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THE AIR ARSENAL OF THE BRITISH COMMONWEALTH: AIRCRAFT DESIGN AND DEVELOPMENT IN CANADA DURING THE SECOND WORLD WAR, 1939-45

By

Martin F. Auger

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Canada

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ABSTRACT

The Canadian aircraft industry made an important contribution to Allied victory during the Second World War. Between 1939 and 1945, Canada produced 16,418 aircraft and ranked as the fourth largest Allied manufacturer of aircraft. But this achievement overshadowed the fact that only five per cent of Canada's total wartime output was made up of domestically developed aircraft types. The bulk of production consisted instead of American and British aircraft designs manufactured under-license. In spite of this, several Canadian government officials and aircraft manufacturers attempted to initiate the development of new aircraft types domestically to meet the specific requirements of the Royal Canadian Air Force and several Canadian airlines.

The purpose of this study is to examine aircraft design and development efforts in Canada during the Second World War. Between 1939 and 1942, a few Canadian aircraft manufacturers and government officials tried to encourage the development of military aircraft and gliders in Canada, but these endeavours proved unsuccessful. Despite these early setbacks, in 1942, the Canadian government began considering ways to strengthen the aircraft industry by improving its design and development capabilities. This was particularly important if Canadian aircraft companies were to successfully compete against foreign manufacturers in postwar markets.

The creation of the Committee on Postwar Manufacture of Aircraft in 1943 testified to the determination of the government to prepare the industry for the postwar years. The committee's ultimate aim was to initiate the design and development of aircraft that could have both commercial and military applications, namely trainers and transports. Unfortunately, there were many divisions between different interest groups as to where to devote time and resources. As a result, the Department of National Defence for Air decided to take matters into its own hands in 1944 and issued formal postwar requirements for two ambitious aircraft projects to be developed in Canada: a twin-engine aircrew trainer and a jet fighter. In the end, although few aircraft of indigenous design were produced in Canada during the Second World War, these efforts helped the Canadian aircraft industry prepare for postwar needs and culminated in a series of innovative indigenous aircraft programmes in the early Cold War.

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ACRONYMS

ACAR	Associate Committee on Aeronautical Research (NRC)
AMAE	Air Member for Aeronautical Engineering
AMAS	Air Members for Air Staff
AMES	Air Member for Aeronautical Engineering and Supply
AMO	Air Member for Organization
AMOT	Air Member for Organization and Training
AMP	Air Member for Personnel
AMRD	Air Member for Research and Development
AMS	Air Member for Supply
AMSO	Air Member for Supply and Organization
AMT	Air Member for Training
AOC	Air Officer Commanding
ASW	Anti-Submarine Warfare
A/V/M	Air Vice-Marshal
BCATP	British Commonwealth Air Training Plan
CAA	Canadian Associated Aircraft Limited
CAC	Commonwealth Aircraft Corporation (Australia)
CAE	Chief Aeronautical Engineer
CARDE	Canadian Armament Research and Development Establishment
CAS	Chief of the Air Staff
CBC	Canadian Broadcasting Corporation
CCF	Canadian Car & Foundry Company Limited
CGS	Chief of the General Staff
CNR	Canadian National Railways
CPA	Canadian Pacific Air Lines
CPMA	Committee on Postwar Manufacture of Aircraft
CPR	Canadian Pacific Railways
CWC	Cabinet War Committee
CWM	Canadian War Museum
CWTS	Cold Weather Test Station (NRC)
DAD	Director of Aircraft Development
DAE	Director of Aeronautical Engineering
DAP	Director of Air Personnel
DAP	Department of Aircraft Production (Australia)
DARD	Director of Air Research and Development
DAT	Director of Air Training
DEA	Department of External Affairs

DGAP	Director General of Aircraft Production (DMS)
DGR	Director General of Air Research
DHC	De Havilland Aircraft of Canada Limited
DHH	Directorate of History and Heritage
DHP	De Havilland Proprietary Limited (Australia)
DMS	Department of Munitions and Supply
DND	Department of National Defence
DND (Air)	Department of National Defence for Air
D of F	Department of Finance
D of T	Department of Transport
DPB	Defence Purchasing Board
DRS	Department of Reconstruction and Supply
DSR	Director of Scientific Research (MAP)
HP	Horsepower
JAG	Judge Advocate General
LAC	Library and Archives Canada
LBS	Pounds
MAP	Ministry of Aircraft Production (Great Britain)
MPH	Miles per Hour
MIT	Massachusetts Institute of Technology
MMS	Minister of Munitions and Supply
MND	Minister of National Defence
MND (Air)	Minister of National Defence for Air
M of F	Minister of Finance
MRS	Minister of Reconstruction and Supply
NACA	National Advisory Committee for Aeronautics (United States)
NAM	National Aviation Museum
NRC	National Research Council of Canada
NSC	National Steel Car Corporation Limited
OCA	Ottawa Car and Aircraft
OSRD	Office of Scientific Research and Development (United States)
PCO	Privy Council Office
PJBD	Permanent Joint Board on Defence
PMO	Prime Minister's Office
RAE	Royal Aircraft Establishment (Great Britain)
RAF	Royal Air Force
RAAF	Royal Australian Air Force
RCAF	Royal Canadian Air Force
RCMP	Royal Canadian Mounted Police
RCN	Royal Canadian Navy
RN	Royal Navy
RNZAF	Royal New Zealand Air Force
SAAF	South African Air Force
SAO	Senior Air Officer
STOL	Short Take Off and Landing
TCA	Trans-Canada Air Lines

TsAGI	Tsentral'nyi Aero-Gidrodinamicheskii Institut — Central Aero and Hydrodynamic Institute (Soviet Union)
TsKB	Tsentral'noe Konstruktorskoe Byuro — Central Design Bureau (Soviet Union)
USAAC	United States Army Air Corps
USAAF	United States Army Air Force
USAF	United States Air Force
USN	United States Navy
VAL	Victory Aircraft Limited
VCGS	Vice-Chief of the General Staff
VSA	Vancouver Sales & Appraisals Limited
VTOL	Vertical Take Off and Landing
WSB	War Supply Board

INTRODUCTION

> The fundamental background of our problem is that we shall be operating both overseas and at home with the British or Americans. The British have standard equipment and so have the Americans. There would be a grave danger in attempting to create a Canadian standard. We have the choice of adopting British or American standards. Thus original design in respect to complete equipments is not our responsibility unless we are developing something for either one of our big neighbours. Our problem of design is restricted to adaptations. We re-design certain commercial products to fit requirements. We alter certain features of British design equipment in order to expedite production and we change the design of certain American products to meet Canadian practice or to expedite production. Our major problem is to produce and not to design ... We must produce munitions and equipment that will be acceptable. We must, therefore, produce our major items of armament and equipment to British or US standards with such acceptable changes as will expedite production and give better or equal performance.[1]
>
> — Brigadier Kenneth Stuart, VCGS

Canada made an impressive contribution to Allied victory during the Second World War. When the Canadian government declared war on Nazi Germany on 10 September 1939, the country's armed services were in a decrepit state following decades of military budget cuts. They were dangerously ill-equipped and under-strength with less than 10,000 soldiers, sailors, and airmen. By contrast, when the war officially ended on 2

September 1945, Canada had the Allies' third-largest navy and fourth-largest air force, and possessed a powerful overseas army of five divisions and two brigades equipped with state-of-the-art military technology. During the six years of war, approximately 1.1 million Canadian men and women served in Canada's armed services while thousands of others joined American, British and other Allied forces, a considerable achievement for a country of less than 12 million people. In all, more than 42,000 members of the Canadian armed services lost their lives and 54,400 were wounded in a war that left more than 55 million people dead worldwide.[2]

The wartime contributions of the Canadian home front were just as great. Protected by three oceans and untouched by the war's destructiveness, Canada developed an impressive military-industrial complex that exceeded anything thought possible at the beginning of hostilities. In 1939, Canada had still not recovered from the Great Depression; unemployment ran high and hundreds of thousands of Canadians remained dependent on direct government relief.[3] The Canadian economy remained rooted in agriculture, the extraction of natural resources, and the export of staple products. Canada's industrial infrastructure remained relatively small and was dominated by foreign capital and expertise. A great number of Canadian companies were in fact branch plants of larger and more powerful American or British firms. More importantly, the country's arms-making capabilities were practically non-existent at the outbreak of hostilities. Yet, despite these shortcomings, Canada emerged from the war as an industrial giant, producing large quantities of vital raw materials, foodstuffs, manufactured products and armaments for itself and its allies. Between 1939 and 1945, Canada produced 8,653 ships and small craft; 16,418 aircraft; 815,729 trucks and

automotive vehicles; 50,663 tanks and armoured vehicles; 42,966 guns and artillery pieces; and 1,767,392 rifles, pistols, machine guns and other small arms. It manufactured over 1.4 billion artillery shells, mortar bombs and grenades, as well as 4.6 billion rounds of small arms ammunition. It made a vital contribution in the production of chemicals, explosives, radios and communication devices, electronic instruments, uniforms and clothing, and a variety of other war materials. And it played an active role in such highly specialized fields as radar technology, nuclear weaponry, and chemical and biological warfare.[4]

It took significant effort to convert Canada into one of the largest Allied arsenals, and to overcome the complications that often arose due to shortages of capital, skilled labour, machine tools, materials and industrial facilities.[5] A substantial proportion of Canada's wartime industrial output emanated from newly created factories; in fact, more than fifty per cent of the country's war production came from industrial plants that were not in existence at the beginning of hostilities.[6] This expansion of Canadian industry was achieved under strict government control through the Department of Munitions and Supply (DMS) and its influential and highly competent minister, Clarence Decatur (or C.D.) Howe. More than four million Canadian men and women contributed to industrial output, at least half of them working directly in arms production.[7] The demands of the war undoubtedly propelled Canadian economic development and, in the words of historian Donald Creighton, "brought technological maturity to Canada."[8]

However, unlike the other major Allied arms-producing countries, Canada's armament research and development capabilities remained relatively limited throughout the war. Most of the armament research and development efforts undertaken in the

country between 1939 and 1945 were for army weapons and military equipment because they were less expensive and complicated to design and manufacture. For example, a sophisticated combat aircraft or major warship required far more time, resources and expertise to design and produce than a tank or snowmobile. The bulk of Canadian production instead revolved around the manufacture of foreign-designed products. Canadian assembly lines became renowned for building, and often improving, American or British weapons and military equipment under-license. The Canadian industry's prewar inexperience in manufacturing armaments had resulted in a lack of necessary design staffs, skilled labour, machine tools, equipment, facilities and funds to initiate the design and development of sophisticated military technology. Moreover, Canada acquiesced to the British Commonwealth practice of standardization in weapons and military equipment. And above all, Canada simply found it easier, cheaper and faster under wartime conditions to mass-produce existing and well-proven armaments of foreign origin than to work on new and unproven indigenous designs. Consequently, very few domestically developed weapon systems and military equipment were made in Canada during the war. This reinforced Canada's dependence on other countries and ultimately thwarted the rise of a strong, sophisticated, and independent Canadian arms industry.

This trend was most evident in the Canadian aircraft industry. Between 1939 and 1945, Canada manufactured 16,418 aircraft, including fighters, bombers, trainers, transports and patrol aircraft, and also assembled more than 3,200 pre-fabricated airframes imported from Great Britain and the United States. The total value of production was fixed at $850 millions. This effort was outstanding considering the fact

that Canada had only manufactured 678 aircraft during the 1919 to 1939 period.[9] Yet, this overshadowed the fact that only 926 aircraft made in Canada during the war were of indigenous design, accounting for little more than five per cent of total production. With the exception of the Fleet 60 Fort trainer and the Noorduyn Norseman general utility transport — both developed in the interwar period — no Canadian-designed aircraft were successfully mass-produced during the war. The bulk of production consisted of American and British aircraft designs manufactured under-license. In spite of this, the Canadian government and several Canadian aircraft companies devoted much time and effort to examining and initiating the development of indigenously designed aircraft, most of which never left the drawing boards. In numerous cases, we can understand why these projects were cancelled: design flaws, financial difficulties, change of policies, loss of government support, and air force interest primarily being in foreign aircraft designs. However, in some circumstances, we are left wondering, as available sources provide no concrete explanations for the abandonment of Canadian designs.

The purpose of this study is to examine aircraft design and development efforts in Canada during the Second World War. In other words, attempts by the Canadian government and industry to create new aircraft types domestically to meet the specific and distinct requirements of the Royal Canadian Air Force (RCAF), and even Canadian airlines. It investigates how wartime developments and relations with stronger Allied powers, most notably Great Britain and the United States, influenced and defined the expansion of the Canadian aircraft industry. It seeks to answer several fundamental questions, such as: why were so few Canadian-designed aircraft developed and produced? What role did the Canadian government — especially the Department of

National Defence and the Department of Munitions and Supply — play in this process? How did Canada's dependence on other countries in the field of aviation affect research and development efforts? How did postwar demobilization impact on Canada's aircraft industry? This study sheds new light on Canada's contributions to the Second World War in the field of aircraft design and development. It also challenges traditional historiography on Canadian arms production, which has viewed massive aggregate output as the principal, if not sole, determinant of success.[10]

This study offers an alternative to a production-based history, and suggests that design efforts should be considered as something more than a mere footnote in Canada's industrial war effort. The Second World War was indeed an industrial war, fought as much in the factories as on the battlefields. But it was also a war of machines, fought with hundreds of thousands of tanks, guns, ships, aircraft and other tools of war. The importance of technological innovation and new weapon systems on the outcome of the war goes without saying, and this alone makes it all the more important to better understand the type of products developed and used by all belligerents, including Canada. It is true that the Canadian aircraft industry made an important production effort during the war, but an analysis of Canada's role in aircraft design paint a very different picture — one of dependence and frustration. Analyzing Canada's attempts to develop its own aircraft designs during the Second World War provides a better comprehension of the wartime dynamics of the Canadian aircraft industry. Only by focusing on design and development efforts can we better appreciate how dependent the industry really was on foreign countries for aircraft designs, or how the industry's reliance on the licensed

production of foreign aircraft types came to worry government officials as the war progressed.

While the body of literature dealing with Canada and the Second World War is certainly vast, very few studies exist on Canadian war production during this period. This is hardly surprising given the absence of any comprehensive study of the wartime industrial front. The fact that J de N Kennedy's 1950 official, and government sponsored, *History of the Department of Munitions and Supply* remains the only major study of industrial production in Canada during the war is very perplexing.[11] As for the existing scholarly literature on the topic, it tends to focus on the scientific war effort and the production of non-armament products, such as radars and electronic equipment. Such studies include Donald Avery's *The Science of War*, Wilfrid Eggleston's *Scientists at War*, John Vardalas' *The Computer Revolution in Canada*, and David Zimmerman's *The Great Naval Battle of Ottawa.*[12] Only a handful of major scholarly studies — most of them periodical articles and unpublished theses — concentrate specifically on the production of armaments in Canada, and these are limited to certain industrial sectors, such as shipbuilding or tank production.[13] These studies represent a path similar to the one taken in this study, but more needs to be done. Currently, there exists no thorough study of arms making in Canada during the war, let alone one on armament design and development. But there is a wealth of popular histories out there focusing on the specific weapon systems and military equipments made in the country during this period.[14] While few of these documents offer detailed analysis, they provide interesting and valuable information on the armoured and automotive vehicles, artillery guns, small arms, ships and aircraft made in Canada between 1939 and 1945, including some Canadian-designed

products. In addition, some general information on Canadian arms production is also found in certain biographies,[15] as well as scholarly treatments and official government studies of Canada's participation in the Second World War. These include J. Mackay Hitsman's *Military Inspection Services in Canada* and C.P. Stacey's *Arms, Men and Governments*,[16] as well as other important works done by W.A.B. Douglas, James Eayrs, J.L. Granatstein, Desmond Morton, Marc Milner, Roger Sarty, Gilbert Tucker and several others.[17]

There is still a lot to learn about arms-making in Canada during the Second World War, especially in the field of research and development. In fact, while only a handful of Canadian-designed weapons and armament products are known to the general public today (such as the now famous Ram tank or the CMP military trucks), hundreds of lesser-known projects of indigenous origin — many of which only reached the prototype stage or never left the drawing boards — remain buried in archival holdings. This is particularly true of the Canadian aircraft industry, one of the most important sectors of the wartime Canadian arms production program. Nothing yet has been written on Canadian aircraft design and development during the war. In fact, only one important study of wartime aircraft manufacturing in Canada exists: Rénald Fortier's *Intervention Gouvernementale et Industrie Aéronautique*.[18] There has, however, been much written on Canadian aviation history. Much of this is popular history and the work can be divided into three broad categories: air force chronologies,[19] aircraft histories[20] and aircraft manufacturer histories.[21] But none of the above-mentioned literature looks in any depth at Canadian aircraft design and development efforts.

This study therefore seeks to fill an important gap. It offers a new interpretation of the wartime Canadian aircraft industry — one focused on the design side of things. In doing so, it relies heavily on primary sources located at the Library and Archives Canada (LAC), such as the papers of the Privy Council Office, Department of Transport, Department of National Defence, Department of External Affairs, Department of Munitions and Supply, and National Research Council of Canada. Valuable material was also gleaned from the personal papers of influential players, including Prime Minister William Lyon Mackenzie King, Minister of Munitions and Supply C.D. Howe, and Minister of National Defence for Air C.G. Power. Primary sources were also obtained from the Department of National Defence's Directorate of History and Heritage (DHH), the Canadian War Museum (CWM), and the National Aviation Museum (NAM). Important material was also derived from printed sources, such as *Jane's All the World's Aircraft*,[22] the wartime issues of Canadian periodicals such as *Canadian Aviation*, *Commercial Aviation*, and *Industrial Canada*, and government publications like *Canada's War in the Air*[23] and *The Industrial Front*.[24]

This study is divided into seven chapters, each dealing with a specific aspect of wartime aircraft design and development in Canada. The first provides an overview of Canadian aircraft production during the Second World War and offers some explanations as to why so few aircraft were developed in Canada during these years. This chapter is designed as an introduction to the wartime production accomplishments of the Canadian aircraft industry and the reasons why few aircraft design and development efforts took place. The second chapter examines some of the attempts made to initiate the production of Canadian-designed military aircraft in the 1935 to 1940 period. It analyzes why most

of these domestically developed designs never left the prototype stage and only a few achieved quantity production. Chapter three looks at the measures taken by some Canadian government officials and aircraft manufacturers to promote the design and development of wooden aircraft and gliders in Canada between 1940 and 1942. Chapter four examines government officials' preoccupation with the Canadian aircraft industry's survival after the war and takes an in-depth look at the work of the Committee on Postwar Manufacture of Aircraft, which was formed in 1943 to oversee aircraft projects that could be undertaken by the Canadian aircraft industry in postwar years. Chapter five looks at attempts made to design and develop transoceanic transport aircraft in the 1943 to 1945 period. Chapter six analyzes the development of a twin-engine aircrew trainer while chapter seven analyzes work undertaken in Canada to design and produce a jet fighter and a suitable jet engine between 1944 and 1945.

NOTES

1 Library and Archives of Canada [LAC], RG-24 [Records of the Department of National Defence], Reel: C-5146, File: HQS 8152-24, "Brigadier Kenneth Stuart (VCGS) to CGS," 7 June 1941.

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3 Canada, *Canada at War – Recapitulation Issue* (Ottawa: Wartime Information Board, 1945), p. 8.

4 Library and Archives of Canada [LAC], RG-28 [Records of the Department of Munitions and Supply], Vol. 862, *Canada's Industrial War Effort, 1939-1945* (Ottawa: Economic Research Branch/Department of Reconstruction and Supply, 1947), Table 8; J. de N. Kennedy, *History of the Department of Munitions and Supply, Volume 2* (Ottawa: King's Printer, 1950). p. 499. See also Michael A. Hennessy, "The Industrial Front: The Scale and Scope of Canadian Industrial Mobilization During the Second World War," in Bernd Horn, ed., *Forging a Nation: Perspectives on the Canadian Military Experience* (St. Catharines: Vanwell Publishing, 2002), p. 135-154; C.D. Howe, "Final Report on War Production, *Industrial Canada*, Vol. 46, No. 8 (December 1945), pp. 120-121.

5 LAC, RG-28, Vol. 862, *Canada's Industrial War Effort, 1939-1945...*, Introductory Summary; Canada, *Canada at War – Recapitulation Issue...*, p. 78.

6 LAC, RG-28, Vol. 862, *Canada's Industrial War Effort, 1939-1945...*, Introductory Summary, pp. 3-4; Canada, *Canada at War – Recapitulation Issue...*, p. 78.

7 Canada, *Canada at War – Recapitulation Issue...*, p. 22.

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CHAPTER ONE

IN THE ARMS OF EMPIRE

> I feel very strongly that the existence of a healthy aircraft industry in Canada is necessary for the defence of the country. The Department of National Defence ... must be backed by an aircraft industry because events of this war have shown that things move so quickly under modern war conditions that it is impossible to say for certainty that we shall be able to obtain our aircraft supplies from either Great Britain or the United States. The best safeguard that we can have is to have an industry of our own, and this war has also shown that Canada can produce aircraft that are in every way as good as those produced by other countries.[1]
>
> — Air Vice-Marshal E. W. Stedman, RCAF

The Canadian aircraft industry played an important role in Canada's Second World War industrial effort. The large-scale output of fighters, bombers, flying boats, trainers and transports represent one of the most remarkable Canadian wartime industrial achievements. As a result, Canada became the fourth largest Allied producer of aircraft after the United States, Great Britain and the Soviet Union, and its products were distributed around the world. However, almost none of the aircraft manufactured in Canada during the six years of war were of indigenous origin; rather, Canadian aircraft factories mass-produced well-proven American and British aircraft designs under-license and improved upon them. This stood in sharp contrast to the three largest Allied aircraft producing countries, all of which designed and developed their own lines of aircraft.

Several factors can account for the absence of indigenously designed and developed aircraft in Canada. First, Canada's prewar aircraft industry was relatively small and did not have much experience in designing, or manufacturing, modern military aircraft. Most Canadian aircraft firms did not have the design staffs, skilled labour, machine tools, equipment, facilities, established markets, or funds to initiate the development of sophisticated military aircraft designs. Moreover, acquiescing to British Commonwealth policies of standardization in weapons and military equipment, the Canadian government found it easier and cheaper in wartime to concentrate on the mass production of existing and well-proven American and British aircraft types. The creation of service aircraft was a complex and costly endeavour that generally required several years of development without any guarantee of success. It was therefore safer and cheaper to leave the design and development of such machines in the hands of stronger and more experienced aircraft design staffs in Great Britain and the United States. Moreover, winning the war was the priority, and manufacturing existing and well-proven aircraft designs in large quantities — no matter their origin — took precedence over design and development efforts. This course of action, however, placed the Canadian aircraft industry in an extremely subservient position, as it had to rely on foreign aeronautical expertise and technology to survive. The industry was all the more vulnerable owing to the fact that Canada did not manufacture aircraft engines, but rather imported them from Great Britain and the United States.

Forging the Tools of War: The Canadian Aircraft Industry at War

When the Canadian government declared war on Nazi Germany on 10 September 1939, the Canadian aircraft industry consisted of only twelve small manufacturing companies, most of them located in Ontario and Quebec. They were: Boeing Aircraft of Canada Limited of Vancouver; Canadian Associated Aircraft Limited (CAA) of Malton and St. Hubert; Canadian Car & Foundry Company Limited (CCF) of Amherst, Fort William and Montreal; Canadian Vickers Limited of Montreal; Cub Aircraft Corporation Limited of Hamilton; De Havilland Aircraft of Canada Limited (DHC) of Downsview; Fairchild Aircraft Limited of Longueuil; Fleet Aircraft Limited of Fort Erie; MacDonald Brothers Aircraft Limited of Winnipeg; National Steel Car Corporation (NSC) of Malton; Noorduyn Aircraft Limited of Montreal; and Ottawa Car and Aircraft Company (OCA) of Ottawa. All these companies were relatively young, having been established during the interwar years, and many were branch plants of larger and more powerful American or British aircraft firms.[2]

The wartime expansion of Canadian aircraft production capabilities was successfully achieved through intense government control of industry. Unlike Great Britain and the United States, the Canadian government created centralized purchasing agencies to administer the war production effort. On 14 July 1939, it created the Defence Purchasing Board, which was given exclusive powers over all contracts placed in Canada for war materials, including aircraft. The decision was taken to prevent profiteering from defence contracts; indeed, there was still much resentment toward the so-called "merchants of death," those industrialists and private investors who had made huge profits from the arms trade during the First World War.[3] After the outbreak of war in

September 1939, however, the government decided to establish a separate department endowed with much wider powers. The Department of Munitions and Supply Act was assented to in the House of Commons on 12 September 1939, but the new government department only became operational in April 1940.[4] In the interim, a War Supply Board responsible to the Minister of Finance was created on 15 September under the provision of the War Measures Act.[5] Its Aircraft Division was set up in October 1939 and coordinated all contracts placed with the Canadian aircraft industry by the British, Canadian, French and other Allied governments.[6]

The Department of Munitions and Supply (DMS) officially came into being through Order-in-Council PC 1435, and it took over the activities of the War Supply Board on 9 April 1940. C.D. Howe was appointed Minister of Munitions and Supply.[7] The new department had the authority to mobilize all Canadian resources for the production of armaments and essential war supplies for the Allied cause.[8] The DMS's Aircraft Production Branch was responsible for coordinating Canada's aircraft production program. It conducted widespread surveys to ascertain how far Canadian industry could go in the production of the latest aircraft designs, created the facilities needed for their manufacture in the shortest possible time, and sold Great Britain and the United States on the idea that Canada could mass-produce virtually any type of aircraft in the air.[9] The aircraft designs to be manufactured in the country were selected in consultation with the Royal Canadian Air Force (RCAF) and other Allied governments. Ralph P. Bell was appointed Director-General of Aircraft Production.[10]

In order to maximize production and properly coordinate specific sectors of the Canadian industry contributing to the war effort, the DMS proceeded to establish

government-owned Crown Corporations. In the aviation sector, three corporations were formed to manage certain aircraft production projects: Federal Aircraft Limited of Montreal on 24 June 1940, Victory Aircraft Limited (VAL) of Malton on 5 November 1942 and Canadair Limited of Montreal on 11 November 1944. VAL and Canadair took over the manufacturing activities of NSC and Canadian Vickers respectively. A fourth Crown Corporation, Turbo Research Limited, was established at Leaside on 7 July 1944 to coordinate the development of jet engines in Canada.[11] In August of that same year, C.D. Howe decided to close the Aircraft Production Branch and to hand over its responsibilities to Federal; as a result, the corporation found itself supervising the entire Canadian aircraft production program until June 1946.[12]

It was under the watchful eyes of the DMS that Canada made its important wartime contribution to Allied aircraft production. In total, Canada received orders for over 18,500 aircraft during the war,[13] and the Canadian aircraft industry managed to manufacture 16,418 before the end of the hostilities in 1945. Table 1.1 shows that the bulk of aircraft types produced in the country were of American or British origin. In fact, the number of American- and British-designed aircraft manufactured under-license in Canada stood at 7,009 and 8,483 respectively (43 per cent and 52 per cent of production respectively). The only Canadian-designed aircraft built were the Fleet Model 60 Fort trainer and the Noorduyn Norseman general utility transport, which accounted for only 5 per cent of production. Moreover, the table shows how 63 per cent of the country's total wartime output of aircraft consisted of non-combat types (trainers and transports). The Canadian aircraft industry actually manufactured 10,327 such aircraft versus only 6,090 combat aircraft (37 per cent of production) during the war

Table 1.1: Canadian Aircraft Production, 1939-45

Aircraft Type	Country of Origin	Numbers Produced	Percentage of Production
Trainers:		**9,493**	**57.8**
North American Harvard	United States	2,800	17.1
De Havilland Tiger Moth	Great Britain	1,384	8.4
De Havilland Menasco Moth	Great Britain	136	0.8
Fleet 16 Finch	United States	430	2.6
Fleet 60 Fort	Canada	101	0.6
Fairchild PT-23	United States	93	0.5
Fairchild PT-26 Cornell	United States	1,642	10
A.V. Roe Anson	Great Britain	2,882	17.6
De Havilland Mosquito	Great Britain	25	0.2
Transports		**834**	**5.1**
Noorduyn Norseman	Canada	825	5
A.V. Roe York	Great Britain	1	0.01
A.V. Roe Lancaster XPP	Great Britain	8	0.1
Patrol Aircraft		**1,020**	**6.2**
Northrop Delta	United States	8	0.1
Blackburn Shark	Great Britain	15	0.1
Supermarine Stranraer	Great Britain	41	0.2
Consolidated PBY Canso	United States	731	4.4
Westland Lysander	Great Britain	225	1.4
Multi-Engine Bombers:		**1,877**	**11.4**
Bristol Bolingbroke	Great Britain	626	3.8
Handley-Page Hampden	Great Britain	160	1
De Havilland Mosquito	Great Britain	668	4
A.V. Roe Lancaster	Great Britain	422	2.6
A.V. Roe Lincoln	Great Britain	1	0.01
Fighters:		**1,466**	**8.9**
Grumman G-23 Goblin	United States	15	0.1
Hawker Hurricane	Great Britain	1,451	8.8
Fighter-Bombers		**438**	**2.7**
De Havilland Mosquito	Great Britain	438	2.7
Dive Bombers:		**1,290**	**7.9**
Curtiss Helldiver	United States	1,290	7.9
TOTAL		**16,418**	**100**

Source: LAC, RG-36, Vol. 17, File: S.15/2, "Aircraft Production in Canada" (Ottawa: Economic Research Division, Department of Trade and Commerce, 8 November 1950), p. 3.

The most important non-combat aircraft produced in Canada were trainers: nearly 9,500 were made between 1939 and 1945. The establishment in Canada of the British Commonwealth Air Training Plan (BCATP), a massive joint scheme for the training of Allied aircrews, can largely account for this phenomenon. The BCATP came into being in mid-December 1939 when representatives of the governments of Australia, Canada,

Great Britain and New Zealand signed the agreement, which had been under negotiation for more than three years. Canada's vast open spaces, large unused human and material resources, proximity to the American aircraft industry, and isolation from enemy attacks made it a natural place to establish air training schools. In the words of American President Franklin Delano Roosevelt, Canada became the "Aerodrome of Democracy."[14] By the end of the war, more than 131,500 airmen had trained in Canada, just over half of them Canadians. BCATP graduates came from the four signatory countries as well as other Allied partners.[15] The establishment of the BCATP led to a growing demand for training aircraft in Canada, and the aircraft industry responded by producing thousands of elementary and advanced trainers in the early years of the war. The production of training aircraft became by far the Canadian aircraft industry's largest wartime contribution.

The Canadian aircraft industry produced close to 3,700 single-engine two-seat elementary trainers of five different types during the war: the American-designed Fleet Model 16 Finch, Fairchild PT-23, and Fairchild PT-26 Cornell, and the British-designed De Havilland DH 82 Tiger Moth and Menasco Moth. The Canadian aircraft industry also produced more than 2,900 single-engine two-seat advanced trainers. Two different types were made: the American-designed North American AT-16 Harvard, and the Canadian-designed Fleet Model 60 Fort. In addition, Canada made more than 2,800 twin-engine trainers. These were all British-designed A.V. Roe 652 Anson. Moreover, the Canadian aircraft industry was actively engaged in the production of transport aircraft, manufacturing more than 830 during the war. About 98 per cent of these were Canadian-designed Noorduyn Norseman general utility transports. The rest consisted of two types

of British-designed four-engine heavy transports: the A.V. Roe 685 York and a civilian version of the A.V. Roe Lancaster bomber, known as the Lancaster XPP.[16]

As for combat aircraft, the largest numbers made consisted of multi-engine bombers; over 1,870 were produced during the war, primarily four different British-designed types: the Bristol Type 149 Bolingbroke and Handley-Page HP 52 Hampden twin-engine bombers, and the A.V. Roe 683 Lancaster and A.V. Roe 694 Lincoln four-engine heavy bombers. These were the first multi-engine bombers to be built in Canada since the First World War. Canada also manufactured over 1,450 fighters of two different types: the American-designed Grumman G-23 Goblin and the British-designed Hawker Hurricane. These were the first fighter aircraft to ever be made in Canada. The Canadian aircraft industry also built more than 770 twin-engine anti-submarine and coastal patrol flying boats. Two different types were made: the British-designed Supermarine Stranraer and the American-designed Consolidated PBY Canso. In addition, the Canadian aircraft industry built more than 2,600 combat aircraft of several other types. This included the American-designed Curtiss SB2C Helldiver dive-bomber and Northrop Delta patrol aircraft, as well as the British-designed Blackburn Shark torpedo-reconnaissance bomber, De Havilland DH 98 Mosquito twin-engine multi-role combat aircraft, and Westland Lysander army cooperation aircraft.[17]

Table 1.2 provides an annual breakdown of production for each Canadian-made aircraft. It shows slow production in the early years of the war, as everything was being done to expand the country's aircraft manufacturing potential and train workers, and how the Canadian aircraft industry only reached maximum output five years after the outset of hostilities. The table also shows the two main phases of aircraft production in Canada

during the Second World War. The first phase, from 1939 to 1942, was the period of expansion for the Canadian aircraft industry. The focus during those years was on the production of simple and easy to build aircraft designs, particularly trainers for the BCATP.

Table 1.2: Annual Output of Aircraft in Canada, 1939-45

Type	1939-41	1942	1943	1944	1945	TOTAL
Trainers:	**1,615**	**2,570**	**3,150**	**1,816**	**342**	**9,493**
Harvard	119	542	1,003	907	229	2,800
Tiger Moth	834	550	0	0	0	1,384
Menasco Moth	136	0	0	0	0	136
Finch	430	0	0	0	0	430
Fort	28	73	0	0	0	101
PT-23 and Cornell	0	42	1,309	384	0	1,735
Anson	68	1,363	838	523	90	2,882
Mosquito	0	0	0	2	23	25
Transport:	**59**	**17**	**211**	**458**	**99**	**834**
Norseman	59	17	209	455	95	825
York	0	0	0	1	0	1
Lancaster XPP	0	0	2	2	4	8
Patrol Aircraft	**139**	**159**	**197**	**472**	**53**	**1,020**
Delta	8	0	0	0	0	8
Shark	15	0	0	0	0	15
Stranraer	41	0	0	0	0	41
Canso	0	9	197	472	53	731
Lysander	75	150	0	0	0	225
Bombers	**196**	**336**	**350**	**598**	**397**	**1,877**
Bolingbroke	97	275	254	0	0	626
Hampden	99	61	0	0	0	160
Mosquito	0	0	82	420	166	668
Lancaster	0	0	14	178	230	422
Lincoln	0	0	0	0	1	1
Fighters	**602**	**700**	**164**	**0**	**0**	**1,466**
Goblin	15	0	0	0	0	15
Hurricane	587	700	164	0	0	1,451
Fighter-Bombers	**0**	**0**	**1**	**2**	**435**	**438**
Mosquito	0	0	1	2	435	438
Dive-Bombers	**0**	**0**	**60**	**832**	**398**	**1,290**
Helldiver	0	0	60	832	398	1,290
TOTAL	**2,612**	**3,782**	**4,133**	**4,178**	**1,713**	**16,418**

Source: LAC, RG-36, Vol. 17, File: S.15/2, "Aircraft Production in Canada" (Ottawa: Economic Research Division, Department of Trade and Commerce, 8 November 1950), p. 3.

Of the fifteen different aircraft types produced in Canada between 1939 and 1942, the majority were obsolete designs by wartime standards. In fact, almost half of them were small biplanes (Finch, Tiger Moth, Menasco Moth, Shark, Stranraer, and Goblin). The situation began to change in early 1942 when the DMS introduced a new aircraft production program. The aim was to reduce the number of aircraft types made in the country in order to facilitate production and to concentrate on more modern, complex and sophisticated designs. As a result, twelve aircraft types were abandoned within the next year or so (Finch, Tiger Moth, Menasco Moth, Fort, Hampden, Lysander, Delta, Shark, Stranraer, Bolingbroke, Goblin, and Hurricane) and six new ones were introduced (PT-23, PT-26, Canso, Helldiver, Mosquito, and Lancaster). This marked the beginning of the second phase of Canadian aircraft production, which lasted until the end of the war in 1945. While the production of trainers continued to dominate the aircraft industry's efforts, focus shifted increasingly towards combat aircraft.

Table 1.3 shows the gross weight and engine power of the aircraft types made in Canada during the Second World War. It demonstrates how most of the aircraft made in the country between 1939 and 1945 were of less than 10,000 lbs gross weight. About 12,000 aircraft were in that weight range, which accounted for 73 per cent of total production. As the table shows, the largest aircraft made in Canada was the 82,000 lbs gross weight Lincoln bomber. Also, most of the aircraft designs built in the country were fitted with engines of less than 1,000 hp, and only a few could reach speeds of over 300 miles per hour. The fastest aircraft produced was the Mosquito at 376 mph. This was owed largely to the fact that most of the aircraft built in Canada during the war were small non-combat types, namely trainers and general utility transport.

Table 1.3: Gross Weight and Engine Power of Canadian-Made Aircraft

Type	Gross Weight (lbs)	Number of Engines	HP Power (Per Engine)	Maximum Speed (mph)
Harvard	5,235	1	600	180
Tiger Moth	1,825	1	130 to 140	110
Menasco Moth	1,825	1	125	98
Finch	2,000	1	125 to 160	117
Fort	3,500	1	225 to 350	162
PT-23	2,747	1	220	131
Cornell	2,650 to 2,736	1	200	122
Anson	7,650 to 9.275	2	330 to 450	190
Norseman	6,050 to 7,400	1	420 to 550	170
York	68,000	4	1,480	298
Lancaster XPP	63,000	4	1,570	310
Delta	7,350	1	775	205
Shark	8,300	1	840	152
Stranraer	19,900	2	800	165
Canso	34,000	2	1,200	179
Lysander	6,000	1	870 to 905	230
Bolingbroke	13,000 to 14,500	2	800 to 920	266
Hampden	18,756	2	980	254
Lancaster	63,000	4	1,620	272
Lincoln	82,000	4	1,750	295
Goblin	4,700	1	745	223
Hurricane	6,600 to 7,400	1	1,030 to 1,300	330
Mosquito	21,000 to 23,000	2	1,300 to 1,600	376
Helldiver	14,000	1	1,700 to 1,900	295

Source: K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 49-455.

The Canadian government also investigated the possibility of producing several other types of foreign-designed aircraft in Canada during the war, but these projects fell through for various reasons. This included American, British and even French aircraft designs. The machines considered were the Harlow PC-5 (Cub, 1939)[18] advanced trainer, the De Havilland DH 90 Dragonfly (DHC, 1940)[19] twin-engine trainer, the Bell P-39 Airacobra (Fleet, 1940-41),[20] Lockheed P-38 Lightning (Fleet, 1940),[21] Hawker Typhoon (CCF, 1941),[22] Chance-Vought F4U-1 Corsair (Canadian Vickers, 1941-42), Grumman F6F Hellcat (Canadian Vickers, 1941-42)[23] and Grumman F8F Bearcat (CCF, 1945)[24] fighters, the Bristol Type 152 Beaufort (Boeing Canada and Fairchild, 1938-39),[25] Amiot 350 (Massey-Harris, 1938-39),[26] Breguet 690 (NSC, 1939),[27] Bristol Type 156

Beaufighter (Fairchild, 1939), Blackburn B-26 Botha (Fairchild, 1939),[28] Douglas DB-7 Boston (1940)[29] and Martin B-26 Marauder (NSC, 1940-41)[30] twin-engine bombers, and the Short Stirling (CAA, 1939-40),[31] Handley-Page Halifax (CAA, 1940-41),[32] Consolidated B-24 Liberator (CCF, 1940-41)[33] and Consolidated B-32 Dominator (NSC, 1941)[34] four-engine bombers.

Thirteen Canadian aircraft companies contributed to the country's wartime aircraft production effort. Table 1.4 shows that the four companies that produced the most were Noorduyn, CCF, DHC and Fleet, their combined output accounting for almost 75 per cent of total production. Moreover, as Table 1.5 demonstrates, the bulk of production emanated from Ontario and Quebec aircraft plants, which together manufactured 14,333 aircraft, representing close to90 per cent of Canada's wartime production. The remaining aircraft were manufactured in factories located in Manitoba, Nova Scotia and British Columbia, which accounted for 6 per cent, 4 per cent, and 2 per cent respectively of total output.

In addition to the 16,418 aircraft manufactured in Canada during the war, the Canadian aircraft industry also assembled 3,257 pre-fabricated American and British aircraft from parts and components shipped from Great Britain and the United States. This included American-designed North American Yale elementary trainers and British-designed Fairey Battle advanced trainers, Airspeed Oxford and A.V. Roe Anson twin-engine trainers, Bristol Beaufort twin-engine bombers, De Havilland Mosquito twin-engine multi-role combat aircraft, and Westland Lysander army-cooperation and reconnaissance aircraft. Some of these aircraft (especially the Anson, Battle and Oxford) were extensively re-engineered and modified in Canada.[35] Finally, in this same period,

the Canadian aircraft industry overhauled and repaired 6,539 aircraft of over 30 different types.[36]

Table 1.4: Output by Canadian Aircraft Companies, 1939-45

Companies and Products	Numbers	Companies and Products	Numbers
Boeing Canada	**377**	**Federal**	**3**
Shark	15	Anson	3
Canso	362	**Fleet**	**2,266**
CAA	**160**	Finch	430
Hampden	160	Fort	101
CCF	**3,097**	PT-23	93
Anson	641	Cornell	1,642
Goblin	15	**MacDonald**	**1,067**
Hurricane	1,451	Anson	1,067
Helldiver	990	**NSC**	**961**
Canadian Vickers/Canadair	**418**	Anson	736
Delta	8	Lysander	225
Stranraer	41	**Noorduyn**	**3,625**
Canso	369	Norseman	825
DHC	**3,026**	Harvard	2,800
Anson	375	**OCA**	**60**
Tiger Moth	1,384	Anson	60
Menasco Moth	136	**VAL**	**432**
Mosquito	1,131	Lancaster	422
Fairchild	**926**	Lancaster XPP	8
Bolingbroke	626	York	1
Helldiver	300	Lincoln	1

Source: LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production and Maintenance* (Montreal: Federal Aircraft Limited, 1947), pp. 8-9, 60-95; LAC, RG-36, Vol. 17, File: S.15/2, "Aircraft Production in Canada" (Ottawa: Economic Research Division, Department of Trade and Commerce, 8 November 1950), p. 3.

Table 1.5: Provincial Output of Aircraft, 1939-45

Ontario	9,281	Quebec	5,052	British Columbia	377
CAA	80	CAA	80	Boeing Canada	377
CCF	2,456	Canadian Vickers	418	**Manitoba**	**1,067**
DHC	3,026	Fairchild	926	MacDonald	1,067
Fleet	2,266	Federal	3	**Nova Scotia**	**641**
NSC	961	Noorduyn	3,625	CCF	641
OCA	60				
VAL	432				

Source: LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production and Maintenance* (Montreal: Federal Aircraft Limited, 1947), pp. 60-95.

The significant wartime output of the Canadian aircraft industry would have been impossible without the participation of more than 200 subcontractors located across

Canada, which produced parts and components for aircraft manufacturing firms, such as fuselages, wings, ailerons, flaps, and tail units. Some companies produced electrical instruments like altimeters, airspeed indicators, bombsights, compasses, generators, radios, starters and gages, while others made hydraulic equipment such as brakes, bomb-bay doors, control valves, landing gears and other actuating devices. Several subcontracting firms were also actively engaged in the production of engine propellers, tires, parachutes, and raw materials such as special alloy steels, aluminum, plywood, plastics and fabric paints.[37]

Moreover, aside from making parts and components for Canadian-built aircraft, the Canadian aircraft industry also did important subcontracting work for American and British aircraft manufacturers. Canadian aircraft companies made numerous parts and components for American-built Boeing B-29 Superfortress four-engine heavy bombers, Chance-Vought F4U Corsair and Grumman F7F Tigercat naval fighters, Consolidated PBY Catalina flying boats, Curtiss SB2C Helldiver naval dive bombers, and for British-built Bristol Blenheim twin-engine bombers, De Havilland Tiger Moth elementary trainers, Fairey Battle advanced trainers and Hawker Hurricane fighters.[38] The Canadian aircraft industry also developed special ski and float undercarriages for Canadian and foreign made aircraft.[39]

The Second World War led to a massive expansion of the Canadian aircraft industry. In 1939, the industry produced an annual average of about 100 aircraft, employed approximately 4,000 workers, and used a total floor space of only 600,000 square feet.[40] During the wartime peak in 1944, it manufactured over 4,000 aircraft per year, possessed a workforce of over 116,000 people (123,200 when including the aircraft

overhaul industry), and used 15.8 million square feet of floor space.[41] Table 1.6 shows that the number of people working for the Canadian aircraft industry, which included workers in aircraft manufacturing plants and subcontractors, grew more than thirty times larger over the course of hostilities, and accounted for about 10 per cent of the entire arms industry workforce.

Table 1.6: Employment in the Canadian Aircraft Industry, 1939-45

Years	Total Industry			
	Arms Industry		Civilian Industry	Total
	Aircraft Industry	Other Sectors		
1939	4,100	181,000	3,611,000	3,792,000
1940	17,000	427,000	3,521,000	3,948,000
1941	42,000	840,000	3,341,000	4,181,000
1942	71,000	1,257,000	3,013,000	4,270,000
1943	104,600	1,411,000	2,864,000	4,275,000
1944	116,200	1,234,000	3,086,000	4,320,000
1945	77,000	305,000	3,941,000	4,246,000

Source: LAC, RG-28, Vol. 3, File: 43, *Location and Effects of Wartime Industrial Expansion in Canada* (Ottawa: Economic Research Branch/Department of Reconstruction and Supply, 1945), pp. 1-34; LAC, RG-28, Vol. 862, *Canada's Industrial War Effort, 1939-1945* (Ottawa: Economic Research Branch/Department of Reconstruction and Supply, 1947), Part II, Chapter 1, Table 1 and Table 2; Part II, Chapter 4; Appendix C, Table 17.

Table 1.7: Expansion of Main Aircraft Manufacturing Firms, 1939-44

Aircraft Maker	Employment (1939)	Employment (1944)	Floor Space (Square Feet) (1939)	Floor Space (Square Feet) (1944)
Boeing Canada	298	10,315	38,650	872,479
CCF	700	15,000	200,000	2,000,000
Canadian Vickers	450	9,084	125,000	707,929
DHC	195	6,809	10,000	1,225,000
Fairchild	1,117	9,620	67,130	717,753
Federal	0	1,068	0	67,277
Fleet	519	2,937	71,777	263,265
Noorduyn	140	12,000	36,000	868,000
NSC/VAL	650	9,521	60,000	1,272,000
TOTAL	**4,069**	**76,354**	**608,557**	**7,993,703**

Source: LAC, RG-24, Vol. 6179, File: HQ 60-1-59, "Report to the Industrial Defence Board by Fred T. Smye (Chairman, Aircraft Committee of the Canadian Ordnance Association)," 1 July 1948; LAC, RG-28, Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production and Maintenance* (Montreal: Federal Aircraft Limited, 1947), pp. 60-95; Kenneth Wilson, "Canada's Aviation Industry is...A Problem Child," *Canadian Aviation*, Vol. 17, No. 11 (November 1944), p. 102; "With Aviation to Victory," *Commercial Aviation*, Vol. 7, No. 10 (November 1945), p. 37.

