A Canadian STOL Air Transport System as a National Major Program

Science Council of Canada

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FOREWORD

In its Report No. 4, Towards a National Science Policy for Canada, the Science Council made its first proposals for the establishment of a series of Major Programs, which it defined as

> "large, multidisciplinary, mission-oriented projects having as a goal the solution of some important economic or social problem in which all sectors of the scientific community must participate on an equal footing."

The Council indicated that, because Canada has a vital need for efficiency in the transportation of her people and produce, it would proceed to attempt to define some of the opportunities which transportation offers for such ventures. This report proposes immediate action on the development of a STOL air transport system, to satisfy a growing need in the area of inter-urban passenger transportation and to capitalize on a significant technological advantage which Canada now enjoys. The Science Council has reviewed the goals of such a program and the problems to be overcome, and presents its views and recommendations in this document.

Since the publication of Report No. 4, significant changes in Canada's transportation research capability have been brought about by the reorganization of the federal Ministry of Transport. The establishment of a Transportation Development Agency will create a focus for planning and research which has long been missing; more importantly, it is expected that this agency will soon be supplied with a widely representative advisory Board whose continuing role should be the provision of advice to the Ministry on national policies and programs in the field of transportation development.

Both in its policy Report No. 4, and its Annual Report for 1969-70, the Council set out its view that in each area where science has a substantial contribution to make, and particularly in the Major Programs, there is a need for a body to formulate a national viewpoint on future policies and programs specific to that area, and to advise the appropriate federal body on these matters. In this light, the Science Council welcomes the recent changes made within the Ministry of Transport and looks forward to the creation of an active Board which should be the source of future proposals for Major Programs on Transportation to complement the initial one now advocated by the Science Council.

As policies and programs in the area of transportation develop in the years ahead the Science Council will be ready to comment, as necessary, on the way in which they are using science and technology to benefit Canada.

P R E F A C E

The Science Council recommendations to the government on the STOL Air Transport System are embodied in this report. In Section I these are summarized in the form of steps for immediate action and qualifications for implementation. Section II incorporates support material in the form of an assessment and discussion of the STOL Air Transport System as a Major Program.

Section I

Recommendations of the Science Council

on the STOL Air Transport System

Recommendations of the Science Council on the STOL Air Transport System

The Science Council recommends the adoption of the STOL Air Transport System as a Major Program, but only on the understanding that the three conditions regarding the structure of the industry, the application of continuing technology assessment and the timing of the program be satisfied. These conditions are listed below under Qualifications for Implementation following the seven recommendations on Immediate Action.

Immediate Action

1. The STOL Air Transport System should be established at the earliest possible date as a national Major Program. Subject to the qualifications for implementation listed below, it meets all the criteria established for a Major Program by the Science Council and is the best option at this time for a significant Canadian participation in the transportation field.
2. New ways of funding the program should be investigated which would ensure that the initial launching costs of the program were recoverable from subsequent successes in the world markets. (Potential sales have been estimated at between $500 million and $1000 million for the aircraft alone). A rough estimate suggests that the total net investment required would peak at about $150 million and would be reached in graduated steps determined by the degree to which the industry could be reorganized. Fully-funded contracts on feasibility studies and long-term developments directed at maintaining a Canadian lead

in the STOL Air Transport System should be awarded in similarly graduated steps of up to about $15 million per annum over a period of 3 to 5 years duration. (Because of lack of data on development costs of some components of the system, these figures are approximations and it would require further studies to establish more precise amounts.)

3. As the objectives of a Major Program in STOL Air Transport System are of interest to a number of departments, the government should take steps to set up a task force to recommend on the management structure necessary both to administer the funds appropriated and to provide the required systems management capability.

4. Work should be initiated to solve the problems associated with the weaknesses of the industrial structure outlined below. While these problems are being solved, it is important that the program get under way and be funded at a modest level, but major financial support should only be committed when a satisfactory industrial structure is achieved.

5. The immediate objective should be to produce a demonstration service. Because of the significance of the FAA's regulatory role and the importance of the U.S. market, this should be preferably between one U.S. and one Canadian city with joint U.S.-Canadian collaboration, but alternatively it could serve between two Canadian cities. The purposes of such a service would be both to demonstrate its economic feasibility and to assess the new technology in terms of external costs and the degree of public acceptance. The long-term objective would

be to support developments which would maintain a Canadian lead, not only in the first, but in the second generation of V/STOL systems.

6. The Major Program should involve the total system, the aircraft, navigational aids, air-traffic control, STOL ports and inter-modal and other supporting services. It would be important to ensure simultaneous development in all components of the system.

7. Both the provincial and municipal levels of government should be involved at an early stage in any program, particularly in those aspects relating to public acceptance of STOL, its potential benefits and role in future transportation developments. STOL systems would have to be recognized in the plans made by these governments, if a successful program was to be implemented.

