Company purposes. The fact that actual flight has been achieved will create an even greater urgency for speedy development. It is conceivable that the Company would then be prepared to sell the vehicle to the U.S.A.F. under a contract which would allocate the use of the vehicle to an engine running and flight test program of the Company's selection. Such a contract would not confer upon the U.S.A.F. any existing patent rights. The price of the vehicle would likely be equivalent to the Company's investment in the program to date of first flight.

Having briefly discussed the possible roles to which the aircraft may be adapted it is apparent that its potential is not limited to a manned version. Its advantages of high altitude, high speed, controlled take-off, hovering, manoeuvrability and landing make it readily adaptable as a superior type of unmanned missile. This might well be the opportunity by which the Company will establish itself as a major contractor in the field of missile development and production.

It is not unusual to find a company attempting, by its own expenditures, to establish for itself a lead position in a field of development and production. In this instance, by reason of the secrecy afforded through military regulations, the Company has been able to maintain a close control of dissemination of knowledge of the inventions and progress made towards adapting them to practical use. The Company has demonstrated its foresight in securing the advantages accruing from its unique position by sponsoring the development of a vehicle which will demonstrate its lead position. It is evident that this endeavour is the beginning of a program which can, by its own momentum, carry the Company to a dominant position in one of the most revolutionary and extensive fields which have opened in recent years.