As shown in Table 1.7, all Canadian aircraft companies grew considerably during the war. The nine most important aircraft-manufacturing companies alone employed more than 76,000 workers at their peak, and possessed a total floor space of 7.9 million square feet.[42]

Given its impressive wartime output of aircraft, Canada rose to become the world's sixth largest manufacturer of aircraft, being surpassed only by the United States, the Soviet Union, Great Britain, Germany and Japan. However, the Canadian output of aircraft was extremely small in comparison. While Canada manufactured 16,418 aircraft between 1939 and 1945, in the same period the United States produced 322,250,[43] the Soviet Union 172,302,[44] Great Britain 131,549,[45] Germany 119,326,[46] and Japan 79,123.[47] Italy occupied the seventh rank with 13,308,[48] followed by France with 8,080.[49] Nonetheless, Canada surpassed easily the production of the other twenty-four smaller aircraft manufacturing countries, which produced a combined total output of approximately 15,000 aircraft during the war.[50] Table 1.8 shows the aircraft production of the leading Allied powers and underscores the United States' superiority in this field; its production capability was about twenty times that of Canada, and about twice that of Great Britain and the Soviet Union, singly. There were also noteworthy discrepancies in size between the aircraft industries of Canada and the United States. At its peak towards the end of 1943, the American industry employed 2.1 million men and women,[51] whereas the Canadian industry employed only 116,000 when it reached its wartime peak in 1944.[52] In comparison, the British aircraft industry employed 1.5 million people at its 1943 peak.[53]

Table 1.8: Aircraft Production by Leading Allied Powers, 1939-45

Year	United States	Soviet Union	Great Britain	Canada
1939	5,856	10,382	7,940	2,612
1940	12,813	10,565	15,049	
1941	26,289	15,735	20,094	
1942	47,675	25,436	23,672	3,782
1943	85,433	34,884	26,263	4,133
1944	95,272	40,300	26,461	4,178
1945	48,912	35,000	12,070	1,713
TOTAL:	322,250	172,302	131,549	16,418

Source: Roger E. Bilstein, *The American Aerospace Industry: From Workshop to Global Enterprise* (New York: Twayne Publishers, 1996), pp. 225-227; Canada, *Annual Industry Report – The Aircraft Industry in Canada, 1939* (Ottawa: Department of Trade and Commerce, Dominion Bureau of Statistics, 1940); Canada, *Annual Industry Report – The Aircraft Industry in Canada, 1940* (Ottawa: Department of Trade and Commerce, Dominion Bureau of Statistics, 1941); Canada, *Annual Industry Report – The Aircraft Industry in Canada, 1941* (Ottawa: Department of Trade and Commerce, Dominion Bureau of Statistics, 1942); Canada, *Annual Industry Report – The Aircraft Industry in Canada, 1942* (Ottawa: Department of Trade and Commerce, Dominion Bureau of Statistics, 1943); Canada, *Annual Industry Report – The Aircraft Industry in Canada, 1943* (Ottawa: Department of Trade and Commerce, Dominion Bureau of Statistics, 1944); Canada, *Annual Industry Report – The Aircraft Industry in Canada, 1944* (Ottawa: Department of Trade and Commerce, Dominion Bureau of Statistics, 1945); Canada, *Annual Industry Report – The Aircraft Industry in Canada, 1945* (Ottawa: Department of Trade and Commerce, Dominion Bureau of Statistics, 1946); I.C.B. Dear and M.R.D. Foot, eds., *The Oxford Companion to the Second World War* (Oxford: Oxford University Press, 1995), p. 1060; Great Britain, *Statistical Digest of the War* (London: His Majesty's Stationery Office, 1951), p. 152; Robert A. Kilmarx, *A History of Soviet Air Power* (New York: Frederick A. Praeger, 1962), pp. 200-202; Donald M. Pattillo, *Pushing the Envelope: The American Aircraft Industry* (Ann Arbor: The University of Michigan Press, 1998), pp. 125, 151; LAC, RG-36, Vol. 17, File: S.15/2, "Aircraft Production in Canada" (Ottawa: Economic Research Division, Department of Trade and Commerce, 8 November 1950), p. 3.

Table 1.9: Aircraft Production by Leading North American firms, 1939-45

United States, 1940-45		Canada, 1939-45	
Manufacturer	Aircraft	Manufacturer	Aircraft
Bell	13,575	Boeing Canada	377
Boeing	18,381	CAA	160
Chance-Vought	7,896	CCF	3,097
Consolidated	30,003	Canadian Vickers	418
Curtiss-Wright	26,154	DHC	3,026
Douglas	30,696	Fairchild	926
Grumman	17,428	Fleet	2,266
Lockheed	18,926	MacDonald	1,067
Martin	8,810	NSC	961
North American	41,188	Noorduyn	3,625
Republic	15,603	VAL	432

Source: Wesley Frank Craven and James Lea Cate, *The Army Air Forces in World War II, Volume 6: Men and Planes* [1955] (Washington D.C.: Office of Air Force History, 1983), pp. 354-355; Brinton Holley, *Buying Aircraft: Matériel Procurement for the Army Air Forces* (Washington D.C.: Department of the Army, 1964), p. 561, 576-579; p. 130. LAC, RG-28,

Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production and Maintenance* (Montreal: Federal Aircraft Limited, 1947), pp. 60-95; LAC, RG-36, Vol. 17, File: S.15/2, "Aircraft Production in Canada" (Ottawa: Economic Research Division, Department of Trade and Commerce, 8 November 1950), p. 3.

Many of the leading American aircraft firms alone produced more aircraft during the war than the entire Canadian aircraft industry. Table 1.9 shows the number of aircraft produced by major aircraft companies in Canada and the United States. It must be noted that American and Canadian aircraft industries enjoyed an enormous advantage over those of their enemies, and of many of their allies, since they were able to operate without the threat of air bombardment or other wartime damage to their factories, without widely feared shortages of critical raw materials, and without any rupture or break in supply lines.[54]

Despite producing far fewer aircraft than the Americans or British, Canada was the second largest British Commonwealth manufacturer of aircraft. It produced over 80 per cent of the aircraft made outside of Great Britain. Canada was truly one of the great air arsenals of the British Empire. Australia trailed behind with a total wartime output of only 3,666 aircraft,[55] followed by New Zealand with 345,[56] and India with about a dozen.[57] There were even discussions of opening an aircraft factory in Newfoundland in the summer of 1943, but that project was not pursued.[58] No aircraft were produced in the other parts of the British Empire during the war. It should be noted that like Canada, Australia, New Zealand and India produced mainly American and British aircraft designs under-license. The only exception was Australia, where five of the eleven military aircraft types manufactured during the war were developed domestically (Wackett elementary trainer, Wirraway advanced trainer and attack aircraft, Woomera twin-engine bomber, and Boomerang and Kangaroo fighters). In all, Australia produced 1,228 aircraft

of the five above-mentioned types, which represented 34.5 per cent of its total wartime production.[59] And so, while Australia's wartime aircraft production was less than one-quarter that of Canada's, it actually managed to contribute more in the field of aircraft design and development. But this was not by choice. Unlike Canada, Australia was directly threatened by Japan and exposed to enemy attacks. Unable to obtain quickly the aircraft it required from overseas sources, the Australians were forced to rely on their local aircraft industry to design and build the combat aircraft their air force required to protect their country. Australia was in many ways an anomaly.

The most important combat aircraft of the Second World War were those designed and built by the six great belligerent powers — Germany, Great Britain, Italy, Japan, the Soviet Union and the United States. The aircraft industries of each of these countries produced their own types of combat aircraft, thus making important contributions and advancements in the field of aeronautics. Only in rare instances did these countries manufacture designs developed elsewhere. Their products were not only used by their own air forces but also by those of their allies and by neutral states. It therefore comes as no surprise to learn that about ninety per cent of fighter and bomber designs produced and used during the war were developed in these six countries. Other important developers of modern fighter and/or bomber designs during the war were Australia, Belgium, Czechoslovakia, Finland, France, Hungary, the Netherlands, Poland, Romania, Sweden, Switzerland and Yugoslavia.[60] The situation was somewhat different in Canada, where despite the emergence of a relatively strong Canadian aircraft industry during the war, no domestically developed combat aircraft type was produced.

None of the aircraft companies of the main Allied powers relied on the licensed production of foreign-designed aircraft, as was the case in Canada. Great Britain, the Soviet Union and the United States possessed well-established aircraft manufacturing firms with the resources and experience necessary to undertake the design and development of aircraft. All three countries possessed strong design staffs made up of well-known aeronautical engineers and aircraft designers educated for the most part in local technical schools and universities.[61] American aircraft firms, for example, maintained very large design staffs; their engineering departments usually accounted for between three to eight per cent of the company's total labour force.[62] In contrast, the number of people working in the engineering departments of Canada's leading aircraft manufacturing companies represented about one per cent of their work forces.[63]

More importantly, the governments of these countries each possessed their own aeronautical research facilities and organizations. In the United States, the most important government agency engaged in aeronautical research was the National Advisory Committee for Aeronautics (NACA), which was founded in 1915. NACA worked closely with the American aircraft industry on aircraft and engine design and development, conducting experiments in its laboratories and testing prototypes; it proved invaluable to advancing aeronautical research in the United States during the war. In 1941, the United States government also created the Office of Scientific Research and Development (OSRD). This body was staffed by scientists and engineers and tasked with coordinating all government-sponsored research activity. In the field of aeronautics, the OSRD coordinated efforts to develop new aircraft designs, helicopters, radar, jet engines, radio-controlled bombs, missiles, rockets and, ultimately, atomic weapons. Important design

and development work was also undertaken by the aeronautical research centers of the United States Army Air Force (USAAF) and United States Navy (USN), as well as university laboratories.[64] In Great Britain, the Royal Aircraft Establishment (RAE) at Farnborough undertook most of the British government-sponsored aeronautical research. The research organizations of the Air Ministry and the Ministry of Aircraft Production also played an important role, as did British universities.[65] In the Soviet Union, the Commissariat for the Aviation Industry possessed two large central design bureaus, TsAGI and TsKB, which contributed immensely to aeronautical research.[66]

The situation was very different in Canada, where almost no aircraft of indigenous design were built during the war. The country's only government aeronautical research facilities were those of the National Research Council of Canada (NRC), which was created in 1916. The NRC was one of the rare Canadian government agencies to be involved in aeronautical research, much of this work being undertaken by the aerodynamics laboratories of the NRC's Mechanical Engineering Division in cooperation with the RCAF, the DMS and individual Canadian aircraft companies. Yet, aside from wind tunnel tests conducted on experimental aircraft scale models, the NRC undertook almost no aircraft design and development activity as most of its wartime aeronautical work revolved around aerial photography, de-icing, cabin heating, aircraft skis, engine maintenance, radar, aviation medicine, the production of wooden aircraft components and jet propulsion research.[67] However, the NRC did operate an Inventions Board (in cooperation with the Canadian armed services) that was responsible for examining all proposals received from the Canadian public and Canadian military personnel for new types of army, navy and air force weapons and military equipment. Some of these

proposals dealt with new aircraft designs, but most of them were found unsuitable and rejected. The few that were acceptable were transferred to the British Ministry of Aircraft Production for further investigation.[68]

In addition to the NRC, the Department of National Defence for Air (DND Air) had its own research and development organization, the Directorate of Aeronautical Engineering (DAE), whose task was to develop air force equipment, compile specifications and approve manufacturers' designs. The DAE was made up of five directorates: Aircraft Development, Engine Development, Armament Development, Radio Development, and Equipment and Instruments. The DAE worked closely with the DMS to assist with the production of military aircraft and special aeronautical equipment, such as canons and bombs, propellers, aircraft instruments and radios. It also served as the main channel of liaison with the NRC and directed the operation of the RCAF Test and Development Establishment at Rockfliffe, Ontario.[69] Moreover, in late May 1945, DND (Air) formed a Research and Development Division, which was subdivided into three directorates dealing with equipment, aircraft and inter-service research and development.[70] Interestingly, the DMS had no body that focused specifically on aircraft design and development. The responsibility of its Aircraft Production Branch was solely to coordinate the Canadian aircraft production program, not to develop new types of aircraft. The DMS did, however, support some aircraft design work through four of its Crown Corporations: Canadair, Federal, Turbo Research Limited and VAL.[71].

The Standardization Barrier

In 1940, the Royal Commission on Dominion-Provincial Relations noted that "Canada is one of the least self-sufficient countries in the world."[72] Four years later, NRC President C.J. Mackenzie complained that Canada was in "a state of economic colonialism" because of Canadian industrial dependence on Great Britain and the United States.[73] These statements applied very well to the Canadian arms industry. Canada might have been the Allies' fourth largest manufacturer of weapons and military equipment, but the bulk of production consisted almost exclusively of American or British-designed products. This was particularly true of the Canadian aircraft industry, where most of the aircraft types produced in the country were of foreign origins.

One of the most important factors that hindered aircraft design and development in Canada during the Second World War was the Canadian armed forces' adherence to British Commonwealth policies of standardization in weaponry and military equipment. From its inception as a self-governing British Dominion in 1867, Canada had imported almost all of its weapons and military supplies directly from Great Britain, the industrial heart and arsenal of the British Empire. This arrangement not only provided Canadian armed services with well-proven British-pattern weaponry and military products, but also guaranteed a certain degree of uniformity with British forces. This latter point was particularly important from operational and logistical points of view as the dominion formed an integral part of the British imperial defence system.[74] Moreover, the threat of war with the United States throughout the nineteenth century made military reliance on Great Britain all the more important as it afforded the dominion easy access to a secure source of munitions supply. As long as the British Empire remained the strongest in the

world, the British government appeared ready to defend its imperial interests worldwide, the Royal Navy dominated international sea-lanes, and military supplies could be furnished relatively easily from industries in Great Britain, Canada had practically no need to rely on alternate sources.[75]

In fact, purchasing weapons and military equipment outside of the British Empire was dismissed as impractical and imprudent, particularly in times of war. Attempts to initiate the development of a local arms industry were rejected as too complex and expensive for Canadian military requirements. Canada was a predominantly agricultural country with a staple economy that depended almost entirely on the extraction and exportation of natural resources. Its industrial capabilities were relatively small and weak compared to major powers like Great Britain or the United States. For years, Canadian industries relied heavily on foreign technology, expertise and capital, leaving them virtually no experience in producing complex and sophisticated military hardware.[76] Accordingly, it was easier and cheaper for Canada to acquire weapon systems and military products in the mother country than to enhance its own arms-making capability.

As the possibility of a European war grew closer in the early twentieth century, a spirit of militarism and imperial solidarity swept the British Empire. The result was more military cooperation between Great Britain and its dominions. The South African War of 1899-1902 had demonstrated how important imperial contributions could be in times of crisis, and made the participation of colonial forces in future British wars almost inevitable.[77] At the same time, the British War Office became increasingly committed to assuring the standardization of the armed forces of the British Empire — uniformity in doctrine, training and organization, as well as weaponry and military equipment — to

facilitate their rapid integration into a more homogenous imperial force in case of emergency. The purpose was to obtain as much standardization as possible in order to ensure quick and efficient coordination of British and colonial forces on the battlefield. The issue was first discussed at the 1907 Imperial Conference; at the 1909 Imperial Conference, British and dominion governments agreed to establish official policies of standardization between their respective armies and navies. The consensus remained that the British model should set imperial standards. In short, all British imperial forces were to rely exclusively on British-pattern weapons and military equipment. This decision did not discourage dominion governments from establishing local arms industries, but it did quell political or commercial ambitions to initiate the manufacture of products of indigenous design that did not correspond to imperial standards. As a result, the dominions' arms factories became committed to the licensed manufacture of British-designed munitions and supplies.[78]

The only exception to imperial policies of armament standardization applied to air forces. The exclusion of air forces from British Commonwealth standardization policies was readily understandable, since aviation was still in its infancy and the military potential of aircraft remained to be discovered and harnessed. After all, it had only been a few years since Orville and Wilbur Wright had flown the world's first aircraft at Kitty Hawk, North Carolina, on 17 December 1903, and only a few months since the Silver Dart had made the first powered flight in Canada at Baddeck, Nova Scotia, on 23 February 1909.[79]

Standardization policies were put to full effect during the First World War,[80] but as these did not apply to air forces, Canada was free to manufacture any aircraft design it

desired. Table 1.10 illustrates the country's aircraft production during the war. Of the thirteen aircraft types manufactured in Canada between 1914 and 1919, only two were of British origin, the rest consisting of American and Canadian designs. More importantly, 1,258 of the 1,280 aircraft manufactured were of American design, accounting for 98.3 per cent of production. This was readily understandable since Canada possessed no independent air force during the war and most of the aircraft ordered were either for the American or British governments.[81]

The principle of armament standardization was applied to British Commonwealth air forces at the 1923 and 1926 Imperial Conferences. The arrangement called for the adoption of a common system of organization and training and the use of uniform patterns of arms, equipment and stores. The only exception applied to the types of aircraft used by each British Commonwealth air force.[82] It was not until the 1937 Imperial Conference that the air forces of Great Britain, Canada and other British Dominions finally decided to standardize on British-pattern aircraft, and that the Canadian government agreed that all military aircraft produced in Canada for military purposes should be of British design.[83] As the Chief of the General Staff told the Minister of National Defence, the RCAF "should be modeled as closely as possible" on the British RAF.[84] Canadian military authorities concluded that it was desirable from Canadian and British points of view that aircraft built in Canada "be completely interchangeable with similar aircraft built in England" and that this was a matter "of importance to the whole of the Empire and not merely a matter of convenience, because it might happen that in an emergency the Dominions could supply many aircraft parts for use by the Royal Air Force and vice versa."[85]

Table 1.10: Aircraft Production in Canada, 1914-19

Aircraft	Type	Country of Origin	Years of Production	Numbers Produced
Canadian Aeroplanes			**1916-19**	**1,234**
Curtiss JN-4 Canuck	Trainer	United States	1917-18	1,210
A.V. Roe 504	Trainer	Great Britain	1918	2
De Havilland D.H.6	Trainer	Great Britain	1917	1
Felixtowe F-5-L	Flying Boat	United States	1918-19	30
Canadian Aircraft Works			**1914-15**	**2**
Canadian Aircraft Works (Model 1)	Trainer	Canada	1914	1
Canadian Aircraft Works (Model 2)	Trainer	Canada	1914	1
Curtiss Aeroplane			**1915-16**	**30**
Curtiss JN-3	Trainer	United States	1915	18
Curtiss Model C Canada	Bomber	Canada	1915-16	12
Hamilton Aero Manufacturing			**1915-16**	**1**
Hamilton	Trainer	Canada	1916	1
Hoffar			**1915-19**	**3**
Hoffar H-1	Flying Boat	Canada	1915	1
Hoffar H-2	Flying Boat	Canada	1918	1
Hoffar H-3	Flying Boat	Canada	1919	1
Polson Ironworks			**1915-16**	**1**
M.F.P. (Polson) B-2/C	Reconnaissance	Canada	1916	1
TOTAL:				**1,280**

Source: K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 458-464.

With this agreement came the issue of licenses and royalty fees.[86] Canadian aircraft companies willing to undertake the production of a particular foreign-designed aircraft had to purchase a license from the foreign aircraft firm that held production rights. This normally consisted of a fixed royalty fee, which was usually agreed upon in the contract between both companies. In exchange, the licensor would furnish the licensee with copies of all necessary drawings, blueprints, details of assembling operation, and data, as well as prototypes of machine tools, jigs, fixtures and other required machinery.[87] In addition, the licensee had to pay the licensor a specific amount for each aircraft produced,[88] usually fixed at about ten per cent of production costs.[89] However, it should be noted that during the Second World War, Canadian aircraft makers

no longer paid royalty fees; this became the responsibility of the Department of Munitions and Supply.[90]

The RCAF's adherence to British Commonwealth policies of armament standardization made it more difficult for Canada to turn to external sources, particularly the United States, to obtain combat aircraft in the event of an emergency. Air Vice-Marshal G.M. Croil, Senior Air Officer, told the Minister of National Defence in December 1938:

> The Royal Canadian Air Force is organized on Royal Air Force practice, and therefore Royal Air Force equipment fits into the Canadian scheme better than American equipment ... We use the same establishment, and to get the best results, should use the same equipment. If we change the equipment, we must change the establishment, which will result in a certain amount of experimentation until satisfaction is achieved. If we change the type of aircraft and go in for the American product, it means that we must also change our supply of bombs, guns, and instruments of all kinds, for the American aircraft are designed to take American accessories of this kind. This is not an insuperable job and could be incorporated in the manufacture if we are building this type of aircraft in Canada. I feel that it is necessary for us to continue to use British accessories, for we have no other supply and these can be purchased through the Royal Air Force from markets which would otherwise be closed to us, and at the same time, we use the Royal Air Force as a proving ground.[91]

Moreover, the United States Neutrality Act of 1935 strictly prohibited the export of arms, ammunition or implements of war to any belligerent countries once the President of the United States had proclaimed that a state of war existed.[92] The enforcement of the neutrality legislation meant that Canada would not be able to acquire American military aircraft in wartime unless the United States became an ally. Canada could only purchase or build an American-designed aircraft under-license if Great Britain agreed to recognize that particular machine as acceptable from a British Commonwealth standardization standpoint. However, as long as American neutrality legislation was enforced, there were

no reasons for British Commonwealth air forces to adopt American aircraft types. Furthermore, information about the latest American designs was also usually kept classified until the particular aircraft went into production, meaning that the Canadian aircraft industry would only be able to produce aircraft that were already at least one year old, a situation that was definitely not enviable from a military perspective.[93] The fastest and safest way to acquire military aircraft remained to go through Great Britain, or to produce British-designed aircraft under-license in Canada.

The beginning of the Second World War changed the rules of the game. In November 1939, the United States government amended the Neutrality Act, allowing arms exports to belligerent countries on a "cash-and-carry" basis only. With the American market now accessible, the British government sent purchasing missions to the United States to investigate American industrial potential and to purchase American-designed war materials, particularly aircraft.[94] Cooperation between Great Britain and the still-neutral United States intensified after the successful German military offensives against Scandinavia and Western Europe in the spring of 1940 and the ensuing Battle of Britain. The British government responded by placing huge orders for American-designed combat aircraft.[95] In September 1940, the two countries formed a Joint Aircraft Committee to coordinate aircraft delivery schedules and decide matters relating to aircraft standardization. The committee was one of the earliest formal wartime organs of Anglo-American cooperation and helped foster aeronautical research in both countries. British aircraft purchased in the United States increased after the Americans passed the Lend Lease Act in late March 1941, which authorized Great Britain to obtain the war materials it required in the United States at no immediate cost.[96] This development had an

inevitable impact on British Commonwealth policies of aircraft standardization, for it not only allowed the RCAF and other British Commonwealth air forces to purchase and use approved American aircraft types, but also facilitated the licensed manufacturing of such machines in Canada.

In the meantime, Canada and the United States strengthened their military and industrial cooperation.[97] On 17 and 18 August 1940, American President Franklin D. Roosevelt and Canadian Prime Minister William Lyon Mackenzie King met at Ogdensburg, New York, to discuss forging a military alliance between both countries. The resulting Ogdensburg Agreement established an American-Canadian Permanent Joint Board on Defence (PJBD) responsible for the defence of the northern half of the Western Hemisphere.[98] Several joint bodies were formed afterwards to coordinate specific aspects of relations between both countries.[99] On 20 April 1941, Roosevelt and King met again at Hyde Park, New York, to discuss industrial cooperation. The two leaders agreed on the general principle that "in mobilizing the resources of this continent, each country should provide the other with the defence articles which it is best able to produce, and above all, produce quickly, and that production programs should be coordinated to this end."[100] On 22 November 1941, the Joint Defence Production Committee — renamed the Joint War Production Committee (JWPC) in December 1941 — was established to coordinate and integrate the production of war materials in both countries.[101] The JWPC was composed of ten joint technical subcommittees, including one on Airplane Production.[102] The JWPC was particularly concerned with standardizing the weapons and military equipment produced in both countries. It was noted in a JWPC report that "if the war is to continue for some years, there is ample reason to do

everything within our power to gain the military and economic advantages of standardization."[103] It became increasingly clear to Canadian authorities that Canada would soon find itself trying to conform to both American and British standards.

Then, on 7 December 1941, Japan attacked parts of the United States Pacific Fleet anchored at Pearl Harbor in the Hawaiian Islands and launched an important military offensive against American, British and Dutch possessions in Southeast Asia and the Pacific. Canada, Great Britain and the United States responded by declaring war on Japan and, a few days later, Germany and its Axis partners in Europe declared war on the United States. The Allies had suddenly gained an important new ally in the United States. The American decision to join the war also had a tremendous impact on Canada's industrial front: complete cooperation with the United States could be undertaken since the Americans were no longer neutral. A complete reorganization of the Allied industrial effort ensued in order to maximize production, achieve as much standardization as possible and avoid duplication of efforts.[104] Measures were immediately taken to integrate American and Canadian resources, and Canada suddenly found itself part of a larger North American arsenal. Canadian aircraft production was directly affected as access to the vast American military-industrial resources lessened Canadian reliance on Great Britain. In fact, it soon became apparent that American production lines could easily fulfill the arms requirements of all Allied armed forces, and the Americans increasingly turned to Canadian aircraft companies to supplement their production. Historian Donald Avery writes that the war transformed the relationship between Canada and the United States "from one of friendly isolationism to one of committed military and economic collaboration."[105]

Yet, not all Canadian officials favoured increased reliance on American-pattern products. Vincent Massey, the High Commissioner for Canada in Great Britain, explained that "we must not lose sight of the fact that a very great part of production was planned and developed as part of the imperial war effort long before the entry of the United States of America into the war." He stressed that while Canada and the United States enjoyed a close relationship with respect to production and defence matters, "we think that there are also extremely close ties between Canada and the United Kingdom alongside whose forces the greater part of the Canadian forces are operating."[106]

In the end, the Allies never achieved standardization, owing largely to the fact that Great Britain and the United States continued to develop weapons and military equipment independent of one another. British historians H. Duncan Hall and C.C. Wrigley wrote that before the war "the design and development of military equipment proceeded quite independently in the United States and Britain, so that at the onset the weapons in use or being prepared for use by the armed forces of the two countries were in very few, if any instances, identical."[107] While both powers agreed that standardization was desirable in order to take full advantage of American mass-production, neither was willing to change.[108] Canadian historian C.P. Stacey explained that both countries had established production programs, and the armed services of both "were unwilling to accept the sweeping consequences in changed organization and tactics, which new weapons might involve." He continued,

> Nothing like standardization was ever achieved. Each side contended that its own weapons were superior. The American armed services were unwilling to devote US production facilities to equipment which they could not themselves use, while the British pointed out that a proliferation of types in the Commonwealth forces would create serious difficulties in the field. In the event, the United States in general made only American-type equipment

> during the war, though British suggestions for improvements were often accepted. The United Kingdom was forced either to accept American models or turn to Canada as the sole North American source of British-type weapons.[109]

In fact, there was much debate between Great Britain and the United States on which type of weapons and military equipment Allied armed forces should standardize. Not surprisingly, both governments thought that their own war materials were superior, and that their own war production programs were too far advanced to change.[110] "Each side stood to gain greatly if its own types could be chosen as the basis for standardization," wrote British historian H. Duncan Hall.[111] In the end, however, the so-called "battle of the types"[112] was resolved when "it appeared that the British would adapt their entire program to permit use of specific American types as substitutes or as supplementary equipment and rely on American production for supplying items that British industry was ill prepared to produce in volume."[113]

Canadian military authorities understood the "great importance of standardization," and expressed willingness to accommodate both the Americans and the British.[114] The Canadian Chief of the General Staff explained that "it should be possible ... to reach a considerable degree of standardization between the USA and Canada" and that "since Canada has, up to the present, depended largely upon the UK for design of weapons and ammunition, it would appear to follow that Canada would accept any standardized items agreed to by the other two countries."[115] Yet, Canadian armed forces remained standardized on approved British-pattern war material. The only American-pattern equipment used by Canadian forces, or manufactured in Canada during the war, were those that had received British approval.[116]

"A Tree without Roots"

The Canadian aircraft industry's prewar activities can also help account for the limited number of indigenous aircraft designs developed in Canada during the war. In 1945, W.B. Burchall, the executive secretary of the Air Industries and Transport Association of Canada, compared the wartime Canadian aircraft industry to "a tree without roots." Canadian aircraft companies had relatively little capital at the beginning of hostilities; their prewar operations had been relatively small and, consequently, their profits had been exceedingly slim. The wartime expansion of the Canadian aircraft industry was therefore undertaken largely with the government's assistance, and under the watchful eye of the DMS. Unlike foreign aircraft companies whose growth was usually linked to the success of their own aircraft designs and the reinvestment of profits in the expansion of their own research and production capabilities, Canadian aircraft manufacturing firms worked under the auspices of the Canadian government, which mostly encouraged the licensed production of existing and well-proven American or British aircraft designs.[117]

Moreover, the Canadian aircraft industry lacked experience in designing, developing and constructing modern military aircraft. American and British aircraft firms had been producing their own lines of aircraft since the dawn of aviation, gaining considerable skill, experience and knowledge over the years and accumulating substantial funds from the sale of their products at home and abroad on civilian and military markets.[118] They were also able to acquire huge design staffs and research facilities. Canadian aircraft companies, on the other hand, had to start from scratch having relied almost exclusively on the production of small flying boats, general utility transports and

elementary trainers during the interwar years. In that period, Canada made only 678 aircraft[119] (or 981 when including the assembly of foreign aircraft types using pre-fabricated parts and components made in other countries),[120] which could not compare to the United States' 44,981.[121] For these reasons, the Canadian government simply found it easier and more effective to rely on the expertise of aircraft design staffs in Great Britain and the United States rather than to establish such teams at home.[122]

Most of the Canadian aircraft companies operating during the Second World War had been created in the 1920s and 1930s. Many were branch plants of larger and more powerful American and British aircraft companies, but by the end of the interwar period, Canadian interests had purchased these branch plants with the exception of Boeing Canada, Cub and DHC, as Table 1.11 shows.

Table 1.11: Second World War Aircraft Manufacturers, 1919-39

Company	Established	Parent Company	Enter Aircraft Production	Canadian Ownership
Boeing Canada	1929	Boeing Airplane (United States)	1929	No
CAA	1938	No	1938	1938
CCF	1909	No	1936	1909
Canadian Vickers	1911	Vickers (Great Britain)	1923	1927
Cub	1936	Piper Aircraft (United States)	1936	No
DHC	1928	De Havilland Aircraft (Great Britain)	1928	No
Fairchild	1929	Fairchild Airplane (United States)	1929	1937
Fleet	1930	Consolidated Aircraft (United States)	1930	1936
MacDonald	1930	No	1930	1930
NSC	1920	No	1937	1920
Noorduyn	1934	No	1934	1934
OCA	1893	No	1924	1893

Source: Rénald Fortier, *Intervention Gouvernementale et Industrie Aéronautique: L'exemple canadien, 1920-1965* Ph.D. Thesis (Quebec City: Université Laval, 1990), pp. 40-53; K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 15-48

As the raison d'être of Canadian branch plants was to manufacture under-license and market in Canada the aircraft designs of their parent companies, most of them had no design staffs and were ill-prepared to develop their own line of products. The parent companies were usually not inclined to have their branch plants develop aircraft designs that could compete with theirs, although some allowed their Canadian branches to build up engineering departments to undertake the development of indigenous aircraft designs. This was the case for Boeing Canada, Canadian Vickers, Fairchild and Fleet, which were all involved in aircraft design and development during the interwar period.

As Table 1.12 shows, Canada's Second World War aircraft manufacturers produced 36 aircraft designs during the interwar period, almost half of which were of indigenous origin. Moreover, 140 of the 558 aircraft made by these companies between 1919 and 1939 were of indigenous design, representing slightly more than 25 per cent of production. In all, these companies manufactured 271 trainers, 118 general utility transports, 89 flying boats, 42 patrol aircraft and 38 fighters. The numbers of Canadian-designed aircraft for each category was as followed: 76 flying boats, 59 general utility transports, 3 trainers, 1 patrol aircraft and 1 fighter. In short, 85 per cent of the flying boats and 50 per cent of the general utility transports made during the interwar period were of indigenous origin. Other smaller aircraft manufacturing companies also produced their own lines of aircraft, the most successful being the Curtiss-Reid Aircraft Company of Montreal, which produced 47 Curtiss-Reid Rambler biplane trainers and 1 Curtiss-Reid Courier high-wing mail carrier between 1929 and 1932.[123]

Table 1.12: Output by Second World War Aircraft Manufacturers, 1919-39

Aircraft	Type	Country of Origin	Years of Production	Numbers Produced
Boeing Canada			**1929-39**	**12**
Boeing C-204 Thunderbird	Flying Boat	United States	1929-30	4
Boeing 40H-4	Mail Carrier	United States	1930-31	5
Boeing A-213 Totem	Flying Boat	Canada	1932	1
Blackburn Shark	Patrol Aircraft	Great Britain	1939	2
Canadian Vickers			**1923-39**	**158**
Vickers Viking	Flying Boat	Great Britain	1923-24	6
A.V. Roe 552	Patrol Aircraft	Great Britain	1924-25	14
Canadian Vickers Vedette	Flying Boat	Canada	1924-30	60
A.V. Roe 504	Patrol Aircraft	Great Britain	1925-28	13
Canadian Vickers Varuna	Flying Boat	Canada	1925-27	8
Canadian Vickers Vanessa	Utility Transport	Canada	1926-27	1
Canadian Vickers Vista	Flying Boat	Canada	1927	1
Canadian Vickers Vigil	Trainer	Canada	1928	1
Canadian Vickers Velos	Patrol Aircraft	Canada	1928	1
Fairchild FC-2	Utility Transport	United States	1928	11
Curtiss HS-3L	Flying Boat	United States	1928-29	3
Canadian Vickers Vancouver	Flying Boat	Canada	1928-30	6
Fokker Super Universal	Utility Transport	United States	1929-30	15
Bellanca CH-300 Pacemaker	Utility Transport	United States	1931	6
Northrop Delta	Patrol Aircraft	United States	1936-39	12
CCF			**1936-39**	**40**
Grumman G-23 Goblin	Fighter	United States	1936-39	37
CCF Maple Leaf I	Trainer	Canada	1938	1
CCF Maple Leaf II	Trainer	Canada	1939	1
CCF FDB-1	Fighter	Canada	1939	1
DHC			**1928-39**	**28**
D.H. 82 Tiger Moth	Trainer	Great Britain	1936-38	28
Fairchild			**1930-39**	**51**
Fairchild 71	Utility Transport	United States	1930-35	21
Fairchild 51/71	Utility Transport	United States	1933-34	1
Fairchild Super 71	Utility Transport	Canada	1933-36	3
Fairchild 82	Utility Transport	Canada	1935-39	23
Fairchild 34-42 Niska	Utility Transport	Canada	1937	1
Fairchild 45-80 Sekani	Utility Transport	Canada	1937-38	2
Fleet			**1930-39**	**245**
Fleet 2	Trainer	United States	1930-32	8
Fleet 7 Fawn	Trainer	United States	1930-38	61
Fleet 10	Trainer	United States	1935-39	160
Fleet 21	Trainer	United States	1937	11
Fleet 50 Freighter	Utility Transport	Canada	1938-39	5
Noorduyn			**1935-39**	**24**
Norseman	Utility Transport	Canada	1935-39	24
TOTAL			**1919-39**	**558**

Source: K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 458-464.

"Design or Die"

American historian Irving Brinton Holley has rightfully argued that the survival of any aircraft industry depends on its research and development capabilities. "The injunction 'design or die' has always been virtually axiomatic. Superior performance expressed in higher speeds, greater ceilings, heavier loads and longer ranges wins contracts. To stay in business, manufacturers ... must maintain engineering staffs capable of exploiting the latest findings of aeronautical science, translating theory into practical designs."[124] This was particularly true for combat aircraft where the "obsolescence in aviation is so great that large numbers of old aircraft rapidly become relatively vulnerable to fewer aircraft of newer design and superior performance."[125]

The problem was that the design and development of modern combat aircraft was complicated, and required a lot of time and effort to perfect. Elizabeth MacGill, the chief aeronautical engineer at CCF during the war, explained some of these complexities in a paper given to the Engineering Institute of Canada in 1940.

> The [combat] aeroplane is designed for performance. The design of a new aeroplane is a failure if the performance does not better that of existing machines of the same power and duty. Thus the aeroplane designer faces a dilemma. To insure the marketability of his product – perhaps, too, the supremacy in flight of his nation's air arm – he must design for the ultimate in performance. To insure production en masse – and perhaps the numerical superiority of his nation's air force, he must design to speed up manufacturing. How antithetical these design aims are at present, is shown by the following example. To facilitate production the designer is called upon to depart from the streamlines form. This may result in a serious decrease in the speed of his machine. To reduce the number of different parts and thereby simplify production, he must adopt certain standard parts throughout with a resultant increase in the gross weight of the machine. An increase in gross weight of five per cent ... may seriously impair the rate of climb (the important characteristic if the machine is an interceptor); or the useful load (fuel, ammunition, bombs), a reduction, which would destroy the aeroplane's potency if it were a bomber. Thus under present condition of

> design, performance, and production are opposed as design aims. Before mass production can be entered upon they must be reconciled, and design for cost and production must assume priority.[126]

Aircraft manufacturers were therefore continually caught between two options: freezing designs for mass production, or constantly altering them to obtain maximum performance. Holley explained well this tension between quality and quantity, high performance and mass production:

> Quantity combined with quality, larger numbers, and superior performance, to say the very least, gives a decided advantage. But this is an ideal combination hard to obtain. Continuing superiority requires continual change. Every innovation introduced by the enemy must be outmatched. Superior performance in aircraft is the sum total of many components — range, speed, climb, maneuverability, fire power, and the like — each conditioned by thousands of features of design ... When one is pitted against an aggressive and determined foe, to maintain superiority is to accept the absolute necessity of frequent change, modification of existing designs to incorporate improvements whenever possible and, ultimately, replacement of old models with new ones. Fluidity of design is a requisite ... Mass production, on the other hand, lies at the opposite extreme ... To freeze design is to facilitate production ... When design is repeatedly subject to alteration, bulk purchasing of materials can be hazardous, production planning more complicated, and retooling continual ... In short, only by minimizing design change is it possible to obtain maximum production.[127]

In addition, very few aircraft designs made it past the conception phase. According to estimates of the time, only one out of every five new combat aircraft design were adopted and mass-produced for an air force.[128]

This was a high price to pay for a middle power with a small aircraft manufacturing capability, such as Canada. While aircraft industries in Great Britain and the United States possessed the necessary capital, resources, research facilities and skilled personnel to undertake the design and development of dozens of parallel aircraft programs at the same time, Canada could not afford to do so as it simply did not have the

capability. In fact, to design an aircraft was a dangerous gamble that could result in serious financial losses and possible bankruptcy if a company had no other project to help it rebound. To make matters more difficult, almost no profits would be made during the development phase. As one RCAF official noted, "building aircraft is one of the most intermittent and fluctuating businesses in the world. There are long periods of profitless non-production between contracts, during which overhead goes steadily on, and at least the nucleus of a skilled and highly-paid staff must be held together."[129]

A fighter, bomber, trainer or transport aircraft project had to go through a series of steps from its inception as an idea to production that tended to be long and time consuming. The average length of time in peacetime was five to eight years. The process customarily used in British aircraft production (which was the same in Canada) usually followed seven separate phases.[130] The first was the period of inception, when air force officials compiled the operational requirements and technical forecasts for a new type of aircraft, or when aircraft companies issued preliminary designs in anticipation of coming operational requirements. This step was usually not confined to a predetermined schedule. Some ideas arose very quickly while others took a long time to mature. The second phase occurred when the air force formulated the official technical specification embodying the operational requirements. The document had to cover all engineering aspects, which often included the type of materials and engines to be used, the intended characteristics and performances of the machine, and many other important points. The preparation of a specification typically took five to six months, but could extend several additional months. The third stage was the competitive tender. The completed specification was usually submitted to several aircraft companies with an invitation to

tender designs. The designs were then analyzed by air force specialists and technical experts, who weighed the disadvantages and advantages of each proposed aircraft. It was customary to choose the two best designs and to order one prototype of each at government expense.[131]

The fourth phase was the construction of the prototype aircraft. This was a long and arduous process that usually began with a meeting between air force officials and aircraft company representatives to discuss the aircraft design in further detail. The company would then build a mock-up, a full-scale model of the aircraft often made of wood, which was usually ready within two to three months. The mock-up allowed air force officials to physically examine the layout of the aircraft and the arrangement of the equipment, and to make necessary modifications. Sometimes, air force officials chose to perform wind tunnel trials with scale models of the aircraft. Work on the prototype aircraft would only begin once all parties concerned found the design acceptable. The prototype process would start with the main assembly, then on the construction of the fuselage, wings and tail units, followed by the installation of equipment such as engines, airscrews, undercarriage, electrical equipment, guns and turrets. Once completed, the prototype would make its maiden flight, after which several days or even weeks of additional work were undertaken to rectify troubles noted in flight. The company also undertook a series of handling trials before the aircraft received a guarantee that it met the safety requirements of the specification. The many unexpected difficulties encountered in the process of building a prototype often delayed delivery. Overall, it was quite customary for a prototype to take up to two years to deliver, and very few projects passed through the prototype phase in less than eighteen months. Important to note is that

it was often during the prototype phase that many aircraft designs were abandoned. The fifth stage involved the prototype's tests and trials. The aircraft would often be sent for several months to a government experimental establishment where it went through numerous handling, performance and operational suitability trials. The sixth and seventh phases covered the development and production orders. Delivery of the first aircraft to the air force would normally commence approximately six months after order.[132]

The progress of new British combat aircraft through the seven stages of design and development under normal peacetime conditions was quite long. As Table 1.13 shows, the approximate time required for the design and development of a small, medium and large size aircraft was 5 ½, 6 ½, and 8 years respectively.[133] The intervals were obviously too long in wartime.

Table 1.13: Stages of British Aircraft Development

Stages	Peacetime Allowed (Months)		
	Small Aircraft	Medium Aircraft	Large Aircraft
1) Air Force Requirement	0	0	0
2) Air Force Specification	5	5	6
3) Competitive Tender	8	9	10
4) Construction of Prototype	12	16	24
5) Tests and Trials	9	14	16
6) Development Orders Development Trials	13 12	12 12	17 12
7) Production Orders	6	8	10
Approximate Total Time	65	76	95

Source: M.M. Postan, *British War Production* (London: Her Majesty's Stationery Office, 1952), p. 333; M.M. Postan, D. Hay, and J.D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organization* (London: Her Majesty's Stationery Office, 1964), p. 142

Procedures to speed up the process were implemented in 1935, such as eliminating the competitive tender stage, but the design and development of successful military aircraft still required several years.[134] It took four years for British fighters such as the Hawker Hurricane, the Supermarine Spitfire and the Hawker Typhoon to get from requirement to delivery to the Royal Air Force (RAF). British bombers such as the Short Stirling and

Handley-Page Halifax took four years to develop, while the A.V. Roe Manchester/Lancaster program spanned over five.[135] The development of combat aircraft in other countries, such as France, Germany, Italy, Japan, the Soviet Union and the United States, stretched over similar periods. American fighters like the Bell P-39 Airacobra, the Lockheed P-38 Lightning and the Curtiss P-40 Warhawk took between three and five years to develop. American bombers were no exception. The Boeing B-17 Flying Fortress, for example, took more than four years to develop while the Consolidated B-24 Liberator and the North American B-25 Mitchell took three.[136]

It was not until the war began in 1939 that the time allocated for the design and development of combat aircraft was reduced considerably. The American and British governments began ordering aircraft "off the drawing-board" instead of delaying mass-production orders until a prototype was tested. If modifications were necessary, they would simply be incorporated into the production series. One of the best known British combat aircraft to have been ordered "off the drawing-board" was the De Havilland Mosquito, which went from the design stage to mass production in about one year.[137] A noteworthy American example was the North American P-51 Mustang fighter, which took little more than a year to go through the same process. All the more impressive, the Mustang prototype made its maiden flight only five months after design work had begun.[138] Despite such successes, the time and energy required to design and develop a sophisticated combat aircraft generally remained long. As a former DMS representative explained after the war:

> The design and development of complicated aircraft ... is a long process, the results of which can only be evaluated after many years of development and service testing ... Accordingly it requires from five to seven years before an aircraft to a new design is available in quantity in a

> truly battle-worthy combat condition. The foregoing explains why so very few aircraft for which the design had not been commenced prior to the outbreak of the ... war saw service in the war. Instead, the war was fought with successive modifications of aircraft whose design had at least been commenced prior to the war and which, in most cases, were well advanced into the prototype testing stage at the outbreak of hostilities. The same time cycle applies to the development of aircraft power plants.[139]

This situation definitely made the design and development of aircraft less attractive to both the Canadian government and Canadian aircraft manufacturers.

In addition, the requirements of the RCAF were simply too small to justify such an expensive undertaking in Canada. Historian C.P. Stacey explained that given the RCAF's limited requirements it was "uneconomic to attempt domestic production" unless costs could be reduced by simultaneous contracts for Great Britain or other British Commonwealth countries.[140] As the Master-General of the Ordnance explained in the first weeks of the war:

> It is essential that we should not diverge from British types in order that steady replacement of wastage in the field may be possible ... it is evident that orders in Canada for the requirements of Canadian forces overseas must march hand in hand with the greater orders required by the Empire Pool, thereby sharing in the capital expenditure of the greater requirements, and we should not place orders generally speaking for equipment which is required only for our comparatively small Canadian requirements ... The logical and cheapest way to meet our requirements is for the purchasing authority in Canada to organize industry on an Empire basis in cooperation with Great Britain and allied governments, pour all the products into an Empire Pool, and for the Canadian government to purchase out of that Pool the needs of its forces in the field and at home.[141]

Unfortunately for Canada, British Commonwealth policies of standardization guaranteed reliance on British-pattern combat aircraft throughout the British Empire, therefore making the sale of Canadian-designed aircraft to British Commonwealth air forces practically impossible. Also, the likelihood of Great Britain or the United States adopting

a Canadian-designed fighter or bomber was relatively slim as these governments usually encouraged self-sufficiency in armament production and gave preference to their own aircraft companies. For example, the United States 1933 Buy American Act instructed government agencies to grant preference to American manufacturing in procurement contracts. Under the terms of this legislation, the United States government was required to purchase goods from domestic sources, except where prices were significantly higher (usually more than 25 per cent) than those of foreign suppliers. The legislation largely compelled America's armed forces to use only domestically produced weapons and military equipment.[142]

Another important reason why few aircraft were designed in Canada has to do with the war itself. The wartime emergency made it necessary to produce large quantities of well-proven military aircraft quickly. Designing new types when successful American and British aircraft designs already existed and were available for production in Canada was a luxury that the Canadian government and the local aircraft industry could simply not afford in wartime. Winning the war was the priority, and producing well-proven aircraft designs in large quantities to meet the needs of the various Allied air forces — no matter what the origin of these aircraft were — clearly took precedence over design and development efforts. Reliance on a new and unproven Canadian-designed fighter or bomber, for example, could have been extremely detrimental to the Canadian aircraft production program, as it would have certainly created unwanted engineering problems, tied up vital human and material resources, and slowed down production because of testing. There was also the possibility that the selected design could end up being a total failure, which would have had catastrophic implications for the Canadian aircraft

industry's war effort. Besides, why re-invent the wheel when more experienced American and British design staffs were already working hard at developing new aircraft types and existing aircraft types were available for large quantity production in Canada.

But producing foreign aircraft designs under-license was no easy task. Companies had to tool up for the job, prepare their assembly lines, study the aircraft's drawings, and train their staffs. Also, their engineering staffs often had to design new parts and components for the aircraft to meet specific client requirements. All of this was expensive and extremely time consuming.

Table 1.14: Time Needed to Build Foreign Aircraft Prototypes in Canada

Aircraft Type	Producer	First Order	First Flight (Prototype)	Approximate Wait Period
Harvard	Noorduyn	Jan 1940	31 Jan 1941	12 months
Tiger Moth	DHC	Oct 1936	21 Dec 1937	14 months
Finch	Fleet	July 1937	8 Feb 1939	19 months
PT-23	Fleet	July 1942	23 Nov 1942	4 months
PT-26 Cornell	Fleet	Dec 1941	9 Jul 1942	7 months
Anson	CCF,	June 1940	14 Aug 1941	14 months
	Federal	June 1940	21 Aug 1941	14 months
	NSC	June 1940	12 Sept 1941	15 months
	DHC	June 1940	21 Sept 1941	15 months
	MacDonald	June 1940	10 Oct 1941	16 months
	OCA	June 1940	5 Nov 1941	17 months
York	VAL	Fall 1942	14 Nov 1944	Over 22 months
Delta	Canadian Vickers	Early 1935	21 Aug 1936	Over 12 months
Shark	Boeing Canada	May 1937	21 July 1939	26 months
Stranraer	Canadian Vickers	Nov 1936	21 Oct 1938	23 months
Canso	Boeing Canada	Sept 1940	26 Jul 1942	22 months
	Canadian Vickers	Sept 1940	2 Dec 1942	27 months
Lysander	NSC	Mar 1938	16 Aug 1939	17 months
Bolingbroke	Fairchild	Nov 1937	14 Sept 1939	22 months
Hampden	CAA	Nov 1938	8 Aug 1940	21 months
Lancaster	VAL	Dec 1941	1 Aug 1943	20 months
Lincoln	VAL	Mar 1945	25 Oct 1945	7 months
Goblin	CCF	Nov 1936	2 Feb 1938	15 months
Hurricane	CCF	Nov 1938	10 Jan 1940	14 months
Mosquito	DHC	Sept 1941	23 Sept 1942	12 months
Helldiver	CCF	May 1942	22 July 1943	14 months
	Fairchild	Dec 1942	28 Aug 1943	8 months

Source: LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production and Maintenance* (Montreal: Analytical Section, Production Group, Federal Aircraft Limited, 1947), pp. 2-15, 37-59; K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 49-455.