Qualifications for Implementation

The recommendation for a STOL Air Transport System as a Major Program is made subject to compliance with the following conditions:

1. Major changes must be made in the organization and management of the aircraft industry before the program proceeds too far. As a result of the studies that have been made, Council feels that the skills do exist in Canada to tackle a program of this type, but they do not reside in any one company. To proceed with a reasonable chance of success and to ensure a continuity of benefits within Canada, it will be necessary to find some viable means of amalgamating the design capabilities of one

company with the production capabilities of another. A strong industrial consortium may qualify, but as most of the components of the engine and airframe industries are subsidiaries of multinational corporations, such an arrangement would have to be carefully scrutinized to guard against the formation of a consortium of convenience. Government participation as a major partner in such a consortium would be an alternative approach. As a major market for STOL systems exists in the U.S., every effort should be made to promote the type of effective U.S. cooperation, which would arrange for the better U.S. acceptance and use of the Canadian STOL system.

2. A continuing assessment of the external costs of the system and the degree of public acceptance must be made throughout all stages of development and prototype demonstration service. The contribution to noise and pollution levels and the effectiveness of land usage must be compared with competitive modes throughout the early stages of the program. Although at present such comparisons appear to favour the STOL system, some of the factors involved can be only fully evaluated by a demonstration service.

3. In order to take full advantage of the lead which Canada now has in STOL systems, the program must be launched soon and vigorously.

Section II

A Canadian STOL Air Transport System

as a Major Program

A Canadian STOL Air Transport System as a Major Program

The Science Council Committee on Transportation was set up to consider whether or not transportation was a subject suitable for identification as a Major Program, and if it was, to delineate the scope of such a program. Since its inception, in July 1969, the Committee has been studying new technological developments and the overall Canadian transportation requirements, for all modes, in an attempt to identify programs which match our present industrial and technological resources with national goals. It has found that there are indeed many opportunities for Major Programs which come under the heading of transportation, although the ones which most closely satisfy the requirements of a Major Program relate to mass transportation of people within and between cities. There are, in fact, two major contenders, advanced-mass-ground transportation and the STOL system of air transport. Although the Committee intends to give equal consideration to both these systems, the urgency for a decision on the STOL system has precipitated a more detailed evaluation of this particular topic.

The Committee has had a series of presentations on the STOL Air Transport System from de Havilland, Canadair, Department of Industry, Trade and Commerce and the Canadian Transport Commission over the past three months. On the basis of the information gained from these inputs and further staff investigations, the STOL System has been compared with the criteria established by the Science Council for a Major Program.

The evaluation which follows in subsequent sections of this report resulted from this comparison.

In making its final recommendation on the STOL Air Transport System, the Science Council has also taken into account the work of the Science Council Committee on Aeronautical Research and Development in Canada. The recently released report of this committee(1) examines possible future programs for aeronautical R & D in Canada and lists as a prime contender the V/STOL Aircraft System.

1.0 The Case for STOL

The STOL Air Transport System (short take-off and landing) involves the operation of medium sized aircraft, 40 to 100 passengers, on a commercial basis between specially designed small airports (STOL ports) not exceeding 2000 feet in length, to the exclusion of all other commercial and business aircraft. By specifying a steep angle of ascent and descent, a maximum noise level at a distance of 500 feet of 95 PNdb and safety standards of conventional airliners, it is possible to locate such STOL ports in downtown metropolitan areas without the deterioration of the environment and the excessive land usage associated with conventional airports. The total system incorporates aircraft, STOL ports, navigational aids, air-traffic control, intermodal facilities and other supporting services, all exclusively devoted to the STOL system.

The application of a STOL system in the next few years would involve development of existing technologies and would utilize a fixed-wing aircraft powered by four turbo-prop engines. A second-generation of aircraft is anticipated by the end of the present decade, making use of new technologies such as turbo-fan engines and aircraft of the augmented wing design and new forms of V/STOL. There will be a continuing need for development in all parts of the system, particularly in meeting improved noise level specifications.

A number of trends are discernible in transportation developments, which indicate that the STOL Air Transport System will have a major role to play in solving world transportation problems. The lead which Canada already has in the development of aircraft of this type could be used to advantage in the promotion of a major program of research and development with the object of giving the Canadian aircraft industry a significant role in these new developments. Some of the factors or trends supporting the promotion of STOL systems are listed below.

1.1 Quality of the Environment and External Costs

There is an increasing public concern with the quality of the environment and with the harmful effects of technology, which has resulted in the U.S. in a call for "technology assessment". The noise, pollution, congestion, questionable land usage and ugliness associated with the expansion of the automobile-highway system and similar problems associated with larger and faster conventional aircraft systems, are sometimes referred to as "external costs" and they raise questions of the validity of extrapolating these types of technological growth into the future. It is questionable whether the benefits provided by supersonic flight, high-capacity jumbo-jets and multilane super-highways sufficiently justify the degradation of the environment and the problems of congestion which they create. Alternatives are being sought, and the dedicated promotion of technology for its own sake is being halted. The alternative for inter-urban travel in the congested areas of North America appears to be a combination of high-speed ground transportation and a STOL Air Transport network. For STOL to qualify, it must not only justify its claim of low noise levels, but demonstrate that these levels meet with public acceptance. The full process of technology assessment must be applied to STOL systems to determine, not only the benefits they can contribute to society, but the problems they may create. In addition to noise and pollution, the problems of reliability and comfort in adverse weather conditions and that of airway congestion should be evaluated.

Any form of mass transportation has inherent external costs built into the system and these costs vary from one situation to another using the same system. The STOL system offers relatively low external costs on all counts except perhaps that of noise. With the careful location of STOL ports, the use of water approaches and of industrial barrier areas, these costs can be held to a minimum pending further developments on noise abatement.