As Table 1.14 demonstrates, it normally took between one and two years for the foreign aircraft designs made in Canada during the war to reach the prototype stage and make their maiden flight. And it would usually take a few additional weeks, or even months, before clients could obtain their first aircraft. Still, the wait period involved in producing an existing foreign aircraft design under-license was relatively short compared to designing and building a completely new and unproven one from scratch, which normally took several years, as shown earlier. Moreover, producing under-license was safer since the aircraft types selected were already successful on the market, which guaranteed sales. This, in turn, made large quantity production economically sound.

Producing aircraft under-license also involved important, local innovation work. Almost all of the foreign-designed aircraft build in Canada were modified and improved locally. Canadian aircraft companies developed several versions of these foreign aircraft designs. For example, the industry produced two different variants of the Delta and Lysander, three of the Anson, four of the Finch, five of the Canso, seven of the Bolingbroke, Helldiver and Hurricane, and nine of the Mosquito.[143] Each variant would usually differ from one another by the use of a different engine type, armament configurations, instruments, and equipment, or by improvements to the cockpit, fuselage, wings, landing gears and other components. This often necessitated important re-design work by the engineering staffs of Canadian aircraft companies. Moreover, because of the industry's heavy reliance on American sources for machinery, tools and components, as well as problems encountered in obtaining vital supplies in Great Britain during the war, Canadian aircraft companies often had to adapt the making of British-designed aircraft to Canadian production and rely increasingly on North American sources of supply. This

often forced the engineering staffs of Canada aircraft companies to re-design or develop new parts and components to be used in the production of those foreign-designed aircraft in Canada.

Another impediment to the rise of a strong Canadian aircraft industry capable of designing and developing its own line of aircraft was the constant search for skilled and semi-skilled labour in Canada.[144] James Young, president of Canadian Propellers, explained during the war that "the development and design of new types of aircraft in Canada is not ... an easy matter, as the number of properly qualified engineers and designers with a proper background in Canada is limited."[145] The Canadian government was well aware of this problem, and attempted on several occasions to rectify the situation.

As early as 1938, the Navy, Army and Air Supply Committee, a special body set up by DND to investigate the productive capacity of Canadian industry for the manufacture of war materials in the event of an emergency, conducted a voluntary national registration of men in the technical and scientific professions.[146] It surveyed approximately 10,000 individuals, 7,000 of whom answered, including some from the aircraft industry.[147] Shortly after war was declared in 1939, the Employment Service of Canada carried out across the country a voluntary registration of skilled and semi-skilled workers whose training and experience qualified them for employment in the arms industry.[148] In addition, the Commercial Air Transport and Manufacturer's Association of Canada (renamed the Air Industries and Transport Association of Canada in November 1942) maintained a register of Canadian aeronautical engineers and key aviation experts since November 1934.[149] In 1940, the government introduced the National Resources

Mobilization Act (NRMA), which gave it special emergency powers to mobilize all of the country's human and material resources. All Canadian men and women over sixteen years of age were forced to register for the NRMA, and the data compiled enabled government officials to encourage, and eventually compel appropriate workers to the armed services or to industry.[150] In early 1941, the shortage of technical personnel in war industries became acute and the Department of Labour responded by establishing a Bureau of Technical Personnel to facilitate graduate scientific training and to direct university graduates to jobs in industry or the armed services where their technical knowledge could be put to best use.[151]

In order to meet current and anticipated shortages in skilled and semi-skilled workers, the Canadian government passed the Vocational Training Coordination Act in August 1942. The legislation established the Dominion-Provincial War Emergency Training Program, which was jointly administered by the federal and provincial governments, technical schools and special training centers across Canada. By the time the war ended in 1945, the program had trained about 424,000 tradesmen, 300,000 of whom were made available for arms production, including the aircraft industry.[152] Moreover, Canadian universities trained engineers, scientists, technicians and other experts for the aircraft industry in cooperation with the Department of Labour.[153] The most famous Canadian graduate was Elizabeth "Elsie" McGill, who was the first women in Canada to earn a degree in engineering (obtained from the University of Toronto). She joined CCF and was the only woman chief engineer in Canada during the war.[154] However, since Canadian universities possessed no aeronautical engineering departments at the time, most Canadian aircraft companies had to send their Canadian-educated

engineers on special training courses in Great Britain or the United States, or had to hire foreign engineers. The DMS's Aircraft Production Branch recognized this and made an arrangement in 1942 with the Aero Industries Technical Institute of Los Angeles, California, to provide courses for Canadian engineers in the manufacture, repair and overhaul of aircraft.[155]

While the number of engineering graduates in Canadian institutions of higher learning rose as a result and many reputed American, British and even Polish aeronautical engineers moved to Canada to work during the war, the Canadian aircraft industry did not truly benefit from this specialized labour force until the end of hostilities. This largely had to do with the wartime emergency, as there was simply no time to waste developing new aircraft designs in Canada when aircraft design staff were already working to that end in Great Britain and the United States. It was felt there was absolutely no reason or time to duplicate efforts elsewhere. In fact, several Canadian-educated scientists and engineers moved to Great Britain and the United States, where they contributed to armament development in those countries. NRC President C.J. Mackenzie commented on this "brain drain" to the Engineering Institute of Canada, stating that Canada had become "an exporter of scientific brains and an importer of the products of our exported genius."[156] As such, Canada's contribution in the field of aeronautical research and development were meager. The British official historian of overseas supplies pointed out that the "reason was obvious: neither aircraft designers nor the scientists behind them could feel much urge to do original work while production was concentrated on planes of British or American origin."[157]

More serious was the complete dependence of the Canadian aircraft industry on foreign sources, especially the United States, for vital components, instruments, materials, tools, engines and other supplies.[158] In 1944, the DMS estimated that more than 60 per cent of the materials and components used by Canadian aircraft manufacturers came from American sources.[159] This situation was owed largely to Canada's geographical proximity to the United States, which facilitated access to the American market, and to the fact that a great number of Canadian industries were American-owned.[160] This was certainly the case in the Canadian aircraft industry: five of the leading American aircraft-making firms opened branch plants in Canada during the interwar years, namely Curtiss (Curtiss-Reid, 1928), Boeing (Boeing Canada, 1929), Fairchild (Fairchild, 1929), Consolidated (Fleet, 1930), and Piper (Cub, 1936).[161]

As a result, Canadian companies became more inclined to adopt American manufacturing methods, making the production of British-pattern products somewhat difficult. As C.D. Howe stated in November 1945:

> Although Canada made so much material of British types, Canadian industry generally was based upon American production methods, standards and techniques and was dependent upon American imports of machinery, spare parts, sub-assemblies and components. The production of British-type equipment frequently involved important adaptations of manufacturing procedures to suit Canadian-American methods.[162]

This also made the development of truly Canadian combat aircraft designs all the more difficult. As historian D.J. Goodspeed explained:

> Because of Canada's contiguity to the Untied States, Canadian industry used American manufacturing techniques and American design and production practices rather than British. Yet for traditional and historical reasons the Canadian forces on the whole were patterned after the British services rather than the American. Thus, a Canadian defence policy, insofar as it concerned

> the design, development and production of weapons and military equipment, was forced to seek a compromise between the British and the American systems. For these reasons, and because Canada would not require large quantities of most types of equipment for her own use, it was obviously neither economical nor desirable that Canada should develop weapons and equipment which were peculiar to herself alone ... Since she was a relatively small country, it was clearly impossible for Canada ... to run parallel projects with her Allies.[163]

Canadian industrial reliance on American production methods also promoted industrial and economic cooperation with the United States. As friendship grew between the American and Canadian governments, so did industrial and economic cooperation between both countries. The Hyde Park agreement of 1941, for example, guaranteed the American and Canadian aircraft industries full access to each other's markets. The American government placed huge orders in Canada. In fact, 5,096 of the aircraft made in Canada during the war were exported to the United States in addition to thousands of different spare parts and components. This work accounted for about 31 per cent of Canada's total wartime production.[164] Meanwhile, the British government maintained considerable economic influence on Canada's industrial war effort, and determined to a large extent the kind of products made in the country because of British Commonwealth standardization policies.[165] In all, the Canadian aircraft industry exported 4,854 aircraft to Great Britain (and other allied countries), in addition to thousands of different components and parts for its aircraft manufacturers during the war. This accounted for about 30 per cent of Canadian production.[166]

Conclusion

In light of all the above reasons, Canadian authorities left aircraft development in the hands of experienced design staff and aeronautical research facilities in Great Britain

and the United States, and to concentrate exclusively on the mass production of simple and well-proven American and British aircraft designs. In wartime, every effort was to be made to provide Allied air forces with aircraft as quickly as possible. Requirements were simply too great to justify wasting valuable resources on designing and developing military aircraft in Canada when larger and more powerful design staffs in Great Britain and the United States were already working at full capacity on such projects. In this context, it was extremely difficult for Canada to justify embarking on such a venture.

NOTES

1 Library and Archives of Canada [LAC], RG-24 [Records of the Department of National Defence], Vol. 6179, File: HQ 60-1-59, "A/V/M E.W. Stedman (For CAS) to H.J. Carmichael (DMS)," 3 November 1944.

2 LAC, RG-28 [Records of the Department of Munitions and Supply], Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production and Maintenance* (Montreal: Analytical Section, Production Group, Federal Aircraft Limited, 1947), pp. 60-95; "Made-in-Canada Aircraft, *Industrial Canada*, Vol. 39, No. 11 (March 1939), pp. 52-56; Leslie Roberts, *Canada's War in the Air* (Montreal: Alvah M. Beatty, 1942), pp. 107-151.

3 LAC, RG-28, Vol. 33, File: 1-1-1, "Orders-in-Council P.C. 1793 and P.C. 1794," 12 July 1939; LAC, RG-28, Vol. 33, File: 1-1-1, "R.C. Vaughan (Vice-President, CNR) to L.R. Thomson (Secretary and Comptroller, DMS)," 18 July 1940. See also Canadian War Museum [CWM], "Department of Munitions and Supply, Quarterly Summary, 1 January to 31 March 1940," 15 May 1945, in *Department of Munitions and Supply Quarterly Reports Vol. 1: First Year's Operations, 1940-1941* (Ottawa: Department of Munitions and Supply, 1945), p. 1.

4 LAC, RG-77 [Records of the National Research Council], Vol. 57, "Report of the Committee on National Defence to the Executive Council, Canadian Manufacturers' Association," 28 September 1939.

5 LAC, RG-28, Vol. 33, File: 1-1-1, "R.C. Vaughan (Vice-President, CNR) to L.R. Thomson (Secretary and Comptroller, DMS)," 18 July 1940. See also CWM, "Department of Munitions and Supply Quarterly Summary, 1 January to 31 March 1940...," p. 2.

6 CWM, "Department of Munitions and Supply, Quarterly Summary, 1 January to 31 March 1940," 15 May 1940, in *Department of Munitions and Supply Quarterly Reports Vol. 1: First Year's Operations, 1940-1941* (Ottawa: Department of Munitions and Supply, 1940), p. 11; J. de N. Kennedy, *History of the Department of Munitions and Supply, Volume 1* (Ottawa: King's Printer, 1950), pp. 4-5; LAC, RG-28, Vol. 33, File: 1-1-1, "Memorandum by W.R. Campbell (Chairman, WSB) and C.E. Gravel (Vice-Chairman, DPB)," 31 October 1939.

7 CWM, "Department of Munitions and Supply Quarterly Summary, 1 January to 31 March 1940...," p. 3.

8 CWM, "Department of Munitions and Supply, Quarterly Summary, 1 January to 31 March 1940," 15 May 1940, in *Department of Munitions and Supply Quarterly Reports Vol. 1: First Year's Operations, 1940-1941* (Ottawa: Department of Munitions and Supply, 1940), p. 11.

9 Canada, *The Industrial Front, Volume 5* (Ottawa: Department of Munitions and Supply, 1944), p. 29. See also Kennedy, *History of the Department of Munitions and Supply, Volume 1...*, pp. 25-33.

10 LAC, RG-28, Vol. 73, File: 1-1-155, "Report on the Organization of the Aircraft Production Branch," 29 June 1940.

11 LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft* Production..., pp. 51-52, 61; LAC, RG-28, Vol. 8, File 27, "History of Federal Aircraft Limited," 1946, pp. 1-46; LAC, RG-28, Vol. 862, *Canada's Industrial War Effort, 1939-1945* (Ottawa: Economic Research Branch/Department of Reconstruction and Supply, 1947), Introductory Summary p. 5. See also K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 20-21, 37-38, 41-44.

12 LAC, RG-28, Vol. 8, File 27, "History of Federal Aircraft Limited, Part 2," 1946, pp. 6-11.

13 W.B. Burchall, "The Aircraft Manufacturing Industry: Great Expansion in Productive Capacity," *Industrial Canada*, Vol. 45, No. 9 (January 1945), p. 118. See also CWM, "Department of Munitions and Supply, Quarterly Summary, 1 July to 30 September 1943," 19 October 1943, in *Department of Munitions and Supply Quarterly Reports Vol. 4: Fourth Year's Operations, 1943-1944* (Ottawa: Department of Munitions and Supply, 1943), p. 34.

14 Stanley W. Dziuban, *Military Relations Between the United States and Canada, 1939-1945* (Washington D.C.: Department of the Army, 1959), p. 283. See also F.J. Hatch, *The Aerodrome of Democracy: Canada and the British Commonwealth Air Training Plan, 1939-1945* (Ottawa: Department of National Defence, 1983).

[15] Canada, *Canada at War – Recapitulation Issue* (Ottawa: Wartime Information Board, 1945), pp. 38-41.

[16] LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, pp. 37-95.

[17] *Ibid.*

[18] American-designed Harlow PC-5: *Project Started:* Early 1939; *Selected Manufacturer:* Cub; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Clients:* Canadian Government; *Project Cancelled:* September 1939; *Reason:* The Canadian Government was not interested in that trainer. See LAC, RG-12 [Records of the Department of Transport], Vol. 759, File: 5010-10-88, "R.L. Gibson (Cub Aircraft Corporation) to D of T," 21 September 1939; LAC, RG-12, Vol. 759, File: 5010-10-88, "A.T. Cowley (Superintendent of Air Regulations, D of T) to Cub Aircraft Corporation," 26 September 1939.

[19] British-designed De Havilland Dragonfly: *Project Started:* June 1940; *Selected Manufacturer:* DHC; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Clients:* Canadian Government; *Project Cancelled:* June 1940; *Reason:* The aircraft was not suitable for air training. See LAC, RG-24, Vol. 5108, File: HQ 1021-9-31, "Air Commodore Robert Leckie (DOT) to AMOT," 15 June 1940; LAC, RG-24 [Records of the Department of National Defence], Vol. 5108, File: HQ 1021-9-31, "W.J. McDonough (Director of Operations, DHC) to the CAS," 17 June 1940.

[20] American-designed Bell P-39 Airacobra: *Project Started:* November 1940; *Selected Manufacturer:* Fleet (CCF was also approached); *Contract Signed:* None; *Numbers of Aircraft to be produced:* Over 300; *Clients:* British and Canadian Governments; *Project Cancelled:* Early 1941; *Reason:* The British backed out of the project. See LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Air Commodore W.R. Kenny (Air Attaché, Canadian Legation, Washington D.C.) to AMES," 8 November 1940; LAC, RG-24, Vol. 5397, File: HQS 60-3-15, "Lawrence D. Bell (President, Bell Aircraft Corporation) to Ralph P. Bell (DGAP)," 18 November 1940; LAC RG-24, Vol. 5397, File: HQS 60-3-15, "A/V/M E.W. Stedman (AMAE) to Deputy MND (Air)," 13 December 1940; LAC RG-24, Vol. 5397, File: HQS 60-3-15, "Lawrence D. Bell (President, Bell) to Ralph P. Bell (DGAP)," 14 December 1940; LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Ralph P. Bell (DGAP) to S.L. de Carteret (Deputy MND (Air))," 19 February 1941; LAC, RG-24, Vol. 5397, File: HQS 60-3-15, "C.D. Howe (MMS) to S.L. de Carteret (Deputy MND (Air))," 22 March 1941.

[21] American-designed Lockheed P-38 Lightning: *Project Started:* Early Autumn 1940; *Selected Manufacturer:* Fleet; *Contract Signed:* None; *Numbers of Aircraft to be produced:* 180; *Client:* Canadian Government; *Project Cancelled:* October 1940; *Reason:* Difficulties in negotiating license agreement with Lockheed. See LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "A/V/M E.W. Stedman (For CAS) to Air Attaché (Canadian Legation, Washington D.C.)," 1 November 1940.

[22] British-designed Hawker Typhoon: *Project Started:* Early 1941; *Selected Manufacturer:* CCF; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Client:* British Government; *Project Cancelled:* 1941; *Reason:* CCF was asked to produce Curtiss Helldiver dive-bombers instead. See LAC RG-24, Vol. 5395, File: HQS 60-3-11, "Ralph P. Bell (DGAP) to S.L. de Carteret (Deputy MND (Air))," 19 February 1941.

[23] American-designed Chance-Vought Corsair or Grumman Hellcat: *Project Started:* December 1941; *Selected Manufacturer:* Canadian Vickers; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Client:* British Government; *Project Cancelled:* Early 1942; *Reason:* Unknown. Canadian Vickers chose the Hellcat for production under the designation of FV-1. See CWM, "Department of Munitions and Supply, Quarterly Summary, 1 October to 31 December 1941," 15 January 1942, in *Department of Munitions and Supply Quarterly Reports Vol. 2: Second Year's Operations, 1941-1942* (Ottawa: Department of Munitions and Supply, 1942), p. 8; Michael J. Hardy, *Sea, Sky and Stars: An Illustrated History of Grumman Aircraft* (New York: Sterling Publishing Company, 1987), pp. 45-52; "Nine Aircraft Types for Canada," *Canadian Aviation*, Vol. 15, No. 3 (March 1942), p. 83.

[24] American-designed Grumman Bearcat: *Project Started:* Early 1945; *Selected Manufacturer:* CCF; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Client:* British Government; *Project Cancelled:* Early 1945; *Reason:* Unknown. CCF was keen on producing the Bearcat under-license under the designation F4W-1. See LAC, MG-27, III B 20, Vol. 69, File: S-27-1-3, Memorandum to the Minister," 7 February 1945. See also Hardy, *Sea, Sky and Stars...*, pp. 71-74.

[25] British-designed Bristol Beaufort: *Project Started:* 1938; *Selected Manufacturer:* Boeing Canada and Fairchild; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Client:* British Government; *Project Cancelled:* Early 1939; *Reason:* The British Government decided instead to sign a contract for the mass production of Beauforts in Australia. See Rénald Fortier, *Intervention Gouvernementale et Industrie Aéronautique: L'exemple canadien, 1920-1965* Ph.D. Thesis (Quebec City : Université Laval, 1990), pp. 206-207, 212-215.

[26] French-designed Amiot 350: *Project Started:* December 1938; *Selected Manufacturer:* Massey-Harris; *Contract Signed:* December 1938; *Numbers of Aircraft to be produced:* 100; *Client:* French Government; *Project Cancelled:* Early 1939; *Reason:* The French Government backed out of the project. See Fortier, *Intervention gouvernementale et industrie aéronautique...*, pp. 222-223.

[27] French-designed Breguet 690: *Project Started:* July 1939; *Selected Manufacturer:* NSC (DHC and Fleet were also approached); *Contract Signed:* August 1939; *Numbers of Aircraft to be produced:* 144; *Client:* French Government; *Project Cancelled:* December 1939; *Reasons:* The British government put pressure on Canada to concentrate on the manufacture of British-designed aircraft. See LAC, RG-24, Reel: C-8353, File: HQC 8037, "Report by Ian Mackenzie (Minister of National Defence)," 3 July 1939; LAC, RG-24, Reel: C-8353, File: HQC 8037, "Report by Ian Mackenzie (Minister of National Defence)," 28 July 1939; LAC, RG-24, Reel: C-8353, File: HQC 8037, "Report by Ian Mackenzie (Canadian Minister of National Defence)," 1 August 1939; LAC, RG-28, Vol. 40, File: 1-1-36-1, "Minutes of the Sixth Weekly Meeting Between Canadian War Supply Board and British Supply Board," 6 December 1939.

[28] British-designed Bristol Beaufighter and Blackburn Botha: *Projects Started:* Early 1939; *Selected Manufacturer:* Fairchild; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Clients:* British and Canadian Governments; *Project Cancelled:* Summer 1939; *Reason:* Canadian Government preferred having Fairchild continue to produce the Bristol Bolingbroke. See LAC, RG-24, Vol. 5397, File: HQS 60-3-24, "British Air Ministry to Canadian CAS," 3 April 1939; LAC, RG-24, Vol. 5397, File: HQS 60-3-24, "A/V/M G.M. Croil (CAS) to RCAF Liaison Officer (British Air Ministry)," 30 June 1939.

[29] American-designed Douglas DB-7 Boston: *Project Started:* March 1940; *Selected Manufacturer:* Unknown; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Clients:* British and Canadian Governments; *Project Cancelled: March 1940*; *Reasons:* Unknown. See Fortier, *Intervention gouvernementale et industrie aéronautique...*, p. 222.

[30] American-designed Martin B-26 Marauder: *Project Started:* Summer 1940; *Selected Manufacturer:* NSC; *Contract Signed:* April 1941; *Numbers of Aircraft to be produced:* Over 200; *Client:* Canadian Government; *Project Cancelled:* December 1941; *Reasons:* NSC to manufacture the A.V. Roe Lancaster bomber instead. See Eric Crawford, "Canadian Aircraft Production: Tooling for the B-26 at Malton," *Canadian Aviation*, Vol. 14, No. 10 (October 1941), pp. 47-48, 74; "Howe Gives Reasons Dropping B-26 Job," *Canadian Aviation*, Vol. 15, No. 6 (June 1942), p. 78; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "Group Captain A. Ferrier (For CAS) to Ralph P. Bell (DGAP)," 14 December 1940; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "S.L. de Carteret (Deputy MND (Air)) to Deputy MMS," 6 February 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Provisional Specification for Martin B-26A Bomber," 29 March 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Group Captain A. Ferrier (For CAS) to DGAP," 29 March 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Contract for B-26 bombers," 8 April 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "RCAF Specification AIR-16-2 for Martin B-26A Bomber," 23 April 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Group Captain A. Ferrier (For CAS) to J.A. Miller (Legal Branch, DMS)," 24 April 1941; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "A/V/M E.W. Stedman (For CAS) to the Air Attaché (Canadian Legation, Washington D.C.)," 7 June 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Wing Commander A.C. Adams (For CAS) to L.E. Marchant (NSC)," 27 June 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Edwin L. Zivi (Administrative Engineer, Glenn L. Martin Company) to Wing Commander J.G. Bryans (Assistant Air Attaché, Canadian Legation, Washington DC)," 1 July 1941; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, A/V/M E.W. Stedman (AMAE) to CAS," 12 July 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Squadron Leader E.H. Higgins (For CAS) to NSC," 16 July 1941; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "A/V/M E.W. Stedman (AMAE) to CAS," 2 September 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Wing Commander A.O. Adams

(D/DAD) to DAE," 18 September 1941; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "A/V/ME.W. Stedman (For CAS) to Ralph P. Bell (DGAP)," 22 September 1941; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "A/V/M E.W. Stedman (For CAS) to Ralph P. Bell (DGAP)," 1 October 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, Wing Commander A.O. Adams (For CAS) to DGAP)," 18 October 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "W.U. Shaw (CAE, NSC) to CAS," 20 October 1941; LAC, RG-24, Vol. 5013, File: HQ 938 CE-1-5, "Wing Commander A.O. Adams (For CAS) to W.U. Shaw (NSC)," 23 October 1941; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "S.L. de Carteret (Deputy MND) to D.K. Sheils (Deputy MMS)," 12 December 1941; "Production of the Martin B-26 'Flying Torpedo' Designed for Speedy Manufacture," *Canadian Aviation*, Vol. 14, No. 5 (May 1941), pp. 48, 58

31 British-designed Short Stirling: *Project Started:* Summer 1939; *Selected Manufacturer:* CAA; *Contract Signed:* January 1940; *Numbers of Aircraft to be produced:* 150; *Clients:* British and Canadian Governments; *Project Cancelled:* December 1940; *Reason:* Stirling of no use whatsoever for the defence of Canada and too many difficulties to be encountered in its production. See "Big Manufacture Plan Revealed," Canadian Aviation, Vol. 13, No. 6 (June 1940), p. 100; LAC, RG-2, 7c, Reel: C-11,789, Volume 2, "Minutes of the Cabinet War Committee," 5 November 1940; LAC, RG-28, Vol. 40, File: 1-1-36-1, "British Supply Board in Canada and the United States Report on the Development of Stirling Capacity in Relation to Overall Airframe Requirements," 7 October 1939; LAC, RG-28, Vol. 40, File: 1-1-36-1, "Draft Note of a Meeting to Consider the Allocation of Floor Space in Various Canadian Factories in Connection with the Production of Stirling Aircraft," 14 November 1939;

32 British-designed Handley-Page Halifax: *Project Started:* December 1940; *Selected Manufacturer:* CAA; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Clients:* British and Canadian Governments; *Project Cancelled:* Early 1941; *Reason:* The British preferred to have another type of bomber manufactured in Canada. See LAC, RG-28, Vol. 5, File 9, "Diary of Visit to Great Britain by C.D. Howe (MMS)," 29 December 1940. See also Barnes, *Handley Page Aircraft since 1907...*, pp. 39, 394.

33 American-designed Consolidated B-24 Liberator: *Project Started:* December 1940; *Selected Manufacturer:* CCF; *Contract Signed:* Summer 1941; *Numbers of Aircraft to be produced:* 100; *Client:* British Government; *Project Cancelled:* Summer 1941; *Reason:* The British order proved too small to render Canadian production of the B-24 economically viable. See "Canadian Car will Make B-24's for Britain in Western Plant," *Canadian Aviation*, Vol. 14, No. 7 (July 1941), pp. 61-62; LAC, RG-28, Vol. 5, File 9, "Diary of Visit to Great Britain by C.D. Howe (MMS)," 31 December 1940; LAC, RG-28, Vol. 5, File 9, "Diary of Visit to Great Britain by C.D. Howe (MMS)," 8 January 1941; LAC, RG-28, Vol. 73, File: 1-1-155, "Memorandum by Ralph P. Bell (DGAP)," 11 June 1941. See also Fortier, *Intervention gouvernementale et industrie aéronautique...*, pp. 307-308.

34 American-designed Consolidated XB-32 Dominator: *Project Started:* Summer 1941; *Selected Manufacturer:* Possibly NSC; *Contract Signed:* None; *Numbers of Aircraft to be produced:* Unknown; *Clients:* British and Canadian Governments; *Project Cancelled:* Fall 1941; *Reason:* NSC to manufacture the A.V. Roe Lancaster bomber instead. See "Hint Manufacture Big Bomber Here," *Canadian Aviation*, Vol. 14, No. 2 (February 1941), p. 75; LAC, RG-24, Vol. 5397, File: HQS 60-3-18, "E.P. Taylor (British Supply Council, Washington D.C.) to C.D. Howe (MMS)," 15 September 1941. See also Lloyd S. Jones, *U.S. Bombers* (Fallbrook: Aero Publishers, 1974), pp. 97-116.

35 CWM, "Department of Munitions and Supply, Quarterly Summary, 1 October to 31 December 1943," 4 February 1944, in *Department of Munitions and Supply Quarterly Reports Vol. 4: Fourth Year's Operations, 1943-1944* (Ottawa: Department of Munitions and Supply, 1944), p. 28; LAC, RG-28, Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production...*, pp. 22, 33-34; H.A. Taylor, *Airspeed Aircraft since 1931* (London: Putnam, 1970), p. 84; H.A. Taylor, *Fairey Aircraft since 1915* (London: Putnam), pp. 277-282.

36 The aircraft overhauled were of the same type as those manufactured or assembled in the country. In addition, there were American-made designs like the Beechcraft Expeditor, Cessna Crane, North American Yale, Stearman PT-27 Kaydet and Stinson Reliant trainers; the Douglas DC-3 Dakota, Grumman Goose, Lockheed Loadstar and Northrop Nomad transports; the Bell P-39 Airacobra, Curtiss P-40 Kittyhawk and Curtiss P-40 Tomahawk fighters; and the Consolidated B-24 Liberator,

Douglas B-18 Digby, Lockheed Hudson and Lockheed Ventura bombers. See LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, pp. 16-31.

37 Among the most important subcontractors were Ontario firms such as Central Aircraft Limited of London, Cockshutt Moulded Aircraft of Brantford, General Motors of Canada Limited of Oshawa, Massey-Harris Company Limited of Weston, and White Canadian Aircraft of Hamilton. Other important Canadian subcontractors were Canadian General Electric, Canadian Marconi, Canadian Propellers Limited, Canadian Power Boat, Canadian Westinghouse, Clyde Aircraft, Cockshutt Plough, Dowty Equipment, Firestone, Goodyear, Northern Electric, RCA Victor, and S&S Aircraft. See LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, pp. 98-108.

38 Boeing Canada, for example, manufactured spare parts for Fairey Battle advanced trainers, and produced 1,011 bomb bay sections for Boeing B-29 Superfortress four-engine bombers for Boeing in the United States; Canadian Vickers supplied 119 Consolidated PBY Catalina flying boat hulls and 172 wing center sections to Consolidated in the United States; CCF produced 1,206 Hawker Hurricane fighter wings and 1,168 oleo leg assemblies for Hawker in Great Britain, and made 1,040 Curtiss Helldiver dive-bomber oleo leg assemblies for Curtiss in the United States; DHC produced over 200 De Havilland Tiger Moth elementary trainer airframes for De Havilland in Great Britain; Dowty Equipment Canada produced various maintenance parts for Fairey Battle advanced trainers and Bristol Blenheim twin-engine bombers; and Fairchild produced components and sub-assemblies for 71 Chance-Vought F4U Corsair naval fighters for Chance-Vought in the United States, and made main components (inner and outer wings, windshields, and front and rear cabins) for 195 Grumman F7F Tigercat twin-engine naval fighters for Grumman in the United States. See Leonard Bridgman, ed., *Jane's All the World's Aircraft, 1945-1946* (New York: The Macmillan Company, 1946), pp. 85-90c; "Fairchild Parts Go Into New US Fighter," *Canadian Aviation*, Vol. 18, No. 7 (July 1945), p. 110; LAC, RG-28, Vol. 1, File: 1, "DMS Release 586," 31 August 1945; LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, p. 41, 43, 55-56, 61-62, 68, 72-73, 81, 100-101; Don Mason, "Boeing of Canada Making B-29 Parts," *Canadian Aviation*, Vol. 17, No. 9 (September 1944), p. 137; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 246-253, 378-381; "Tigercat for US Navy," *Canadian Aviation*, Vol. 18, No. 8 (August 1945)," p. 112; "With Aviation to Victory," *Commercial Aviation*, Vol. 7, No. 10 (November 1945), p. 40.

39 Canadian aircraft manufacturers and the National Research Council of Canada (NRC) worked on the development of fixed and retractable ski undercarriages for Airspeed Oxford, A.V. Roe Anson, Cessna Crane, Fairey Battle, Fleet Fort, and North American Harvard trainers, Noorduyn Norseman general utility transports, Westland Lysander army cooperation aircraft, Bristol Blenheim, Bristol Bolingbroke, Handley-Page Hampden and Lockheed Ventura twin-engine bombers and Hawker Hurricane and Supermarine Spitfire fighters. In addition, between 1941 and 1943, the USAAF cooperated with the NRC and tested several fighters fitted with American-designed ski undercarriages in Canada, including the Bell P-39 Airacobra, Bell P-63 Kingcobra, Curtiss P-36 Hawk, Curtiss P-40 Warhawk, Lockheed P-38 Lightning, North American P-51 Mustang and Republic P-47 Thunderbolt. Except for the P-47 and P-39, all were equipped with retractable ski undercarriages. Moreover, the Canadian aircraft industry developed special float undercarriages for Bristol Bolingbroke twin-engine bombers, Northrop Delta patrol aircraft and Noorduyn Norseman general utility transports. LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "CAS to RCAF Overseas HQ," 11 October 1941; LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Group Captain A. Ferrier (For CAS) to AOC RCAF Overseas HQ," 21 October 1941; LAC, RG-24, Vol. 5396, File: HQS 60-3-14, "Air Commodore A. Ferrier (For Chief of the Air Staff) to B.S. Shenstone (British Air Commission)," 25 April 1942; Canada, *War History of Division of Mechanical Engineering* (Ottawa: National Research Council of Canada, 1940s), pp. 194-195; LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, p. 34; Larry Milberry, *Sixty Years: The RCAF and CF Air Command, 1924-1984* (Toronto: CANAV Books, 1984), pp. 194-196; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 121-122, 339, 404, 415-416, 452.

40 LAC, RG-28, Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production...*, pp. 60-95; LAC, RG-36, Vol. 17, File: S.15/2, "Aircraft Production in Canada" (Ottawa: Economic Research Division, Department of Trade and Commerce, 8 November 1950), pp. 1-2. Kennedy, *History of the Department of Munitions and Supply, Vol. 1...*, p. 25.

41 CWM, "Department of Munitions and Supply, Quarterly Summary, 1 January to 31 March 1944," 1May 1944, in *Department of Munitions and Supply Quarterly Reports Vol. 4: Fourtht Year's Operations, 1943-1944* (Ottawa: Department of Munitions and Supply, 1945), p. 27; LAC, RG-36, Vol. 17, File: S.15/2, "Aircraft Production in Canada" (Ottawa: Economic Research Division, Department of Trade and Commerce, 8 November 1950), pp. 1-2; Kenneth Wilson, "Canada's Aviation Industry is...A Problem Child," *Canadian Aviation*, Vol. 17, No. 11 (November 1944), p. 102.

42 LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, p. 96, 105.

43 Roger E. Bilstein, *The American Aerospace Industry: From Workshop to Global Enterprise* (New York: Twayne Publishers, 1996), pp. 77, 225-227. See also Wesley Frank Craven and James Lea Cate, *The Army Air Forces in World War II, Volume 6: Men and Planes* [1955] (Washington D.C.: Office of Air Force History, 1983), pp. 331-332; I.C.B. Dear and M.R.D. Foot, eds., *The Oxford Companion to the Second World War* (Oxford: Oxford University Press, 1995), p. 1060; Irving Brinton Holley, *Buying Aircraft: Matériel Procurement for the Army Air Forces* (Washington D.C.: Department of the Army, 1964), p. 548.

44 Jean Alexander, *Russian Aircraft since 1940* (London: Putnam, 1975), p. 4; Alexander Boyd, *The Soviet Air Force since 1918* (London: MacDonald and Jane's, 1977), pp. 187-204; Otto Preston Chaney Jr. and John T. Greenwood, "Patterns in the Soviet Aircraft Industry," in Robin Higham and Jacob W. Kipp, eds., *Soviet Aviation and Air Power: A Historical View* (London: Brassey's, 1978), pp. 277, 281-282; Dear and Foot, *The Oxford Companion to the Second World War...*, p. 1060; Robert A. Kilmarx, *A History of Soviet Air Power* (New York: Frederick A. Praeger, 1962), pp. 200-202.

45 Great Britain, *Statistical Digest of the War* (London: His Majesty's Stationery Office, 1951), pp. 152; M.M. Postan, *British War Production* (London: Her Majesty's Stationery Office, 1952), pp. 484-485. See also H. Duncan Hall and C.C. Wrigley, *Studies of Overseas Supply* (London: Her Majesty's Stationery Office, 1956), p. 5; Dear and Foot, *The Oxford Companion to the Second World War...*, p. 1060; Erik Lund, "The Industrial History of Strategy: Reevaluating the Wartime Record of the British Aviation Industry in Cooperative Perspective, 1919-1945," *The Journal of Military History*, Vol. 62, No. 1 (January 1998), pp. 75-99.

46 Annual German production was the following: 8,295 (1939), 10,826 (1940), 11,776 (1941), 15,556 (1942), 25,527 (1943), 39,807 (1944), and 7,539 (1945). See Marcel Baudot, Henri Bernard, Hendrik Brugmans, Michael R.D. Foot and Hans-Adolf Jacobsen,, eds., *Encyclopédie de la Guerre 1939-1945* (Paris: Casterman, 1977), p. 89; Bilstein, *The American Aerospace Industry...*, p. 77; Dear and Foot, *The Oxford Companion to the Second World War...*, p. 1060; Holley, *Buying Aircraft...*, p. 555; Postan, *British War Production...*, p. 471; United States, *The United States Strategic Bombing Survey: The Effects of Strategic Bombing on the German War Economy* (Washington D.C.: Overall Economic Effects, 1945), pp. 148-162, 277. See also William Green, *The Warplanes of the Third Reich* (London: MacDonald, 1972); J.R. Smith and Antony L. Kay, *German Aircraft of the Second World War* (London: Putnam, 1972).

47 Annual Japanese production was the following: 4,467 (1939), 4,768 (1940), 5,088 (1941), 8,861 (1942), 16,693 (1943), 28,180 (1944), and 11,066 (1945). See Basil Collier, *Japanese Aircraft of World War II* (London: Sidgwick & Jackson, 1979), p. 16; Dear and Foot, *The Oxford Companion to the Second World War...*, p. 1060; R.J. Francillon, *Japanese Aircraft of the Pacific War* (London: Putnam & Company, 1970), pp. 4, 10.

48 Annual Italian production was the following until the 1943 Italian surrender: 1,800 (1939), 3,257 (1940), 3,503 (1941), 2,818 (1942) and 1,930 (1943). See Enzo Angelucci, *The Rand McNally Encyclopedia of Military Aircraft* (Chicago: Rand McNally & Company, 1981), pp. 167, 361; R.J. Overy, *The Air War, 1939-1945* (London: Europa Publications, 1980), p. 150.

49 Between the beginning of the Second World War in September 1939 and the French capitulation to Germany in June 1940, the French aircraft industry manufactured 2,927 aircraft (1,162 between September and December 1939, and 1,765 between January and May 1940). The French then collaborated with the Germans and produced 4,146 aircraft for both the German and Vichy French air forces (1,001 between May 1940 and December 1941; 1,121 in 1942; 1,444 in 1943; and 576 in 1944). After the Allies liberated France in 1944, the French aircraft industry resumed production for

the Allied camp. It manufactured 1,007 aircraft between the liberation of 1944 and the end of 1945. See Charles Christienne and Pierre Lissarague, *A History of French Military Aviation* (Washington D.C.: Smithsonian Institution Press, 1986), pp. 327, 330-331, 378, 434.

50 These twenty-four countries were Argentina, Australia, Belgium, Brazil, Bulgaria, China, Czechoslovakia, Denmark, Finland, Hungary, India, Mexico, the Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Turkey and Yugoslavia. The figure of 15,000 aircraft is an approximation based on data obtained from various sources, most notably John M.G. Emory, *The Source Book of World War Two Aircraft* (Poole: Blandford Press, 1986), pp. 11-175 and Michael J.H. Taylor, *Jane's Encyclopedia of Aviation* (New York: Portland House, 1989), pp. 16-908.

51 Bilstein, *The American Aerospace Industry...*, p. 72; Craven and Cate, *The Army Air Forces in World War II, Volume 6...*, p. 345.

52 LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, Part II, Chapter 1, Table 2.

53 William Hornby, *Factories and Plant* (London: Her Majesty's Stationery Office, 1958), p. 251.

54 Stanley W. Dziuban, *Military Relations Between the United States and Canada, 1939-1945* (Washington DC: Department of the Army, 1959), pp. 273-295; Donald M. Pattillo, *Pushing the Envelope: The American Aircraft Industry* (Ann Arbor: The University of Michigan Press, 1998), p. 148.

55 Hall and Wrigley, *Studies of Overseas Supply...*, p. 477-484; D.P. Mellor, *The Role of Science and Industry: Australia in the War of 1939-45* (Canberra: Australian War Memorial, 1958), pp. 381-422.

56 J.V.T. Baker, *The New Zealand People at War: War Economy* (Wellington: Department of Internal Affairs, 1965), pp. 149-150; Philip J. Birtles, *De Havilland* (London: Jane's, 1984), p. 107-108; A.J. Jackson, *De Havilland Aircraft since 1909* (Annapolis: Naval Institute Press, 1984), p. 317; J.M.S. Ross, *Royal New Zealand Air Force: Official History of New Zealand in the Second World War, 1939-45* (Wellington: Department of Internal Affairs, 1955), p. 33.

57 N.C. Sinha and P.N. Khera, *Indian War Economy: Supply, Industry and Finance* (Kanpur: Orient Longmans, 1962), pp. 205-206, 250-253.

58 LAC, RG-25 [Records of the Department of External Affairs], Vol. 8470, File: 5486-40, Proposals for the Establishment of an Aircraft Factory in Newfoundland, 13 July 1943 to 20 August 1943.

59 The Commonwealth Aircraft Corporation (CAC) manufactured 1,287 aircraft between 1939 and 1945: 250 Boomerang (CA-12, CA-13, CA-14 and CA-19) one Kangaroo (CA-15), and 59 American-designed North American P-51 Mustang (CA-17 and CA-18) fighters; two Woomera (CA-4 and CA-11) twin-engine bombers; 220 Wackett (CA-2 and CA-6) elementary trainers; and 755 Wirraway (CA-1, CA-3, CA-5, CA-7, CA-8, CA-9 and CA-16) advanced trainers and attack aircraft. De Havilland Aircraft Proprietary Limited (DHP) produced 1,350 British-designed aircraft: 1,085 De Havilland DH 82 Tiger Moth elementary trainers; 87 De Havilland DH 84 Dragon twin-engine aircrew trainers; and 178 De Havilland DH 98 Mosquito twin-engine multi-role combat aircraft. Finally, the Australian Department of Aircraft Production (DAP) manufactured 1,029 British-designed aircraft: 700 British-designed Bristol Type 152 Beaufort and 329 Bristol Type 156 Beaufighter twin-engine bombers. Moreover, Australia manufactured more than 3,000 aircraft engines during the war. See S.J. Butlin, *War Economy, 1939-1942* (Canberra: Australian War Memorial, 1955), pp. 6-7, 322-327, 441-445; Hall and Wrigley, *Studies of Overseas Supply...*, p. 477-484; Mellor, *The Role of Science and Industry...*, pp. 381-422; Alan Stephens, *The Royal Australian Air Force, Volume II* (South Melbourne: Oxford University Press,2002), pp. 50-54, 147; Joe Vella, "From Fisherman's Bend: The Aircraft of the Commonwealth Aircraft Corporation," *Air Enthusiast*, No. 61 (January-February 1996), pp. 25-35.

60 John M.G. Emory, *The Source Book of World War Two Aircraft* (Poole: Blandford Press, 1986), pp. 11-175. See also Hans G. Anderson, *SAAB Aircraft since 1937* (London: Putnam, 1997); Denes Bernad, *Rumanian Air Force: The Prime Decade, 1938-1947* (Carrollton: Squadron/Signal Publications, 1999); K.R. Böhme, *The Growth of the Swedish Aircraft Industry, 1918-1945: The Swedish Air Force and Aircraft Industry* (Manhattan: Sunflower University Press, 1987); Jerzy B. Cynk, *Polish Aircraft, 1893-1939* (London: Putnam, 1971); "From Seventeen to Thirty-Nine: A SAAB Half-Century," *Air Enthusiast*, No. 33 (May-August 1987), pp. 9-25, 60-68; Henri Hegener, *Fokker — The Man and the Aircraft* (Letchworth: The Garden City Press, 1961); Kalevi Keskinen

and Farl Stenman, *Finnish Air Force, 1939-1945* (Carrollton: Squadron/Signal Publications, 1998); George Punka, *Hungarian Air Force* (Carrollton: Squadron/Signal Publications, 1994); Miklós Szabó, "The Development of the Hungarian Aircraft Industry, 1938-1944," *The Journal of Military History*, Vol. 65, No. 1 (January 2001), pp. 53-76; Jakob Urech, *The Aircraft of the Swiss Air Force since 1914* (Stafa: Verlag, 1975).

61 Large aircraft manufacturing companies in Great Britain, the Soviet Union, and the United States were active in the design and development of combat aircraft. The following were some of the most important: *Great Britain:* Armstrong-Whitworth, A.V. Roe, Bristol, De Havilland, Fairey, Gloster, Handley-Page, Hawker, Supermarine, Vickers, and Westland; *Soviet Union:* Ilyushin, Lavochkin, Mikoyan-Gurevich, Petlyakov, Polikarpov, Sukhoi, Tupolev, and Yakolev; *United States:* Beech, Boeing, Chance-Vought, Consolidated, Curtiss-Wright, Douglas, Grumman, Lockheed, Martin, and North American. See Jean Alexander, *Russian Aircraft since 1940* (London: Putnam, 1975), pp. 1-9; M.M. Postan, D. Hay and J.D. Scott, *Design and Development of Weapons: Studies in Government and Industrial Organization* (London: Her Majesty's Stationery Office, 1964), pp. 25-44.

62 Postan, Hay, and Scott, *Design and Development of Weapons...*, p. 40.

63 For example, at its wartime peak in 1944, Noorduyn — one of Canada's largest manufacturers of aircraft — employed 12,000 people, but only 172 worked in its engineering department. This accounted for only 1.4 per cent of the company's total labour force. See LAC, RG-24, Vol. 5051, File: HQ 938NIV-27-5, "R.B.C. Noorduyn (Vice President and General Manager, Noorduyn) to W.A. Newman (President, Federal)," 1 December 1944.

64 Ruth Schwartz Cowan, *A Social History of American Technology* (New York: Oxford University Press, 1997), pp. 253-258; Craven and Cate, *The Army Air Forces in World War II, Volume 6...*, pp. 226-239; Holley, *Buying Aircraft...*, pp. 22-23.

65 Postan, Hay, and Scott, *Design and Development of Weapons...*, pp. 44-67.

66 Alexander, *Russian Aircraft since 1940...*, p. 1.

67 W.E. Knowles Middleton, *Mechanical Engineering at the National Research Council of Canada, 1929-1951* (Waterloo: Wilfrid Laurier University Press, 1984), pp. 65-136. See also Wilfrid Eggleston, *National Research in Canada – The NRC, 1916-1966* (Toronto: Clarke, Irwin & Company Limited, 1978); Wilfrid Eggleston, *Scientists at War* (London/Toronto: Oxford University Press, 1950); George R. Lindsey, ed., *No Day Long Enough: Canadian Science in World War II* (Toronto: Canadian Institute of Strategic Studies, 1997); M. Thistle, *The Inner Ring: The Early History of the National Research Council of Canada* (Toronto, 1966).

68 LAC, RG-24, Vol. 10,264, File: 59/Bertrand J./1, "Private Jacques Bertrand (Régiment de Maisonneuve) to Lieutenant-Colonel M.L. De Rome (Commanding Officer, Régiment de Maisonneuve)," 29 October 1942; LAC, RG-24, Vol. 10,264, File: 59/Bertrand J./1, "Major G.I. Mackenzie (Secretary, Overseas Invention Board) to Private J. Bertrand (Régiment de Maisonneuve)," 6 January 1944.

69 Canada, *Report of the Department of National Defence* (Ottawa: Edmond Cloutier, 1942), p. 24.

70 Canada, *Report of the Department of National Defence* (Ottawa: Edmond Cloutier, 1946), p. 50.

71 Kennedy, *History of the Department of Munitions and Supply, Vol. 1...*, pp. 25-33, 351-364, 456-460, 468-473.

72 Robert Bothwell, ""Who's Paying for Anything These Days?" War Production in Canada, 1939-1945," in B.D. Hunt and R.G. Haycock, eds., *Canada's Defence: Perspective on Policy in the Twentieth Century* (Toronto: Copp Clark Pitman Ltd., 1993), p. 119.

73 Eggleston, *National Research in Canada...*, pp. 263-266.

74 J. Mackay Hitsman, *Military Inspection Services in Canada, 1855-1950* (Ottawa: Department of National Defence Inspection Services, 1962), pp. 11-14.

75 Richard A. Preston, *Canada and Imperial Defense: A Study of the Origins of the British Commonwealth's Defense Organization, 1867-1919* (Toronto: University of Toronto Press, 1967); Richard A. Preston, *Canadian Defence Policy and the Development of the Canadian Nation, 1867-1917* (Ottawa: The Canadian Historical Association, 1970); Richard A. Preston, *The Defence of the Undefended Border – Planning for War in North America, 1867-1939* (Montreal: McGill-Queen's University Press, 1977); C.P. Stacey, *Canada and the British Army, 1846-1871: A Study in the Practice of Responsible Government* [1936] (Toronto: University of Toronto Press, 1963); C.P.

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produced the equivalent of 1,611 Curtiss JN-4 Canucks in spare parts. The remaining 1.3 per cent of production, or 16 aircraft, came from four Canadian companies: the Canadian Aircraft Works of Montreal, the Hamilton Aero Manufacturing Company Limited of Vancouver, the Hoffar-Beeching Shipyards Limited of Vancouver and the Polson Ironworks Company of Toronto. All of the above companies ceased producing aircraft with the end of the war. See David Carnegie, *The History of Munitions Supply in Canada, 1914-1918* (London: Longmans, Green and Company, 1925), pp. 174-192; C.G. Grey, ed., *Jane's All the World's Aircraft 1917* (London: Sampson Low, Marston & Company, 1917), p. 110-112; C.G. Grey, ed., *Jane's All the World's Aircraft 1918* (London: Sampson Low, Marston & Company, 1918), p. 143; K.M. Molson, "Aircraft Manufacturing in Canada during the First Great War," *Canadian Aeronautical Journal*, Vol. 5, No. 2 (February 1959), pp. 47-54; K.M. Molson, "The Curtiss Canada...A Canadian First," *Aircraft*, Vol. 25, No. 5 (May 1963), pp. 16-19, 42; K.M. Molson, "The Canadian JN-4," *Canadian Aeronautics and Space Journal*, Vol. 10, No. 3 (March 1964), pp. 57-63; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 23-24, 31, 49-50, 119, 211-233, 245-246, 333-335, 372-374, 382-385, 393-395, 421-422, 458-464; Alan Sullivan, *Aviation in Canada, 1917-1918: Being a Brief Account of the Work of the Royal Air Force Canada, the Aviation Department of the Imperial Munitions Board and the Canadian Aeroplanes Limited* (Toronto: Rous & Mann Limited, 1919), pp. 25-55

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CHAPTER TWO

AN ILLUSION OF AUTONOMY

> At an Imperial Conference ... the decision was made that the RCAF squadrons should be equipped with British aeroplanes and engines, so that all logistic and training questions would be simplified. In theory this looked to be a good arrangement but subsequent events proved that it had its drawbacks. It was very nice for the British aircraft industry to have the RCAF as a customer in slack times but when war was declared we found ourselves in the position of having only the smallest number of service aircraft and with no industrial production of aircraft engines. Great Britain, our source of supply, was fully occupied with her own problems of manufacturing the aircraft and engines required for the RAF and certainly could not supply us with any equipment of this kind ... Our other possible source of supply, the United States, was temporarily cut off by reason of its Neutrality Act and as a result we were left without any aircraft for defence purposes. Luckily we were not threatened at home, but we cannot assume that the same conditions will apply at any future time.[1]
>
> - Air Vice-Marshal E.W. Stedman, RCAF

When the Second World War began, Canadian aircraft companies did not have the necessary experience to pursue the risky, complex, costly, and time-consuming business of producing their own lines of military aircraft. After the end of the First World War until the beginning of rearmament era around 1935, the bulk of Canadian aircraft production consisted of small general utility transport, flying boats, and training aircraft. More importantly, Canada did not manufacture any combat aircraft, as aircraft makers

were more interested in producing aircraft that responded to the demands of the civilian market. Accordingly, when the demand for military aircraft rose and it became imperative to produce such machines in Canada for security reasons, the Canadian government turned to Great Britain and the United States for assistance. The growing demand for military aircraft created by the wartime emergency meant that Canada did not have the luxury of time. An existing and well-proven American or British designed aircraft could be produced in a much shorter period of time than any new locally developed design. Yet, some attempts were made to initiate the production of Canadian-designed military aircraft in the 1935 to 1940 period. This chapter will analyze those domestically developed aircraft projects in further detail, and will assess their successes and failures.

Canadian Aircraft Design and Development: A Wartime Failure

In the late 1930s, only four of Canada's aircraft manufacturing companies were actively engaged in design and development work: CCF, Fairchild, Fleet and Noorduyn.[2] These companies had been developing and constructing several types of trainers and general utility transports for both civilian and military markets since the beginning of rearmament in the mid-1930s. These aircraft were relatively simple and cheap to design and produce compared to modern combat aircraft, and they were in high demand in the Canadian market to train pilots and access the country's most remote regions. Moreover, Canadian aircraft companies preferred modest initiatives to avoid costly and sophisticated experimental aircraft programs.

Fairchild was an active player in the design and development of general utility transports. Since its creation in 1929, the company had gained considerable experience with the licensed construction of transports of American-design and, as such, decided in 1933 to initiate the development of its own aircraft. The result was the single-engine high-wing Fairchild Super 71, a 7,000 lbs gross weight transport powered by a 525 hp Pratt & Whitney Wasp engine intended specifically for freighting operations in northern Canada. Francis Percival Hyde Beadle, the company's British-born chief aeronautical engineer, designed the aircraft.[3] The prototype flew for the first time in October 1934. An unusual feature of the aircraft was the position of the pilot, who was seated in a small cockpit with a sliding canopy high atop the rear fuselage behind the wing. The cabin had a large freight door and could accommodate up to eight passengers. The RCAF ordered two modified Super 71 for reconnaissance duties. The military version, known as the Super 71P, was delivered in 1936 and had an enclosed cockpit at the front of the aircraft, a more powerful 600 hp Wasp engine, camera installations and carried radio equipment. The last of the RCAF Super 71 was retired in 1940. In the end, only three Super 71s were produced between 1934 and 1936.[4] Unfortunately, the aircraft was not as successful as originally hoped so Fairchild engineers went back to the drawing boards to design a completely new aircraft. The result was the new Fairchild Model 82, a single-engine, high-wing, 6,300 lbs gross weight general utility transport aircraft capable of carrying eleven passengers or a payload of 1,762 lbs. It could operate on wheels, floats or skis. The Model 82 prototype made its maiden flight on 6 July 1935 and the company built 23 until production ceased in 1939. While used by commercial operators in Canada and South America, its only military user was the Argentine Navy.[5] Four versions of the

Fairchild 82 were developed, each powered by different engine configurations: the 82A with a 450 hp, 525 hp or 550 hp Pratt & Whitney Wasp, the 82B and 82D with a 600 hp Wasp, and the 82C with a 420 hp Wright R-975. A special variant of the Fairchild 82 fitted with a 420 hp Ranger engine was also built under the designation Model 34-42 Niska. The prototype made its maiden flight in late March 1937, but the company did not sell one aircraft.[6]

In 1936, Fairchild began the design and development of a 10,000 lbs gross weight twin-engine general utility transport aircraft known as the Model 45-80 Sekani. Nathan Floyd Vanderlipp, the company's new general manager and chief aeronautical engineer, who had recently come from Bellanca Aircraft in the United States, designed the aircraft.[7] The Sekani was powered by two 400 hp Pratt & Whitney Wasp Junior engines, was capable of transporting 10 passengers and could be operated on wheels, floats or skis. The prototype flew for the first time on 24 August 1937, but the RCAF and commercial operators never showed interest because the aircraft was beset with troubles. It was only certified for a 9,500 lbs gross weight, rather than the intended 10,000 lbs. There were also aerodynamic and control problems. When the RCAF tried the machine in October 1937, it reported that its very slow climb rate, low service altitude, poor cockpit visibility, restricted loading facilities and other deficiencies made it unsuitable for aerial photography or reconnaissance. In the end, the Sekani did not live up to expectations and Fairchild decided to abandon the program altogether in 1938, having built only two aircraft. The company also planned for a time to develop a single engine version of the Sekani known as the Model 45-65 Nahanni, which would have been powered by a 650 hp Pratt & Whitney Wasp engine, but gave up.[8] The company also worked on a smaller

7,240 lbs gross weight eight-seat twin-engine transport derived from the Sekani known as the Model 40-50, which was to be powered by 250 hp Ranger engines, but it never left the drawing boards. The same fate awaited the Model 40-60, Model 40-68 and Model 45-84 twin-engine transports, which were to be versions of the Model 40-50 powered by 300 hp, 340 hp and 420 hp Ranger engines respectively. [9]

Noorduyn was somewhat more successful in this field. In November 1934, Robert Bernard Cornelius Noorduyn, a Dutch-born aircraft designer who had just immigrated to Canada, began the development of a medium size high-wing general utility transport aircraft capable of carrying between six and ten passengers and operating on wheels, skis or floats.[10] The new aircraft, known as the Norseman, was designed to meet the specific requirements of Canadian aircraft operators.[11] In early 1935, Noorduyn bought a factory at Cartierville near Montreal, and formed Noorduyn Aircraft Limited (later Noorduyn Aviation Limited).[12] The company was particularly proud of its first product, a Noorduyn representative noting:

> The Noorduyn Norseman plane is designed in Canada — built in Canada — for conditions in Canada — the company is owned in Canada. No other plane has ever been planned so definitely to accomplish what is expected of the Norseman. Most planes in commercial use in Canada are [of] foreign design and/or manufacture. Canada has had to choose the most suitable of these for its needs, and make what adaptations where possible ... R.B.C. Noorduyn, the designer, has had twenty-three years experience in aircraft engineering, design and factory management in Europe and the United States. His association with the Fokker and Bellanca companies ... gave him opportunities to observe Canadian requirements ... The Norseman incorporates the best features.[13]

A wooden mock up was soon built, and, in May 1935, work began on the construction of the prototype known as the Norseman I. It had a gross weight of 6,050 lbs, was powered by a 420 hp Wright R-975 Whirlwind engine, and was capable of transporting a freight

load of 1,500 lbs. The Norseman prototype made its maiden flight on 14 November 1935.[14] The production model, designated Norseman II, flew in May 1936. It was almost identical to the Norseman I prototype, except for an increased gross weight of 6,235 lbs, wider float tracks and other small differences. Unfortunately, the Wright engine was not powerful enough, leading to poor aircraft performance. As a result, only three Norseman II transports were built. In 1936, the company came out with the new and improved Norseman III. It had a gross weight of 6,450 lbs and was powered by a 450 hp Pratt & Whitney Wasp engine, but overall offered only a modest improvement over the Norseman II, and, as such, only one was built.[15]

The company joined the big leagues with the Norseman IV that used a 550 hp Pratt & Whitney Wasp engine. The prototype first flew on 5 November 1936 and became an instant commercial success. Noorduyn sold the Norseman IV to Canadian civil operators, as well as the Royal Canadian Mounted Police (RCMP). The RCAF also purchased 79 between 1937 and 1942, for use as transports and for wireless training duties.[16] Meanwhile, in the summer of 1941, the United States Army Air Force (USAAF) requested six Norseman IVs for testing. The slightly modified aircraft, known as YC-64 Norseman, were delivered in the autumn. The Americans were impressed with the aircraft, and after entering the war in December 1941, the USAAF placed the first of several orders for a special cargo version of the Norseman designated C-64 Norseman.[17] This model, modified to suit USAAF requirements, differed in many ways from the Norseman IV: it had an increased gross weight of 7,400 lbs; an improved undercarriage; increased fuel capacity; additional space for freight and baggage; folding benches on each side of the cabin for troops; and the latest USAAF instruments.[18] By May 1942, the

USAAF had 300 aircraft on order.[19] The C-64 prototype flew for the first time in January 1943.[20]

The next year, the USAAF began to doubt whether Noorduyn could deliver enough C-64s to suit its requirements and gave a contract to the Aeronca Aircraft Corporation of Middletown, Ohio, for 600 additional Norseman in early 1944. The order was cancelled before any were completed.[21] The Americans found the Norseman extremely reliable and used it for various purposes in North America, India, China and Europe. Norseman missions ranged from the transportation of small cargo loads, to picking up downed airmen in isolated regions, and to evacuate casualties.[22] The Americans unofficially nicknamed the Norseman the "flying one-ton truck."[23] The USAAF alone purchased 752 C-64 Norseman during the war,[24] but delivered some to other allied air forces (three went to the United States Navy under the designation JA-1 Norseman, twenty to the RCAF as Norseman VI, and about sixty to the Australian, Brazilian, Dutch East Indies, Hondurian, Norwegian and Swedish air forces).[25] During the war, Noorduyn received orders for 1,146 Norseman,[26] and made a total of 825 before the end of hostilities.[27] With the end of hostilities in Europe in May 1945, Noorduyn offered a civilian version of the Norseman VI, known as the Norseman V, which first flew in June 1945.[28] Norseman production continued after the war; in all, 904 aircraft were made between 1935 and 1959.[29]

For its part, in late 1936, Fleet initiated the design and development of an 8,000 lbs gross weight twin-engine general utility transport known as the Fleet Model 50 Freighter. Fairchild was working on its twin-engine Sekani, and Fleet was determined to compete. The company wanted to produce an aircraft that could supplement single-

engine machines operating in the Canadian bush. Designed by Fleet President W.J. Sanderson and Project Engineer R.E. Young, the Freighter was to be rugged, easy to load, capable of short take-offs and landings, easily dismantled to facilitate repairs in remote areas and suitable for operating on wheels, floats or skis. After several months of work, the prototype made its first flight on 22 February 1938. The Freighter's handling qualities and performance were good and its freight loading capabilities were exceptional. The aircraft had a large door on each side of the rear cabin, a large door at the front, and a hatch in the front cabin floor. Moreover, the nose's lower portion was removable to allow easy loading of long items such as lumber or pipes. The Freighter could easily be converted for passenger transport with the addition of seats. Fleet also proposed a military version of the aircraft, with a fixed forward-firing machine gun and two flexible machine gun positions at the rear, on the top and bottom of the fuselage. Small bombs could also be stowed in the cabin area. This version, however, was never constructed. In the end, only five Freighters were built between 1938 and 1942 owing largely to the engine's unpopularity and the aircraft's concomitant lack of power.[30]

Yet, when the RCAF began looking for a paratroop training aircraft in August 1942, Fleet immediately offered its Freighter.[31] It seemed that the aircraft would be suitable. The large freight doors on each side of the aircraft would provide sufficient clearance for safe jumping. The size of the Freighter was adequate to carry ten paratroopers and one jump master in addition to two crew members. With a maximum speed of only 125 mph, it would provide an excellent platform from which to safely drop paratroopers. Its range of 650 miles and low altitude of 15,000 feet made it all the more attractive as a training aircraft. More importantly, the aircraft was already on the market

so no time would be wasted with the development of a new design.[32] The paratroop training version would only require a few slight modifications, such as the installation of cable-static lines, signal lights, folding benches, and safety belt clips on the cabin wall.[33] Consequently, the RCAF began to seriously consider acquiring a small number of Freighters.[34] This marked a definite change in attitude. In 1938, the RCAF had refused Fleet's offer to test the Freighter on the grounds that the aircraft did not meet its requirements.[35] Still, in September 1942, Fleet loaned two Freighters to the RCAF for trials.[36] Unfortunately, the aircraft did not meet all RCAF paratroop trainer requirements and was rejected in mid-October.[37] The two loaned Freighters remained in RCAF service as cargo transports, were modified as air ambulances in early 1943,[38] and were discarded in the spring of 1944.[39]

Fleet also developed the 3,500 lbs gross weight Fleet Model 60 Fort low-wing two-seat monoplane trainer, which was designed by Richard E. Young, the company's chief engineer. The project started as a private venture in 1938.[40] The company wanted to develop an aircraft capable of competing with the American-designed North American AT-16 Harvard advanced trainer, which Noorduyn was planning to manufacture under-license in Montreal. Fleet officials were aware that British and Canadian governments were discussing the establishment of air training schools in Canada, and they knew that advanced trainers would be required. The AT-16 would receive serious consideration, but the solution was to design an aircraft that met both British and Canadian specifications and that offered significantly lower production and operation costs than the AT-16. The Fort would be available in three versions fitted with different Jacobs engines: the Model 60L elementary trainer powered by the 225 hp L-4; the Model 60K intermediate trainer

by the 330 hp L-6; and the advanced trainer by the 350 hp L-7. The Jacobs engine was chosen because of its proven reliability and simplicity, which, according to Fleet's President W.J. Sanderson, would make such engines easy to manufacture in Canada in case of emergency.[41]

The Fort design incorporated a number of special features useful for training. The rear cockpit, for example, was raised so that an instructor or student could see over the top of the front cockpit. The fixed undercarriage was to be fitted with retractable fairings over the wheels so as to accustom students to operating the undercarriage retraction mechanism without risk of damaging the aircraft. The aircraft could also be operated with skis or floats.[42] A scale model of the Fort was built and successfully tested in the wind tunnel of the NRC in Ottawa in early 1939. The program evolved slowly until war was declared a few months later. Then, work progressed around the clock,[43] and by early January 1940 a prototype was almost completed.[44] The aircraft was successfully test-flown on 22 March 1940 by Fleet's chief aeronautical engineer and was thoroughly tested over the next month.[45]

Fleet proposed the Fort to the RCAF in April 1940. Fleet manager W.N. Deisher made his pitch to the Deputy Minister of National Defence, stating in part:

> Our Fleet Model 60 low wing advanced trainer should have its test completed and have a certificate of airworthiness within the next week. When the aircraft is approved, we have made arrangements to turn the Model 60 over to the RCAF for tests. This aircraft has been designed by our own organization and can be produced in quantities, as we are assured of a supply of engines and material. The Fleet Model 60 is directly comparable to the Harvard in performance and can be operated more economically. Due to the fact that this aircraft can and will be produced in Canada, we can offer you a considerable saving in the cost per unit, especially in view of the exchange situation which now prevails between Canada and the United States. We have kept the RCAF advised regarding progress in the design and construction of this aircraft and we feel that before further orders are

> placed for advanced trainers that the possibilities of our aircraft should be thoroughly investigated.[46]

The RCAF agreed to test the Fort to ascertain its suitability as a single engine intermediate trainer for the BCATP.[47] The Model 60K prototype was inspected and test flown by air force officials, who found it to be "extremely pleasant, and easy to fly." Officials also considered the aircraft to be "a very suitable intermediate trainer" that could also be adapted for advanced training by installation of front and rear guns as well as bomb racks. The RCAF found the retractable fairings undercarriage a particularly interesting feature noting, "the reputed little damage which occurs, if a landing is carried out with fairings down, is ... desirable." In comparison with the AT-16 Harvard, it was reported that the Fort was "gentler on stalls and spins, and has no tricks in landing." In the end, air force officials recommended that two versions of the Fort be constructed for the RCAF. The first was to be powered by a 225 hp Jacobs L-4 engine for elementary training and the second equipped with 350 hp Jacobs L-8 engine for intermediate and advanced training. Air force officials also considered fitting a Pratt & Whitney Wasp engine in the aircraft.[48] The RCAF immediately placed an order for 200 Fleet 60.[49] The first aircraft were to be delivered to the RCAF in late December 1940,[50] and were to be used by the BCATP in Canada for pilot training only.[51]

The future of the Fort seemed promising. Fleet even received a proposal from an American company, Intercontinental Corporation of New York City, to manufacture the aircraft under-license in the United States. This marked the first time that a Canadian-designed aircraft was proposed for licensed production in another country. C.H. Dolan, vice-president of the Intercontinental Corporation, told RCAF authorities in May 1940:

> We are sure that you are just as enthusiastic as we are over the successful performance of the new Canadian Fleet Model 60 low wing all metal advanced trainer ... This fine airplane, conceived, designed, and built exclusively by Canadians in Canada, is the result of several years of planning and hard work in close cooperation with the military aviation authority of Canada and Great Britain. We are negotiating for the American license for the manufacture of the Canadian Fleet Model 60 airplane, and, if successful, it is our plan to augment the manufacturing of Fleet Aircraft Limited of Fort Erie, Ontario, by arranging for additional manufacturing facilities in the United States, to the end that the combined facilities will be able to produce from 3 to 7 planes per day of this particular type ... In our opinion, it is the best and most economical plane in its class.[52]

The Fort was also highly praised in Canada. *Canadian Aviation* reported in its May 1940 issue that "the design and manufacture of a successful low-winged monoplane trainer in a Canadian aircraft plant represent a significant achievement for the aviation industry in this country and speak well for its future."[53] There were even plans in the early autumn of 1940 to have Boeing Canada manufacture 100 additional Fort under-license to supplement Fleet's production.[54]

But problems soon plagued the program as Fleet experienced serious difficulties tooling up. In November 1940, it was reported that only 50 per cent of the tools had been completed and proven, a problem attributable to the company's lack of toolmakers.[55] As a result, Fleet was unable to hold true to its promise to deliver a first aircraft to the RCAF in December 1940. The delay led to frustration in air force circles. The Air Member for Supply (AMS) noted in January 1941 that he saw "no outlook for continuing production of Fleet 60 aircraft beyond the two hundred at present on order."[56] In April, Fleet reported to the RCAF that they were going ahead as fast as they could on the project, but the chief engineer was "handicapped by a shortage of good men capable of doing layout work" and they "are, therefore, obliged to go slowly and do a considerable amount of rearranging on the job."[57] The RCAF resident inspector at Fleet even reported instances

of poor and inaccurate jigging and tooling, as "accurate drawings for tools were produced by the engineering department but ignored by the shop." This problem evidently contributed to delays.[58] For all these reasons, the first production aircraft was not flown until April 1941.[59]

The slow pace of production caused problems with the RCAF. The original schedule indicated that 174 aircraft were to be ready before the end of May 1941; however, air force officials reported that only 10 had been delivered to the RCAF by that time. A top RCAF official wrote "the production of this aeroplane is most disappointing. Is it not possible to obtain a delivery schedule which we can feel fairly confident will be adhered to?"[60] Ralph P. Bell reported to the Minister of Munitions and Supply a few months later that the Fleet "is in a most unfortunate mess" and "so far as we can intelligently forecast, cannot possibly finish their Fleet Forts ... before the end of September 1942."[61]

To make matters worse, the aircraft did not meet expectations. Bell reported to C.D Howe in early June 1941, "it is doubtful if this machine is going to fill the niche in the training field that was originally anticipated, as preliminary reports from technical officers and test pilots indicate that, while the machine is ... good ... to fly and satisfactory in most respects, it is too easy to make a satisfactory advance trainer and, alternately, it is too expensive for an elementary trainer."[62] The RCAF had problems using the aircraft as an intermediate trainer and, as a result, reconsidered the Fort program entirely in the fall of 1941. The office of the Chief of the Air Staff reported in October 1941 that the aircraft "does not fit into the training program very well because it takes as long to move a pilot from an elementary trainer to a Fort and from a Fort to a Harvard as

it does to move him directly from an elementary trainer to a Harvard. Therefore, the use of an aircraft such as the Fort in the training program is wasteful ... [of] an instructor's time."[63] Moreover, the RCAF had discovered many defects in the aircraft.[64] It was in fact reported that some of the aircraft were unserviceable because of "extremely poor workmanship."[65] The RCAF was even more shocked to learn that Fleet had changed about 2,000 of the 7,000 Fort drawings approved by government officials at the beginning of the program without notifying air force officials. This was a serious problem that could hinder the interchangeability of parts between aircraft already produced and those to be delivered in the future. "A project of this nature requires cooperation and good faith on all sides; there is little doubt that this did not exist," explained an RCAF officer.[66] Needless to say, the air force was not impressed with Fleet or its product.

Fleet stood its ground, as it upheld the aircraft's suitability and told the RCAF that "it is agreed by all who have had the opportunity of observing the construction of this aircraft ... that it is a very simple aircraft to manufacture and ideal for production economically. Combining the flying characteristics, the economical manufacturing possibilities and the fact that no special materials are required, this aircraft could be used to good advantage for an elementary to a semi-advanced trainer."[67] On 30 October 1941, the Air Council discussed the Fort and decided "to close the Fort contract as soon as possible."[68] The RCAF was no longer interested in pursuing production, and would not make further orders.[69] In mid-November 1941, RCAF and DMS representatives visited the Fleet factory to decide on the most economical way of terminating the contract.[70] There, they noticed first hand some of the major organizational problems affecting the company and its production. Their report noted:

> It was quite apparent that a most unfortunate condition exists within the company. It seems that the President has reserved the right to make all decisions, not having delegated any authority to officers in charge of departments. The direct result is that no officer, however capable, is willing to venture any opinion, regarding the aircraft, or matters pertaining thereto. Further, the plant appears to be very poorly organized, and is not getting results commensurate with the expenditure in labour and materials. The number of changes and modifications to the aircraft seems endless. Another result of the situation is apparent in the attitude of various plant officials towards one another. One was conscious of an atmosphere of tension, with the feeling that open hostilities might develop at any moment. It is hard to see how any worthwhile work can be expected from this plant, without a radical change in the set-up.[71]

In the end, the group recommended that the contract be terminated after the 90th aircraft had been made and that the equivalent of 30 aircraft worth of spare parts had been delivered.[72] This quota was raised to 100 aircraft in February 1942.[73]

The Fort was perhaps inadequate as an intermediate trainer, but it was decided in late fall of 1941 to convert the aircraft into a wireless trainer to relieve the BCATP's overworked Menasco Moths. Fleet was to re-design the aircraft and provide drawings to the RCAF, who would carry out the required modifications in its aircraft repair depots.[74] The Canadian company submitted all of the necessary drawings in January 1942 and a prototype radio trainer was built at the RCAF Test and Development Establishment in Rockcliffe, Ontario.[75] The most important change was to replace the rear cockpit's instruments and controls with electronic and radio equipment.[76] The wireless trainer prototype was tested in February and was found to be satisfactory, despite the fact that it was too tail heavy and that there was "so much interference noise as to make the wireless useless." The report noted that "performance is good," and that the aircraft "handles nicely and is stable in flight."[77] Most of the RCAF Fort trainers were converted to wireless trainers, designated as Fort II.[78] Moreover, in early 1942, Fleet proposed to

develop a special ground-strafing version of the Fort for the Canadian Army. As company president W.J. Sanderson explained:

> The actual aircraft would be specially equipped with machine guns in the wings, pointing down, canon in the fuselage, pointing down at such an angle as to avoid the propeller, and two to three hundred pounds of bombs. The gas tank would be bullet-proof; the pilot, engine, gas line, controls etc. would be protected below by armour plate. The tires would be a special type (not pneumatic) so that they would be unaffected by bullets. The aircraft would have a top speed of not more than 170 miles per hour and would fly ... close to the ground, hoping over trees and buildings ... The units would be designed to be especially mobile and useable on any fairly smooth field. The cost of these aeroplanes would be the minimum since we would not install elaborate instruments but concentrate on the simplest aircraft that could possibly be built ... The aeroplane that I have in mind is the "60" developed by us for intermediate training. It would be ideal for such a job.[79]

But the army was not interested in such a combat aircraft and, as a result, Fleet did not pursue the project.[80] In the end, Fleet produced a total of 101 Fort trainers before production ceased in the spring of 1942. All of these aircraft were taken out of service at war's end.[81]

The fourth Canadian aircraft company to be actively involved in design and development work was CCF. In 1937, CCF decided to launch its own line of aircraft. In the next two years, the Canadian company developed three indigenous types: two Maple Leaf trainers and the FDB-1 fighter. These projects helped CCF forge a reputation as a serious aircraft designer, but they proved failures on the markets. In fact, none of these machines went beyond the prototype stage.[82]

The Maple Leaf I trainer project began in mid-1937 when CCF hired Leland Stamford Wallace, a prominent aeronautical engineer from Bird Airplane Corporation in the United States.[83] Wallace had been working for several years on a small two-seat open canopy biplane trainer of his own design, the plans for which were almost complete by

the time he arrived at Fort Williams. He immediately proposed his aircraft to top CCF officials, who responded enthusiastically to the idea of manufacturing it in Canada. It was an attractive project for a company still trying to break into a Canadian market that was dominated by established aircraft companies such as Canadian Vickers, DHC and Fleet. On 12 June 1937, CCF representatives advised the Department of Transport that they had just secured design and production rights for a "Wallace Trainer," which they proposed to manufacture for the RCAF and the commercial market. The Department of Transport responded that if the company wanted to offer the "Wallace Trainer" to the RCAF, the aircraft had to meet air force trainer specifications. The issue would have to be discussed with RCAF officials.[84]

It would seem that CCF partook in Wallace's project solely because the aircraft's design was complete and ready for production. Company officials, who were eager to manufacture the aircraft to put it on the market, paid little attention to preliminary stress tests or to the design. CCF had a potential order for ten to twelve of these trainers from Nicaragua, so it was anxious to build the prototype and get it into the air. The belief was that once the aircraft proved its worth, it would attract additional contracts.[85] Work on the Maple Leaf I prototype began in September 1937 and the aircraft made its first flight at Fort William on 18 April 1938 bearing Nicaraguan markings. It had a gross weight of 1,950 lbs and was powered by a 125 hp Kinner B5 engine.[86] The Maple Leaf I was flight tested in late April and early May 1938, but its performance proved unsatisfactory for it was determined that its speed, rate of climb and service ceiling were too low compared to similar aircraft. According to the flight test report, the Maple Leaf I was also very unstable as it had "a vicious tendency to drop a wing, with consequent loss of aileron

control." In fact, the test pilot was almost killed during some of the flight trials owing to the aircraft's instability. The only solution lay in re-designing the wings. However, the empty weight of the Maple Leaf I was excessive, resulting in a gross weight that was too high for an aircraft of this type. "It is apparent then that from the outset, the Maple Leaf trainer was doomed to failure since the machine as designed was too heavy for its purpose and power," wrote CCF engineer Elizabeth MacGill in a report on the problems encountered with the aircraft. The only way to improve the aircraft's performance was to either decrease its empty weight by 150 lbs. or to increase its engine power, but neither were recommended.[87] The Maple Leaf I trainer project was put on hold and finally discontinued on 21 June 1938. Wallace left the company soon after. CCF's early attempt at indigenous production had ended in utter failure.[88]

At roughly the same time as the Maple Leaf I project began, CCF also initiated the development of a truly Canadian fighter aircraft design, the FDB-1. In late 1937, the company hired Michael Gregor, a distinguished Russian-born aeronautical engineer who had previously worked for the Seversky Aircraft Corporation in the United States, to design its indigenous fighter.[89] Overlooking the fact that speedy low-wing monoplane fighters were making an impressive debut on the international market and being adopted by all of the world's major air forces, Gregor inadvertently pointed his new employer in the wrong direction by proposing to design a biplane fighter. Gregor firmly believed that a carefully designed biplane could outperform a monoplane. As he explained: "The modern biplane fighter, approaching a monoplane in top speeds, should be given a chance in actual military operation. It is my belief that the biplane built on similar specifications having advantage of manoeuvrability, rate of climb and greater ceiling,

will outfight the latter."[90] Given its experience with the Grumman G-23 Goblin biplane fighter, CCF expressed much interest in Gregor's proposal. In choosing a biplane, CCF maintained that it would be dealing with a well-known configuration, thereby reducing risk. However, the aircraft's potential success on the international market was bleak as the monoplane fighter was the wave of the future. Aviation historians Gordon Burkowski and Gerry Beauchamp wrote that by deciding to develop a biplane fighter, CCF and Gregor embarked "on a giant step backward."[91]

Design work began in early 1938, and by the spring a wooden model was tested in the wind tunnel of Hawker Aircraft in Great Britain.[92] The aircraft was originally known as the Gregor Model 10 Single Seat Fighter,[93] but was re-designated FDB-1 (Fighter-Dive-Bomber-1) in the fall of 1938 for its intended multi-dimensional role. The aircraft, popularly known as the "Gregor" fighter,[94] was the first fighter in the British Commonwealth to be designed outside of Great Britain.[95] Gregor used the latest technologies in the FDB-1, including pneumatic systems for the retractable landing gear, all-metal construction and gull-wing configuration. The most novel feature was a drag parachute housed in the rear of the aircraft, used to pull the aircraft out of an uncontrolled spin; it could be jettisoned as soon as the pilot regained control.[96] The prototype had a gross weight of 4,250 lbs and was powered by a 750 hp Pratt & Whitney Twin Wasp Jr. SB4-G engine, although its airframe was conceived to take engines of up to 1,200 hp. According to estimates, the aircraft would reach a maximum speed of 300 mph and 364 mph when fitted with the 750 and 1,200 hp engines respectively. The aircraft was to be capable of flight at an altitude of 33,000 feet over a maximum range of 645 miles. Armament consisted of two synchronized .50 caliber machine guns, mounted in the upper

wing roots, loaded with 1,000 rounds of ammunition. The aircraft could also carry two 116 lbs bombs under the lower wing.[97]

The prototype made its maiden flight at Fort William on 17 December 1938.[98] It was test flown during the next five months and survived two minor runway accidents at St. Hubert airport near Montreal, Quebec, in March 1939.[99] On 10 May 1939, the FDB-1 underwent Department of Transport airworthiness trials at St. Hubert, which included take-off, landing, initial climb, full aerobatics and terminal velocity dive tests. The RCAF test pilot reported that "as a prototype ... the Gregor aircraft is a most successful effort." He noted that "it has manoeuvrability to the extreme point wherein the limitation of manoeuvre rests with the human body and not the aircraft ability" and that "below 15,000 feet, a contemporary low-wing monoplane type of interceptor or single-seater, despite superior performance, could not successfully engage the Gregor singly." The aircraft performed relatively well and was capable of an initial climb rate of 2,800 feet per minute (expected to be 3,500 feet per minute with a 1,200 hp engine), which was superior to British monoplane fighters like the Supermarine Spitfire or Hawker Hurricane, which could only do 2,300 feet per minute. The FDB-1 could also reach a maximum altitude of 27,000 feet, which was good despite initial estimates of 33,000 feet. During terminal velocity dive tests, the FDB-1 remained steady and vibration free throughout plunges from 22,000 to 8,000 feet.[100]

However, there were major deficiencies. The maximum speed attained during normal flight trials was 261 mph at 13,100 feet altitude, which was inferior to the RCAF requirements or the company's initial claim of 300 mph. Moreover, the aircraft was only capable of a cruising speed of 205 mph at 10,000 feet, but it was noted that CCF was

considering replacing the present 750 hp Wasp Junior engine with a more powerful one of 1,200 hp. The aircraft also failed its aerobatic tests because the cockpit coupe top was found to be too weak. The test pilot wrote that "the aircraft performed rolls and spins satisfactorily without excessive vibration of the coupe top, but loops could not be executed without excessive vibration and distortion of the top. On several occasions, it was feared that the coupe top would tear free from the fuselages."[101] There was another more serious problem with the cockpit. The sliding section of the coupe-top was self-locking and access to the cockpit from the outside was only possible with the use of a separate key. While this method was principally adopted to prevent entry of unauthorized persons into the cockpit, it could create serious problems if an emergency arose in which access to the cockpit from the outside was urgently needed, but no key was readily available.[102] A strengthened and modified cockpit cover was therefore requested. Moreover, the visibility from the cockpit was recorded as poor, both on the ground and during take-off, owing to the top wing's position. It was also noted that flight visibility in a "forward downward direction is insufficient for dive bombing requirements."[103] The test pilot also reported that the flight controls were unbalanced and overly sensitive:

> Directional ground control is maintained by use of the hydraulic wheel brakes, which are powerful and extremely sensitive ... The take-off is extremely short and development of power for full climb almost instantaneous. The undercarriage, operated by pneumatic power, folds very quickly upward and inward into wheel recesses, its position being indicated to the pilot by red and green warning lights on the instrument panel. As in all manoeuvres with this aircraft, on the take off elevator and rudder controls are extremely sensitive, almost to the point of being dangerous. Fractional movements on the control column and rudders react instantly and in violent form on the control surfaces ... The aircraft can be safely controlled, but extreme care is continually required ... Extreme delicacy must be exercised to prevent over-controlling on the landing.

The aircraft was also "over-flapped." It was equipped with four pneumatically controlled flaps, lowering to 48 degrees on the bottom wings and 41 degrees on the top wings, which greatly reduced its speed in flight. This was particularly problematic when gliding. In fact, it was noted that power was constantly required to perform a normal glide or landing. The solution was to remove two of the four flaps, or to reduce the flap area. Finally, the aircraft was said to be under-armed as it carried only two machine guns and two bomb racks capable of carrying approximately eight light bombs.[104]

Unfortunately, Gregor's biplane design had come a few years too late, as engineers increasingly looked to the possibilities afforded by higher-powered monoplanes.[105] The outcome was all too predictable: CCF was unable to sell its FDB-1 fighter to the RCAF. The Mexican government, however, showed interest,[106] and in early May 1940, CCF decided to sell its single FDB-1 prototype to Mexico as a last-ditch effort. CCF hoped that the aircraft might serve as a demonstrator and ultimately lead to orders from the Mexican Air Force. Preparations were made to fly the aircraft to Mexico,[107] but the Canadian government denied CCF its application for an export permit to allow the fighter to be flown out of the country.[108] In October 1940, CCF tried again to export the FDB-1 to Mexico, but without success. As a result, CCF asked the government to cancel the aircraft's certificate of airworthiness, and placed the machine in storage for the remainder of the war.[109] The prototype was destroyed in a hangar fire at Montreal's Cartierville Airport in 1945.[110] Although the FDB-1 was not adopted by any air forces, it arguably still remains one of the most advanced biplane fighters in the world.[111] It was the first fighter of original design to be built in Canada.[112] It should be noted that the FDB-1 was not the only combat aircraft of indigenous design that CCF worked on during

the interwar period. In the August 1938 issue of *Canadian Aviation*, it was reported that the company was developing a long-range multi-engine heavy bomber and a high-speed twin-engine light bomber of its own design, but for unknown reasons none were built.[113]

In late 1938, CCF undertook the development of a new single-engine two-seat biplane elementary trainer specifically suited for high altitude operations. The Mexican Air Force was at the time looking for such an aircraft and CCF hoped that its trainer would meet the requirements. The aircraft's design was assigned to Elizabeth MacGill, who had succeeded Michael Gregor as CCF's chief aeronautical engineer. The 1,835 lbs gross weight trainer was designated the Maple Leaf II, but it was a completely new design.[114] It would be powered by a 160 hp Kinner R-5, but the prototype was fitted with the 145 hp Warner Super Scarab 50. It would use a number of parts and components that had been originally designed for the Maple Leaf I and FDB-1 fighter in order to facilitate production and enable a greater degree of interchangeability of parts between the different types of CCF aircraft.[115] As the aircraft was built for service in warmer climates, designers did not consider a ski landing gear.[116]

The company planned to have the prototype Maple Leaf II trainer ready by the fall of 1939.[117] In order to avoid interfering with its Hurricane production, CCF subcontracted some work to other Canadian aircraft manufacturers. DHC built the ribs and spars, and assembled and covered the lower wings. MacDonald made all the wing fittings, center-section struts, elevator ribs and ailerons. These components were sent to the CCF factory at Fort William, where they were put into the final aircraft.[118] The Maple Leaf II prototype passed Department of Transport inspection in mid-October 1939.[119] It made its maiden flight on 21 October,[120] and official flight trials under the supervision of

government officials were done in mid-December.[121] According to the test pilot's report, the Maple Leaf II had "excellent controllability," "handles nicely in acrobatic manoeuvres" and its "stall and spin characteristics are excellent." It was also noted that its "good visibility and stability provide safety for the student." The Maple Leaf II received its Department of Transport certificate of airworthiness in early January 1940. A few moths later, CCF offered the Maple Leaf II to the RCAF. It noted that the aircraft could be fitted with a more powerful 165 hp engine, that it could be equipped with an enclosed cockpit canopy, and that arrangements could be made to have it operate on wheels, skis, or floats.[122] In May 1940, CCF arranged to have the Maple Leaf II test flown by the RCAF in Trenton, Ontario. Air force officials found the aircraft to be excellent, but it did not matter much since the RCAF had already standardized its fleet of elementary trainers on the De Havilland Tiger Moth and the Fleet Finch, both of which were used in the BCATP.[123]

Following the RCAF trials, CCF planned to fly the Maple Leaf II prototype to Mexico in the hope of securing orders from the Mexican Air Force. This plan fell through as CCF was asked to concentrate instead on the production of the Hurricane.[124] C.S. Wallace, CCF aircraft sales manager, explained that "the company is too busy currently with the production of Hawker Hurricanes to go into production on the Maple Leaf," but added that the aircraft might be produced for the BCATP at a later date.[125] In the summer of 1940, there were even plans to open a CCF subsidiary in Mexico to produce under-license an improved Maple Leaf II trainer powered by a more powerful 165 hp engine. This scheme never materialized, despite rumors that CCF operated a plant in Mexico and produced a few Maple Leaf II trainers there.[126] Rumors also circulated that the Maple

Leaf II was not up to BCATP requirements and, as a result, was "farmed out to the Mexican government rather than being produced locally as an RCAF *ab initio* trainer." This was not true, as the Maple Leaf II was fully aerobatic and in accordance to British Air Ministry specifications for elementary trainers.[127]

Finally, in August 1940, the Columbia Aircraft Corporation of Port Washington, New York, showed interest in manufacturing the Maple Leaf II under-license in the United States. The American company asked CCF if it would be willing to sell it the manufacturing rights to the Maple Leaf II, as well as all accompanying technical data.[128] CCF authorities agreed as they did not foresee any orders in Canada. In mid-October 1940, CCF sold and exported the Maple Leaf II prototype to Columbia Aircraft,[129] and sent with it "two-half finished aircraft, all accessories, spare parts, jigs, tools and fixtures, tracings and blueprints of drawings and reports."[130] The American company apparently wanted to manufacture the aircraft for the U.S. Navy under the designation of GN-4, but the project was abandoned for unknown reasons. Everything was then sold to the Mexican government, which apparently completed at least one of the unfinished aircraft with enlarged tail surfaces and a new engine around 1944, and renamed it the Ares Núm 2.[131] In the end, CCF produced only one Maple Leaf II.[132]

The CCF-Burnelli Connection

CCF also worked on its own line of transport aircraft. In 1936, CCF obtained the manufacturing right to the American-designed Barkley-Grow T8P-1 twin-engine transport,[133] and made an arrangement with Vincent Justus Burnelli of the Burnelli Aircraft Corporation in the United States for the production of his lifting fuselage aircraft

principle. [134] This was a radical aeronautical concept. Instead of relying on a conventional cigar shape fuselage with wings and tail surfaces, Burnelli combined the fuselage and the wings into a single structure resembling a flying wing. The basic theory underpinning the lifting body concept was that the fuselage could contribute at least 50 per cent of the aircraft's lift if it was shaped like an airfoil. This was a major advantage over conventional cylindrical designs that produced "parasite drag," a phenomenon hampering lift.[135] In summarizing the Burnelli lifting fuselage principle, Dr. Alexander Klemin, Dean of the Daniel Guggenheim School of Aeronautics at New York University, wrote:

> The basic idea is that the conventional fuselage shall be eliminated and housing space shall be provided within a lifting airfoil while tail surfaces are supported at the end of appropriate booms. From the elimination of the fuselage which is an element of purely parasitical drag, there follows reduction of aerodynamic resistance ... From the reduction in aerodynamic drag, there follows improvements in performance, that is in high speed, climb and fuel consumption for a given weight of the airplane and horsepower.[136]

Klemin added that the specific employment of the airfoil in lieu of the conventional fuselage "permits the volume of housing capacity to be largely increased without any sacrifice of aerodynamic efficiency." This was particularly useful for military aircraft such as heavy bombers or large transports. He concluded that the Burnelli lifting fuselage principle "offers an advance in the art, in efficiency and economy."[137] There were also operational advantages to using the Burnelli lifting fuselage aircraft, including increased cabin capacity, excellent accommodation for sleeping berths, ease of housing for retractable landing gear, in-flight accessibility to the landing gear and engines and higher operating efficiency in terms of speed, payload and range. Transoceanic pilot Clyde Pangborn explained how this design enhanced safety and performance.

> The engines are ahead of all structures. This is very important to safety in the event of accident, as the engines and their strong mounts would absorb a large degree of the impact, thereby protecting the cabin and passengers. The propellers operate ahead of all structure and are not attached to the lighter outboard wings. This is an important safety factor in the event of propeller failure, as no parts would strike into the structure or cabin sections or affect any sustaining surface through the tearing loose of the engine mount. The propellers operate close together with no body in between, as is conventional. The advantage of this quality though obvious for flying with one engine stopped, is immediately noticeable in the more efficient flying and control qualities of the plane, as the corrective use of controls to overcome the offset propeller thrust augmented by the stopped propeller drag, is practically nil and right or left turns easily made. Ease of inspection and maintenance is an important factor of safety and the human element will always be a problem in this respect. The Burnelli ship is in a class by itself in this future. Because not only are all engine details, fuel, instruments, leads and controls, more compact and easily accessible in the nose of the wide body, but the distinct feature of these elements being visible to the pilot and accessible in flight also, must be appreciated as a most desirable maintenance and safety feature. The retractable landing gear is not only visible to the pilot in flight, but accessible for inspection or adjustments, another exclusive advantage. An interesting inherent quality of the design for over water operation is the fact that the wide body, made water tight, will serve as a boat bottom for distress landing and float indefinitely, as the body will provide adequate buoyancy with required stability serving as a life raft.[138]

Pangborn added that the Burnelli lifting fuselage design embodied "extremely good flying qualities under all conditions,"[139] that it "offers many structural advantages for design improvement," and that from his experience, "this type of airplane appears to be the most practical"[140]

The Burnelli Aircraft Corporation also claimed that the lifting fuselage had a better crash safety than conventional aircraft. In January 1935, for instance, Vincent Burnelli's prototype UB-14, a twin-engine lifting fuselage transport capable of carrying 14 passengers, crashed near New York City. Interestingly, what should have been a disaster turned into a success story. The empty passenger cabin remained intact, its seats still fixed in position. There was no fuel leak or fire and, more importantly, the crew walked

out of the wreckage alive. Test pilot Louis T. Reichers explained what happened in his accident report.

> I flew the ship into the ground from about 200 feet altitude and estimate the speed of contact at about 130 mph, the right wing being nearly vertical and absorbing first shock. This impact caused the airplane to cartwheel, tearing off the engines and crushing the wings and tail group, with the body tumbling through but remaining intact. No fuel leaked from the wings. It is my firm belief that the box body strength of this type, combined with the engines forward and the landing gear retracted, saved myself and the engineering crew and had the cabin been fully occupied with passengers with safety belts properly attached, no passengers would have been injured. This crash landing, in my opinion, is an extraordinary example of the crash safety that can be provided by the lifting body type of design.[141]

The accident re-enforced Burnelli's faith in the lifting fuselage. Few conventional aircraft crashing in similar circumstances would have had survivors to tell the tale.

But there were, however, disadvantages to the lifting fuselage concept. As noted in a 1944 *Canadian Aviation* article, the advantages of the lifting fuselage were "very largely offset by the cumbersome empennage mounted on booms." Experts believed that if the lifting fuselage was a true flying wing and discarded its empennage, the aircraft would prove much more efficient than conventional craft.[142] Moreover, the look of the lifting fuselage aircraft was not aesthetically pleasing. As one American pilot noted in 1935, "it seems to be the cargo ship of the future all right, but it sure is an ugly duckling in appearance." The lifting fuselage aircraft's bulky shape, which made it somewhat less attractive than more conventional aircraft was, in the words of a top USAAF officer "an unfortunate psychological but very real handicap."[143]

In spite of the fact that the Burnelli lifting fuselage principle was still very much at an experimental stage, CCF decided to launch itself in the production of this aircraft type in Canada. Why CCF decided to undertake such a risky business remains a mystery,

especially since the company was fairly new to the aircraft manufacturing business and possessed virtually no experience in the production of aircraft. One can only assume that playing a significant role was the notion that to be among the first to produce this highly innovative aircraft would bring it significant sales. All the more surprising, however, was that though CCF had acquired the right to manufacture the Burnelli UB-14 transport under-license in Canada in 1936, the company decided instead to design and develop its own line of lifting fuselage aircraft in cooperation with the Burnelli Aircraft Corporation. In late 1937 and early 1938, Michael Gregor, CCF's chief aeronautical engineer, worked with Vincent Burnelli to design a three-engine lifting fuselage transport capable of carrying thirty-four passengers, known as the CB-34. The aircraft was to have a gross weight of 33,000 lbs and be powered by three 1,100 hp Wright 1820 Cyclone engines.[144] CCF built a 1/24 scale model of the aircraft and tested it in the wind tunnel of the NRC in Ottawa in May 1938.[145] The company also built a scale model of a bomber version of the aircraft fitted with two machine gun turrets in the booms,[146] and manufactured a full-scale wooden mock-up of the CB-34.[147] Yet, the project was abandoned shortly after as the Department of Transport lent little encouragement as it deemed the aircraft too large. In the meantime, CCF had also received a large order from the British government for Hawker Hurricane fighters.[148]

When war began, CCF officials remained confident in the lifting fuselage design and its outstanding value for transport purposes. In 1939, CCF designed a twin-engine military transport known as the MB-2, using the Burnelli lifting fuselage principle.[149] The aircraft was meant to compete with the American-designed Curtiss C-76 Caravan twin-engine transport, made almost entirely out of wood. In 1941, the company presented this

new design proposal to the USAAF, stating that it was ready to commit funds to construct the MB-2 as a private venture. Many American military officials were in favour of the MB-2 lifting fuselage. A top USAAF officer reported to his superior: "I personally would rather see this particular two-engine Burnelli MB-2 type constructed than our own C-76 because structural problems in wood of a conventional fuselage type cargo plane of such gross weights, speeds and stresses should cause the latter's designs to defeat itself." He added that bonded plywood was not as uniform as metal and, as such, "compound curves, vibrations, resonance problems, etc., may not be practical in wood in the C-76 conventional type whereas the big box girder structure of the Burnelli with its flat panels and a certain amount of steel fittings apparently is quite a simple problem."[150] CCF built a 1/24 scale model of the MB-2, which was tested in the wind tunnel of the NRC in August 1942.[151] In the end, however, the MB-2 project was abandoned as the United States could manufacture aircraft of similar size in large enough quantities to supply the needs of almost all Allied air forces. CCF did not produce a single MB-2.