1.2 Regional Development

The principle of the STOL transport system is one which has a number of important implications for the type of regional expansion which many consider desirable in both Canada and the U.S. In recent years the tendency in aircraft development has been towards faster, larger and noisier aircraft requiring large airports with long landing strips. Such facilities can only be justified in major urban centres. This trend has in itself created a problem relating to public acceptance and a demand for further expansion of such airports to be curtailed and for new airports to be removed to greater distances from urban settlements. At the same time there has been a growing popularity of air travel amongst those who travel, both for business and pleasure.

The consequence of all this has been the stimulated growth of major urban centres and an increasing problem of airport access times. Extrapolation of trends in population growth into the future will inevitably show the growth of existing cities and their associated airports, with a need for high speed links between airport and city centre. A more attractive alternative, in which a change in the transportation system would affect patterns of urban and regional growth, might be found in a moderate-capacity, dispersed, transportation system, as opposed to a high-capacity, spinal system.

The STOL system would appear to offer this alternative. By delaying the expansion of the larger airports, which cover thousands of acres and by promoting a system of STOL ports, requiring no more than 50 acres each, it would be possible at a relatively modest cost to give equal travel opportunities to those who dwell in both large and small cities. In contrast with the more permanent "spinal" system of transportation, a dispersed system, such as that which could be provided by STOL, would be flexible and able to adapt to regional development; it could also handle high-density, short-haul traffic from STOL ports in and around metropolitan areas. The optimum mix of modes in the future may well be a mixture of advanced high speed ground transportation (spinal) and STOL transportation system.

1.3 Northern Transportation

Although this is perhaps part of regional development, there is a distinct market for STOL Systems in the Canadian North. This has been assessed in the Northern Transport Model developed by the Institute for Aerospace Studies[5], where it is shown that the increased aircraft costs must be balanced against the decreased ground installation costs in evaluating the STOL system application in the North. The flying distances involved and the cargoes carried are also significant. As the potential mineral wealth of the North is developed, it is expected that the increasing number of mine sites, well heads and pipeline stations will contribute greatly to the attractiveness of STOL. A modification of the low-noise version of the aircraft, used in high population densities, may be necessary for greater efficiency in the northern application.

1.4 Relief of Airport and Airways Congestion

Apart from the obvious relief which STOL ports would provide for conventional airports, it is proposed that they would make use of separate airways and air-traffic control systems, thus promoting greater safety in aviation in general. The existing air-traffic control systems, en route and in the terminal areas, would then be able to handle the normal increases in long-haul traffic in a safe and expedient manner.

The U.S. Civil Aeronautics Board, Northeast Corridor VTOL Investigation, in its initial decision served on February 2, 1970, concluded as follows:

> "A new, additional air service between major cities in the Northeast Corridor, to be provided by STOL, VTOL and V/STOL aircraft using central city landing sites and sites in densely populated suburban areas is technically and economically feasible and it will fill a pressing need to reduce congestion and delay, and enhance the quality of air transportation in these markets."

and later, September 8, 1970:

> "...we find the evidence in the record more than ample to support the examiner's conclusion that metroflight(VTOL, V/STOL or STOL) is both necessary and feasible.... ...we urge municipal and other parties to submit more detailed data on suitable landing sites, including locations, field and terminal design, parking facilities, access roads, cost estimates and plans for funding...."

Air traffic congestion is beginning to result in significant losses to the economies of major cities. It has been estimated that the loss to New York City's economy in 1975 due to air traffic congestion will be $200 million. While the U.S. problems have not hit Canada to the same extent, metro Montreal and Toronto are beginning to experience problems, in particular, noise and access to airports. Canada has an opportunity to build a model system of conventional and STOL airports.

1.5 A Canadian System

Perhaps the greatest potential for STOL, in the Canadian context, lies in the opportunity to develop an all-Canadian system, with all the economic advantages associated with the strengthening of high-technology industries. This would involve not only the aircraft, but the whole system, including communications, radar, air-traffic control, airports, ticketing, passenger handling and other supporting services. These need not follow the pattern set by conventional aircraft and airports, but their development would provide many opportunities for innovation, particularly in improving safety, reliability, quality of service, and inter-modal transfer efficiency. To establish a pattern of reliable and efficient operations in STOL systems would be to identify STOL as a Canadian development, which would promote Canadian participation in similar developments abroad. Although it would be naturally desirable to utilize a Canadian aircraft in the initial stages, the idea of a Canadian system does not necessarily preclude the use of a more advanced type of aircraft of non-Canadian design at a later stage of STOL development. It is perhaps more important that Canada become identified with the system rather than the vehicle, and that Canadian industry participate in more advanced STOL aircraft programs as plans develop.

Canadian industry has at present a recognized competence in small aircraft development and avionics, but it does not have the resources to compete with the large U.S. companies on the larger and faster aircraft being developed for long distance air travel. (See references 1, 4 and 5). The air industry must find a specialized market if it is to survive, retaining a degree of independence and producing a product which is distinctly Canadian in both design and production. The STOL Air Transport System is an opportunity tailored to this requirement and it is one which is unlikely to occur again.

The Science Council report on Aeronautical Research and Development in Canada has already pointed to the strength which exists in the avionics industry and the need for continued support. A STOL Air Transport System would encompass a large area of avionics and would certainly provide the challenge and support needed in this industry.