In the summer of 1940, the Burnelli Aircraft Corporation was renamed V.J. Burnelli Airplanes Inc. The new company associated itself with the Central Aircraft Corporation, a relatively young company that had just entered the manufacturing business and hoped to mass produce fighters, bombers, trainers, transports and reconnaissance aircraft using the Burnelli lifting fuselage principle for the USAAF.[152] CCF began to work with the Central Aircraft Corporation, and soon found itself partially in control of the American company as it retained twenty-four per cent of its capital stock distribution.[153]

In ensuing months, the USAAF showed interest in several Burnelli combat aircraft designs and expressed a desire to purchase large numbers. In 1941, Vincent Burnelli, L.E.

Peto (vice-president of CCF), and other representatives of V.J. Burnelli Airplanes and Central Aircraft Corporation met with American President Franklin D. Roosevelt to settle the contract. The story goes that Roosevelt was about to sign the directive when he inquired as to who would finance the production of so many aircraft. Peto explained that the CCF had important resources and Burnelli added that if more money was required they could always count on one of his backers, Arthur E. Pew of the Sun Oil Company. Upon hearing this, Roosevelt allegedly had a fit, threw his pen across the room and proclaimed loudly that Burnelli would never get an order as long as he was alive. It came to be known that Pew had financed Wendell Wilkie, Roosevelt's opponent in the last presidential election.[154]

A few weeks later, the USAAF Board of Review recommended that "no steps be taken towards committing the USAAF to the design and construction of these aircraft." It concluded that "the development of a new and especially unorthodox design introduces new training and maintenance problems which must be clearly and unmistakably outweighed by the excellent, novelty and desirability of the proposed development" and that "the Burnelli lifting fuselage design does not offer sufficient new or novel ideas of military value to warrant the construction of experimental or production airplanes." The board was unequivocal in its decision, noting that "after due consideration it has been determined that the lifting fuselage design of aircraft, or any other design of aircraft embodying substantially the same aerodynamic principles, does not possess sufficient merit for military purposes to warrant further consideration by the War Department."[155] The board also alleged that Central Aircraft Corporation's partial ownership by foreign interests, namely CCF, restricted the company from engaging in business with the United

States government under the Buy American Act. The USAAF decision dealt a serious blow to Vincent Burnelli and his supporters, but not all hope was lost. There was still the Canadian market, and in late 1941, Vincent Burnelli accepted an offer to act as consulting engineer for CCF. [156]

The Problem of Foreign Dependence

The difficulties experienced by the RCAF in finding a suitable twin-engine fighter for home defence during the early war years served to illustrate the problems that could ensue from dependence on foreign sources of supply for combat aircraft. It was a harsh lesson that the RCAF would not soon forget. The problem started in 1935 when Major-General A.G.L. McNaughton, the outgoing Chief of the General Staff, revealed the impoverished state of Canadian defence in a memorandum to the Canadian government. He pointed out, among other things, that the air force did not possess a single service aircraft fit to employ in active operations.[157] The RCAF was, in fact, ill equipped to counter any enemy air attacks against Canada; its fighter strength then consisted of only half a dozen obsolete British-made Armstrong Withworth Siskin biplanes.[158] In 1936, the Joint Staff Committee warned that, "Canada's air force is entirely inadequate to meet her modest defence requirements."[159] The air force desperately needed modern combat aircraft, especially fighters.

In February 1938, the RCAF issued a requirement for a two-seat, all-metal twin-engine fighter monoplane for Canada's air defence. The aircraft had to be capable of reaching a top speed of 300 mph at 15,000 feet altitude; have a cruising range of about 1,000 miles; operate with wheels, skis or floats; carry small bombs and be armed with

machine guns mounted in its nose and wings; and have a special rotating turret capable of providing a 360° arc of fire.[160] The RCAF explained that defending a country the size of Canada, where vast distances separated airfields, required maximum mobility in order to respond effectively to an attack. A Canadian fighter had to be capable of operating far from the vicinity of airbases over inhospitable country or coastlines; so long-range twin-engine fighters could reduce the risk of forced and potentially deadly landings.[161]

The problem, however, was that the Canadian aircraft industry was simply too small and inexperienced to undertake the design and development of such a powerful aircraft. No Canadian aircraft company had ever manufactured fighters with the exception of CCF that was at the time producing the obsolete Grumman G-23 Goblin fighter and working on developing the FDB-1.[162] Unfortunately, these two biplane aircraft did not meet the RCAF requirements. The time required to create and produce a suitable twin-engine fighter in Canada was too long to meet the RCAF's urgent requirements.[163] Air Commodore G.M. Croil despairingly noted, "it is ... hopeless to look to the small Canadian aircraft industry for immediate supply, as it is not in a position to turn out new [combat aircraft] types at short notice."[164]

The Canadian government turned to Great Britain, its traditional source of supply for weapons and military equipment. Unfortunately, the British were in the midst of their own rearmament program and required all the combat aircraft their industry could produce. The British responded that Canada would have to wait a few years before their factories were in a position to help fill the needs of the RCAF. Furthermore, no existing British aircraft met the RCAF specification for a twin-engine two-seat fighter capable of reaching speeds in excess of 300 mph. The problem was that geographic and climatic

differences between Europe and North America made for distinct fighter requirements. As Great Britain was vulnerable to sustained air attack from the European mainland, the RAF needed short-range, single-engine fighters capable of fast speed, rapid climb rates and high operational altitudes to operate over populated territories. The RCAF, on the other hand, required heavily armed, long-range, twin-engine fighters to fly over vast undeveloped territory.[165] Clearly, standardization on British aircraft types as agreed upon at the 1937 Imperial Conference was problematic from a Canadian perspective. In March 1938, the RCAF noted that "it is apparent that the delay in determining a source of supply for a suitable fighter aircraft is prejudicing our position with regard to the defence of the Dominion."[166]

Canadian military officials turned their attention to the United States, which was said to be "most desirous of being cooperative."[167] The RCAF originally expressed some interest in the Seversky P-35 fighter, for despite its single-engine configuration, its characteristics and performance were believed to closely fulfill Canadian requirements. Attempts were soon made to obtain the rights to manufacture the P-35 in Canada for the RCAF,[168] but these were abandoned upon learning that the Seversky fighter did not meet the required high speed and long range. The Americans recommended instead the twin-engine Curtiss A-18 Shrike, and advised Canadian officials that the American War Department was continually experimenting with new aircraft designs.[169]

In late April 1938, a RCAF delegation traveled to Washington to obtain additional information on a variety of American fighters. The plan was to select an aircraft that would be manufactured under-license in Canada. The delegation met with top USAAC officials, who proposed several readily available aircraft for production in Canada,

namely the Seversky P-35 and Curtiss P-36 Hawk fighters, and the twin-engine Curtiss A-18 Shrike. As these aircraft were "comparatively old and did not meet RCAF requirements," the Americans suggested their latest types: the Vultee VTX-1 and Curtiss XP-37 fighters, as well as the twin-engine Vultee VT-35 and Bell XFM-1 Airacuda. All of these aircraft were in the experimental stage and, in the case of the VT-35, still in the process of being designed. RCAF officials were particularly interested in the XFM-1, but were concerned that it was still under development. Another problem was that the United States government was not initially inclined to grant licenses for the manufacture of any of these modern aircraft outside of the United States.[170]

The RCAF also ran into difficulties with American neutrality laws, which only allowed American companies to release their latest combat aircraft to foreign governments six months after delivery of the second aircraft of the production order to the USAAC. This proviso extended to the granting of licenses for manufacture outside of the United States. In practical terms it meant that the XFM-1 would be at least two years old before being available on the market. As aeronautical technology moved forward at an extremely fast pace, there was always the possibility that another world power could develop a superior fighter in the interim. The RCAF attempted to find ways to relax United States regulations and accelerate the XFM-1 acquisition process.[171] In the end, however, the Bell XFM-1 fighter was found to be too expensive so the idea of acquiring it was abandoned in June 1938.[172] Soon thereafter, the United States War Department informed the RCAF that it would be willing to supply information on the Bell XFM-1 and allow Canadian officials to negotiate with the Bell Aircraft Corporation of Buffalo,

New York, for the production of the fighter in Canada.[173] Still, the shift in American attitude did nothing to change the RCAF's concerns about the aircraft's high cost.[174]

The Canadian government then looked into the possibility of re-designing the Canadian-built twin-engine Bristol Bolingbroke reconnaissance-bomber into a fighter. This proposal initially attracted considerable interest as it seemed that the project merely entailed the designing of a new aircraft nose that could carry a nest of machine guns. The remainder of the aircraft would remain essentially the same, and thus be interchangeable with the reconnaissance-bomber version. Yet, after further consideration, this option was not pursued as the Bolingbroke's performance was simply not adequate for a fighter.[175]

The solution was to strengthen the structure of the aircraft and fit larger engines,[176] but in so doing the weight of the aircraft would increase considerably. Another option was to have Fairchild completely re-design the aircraft, a process that promised to take significant time.[177] The RCAF finally abandoned the idea of redesigning the Bolingbroke into a twin-engine fighter.[178] Unable to find a satisfactory twin-engine fighter in both Great Britain and the United States, the RCAF concluded, "it appears that it will be necessary to accept a single-engine, multi-gun fighter for the present to fill the gap in Canadian air defence." An enquiry was therefore forwarded to the British Air Ministry to ascertain if a small number of Supermarine Spitfire or Hawker Hurricane could be made available to Canada.[179]

It was not until the Czechoslovakian crisis of September 1938, when war seemed imminent in Europe that the RCAF began to seriously reconsider the Bell XFM-1. Canada's serious shortage of modern combat aircraft placed the RCAF in an extremely vulnerable position in the event of war, including in its ability to adequately respond to

the possibility of enemy air raids on Canadian territory. The RCAF sent a purchasing mission to the United States to secure the importation of American-built combat aircraft, and to discuss the production of the XFM-1 under-license in Canada.[180] Negotiations were undertaken with the Bell Aircraft Corporation, which agreed to provide Canada with all the necessary information and to allow a Canadian delegation to visit its facilities in Buffalo.[181] By early 1939, the Bell Aircraft Corporation floated the idea of establishing a branch plant in Montreal to produce the XFM-1 and other Bell products under-license. British military authorities believed what Bell really wanted was access to the powerful British-designed Rolls-Royce Merlin engine, as it had shown much interest in the engine in the past and intended to fit it in the XFM-1, possibly in its new Montreal branch plant.[182] In the end, Bell chose not to follow through with its idea when the RCAF advised that it would not purchase the XFM-1 after serious technical problems had been experienced in the United States.

The RCAF's inability to find a suitable twin-engine fighter for home defence caused serious headaches in Canadian military circles. It became obvious that Canada would not be able to obtain the required fighter, so a single-engine aircraft would have to do for the time being. Accordingly, in early 1939, the RCAF considered converting the H-1 racing aircraft developed by Howard Hughes in the United States into a fighter. The Hughes H-1 was a single-seat, single-engine monoplane of considerable range and speed; in fact, it had set the world's speed record a few years earlier. The plan was to produce and modify the aircraft in Canada under-license. At first glance, the transformation seemed possible, but information showed that the H-1 would be "entirely unsuitable for employment as a fighter." The entire structure of the aircraft would have to be re-

designed, which might cause difficulties in accommodating machine guns and other military equipment. It was noted that when converted as a combat aircraft, the H-1 would probably be much heavier than contemporary fighters. In order to maintain its efficiency, the H-1 would have to be mounted with only two machines guns, leaving it inadequately armed. In the end, it was reported that "the resources of this country do not warrant the risk and expense involved in attempting such a development and the more conservative course of purchasing well-tried service aircraft of proven military merits has to be followed. The expense of developing a fighter aircraft could not be justified for the number of such a type required by this department." It was also noted that the British would not be interested in this project as they already had aircraft of equal power capable of mounting more machine guns.[183] The idea of manufacturing a fighter version of the Hughes H-1 in Canada was abandoned. As a result, when the Canadian government declared war on Nazi Germany on 10 September 1939, the RCAF still did not have a suitable fighter for home defence.

The German invasion of Denmark and Norway in April 1940 alarmed Canadian military authorities to the possibility of enemy action against Canadian territory by way of the Arctic. There were fears that German long-range aircraft based in northern Norway might travel across the polar ice cap to attack the Canadian mainland.[184] To make matters worse, the Soviet Union had signed a Non-Aggression Pact with Nazi Germany in 1939, raising concerns as to whether the Soviets might decide to join the Germans in their fight against the Allies (the Soviet Union only joined the Allies in 1941). Air force officials believed that Soviet heavy bombers could conduct air strikes against Canadian territory across the Arctic from bases in northern Siberia.[185] There were also increased fears that

Germany might use Iceland, the Danish colony of Greenland, or even remote regions of Canada's north as potential bases of operation to conduct air attacks against Canada or the British possessions of Newfoundland and Labrador.[186] More troubling was that Greenland was the world's principal source of natural cryolite, a mineral essential to the production of aluminum, which was vital to the manufacture of aircraft in Canada. The Canadian government was particularly concerned that the cryolite mines of Ivigtut might be shut down by sabotage or fall under control of a German landing party.[187] The fear worsened when the Germans invaded Western Europe between May and June 1940. It became of utmost importance to find a twin-engine fighter to defend Canada from such threats.

All the more disconcerting was the beginning of the Battle of Britain in the summer of 1940 and the possibility of a German invasion of the British Isles. If such a scenario transpired, Canadian aircraft manufacturers would no longer be able to rely on Great Britain to obtain essential components and engines, not to mention plans, drawings and information on the British-pattern combat aircraft to be produced under-license in Canada. The approved British Commonwealth policy of standardizing on British-pattern weapons and military equipment would evidently have to be abandoned, and new sources of supply would have to be found. Moreover, technically the United States would be unable to provide Canada with its latest aircraft designs owing to its neutrality laws. It became increasingly imperative that the Canadian government encouraged aircraft design and development as soon as possible. In the meantime, the RCAF tried to obtain a few British-designed Hawker Hurricane fighters from CCF, which had just begun producing the aircraft under-license in the autumn of 1938. But unfortunately, none were readily

available, as the bulk of production was destined to the British government. The RCAF therefore had to content itself with the purchase of fifteen obsolete Grumman G-23 Goblin biplane fighters from CCF for home defence.[188]

In July 1940, Air Commodore A.A.L. Cuffe, the Air Member for Air Staff (AMAS), pointed out that most of the aircraft in the RCAF inventory for home defence were old and needed to be replaced. He suggested that Canada design and develop its own line of combat aircraft, as well as produce aircraft engines. The intention was "to assure a continuous supply of aircraft to the design required, free from interruption by overseas demands." Cuffe urged that suitable airframe factories be built "with all possible speed" and that an aircraft design staff be "obtained from any source" to produce three types of aircraft: an amphibian flying boat, a twin-engine bomber and a twin-engine fighter. The flying boat was to be of wooden construction, if possible, and designed for long-range reconnaissance purposes. The aircraft was to be capable of a maximum speed of 150 mph and of carrying a 1,000 lbs bomb load. Armament was to consist of one cannon at the front of the aircraft and a four-machine gun turret aft. The twin-engine bomber was to be designed primarily as a strike aircraft capable of high speeds and heavy bomb loads. Machine gun turrets were to be installed at the front and back. Meanwhile, the twin-engine fighter was to be of wooden construction and be capable of escorting bombers. Armament was to consist of two cannons at the front and a four-machine gun turret aft. Cuffe explained: "It is realized that the design of the above new aircrafts entails a very great deal of work, but it is possible that existing designs may be obtained and adapted as required."[189] In the end, Canadian military officials rejected the proposal in favour of examining the possibility of producing the American-designed Consolidated

PBY Catalina or Sikorsky S-43 flying boats, and the twin-engine Lockheed P-38 Lightning fighter under-license. As for the twin-engine bomber, consideration was given to the Douglas B-23 Dragon of American origin, but officials opted for the British-designed Bristol Bolingbroke that was already being produced under-license by Fairchild.[190]

Canada was particularly interested in building the P-38 fighter for the British and Canadian governments, and it undertook negotiations with Lockheed in the fall of 1940.[191] The idea was to give Fleet a contract to produce these fighters and there were even plans of establishing a new factory in London, Ontario, for this purpose. The plant, to be operated by Fleet in cooperation with a British firm known as the Briggs Motor Bodies Company, was to be the largest in Canada, employing up to 5,000 workers.[192] The RCAF was particularly pleased with the idea of adopting the P-38. In the words of the Air Vice-Marshal Ernest W. Stedman, the Air Member for Aeronautical Engineering and Supply (AMES), "provision of a fighter for use in Canada depends upon conditions which are very similar to those existing in the United States, and, therefore, a fighter aircraft designed for use in the US is probably preferable to one of British design."[193] The RCAF planned to order a total of 180 of these aircraft from Fleet. Negotiations went on for several weeks without much progress, and the Canadian government finally decided to abandon the P-38 project in late October 1940.[194]

Meanwhile, Canadian military officials considered the possibility that Canada might have to spearhead the fight alone from North America. In such an event, the RCAF would require a weapon capable of striking across the Atlantic Ocean at targets in German-occupied Europe from bases in Canada. What was needed was a powerful long-

range transoceanic four-engine bomber capable of flying at high altitudes, but this was an especially ambitious project. In early September 1940, the Air Council decided to initiate experimental work on the bomber design.[195] Air Vice-Marshal Stedman immediately drafted a specification for such an aircraft. It was to have a range of 3,000 miles at an altitude of 45,000 feet, be capable of transporting a bomb load of 1,500 lbs, and achieve a top speed of 500 mph. Such an aircraft required limited protection because it utilized altitude as a cover against anti-aircraft fire and enemy aircraft. For this reason, defensive armament would only consist of a power operated mid-upper turret mounting four Browning machine guns and a flexible gun mount on the underside, serving as an alternative position for the gunner in case of emergency. Stedman's specification was sent to the NRC's Aeronautical Laboratories' staff for further investigation. Two months later, the NRC submitted a report entitled *Preliminary Design and Performance Estimates for a Long Range Stratosphere Bomber.*[196]

The NRC approved all the requirements listed in the specification, except for the top speed, which would have to be lowered to 435 mph. "There appears to be no feature about this proposal that cannot be realized," Stedman said, "the most experimental thing at the present time being the design of the supercharger." Stedman was also keen on the possibility that a high speed, high altitude fighter could be developed by reducing the bomber's range and weight. Such a fighter could provide a strong line of defence against enemy high altitude bombers.[197] The NRC report was then submitted to the British Air Ministry for consideration. Stedman was particularly anxious to know if "any further investigation work along these lines that can be done here" and alternatively if the Air Ministry would like Canada to "undertake any development work upon an aircraft to

meet these condition"[198] The British strongly recommended that Canada not undertake such an ambitious indigenous project, preferring instead that it produce a multi-engine bomber whose design had already been approved by the British government. The RCAF high altitude bomber project was abandoned because Canadian requirements alone were not large enough to justify the high costs associated to the development and production of such an aircraft in Canada

In the meantime, the RCAF began looking at two single-engine American fighter designs for production in Canada, the Bell P-39 Airacobra and the Curtiss P-40 Kittyhawk.[199] Air force officials were particularly interested in the former. Accordingly, in November 1940, the Canadian government approached the Bell Aircraft Corporation of Buffalo, New York, to negotiate a license agreement for the manufacture of the P-39 in Canada. The agreement was to build a minimum of 300 aircraft within the first two years at a rate of 25 per month for the Canadian government. Furthermore, Bell proposed to sell the Canadians all the necessary machine tools and equipment for the fabrication of the P-39 for a few hundred thousand dollars, and to lend ten experienced engineers.[200] Although officials initially planned to assign the project to CCF,[201] it was decided instead to give the work to Fleet, which could produce the aircraft in the new factory that it had earlier proposed to build in London to manufacture the P-38.[202]

But not everybody was enthusiastic about Canada building American fighters under-license. In late December 1940, the British government told C.D. Howe that they were most anxious to have Canada build British instead of American aircraft types.[203] There were discussions of having CCF produce the British-designed Hawker Typhoon fighter for the British government upon completion of the Hurricane contract.[204] Yet,

Canadian enthusiasm for the P-39 remained unshaken. Canadian officials were especially excited because the British had expressed interest in the aircraft, and had even ordered over 600 slightly modified machines to be known as P-39 Caribou from American sources.[205] It was hoped that initiating the production of the P-39 in Canada might incite the mother country to place some orders north of the border. The British refused, stating that "they have sufficient fighter production on this continent" and that "they would not care to participate with Canada in the production of additional fighters to be manufactured in Canada." Without British orders, Canadian officials quickly realized that the country's total requirement for P-39 was too small to warrant the manufacture of the aircraft in Canada. The only possible solution was to place orders in the United States.[206] No Bell P-39s or Hawker Typhoons were manufactured under-license in Canada.

By early 1941, the RCAF had still not found a suitable fighter for home defence. As none were readily available from American or British sources, Canadian military authorities turned to its aircraft industry and looked again to the Hawker Hurricane, the only fighter then in production in the country. The Hurricane, however, was unsuitable for home defence due to its short range. It would have to be fitted with external fuel tanks that could be jettisoned in flight before any battle. The urgency of the situation compelled the RCAF to go with the Hurricane for the Home War Establishment.[207] The problem, however, was that CCF assembly lines were already fully committed to the production of Hurricanes for the British government, leaving Canada to request a small number of Canadian-made Hurricanes from the British order. In a twist of irony, the Canadian government found itself having to negotiate with another country to obtain Canadian-made aircraft for its own defence.[208] The British agreed to release a few to the RCAF, but

Canada's Chief of the Air Staff, Air Marshal L.S. Breadner, rejected the British offer on the assumption that the much superior Bell P-39 or Curtiss P-40 fighters would soon be readily available from American sources.[209] Canada's Deputy Minster of National Defence for Air explained in July 1941 that "there is little object in equipping the RCAF with an obsolete type of fighter" so it was preferable to continue efforts to obtain the P-39 or P-40 "even if we have to wait for them."[210] In the late summer of 1941, the idea was abandoned when reports revealed that the P-39s performance was "seriously short of expectations" and that "it was doubtful if the British authorities were ordering any more."[211]

By the fall of 1941, the need to find a suitable twin-engine fighter for home defence became pressing as the possibility of war against Japan grew more imminent. Consequently, the RCAF reconsidered converting the Canadian-made twin-engine Bolingbroke reconnaissance bomber into a long-range night fighter for service on Canada's west coast. Fairchild would modify the proposed aircraft by using canons or .50 caliber machine guns in addition to four .303 Browning machine guns in its nose to attack enemy long-range bombers. The fighter version had to be capable of "exceptional manoeuvrability," which was unfortunately not a characteristic of the conventional Bolingbroke bomber. The aircraft would therefore have to be completely re-designed for the purpose.[212] The project was deferred until such time as additional information could be obtained on Japanese aircraft and their likelihood of reaching the Canadian west coast in the event of war.[213]

The problem reached a culmination on the early morning of 7 December 1941, as Japan attacked Pearl Harbor and American, British and Dutch colonial possessions in

Southeast Asia and the Pacific. A few hours later, Canada declared war on Japan along with Great Britain and the United States. Japan possessed several aircraft carriers, and it was widely feared that it might eventually launch air strikes against strategic points along the west coast. The RCAF had to be capable of countering this threat rapidly. It desperately needed twin-engine fighters, but none were available at the time. The only fighter then in production was the Hurricane, which was inadequate for operations in North America. Desperate times called for desperate measures so in early 1942 the RCAF requisitioned 400 CCF-made Hurricanes that were initially on British order,[214] and were originally slated for use by the air forces of China, the Dutch East Indies, the Soviet Union, and even the United States.[215] The situation caused some problems with the British, but as Air Vice-Marshal F.V. Heakes, the air officer commanding RCAF Western Air Command, stated, "we must exercise firm control of the only weapon we possess, namely the production of our own industry." The Air Member for Supply (AMS) added that compromise would only be possible if "the security of our country was not at stake."[216]

The RCAF was also planning to equip its home defence squadrons with 250 British-designed De Havilland DH 98 Mosquito twin-engine fighters.[217] The aircraft were to be ordered from DHC, which had agreed in August of 1941 to manufacture the Mosquito under-license in Canada for the British and Canadian governments. A problem arose in mid-December 1941 when the DMS found out that DHC was building the unarmed bomber version of the Mosquito. The decision had apparently been taken at the request of the British government. Ralph Bell was furious that the British had changed the Canadian Mosquito program without consulting Ottawa. He explained to Charles

Banks, the DMS representative in Great Britain, that when he originally advocated Mosquito production in Canada, "it was on the express condition that it was to be built as the fighter." He added that he would not have supported the undertaking had he known the outcome. In fact, the British told Canadian authorities that they were now planning to have the unarmed bomber, fighter-bomber and trainer versions of the Mosquito produced in Canada.[218] The whole affair caused much frustration and dissatisfaction. As Banks told Bell:

> Because of our most unsatisfactory experience in manufacturing British types on this continent we had long since determined that we would never undertake another British machine in Canada, but in this instance we were impressed with certain features of the machine itself, we were satisfied that it could be built complete from North American sources, we were without a fighter in production in Canada except for the Hurricane which was obsolescent, and we decided to allocate the necessary facilities for this job, feeling that if anything subsequently happened which brought the war directly to this continent, we would have this fighter production available. Meantime, of course, as initiated and developed it would continue to flow to England or wherever England might indicate. The bomber version, however, does not provide the same insurance from our point of view ... we could quite properly insist that the entire production be of the fighter type. But believing that there must be some good reason why the type was changed, we are content to permit it to proceed on that basis, provided that facilities are set up to produce at least a couple of the fighter type here.[219]

Bell replied that this behaviour was "typical of our contracts throughout with the British on aircraft and I am sorry that we ever touched the thing ... It is one of those completely unfortunate situations and, so far as I am concerned, it is the last time I will have a thing to do with English aircraft in Canada. I should have learned my lesson earlier than this."[220]

In the early fall of 1942, the RCAF learned that the United States was working on two new long-range twin-engine fighter designs capable of operating at high altitudes and high speeds, namely the Lockheed XP-49 and XP-58.[221] The Deputy Minister of National

Defence inquired whether the DMS was interested in producing these two types, or aircraft of like performance, under-license in Canada.[222] The RCAF also looked at other American experimental fighter projects, such as the Bell XP-63 and XP-77, the Curtiss XP-55, XP-60 and XP-62, and the twin-engine Curtiss XP-71 and McDonald XP-67,[223] but none of these aircraft were adopted or build under-license in Canada.

In October 1942, the RCAF expressed interest in four detailed combat aircraft design proposals sent by a Canadian serviceman to the NRC's Inventions Board. The first called for a twin-engine flying boat powered by Merlin engines to be used for reconnaissance patrols, anti-submarine operations, and convoy escort mission. The aircraft was to be fitted with two machine gun turrets (one located in the bow and the other amidships) and capable of carrying bombs. The second proposal was for a multi-seat twin-engine fighter powered by 1,200 hp engines and armed with four 20mm canons in the nose, four machine guns in each wing, and one power-operated machine gun turret in the rear. The third proposal was for a multi-role three-seat combat aircraft powered by two 1,400 hp engines. The aircraft was to be capable of operating as a fighter, bomber, torpedo bomber and reconnaissance aircraft. Armament was to consist of two 20mm canons in the nose, six machine guns in the wings, and four canons in a power driven turret. In addition, the aircraft was to be capable of carrying bombs and torpedoes. The fourth proposal was for a single-engine, single-seat fighter armed with six .50 calibre machine guns in its nose. The proposals were sent to the British Ministry of Aircraft Production for thorough investigation as to their suitability, but were rejected on the ground that they presented no novel features.[224] In the end, none of these four Canadian-designed aircraft were built. [225]

In the meantime, work continued on making the Hurricane suitable for home defence. Between 1942 and 1943, a few RCAF Hurricanes were tested for winter operations in North America with experimental ski undercarriages, but no "Ski Hurricane" was ever used operationally.[226] The RCAF also briefly discussed the possibility of re-designing the Hurricane to carry long-range fuel tanks instead of bombs for operations in North America.[227] The RCAF even contemplated using more than seventy Canada-made Curtiss SB2C Helldiver dive-bombers as fighters for home defence in September 1943, but this project fell through.[228] In the end, the RCAF never got the twin-engine fighter it so desired and was forced to rely on the Hawker Hurricane and the Curtiss P-40 Kittyhawk for home defence until the end of hostilities.

Conclusion

Canadian aircraft design and development efforts were extremely limited during the war. A mere handful of aircraft designs were conceived in the country, and only two were mass-produced: the Fleet 60 Fort trainer and the Noorduyn Norseman general utility transport. Compared to the other great Allied powers, Canada was clearly not autonomous in the field of aircraft production. The experience of being unable to secure a suitable twin-engine fighter served as a harsh reminder of the dangers of being dependent on foreign sources of supply for military aircraft. By 1942, the policy of constructing American and British military aircraft under-license in Canada was generating growing discontent and frustration in some government circles, particularly within the RCAF and the DMS. The British government's declaration of early 1942 that "nothing is to be ordered in England unless it was impossible to obtain the material or

equipment required on the North American continent and only on condition that the material so ordered is essential to our war program," merely added fuel to the fire. It became increasingly clear that Canada needed to become self-sufficient.[229]

NOTES

1 E.W. Stedman, *From Boxkite to Jet – The Memoirs of an Aeronautical Engineer* (Ottawa: Canadian War Museum, Canadian Museum of Man, and National Museums of Canada, 1972), p. 169.

2 NSC was also interested in designing its own line of aircraft. When the NSC Aircraft Division was established in 1936, company president Robert J. Magor elaborated a long-term plan whereby NSC would manufacture foreign-designed aircraft under-license until enough experience had been gained. The company would then initiate the development of indigenous aircraft designs. It was with this in mind that Magor hired Fairchild's Francis Percival Hyde Beadle as chief aeronautical engineer that same year. But the Second World War put an end to Magor's dream. See Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 41-42.

3 Francis Percival Hyde Beadle was a British aircraft designer who worked for the Fairchild Airplane Manufacturing Corporation in the United States before joining the Canadian company as chief aeronautical engineer in early 1931. See K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 316-319.

4 William Paul Ferguson, "The Super 71...A Canadian Fairchild," *Air Enthusiast*, No. 4 (1977), pp. 208-211; C.G. Grey and Leonard Bridgman, eds., *Jane's All the World's Aircraft 1935* (London: Sampson Low, Marston and Company, 1935), pp. 98-99c; Kent A. Mitchell, *Fairchild Aircraft, 1926-1987* (Santa Anna: Narkiewicz/Thompson, 1997), pp. 35-36; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 316-319, 462; K.M. Molson, "The Made-in-Canada Fairchilds," *Canadian Aeronautics and Space Journal*, Vol. 13, No. 2 (February 1967), pp. 58-59

5 Grey and Bridgman, *Jane's All the World's Aircraft 1935...*, pp. 99-100c; C.G. Grey and Leonard Bridgman, *Jane's All the World's Aircraft 1939* (London: Sampson Low, Marston & Company, 1939), p. 79c; C.G. Grey and Leonard Bridgman, *Jane's All the World's Aircraft 1940* (London: Sampson Low, Marston & Company, 1940), p. 58c; Mitchell, *Fairchild Aircraft...*, pp. 36-37, 41; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 320-323, 462; Molson, "The Made-in-Canada Fairchilds...," pp. 59-60.

6 The designation Niska was apparently in line with a new policy adopted by Fairchild in 1936 to identify its future products using Amerindian tribal names. See Mitchell, *Fairchild Aircraft...*, p. 37, 41; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 321-322; Molson, "The Made-in-Canada Fairchilds...," pp. 59-60.

7 Nathan Floyd Vanderlipp replaced Francis Percival Hyde Beadle as chief aeronautical engineer, the latter having left Fairchild in 1936 to become chief aeronautical engineer and general manager of NSC's newly-created Aircraft Division. See Molson and Taylor, *Canadian Aircraft since 1909...*, p. 324-326.

8 "The Fairchild Sekani: The New Twing-Engined Convertible Monoplane," *Canadian Aviation*, Vol. 10, No. 3 (March 1937), p. 22; "The Fairchild Sekani: a New All-Purpose Monoplane," *Canadian Aviation*, Vol. 10, No. 11 (November 1937), p. 7. See also Mitchell, *Fairchild Aircraft...*, pp. 37-39; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 324-326, 513-514; Molson, "The Made-in-Canada Fairchilds...," pp. 60-61.

9 Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 513-514.

10 Robert Noorduyn was born in the Netherlands and received his engineering education there and in Germany. He went to Great Britain in 1913 and worked in the engineering department of Sopwith Aviation Limited. In 1917, he worked for the British Aerial Transport Company as chief draftsman, working directly with Frederick Koolhoven (a highly-talented Dutch aircraft designer) on the Koolhoven FK-26 transport. He returned to the Netherlands in 1919 and worked for aircraft designer Anthony Fokker. Fokker wanted to manufacture and sell aircraft in the United States so, in 1921, he sent Noorduyn there to establish a branch plant: the Fokker Atlantic Aircraft Corporation. Noorduyn headed the American company and designed the famous Fokker Universal general-utility transport. He also instigated the design of the three-engine Fokker F.VII. In early 1929, Noorduyn joined the Bellanca Aircraft Corporation as vice-president and designed the Bellanca Skyrocket general-utility transport. He moved to Canada in 1934, where he designed the Noorduyn Norseman general utility transport, and opened Noorduyn Aircraft Limited the next year. See Canadian War Museum

[CWM], *Building for Victory: How Noorduyn Aviation Makes Trainers and Transport for the United Nations* (Montreal: Noorduyn Aviation Limited, 1943), p. 1; Robert S. Grant, "Canada's Thunder Chicken," *Air Enthusiast*, No. 29 (November 1985-February 1986), p. 12; Library and Archives of Canada [LAC], RG-24 [Records of the Department of National Defence], Vol. 5108, File: HQ 1021-9-40, "L.M. Coughtry (Noorduyn Aircraft Limited) to J.A. Wilson (Controller of Civil Aviation)," 4 September 1935; LAC, RG-28 [Records of the Department of Munitions and Supply], Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production and Maintenance* (Montreal: Federal Aircraft Limited, 1947), p. 92.

11 LAC, RG-24, Vol. 5108, File: HQ 1021-9-40, "R.B.C. Noorduyn (Vice-President and General Manager, Noorduyn) to Colonel Clyde Scott (DND)," 10 August 1935.

12 LAC, RG-24, Vol. 5108, File: HQ 1021-9-40, "F.W. Chandler (Resident Inspector AID) to CAE," 27 May 1935; LAC, RG-28, Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production...*, p. 92.

13 LAC, RG-24, Vol. 5108, File: HQ 1021-9-40, L.M. Coughtry (Noorduyn) to J.A. Wilson (Controller of Civil Aviation)," 4 September 1935.

14 Ralph P. Bell, "Canada's Aircraft Industry," *Canadian Geographical Journal*, Vol. 24, No. 3 (March 1942), p. 116. See also Molson and Taylor, *Canadian Aircraft since 1909...*, p. 396.

15 Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 397-398.

16 Grant, "Canada's Thunder Chicken...," p. 15; LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, p. 42; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 398

17 LAC, RG-24, Vol. 4968, File: HQ 606-38AK, "Group Captain C.B. Turner (DPA) to DAE," 11 September 1942; LAC RG-24, Vol. 4968, File: HQ 606-38AK, "Squadron Leader B.H. Russell (For AMAE) to AMAS," 24 September 1942; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 398.

18 LAC, RG-24, Vol. 4968, File: HQ 606-38AK, "Noorduyn to J.A.D. McCurdy (Supervisor of Aircraft Purchases, DMS)," 4 May 1942.

19 LAC, RG-24, Vol. 4968, File: HQ 606-38AK,"F.H. Brown (Deputy Minister) to Noorduyn)," 6 July 1942; LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, p. 42; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 399-400.

20 Canada's Norseman Goes Abroad to Serve the United Nations," *Canadian Aviation*, Vol. 16, No. 4 (April 1943), pp. 52-53; D.D. McLaren "Testing the Military Norseman," *CAHS Journal*, Vol. 27, No. 1 (Spring 1989), p. 21.

21 LAC, RG-28, Vol. 8, File: 27, Aircraft Production, *A Report of the Canadian Programme of Aircraft Production...*, p. 42; "Noorduyn Norseman in a New Dress: Aeronca to Build Canadian Designed Aircraft," *Commercial Aviation*, Vol. 6, No. 3 (March 1944), pp. 72-74; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 400.

22 LAC, RG-24, Vol. 5403, File: HQC 60-3-62 Norseman Aircraft, "Group Captain H.R. Stewart (D. of I. for CAS) to A/V/M A. Ferrier (Air Transport Board, Ottawa)," 18 April 1945. See also LAC, RG-24, Vol. 5403, File: HQC 60-3-62 "Group Captain H.R. Stewart (for CAS) to Air Member, Canadian Joint Staff, Washington D.C.)," 8 February 1945; LAC, RG-28, Vol. 8, File: 27, Aircraft Production, *A Report of the Canadian Programme of Aircraft Production...*, p. 42.

23 "Noorduyn in Full Swing on Harvards and Norseman," *Canadian Aviation*, Vol. 15, No. 12 (December 1942), p. 54.

24 Irving Brinton Holley, *Buying Aircraft: Matériel Procurement for the Army Air Forces* (Washington D.C.: Department of the Army, 1964), p. 578.

25 Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 399-403.

26 W.B. Burchall, "The Aircraft Manufacturing Industry: Great Expansion in Productive Capacity," *Industrial Canada*, Vol. 45, No. 9 (January 1945), p. 118.

27 LAC, RG-24, Vol. 4968, File: HQ 606-38AK,"F.H. Brown (Assistant Deputy Minister) to Noorduyn," 6 July 1942; LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, p. 42; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 400.

28 The designation Norseman V was reserved for the model released after the war to celebrate the Allied victory, which the aircraft projected through the V of Victory symbol. See Ronald A. Keith,

"Introducing the Norseman V," *Canadian Aviation*, Vol. 18, No. 8 (August 1945), pp. 50-53, 114; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 400.

29 C.G. Grey and Leonard Bridgman, *Jane's All the World's Aircraft 1939* (London: Sampson Low, Marston & Company, 1939), p. 82-83c; C.G. Grey and Leonard Bridgman, *Jane's All the World's Aircraft 1940* (London: Sampson Low, Marston & Company, 1940), p. 61-62c; Leonard Bridgman, *Jane's All the World's Aircraft 1941* (New York: Macmillan, 1942), p. 56-58c; Leonard Bridgman, *Jane's All the World's Aircraft 1942* (New York: Macmillan, 1943), p. 59-60c; Leonard Bridgman, *Jane's All the World's Aircraft 1943-1944* (London: Sampson Low, Marston & Company, 1944), p. 68-70c; Leonard Bridgman, *Jane's All the World's Aircraft 1945-1946* (New York: Macmillan, 1946), p. 89-90c; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 400-403, 463. See also Glenn D. Angle, ed., *Aerosphere, 1941* (New York: Aircraft Publications, 1941), p. A-181.

30 Grey and Bridgman, *Jane's All the World's Aircraft 1939...*, p. 80-81c; Grey and Bridgman, *Jane's All the World's Aircraft 1940...*, p. 59-60c; Bridgman, *Jane's All the World's Aircraft 1941...*, pp. 55-56c; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 349-352. See also Angle, *Aerosphere, 1941...*, p. A-180; M.L. McIntyre, "The Fleet 50 Freighter," *CAHS Journal*, Vol. 7, No. 1 (Spring 1969), pp. 3-14.

31 LAC, RG-24, Vol. 5050, File: HQ 938NIV-11-5, "W.N. Deisher (General Manager, Fleet) to A/V/M A. Ferrier (RCAF)," 15 August 1942.

32 LAC, RG-24, Vol. 5050, File: HQ 938NIV-11-5, "Squadron Leader B.H. Russell (AD1) to DAE," 20 August 1942; LAC, RG-24, Vol. 5050, File: HQ 938NIV-11-5, "A/V/M Robert Leckie (AMT) to DAT," 21 August 1942. See also LAC, RG-24, Vol. 5050, File: HQ 938NIV-11-5, Flight Lieutenant K.Y. Lochhead (RCAF) to D/DAD," 21 March 1944.

33 LAC, RG-24, Vol. 5050, File: 938NIV-11-5, "Squadron Leader B.H. Russell (For CAS) to W.N. Deisher (General Manager, Fleet)," 26 September 1942; LAC, RG-24, Vol. 5050, File: 938NIV-11-5, "Squadron Leader B.H. Russell (For CAS) to G. Otter (CAE, Fleet)," 8 October 1942.

34 LAC, RG-24, Vol. 5050, File: HQ 938NIV-11-5, "Group Captain A.F. Britton (For CAS) to AOC No. 16 Aeronautical Inspection District (Edmonton, Alberta)," 1 September 1942.

35 LAC, RG-24, Vol. 5100, File: HQ 1021-3-431, "W.J. Sanderson (President, Fleet) to SAO (RCAF)," 11 April 1938; LAC, RG-24, Vol. 5100, File: HQ 1021-3-431, "L.R. Lafleche (Deputy MND) to W.J. Sanderson (President, Fleet)," 20 April 1938.

36 LAC, RG-24, Vol. 5050, File: 938NIV-11-5, "Wing Commander P.H. Stibbs (For CAS) to Ralph P. Bell," 25 September 1942.

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81 Grey and Bridgman, *Jane's All the World's Aircraft 1939...*, p. 81c; Grey and Bridgman, *Jane's All the World's Aircraft 1940...*, pp. 60-61c; Bridgman, *Jane's All the World's Aircraft 1941...*, pp. 54-55c; Bridgman, *Jane's All the World's Aircraft 1942...*, pp. 57-58c; LAC, RG-28, Vol. 8, File: 27, *A Report of the Canadian Programme of Aircraft Production...*, p. 49; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 352-354, 462. See also R. Eric Crawford, "Fleet 60 Manufacture Gets the Green Signal," *Canadian Aviation*, Vol. 14, No. 9 (September 1941), pp. 41-42, 64; "Fleet Fort in Production," *Commercial Aviation*, Vol. 3, No. 8 (August 1941), pp. 57-60; "Flying the New Fleet Fort," *Canadian Aviation*, Vol. 14, No. 10 (October 1941), pp. 22-23.

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83 Leland Stamford Wallace had been active in American aviation since its pioneer days. He worked for the Martin, Curtiss, Christofferson, Standard, Lawson and Aeromarine aircraft companies. Before coming to CCF, Wallace served as chief engineer of the Bird Aircraft Corporation from 1931 to 1934. See Molson and Taylor, *Canadian Aircraft since 1909*, p. 165.

84 LAC, RG-12, Vol. 2636, File: 5010-10-59, "F.A. Dobson (Aeronautical Engineer, CCF) to Wing Commander A.T. Cowley (Superintendent of Air Regulations, D of T)," 12 June 1937; LAC, RG-12, Vol. 2636, File: 5010-10-59, "A. Ferrier (CAE, D of T) to CCF," 19 June 1937.

85 Gordon Burkowski, *Can-Car – A History, 1912-1992* (Thunder Bay: Bombardier Inc., 1995), p. 45.

86 LAC, RG-12, Vol. 2636, File: 5010-10-59, "Application for Certificated of Airworthiness for Export," 30 September 1937. See also LAC, RG-12, Vol. 2636, File: 5010-10-59, "A.K. Tate (Assistant to Vice President, CCF) to Wallace," 30 September 1937.

87 National Aviation Museum [NAM], File: CCF Maple Leaf, "CCF Report on the Maple Leaf Trainer Aeroplane by Elizabeth G. MacGill," 6 April 1939.

88 Burkowski, *Can-Car...*, p. 45; Molson and Taylor, *Canadian Aircraft since 1909*, p. 165.

89 Michael Gregor was born in Russia in 1888. He worked as an aeronautcal engineer with several Russian aircraft companies before immigrating to the United States in 1921. He joined the Bird Aircraft Corporation in 1927 as chief engineer and developed a number of aircraft designs, including a two-seat biplane elementary trainer known as the Gregor GR-1 Continental, which was first flown in 1930. In 1931, Gregor joined the Seversky Aircraft Corporation and contributed to the development of the Seversky SEV-3 high performance aircraft, which made its maiden flight in 1933. He left Seversky in late 1937 to become chief engineer at CCF. He stayed with the Canadian company until 1940. Gregor was responsible for the shape of the superlative semi-elliptical wing, which made its first appearance on the GR-1 trainer and was subsequently used on the Seversky SEV-3 and the CCF FDB-1 fighter. It was also used, with minor alterations, on American fighters, such as the Seversky P-35, the Republic P-43 Lancer, and the Republic P-47 Thunderbolt. See Gordon Burkowski and Gerry Beauchamp, "Twin Wings and Not Even a Prayer," *Wings*, Vol. 27, No. 3 (June 1997), p. 8, 13; "Gregor's Geldings FDB-1 & GR-1," *Aerophile*, Vol. 2, No. 1 (June 1979), pp. 30-33; Molson and Taylor, *Canadian Aircraft since 1909*, p.168; Peter Lewis, "Canadian Car & Foundry Gregor FDB-1," *Air Pictorial*, (December 1972), p. 476.

90 Burkowski, *Can-Car – A History...*, p. 41.

91 Burkowski and Beauchamp, "Twin Wings and Not Even a Prayer...," p. 9.

92 Burkowski, *Can-Car – A History...*, p. 41.

93 NAM, File: CCF FDB-1, "CCF Blueprint of Gregor Model 10 Single Seater Figher (FDB-1)," 28 September 1938; LAC, RG-12, Reel: T-7462, File: CF-BMB, "E.J. Soulsby (Assistant Works Manager, Aviation Division, CCF) to Superintendent (Air Regulations, D of T)," 5 November 1938.

94 Burkowski, *Can-Car – A History...*, p. 42; Molson and Taylor, *Canadian Aircraft since 1909*, p. 168.

95 Burkowski, *Can-Car – A History...*, pp. 41-42.

96 "A Canadian Light Fighter: An Unusual Fighter Type Designed by a Canadian Company with Considerable Experience," *Aircraft Engineering*, Vol. 12, No. 133 (March 1940), pp. 69-72; "The Canadian Car and Foundry FDB-1," *The Aeroplane Spotter*, Vol. 7, No. 175 (November 1946), p. 256; "Canadian Car & Foundry's Single Place Fighter," *Aero Digest* (June 1939), pp. 89-90, 133; "Single Seat Fighter Developed by Canadian Car and Foundry," *Canadian Aviation*, Vol. 12, No. 5 (May 1939), p. 33.

97 "A Canadian Light Fighter...," pp. 69-72; "The Canadian Car and Foundry FDB-1...," p. 256; "Canadian Car & Foundry's Single Place Fighter...," 89-90, 133; LAC, RG-12, Reel: T-7462, File: CF-BMB, "Certificate of Airworthiness (D of T)," 29 May 1939; "Single Seat Fighter Developed by Canadian Car and Foundry...," p. 33. See also Glenn D. Angle, ed., *Aerosphere, 1941* (New York: Aircraft Publications, 1941), p. A-177; Molson and Taylor, *Canadian Aircraft since 1909*, pp. 168-169.

98 Burkowski, *Can-Car – A History...*, p. 43; Molson and Taylor, *Canadian Aircraft since 1909*, p. 169.

99 The first accident occurred on 3 March 1939. It was caused by the collapse of the undercarriage while taxing on the icy runway at St. Hubert, damaging the right wing and other parts of the aircraft. The second accident took place during take off on 31 March when the aircraft struck a snow bank and overturned in deep snow with slight damage. LAC, RG-12, Reel: T-7462, File: CF-BMB, "S. Graham (District Inspector, Civil Aviation, D of T) to Superintendent, Air Regulations, Department of Transport)," 4 March 1939; LAC, RG-12, Reel: T-7462, File: CF-BMB, "M. Gregor (CAE, CCF) to Squadron Leader A. Ferrier (CAE, D of T)," 3 April 1939; LAC, RG-12, Reel: T-7462, File: CF-BMB, "Squadron Leader A. Ferrier (CAE, D of T) to M. Gregor (CAE, CCF)," 5 April 1939.

100 NAM, File: CCF FDB-1, "Flight Lieutenant Lawrence E. Wray (RCAF) to AOC, RCAF Station Ottawa," 22 May 1939.

101 *Ibid.*

102 LAC, RG-12, Reel: T-7462, File: CF-BMB, "D.T. Jackson (For District Inspector, Civil Aviation, D of T) to Controller of Civil Aviation (D of T)," 6 May 1939; LAC, RG-12, Reel: T-7462, File: CF-BMB, "Squadron Leader A. Ferrier (CAE, D of T) to District Inspector (Civil Aviation, D of T)," 9 May 1939.

103 NAM, File: CCF FDB-1, "Flight Lieutenant Lawrence E. Wray (RCAF) to Commanding Officer (RCAF Station Ottawa)," 22 May 1939

104 *Ibid.*.

105 The FDB-1 was obsolete as a fighter, but some experts believed that it could be used efficiently in other combat roles. It was reported in the March 1940 issue of *Aircraft Engineering* that "the FDB-1, as originally designed ... is a comparatively low-powered single-seater fighter by modern standards ... Armament, as fitted to the prototype, is not very heavy, but the layout of the machine, together with its low weight, point to the easy fitting of a number of guns more commensurate with the latest ideas. The success of the Italian Fiat CR 32 and Russian [Polikarpov] I-15 biplanes against monoplanes of greatly superior performance in Spain and the fact that some authorities in Germany still favour the biplane for special duties, such as ground attack, where manoeuvrability is of greater account than performance, add interest to the Gregor design, where performance has not been sacrificed for powers of manoeuvre." Another expert noted in the December 1943 issue of *Model Airplane News*: "If it is not too tricky to fly and lives up to its performance the FDB-1 should be a formidable offensive weapon. Although slower than our highly-powered Spitfire and Hurricane ... monoplane fighters ... the biplane is almost always more manoeuvrable than the cleaner and faster monoplane, so that such a machine as this should be very useful for ground attack work and for engaging the slower bombers, reconnaissance and army cooperation machines." See"A Canadian Light Fighter...," p. 69; "The Gregor Fighter: Canada's First Fighter is a 300 mph Biplane," *Model Airplane News* (December 1943), pp. 381-382.

106 Burkowski, *Can-Car – A History...*, p. 43; Molson and Taylor, *Canadian Aircraft since 1909*, p. 169.

107 LAC, RG-12, Reel: T-7462, File: CF-BMB, "O.G.S. Wallace (Aircraft Sales Division, CCF) to Stewart Graham (D of T)," 2 May 1940; LAC, RG-12, Reel: T-7462, File: CF-BMB, "Telegram – Civil Aviation Branch (D of T) to O.G.S. Wallace," 7 May 1940; LAC, RG-12, Reel: T-7462, File: CF-BMB, "Murray Semple (Assistant to Vice-President and General Manager, CCF) to Superintendent Air Regulations (D of T)," 14 May 1940; LAC, RG-12, Reel: T-7462, File: CF-BMB, "G.S. Abbott (Acting Superintendent Air Regulations, D of T) to Murray Semple," 21 May 1940.

108 LAC, RG-12, Reel: T-7462, File: CF-BMB, "Murray Semple (Assistant to Vice-President and General Manager, CCF) to C.T. Travers (D or T)," 28 June 1940.

109 LAC, RG-12, Reel: T-7462, File: CF-BMB, "O.G.S. Wallace (Aircraft Sales Division, CCF) to C.T. Travers (D of T), 8 October 1940.

110 Throughout the war, Gregor remained an ardent supporter of the biplane fighter, claiming "they'll start this war with monoplanes, but they'll finish it with biplanes." See Burkowski, *Can-Car – A History...*, p. 43; Molson and Taylor, *Canadian Aircraft since 1909*, p. 169.

111 S. Calhoun Smith, "Last of the Biplane Fighters: The FDB-1," *Air Trails Pictorial* (March 1950), pp. 40-43.

112 C.G. Grey and Leonard Bridgman, *Jane's All the World's Aircraft 1939...*, p. 77c.

113 "Canadian Car's Rapid Progress," *Canadian Aviation*, Vol. 11, No. 8 (August 1938), p. 43.

114 "CC & F's New Maple Leaf Trainer," *Commercial Aviation*, Vol. 1, No. 12 (December 1939), p. 32; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 167.

115 LAC, RG-12, Vol. 2636, File: 5010-10-85, "Elsie G. MacGill (CAE, CCF) to A. Ferrier (CAE, D of T)," 13 May 1939; LAC, RG-12, Vol. 2636, File: 5010-10-85, "Application for Certificate of Airworthiness for Export," 13 May 1939.

116 LAC, RG-12, Vol. 2636, File: 5010-10-85, "A. Ferrier to Elsie MacGill," 22 August 1939; LAC, RG-12, Vol. 2636, File: 5010-10-85, "Elsie MacGill to A. Ferrier," 18 October 1939.

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118 LAC, RG-12, Vol. 2636, File: 5010-10-85, "Elsie MacGill to A. Ferrier," 19 August 1939; LAC, RG-12, Vol. 2636, File: 5010-10-85, "Elsie MacGill to A. Ferrier,: 9 September 1939.

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120 LAC, MG-31, K-7, Vol. 12, File: 9, "Elsie Gregory MacGill (Consulting Engineer) to W.J. Wheeler," 27 January 1966; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 167.

121 "C.C. & F's New Maple Leaf Trainer," *Commercial Aviation*, Vol. 1, No. 12 (December 1939), p. 32; LAC, RG-12, Vol. 2636, File: 5010-10-85, "Report on Official Flying Trials Maple Leaf II for

Certificate of Airworthiness by George E. Wallingford and T.M. Shields," 18 December 1939; LAC, RG-12, Vol. 2636, File: 5010-10-85, "Official Flying Trials – Maple Leaf II," 19 December 1939.

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123 LAC, RG-12, Reel: T-7465, File: CF-BPU, "Vice President and General Manager (CCF) to J.A. Wilson (Controller of Civil Aviation, D of T)," 18 April 1940; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 167.

124 LAC, RG-12, Reel: T-7465, File: CF-BPU, "Vice President and General Manager (CCF) to J.A. Wilson (Controller of Civil Aviation, D of T)," 18 April 1940; LAC, MG-31, K-7, Vol. 12, File: 9, "Elsie Gregory MacGill (Consulting Engineer) to W.J. Wheeler," 27 January 1966.

125 "Introducing the Maple Leaf Trainer," *Canadian Aviation*, Vol. 13, No. 8 (August 1940), pp. 20-21.

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128 LAC, RG-12, Reel: T-7465, File: CF-BPU, "Charles F. Dycer (CAE Flight Test & Inspection Section, Civil Aeronautics Authority, Washington) to Controller of Civil Aviation (D of T)," 16 August 1940; LAC, RG-12, Reel: T-7465, File: CF-BPU, "J.A. Wilson (Controller, Civil Aviation, Department of Transport) to C.F. Dycer (Civil Aeronautics Authority, Washington)," 22 August 1940.

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143 CHGP, "Lieutenant-Colonel Harold E. Hartney to General H.H. Arnold (Chief, USAAF) 3 July 1943. (www.aircrash.org/burnelli/pdf/hartney.pdf

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145 NAM, File: CCF CBY-3, "G.S. Levy (NRC) to J.H. Parkin (NRC)," 24 July 1945.

146 A.H. Sandwell, *Planes Over Canada* (Toronto: Thomas Nelson and Sons, 1938), p. 46; Ray Conrath, "The Cancargo CBY-3 Loadmaster: From Railways Boxcars to a Flying Boxcar," *CAHS Journal*, Vol. 42, No. 1 (Spring 2004), pp. 8-9. See also "The Burnelli Bomber CB-34," *Model Airplane News* (December 1939).

147 LAC, MG-31, K-7, Vol. 14, File: 22, "Michael Rosen (San Francisco, California) to Elsie Gregory MacGill (Consulting Engineer)," 2 August 1976; Conrath, "The Cancargo CBY-3 Loadmaster...," pp. 6-7.

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152 CHGP, "Procedures of a Board of Review (USAAC)," 17 September 1941. (www.aircrash.org/burnelli/pdf/aircorps.pdf); Leonard Bridgman, ed., *Jane's All the World's Aircraft 1941...*, p. 144.

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156 CHGP, "Lieutenant-Colonel Harold E. Hartney to General H.H. Arnold (Chief, USAAF) 3 July 1943. (www.aircrash.org/burnelli/pdf/hartney.pdf).

157 C.P. Stacey, *Arms, Men and Governments: The War Policies of Canada, 1939-1945* (Ottawa: Department of National Defence, 1970), p. 3.

158 LAC, MG-27, III B 20, Vol. 52, File: S-14-1, "A/V/M G.M. Croil (SAO) to MND," 7 October 1938. See also W.A.B. Douglas, *The Creation of a National Air Force: The Official History of the Royal Canadian Air Force, Volume 2* (Toronto: University of Toronto Press, 1986), p. 126.

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161 LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Air Commodore G.M. Croil (SAO) to the MND," 12 July 1938

162 The idea of building fighters locally first surfaced in 1930 when the RCAF expressed interest in the British-designed Blackburn F.2 Lincock II biplane fighter and discussed the possibility of building it in Canada. The project was abandoned when air force officials decided not to adopt the aircraft. Then, in early 1932, Boeing Canada expressed interest in producing the American-designed Boeing

P-12 biplane fighter for China. The project fell through because an international embargo on the exportation of arms to China was in place since the 1900 Boxer Rebellion. That same year, the Curtiss-Reid Aircraft Company of Montreal attempted to enter the combat aircraft business with a fighter of its own design for intended sales to China. The company made detailed drawings of the proposed Canadian-designed fighter, which apparently resembled British-designed Gloster biplane fighters of the era, but the project was abandoned for the same reason as the P-12 project. See A.J. Jackson, *Blackburn Aircraft since 1909* (Annapolis: Naval Institute Press, 1989), pp. 259-269; LAC, RG-25, Vol. 1625, File: 353, "E.F. Elderton (CAE, Boeing Canada) to R. Carter Guest (Inspector Civil Aviation in Vancouver, British Columbia)," 30 March 1932; LAC, RG-25, Vol. 1625, File: 353, "G.J. Desbarats (Deputy Minister of External Affairs) to O.D. Skelton (Undersecretary of State for External Affairs)," 9 April 1932; LAC, RG-25, Vol. 1625, File: 353, "O.D. Skelton (For Secretary of State for External Affairs) to W.D. Herridge (Canadian Minister to the United States)," 18 April 1932; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 513.

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164 *Ibid.*

165 LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "L.R. Lafleche (Deputy MND) to O.D. Skelton (Under Secretary of State for External Affairs)," 7 February 1938; LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Air Commodore G.M. Croil (SAO) to L.R. Lafleche (Deputy MND)," 15 March 1938; LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Managing Director (British Aeroplane Engines Limited) to Lieutenant-Colonel L.R. Lafleche (Deputy MND)," 24 June 1938.

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169 LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Herbert M. Marler to O.D. Skelton (Secretary of State for External Affairs)," 15 February 1938.

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171 LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Air Commodore G.M. Croil (SAO) to L.R. Lafleche (Deputy MND)," 6 May 1938; LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "L.R. Lafleche (Deputy MND) to O.D. Skelton (Under Secretary of State for External Affairs)," 19 May 1938.

172 LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "L.R. Lafleche (Deputy MND) to O.D. Skelton (Under Secretary of State for External Affairs)," 7 June 1938.

173 LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "Sumner Welles (United States Under-Secretary of State) to MND," 29 June 1938.

174 LAC, RG-24, Vol. 5395, File: HQS 60-3-11, "L.R. LaFleche (Deputy MND) to O.D. Skelton (Under-Secretary of State for External Affairs)," 15 July 1938.

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[225] At the same time, the RCAF expressed interest in a detailed design proposal for a torpedo bomber seaplane submitted to the Inventions Board by another Canadian serviceman. The aircraft fuselage was of unconventional design; it was propelled by a pusher-type propeller in the rear and was fitted with helicopter-style rotating vanes in each wing for quick take off and landing. The aircraft would have a crew of three consisting of a pilot/navigator, an observer/wireless operator and a machine gunner. It was to be armed with a rotating mid-upper machine gun turret and four canons in each wing. An unusual feature of the aircraft was its ability to carry a torpedo inside each float. Canadian military authorities found this design unsatisfactory, but liked the idea of torpedo tubes in the floats. So they asked the serviceman to prepare a design proposal for a new, more conventional, torpedo bomber seaplane incorporating this new feature. The resulting twin-engine aircraft had a twin-boom configuration and was fitted with a machine gun turret in the nose and another in the rear. The Director of Scientific Research at the MAP examined in detail this design proposal, but concluded that "the only new feature is the method of carrying the torpedoes in the floats" and that "it is not at the moment considered that this feature has sufficient advantage over alternative methods of stowage to justify any further action on it." The project was abandoned shortly after. See LAC, RG-24, Vol. 10,265, File: 59/Clowes H.P.W./1, "Sergeant H.P.W. Clowes (No. 1 Canadian Machine Gun Reinforcement Unit) to Inventions Board," 16 August 1942; LAC, RG-24, Vol. 10,265, File: 59/Clowes H.P.W./1, "Proposal for a Torpedo Bomber by H.P.W. Clowes," 16 August 1942; LAC, RG-24, Vol. 10,265, File: 59/Clowes H.P.W./1, "Major-General P.J. Montague (For Senior Officer, Canadian Military Headquarters) to Sergeant H.P.W. Clowes," 8 September 1942; LAC, RG-24, Vol. 10,265, File: 59/Clowes H.P.W./1, "Proposal for a Twin-Engine Torpedo Bomber by H.P.W. Clowes," 26 November 1942; LAC, RG-24, Vol. 10,265, File: 59/Clowes H.P.W./1, "Lieutenant-Colonel F.F. Fulton (For Senior Officer, Canadian Military Headquarters) to MAP," 4 December 1942; LAC, RG-24, Vol. 10,265, File: 59/Clowes H.P.W./1, "Lieutenant-Colonel F.F. Fulton to Sergeant H.P.W. Clowes," 26 January 1943.

[226] LAC, RG-24, Vol. 5396, File: HQS 60-3-14, "A/V/M H. Edwards (AOC RCAF Overseas) to DND (Air))," 9 April 1942; LAC, RG-24, Vol. 5396, File: HQS 60-3-14, "Air Commodore A. Ferrier (For CAS) to B.S. Shenstone (British Air Commission)," 25 April 1942; LAC, RG-24, Vol. 4993, File: HQ 938AF-1-5, "Memorandum by Wing Commander T.R. Loudon (O.C. Test & Development Establishment, RCAF Station Rockcliffe)," 6 March 1943; LAC, RG-24, Vol. 5396, File: HQS 60-3-14, "Flight Lieutenant D.H. Cunningham (For AOC RCAF Overseas) to DND (Air)," 19 December 1942. See also Molson and Taylor, *Canadian Aircraft since 1909...*, p. 380.

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CHAPTER THREE

PLAYING WITH WOODEN PLANES

> Plywood, weight for weight, is stronger than steel and much less flexible, a fact which makes it ideal for the building of aeroplane bodies and wings. It is highly resistant to fatigue and shock. It is proof against bacteria, rotting and corrosion. Used as an aeroplane skin, it provides a strong smooth surface, which does not dent and can be moulded and fixed to a simple framework with water and heat resistant glues [such as those produced from synthetic resins] in place of rivets. It is more highly resistant to temperature changes than the metals used in aircraft construction, and, when made with certain glues, it is fireproof. Finally, the strength of plywood and its rigidity under pressure is such that weight for weight, it provides a greater lifting surface than metal, and therefore, the means of constructing a machine capable of carrying a greater load or of greater speed ... The fact is that it is possible, with the use of modern types of plywood and laminated woods, to produce a modern high speed aircraft in every respect equal to or better than metal aircraft.[1]
>
> — Leonard W. Brockington, PMO

Soon after the outbreak of war, there developed a critical shortage of aluminum alloy extrusions required for metal aircraft construction and this problem was expected to persist for some time. The German invasion of Scandinavia and Western Europe between April and June 1940 led to increased demand for combat aircraft and forced Canadian authorities to consider using alternate raw materials to fabricate airframes, such as wood. Wood had been used in early aircraft design, but abandoned in favour of light metal

alloys following the First World War, when it was felt that aluminum airframes were stronger and could withstand greater heat and air pressure. In the late 1930s, however, technical advances were made in the fields of plastics and colloidal chemistry; as a result, wood gained popularity as a structural material. For example, the development of moulded plywood and synthetic resins enabled the construction of highly resistant wooden aircraft that could be equal or, in some cases, superior in quality to metal ones. This field was of particular interest to Canadian scientists and military officials.[2] This chapter will analyze wartime efforts to design and develop wooden military aircraft in Canada.

The Wooden Military Aircraft Program

In May 1940, John Parkin, Director of the NRC's Aeronautical Laboratories, submitted a secret report that examined the feasibility of designing and constructing wooden aircraft in Canada. Following an in-depth analysis of the characteristics and capabilities of a number of existing modern wooden aircraft designs,[3] Parkin concluded that high performance military aircraft made entirely of wood and plywood could meet operating requirements and be as strong, powerful, secure and fireproof as metal aircraft. The former could also be produced faster, cheaper and in greater number. He was confident that Canada could design and develop in wood any type of aircraft required by the RCAF, including trainers, fighter interceptors and light bombers; the only metallic components would be the engine, armaments, instruments, and actuating parts. Parkin emphasized that wood suitable for aircraft construction (spruce, birch and cottonwood) was available in Canada in almost unlimited quantities. According to the Dominion

Forest Service, British Columbia alone had over six billion feet of accessible Sitka spruce scattered along its coast, enough to supply the aircraft industry for years and years.[4] The Canadian woodworking industry also possessed a large skilled labour force of approximately 60,000 that was not directly engaged in war work at the time. Parkin believed that at least 12,000 of them could be immediately drafted for the production of aircraft. Moreover, since wooden aircraft were simpler to design and manufacture than metal ones, a higher proportion of unskilled labour could take part in their fabrication. Parkin estimated that a force of 48,000 unskilled woodworkers could produce about 6,000 airframes per year, almost five times the output of the Canadian metal aircraft industry.[5]

Wooden aircraft also required fewer machinery and shop facilities to produce, meaning greater savings in production time and costs. Parkin explained that "the factories turning out metal aircraft can achieve an approach to large-scale production only by enormous expenditure for equipment, and extensive sub-contracting. Most of the equipment consists of costly dies and jigs which are used for a single aircraft type and which must be scrapped when the type is altered or superseded." Wooden aircraft, on the other hand, "require only the simplest tools for fabrication and assembly. These tools, as well as the men who know how to use them, are available in Canada in large quantities. Intricate jigs and dies are unnecessary with wood." In his opinion, a prototype could be completed in six to nine months, as compared to a metal aircraft that typically required at least one year.[6]

In the end, Parkin recommended that the design and manufacture in Canada of wooden military aircraft be initiated at once under the supervision of a special committee

consisting of experienced aeronautical designers, engineers and technical personnel from the RCAF, the NRC Aeronautical Laboratories, the Forest Product Laboratories of the Department of Mines and Resources, the Aeronautical Engineering Section of the Department of Transport, and the Canadian aircraft industry.[7] The NRC's Inventions Board carefully investigated Parkin's proposal and expressed enthusiasm. On 7 June 1940, C.J. Mackenzie, president of the NRC, sent a copy of Parkin's report to C.G. Power, Minister of National Defence for Air, to find out whether the RCAF was interested in such aircraft.[8] Power was favorable to the idea, but pointed out that an "aircraft so designed would have to meet some particular requirements arising from the present war situation" and that, for such a reason, they would have to seek the views of the British Air Ministry.[9] A formal request was sent through the British Supply Board in Ottawa on 11 June 1940 to determine RAF interest in wooden aircraft and to obtain specifications on types that could be built in Canada.[10] At the same time, a Subcommittee on Wooden Aircraft was formed at the forty-sixth meeting of the NRC's Associate Committee on Aeronautical Research (ACAR) held on 24 June 1940. It consisted of members of the Forest Product Research Laboratories of the Department of Mines and Resources, the RCAF, and the Chemistry and Mechanical Engineering Divisions of the NRC. The subcommittee's aim was to foster research to develop better methods of wooden aircraft construction and materials.[11]

The private sector was also interested in the fabrication of wooden military aircraft. One company in particular was determined to produce this type of aircraft in Canada: Vancouver Sales & Appraisals Limited (VSA). Unaware of the discussions taking place in government circles, company officials contacted the DMS on 20 June

1940 and submitted a proposal to build wooden training aircraft for the RCAF.[12] DND (Air) was immediately notified, but its initial response was not positive. "This Department is bombarded with offers of a similar nature," replied the Chief of the Air Staff, "and when studied it usually transpires that the project is in the early experimental stage and that no aeroplane has been built to meet a specific purpose ... We are not willing to take a chance by relying for our immediate requirements upon an experimental form of construction."[13] The RCAF Technical Detachment in Vancouver nonetheless examined the issue.[14] Its technical officers met with VSA officials on 24 June and learned that the company had been working for several years with Aircraft Research Corporation of Bendix, New Jersey, which was renowned for having invented the famous Vidal process, a manufacturing method for the construction of moulded plywood aircraft reinforced with synthetic resins.[15] VSA officials stated they were ready to manufacture trainers, dive-bombers, and even torpedo boats in moulded plywood, and boasted that their plant could produce more than 300 aircraft per month for the RCAF.[16] The President of VSA even claimed that his company could build a small two-seat trainer with only nine workers in approximately five hours.[17]

On 9 and 10 July 1940, delegates from VSA and Aircraft Research Corporation traveled to Ottawa to meet with technical experts of the Canadian government, namely representatives from the RCAF, DMS and NRC. The experts seemed impressed by the Vidal method. The RCAF Director of Aeronautical Engineering (DAE) stated: "It is my opinion that this process is of considerable interest to this department and that the steps should be taken to make full use of its advantages in the construction of aircraft in Canada." As a result, J.H. Parkin of the NRC arranged to have members of the recently

created Sub-Committee on Wooden Aircraft visit the Aircraft Research Corporation plant in the United States to examine how the Vidal process worked.[18]

Parkin and several other NRC and RCAF technical officers visited the factory the next week and they were shown a variety of aviation products constructed from the Vidal process, including a 90 per cent completed wooden dive-bomber being built for the USAAC. The Canadian delegation was most impressed with the rapidity and cost of producing plywood wings and fuselages and recommended that steps be immediately taken to have experimental aircraft developed in Canada for the RCAF using the Vidal method of construction.[19] C.J. Mackenzie explained the advantages of the process to General Andrew McNaughton, commander of the 1st Canadian Division and former NRC president: "Forms are made for half a fuselage, veneer in strips is placed against the forms in three layers and forced together by means of a bag which presses against the inside surface. The veneer strips are coated on both sides with a plastic and the whole assembly is run into a tank and subjected to a pressure of forty to fifty pounds [per square inch] of steam. In fifty minutes the assembly comes out and it is a marvelous-looking job. The equipment required in the shops is ridiculously small."[20] After examining several other moulded plywood aircraft manufacturing techniques, the Subcommittee on Wooden Aircraft asked the DMS on 22 July to negotiate a license agreement with Aircraft Research Corporation for the Vidal process. Interestingly, Canadian authorities refused to negotiate with officials from VSA on the ground that they "had no valid claim in the matter" and that "their mediation was neither desirable nor necessary."[21]

The adoption of the Vidal process generated much enthusiasm in Ottawa for the manufacture of wooden aircraft. Not only did the project promise to resolve problems

evident in the metal aircraft industry, but also offered Canada an opportunity to begin developing its own types of military aircraft and to lessen its dependence on Great Britain and the still-neutral United States for designs. The NRC and the Prime Minister's Office (PMO) were particularly interested in the production of indigenous wooden aircraft. The beginning of the Battle of Britain, combined with increased fears of a possible German invasion of the British Isles, meant that Canada might soon find itself fighting alone against the combined military might of Nazi Germany and Fascist Italy. If such a scenario unfolded, the Canadian aircraft industry would no longer be able to rely on British aeronautical expertise and aircraft design staffs. Moreover, Canada's only other viable source of supply was in the United States, where neutrality policies had to constantly be circumvented in order to obtain licenses or information on the latest American aircraft design. The seemingly responsible thing to do was to increase Canada's design capability and move away from license production: the wooden aircraft program offered such an opportunity. Leonard W. Brockington, former Chairman of the Canadian Broadcasting Corporation (CBC) who now worked for Prime Minister Mackenzie King, explained this to DND (Air):

> It must be remembered that our country is entirely dependent upon Great Britain and the United States for designs, engines and many essential instruments ... Many men trained in aeroplane design are now engaged in superintending production according to designs brought in from Great Britain and the United States, and they are not, for that reason, engaged in doing what they are equipped to do; to produce new types of planes. The aeronautical experts of the NRC are engaged in testing work and in providing government officials with opinion on various matters connected with aviation, but are not organizing or contributing to the development of an indigenous aircraft industry ... What is immediately required is a recognition in governmental circles of the need for an independently constituted aircraft industry together with some concrete assistance in the shape of an appropriation to commence work upon design immediately ... Thus far, we have based our policy with respect to the production of war

> equipment upon the optimistic delusion that we can depend upon Great Britain and the United States. The point has been reached where we can rely upon neither. Aerial bombardment may render Britain an uncertain source of supply ... The United States may limit or cut off our supplies from the necessities of its own policy, or because of the political animosities of certain interests. Canada has now got to stand on her own feet, and utilize the resources she has for her own defence.[22]

Brockington proposed the creation of an Aircraft Design Institute, which would be administered by the DND (Air) or the DMS until attached to a Department of Research. Its purpose would be to design, build, and test wooden aircraft prototypes, and then to provide Canadian aircraft manufacturers with plans and blueprints for their mass production. This organization would be divided into five sections — Design, Aerodynamic Research, Structural Research, Prototype Construction, and Production and Organization Research — that would be staffed with designers and draughtsmen from the Canadian aircraft industry as well as technical experts from the NRC and the Forest Product Research Laboratories of the Department of Mines and Resources.[23]

The DND (Air) rejected the idea. J.S. Duncan, the Deputy Minister, explained that "the policy should be to build in Canada a type that has already been designed and found successful in Great Britain or the United States." It was obviously simpler, cheaper, and much faster to redesign or modify an existing aircraft in wood than to design a completely new one. According to Duncan, the Canadian market was simply not big enough to support a large aircraft industry capable of designing its own commercial or military aircraft. He thought it was easier and cheaper to produce a well-proven American or British design that responded directly to British Air Ministry specifications and British Commonwealth standardization policies, than to rely on an un-proven Canadian design that would likely not be profitable on foreign markets.[24] Besides, the British Ministry of

Aircraft Production (MAP) considered it "unwise to encourage Canadian designers to embark on a scheme of this sort" on the basis that "the problem of using all-wood construction for the design of high-performance aircraft is so difficult that no designer has yet succeeded in solving it" and that "it is very doubtful whether the Canadian project, even if successful, would be completed in time to be of value during the present war."[25] Duncan added that the creation of indigenous combat aircraft was a risky business, as four out of every five designs were usually rejected. This was why it had been decided several years ago that "the Canadian public could not be asked to support such an expensive and relatively unproductive undertaking as the design of military types."[26] While some RCAF officers disagreed and continued to favor the development of an indigenous design, the DND (Air) made it quite clear that any aircraft manufactured in Canada using the Vidal process would be of American or British origin.

It should be pointed out that there was some opposition in the RCAF to building moulded plywood aircraft in Canada. C.G. Power, the Minister of National Defence for Air, explained "the development of wooden construction for the airframe is by no means the most important nor the most difficult. On the contrary it is the easiest. There can be no real aircraft defence industry until facilities exist within the Dominion for the manufacture of aero engines, propellers, instruments, machine guns and the numerous items without which a military aeroplane cannot fulfill its function."[27] Air Vice-Marshal Stedman, the AMAE, was also critical of wooden aircraft construction, commenting:

> Moulded wood veneer construction applies only to the carcass of an aeroplane, and apart from the conservation of aluminum alloy sheet and the elimination of the expensive process of riveting, the adoption of this process would have very little effect upon the major bottlenecks of aircraft production which are all associated with the output of machined metal parts such as engines, airscrews, instruments, undercarriages,

> pumps, electric motors, not to mention the military equipment such as guns, turrets, bomb racks, bomb sights, all of which are necessary, whatever the basic form of construction of the vehicle body ... We have yet to ascertain how the moulded wood veneer construction will stand up to weathering, and the different kinds of abuse to which it might be subjected in an intensive training programme.[28]

However, such arguments did not deter the Canadian government from undertaking the construction of moulded plywood aircraft.

Canadian military authorities still had to decide what type of aircraft was most needed for the wooden aircraft program. Opinions were split between trainers, transports, fighters or bombers.[29] The aircraft design selected had to be suitable for conversion into wood, required in large enough quantities by Great Britain, and had to meet Canadian home defence or air training requirements. Conversations with the British Air Ministry recommended that Canada undertake the production of wooden elementary and advanced trainers before the construction of combat aircraft. RCAF officials were particularly keen on converting into wood either the A.V. Roe Anson or the Fleet 60 Fort trainers, both in production in Canada.[30] At this point, British authorities pointed out that F.G. Miles, the managing director of the Phillips and Powis Aircraft Company in Great Britain, which had a good reputation in wooden aircraft construction, considered opening a factory in Eastern Canada. Although Canadian firms like OCA tried on several occasions to obtain production rights to the British-designed Miles Magister elementary trainer and Miles Master advanced trainer, F.G. Miles was more interested in establishing his own branch plant in Canada, as he claimed that he could have Canadian-built aircraft flying in less than six months, provided that engines and certain parts were secured from American sources.[31] RCAF officers visited the Phillips & Powis factory in Great Britain in late July 1940 and concluded that the mass production of the Magister or Master in Canada could

be done with "no serious difficulty." The delegation reported that the British company was conducting work on an experimental all-wooden fighter and an improved Master II advanced trainer, both of which could be manufactured in Canada.[32]

The DND (Air) encouraged the establishment of a Phillips and Powis branch plant in Canada, but disagreed with the British Air Ministry's proposed type of aircraft to be built. Canadian military authorities were more interested in producing combat aircraft than trainers. J.S. Duncan explained in late August 1940 that because the Canadian aircraft industry was already committed to the production of training aircraft, "there would be little object in building the Miles Master or Miles Magister in Canada unless these types are required for the United Kingdom." Preference was for the experimental fighter developed by Miles as well as another British type, the Armstrong Whitworth A.W. 41 Albemarle twin-engine medium bomber, which had been recommended by the British Air Ministry as a suitable wooden combat aircraft for later Canadian production.[33]

The British were not happy with the Canadian preference and repeatedly asked Ottawa to reconsider, emphasizing the importance of the Master as an advanced trainer.[34] After further consideration, Canadian military authorities changed their minds, indicating Canada's willingness to construct the Miles Master "provided that the United Kingdom can guarantee to take the whole output as Canada is fully committed for single engine advance trainers by the Harvard program ... and can assure a supply of suitable engines." Canadian military officials also rejected the idea of building the Albemarle on the basis that a considerable quantity of steel was required in its fabrication, thus making it an unsuitable aircraft for production in wood. They did, however, remain committed to the wooden experimental fighter known as the Miles M.20, and requested British authorities

to supply plans and specifications for this aircraft that could be built in Canada "as a continuation project alongside the Canadian Master production."[35] Phillips and Powis had initiated this project in the early summer of 1940. The original purpose was to design a fighter that could be produced in record time; in fact, the aircraft was designed and built in only nine weeks, or one third the time it took to construct the Hawker Hurricane or Supermarine Spitfire fighters. Elements in the design were subordinate to speed of production, such as the elimination of hydraulics and reliance on a fixed undercarriage. More importantly, because the aircraft was of all-wood construction, it could be put into immediate and rapid production in both Canada and Great Britain.[36]

The M.20 prototype made its maiden flight in Great Britain on 14 September 1940 and proved to be as efficient as existing British metal fighters. In the end, the Battle of Britain was won before available stocks of Hurricane and Spitfire fighters were depleted, eliminating the need for the M.20. As a result, Canada did not begin mass production of this combat aircraft.[37] In the next year, the British company worked on more advanced wooden combat aircraft designs, such as the Miles M.22 twin-engine fighter and the Miles M.23 fighter, but neither left the drawing boards.[38]

In the meantime, the Subcommittee on Wooden Aircraft continued to gather information on the Vidal process and other methods of moulded plywood fabrication. It visited Aircraft Research Corporation and other wooden aircraft manufacturers in the United States to gather as much information as possible to prepare the design and building of wooden aircraft in Canada. It also wanted to finalize the license agreement for the Vidal process with Aircraft Research Corporation. Moreover, Canadian authorities had selected an existing aircraft design for re-engineering in moulded plywood in

Canada: the British-designed A.V. Roe Anson twin-engine trainer. In September 1940, the subcommittee initiated a comprehensive testing program and arranged for the construction of two experimental moulded plywood Anson fuselages from Aircraft Research Corporation. The American company agreed to let Canadian technical officers observe the fabrication of the two airframes to learn as much as possible about the Vidal process.[39] The agreement also called for Aircraft Research Corporation to redesign the complete fuselage and to construct the necessary moulds and two airframes in moulded plywood. Moreover, 100 days after satisfactory tests, the company was to supply 100 additional fuselages and grant a Canadian company the right to produce them under-license in Canada.[40]

In early October 1940, J.S. Duncan met with top RCAF, NRC, and DMS representatives to discuss Canada's position regarding wooden aircraft. It was then decided to "proceed further with the project of building complete Anson aeroplanes using the Vidal methods of moulded wood construction" and agreed "not to pursue any further for the time being the construction of the Miles Master or any other type." The only exception was the Miles M.20 experimental fighter, which was still of interest to Canadian military officials. This decision was contingent upon the promise that Great Britain absorb a large number of Anson for the BCATP. The NRC Aeronautical Laboratories were asked to set up a design and engineering staff in collaboration with the DND (Air) to gather as much information as possible about the Vidal process from Aircraft Research Corporation, and to proceed with the redesign and engineering in moulded plywood of Anson wings, nacelles, and control surfaces. All of these components were to be built by the NRC woodworking shops.[41] As it became clear that

Canada would soon begin producing wooden Anson airframes it was agreed that the Canadian aircraft industry possessed the necessary equipment and facilities to undertake such an endeavour. Besides, Canadian manufacturers such as DHC, Fleet, Massey-Harris and OCA had already expressed growing interest in becoming involved in the construction of moulded plywood aircraft. Consequently, in late January 1941, the Subcommittee on Wooden Aircraft expanded its membership to include representatives of the Canadian aircraft industry.[42]

The Canadian government's decision to concentrate on the A.V. Roe Anson did not deter VSA from trying to conclude negotiations with the RCAF. In October 1940, VSA representative Alex Johnson told air force officials that Harry N. Atwood, an American aeronautical engineer who had apparently worked for Aircraft Research Corporation and held some of the Vidal process patents, was coming to Vancouver to develop and build a prototype wooden aircraft. Johnson explained that Atwood had told him that he could design and construct a wooden fighter in approximately ninety days and that production could be undertaken at a rate of one aircraft per day. Johnson asked the RCAF to provide specifications on the types of combat aircraft it required that could be built by VSA.[43] In a letter to the RCAF Technical Detachment in Vancouver, DND (Air) explained it was not interested because it was "at present working on the plastic process of aircraft construction with the Aircraft Research Corporation, and does not desire to encourage Mr. Johnson's principle." A reply was later sent to Johnson explaining that the RCAF "is unable to recommend any particular make of aircraft for your experiment or to provide drawings or specifications," but they suggested that VSA work on an elementary trainer instead.[44] In mid-October, Johnson told the RCAF that the

Brisbane Aviation Company had agreed to have Atwood design and construct an experimental trainer.[45] The RCAF inspected the project in December 1940 but reported that "very little progress had been made beyond outline drawings of the trainer aircraft and a few wooden forms in connection with the wings."[46] VSA abandoned its trainer project owing to problems with fabrication methods. In late January 1941, Johnson expressed to the RCAF his regret "at having been dazzled by Mr. Atwood's extravagant claims" and explained that VSA had acted in good faith but should have exercised more caution. VSA was not heard of again.[47]

For its part, the NRC continued to favor the design and development of a truly Canadian wooden aircraft. In mid-November 1940, the RCAF had issued a specification for a single-engine, two-seat, low or mid wing monoplane elementary trainer with dual control and removable transparent cockpit cover to replace its obsolete Tiger Moth and Finch biplanes. The new aircraft was to be powered by either the 135 hp de Havilland Gipsy Major or the 132 hp Menasco engine and was to be capable of a maximum speed of at least 130 mph. It was to be equipped with a fixed landing gear capable of accommodating both wheels and skis. More importantly, the new aircraft was to be manufactured in Canada and was to incorporate as many wooden components as possible to safeguard vital Canadian supplies of aluminum for more essential war purposes. Under consideration were three methods of wood construction. The preferred choice was an aircraft made entirely of moulded plywood bonded with synthetic resin. The other choices were a composite aircraft consisting of a steel tube fuselage covered in wood and fitted with wooden wings, or a composite aircraft consisting of a steel tube with fabric

cover and wooden wings.[48] At the time, there was a requirement for more than 1,400 elementary trainers in Canada alone.[49]

J.H. Parkin immediately proposed having the NRC Division of Mechanical Engineering design and construct the moulded plywood elementary trainer rather than to work on the wooden Anson wing and component project. He firmly believed the latter "was not a satisfactory example on which to develop a practical and theoretical technique for moulded wood construction" because it did not provide a great amount of technical experience. "The merits of moulded wood construction for aircraft can be more readily and definitely determined by the construction of a relatively simple aircraft which can be engineered from the start to take advantage of the constructional methods available through the moulded wood process."[50] RCAF officials did not agree with Parkin's proposal, pointing out that their requirements alone were not sufficient to justify such an enterprise and that "in view of the urgency with which this department requires to secure a replacement type of trainer, it is intended to select an existing type which most closely conforms to our requirements, and arrange for its production in Canada with such modifications as are necessary to make it suitable for purely Canadian operation." Furthermore, Allied air forces would more likely adopt an approved trainer design than an unproven Canadian one. Important to understand was that Parkin's project was very risky for the RCAF for it rested on the design of a completely new aircraft that also used a process and materials that had never been tested in Canada.[51] In December 1940, the RCAF decided instead to send the elementary trainer specification to several American and Canadian aeronautical firms and invited each to submit proposals before 15 January 1941.[52] In the end, only three of the Canadian companies, all of them from Ontario,

showed interest in the project — Fleet Aircraft Limited of Fort Erie, Maple Leaf Aircraft Company of Lucknow, and White Canadian Aircraft Limited of Hamilton.[53]

Problems quickly followed. Fleet had no new elementary trainer design available, so it proposed to develop one to meet the specification. RCAF officials refused the offer on the grounds that "it is not thought that initiation of a new design and construction of a prototype will achieve our object soon enough." The Fleet proposal was thus rejected.[54]

Like Fleet, White had no suitable aircraft design available to meet the specification and knew that it could not develop a new trainer in such a short time. The company, however, was a branch plant of the White Aircraft Corporation in the United States. It suggested, as a compromise, to manufacture under-license the American-designed White PT-7 two-seat biplane trainer for the RCAF. The aircraft had a welded fuselage and wooden wings, both of which were covered with fabric. White tooled up for the production of the PT-7 in Canada, but the RCAF balked on acceptance because the aircraft did not met its requirements. The project was ultimately abandoned.[55]

White made a second proposal shortly after when company officials reported that they possessed a suitable low-wing trainer design and a fully equipped plant to build it. White had recently purchased Union Aircraft and Marine Limited, a wooden boat building firm located at Gravenhurst, Ontario, which underwent conversion during the war to do subcontracting work for the Canadian aircraft industry. Prior to the war, the company had begun the construction of an amphibian low-wing plywood aircraft, but had suspended all work at the outbreak of hostilities. A single prototype aircraft had been built and had reportedly already flown 250 hours. It had a welded steel tube fuselage covered in wood as well as wooden wings. The aircraft had not yet received a Canadian

government certificate of airworthiness, thus explaining why its existence was unknown to military authorities. While the aircraft had not originally been designed as a trainer, White officials believed that a slightly modified version of the aircraft could suit the RCAF's specifications; the proposed trainer was designated the Neylan 2P-CLM after F.E. Neylan, the project supervisor.[56] White explained that the Union Aircraft and Marine factory had a floor space of more than 40,000 square feet, hired many skilled wood workers, and was fully equipped to build such an aircraft. As it reported: "It would seem that to make use of the complete wood-working machinery that was used to produce the finest quality speed boats would be expedient in Canada's war effort."[57] Although at first glance the Neylan 2P-CLM conformed to RCAF requirements on speed, climb rate, and endurance, air force officials decided that they did not have enough information and that the aircraft was "not worth further consideration."[58]

Maple Leaf, on the other hand, proposed a low-wing 1,096 lbs gross weight trainer of indigenous design known as the Libra. It was entirely made of "hot pressed resin bonded plywood," including the wings and fuselage, which was exactly what the RCAF was looking for.[59] In order to accelerate the construction of the prototype, the Canadian company associated itself with the Zodiac Aircraft Corporation in the United States.[60] Maple Leaf was to undertake the mass production of the Libra at a later date. Noteworthy is that Maple Leaf had not yet produced any aircraft. But soon after, Zodiac delayed construction of the Libra prototype, forcing Maple Leaf to postpone the aircraft trials on several occasions and resulting in the RCAF abandoning interest in the project.[61] In the end, none of the proposals submitted by Canadian aircraft manufacturers proved acceptable to the RCAF.

In late January 1941, the NRC made another attempt to design and develop an elementary trainer in Canada. The project began when the RCAF asked W.T. Reid to visit the Fairchild and Noorduyn factories to determine the possibility of fabricating Bolingbrokes and Harvard wings and components in moulded plywood. Reid concluded that "it would be difficult, and perhaps unwise" to do so because of the considerable progress that had been made in the fabrication of assemblies, components and parts for both aircraft. He added, however, that the "most satisfactory way of determining the possibility and difficulties of the process would be to undertake the complete design of a specified metal airframe, with the possible but not necessarily essential, exception of the wing." The elementary trainer aircraft seemed an obvious choice.[62] Reid had considerable experience as an aeronautical engineer, having designed several aircraft during the interwar period, such as the Varuna, Vanessa, Vista, Vigil and Velos for Canadian Vickers, as well as the successful Curtiss-Reid Rambler.

Again, the RCAF answer was negative. In early February, Air Vice-Marshal E.W. Stedman told Parkin and Reid that the NRC "should act as a pilot plant to investigate useful application of moulded wood veneer construction to aircraft components, and that it should not attempt to design complete aircraft as this was an encroachment upon the industries." Stedman wanted the NRC woodworking shops to proceed with the development of a wooden Anson wing, to investigate the possibility of designing an Oxford wing, and to prepare production of other smaller aircraft components such as Anson and Harvard tail planes.[63] Parkin and Reid were disappointed, as was C.J. Mackenzie who wrote General Andrew McNaughton:

> Our work in aeronautical engineering is not developing as well as we thought. Parkin has an excellent staff of about twenty keen, alert young

> men but no work for them ... We have been interested in developing wooden aircraft and have made up miscellaneous parts and are studying the scientific and technical design aspects in this new medium, but it seems absolutely impossible to get in action. Everyone appears to assume that we should be canvassing this matter seriously but we are blocked when it comes to getting any authority to design and construct an aeroplane in the moulded wooden plastic construction.[64]

The NRC was not happy for it had been hoping to initiate the design and development of a moulded wood aircraft for several months, and was still at a standstill.

Several American aircraft companies also submitted proposals for the RCAF elementary trainer program.[65] All agreed to have their respective products manufactured under-license in Canada. Unfortunately, some of these aircraft were still at the design stage. After thorough investigation by the RCAF, only five companies were invited to provide prototypes for competitive trials in February and March 1941. In the end, the RCAF selected the Fairchild M-62 Freshman,[66] an aircraft that air force officials had an eye on since the fall of 1939.[67] The DMS immediately negotiated an agreement for the licensed production of an improved version of the Fairchild M-62 in Canada, which was later known as the Fairchild PT-26 Cornell.[68] Production was to start as soon as possible, and by fall 1941 at the latest, in order to eliminate any risk of delays in the Canadian aircraft production program.[69] The NRC had lost the elementary trainer battle.

At the meeting of the Sub-Committee on Wooden Aircraft on 30 April 1941, Parkin expressed deep disappointment with the RCAF for not encouraging the NRC to proceed with the design and development of a prototype elementary trainer. He was especially upset with recent suggestions that the NRC should work on the development of a prototype wooden wing for Hurricane fighters. Parkin pointed out that "the only method of anticipating design and construction difficulties was to proceed with the design and

construction of a complete aeroplane." RCAF officials replied that the new elementary trainer needed to be supplied to the air force at the earliest, and that no time should be wasted on designing a new type of aircraft or overcoming delays that were bound to occur with the production of any prototype using new methods of construction like the Vidal process.[70] Then, on 5 May, Air Vice-Marshal Stedman telephoned C.J. Mackenzie to tell him that he objected to Parkin undertaking the design of a new aircraft on the grounds that he opposed design and development by government agencies. Stedman believed that such initiatives should be left to the private sector.[71]

Still committed to building a complete moulded wood aircraft, Parkin sought to compromise by proposing to construct a replica of an approved elementary trainer design. He explained that this process would enable a direct comparison to be made with the metal aircraft and would therefore give the best indication of the relative advantages and disadvantages of wooden construction. Parkin contended that "it appears to be useless to pursue the investigation into the merits of moulded wood unless it can be demonstrated in the near future just what can be done in Canada towards producing an aircraft structurally as good or better than one of conventional materials and it would also appear desirable to do so on a type needed in this country."[72] Stedman discussed the issue with RCAF officials and, after reviewing various types of aircraft likely to be needed in large numbers in Canada in the near future, agreed to have the NRC reproduce the Canadian-designed Fleet 60 Fort trainer in moulded wood.[73] The aircraft was chosen because all parties agreed that the construction of anything larger than a single engine trainer would be beyond the capacity of the NRC.[74] In fact, Fleet had considered the feasibility of constructing the Fort trainer in wood instead of metal several months earlier.[75]

The NRC enthusiastically took on the experimental project and quickly began to investigate the possibility of developing a wooden version of the Fort.[76] The program aimed to compare the wooden and metal Fort, and had two main objectives.[77] The first was "to determine the relative value of the moulded wood type of construction as compared to equivalent all metal designs from the standpoint of cost, production time, skilled labour requirements, weight and performance." The second was "to reproduce in moulded wood an existing all metal Canadian manufactured aircraft, or component thereof, to permit an immediate saving of strategic material should this become necessary."[78] The NRC asked Fleet to furnish all necessary metal parts and equipment to be used in the wooden version of the Fort.[79] Moreover, in June 1941, a Fort was allotted to the RCAF Test and Development Establishment at Rockcliffe, Ontario, to study its possible conversion to wood.[80] The aircraft was dismantled and studied thoroughly by NRC experts.[81] Yet, the Fort project was short-lived. In late October 1941, the RCAF notified the NRC of the Fort's unsuitability as an intermediary trainer and of its intention to abandon it altogether for the BCATP. It was suggested that the Sub-Committee on Wooden Aircraft give the matter some consideration and make recommendations as to "whether the construction of a moulded wooden aircraft of this type should continue, or whether the work should not be devoted to some other type." The RCAF noted, however, that the Anson remained its "main production program problem" and that "anything that could be done to increase the speed of production ... would be of considerable assistance."[82]

The Fort project, which had been underway for six months, was reviewed at the November 1941 meeting of the Subcommittee on Wooden Aircraft Construction. The

subcommittee reported that the construction of the rudder stabilizer and elevator were underway; the fuselage and fin had been designed and construction of the mould had started; and a considerable amount of experimental work had been completed to determine satisfactory methods of fabrication.[83] After thorough investigation, the group decided to abandon the project and to replace it with the development of an experimental moulded wood version of the Harvard trainer.[84] The Harvard had not been chosen in the first place because a similar project was already under way in the United States. Once the Fort program was abandoned, the discourse changed as it was now said that "the Harvard project will achieve the main object, and duplication of the American effort would not be out of place." The subcommittee agreed that "there would be a bad psychological effect" if the NRC was asked to continue work on the Fort knowing it was not wanted by the BCATP.[85]

The NRC immediately proceeded with the redesign and construction of a moulded plywood version of the Harvard trainer's rear fuselage and tail surfaces (vertical and horizontal stabilizers, elevators, and rudders). DHC provided the wooden wings.[86] Most of the NRC components were ready by the summer of 1942 and the first Harvard fitted with a wooden rear fuselage and tail assembly was test-flown later that year.[87] The results were satisfactory and it was reported that work on the wooden Harvard "had now reached the stage where it was necessary to consider the future program." Although C.J. Mackenzie wanted a complete wooden Harvard built by the NRC, the project was never pursued.[88] Instead, work began on a second rear fuselage and tail surface Harvard unit in early 1943. The second aircraft was completed in September, and was successfully test-flown by the RCAF. In November, the NRC even reported that it was building two

additional Harvard units said to be 75 per cent complete.[89] In the end, however, the hybrid Harvard was never adopted as the supply of aluminum alloys increased throughout the war, thus reducing the demand for this moulded plywood aircraft.