An article in the March 7, 1970, issue of Financial Post, referring to the member companies of the Air Industries Association of Canada, said that "the ninety companies with their 44 thousand employees, had sales last year of $681 million ($475 million of them exports) which marked a decline of 12 per cent from 1968. Nothing in the immediate future indicates this declining trend will be reversed." A Major Program in STOL Air Transport has all the potential to reverse this trend!

1.6 The Canadian Application for STOL

The immediate application of STOL in a Canadian situation may lie in the heavily populated corridor areas between Quebec and Windsor and, in particular, between Toronto and Montreal. This situation is assessed in a recent systems analysis of the corridor undertaken by the Canadian Transport Commission[3]. Preliminary results indicate that the STOL system is a prime contender, based on financial considerations alone, of maximum return on investment with minimum capital outlay.

Quite apart from the corridor study being undertaken by the CTC, there may be other Canadian situations where STOL would be applicable. The acceptance of a corridor study is in itself a denial of the importance of regional development. A study of a complex of cities which could form centres in a STOL network should also be considered (e.g., Sherbrooke, Peterborough, Kingston, Ottawa, Waterloo, Sarnia, Sudbury might be included). In a study of this nature some weight would have to be given to the advantages of a pattern of regional development which could be promoted by such a service.

Other potential air routes for early development of STOL services may lie on the West Coast between Vancouver, Victoria and Seattle.

1.7 The U.S. Application for STOL

The results of the U.S. Northeast Corridor study indicate that STOL would be a competitive and viable mode of service, but that demonstration services are necessary in order to determine the degree of public acceptance. The choice of aircraft for the first demonstration run could be a crucial factor in the eventual acceptance of STOL as a regular transportation service. At this stage it is difficult to forecast the demand, although studies of air and highway modes[2] have indicated that by 1975 the potential annual passenger-miles for STOL will approach 3,000 million and that operator expenditures of $200 million per annum would produce a competitive system in the Northeast Corridor.

Once the STOL system was accepted in a situation such as the Northeast Corridor, there is a possibility that it could be extended to other areas of the U.S. Studies have already been made by the FAA and the CAB related to the corridors Minneapolis-Chicago-St.Louis-Dallas, and the high density routes between San Diego-Los Angeles and San Francisco.

1.8 The International Outlook

The opportunity for Canada to benefit from a Major Program on the STOL Air Transport System has been made even greater by the recent Canadian-U.S. agreement to cooperate more closely in research into common transportation problems. This agreement, signed on June 18, by Transport Minister Donald Jamieson and U.S. Secretary of Transportation John Volpe, calls for immediate cooperative research efforts in five specific areas:

(1) vertical and short take-off and landing air transport design, demonstration and operation;

(2) high speed ground transportation on intercity corridors;

(3) air-traffic control and airways navigational aids equipment development and supply;

(4) demand forecasting and information systems; and

(5) transportation safety related to all modes.

The background notes provided with the memorandum of agreement indicated that an international air service, flown by STOL aircraft, may be one of the research projects undertaken under the agreement. The notes stated that "the Canadian Ministry of Transport and the U.S. Department of Transportation will therefore collaborate to seek solutions to the problem of STOL service certification and on investigating the viability of a STOL experimental service." At the present time, Canada is in the best position to supply the aircraft for such an experimental service.

In their search for a situation where a demonstration STOL service could prove its worth under favourable conditions, there are some indications that the U.S. Department of Transportation might consider a joint U.S.-Canadian service. The most favourable situations are to be found in large, high density urban areas, and New York City is a prime contender. However, because of high land values and public antipathy towards new STOL ports in built-up areas, it is conceivable that interest might shift to cities with water approaches and existing STOL ports (or the equivalent) such as Toronto, Cleveland and Chicago. As New York is the key to the Northeast Corridor STOL services, the FAA, City planners and major airlines are examining all STOL port alternatives, including floating STOL ports and STOL ports built over abandoned piers on the Hudson River.

1.9 Aid to Developing Countries

In Canadian aid to developing coutries, the STOL aircraft could play a significant role. The Canadian International Development Agency (CIDA) is the agency involved; they have provided figures on aid, relating to aircrafts, airports and navigational aids, which indicate that the bulk of this assistance goes to the Caribbean and to the Asian countries.

Out of a total of approximately $28 million for airport and aircraft systems during the current year, approximately $15 million will have been spent on relatively small aircraft of the STOL type together with spares (Twin Otters and Caribous). The remaining $13 million was primarily, although not entirely, spent on major airports.

There seems to be every indication that STOL aircraft have a role to play in the progress of many developing countries. Where internal transportation is of a major significance for development, as in Indonesia, there is a demand for STOL aircraft. Should Canada undertake development of complete STOL systems as a Major Program, the hand of CIDA would be considerably strengthened if this agency were able to offer appropriately sized, complete, STOL-system "packages" to developing countries. Those countries which rely heavily on a tourist trade, brought in by large conventional jets, often as "package tours", have received aid in the past in the form of support for major airports, but their future growth will no doubt be related to internal and local transportation, for which STOL would appear to be a leading contender.

2.0 The Limitations of STOL

An evaluation of the STOL system would be incomplete without some estimate of the limitations and inherent problems associated with this type of aircraft.