In the meantime, Phillips and Powis remained interested in producing wooden aircraft in Canada. In early 1942, the British company developed two large wooden military transport aircraft: the 70,000 lbs gross weight four-engine Miles M. 40, which could carry a payload of 28,000 lbs or 120 troops, and the larger 117,000 lbs gross weight six-engine Miles M.41, capable of transporting a payload of 48,200 lbs or 180 troops. Both projects were designed specifically for construction in both Great Britain and Canada. In the end, however, the British government did not order either of the two aircraft and the project never left the drawing board.[90] Another project initiated by Phillips and Powis in 1942 for possible production in Canada was the 13,000 lbs gross weight Miles M.36 Montrose twin-engine aircrew trainer. In the end, the British government was not interested and the Montrose was never built, putting an end to Phillips and Powis' aspirations of manufacturing their aircraft in Canada.[91]

Another attempt was made by CCF in the summer of 1943 when it proposed to mass produce a moulded plywood version of the American-designed Burnelli UB-14 twin-engine lifting fuselage transport in Canada. The aircraft was to use only surplus engines, accessories and non-critical materials, as not impinge on Canadian war production. The company offered to produce twenty-five wooden UB-14 transports for the Brazilian government, and to manufacture this aircraft in vast quantities for the American and Chinese governments for service in the Far East. Company officials asked the DMS for permission, but it was decided not to proceed with the project as American

aircraft manufacturers could fulfill the transport needs of almost all Allied air forces. CCF was to concentrate instead on the production of combat aircraft, namely Curtiss Helldiver naval dive-bombers for the United States Navy.[92]

The Canadian wooden aircraft program, on the other hand, remained committed to the re-engineering of the British-designed A.V. Roe Anson twin-engine aircrew trainer into moulded plywood. The Canadian government had already made arrangements with Aircraft Research Corporation to design and produce two experimental Anson fuselages in moulded plywood in the fall of 1940. The first airframe was ready by April 1941 and a second airframe was sent to Canada the following month. The experimental aircraft, known as the Vidal Anson, was inspected by the RCAF. Air force officials were highly impressed and prepared a specification for the mass production of a slightly modified version of the aircraft to be known as the Anson V.[93] The first production aircraft, built by Federal, was ready by early December 1942 and was test flown on 4 January 1943. Both CCF and MacDonald undertook production of the Anson V under the supervision of Federal. Although 2,300 Anson V were ordered, 1,048 were delivered before war's end in 1945.[94] While the Anson V was used for training navigators, wireless operators and bombardiers, a new aircraft known as the Anson VI was designed specially for bombing and gunnery training. The main difference between the two types was the addition of a hydraulically operated gun turret in the latter. The Anson VI prototype, built by Federal, made its maiden flight on 21 September 1943. A total of 500 Anson VI were ordered during the war, but only one prototype was produced.[95]

Canada also committed itself to the mass production of the British-designed De Havilland DH 98 Mosquito twin-engine multi-role combat aircraft. This aircraft was

probably the most versatile of the war, being used in a fighter, fighter-bomber, bomber, reconnaissance, trainer, and even high-speed transport role. Appropriately nicknamed the "Wooden Wonder," the Mosquito had its wings, tail surface, fuselage, and other components made entirely out of moulded wood.[96] In July 1941, De Havilland representatives traveled to Canada to visit the DHC facilities. Negotiations ensued and it was decided to have the Canadian company produce the Mosquito under-license in Canada. In September, the British government placed an initial order for several hundred Mosquitoes. The Canadian Mosquito prototype made its maiden flight on 23 September 1942.[97] Other contracts followed, raising the total ordered to 1,500. [98] With the help of many Canadian subcontractors, DHC manufactured 1,131 Mosquitoes before production ceased in August 1945. Nine different versions of the aircraft were made in Canada: three bombers, two fighter-bombers, three trainers and one photographic reconnaissance aircraft.[99] Canadian-made Mosquitoes equipped the RAF, the RCAF, and the USAAF during the war, and several were taken over by the Chinese government after the war.[100]

The NRC produced a few experimental nose sections for British-designed Bristol Bolingbroke and Blenheim twin-engine bombers. It also helped develop jettisonable fuel tanks for Hawker Hurricane fighters, leading edges for British-built Airspeed Oxford twin-engine trainers, as well as tail planes, wing root fillets, nose fairings and pilot seats for British-built Miles Master trainers. It also helped develop other moulded plywood parts (such as fuel tanks, airscrews, fins, rudders, hatch handles, tables, containers and seats) for several Canadian-made aircraft types.[101] The NRC even briefly contemplated the development of plywood seaplane floats in Canada.[102]

While Canada did not develop any indigenous wooden aircraft during the war, it made a final attempt in the spring of 1944 when the Subcommittee on Wooden Aircraft recommended that postwar plans for the Canadian aircraft industry include "the design and production of some types of aircraft in wood."[103] At about the same time, a request came from the British Wooden Aircraft Technical Mission in Canada that proposed to have the NRC laboratories design and build "a small high speed aircraft out of wood to test the latest wood technique." The project was to be undertaken in cooperation with the RCAF and the DMS. After much debate, the Canadian government refused the offer on the grounds that this was not a sound laboratory project.[104] This decision effectively quashed Parkin's dream of designing and developing training or combat aircraft in Canada out of moulded plywood.

The Transport Glider Scheme

The importance of gliders to military operations was revealed during the early stages of the Second World War. The successful use of gliders by the Germans for transportation of troops and military supplies behind enemy lines during their invasion of Norway, the Netherlands, and Belgium in 1940 introduced a new kind of airborne warfare. As a result, Great Britain and the United States expressed much interest in military gliders. Gliders were useful weapons in combat and desirable air transport vehicles for several reasons: they gave mobility to ground troops, enabling them to leap over difficult terrain or enemy defences; they could carry fully-equipped companies of soldiers and land them in a specific area ready to fight (unlike paratroopers who had to regroup after having been scattered on the ground); and they could carry a wide variety of

loads, such as fuel, water, ammunition, tanks, armoured vehicles, and artillery that could not be carried by most transport aircraft. An aircraft towing a number of gliders could double or triple the amount of cargo it could normally carry and at a fraction of the cost. Moreover, gliders were much cheaper, faster and easier to manufacture than powered aircraft. Most important, gliders were silent, which afforded them a valuable element of surprise during airborne operations behind enemy lines.[105]

Recognizing gliders' crucial role in military operations, the American and British governments began working on homegrown military glider projects. In the summer of 1940, Great Britain issued a requirement for troop and tank-carrying gliders. Four main types of gliders were designed and developed: the General Aircraft Company's Hotspur, an 8-seat troop carrier (more than 1,000 produced during the war); the Airspeed Aviation Company's Horsa, a 25-seat troop carrier (close to 4,000 were made during the war); the Slignsby Sailplanes' Hengist, a 15-seat troop carrier (only eighteen were built); and the . General Aircraft Company's Hamilcar, the largest glider built by the Allies that could carry a light tank, small armoured vehicles, artillery guns, or 40 fully-equipped troops (412 were made during the war). In all, Great Britain, manufactured over 5,000 military gliders.[106] In the United States, the design and development of military gliders began in early 1941. The most important was the CG-4, a transport glider capable of transporting 13 fully-equipped troops. An astonishing 13,909 were produced by war's end, and the British used more than 700 of these gliders under the designation of Hadrian. The Americans also worked on more than thirty other wartime military glider designs, the most important being the CG-3, the CG-13 and the CG-15. In all, 15,697 military gliders were produced in the United States during the war.[107] Other Allied countries — Australia,

India and the Soviet Union — also contributed to the design and development of military gliders.[108] In all, the Allies made over 21,500 military gliders, representing four times the combined output of Germany, Italy, and Japan.[109]

Canadian interest in the production of military gliders began in the summer of 1941, when employees of the DHC engineering department created a gliding club and subsequently decided to design and build a small training glider.[110] The idea originated with Waclaw Czerwinski, a Polish aeronautical engineer who had been specializing in the development of long-range gliders in his home country before fleeing to Canada early in the war and joining DHC. Czerwinski had considerable experience as an aeronautical engineer, having held high positions in several aircraft companies and developed sixteen glider and three powered aircraft designs before the Germans invaded Poland.[111]

Czerwinski's original intention was to initiate and promote interest in the sport of gliding in Canada. P.C. Garratt, the managing director of DHC, took special interest in the glider project, and agreed to provide funds, material and labour for its construction. Members of DHC's drawing office worked on the design in their spare time under the supervision of Czerwinski. It took six months to complete the drawings.[112] The DHC glider was in fact very similar to a small glider that Czerwinski had built a few years earlier in Poland.[113] The manufacturing of the glider then began in the company's experimental department.[114] Czerwinski himself conducted the maiden flight of the DHC glider, known as the DHC Sparrow, in the spring of 1942. Yet, only one Sparrow glider was built.[115]

Czewinski and other DHC engineers attempted to interest the Canadian government in military gliders, particularly for the transport of troops and material. For

several months, military authorities had already been contemplating the production of gliders in Canada. In October 1941, the Air Council had discussed the possibility of initiating the production of wooden military gliders in Canada.[116] In response, the Cub Aircraft Corporation Limited of Hamilton, Ontario, submitted a proposal to the DMS.[117]

The most serious proposal, however, came from DHC, which was interested in designing and developing a whole line of military gliders. Wsiewolod J. Jakimiuk, a Polish aeronautical engineer who escaped to Canada during the war to become Chief Aeronautical Engineer at DHC, was in charge of the project. Jakimiuk had considerable experience — having developed eight aircraft designs, most of them fighters, before Germany invaded Poland.[118] In a February 1942 letter to the RCAF, Jakimiuk explained why DHC should venture into the design and development of gliders. "We have in our engineering department, several Polish engineers, among them experienced glider and transport plane designers and glider pilots, and we feel capable of undertaking any work connected with design, construction and test of gliders."[119] He later wrote P.C. Garratt that DHC was the perfect company to undertake work on military gliders: "We have on our engineering staff several men who have had considerable experience in designing and building gliders and transport planes ... [and] we have glider pilots with considerable experience, which may help in carrying out glider flight tests."[120] Indeed, other prominent Polish aeronautical engineers with considerable experience in the design of aircraft and gliders worked at DHC.[121] In all, forty Polish aeronautical engineers, many of whom went into exile in France and Great Britain after the German conquest of Poland in September 1939, soon arrived in Canada to work at DHC as the result of an agreement between the Canadian government and the Polish government-in-exile.[122]

In March 1942, Jakimiuk and Czerwinski published an article in *Canadian Aviation* in which they promoted the making of military transport gliders in Canada and stressed the availability of designers, materials and even idle equipment.[123] The article explained some of the advantages of using transport gliders:

> Theoretical considerations show that transportation by a train composed of towing airplane and glider is more economical than transport by airplane; in other words, using the same quantity of fuel and the same speed, we can transport over the same distance, larger loads by combination airplane-glider, than with the airplane alone ... We must ... point out that this system provides considerable elasticity when using one towing plane with gliders of different sizes ... This, of course, will reduce the cost of investments, since the combination of one towing plane with gliders of different sizes always will be cheaper than a number of planes of different sizes which will be required to perform the same task ... Cruising speed, maximum load capacity and consumption of fuel per unit are almost constant in transport planes. The consumption of fuel and cruising speed will be practically the same for the engine powered plane when it flies with full load or half empty. The glider train, composed of towing plane and glider, offers a much greater possibility of variation of speed and load conditions.[124]

The two aeronautical engineers then pointed out the military advantages of using transport gliders in wartime. They noted that a single heavy bomber could easily tow three such gliders and that each of these gliders could be readily designed and built to carry up to fifty fully equipped soldiers, or a corresponding quantity of weapons, ammunition and supplies.[125] This, they argued, "seems to be the only possibility that will compensate for the shortage of big transport planes." Moreover, Jakimiuk and Czerwinski emphasized the fact that gliders "will give the defensive forces of the country full capacity for transportation of troops and material by air" in the event the enemy attacked Canada As they explained:

> Transportation of troops which are intended to check the first attacks of the enemy should be, in so far as is practicable, independent of railway or road communication, since these may be very easily destroyed or damaged by the enemy's air attacks in the first days, or even the first hours, of offensive

> operations. Air transportation is particularly important for countries sparsely populated, or with not very greatly developed communication systems, and which are accessible from many sides to the enemy. Very directly concerned with this difficulty are countries such as Canada ... the United States ... as well as Australia. The ability to achieve rapid concentration of elite troops, well-equipped with modern arms and particularly with anti-tank guns and field guns, also with light tanks, may be decisive for the defensive party. Transport gliders solve this problem effectively. They land easily on seashore, on water, on snow, and even on grounds completely unsuitable for the landing of transport planes. Enemy airborne and seaborne invasion forces will have quantity and strength relatively limited and can be annihilated if the problem of very rapid transportation of defensive forces in the menaced countries is adequately solved ... It is manifest from the foregoing comments that the transport glider may become a military factor of outstanding importance ... It will make possible the concentration of powerful forces at a carefully selected location, forming a vanguard which may proceed to prepare the ground for follow-up and for larger landing parties. If we add to this the potentiality of collaboration with tanks transported in the same way, a considerable operative unit may be created, capable of performing tasks of vital importance.[126]

They also contended that gliders could be used for offensive operations against enemy territory, as the Germans had done during their invasion of Norway and the Low Countries in 1940. In such cases, defensive armament could be installed on the glider to protect it from enemy fighters and anti-aircraft fire.[127] Moreover, gliders could be used to train aircraft pilots.[128] More importantly, Jakimiuk and Czerwinski stated that military transport gliders could be easily made in Canada:

> Production of such gliders may be made apart from the aircraft industry, because gliders will be built of wood and produced in buildings and by men who are not engaged in war industries ... Gliders should be built of moulded plastic wood and reinforced synthetic resins. Because of their size and simple equipment, the construction of the aircraft is very simple and very easily may be adapted to quantity production. The most important and interesting feature of transport glider production is that it will not interfere with the present war production. There is no engine plant installation. Consequently, items which usually are the greatest factor in holding up production — such as engines, propellers, fuel, oil and hydraulic installations, engine gauges, pipes, tanks, etc. are not needed ... The airframe, when properly designed and prepared for quantity production, will be built outside of actual aircraft plants.[129]

Jakimiuk and Czerwinski were clearly in favour of designing and developing military transport gliders in Canada. The men sent a copy of the article to the RCAF in hopes that it would stimulate discussion and "contribute to the design and development of gliders in Canada."[130] They wanted the Canadian government to begin the process as soon as possible, and to award the contract to DHC.

The RCAF did become increasingly interested in the use of military gliders. It even planned to organize a special mobile army strike force composed of 40 heavy transport aircraft and 200 transport gliders that could be rapidly deployed by air to any threatened area in Canada. Half of the gliders were to be tank carriers capable of transporting a seven-ton tank or two Universal Carrier armoured vehicles. The others were to be used for the transportation of up to 25 fully armed troops.[131]

In March 1942, Jakimiuk developed a design proposal for a large military transport glider to be built by DHC under the designation of SK. 1920. It was designed to a US Army specification for a large glider capable of transporting 30 passengers. The proposed aircraft had a gross weight of 16,000 lbs and was to be capable of carrying a load of 8,000 lbs. It could be used for transporting one of the following combinations: 30 fully armed troops, 2 jeeps with crew and equipment, 2 howitzers, or 1 howitzer and 1 jeep. Loading would be done through a large door in the nose of the glider.[132] The glider would use a steel tube fuselage and, as per RCAF request, was to be capable of landing on water and snow. Jakimiuk estimated that it would cost at least $100,000 to develop the glider and produce a prototype. He submitted his proposal to the RCAF, saying that he preferred to work on a new design instead of an American or British one.[133] After considering Jakimiuk's proposal, the RCAF issued its response in early May 1942.[134] Air

force officials had problems with the configuration of the proposed design, particularly the fact that it only had one large door in the nose. The RCAF explained that "in any designs intended to carry vehicles which are too heavy to be manhandled, there should be an alternative exit or entry. This is most easily effected with a short, fat hold or cargo chamber and twin tail booms. The reason is that there is always the possibility that the glider may be forced to make a crash landing with its nose up against some obstruction."[135] Jakimiuk noted that this problem could be solved by providing the crew with several saws and axes to cut their way though the fuselage.[136] But RCAF authorities refused to pursue the project as they considered that the SK. 1920 design was not as advanced as existing gliders.[137]

By this time, government officials were seriously considering initiating the production of American and British glider designs in Canada. In March 1942, for example, the RCAF had suggested that licensed production of the British-designed Hotspur, Hengist, Horsa and Hamilcar military transport gliders be started in Canada as soon as possible.[138] In the next months, RCAF officials asked British military authorities to send blueprints and drawings of these four gliders to Canada.[139] In early August, the requested information was received and, interestingly, was stored at DHC.[140] The RCAF also investigated the possibility of manufacturing in Canada the American CG-3, CG-4, XLRA-1, XLRG-1, XLRH-1, and XLRQ-1 transport gliders.[141]

DHC did not give up work on developing Canadian military glider designs. The company developed its own specification known as Specification T.G. 3, which tried to incorporate RCAF comments. On 19 May 1942, DHC completed two new transport glider design proposals that met these requirements. The first called for a large military

transport glider known as the SK. 3019 that was to be bigger than the SK. 1920. It had an aerodynamic fuselage, a tricycle undercarriage for greater ground stability, and three doors. A large rear upward-opening cargo door would be used for loading vehicles, howitzers and men, and for bailing out parachutists. The two front doors, located on each side of the fuselage, were to be used as secondary exits. An emergency escape hatch was even provided above the pilot's cockpit. All these doors marked a noteworthy improvement from the SK. 1920.[142] The second design called for an intermediate glider known as the SK. 3012, a smaller version of the SK. 3019. DHC also offered an amphibious or "sea-glider" variant known as the SK. 3036, which would be fitted with floats under the wings.[143] DHC submitted both design proposals to the RCAF on 27 May 1942,[144] but the latter refused to adopt either as it was more interested in American and British glider designs.

On 15 June 1942, DHC made another attempt and issued a design proposal for a new tank-carrying glider, the SK. 3073, that would be much heavier than the above-mentioned designs. Its cargo bay would be large enough to carry an armoured vehicle or tank weighing 13 tons, which could be loaded through a rear door. A dorsal gun turret was to be installed on top of the fuselage allowing it to defend itself both on the ground and in flight.[145] DHC also issued a report on an experimental glider known as the SK 3075, a quarter size replica of the SK 3073.[146] Again, both initiatives proved failures. The RCAF noted that the design and production of a tank-carrying glider in Canada would take an estimated 12 to 18 months, a delay it considered unacceptably long.[147]

On 17 June 1942, DND (Air) put an end to all this, explaining to DHC that "it seemed to be unlikely that this department would launch into a new design for the small

number of gliders required, and they are much more likely to adopt existing British or American designs."[148] By that time, the RCAF was more interested in producing the American CG-4 in Canada.[149] The RCAF even considered for a while converting Canadian-made A.V. Roe Anson trainers into 15-seat gliders by removing the engines and nacelles, and building an extension to the nose of the fuselage.[150] This project was never pursued as some air force officials questioned the economic benefits of converting an existing aircraft into a glider. It was noted that "either the modifications would have to be very extensive, or the aircraft would be fitted with unnecessarily complicated equipment such as hydraulically retracted undercarriage, which would have to be operated by the hand pump as no power plant would exist." [151]

The idea of building military transport gliders in Canada gradually faded as the Canadian government was able to purchase its requirements from American and British sources. In 1943, there were discussions of having CCF produce the large American-designed Bowlus MC-1 (later known as the XCG-16) flying wing transport glider, capable of carrying more than forty fully armed soldiers, but the project never materialized.[152] In February 1945, an attempt was made to establish a glider manufacturing industry in Sherbrooke, Quebec. The company, made up of ex-RCAF personnel, wanted to design and develop a whole line of military gliders and was ready to construct a prototype. The project, however, was never pursued. In the end, no gliders were mass-produced in Canada during the war.[153]

Conclusion

Not all Canadian government officials and aircraft industry personnel accepted that the country should only produce American and British aircraft designs under-license and not be innovative in the field of design and development. This opinion gained popularity following the German conquest of Scandinavia and Western Europe in the spring of 1940, when Canadian officials started to fear that they might have to continue the fight largely alone in the event of a British defeat. If such a scenario were ever to transpire, Canada needed to be self-sufficient in aircraft production. In the summer of 1940, a wooden aircraft program was initiated owing to the NRC's efforts. The NRC's dream of designing and developing a whole line of wooden fighters, bombers, trainers and transports in Canada, however, was never pursued. Instead, the Canadian government opted to modify existing American or British aircraft designs manufactured in Canada from metal to wood. Still, the NRC's attempt showed the Canadian government that a number of experts in Canada were willing to undertake work in the field of aircraft design and development. At the same time, DHC attempts to design and develop military transport gliders in Canada were equally unsuccessful. The Canadian government clearly preferred to go with the licensed manufacture of existing and well-proven gliders of American or British origin than to rely on Canadian designs. Nevertheless, the wooden aircraft program and the military transport glider scheme revealed an interest in developing Canadian-designed aircraft in Canada and initiated important discussions on the issue.

NOTES

1 Library and Archives of Canada [LAC], RG-24 [Records of the Department of National Defence], Vol. 5054, File: HQ 938-3-4, "Leonard W. Brockington (PMO) to C.G. Power (MND (Air))," 12 July 1940.

2 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Leonard W. Brockington (PMO) to C.G. Power (MND (Air))," 12 July 1940. For more information on the advantages of using moulded plywood in aircraft construction, consult also LAC, RG-24, Vol. 5393, File: HQS 60-1-32, "Use of Plastics in Aircraft Structures," 14 April 1942; R.D. Hiscocks, "Wooden Aircraft: A Wartime Experiment," *CAHS* Journal, Vol. 26, No. 4 (Winter 1988), pp. 148-150; Philip Jarrett, ed., *Biplane to Monoplane: Aircraft Development, 1919-39* (London: Putnam, 1997); Thomas D. Perry, "Canadian Aircraft Production: Using Plywood Methods in Aircraft Production," *Canadian Aviation*, Vol. 14, No. 3 (March 1941), pp. 41-44, 50; Eric Schatzberg, *Wings of Wood, Wings of Metal: Culture and Technical Choice in American Airplane Materials, 1914-1945* (Princeton: Princeton University Press, 1999).

3 Parkin counted 219 different types of aircrafts worldwide which employed wood as a structural material. These ranged in gross weight from 600 to 30,000 lbs. 86 were all-wood designs (utilizing wood for both wings and fuselage). The other 133 were composite aircrafts (utilizing wood for only part of the structure, usually the wings). Parkin also noted that British, French and German aircraft companies were in the process of designing wooden fighters and dive-bombers. He also pointed out that wooden combat aircraft were successfully used during the Spanish Civil War (1936-1939) and the Soviet-Finn Winter War (1939-1940). See LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Memorandum Regarding the Design and Construction of Wooden Military Aircraft in Canada by J.H. Parkin (Director of the Aeronautical Laboratories, NRC)," May 1940.

4 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Memorandum Regarding the Design and Construction of Wooden Military Aircraft in Canada by J.H. Parkin (Director of the Aeronautical Laboratories, NRC)," May 1940.

5 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Memorandum Regarding the Design and Construction of Wooden Military Aircraft in Canada by J.H. Parkin (Director of the Aeronautical Laboratories, NRC)," May 1940; LAC, RG-28 [Records of the Department of Munitions and Supply], Vol. 862, *Canada's Industrial War Effort, 1939-1945* (Ottawa: Economic Research Branch/Department of Reconstruction and Supply, 1947), Chapter 4.

6 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Memorandum Regarding the Design and Construction of Wooden Military Aircraft in Canada by J.H. Parkin (Director of the Aeronautical Laboratories, NRC)," May 1940.

7 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Memorandum Regarding the Design and Construction of Wooden Military Aircraft in Canada by J.H. Parkin (Director of the Aeronautical Laboratories, NRC)," May 1940.

8 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "C.J. Mackenzie (President, NRC) to C.G. Power," 7 June 1940.

9 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.S. Duncan (Deputy MND (Air)) to C.J. Mackenzie," 11 June 1940.

10 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.S. Duncan to Colonel Greenly (Controller General, British Supply Board)," 11 June 1940.

11 Canada, *War History of Division of Mechanical Engineering* (Ottawa: National Research Council of Canada, 1940's.), pp. 197-198; W.E. Knowles Middleton, *Mechanical Engineering at the National Research Council of Canada, 1929-1951* (Waterloo: Wilfrid Laurier University Press, 1984), p. 113.

12 LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Alex Johnson (President, VSA) to C.D. Howe (MMS)," 20 June 1940.

13 LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Wing Commander A. Ferrier (DAE for CAS) to W.J. Sanderson (Director of Aircraft Supply, DMS)," 22 June 1940

[14] LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Wing Commander A. Ferrier (DAE) for CAS) to W.J. Sanderson (Director of Aircraft Supply, DMS)," 22 June 1940.

[15] The Vidal process is a fairly simple method for constructing wooden aircrafts. The basic idea is to build a collapsible mould (or model) to the exact contour of the fuselage, wings, and other items to be constructed. Over each mould is placed a layer of plywood, which is then stapled and glued. Saturated strips of plywood are then wrapped around the carcass, with a synthetic resin adhesive between each lamination. Each ply is about 1/28 of an inch thick and 6-inch wide. As many strips as necessary as added. After building up to the necessary thickness, the fuselage and wings are then placed on a conveyor and hauled into an oven for curing under steam and air-pressure (about 40 lbs. per square inch at a temperature of 250° F) The steam pressure entirely alters the chemical constituents, causing the synthetic resin cement to set, and holds the plywood in the required shape. After completion of the curing process, in just less than an hour, the conveyor is pulled out of the oven and the collapsible mould is then taken out of the monocoque plywood carcass to be used again as often as required. Doors and panels are then cut out of the fuselage. The wings are then bolted to the fuselage thus allowing for replacement of wings, should one be damaged, without scrapping the entire plane. The engine is inserted in the fuselage and a plastic hood covers this end. Instruments and general assembly are then completed. Static tests undertaken in the United States at the time showed that a wooden structure of this type weighed 40 per cent less than the equivalent light alloy structure and could carry approximately 150 per cent of the load. According to Alex Johnson, President of VSA, such an aircraft could easily out-perform, out-maneuver, and out-fly any similar plane powered with a similar engine, fabricated in metal. It could also be produced faster and with fewer people because the Vidal process required no heavy machinery or jigs. See LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Alex Johnson (VSA) to DND (Air)," 27 June 1940. Also consulted: LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Squadron Leader H.S. Rees (RCAF) to Wing Commander A. Ferrier," 19 July 1940; LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "A/V/M E.W. Stedman (AMAE) to S.L. DeCarteret (Deputy MND (Air)," 8 September 1941.

[16] LAC, RG-24, Vol. 5393, File: HQS 60-1-32, "Alex Johnson (Aircraft Division, VSA) to RCAF," 29 June 1940.

[17] LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Alex Johnson (President, VSA) to DND (Air)," 27 June 1940.

[18] LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "A/V/M E.W. Stedman, to C.G. Power," 4 June 1941; LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Summary of Correspondence and Action with VSA Regarding Moulded Veneer Construction," June 1941

[19] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Squadron Leader H.S. Rees (RCAF) to A. Ferrier," 19 July 1940.

[20] "C.J. Mackenzie to General Andrew G.L. McNaughton (1st Canadian Division)," 25 July 1940 in Mel Thistle, Ed., *The Mackenzie-McNaughton Wartime Letters* (Toronto: University of Toronto Press, 1975), p. 45. See also Middleton, *Mechanical Engineering at the National Research Council...*, p. 114.

[21] LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "A/V/M E.W. Stedman to C.G. Power," 4 June 1941.

[22] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Leonard W. Brockington to C.G. Power," 12 July 1940.

[23] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Leonard W. Brockington to J.S. Duncan," 30 July 1940.

[24] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.S. Duncan to Leonard W. Brockington," 6 August 1940

[25] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "A. Henry Self (British Purchasing Commission) to G.K. Sheils (Deputy MMS)," 31 August 1940.

[26] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.S. Duncan to Leonard W. Brockington," 6 August 1940.

[27] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "C.G. Power (MND (Air)) to L.W. Brockington (PMO)," 20 July 1940.

[28] LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Memorandum by A/V/M E.W. Stedman (AMAE)," 8 September 1941.

[29] LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "C.G. Power (MND (Air)) to L.W. Brockington (PMO)," 20 July 1940.

30 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Wing Commander A. Ferrier to AMES," 11 July 1940.

31 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Charles A. Banks (Representative of the DMS, Office of the High Commissioner for Canada, London) to G.K. Sheils," 17 July 1940.

32 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Air Commodore G.V. Walsh (AOC RCAF in Great Britain) to Charles A. Banks," 9 August 1940.

33 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Charles A. Banks to G.K. Sheils," 12 August 1940; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.S. Duncan to G.K. Sheils," 22 August 1940.

34 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "A. Henry Self to G.K. Sheils," 31 August 1940.

35 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.S. Duncan to G.K. Sheils," 24 September 1940; LAC RG-24, Vol. 5054, File: HQ 938-3-4, "Memorandum by Wing Commander A. Ferrier," 24 September 1940.

36 Don L. Brown, *Miles Aircraft Since 1925* (London: Putnam, 1970), pp. 172-177.

37 *Ibid.*

38 Brown, *Miles Aircraft Since 1925...*, pp. 182-187.

39 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.H. Parkin to A/V/M E.W. Stedman (AMES)," 6 September 1940; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Eugene L. Vidal (President, Aircraft Research Corporation) to Ralph P. Bell (DGAP)," 23 September 1940; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Contract for the Supply of Reinforced Veneer-Plastic Fuselages from Aircraft Research Corporation and Untied States Plywood Corporation," 1 November 1940; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Proposed Agreements between Canadian Government and Aircraft Research Corporation and United States Plywood Corporation," 9 December 1940; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Group Captain A. Ferrier (for AMAE) to Deputy MND," 17 December 1940.

40 K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 60-61.

41 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.S. Duncan to Ralph P. Bell (DGAP)," 4 October 1940.

42 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.H. Parkin (Director, NRC Division of Mechanical Engineering) to Group Captain A. Ferrier (For CAS)," 21 January 1941; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Group Captain A. Ferrier (For CAS) to Dean C.J. Mackenzie (President, NRC)," 25 January 1941.

43 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Harry N. Atwood to VSA," 11 September 1940; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Alex Johnson (VSA) to Wing Commander A. Ferrier (DAE)," 7 October 1940.

44 LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Summary of Correspondence and Action with VSA Regarding Moulded Veneer Construction, by Squadron Leader E.H. Higgins " June 1941

45 LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Alex Johnson (President, VSA) to Group Captain A. Ferrier (DAE)," 17 October 1940; LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "J.H. Parkin (Director, NRC Division of Mechanical Engineering) to Group Captain A. Ferrier (DAE)," 18 November 1940; LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Summary of Correspondence and Action with VSA Regarding Moulded Veneer Construction, by Squadron Leader E.H. Higgins " June 1941.

46 LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Squadron Leader A.R. Layard (AOC No. 13 Technical Detachment, Vancouver) to the DND (Air)," 3 December 1940.

47 LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Summary of Correspondence and Action with VSA Regarding Moulded Veneer Construction, by Squadron Leader E.H. Higgins " June 1941; LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "A/V/M E.W. Stedman (AMAE) to the MND (Air)," 4 June 1941

48 LAC, RG-24, Vol. 3196, File: 601-38-3, "Air Commodore Robert Leckie (D of T) to AMOT," 26 October 1940; LAC, RG-24, Vol. 3196, File: 601-38-3, "RCAF Draft Specification for an Elementary Trainer Aeroplane," October 1940; LAC, RG-24, Vol. 3196, File: 601-38-3, "RCAF Specification AD/2 for Elementary Training Aeroplane," 13 November 1940. See also "New Trainer for Air Force," *Canadian Aviation*, Vol. 13, No. 12 (December 1940), p. 25, 48.

49 LAC, RG-24, Vol. 3196, File: 601-38-3, "Air Vice-Marshal E.W. Stedman (AMAE) to AMS," 15 November 1940; LAC, RG-24, Vol. 3196, File: 601-38-3, "W.J. Macdonald (Controller of Air Records) to the Deputy MND (Air)," 21 December 1940.

50 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.H. Parkin (Director, NRC Division of Mechanical Engineering) to A/V/M E.W. Stedman (AMES)," 11 December 1940.

51 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Group Captain A. Ferrier (For CAS) to J.H. Parkin (Director, NRC Division of Mechanical Engineering)," 17 December 1940; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Group Captain A. Ferrier (For CAS) to Ralph P. Bell (DGAP)," 14 January 1941.

52 The RCAF sent the specification to 21 American and 16 Canadian companies. The Canadian firms were Boeing, CCF, Canadian Pratt & Whitney (Longueuil, Quebec), Canadian Wright Limited (Montreal, Quebec), Canadian Vickers, Coates Limited (Vancouver, British Columbia), Cub, DHC, Fairchild, Fleet, MacDonald, Maple Leaf Aircraft Company (Lucknow, Ontario), NSC, Noorduyn, OCA, and White Canadian Aircraft Limited (Hamilton, Ontario). See LAC, RG-24, Vol. 3196, File: 601-38-3, "F.L. Jeckell (For DGAP) to Flight Lieutenant J.G. McArthur (AMS)," 27 December 1940.

53 LAC, RG-24, Vol. 3196, File: 601-38-3, "F.L. Jeckell (For DGAP) to Flight Lieutenant J.G. McArthur (AMS)," 27 December 1940.

54 LAC, RG-24, Vol. 3196, File: 601-38-3, "A/V/M E.W. Stedman (For CAS) to DGAP," 9 December 1940.

55 LAC, RG-24, Vol. 3196, File: 601-38-3, "R.M. Crooks (General Manager, White Canadian Aircraft Limited) to Ralph P. Bell (DGAP)," 19 December 1940. See also Glenn D. Angle, ed., *Aerosphere, 1941* (New York: Aircraft Publications, 1941), p. A-182.

56 LAC, RG-24, Vol. 3196, File: 601-38-3, "F.E. Neylan (White Canadian Aircraft Limited) to Ralph P. Bell (DGAP)," 8 January 1941; LAC, RG-24, Vol. 3196, File: 601-38-3, "Wing Commander A.F. Britton (AMAE) and Squadron Leader R.F. Davenport (AMT) to DAE," 24 January 1941

57 LAC, RG-24, Vol. 3196, File: 601-38-3, "F.E. Neylan (White Canadian Aircraft Limited) to Ralph P. Bell (DGAP)," 8 January 1941.

58 LAC, RG-24, Vol. 3196, File: 601-38-3, "Wing Commander A.F. Britton (AMAE) and Squadron Leader R.F. Davenport (AMT) to DAE," 24 January 1941

59 LAC, RG-24, Vol. 3196, File: 601-38-3, "R.M. Crooks (CAE, Maple Leaf Aircraft Corporation Limited) to Ralph P. Bell (DGAP)," 1 February 1941; LAC, RG-24, Vol. 3196, File: 601-38-3, "R.M. Crooks (CAE, Maple Leaf) to Wing Commander A.F. Britton (RCAF)," 7 February 1941; LAC, RG-24, Vol. 3196, File: 601-38-3, "General Specification of Libra Low Wing Trainer by R.M. Crooks (CAE, Maple Leaf)," February 1941.

60 William Austin, "Fairchild Trainer Chosen by RCAF," *Canadian Aviation*, Vol. 14, No. 4 (April 1941), p. 89.

61 LAC, RG-24, Vol. 3196, File: 601-38-3, "R.M. Crooks (CAE, Maple Leaf) to Wing Commander A.F. Britton (DND (Air))," 17 February 1941. See also Austin, "Fairchild Trainer Chosen by RCAF...," p. 89.

62 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "W.T. Reid (NRC) to Group Captain Alan Ferrier (DAE)," 31 January 1941; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Group Captain A. Ferrier (DAE) to A/V/M E.W. Stedman (AMES)," 3 February 1941.

63 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Memorandum by Group Captain A. Ferrier," 13 February 1941.

64 "C.J. Mackenzie to General Andrew G.L. McNaughton (1st Canadian Division)," 11 February 1941 in Mel Thistle, Ed., *The Mackenzie-McNaughton Wartime Letters* (Toronto: University of Toronto Press, 1975), p. 64

65 Among the American aircraft proposed were the Bellanca T14-14 of the Bellanca Aircraft Corporation (New Castle, Delaware), the Fairchild M-62 of the Fairchild Engine and Airplane Corporation (Hagerstown, Maryland), the Howard DGA-165 of the Howard Aircraft Corporation (Chicago, Illinois), the Monocoupe PT-125 of the Universal Moulded Products Corporation (Orlando, Florida), the Ryan ST-3 of the Ryan Aeronautical Company (San Diego, California), the St. Louis PTLM-4 of the St. Louis Aircraft Corporation (St. Louis, Missouri), the Stearman Model 90 of the Boeing Airplane Company (Wichita, Kansas), and the Vega 35-70 of the Vega Airplane Corporation (Burbank, California). See LAC, RG-24, Vol. 3196, File: 601-38-3, "Wing Commander A.F. Britton to DAE," 8 January 1941; LAC, RG-24, Vol. 3196, File: 601-38-3, "Wing Commander A.F. Britton (AMAE) and Squadron Leader R.F. Davenport (AMT) to DAE," 24 January 1941;

LAC, RG-24, Vol. 3196, File: 601-38-3, "Group Captain A. Ferrier (For CAS) to Ralph P. Bell (DGAP)," 31 January 1941.

66 The five companies selected were Bellanca, Fairchild, Ryan, Vega and St. Louis. See LAC, RG-24, Vol. 3196, File: 601-38-3, "Report on Elementary Trainer Competition March 1941 by Group Captain A.L. Paxton (AMT/DAT), Group Captain A. Ferrier (AMAE/DAE), Wing Commander A.F. Britton (AMAE/DDAD), and Squadron Leader G.F. Overbury (AMT/DAT/TF2)," 12 March 1941. See also Austin, "Fairchild Trainer Chosen by RCAF...," p. 89; "Fairchild Trainer Selected by Royal Canadian Air Force," *Canadian Aviation*, Vol. 14, No. 4 (April 1941), pp. 35-36.

67 LAC, RG-24, Vol. 3196, File: 601-38-3, "Air Commodore G.O. Johnson (AMOT) to AMES," 25 November 1939.

68 LAC, RG-24, Vol. 3196, File: 601-38-3, "Air Commodore S.G. Tackaberry (AMS) to Deputy MND (Air)," 3 January 1941.

69 LAC, RG-24, Vol. 3196, File: 601-38-3, "Air Commodore S.G. Tackaberry (AMS) to Deputy CAS)," 21 January 1941.

70 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "Minutes of the Sixth Meeting of Sub-Committee on Wooden Aircraft," 1 May 1941.

71 Middleton, *Mechanical Engineering at the National Research Council of Canada...*, pp. 115-116.

72 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "J.H. Parkin (Director, NRC Division of Mechanical Engineering) to A/V/M E.W. Stedman (AMES)," 8 May 1941.

73 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "A/V/M E.W. Stedman (AMES) to J.H. Parkin (Director, NRC Division of Mechanical Engineering)," 16 May 1941; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "A/V/M E.W. Stedman (AMES) to W.J. Sanderson (President and Managing Director, Fleet)," 16 May 1941; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "W.J. Sanderson (President and Managing Director, Fleet) to A/V/M E.W. Stedman (AMES)," 20 May 1941.

74 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Squadron Leader E.H. Higgins (For CAS) to DAE," 12 November 1941; *War History of Division of Mechanical Engineering...*, p. 104.

75 LAC, RG-24, Vol. 5125, File: HQ 1021-9-72, "W.J. Sanderson (President and Managing Director, Fleet) to Ralph P. Bell," 11 January 1941.

76 LAC, RG-24, Vol. 5055, File: HQ 938-3-6, "Memorandum by A/V/M E.W. Stedman (AMAE)," 8 September 1941.

77 *Ibid.*

78 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Squadron Leader E.H. Higgins (For CAS) to DAE," 12 November 1941.

79 LAC, RG-24, Vol. 5125, File: HQ 1021-9-72, "W.T. Reid (NRC Division of Mechanical Engineering) to Group Captain A. Ferrier," 18 July 1941; LAC, RG-24, Vol. 5125, File: HQ 1021-9-72, "Group Captain E.C. Farman (DSA) to DDSA," 18 August 1941.

80 LAC, RG-24, Vol. 5125, File: HQ 1021-9-72, "Flight Lieutenant G.T. Collinson (For CAS) to AOC, No. 12 Technical Detachment, Toronto, Ontario," 7 June 1941.

81 LAC, RG-24, Vol. 5125, File: HQ 1021-9-72, "Group Captain A. Ferrier (DAE) to AMS (DPA)," 20 August 1941.

82 LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "A/V/M Stedman (For CAS) to J.H. Parkin (NRC)," 31 October 1941.

83 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Squadron Leader E.H. Higgins (For CAS) to DAE," 12 November 1941.

84 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Squadron Leader E.H. Higgins (For CAS) to DAE," 12 November 1941; LAC, RG-24, Vol. 5054, File: HQ 938-3-4, "A/V/M E.W. Stedman (For CAS) to Ralph P. Bell (DGAP)," 25 November 1941.

85 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Group Captain A. Ferrier (DAE) to AMAE," 21 November 1941.

86 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Air Commodore A. Ferrier (For CAS) to J.H. Parkin (Director, Division of Mechanical Engineering, NRC)," 24 April 1942; LAC, RG-77 [Records of the National Research Council of Canada], Vol. 302, File: 4-A3-6, "Proceedings of the 48th Meeting of the ACAR," 23 June 1942; LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "W.T. Reid to Wing Comander C.W. Crossland (CAS)," 30 June 1942; LAC, RG-24, Vol. 5054, File: HQS 938-3-4,

"C.J. Mackenzie (Acting President, NRC) to J.R. Nocholson (Deputy Controller, Supplies Control, DMS)," 13 July 1942.

87 Middleton, *Mechanical Engineering at the National Research Council...*, pp. 116-117.

88 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Proceedings of the 13th Meeting of the Subcommittee on Wooden Aircraft," 23 December 1942.

89 LAC, RG-77, Vol. 302, File: 4-A3-6, "Proceedings of the 49th Meeting of the ACAR," 19 November 1943. See also Middleton, *Mechanical Engineering at the National Research Council...*, pp. 116-117.

90 Brown, *Miles Aircraft since 1925...*, pp. 243-245.

91 Brown, *Miles Aircraft since 1925...*, pp. 220-221.

92 Chalmers H. Goodlin Papers [CHGP], "Lieutenant-Colonel Harold E. Hartney to General H.H. Arnold (Chief, USAAF) 3 July 1943. (www.aircrash.org/burnelli/pdf/hartney.pdf).

93 Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 61-62.

94 LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Group Captain A.F. Britton (For CAS) to J.L. Giles (British Air Commission)," 28 September 1942; LAC, RG-24, Vol. 5393, File: HQS 60-1-32, "Air Commodore A.L. Johnson (For CAS) to AOC RCAF Headquarters Overseas," 2 September 1943; LAC, RG-28, Vol. 8, File: 27, "History of Federal Aircraft Limited," 1946, pp. 10-11, 22-25, 41; Molson and Taylor, *Canadian Aircraft Since 1909...*, p. 458.

95 William A. Hunter, "Federal Aircraft Limited and the Avro-Anson V," *Commercial Aviation*, Vol. 5, No. 9 (September 1943), pp. 38-42; LAC, RG-28, Vol. 8, File 27, "History of Federal Aircraft Limited," 1946, pp. 1-46; Molson and Taylor, *Canadian Aircraft Since 1909...*, pp. 56-64, 458; "To Order Many Anson Mk. V Trainers," *Canadian Aviation*, Vol. 16, No. 3 (March 1943), p. 111

96 LAC, RG-28, Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production...*, pp. 53-54. See also Edward Bishop, *The Wooden Wonder: The Story of the De Havilland Mosquito* (London: Max Parrish, 1959).

97 LAC, RG-28, Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production...*, pp. 53-54; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 253-254.

98 LAC, RG-24, Vol. 4969, File: HQ 606-38BG2, "C.D. Howe (MMS) to DHC," 22 August 1942.

99 Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 253-260, 461.

100 LAC, RG-28, Vol. 8, File: 27, *A Report on the Canadian Programme of Aircraft Production...*, p. 53-54, 75-78; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 253-260.

101 LAC, RG-77, Vol. 302, File: 4-A3-6, "Proceedings of the 47th Meeting of the ACAR," 7 July 1941; LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Squadron Leader J.O.P. Dibbs (RAAF) to Australian Air Liaison Officer (Ottawa)," December 1941; LAC, RG-24, Vol. 5054, File: HQS 938-3-4, "Proceedings of the 13th Meeting of the Subcommittee on Wooden Aircraft," 23 December 1942; LAC, RG-24, Vol. 5393, File: HQS 60-1-32, "Air Commodore A.L. Johnson (For CAS) to AOC RCAF Headquarters Overseas," 2 September 1943; LAC, RG-77, Vol. 302, File: 4-A3-6, "Proceedings of the 49th Meeting of the ACAR," 19 November 1943.

102 LAC, RG-77, Vol. 302, File: 4-A3-6, "Proceedings of the 49th Meeting of the ACAR," 19 November 1943.

103 LAC, RG-77, Vol. 302, File: 4-A3-6, "Proceedings of the 50th Meeting of the ACAR," 12 April 1944.

104 LAC, RG-77, Vol. 302, File: 4-A3-6, "Proceedings of the 50th Meeting of the ACAR," 12 April 1944; LAC, RG-77, Vol. 302, File: 4-A3-6, "Proceedings of the 16th Meeting of the Subcommittee on Wooden Aircraft," 10 July 1944.

105 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "A Survey of Recent Developments in Towed Load-Carrying Gliders for Military Applications by J.L. Orr (Aeronautical and Mechanical Engineering Division, NRC)," March 1942.; James E. Mrazek, *Fighting Gliders of World War II* (New York: St. Martin's Press, 1977), pp. 21-22. See also LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "J.H. Parkin (Director, Division of Mechanical Engineering, NRC) to A/V/M E.W. Stedman (RCAF)," 5 March 1942.

106 Mrazek, *Fighting Gliders...*, pp. 60-83, 199.

107 Holley, *Buying Aircraft...*, p. 552; Mrazek, *Fighting Gliders...*, pp. 99-159, 199-200.

108 The Soviet Union produced more than 800 gliders, the bulk of production consisting of the Antonov A-7, an 8-seat assault glider, and the Yakolev Yak-14, a large transport that could carry small vehicles or 35 fully-equipped troops. The Soviets worked on several others designs, including a glider transport system that could carry a small tank into battle. Work on military gliders was also undertaken in India, where Hindustan Aircraft Limited designed an 8-seat military transport glider known as the G-1, but only one prototype was built. In Australia, De Havilland Aircraft Proprietary Limited developed two types of transport gliders capable of carrying seven fully-equipped soldiers: the DHG-1 and the DHG-2. Eight of these gliders were produced during the war. See Philip J. Birtles, *De Havilland* (London: Jane's, 1984), pp. 144-146; D.P. Mellor, *The Role of Science and Industry: Australia in the War of 1939-45* (Canberra: Australian War Memorial, 1958), p. 414; Mrazek, *Fighting Gliders...*, pp. 160-179, 187, 198-199.

109 Mrazek, *Fighting Gliders...*, pp. 198-200.

110 W.J. Jakimiuk, W. Czerwinski, and T.B.S. Tarczynski, "Glider Training," *Canadian Aviation*, Vol. 15, No. 5 (May 1942), p. 30.

111 Czerwinski worked for ZASPL (Zwiazek Awiatyczny Studentow Polittechniki Lwowskiej) from 1923 to 1935 and became chief aeronautical engineer of the WWS (Wojskowe Warsztaty Szybowcowe) and PWS (Podlaska Wytwornia Samolotow) aircraft companies between 1935 and 1939. The gliders he designed were the CW-1, CW-2, CW-3, CW-4, CW-5, CWJ, CW-7, CW-8, ITS-2, WWS-1 Salamandra, WWS-2 Zaba, WWS-3 Delfin, PWS-101, PWS-102 Rekin, and PWS-103. The aircraft were the PWS-33 Wyzel twin-engine fighter-dive-bomber trainer, the PWS-41 light reconnaissance-bomber trainer, and the PWS-40 light civilian utility aircraft. See Jerzy B. Cynk, *Polish Aircraft, 1893-1939* (London: Putnam, 1971), pp. 464-468, 473-475, 687-700, 704-707, 724-729; W.J. Jakimiuk and W. Czerwinski, "Military Transport Gliders Could be Made in Canada," *Canadian Aviation*, Vol. 15, No. 3 (March 1942), p. 29.