2.1 Noise

The questions of noise and steepness of approach in landing and take-off are intimately related. Is 95 PNdb at 500 feet acceptable, and if so, will higher noise levels be tolerated immediately below the initial take-off path?

2.2 Air Pollution

In constricted downtown areas, the exhaust fumes from the take-off and landing of STOL aircraft may present a problem. This should be balanced however against equivalent pollution from the turbo-train with the same number of similar engines.

2.3 Reliability and Comfort

In meeting the rigid demands on noise level and short take-off distance, there will presumably be some trade-offs in the maximum altitude, which in turn will affect the comfort level in poor weather conditions.

2.4 Air Congestion

The promotion of intercity travel by STOL will inevitably lead to congestion of the airways, which, despite separate and improved control systems, may present problems.

2.5 Public Acceptance

The public reaction against the noise and pollution associated with conventional airports will probably be directed against the quieter and smaller STOL ports, however irrational the arguments may be.

Another aspect of public acceptance relates to that segment of the public which has never considered air travel as an acceptable means of transportation and which will always demand an alternative mode.

2.6 Institutional Weaknesses

The Canadian aircraft industry is small compared with the international competition and individual companies are themselves parts of multinational corporations with little authority for independent action. This creates difficulties in mounting an all-Canadian united effort in the unified control and management of a national program. If STOL systems were to prove successful, there is little doubt that very strong competition would develop in the U.S. for the second round of aircraft of the augmented-wing type. A demand for larger, more sophisticated aircraft in large quantities could not be met by the Canadian aircraft industry at present, which must limit itself to small or medium sized aircraft to meet specialized requirements. However, if Canada is successful in producing aircraft for the first-generation STOL, in an all-Canadian effort (DHC-7 size), then the Canadian industry could participate in later STOL programs as part of an international consortium or as a major subcontractor.

3.0 The Opportunity, Potential Market and Required Investment

A study carried out by an interdepartmental committee on the de Havilland STOL Aircraft Program (with membership from the Department of Industry, Trade and Commerce, the Ministry of Transport and the Canadian Transport Commission), but not yet released, has concluded that de Havilland's proposed 48 passenger, four-engine, turbo-prop aircraft, the DHC-7, is the only aircraft of its size, or larger, that could be available in the next three to five years which would meet the generally accepted noise criteria for city-centre operation. (95 PNdb at 500 feet) Here lies the opportunity to pioneer a new field and produce a major component of the STOL Air Transport System in Canada and thus improve the chances of an all-Canadian system and of the implementation of the results of Canadian R & D work in more advanced components of the system.

The Science Council has neither the staff nor the resources to carry out a thorough market survey on STOL systems and to assess the investment opportunities. These are, of course, key issues in any major decision on STOL. An attempt has therefore been made, with the full cooperation of the departments concerned, to summarize the information which is already available on these topics, and the results are given below.

The best available estimate of the future market for STOL aircraft comes from the U.S. Federal Aviation Administration (FAA), which made projections, approximately two years ago, for the world demand for STOL aircraft of the de Havilland DHC-7 type of between 1,100 and 1,200 aircraft. It is estimated that de Havilland could expect orders for approximately 500 of this number. The market appears to exist, but the timing is the crucial factor. Orders for aircraft from the airlines, or a decision on

STOL ports by the FAA, would no doubt signify that the time had arrived. Some activity, such as the requests for proposals (RFP) on Buffalo aircraft by American Airlines for experimental services, the RFP for a common civil-military aircraft and the RFP for STOL ports, is already taking place. In the meantime, the U.S. aircraft manufacturers are beginning to show an interest in STOL as their backlog of orders for conventional and military aircraft is reduced. The main interest of Boeing and Douglas is focused on a second-generation, jet-STOL (120-150 seat) aircraft to replace the 727 and DC-9.

A recent consultant study sponsored by the Ministry of Transport indicates a potential demand for between 70 and 80 STOL aircraft of the DHC-7 type by 1980, to service the major Canadian, intercity, high-density routes, including trans-border operations and intercity, low-density routes. DHC-7 size, STOL aircraft can be transferred to new developing areas as second-generation aircraft take over high-density routes.

SAAB have estimated that the share of the world market gained by the DHC-7 STOL aircraft would be 800. de Havilland have stimated 480 as their share, but they did not include South America in their market survey. The Department of Industry, Trade and Commerce estimates that de Havilland's DHC-7 could obtain orders for 300 to 500 aircraft. This would amount to sales of $600 to $1,000 million, of which $440 to $840 million would be export. The advantage of being "first" in the marketplace with the right aircraft is clearly signficant and would increase the chances of achieving the higher sales figure.

The amount of government assistance to STOL system manufacturers has amounted to a total of approximately $35 million, of which $26 million went to de Havilland, most of it for development (Caribou , Buffalo. Twin Otter and DHC-7).

To produce two prototype aircraft, a total investment of between $30 and $33 million would be involved, with an additional sum of $10 million to conform to FAA certification (all figures very approximate). Assuming that a market has been established for the DHC-7, it is estimated that the peak investment would be between $75 and $80 million, to design and develop the aircraft alone and put it into production at an initial rate of four aircraft per month. These figures refer to total costs and not just the government contribution.

A full evaluation of the costs for other components of the STOL system have yet to be completed and it would probably require a fully funded contract to obtain all the figures. Individual STOL ports (exclusive of land costs) would be of the order of $5 million and probably five would be required initially, giving a total of $25 million. The costs of developing the avionics, control systems and other supporting services have not been calculated, but an approximate figure of $50 million is advanced here.

From these rough estimates it is apparent that the total net investment required, to produce four aircraft per month and provide a fully equipped and independent demonstration service, would peak at about $150 million.

4.0 Organization

The adoption of the STOL Air Transport System as a Major Program would present certain organizational problems which are peculiar to STOL. The system involves a number of components, aircraft, STOL ports, navigational aids, air-traffic control, inter-modal facilities and other supporting services. None of these can be developed without the concurrent development of all the other components of the system.

There is clearly a primary role for the federal government in making a commitment to the STOL Air Transport System and promoting simultaneous development of all the components of the system. This could be done by identifying a demonstration service, providing financial support both for research and development and for supporting STOL facilities and by actively promoting the establishment of STOL regulations at both the domestic and international level. As the goals of a STOL program will involve more than one government department, there will be a need for a project office or agency, with the necessary authority and resources, to be made clearly responsible for the management of the program. Such an office or agency might include elements from the private sector.

The provincial and municipal levels of government must be involved at an early stage in any program, as their approval will be required in the implementation of STOL services. They should participate in the full process of technology assessment. A program of public relations directed at informing the public of the nature of STOL, its potential benefits and role in future transportation developments will probably be necessary in winning public acceptance of the system.

Finally, as already mentioned above, the structure of the Canadian aircraft industry is in itself a problem. All the skills required for the success of a Major Program in STOL Air Transport Systems are available in Canada, but they do not reside in any one company. The industry is small compared with the international competition and individual companies are themselves parts of multinational corporations. In marketing internationally, a conflict of interest will inevitably arise between the Canadian subsidiary's desire to sell a Canadian product and the parent company's desire to optimize operations internationally, once a market has been established. A consortium of companies with both legal and financial ties and a common systems analysis group has been proposed and may well be the solution. In any large scale support of STOL development by the federal government, however, it would be necessary to guard against the consortium of convenience and to ensure that the economic benefits achieved were predominantly Canadian. If this could not be achieved by working through the existing industrial structures, or proposed consortium, some more active participation by the government through an organization such as the Canadian Development Corporation might be appropriate. Consideration should also be given to utilizing government purchasing power in promoting a bilateral agreement between Canada and either the U.S. Government or one of the larger U.S. aircraft companies. This would enhance the marketing and production facilities of Canadian companies in STOL and enable a complete system to be developed and produced in Canada in exchange for an agreement on other systems.

A major commitment to the STOL system should only be made in close association with the development of conventional airports. Consideration might be given to the eventual restriction of conventional jet aircraft to intercontinental and trans-continental flight, thus limiting the growth of the larger airports. In plans for new airports or extensions to existing airports, the strategic location of a STOL port should be given priority. The operation of STOL Air Transport System should be an activity separated administratively from conventional airline services and given the opportunity to demonstrate improved benefits in both service and economy.

5.0 Canadian Sources of Information on STOL

During the period of the last twelve months, over which the Science Council Committee on Transportation has been studying the question of major programs in transportation, other organizations have been carrying out studies on STOL and related topics. Many of these organizations have provided informal input to the committee, but their reports are only now being released for circulation or publication. The following provide valuable information on STOL Air Transport Systems and should be used for more detailed technological assessment of the system.

(a) Special Study on Aeronautical R & D in Canada for the Science Council(1)

This study, recently completed for the Science Council, examines possible future programs for aeronautical R & D in Canada and lists one of these as V/STOL Aircraft as a Total System. It suggests that the C/STOL aircraft is an interim solution to the problem of highway and airport congestion, during the period in which VTOL matures, but emphasizes the total system approach and concedes that "...the pure VTOL development may not be essential to a portal-to-portal system..." The report recommends that attention be given to the non-vehicle elements of the system, such as navigation aids, approach aids and STOL-port criteria. Areas for effective research and development are indicated and include propulsive systems, noise abatement and a long range program utilizing direct lift or vectored thrust as a total system. Recommendations of the report on an active V/STOL development program are based partially on research capabilities in Canada, which give this country a leading position.

The facilities and competence of the National Aeronautical Establishment and the Institute for Aerospace Studies are specifically mentioned.

(b) The Intercity Passenger Transport Study of the Canadian Transport Commission[3]

An evaluation is made of the transportation needs of the Windsor-Quebec Corridor over the next twenty years and alternative ways of meeting these needs are assessed in terms of new technology and investment decisions. Although the final report has not been officially released at this time, it draws some preliminary conclusions. The major conclusion is that to improve intercity passenger service between Toronto, Ottawa and Montreal, massive investment in conventional railway systems is not justified. The best returns would be obtained by modest improvements to existing equipment of the Turbo or Advanced Passenger Train variety. The report also recommends more detailed investigation of STOL and TACV (Tracked air-cushion vehicle) technologies. In the body of the report a detailed analysis of various transportation development strategies are made and it is here that the STOL Air Transport System shows up as a viable system with low initial investment.

(c) Report of the Interdepartmental Committee on the de Havilland STOL Program[4]

This committee, with membership drawn from the Department of Industry, Trade and Commerce, the Ministry of Transport and the Canadian Transport Commission, has coordinated and compiled a number of studies in order that recommendations can be developed for a government position towards the de Havilland DHC-7 program in particular, and the future of STOL in Canada in general, both from the points of view of the aircraft industry and the national transportation system. Again, this report has not been released at this time, but its conclusions generally favour a national STOL program with the de Havilland DHC-7 as a component of the first-generation system. Detailed analyses of the technological environment, regulatory climate, competitive systems, Canadian demand and an export market analysis are provided.

(d) Report of the Institute for Aerospace Studies, University of Toronto, on STOL Technology(5)

The Institute has recently produced two very comprehensive reports. "An Assessment of STOL Technology" and "A Bibliography of STOL Technology", for the Canadian Transport Commission. The assessment provides operational models designed to calculate the traffic attracted to a STOL system in various situations. It also makes an assessment of STOL impedances and makes recommendations on research programs.

6.0 Assessment of STOL on Science Council Criteria for a Major Program

The STOL Air Transport System meets the criteria for a Major Program established by the Science Council in Report No. 4 "Towards a National Science Policy for Canada". The seven criteria (listed in Appendix I)have been applied to STOL in a detailed assessment and the results are as follows:

1. The objective of the STOL system is of real importance to Canada, as it has the potential in the short term to provide an improved and viable means of transport between major urban centres in the densely populated Quebec to Windsor corridor. The STOL system would provide shorter total trip time and lower noise levels than conventional air transport systems. In addition, it offers the flexibility, for the long term, to provide improved transportation to smaller regional centres, as well as to less readily accessible centres in Canada's north. The STOL system requires lower investment in airport facilities due to the short landing strips, and has the further advantage of not requiring large amounts of capital in rail, guideway and highway rights-of-way.

2. The STOL Air Transport System does not, as yet, duplicate major programs underway in other developed nations, as Canada is a leader in this technology, and other developed nations have been preoccupied with military and large, high-speed, jet aircraft. de Havilland has a world-wide reputation for aircraft with short take-off capability; Canadair has development experience in its tilt-wing, vertical and short take-off and landing aircraft (V/STOL); Douglas has experience in the building of

large air frame components, United Aircraft in engines, and others have capabilities in avionics.

3. There is a demonstrable prospect of direct social and economic benefit, since STOL air transport will provide improved overall national service of use to all regions in Canada, reduce noise (over present jet aircraft), retain and employ highly skilled technical manpower in Canada, encourage the development of new Canadian technology-based industry, provide increased exports, and develop technology and equipment of real value to the world's developing nations. The application of the STOL system could be integrated into our CIDA program.

4. The scientific and technological challenges are fundamental and far-reaching enough, inasmuch as highly-sophisticated, precision equipment and systems are required to establish the demanding air navigation, air traffic control, meteorological and instrument-landing systems which would provide safe, reliable, all-weather operation to and from the very short-length landing strips. In addition, specialized runway and terminal construction and equipment, passenger handling techniques, lighting and emergency and servicing equipment will have to be developed. Development and engineering progress by the Canadian aircraft industry to date indicates that tangible progress can be made within a reasonable time span.

5. The development of a STOL Air Transport System will challenge technologies over a broad, varied and open frontier, and will

involve various engineering, physics, mathematics and electronics disciplines to reach its objectives. The recent addition of a $6 million, low-speed, aerodynamics tunnel at NRC is an example of the supporting services already provided. In the academic year 1968-69, the Universities of Toronto (including their Aerospace Institute), McGill, Laval, McMaster, Waterloo, Carleton, Manitoba, Alberta and British Columbia all had grants in support of aeronautical research, which totalled $794,000 and involved thirty faculty members and 132 graduate students and post-doctoral fellows.

6. The program must be mounted on a large financial scale so that the various R & D groups will be of above-critical size. The STOL aircraft program has been supported by $30 million in federal funds to date, and a further program to develop a 48-passenger de Havilland DHC-7 STOL aircraft to the point of aircraft certification is estimated to cost $44 million. The Department of Industry, Trade and Commerce has estimated a peak gross launching cost of $75-80 million for aircraft alone. This cost is based on the production of four aircraft per month. The cost of individual STOL ports (exclusive of land costs) would be of the order of $5 million, with possibly five required ($25 million), but the cost of developing the avionics and control systems can only be estimated very approximately at present (approximately $50 million). This involves a maximum total investment of $150 million.

7. The choice of the program is based on a conjunction of need and of scientific and technological opportunity. Canada has the need for improved transportation service between major

urban areas, regional urban centres and for the developing north. The technological expertise in designing aircraft with short take-off and landing capability has already been demonstrated. In addition, the Science Council Special Study on Aeronautical Research and Development in Canada has concluded that a program of R & D in commercial V/STOL aircraft could bring into focus the efforts of government, industry and the universities in establishing a national objective. Within the framework of this objective major contributions could be made to Canada's technological progress, industrial competence, transportation efficiency, and export capabilities.

7.0 Conclusions

The growth of large areas of relatively high population density, sometimes referred to as "megalopolis" in the developed countries of the world, is creating a demand for new modes of mass transportation, which will relieve the congestion, noise and air pollution associated with many of the existing systems. In the long run, some form of high-speed ground transportation offers the greatest over-all benefit, but the economic viability of such high-capital ventures will not be achieved until high-volume traffic is developed, which, for Canada, will be a matter of at least two or three decades. In the U.S. there are indications that the high-volume traffic is available, but institutional barriers will delay the extensive application of high-speed ground transportation. The STOL Air Transport System offers a contribution to the over-all solution, which could be brought into operation without heavy capital investment.

STOL systems have the inherent capability to promote regional development. There will be an intermediate period of two or three decades between now and the introduction of economic, high-speed, ground transportation systems and, during this period, patterns of regional growth could develop which would otherwise be prevented by the immediate application of "spinal" system of transportation.

A STOL Air Transport System satisfies the requirements of a Major Program suggested by the Science Council. There is an urgency to implement the program because of the technological lead which Canada now holds and the potential market available which would support the air industries in Canada and provide a rare opportunity to produce a

Canadian system.

The degree of public acceptance of STOL and the size of the export market available are the two primary unknowns in the analysis of the STOL system. Demonstration services on selected routes appear to be an essential step in any further promotion of the system. Ideally such a demonstration service should be a joint U.S.-Canadian venture, as a major market for STOL lies in the U.S. and provision has been made for such cooperative action in the recent Canadian-U.S. agreement to cooperate in transportation research. The importance of timing, however, is such that failing agreement on a joint service, a Canadian demonstration service should be considered.

Provincial and municipal governments must be involved in the program at an early stage, as STOL systems are intimately connected with the planning of these levels of government.

There are organizational and management problems associated with the launching of a Major Program on a STOL Air Transport System. These require that industry organize itself, with or without government participation, into a viable consortium to accept public support of the system and that the government designate an agency or project office to organize the public participation and administer the funds made available.

The funding of the program should be done over a period of 3 to 5 years in two ways:

a) Step-by-step funding to the extent of $150 million with a formula for recovery in the event of success.

b) Fully-funded contracts on feasibility studies and long-term developments, directed at maintaining a Canadian lead in the initial system and in future generations of the system, amounting to about $15 million per annum.

Detailed recommendations resulting from this assessment are listed at the beginning of the report in Section I, as steps for immediate action and qualifications for implementation.

8.0 References

1. Science Council Special Study No. 12, 1970, "Aeronautics - Highway to the Future".

2. Northeast Corridor Transportation Project, Summary and Status, U.S. Office of High Speed Ground Transportation, August, 1969.

3. Intercity Passenger Transport Study, Canadian Transport Commission, Research Branch. (available in 1971).

4. Report of the Interdepartmental Committee on the de Havilland STOL program (unpublished).

5. "An Assessment of STOL Technology" and "A Bibliography of STOL Technology", Institute for Aerospace Studies, University of Toronto, July, 1970, prepared for the Canadian Transport Commission.

APPENDIX I

Science Council Criteria for Major Programs

(1) The objective selected for each major program must be of real importance to Canada, and perhaps even peculiar to Canada. Each should be such that the solutions would cope with problems posed by Canadian conditions—of climate, of organizational structure, or of availability of resources—and some of them should offer prospects of being more generally applicable in other areas of the world.

(2) No major program should duplicate work already under way in other developed nations. Rediscovering technology is expensive and pointless. If a problem for example is of great importance to another nation which has already set out to find a solution, Canada should attempt to learn from the other efforts by importing the technology being developed rather than squander much-needed resources by repeating work already done elsewhere.

(3) There must be some demonstrable prospect of direct social or economic benefit which in an overall view would be commensurate with the resources invested. The concept of social needs can be extended to encompass Canada's obligation to contribute usefully to the progress of the world's developing nations.

(4) The scientific and technological challenges must be fundamental and far-reaching enough, that they will not be quickly exhausted, and yet in general not so far-out that there is little hope of tangible progress with time spans of ten or twenty years. The challenge must stimulate genuine innovation, and it must be sustained consistently over a long enough period that manpower training sources respond and adapt, and new industries both come into being and get established on a viable footing.

(5) The unpredictable quality of research and the openendedness of the future must be clearly recognized. The programs should be regarded as campaigns to open up new opportunities. They should therefore challenge technologies over a broad, varied and open frontier rather than proceeding down a narrow and confining lane. Skills, capabilities, and organizations will thus be brought into existence in readiness to exploit breakthroughs and inventions, made in Canada or elsewhere, in the most opportune ways. Particular projects within the broad program areas should be chosen more as stepping stones to future positions of advantage or readiness, than as fixed goals not subject to revision.

(6) Not only does a program need to be sufficiently sustained in time, if it is to be effective in building new industry and in supporting new ideas through the complete cycle to practical innovation, but it must be mounted on a sufficiently large financial scale that the various R&D groups formed to attack the special problems will be of above-critical or viable size, and will have reasonable prospects of a steady diet of challenging projects within their range of competence.

(7) The choice of a program should be based on a conjunction of need, and of scientific or technological opportunity. Thus a major program to develop atomic energy for power generation would have been premature in 1920, when there was no felt shortage of power from hydro plants or coal, and before the necessary basic discoveries in nuclear physics had been made. Further, the potential innovative fertility of the program area must be considered, since the benefits from the unexpected and unpredicted discoveries and opportunities may well exceed the benefits from those outcomes that could be predicted at the start.

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