112 W.J. Jakimiuk, W. Czerwinski, and T.B.S. Tarczynski, "Glider Training," *Canadian Aviation*, Vol. 15, No. 5 (May 1942), p. 30.

113 This was the WWS-1 Salamandra glider. See Cynk, *Polish Aircraft...*, pp. 725-727.

114 W.J. Jakimiuk, W. Czerwinski, and T.B.S. Tarczynski, "Glider Training," *Canadian Aviation*, Vol. 15, No. 5 (May 1942), p. 30.

115 "Canadian-Built Glider Flies," *Canadian* Aviation, Vol. 15, No. 9 (September 1942), p. 56; Fred W. Hotson, *The De Havilland Canada Story* (Toronto: CANAV Books, 1987), pp. 64-65.

116 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Minutes of Air Council Meeting," 20 October 1941.

117 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Isabel Gough (DND (Air)) to the CAS," 2 December 1941; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "S.L. de Carteret (Deputy MND (Air)) to the Deputy MMS," 12 December 1941.

118 Jakimiuk worked for about ten years as chief aeronautical engineer at PZL (Panstwowe Zaklady Lotnicze), the national aviation establishment in Warsaw, Poland. His most famous designs were the PZL P-11 and PZL P-24 high-wing fighters, the PZL P-44 Wicher twin-engine transport, and the PZL P-50 Jastrzab, and PZL P-56 Kania low-wing fighters. See Cynk, *Polish Aircraft...*, pp. 158-172, 201-214, 244-250, 259-265; Hotson, *The De Havilland Canada Story...*, pp. 64-66, 119; W.J. Jakimiuk and W. Czerwinski, "Military Transport Gliders Could be Made in Canada," *Canadian Aviation*, Vol. 15, No. 3 (March 1942), p. 28. Michael J.H. Taylor, *Jane's Encyclopedia of Aviation* [1980] (New York: Portland House, 1989), pp. 753-754.

119 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "W.J. Jakimiuk (Chief Designer, DHC) to A/V/M E.W. Stedman (RCAF)," 19 February 1942.

120 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "W.J. Jakimiuk (DHC) to P.C. Garratt (DHC)," 27 February 1942.

121 Among the Polish engineers working at DHC was Kazimierz Korsak, who had been responsible for the design of the Polish PZL P-45 Sokol low-wing fighter, whose prototype was being built in 1939. Other prominent Polish engineers were Wieslaw Stepniewski and Tadeusz Tarczynski, who had worked on two relatively successful Polish gliders: the TS-1/34 Promyk and the ITS-8. See Cynk, *Polish Aircraft...*, pp. 250-253, 651-654, 702-703.

122 Hotson, *The De Havilland Canada Story...*, pp. 64-66.

123 W.J. Jakimiuk and W. Czerwinski, "Military Transport Gliders Could be Made in Canada," *Canadian Aviation*, Vol. 15, No. 3 (March 1942), p. 26.

124 Jakimiuk and Czerwinski, "Military Transport Gliders Could be Made in Canada...," pp. 26-27.

125 "Troop Transport Gliders Should be Made in Canada," *Canadian Aviation*, Vol. 15, No. 4 (April 1942), p. 31.

126 Jakimiuk and Czerwinski, "Military Transport Gliders Could be Made in Canada...," pp. 27-28.

127 *Ibid.*, p. 29.

128 W.J. Jakimiuk, W. Czerwinski, and T.B.S. Tarczynski, "Glider Training," *Canadian Aviation*, Vol. 15, No. 5 (May 1942), pp. 30.

129 W.J. Jakimiuk and W. Czerwinski, "Military Transport Gliders Could be Made in Canada," *Canadian Aviation*, Vol. 15, No. 3 (March 1942), pp. 27-30, 40.

130 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "W.J. Jakimiuk (Chief Designer, DHC) to A/V/M E.W. Stedman (RCAF)," 19 February 1942. See also LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "*Military Transport Gliders* by W. Czerwinski and W.J. Jakimiuk (DHC)," 18 February 1942.

131 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Group Captain C.B. Turner (For CAS) to P.T. Smye (Assistance to Ralph Bell, DGAP)," 24 March 1942; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Group Captain A.F. Britton (DAE) to AMAE," 30 March 1942; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "A/V/M N.R. Anderson (AMAS) to CAS," 14 April 1942. See also Canadian War Museum [CWM], "Department of Munitions and Supply, Quarterly Summary, 1 January to 31 March 1942," 15 April 1942, in *Department of Munitions and Supply Quarterly Reports Vol. 2: Second Year's Operations, 1941-1942* (Ottawa: Department of Munitions and Supply, 1942), p. 10.

132 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Preliminary Sketch DHC Military Transport Glider by W.J. Jakimiuk (Chief Designer, DHC)," 25 March 1942; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "W.J. Jakimiuk (Chief Designer, DHC) to Air Commodore A. Ferrier (RCAF)," 5 May 1942.

133 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "DGR to DAE," 25 March 1942.

134 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (For CAS) to DGAP)," 30 March 1942; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "W.J. Jakimiuk (Chief Designer, DHC) to Air Commodore A. Ferrier (RCAF)," 28 April 1942.

135 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (For CAS) to W.J. Jakimiuk (DHC)," 2 May 1942.

136 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "W.J. Jakimiuk (Chief Designer, DHC) to Air Commodore A. Ferrier (RCFA)," 5 May 1942.

137 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (For CAS) to W.J. Jakimiuk (DHC)," 2 May 1942.

138 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "J.H. Parkin (NRC) to Air Commodore A. Ferrier (RCAF)," 20 March 1942. See also LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (DAE) to AMAS and DOP," 28 February 1942; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (For CAS) to Air Attaché (Canadian Legation, Washington D.C.)," 20 March 1942.

139 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (For CAS) to Ralph P. Bell (DGAP)," 20 July 1942.

140 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "A/V/M A. Ferrier (For CAS) to Ralph P. Bell," 1 August 1942; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Donald C. Markey for Fred T. Smye (Executive Assistant to the DGAP) to Air Vice-Marshal A. Ferrier (AMAE)," 5 August 1942.

141 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Colonel T.A. Sims (USAAF Assistant Technical Executive) to A/V/M E.W. Stedman (RCAF)," 19 May 1942; LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Group Captain A.F. Britton (For CAS) to Air Attaché (Canadian Legation, Washington D.C.)," 10 August 1942. See also LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (DAE) to AMAS," 6 March 1942.

142 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "DHC Report 108 – Description of Military Transport Glider SK. 3019," 19 May 1942.

143 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "DHC Report 109 – Description of Military Transport Glider SK. 3012," 19 May 1942.

144 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "W.J. Jakimiuk (Chief Designer, DHC) to Air Vice-Marshal E. W Stedman (RCAF)," 27 May 1942.

145 LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "DHC Report 116 – Description of Tank Carrier Glider No. 3073 by K. Korsak," 15 June 1942.

[146] LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "DHC Report 117 – Description of Experimental Glider No. 3075 by K. Korsak (DHC)," 15 June 1942.

[147] LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Report of the Committee on Glider Pilot and Paratroop Training," 25 July 1942.

[148] LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Vice-Marshal E.W. Stedman (For CAS) to W.J. Jakimiuk (DHC)," 17 June 1942.

[149] LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Report of the Committee on Glider Pilot and Paratroop Training," 25 July 1942.

[150] LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "A/V/M E.W. Stedman (DGR) to AMAE," 15 July 1942.

[151] LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Air Commodore A. Ferrier (AMAE) to A/V/M N.R. Anderson (AMAS)," 18 July 1942.

[152] LAC, RG-24, Vol. 5404, File: HQS 60-6-1, "Memorandum fro Canadian Joint Staff Washington to DND (Air)," 1 December 1943.

[153] LAC, RG-28, Vol. 213, File: 196-3, "J.F. Lenaghan to J.G. Godsoe (Chairman, Wartime Industries Control Board)," 5 February 1945; LAC, RG-28, Vol. 213, File: 196-3, "J.G. Godsoe (Chairman, Wartime Industries Control Board) to J.F. Lenaghan," 8 February 1945.

CHAPTER FOUR

AWAKENING A SLEEPING GIANT

> The function of design, research and development are new to the Dominion, but if our aviation industry is to survive, it must take on the full responsibilities of these functions to produce aircraft for domestic and export markets. Canadians have proved their ability to produce, and now they will have the opportunities to develop and experiment with wholly Canadian designs.
>
> — *Commercial Aviation*[1]

While the Canadian aircraft industry produced relatively few aircraft of indigenous origin during the Second World War, government officials nonetheless encouraged aircraft manufacturers to design and develop their own line of aircraft. This situation owed to a growing spirit of independence in Canadian aeronautical circles caused by the rapid wartime expansion and massive output of the Canadian aircraft industry, an increase in Canadian design expertise, but also by frustrations encountered in the manufacture of licensed aircraft and difficulties in securing essential supplies from American and British sources. None of these proposals led to any homegrown aircraft prototypes, but they helped the industry prepare for postwar needs and culminated in a series of innovative indigenous aircraft programmes in the early Cold War. This chapter looks at some of the measures taken by the Canadian government to improve Canada's aircraft design and development capabilities.

"The Canadian Aircraft Industry ... Must be Capable of Creation"

The RCAF was first to initiate discussions about the perpetuation of the Canadian aircraft industry. It realized the "very weak position" that Canada had found itself in at the outset of hostilities in regard to the supply of aircraft and associated equipment, as Great Britain produced for itself and the United States imposed neutrality restrictions. This was a serious problem from a national security standpoint as the RCAF was unable to procure sophisticated and well-proven combat aircraft from its traditional supply sources to meet wartime requirements. Moreover, the Canadian aircraft industry was unable to furnish the RCAF with indigenous military aircraft designs. Most of the aircraft developed in the country during the interwar period had been designed to meet the demands of the civilian market, and relatively few were suitable for military applications.[2] For all these reasons, the RCAF believed that a sound aircraft industry capable of producing its own designs was an absolute prerequisite for future Canadian air power.

To this end, on 6 November 1942, Air Vice-Marshal Ernest W. Stedman, Director General of Air Research (DGR), recommended that the Canadian aircraft industry begin to develop its own military aircraft designs. Explaining that the existing policy of building aircraft under license in Canada was appropriate for the earlier stage of the war and for Canada's nascent aircraft industry, he questioned "whether the time has come when we should encourage some of our larger aircraft manufacturers to strengthen their design staffs and equip their factories with wind tunnel facilities so that they are in a position to undertake to produce new designs." Stedman suggested two types of military aircraft suitable for Canadian design: a seaplane-fighter that could easily be converted

into a ski-fighter and a medium-sized amphibian flying boat similar to the American Consolidated PBY but of more modern design. The advantage was that these aircrafts could be built to meet Canadian specifications and requirements, meaning the RCAF would be able to operate aircraft specifically suited for operations in North America and adapted to Canadian climatic and geographical conditions. Stedman also outlined the long-term benefits.

> The establishment of test factories and trained design staffs would place the Canadian aircraft industry in a much better position to continue in existence after the war when foreign manufacturers, having large factories and small orders, may refuse to grant licenses for manufacture in Canada, action which would prove a bad blow to our industry as constituted at present. It is essential that the Canadian aircraft industry, now that it has been established, should be placed in such a position that it can continue to be available for supplying our needs for defence purposes, and designers take a long time to train, not only individually but to work together as a team. It may be argued that these considerations can be left till later — 'Nothing matters now but Victory' — and that all aircraft manufacturers in Britain and the USA will have surplus design staff personnel, who will be available for employment by us, after the war, if we need them. We have, however, no knowledge of the probable length of the war, and facilities established now, may still be of considerable value during the present conflict, practically if British factories suffer from enemy action.[3]

Stedman's proposal was meant to encourage a reversal of current aircraft manufacturing policies that favored the production of proven American and British designs under-license in Canada.

Air Vice-Marshal Alan Ferrier, Air Member for Aeronautical Engineering (AMAE), supported Stedman's suggestion. "If the Canadian aircraft industry is to survive, it must become capable of creation," he told the Chief of the Air Staff. "The government is the only customer in Canada with sufficient resources to initiate and foster any Canadian design projects."[4] Air Vice-Marshal N.R. Anderson, Air Member for Air Staff (AMAS) and Deputy Chief of the Air Staff, concurred:

> Every possible step should be taken to encourage aircraft manufacturers in Canada to establish design staffs and associated facilities which will permit them to create new aircraft designed for manufacture in Canada ... The wide expanse of Canadian territory offers suitable sites for the manufacture of aircraft far removed from present and possible future battlefronts and it would appear wise for the United Kingdom to encourage the maintenance of adequate aircraft manufacturing facilities in this country including the manufacture of aircraft engines as a guaranteed supply against the possibility of their own factories being knocked out by enemy bombing. Canada must also take action in this regard as a matter of self-preservation and to maintain her position as the most important self-governing Dominion of the British Commonwealth of Nations.

Yet, Anderson felt that Canada should concentrate on the development of transport aircraft on the grounds that these products would be more beneficial in the postwar world.

> We now have service aircraft ... but lack commercial aircraft. Plans should be laid now for developing commercial aircraft on a grand scale when peace comes. Rapid, safe, cheap air transportation, enabling anyone to visit any part of the British Commonwealth of Nations for a few dollars will be the chief means of maintaining those friendships established under war conditions and holding the Commonwealth together. Rapid transportation of goods by air will also become more and more prevalent.[5]

Anderson seemed more inclined to encourage the development of aircraft that were more suited for peacetime rather than wartime. He knew of some of the problems encountered in the creation of new aircraft, namely that each model took several years to develop, and that usually only one out of every five designs was successful. He also knew that Canada lacked experience with service types such as fighters and bombers, for aside from the Curtiss Model C Canada twin-engine bomber of the First World War and the FDB-1 fighter biplane developed by CCF in the late 1930s, no combat aircraft had ever been designed in the country. Canada would have to start from scratch.

Anderson believed there was no reason for Canada to waste time and resources designing new warplanes when well-proven American and British designs could easily be

manufactured in Canadian aircraft factories. The United States and Great Britain possessed strong design teams that had been creating service aircraft long before the outbreak of war. In fact, most of the combat aircraft that equipped the Allied air forces were designed during the interwar years. This meant that while interwar aircrafts such as the British Hurricane fighter were being mass produced on assembly lines, design teams could concentrate on the development of more advanced service aircrafts. It was therefore easier in wartime to rely on the expertise of American and British design teams, and to produce aircraft under-license, than to build up Canada's capability to design combat aircraft when Allied air forces desperately needed and wanted well-proven fighters and bombers. Transport aircraft, on the other hand, had been built in Canada for several years, and most Canadian aircraft companies had experience with such aircraft. In addition, more time could be allocated to the design and development of transport aircraft since the Allies did not urgently require these types of machines. Yet, the greatest advantage was that transport aircraft could easily be adapted for both military and commercial purposes, making them perfect for the postwar world.

Ferrier agreed with Anderson, stating that "a healthy military aircraft industry must rest upon a sound air transportation industry. The design and development of a transport type would be more within the existing scope of Canadian facilities. In my opinion, the axiom that only about one in five of the types designed are successful should not be allowed to act as a strong deterrent." He believed that there would be a great demand for re-equipping civil airlines after cessation of hostilities, making it extremely difficult for Canadian companies to procure suitable aircraft. He felt that Canada might

be in a position to fill its own requirements in the postwar years if it soon initiated a project for a medium size transport of 25,000 to 30,000 lbs. gross weight.[6]

The DMS was simultaneously preparing the Canadian aircraft industry for postwar years. On 7 December 1942, Ralph P. Bell, the Director-General of the Aircraft Production Branch, sent a letter to each Canadian aircraft manufacturer asking them to consider their companies' postwar future. "No unit in the Canadian aircraft industry will have a chance in the postwar period unless it can produce aircraft as cheaply, or more cheaply, than our competitors in England or the United States," he explained. "I don't know of any reason why we shouldn't be able to beat both these countries ... We have the facilities, which there are none better in the world, and it is up to each of us individually, and all of us collectively, to devise ways and means which will enable us to compete with all comers." Bell urged Canadian aircraft manufacturers to make every effort to lower their costs and warned that if they could not put Canadian aircraft on a competitive basis with other countries they could "kiss this industry goodbye." He wrote in conclusion: "We wouldn't think much of our generals, our admirals, and our air marshals if they were satisfied with soldiers, or sailors, or airmen that got licked every time they went up against the enemy ... We think the Canadian soldier, sailor, and airman is the best in the world. Is there any reason why we shouldn't take the same pride in our war industry?"[7]

While most Canadian aircraft manufacturers agreed with Bell,[8] J.C. Ruse of Clark Ruse Aircraft Limited of Dartmouth, Nova Scotia, pointed out that Canadian aircraft companies were handicapped by the fact that they had tended to build foreign-designed aircrafts under-license. The situation would have to change in postwar years, as Canadian

aircraft makers would need to design, develop, and market their own commercial and military aircraft. "Unless we have a distinctly Canadian type to sell, we can only expect to manufacture under-license," Ruse explained. "These licenses usually are limited as to territory by the parent organization, which is not a healthy condition for the industry. What we need is something we can sell the world ... and we need ... markets."[9]

Bell expressed a similar opinion in his 23 December letter to C.D. Howe. As he wrote, "while we can, today, procure licenses to build any plane we like, the situation probably will not hold true once the war is over." Bell was particularly concerned that the Canadian aircraft industry might not be able to get production licenses for foreign-designed aircraft at the end of hostilities. "We may still be able to get permits to build 'for sale in Canada,' but it is highly unlikely that we will be able to procure licenses to build 'for sale in the export field,' so that if the industry is to survive it seems to me the country will have to subsidize design teams." He believed that American and British aeronautical engineers and technical personnel could form the basis of strong design teams as they would be attracted to work in Canada for they would be given an opportunity to make their name by designing their own aircraft. In order to expedite the process, Bell believed the DMS should designate and control the field of operations of such teams. "The Canadian aircraft industry must move, and move rapidly, if it is to be a factor in the postwar situation ... It is highly improbable that the present ... manufacturing plants in Canada can all continue on a substantial basis, but it seems to me that it is possible that a smaller number of strong organizations which would be able to assemble the best key men now scattered throughout the industry might with the proper help and direction pull through."[10]

The RCAF Air Council met on 6 January 1943 to discuss the future of Canada's aircraft industry and the development of indigenous aircraft designs.[11] In attendance were high-ranking officials of the RCAF and the DMS' Aircraft Production Branch. The overall consensus was that Canada's place in postwar aviation depended on the industry's capability to create its own aircraft. Participants recognized that American and British aircraft companies had a two-fold objective to satisfy immediate wartime demands and to facilitate transition to postwar commercial aviation. To this end, they had developed transport aircraft that were adapted to both military and civilian markets, had re-equipped their factories to facilitate conversion to postwar manufacturing, had fostered technical progress by placing orders for the design of new experimental aircraft types, and had subsidized the industry. If the Canadian aircraft industry hoped to compete with American and British aircraft companies in the postwar world, plans for the design of indigenous aircraft had to be prepared in wartime.[12]

The DMS expressed particular interest in overseeing this initiative. Ralph Bell explained that since December 1942, he and C.D. Howe agreed that steps should be taken immediately to protect the future of the Canadian aircraft industry. Howe had a long-term interest in promoting Canadian aviation, for he had been instrumental in creating Trans-Canada Air Lines (TCA) in 1937 as Minister of Transport. Both men knew that Canadian commercial aviation had grown considerably since the beginning of the war and that now, more than ever, air lines required modern passenger and cargo transports to compete on the international markets. Bell felt that a strong Canadian aircraft industry capable of designing its own aircraft could provide employment to many ex-servicemen after the war, including engineers and designers. The development of indigenous aircraft

designs could also enable Canada to market aircraft worldwide. "Canada would always be able to buy licenses for the manufacture of aircraft from foreign designs for sale within Canada," Bell warned, "but it is highly improbable that the companies originating these licenses would be willing to make them available to Canadian manufacturers for competitive sale in export markets." In his opinion, Canadian airlines would be more than willing to buy Canadian-designed transport aircrafts. The Air Council agreed that the proposal to prepare Canada's aircraft industry for the postwar world was "sound" and that "means to this end should be determined."[13]

On 11 January 1943, Bell wrote again to Howe on the need to establish strong aeronautical design staffs and to manufacture aircraft at competitive costs. He stressed the urgent need to address the future of Canada's aircraft industry and postwar air transportation, especially since the American and British governments were already preparing their own aircraft industries. Bell felt that the future of Canada as a trading nation depended on this decision:

> Geographically, Canada is the keystone in aerial transportation ... Our populations probably have the greatest background of knowledge and experience in northern flying of any country on the globe with the possible exception of Russia ... The post that Canada will play in the field of aerial world transportation and the position our aircraft industry maintains in the postwar economy will in a large measure determine the relative position we continue to maintain in world trade.[14]

A healthy postwar Canadian aircraft industry would therefore be good for Canadian trade and commerce and for the economy. More importantly, however, it would contribute to maintaining a strong work force at home by providing employment to the thousands of people working in aircraft manufacturing plants; in subcontracting industries; and in Canadian airway companies, airports, radar stations, and other fields of aviation. Finally,

it could also provide jobs to the thousands of young RCAF men and women who would be seeking employment in the civilian market after the war.[15]

In early February 1943, TCA issued a complete list of its postwar civil aviation requirements to the DMS. It included two different types of commercial aircraft.[16] The first was a twin-engine 45,000 to 50,000 lbs. gross weight intercity/cargo transport capable of carrying passengers and cargo over short distances. This aircraft was to be capable of carrying a payload of 10,000 lbs., including 36 passengers, over a range of 1,200 miles. It was to be powered by 2,000 hp engines and capable of a maximum speed of 275 mph.[17] The second was a four-engine 100,000 to 120,000 lbs gross weight transoceanic/transcontinental transport capable of carrying a payload of 10,000 lbs, including 50 passengers and a crew of nine, over a range of 3,200 miles. It was to be powered by 2,000 hp engines and capable of a maximum speed of 325 mph.[18] A Crown Corporation operated by the DMS called Victory Aircraft Limited (VAL) immediately proposed "to get a design team together to meet these requirements."[19] Besides possessing a fairly strong group of aeronautical engineers, VAL was the only company in Canada to produce four-engine aircraft, considered to be the best configuration to meet TCA's postwar commercial aircraft requirements. Ralph Bell very much favoured VAL and agreed to assemble a strong design team at the company to meet TCA's requirements. "Since our four-engined jobs are at Victory," he told C.D. Howe, "I propose to take the specification of Trans-Canada's ideal four-engined job and turn it over to [Wilhelm Ulric] Shaw, chief engineer at Victory. [Alfred] Sewart of A.V. Roe, their resident technical man attached to us at this plant, is a highly practical chap of great ambition and confidence, and coupled with [David] Boyd's [General-Manager of

Victory] practical ability as a builder, I am confident that we can create around Shaw a team that will produce something worthwhile."[20]

At the time, VAL was manufacturing the A.V. Roe Lancaster bomber under-license and was about to begin production of another heavy four-engine British-designed aircraft, the A.V. Roe York transport. The DMS had asked VAL to produce the York under-license in the fall of 1942. The aircraft incorporated many of the Lancaster's parts and components, which meant that many of the bomber's machine tools, jigs and assemblies could also be used for the York, thus facilitating the manufacturing process and lowering production costs.[21] In early 1943, VAL had been given a contract for fifty York transports to be divided between the RCAF and Canadian airlines.[22] The DMS initially suggested that TCA adopt a civilian version of the Lancaster or the York, but the President of TCA, H.J. Symington, rejected the proposal on the grounds that none of these aircraft met his airline's postwar requirements. He told Bell that "our people view these planes as for use during the intermediate period of the war and really as war operation," and explained that he was more interested in an aircraft designed to meet TCA's specific postwar needs. While these discussions were not conclusive, Symington believed this was a real opportunity for Canada to initiate the design, development, and construction of postwar commercial aircraft.[23]

On 12 February 1943, Bell submitted a memorandum outlining his Department's view on the design and development of indigenous aircraft in Canada for the postwar. C.D. Howe "is in complete sympathy and agreement with the proposal that immediate steps should be taken to safeguard the postwar future of Canada's aircraft industry," as long as action taken "conformed to the overall policy adopted by the government with

respect to wartime industry." Bell explained that the Aircraft Production Branch had recently concluded an arrangement with TCA to put together project design teams to create at least two distinctive Canadian commercial types of aircraft, including a four-engine transport. Bell proposed that the same be done for RCAF requirements, and that the Department of National Defence for Air (DND Air) immediately provide the Aircraft Production Branch with contract demands for prototypes of service aircraft that they wished to have designed and produced in Canada.[24]

The issue was thoroughly discussed at the Air Council meetings held on 20 and 22 February 1943. Members were asked to recommend types and specifications for aircraft to be manufactured in Canada with "the objective of establishing a continuing aircraft industry ... for which Canadian experience gives her qualifications in the field of design." The group agreed that it was "not feasible to develop all types of service aircraft in Canada with the existing facilities" and that "the enormous establishments required for such an undertaking should not be set up at the present time." It also specified that no combat aircraft were to be designed in Canada at this stage; rather, it proposed the development of trainers or transports (passenger and cargo) given the Canadian aircraft industry's previous experience with such designs and anticipated postwar civilian and military requirements. The AMAE agreed to issue specifications for both types of aircraft in consultation with the AMAS and Air Member for Training (AMT). [25]

As the RCAF had already placed huge orders for Canadian-built training aircraft, there was no urgency to develop a new trainer. At the top of the priority list therefore were high-speed, long-range, heavy-lift transports. The RCAF had few, and Air Council members rightfully believed that there would be an increasing demand for such machines

before war's end to carry paratroopers, personnel, supplies and equipment to various battlefronts. Air Council members showed much interest in the four-engine transport aircraft project being developed by the Aircraft Production Branch and TCA, as they realized it would be as useful to the RCAF as to commercial airlines. This seemed like the perfect postwar aviation program. Those involved agreed that the DND (Air) should actively partake in its design and development. Accordingly, a recommendation was put forward to create a special committee under the chairmanship of the DMS, composed of representatives from the Department of Transport, DND (Air), TCA, and Canadian Pacific Air Lines (CPA), to determine general specifications for any type of aircraft proposed to be designed and built with government support in Canada for postwar use.[26]

On 1 March 1943, the Minister of National Defence for Air, C.G. Power, discussed the idea with C.D. Howe.[27] At this time, the DMS was contemplating the formation of a new Crown Ccorporation to undertake the design and development of aircraft in Canada. The aim of the corporation, which was to be named Aircraft Design and Development Limited or Aircraft Experimental Design Limited, would be "to undertake and carry on, under government auspices, extensive experimental development work in the field of aircraft, including aircraft which may be used for transport purposes and which may involved substantial improvements upon present conventional designs and motive powers."[28] Howe preferred Power's idea and abandoned plans to create the new Crown Corporation. He also recommended that the small committee consist of one representative from the DMS, NRC, TCA and two from DND (Air). Howe did not want any CPA representation. As he told Power: "I rather question the wisdom at this stage of bringing in Canadian Pacific Air Lines, which would not be consistent with a committee

of government officers planning to spend public funds."[29] In truth, Howe did not want a rival airline to TCA on the project: CPA, created in the spring of 1942, was perceived as a potential threat to the future hegemony of TCA.[30]

After much discussion, Howe accepted Power's original proposal to include CPA representation on the committee.[31] Howe outlined the following terms of reference for the new Committee on Postwar Manufacture of Aircraft (CPMA):

> To consider and recommend as to the types of planes most useful in the postwar period on which design effort should be concentrated; to recommend what arrangements in the nature of subsidy or otherwise should be made to enable the industry to carry out such design work; to suggest for what period of time such contracts should be made; to advise in what manner this work could be most fairly and advantageously distributed throughout the industry.[32]

The committee was officially formed on 8 April 1943, and its composition was decided the same day. Ralph Bell of the DMS was named chairman. The other representatives included C.P. Edwards (Deputy Minister of Transport), A. Ferrier (RCAF), J.H. Parkin (NRC), O.T. Larson (Vice-President of TCA), and L.B. Unwin (President of CPA). In addition, one person would represent the eight major Canadian aircraft companies (Boeing, CCF, Canadian Vickers, DHC, Fairchild, Fleet, Noorduyn and VAL.[33] Bell contacted the president of each of these companies and asked them to select a representative.[34] The aircraft manufacturers met shortly thereafter and chose Walter F. Thorn of the Air Industries and Transport Association of Canada.[35]

In the meantime, TCA had already submitted a specification on 15 February 1943 for its four-engine 100,000 to 120,000 lbs. gross weight transoceanic/transcontinental transport, and Howe suggested that the DND (Air) follow suit.[36] On 3 March 1943, Howe submitted a request to the Privy Council Office for a contract with VAL to design and

construct a four-engine transport aircraft prototype in accordance with the basic performance specification supplied by TCA,[37] and on 17 March he approached the Cabinet War Committee for funds. Howe explained that "this would be Canada's first attempt to design and produce a purely Canadian type of transport plane," adding that it would likely take three years or more to complete the project. The committee authorized an appropriation of $500,000,[38] and two days later, the Privy Council passed Order-in-Council PC 1720, authorizing the DMS to proceed with the project and to sign a contract with VAL.[39]

The DMS's other aircraft Crown Corporation, Federal Aircraft Limited, wondered why it had not been considered for design and development work. The answer lay in the fact that Federal had been created solely to coordinate the activities of Canadian aircraft manufacturers engaged in the production of Anson trainers. VAL, on the other hand, was operating the largest aircraft manufacturing plant in Canada, was building the largest aircraft in the Canadian program, the Lancaster, and was not limited to the manufacture of a single machine.[40] On 6 April 1943, the DMS notified VAL to immediately begin development.[41] A copy of the TCA basic specification was subsequently submitted to Air Vice-Marshal Alan Ferrier, the AMAE, for the RCAF's review and comments.[42]

VAL quickly set up an aircraft design staff to work on the four-engine transport. Company representatives were most ambitious, for they felt that a strong team of aeronautical engineers and aircraft designers should be assembled not only to work on the proposed TCA transport, but also on other postwar aircraft projects. Yet, in late April 1943, problems surfaced when VAL was unable to secure the service of a chief aeronautical engineer. David Boyd, director-general of VAL, and Ralph Bell had looked

to Great Britain for technical personnel, and had found a suitable candidate in S.D. Davies of A.V. Roe.[43] The two men had allegedly discussed the issue with Davies during a recent visit to Canada, and a formal Canadian request was later sent to A.V. Roe. Davies was reportedly very keen to move to Canada to work on this project, and "everybody thought his services could be obtained," but Boyd and Bell were wrong. Sir Roy H. Dobson, managing-director at A.V. Roe, refused the Canadian request on the grounds that "neither Bell nor Boyd know present design development or production position here [in Great Britain]."[44] A.V. Roe was still working hard on the design and development of military aircraft of its own, and was unwilling to lose one of its top engineers to work on a postwar project in Canada. The fact that a suitable design team could not be obtained from Great Britain came as a shock to Bell who wanted to start work on the four-engine transport as soon as possible.[45] In the end, VAL entrusted the TCA project to its existing chief aeronautical engineer, W.U Shaw.

In the meantime, Air Vice-Marshal Anderson, the AMAS, began preparing the RCAF's transport aircraft specifications. The RCAF wanted the design to be very technically advanced so that it would not become obsolete by the end of the war.[46] In particular, it was interested in the heavy-lift capability of the aircraft, for it hoped that the machine would be able to carry the largest pieces of equipment used by the Canadian Army, such as the Churchill, Ram and Grizzly tanks, the Sexton 25-pounder self-propelled gun and the 6x6 CMP truck.[47] The AMAS issued a draft of the specification on 15 April 1943, calling for a long range, high-speed, military transport capable of carrying both personnel and equipment under any weather conditions.[48] It would not carry offensive or defensive armaments, nor bombs or depth charges. The specifications called

for a range of 4,500 miles fully loaded and a cruising speed of more than 300 mph at an altitude of 25,000 feet. A crew of nine located in a pressurized cabin would man the aircraft: three pilots, two navigators, two flight engineers, and two wireless operators. The desired aircraft would be able to carry a cargo load of 80,000 lbs. or a passenger load of 60,000 lbs, and its cargo bay would be large enough to carry a 26-foot long, 12-foot wide, and 12-foot high 40-ton tank. Provisions were also to be made to transport paratroopers, or to tow gliders. Operational requirements dictated that the machine be able to remain afloat in the event of an emergency landing on water. At least 30 per cent of the fully loaded aircraft was to serve as excess buoyancy, including the fuel tanks that could be quickly emptied and resealed.[49]

This draft specification was submitted for review to Squadron Leader F.S. Nowlan, the Director of Aeronautical Engineering (DAE). He concluded that the proposed transport aircraft would be too large, estimating that the smallest aircraft capable of carrying a cargo load of 80,000 lbs would require a minimum gross weight of 446,000 lbs, a wing span of 286 feet, and a take-off-power of 34,300 hp. Such an aircraft would be almost twice as large as the biggest experimental project in the United States at the time, the 265,000 lbs gross weight Consolidated XB-36 transoceanic bomber, and nearly three times as big as the next largest project, the 162,000 lbs. gross weight Northrop XB-35 flying wing bomber.[50]

The DAE explained that the most powerful engines then under development were designed to provide about 3,000 hp for take-off, meaning the draft project would require twelve engines. Even if 5,000 hp power units were developed in the near future, the aircraft would need no less than seven. The fuel consumption would be so great that the

aircraft would only be capable of achieving a cruising speed of 180 mph at 10,000 feet. Moreover, if the machine was to fly at the recommended cruising speed of 300 mph at an altitude of 25,000 feet, the increase in fuel load would reduce the payload to 10 per cent of the gross weight. In other words, the aircraft would become a flying gas tank. The DAE was also particularly concerned with the aircraft's loading capability:

> The carriage of a 40-ton tank in such a fuselage would mean a very large cross section and large skin openings which would be difficult to seal effectively when the aircraft is used for passenger-carrying. It would probably be impossible to have a two-deck passenger compartment ... which could be easily removed to provide space for stowing the tank. Loading of the tank would be very difficult unless there were a special nose as in the German Merseburg. It would be extremely difficult, if not impossible, to design a special fuselage to facilitate tank loading and also obtain the low drag characteristics necessary for long range flights.

Finally, the DEA felt that if such a huge aircraft was to perform a successful ditching at sea, its design would have to be extremely hydrodynamic, which would affect its size and weight.[51] For these reasons, and yet others, Air Vice-Marshal Ferrier, the AMAE, opposed the specification, writing:

> The cost of one 446,000 lbs. aeroplane, exclusive of engineering development costs, could not be less than $2,230,000. This is an optimistic figure based on the costs of series production. A prototype aeroplane would probably cost twice as much excluding engineering and development. Going back to the beginning of this whole matter, it is apparent that the main object is to ensure the continued existence of Canadian air power by creating and maintaining a Canadian aircraft industry which shall be capable of designing and producing AND SELLING useful commercial aircraft. I am firmly of the opinion that such an industry cannot be supported on the basis of aircraft of the scale which you have specified. TCA has drawn up a tentative specification which would call for a gross weight of about 100,000 to 120,000 pounds and a span between 120 and 140 feet, and I am morally certain that no Canadian commercial airline will be interested in any type very much in excess of TCA's specification. If my judgment is correct, this Department would be left as the only possible customer for the super aeroplane, and this would not achieve the object in view, namely air power based on an industry serving common interest of commerce and defence. Apart from all other

> considerations, I think it is asking too much of an infant industry, which at present time has little or no resources on the design side, to undertake a development away beyond the most ambitious development yet undertaken in a country like the USA with its vast resources of technical and research personnel.[52]

Air Vice-Marshal Anderson was shocked. "Our understanding was that this aircraft would be well in advance of any present day aircraft and that we should state what we would like it to do, without trying in any way to link it up with any aircraft now flying or under development." He felt the TCA specification was "very little ahead of aircraft now flying" and, for this reason, should not be used as a basis for an RCAF transport aircraft.[53]

Ferrier considered the TCA specification to be "a very reasonable one" that was somewhat more realistic than the AMAS' proposal, but also had doubts about the former. As he told Ralph Bell, a 100,000 to 120,000 lbs. gross weight aircraft would be nearly twice the size of the A.V. Roe York, one of the biggest transport aircraft produced by the British aircraft industry, that was about to be built under-license in Canada by VAL. Ferrier explained that such an aircraft "would be classed as big stuff even four or five years from now." Given that few of these huge aircrafts would be required by commercial airlines, he recommended instead the development of a medium size transport similar to the American Douglas DC-3, or its military counterpart, the C-47. "I have reason to believe that TCA will continue to have a need for a medium transport type [and] I cannot visualize a peacetime Canadian aircraft industry building only trainers and 'heavies.'"[54] Bell concurred with Ferrier.[55]

The division between the AMAS and AMAE led Stedman to reiterate his original request that Canada concentrate on the design and production of combat aircraft,

suggesting this time the development of a fighter and a long-range bomber. In his opinion, the Canadian aircraft industry should not rely solely on commercial aircraft projects. Stedman explained that lessons should be learned from the equipment problems the RCAF encountered in the early years of the war owing to Canada's dependence on foreign countries for military aircraft:

> Previous to the war the RCAF had through the government been committed at Imperial Conferences to the use of British types of aircraft for service purposes. The result of this was that very little aircraft construction had been done in Canada and when in fact we required aircraft for war purposes we found that none were available because they were all required by Great Britain. At this juncture we were forced to turn to the United States, and there we found that no aircraft were available because a Neutrality Act had been brought into force. These facts make it necessary that some consideration should be given to the desirability of building service aircraft in Canada for use by the RCAF ... The production of service aircraft in Canada would allow us to retain at the same time some of the manufacturing facilities ... that will be again necessary if we should be unlucky enough to get into another war at a later date.

Production of Canadian-designed combat aircraft would not only create a secure supply source for the RCAF, but would also promote the development of aircraft specifically suited to Canadian conditions and needs. Stedman anticipated that transport aircraft would be available in large quantities from American and British sources after the war, making it very difficult for the Canadian aircraft industry to compete, and that Canadian airlines requirements would be very small. Consequently, these could be purchased on the open market from any source available.[56]

Due to considerable divergence of opinion within the DND (Air) regarding the postwar manufacture of aircraft in Canada, Ferrier met with Anderson and Stedman. He reminded them that the Air Council had agreed not to embark upon the design and development of combat aircraft because the existence of a healthy aircraft industry in

Canada in peacetime depended upon the manufacture of training and transport aircraft suited to both commercial and military applications. Ferrier wanted to settle the issue with the other Air Council members before the special committee assigned to study the development of indigenous aircraft in Canada convened.[57]

The Committee on Postwar Manufacture of Aircraft

The first meeting of the CPMA, held on 7 June 1943, was attended by top representatives from the NRC, DND (Air), DMS, Department of Transport, TCA, and CPA. All agreed that the Canadian aircraft industry's survival depended on its capacity to create aircraft designs. Bell stated that "there is no reason why Canada should not be quite as capable as any other country to produce aircraft for sale anywhere in the world." As it was assumed that Canada would not participate independently in any war and that, based on past experience, it would use the same equipment as its allies, the Committee felt that the aircraft industry should not begin to design and develop combat aircraft in competition with other major powers. Rather, it should concentrate on the creation of aircraft adapted for both military and commercial markets. The Committee concluded that it was in Canada's interests to encourage the development of Canadian designed aircraft and, for this reason, the government "should adopt a policy which will provide initial contracts for at least the next ten years and for an adequate measure of continuity subsequent to the initial period." A Sub-Committee on Types of Aircraft was appointed to investigate the postwar requirements of the RCAF, TCA and CPA and to propose aircraft designs that could successfully be developed in Canada. A Sub-Committee on Finance, a Sub-Committee on Distribution of Work to the Industry, and a Technical Sub-

Committee were also mandated to study other aspects of the aircraft manufacturing process.[58]

The Sub-Committee on Types of Aircraft met in Montreal on 11 June 1943. In addition to representatives from the RCAF, TCA, and CPA, Robert Noorduyn, President of Noorduyn, was invited to represent the interests of Canadian aircraft manufacturers. The sub-committee first looked at the RCAF's requirements. Air Vice-Marshal Ferrier indicated that there would soon be a need for an elementary trainer, an advanced trainer, a twin-engine trainer, and a large high-altitude transoceanic transport. The elementary and advanced trainers were to replace the Cornell and Harvard, and Ferrier believed civilian flying clubs could also use them. Noorduyn was particularly interested in the advanced trainer, maintaining that his company could undertake such a project because of its experience with the Harvard. However, the sub-committee worried there would be little civilian interest, so these aircraft were given low priority. The twin-engine trainer seemed more promising, as it could be adapted as a civilian twin-engine utility aircraft. The RCAF required a machine of approximately 12,000 lbs. gross weight to serve as a flying platform for the training of air navigators, radio operators, and other aircrew. There was also interest in the transoceanic transport due to its potential use as a civilian airliner. This aircraft was similar to the one previously discussed by the AMAE and the AMAS, the difference being that its payload was reduced to 25,000 lbs in freight or passengers.[59]

The discussion then turned to the requirements of the Canadian airlines. J.T. Bain of TCA stated that his company was interested in a twin-engine 35,000 to 40,000 lbs. gross weight intercity/cargo transport capable of carrying 30 to 40 passengers and having 800 cubic feet of cargo space. The aircraft would have a range 1,200 miles. TCA also had a

requirement for a four-engine, high-altitude, transoceanic/transcontinental transport of 100,000 to 120,000 lbs. gross weight capable of carrying up to 65 passengers and 18,000 lbs. of cargo.[60]

L.B. Unwin and C.H. Dickens of CPA indicated that their company was interested in five different types of transports. The first was a large four-engine 100,000 to 120,000 lbs gross weight high altitude transoceanic transport capable of non-stop flight between Great Britain and Montreal or New York, with a maximum range of 4,500 miles. Each engine was to be of 2,500 to 3,000 hp. The aircraft was to have a crew of four, be capable of carrying a 22,000 lbs payload (up to 100 passengers seated or 50 with sleeping accommodation as well as 10,000 lbs of mail or freight in its cargo bay). The second was a smaller four-engine transcontinental transport similar to the American-designed Curtiss C-46 Commando and Douglas DC-4, for the North and South Atlantic routes, and the trunk routes of the British Empire. The third was a 45,000 to 50,000 lbs. gross weight twin-engine inter-city transport similar to the American-designed Douglas DC-3 with a range of 1,500 miles. The aircraft was to be capable of carrying up to 40 passenger and room for 1,500 cubic feet of cargo space. The fourth was a small 15,000 to 20,000 lbs gross weight twin-engine general utility transport for local or feeder line service, capable of transporting 14 passengers and 1,500 lbs of freight or 4,000 lbs of mail and freight over a range of 1,000 miles. It was also to be designed for conversion to skis, wheels, or floats. The two CPA officials noted that their company "would require larger numbers of this twin engine utility than any other type of aircraft." The first was a small single-engine 7,000 to 9,000 lbs. gross weight general utility transport capable of operating on floats, wheels or skis to replace the Noorduyn Norseman. CPA also showed interest in

helicopters (to replace general utility transports in the bush) as well as transport gliders that could be towed by special tug aircraft.[61]

After careful consideration of all parties' requirements, the members of the sub-committee recommended the development on a low priority basis of an elementary trainer and a single engine advanced trainer for the RCAF. They also recommended a 15,000 lbs. gross weight twin-engine general utility transport aircraft, and a 50,000 lbs. gross weight inter-city transport that could pave the way for a larger four-engine transoceanic aircraft project. While there were no immediate requirements for a Norseman replacement, the sub-committee agreed that a single-engine utility aircraft in the order of 7,500 lbs. gross weight "was an essential type" and that "its development should be kept up to date."[62] These recommendations were presented at the second meeting of the CPMA on 30 June 1943, where members also recommended that DMS authority be sought to enter into agreements with Boeing Canada, CCF, Canadian Vickers, DHC, Fairchild, Fleet, and Noorduyn to prepare preliminary designs for these five projects.[63]

In the meantime, the Technical Sub-Committee on Postwar Manufacture of Aircraft discussed in length the design and development of large transport aircraft. The sub-committee agreed that aircraft produced in Canada "should utilize as much as possible Canadian facilities for equipment manufacture" and "Canadian produced materials," but worried that the Canadian aircraft industry did not possess the necessary experience or facilities to design and develop the required transports. J.T. Bain of TCA noted that no Canadian company had sufficient data to develop a large aircraft. He feared that instead of designing and developing their own machines, the designers would be compelled to

approach American or British manufacturers with experience in the production of large transports. In other words, it was highly probable that the designer would merely convert existing types of aircraft. "Either we are going to get a composite aircraft with components from various countries or else a very dubious aircraft," said Bain who reported that even large American aircraft makers such as Lockheed were not completely self-sufficient, for almost half of their transport aircraft parts and components (such as engines, electric instruments, hydraulic systems, and other accessories) came from outside sources. Based on these numbers, Bain explained that if Canadian manufacturers were to obtain about half of the components needed for their large transport from outside sources, combined with the wings, panels, and other parts from existing foreign-designed aircraft, the proposed Canadian-made transport would in fact consist of 90 per cent foreign materials.[64] E.J. Carlisle of CPA added that small Canadian aircraft firms would essentially become each other's subcontractors. Moreover, the probability that each of the selected seven Canadian aircraft firms would be able to produce seven different designs seemed highly unlikely. Carlisle felt it was wiser to concentrate on smaller types of aircraft, such as twin-engine utility transports.[65]

In the meantime, Escott Reid of the Department of External Affairs questioned the work of the CPMA and especially the promotion of indigenous transport aircraft production. "There is, I am afraid, some danger that the committee may be proceeding on assumptions which are contrary to the general principles of international economic policy favoured by the government," he explained to Norman Robertson, the Under Secretary of State for External Affairs. That assumption was that Canadian airlines would have to buy their aircraft from Canadian companies after the war, a practice that would constitute "an

attempt by Canada to monopolize the aircraft market in Canada." He felt airlines' efficient and economical service rested on their ability to get the best aircraft available at the cheapest price, at home or abroad.[66]

Reid then attacked VAL's four-engine transport aircraft project that was underway following the TCA specification of 15 February 1943. According to him, the rationale for going forward with this aircraft was that it might be useful in the event of a long war, or that there could be a shortage of large transports in the postwar. "I think that consideration might usefully be given to revising the decision," Reid told Robertson.

> Any prototype which is begun this year will not be coming off the assembly lines for another three or four years. In view of the development in the European theatre of war, it would appear highly improbable that the European phase of hostilities will still be on in three or four years' time. Consequently, it would seem likely that transport aircraft will be available from United States factories in three or four years time. If they are not, we are in any event constructing Yorks in Canada and they could serve as a stop-gap until long-distance aircraft are available from the United States or Great Britain. It would seem most unlikely that we could succeed in building in Canada with our limited resources a four-engine long distance craft which would be as good as a United States or British craft at the same price. If this is so, should we not concentrate on the production of types of aircraft in which we might have a reasonable chance to compete successfully in world markets? The only plane which is now being built in Canada which is of Canadian design and of which the license is held in Canada is the Noorduyn Norseman which is a one-ton truck of the air and is an all-purpose craft being fitted with wheels, skis and pontoons.[67]

Reid added that American aircraft manufacturers believed that their most important postwar markets would be in Latin America and Canada, meaning the competition for Canadian aircraft manufacturers would be intense. He concluded by indicating that CPA felt that the best postwar passenger aircraft would be the American-designed Douglas DC-4. VAL nonetheless pursued work on the four-engine transport.

In fact, the VAL project attracted interest in Australia, where the press carried a dispatch from C.D. Howe announcing "that four-engine transport planes were being designed for production in the next years." Ivan N. Holyman, Managing Director of Australian National Airways, expressed interest in equipping his airline with the proposed Canadian-designed transport. "This is of considerable interest to me as under normal conditions, we would obviously give preference to Empire productions for our future requirements."[68] In response to his request for additional information, Canadian authorities suggested that he correspond with TCA.[69] It was even proposed that the Australian and Canadian governments cooperate on this particular project because both countries had build up a strong aircraft industry during the war. The difference was that the Australians had designed and developed their own line of combat aircraft, which included the Boomerang fighter and the Woomera bomber, and were manufacturing aircraft engines. Therefore, a joint program would benefit the Canadian aircraft industry. As T.C. Davis, High Commissioner for Canada in the United Kingdom, commented: "A reciprocal deal could be made with Australia whereby we would furnish her with the planes she requires and she, in turn, could furnish us with the engines which we might require."[70] Yet, Ralph Bell could not accept that the Canadian transport project turn into a joint Australian-Canadian initiative since the program was intended specifically to prepare the Canadian aircraft industry for the postwar. The response was negative. "We do expect to be actively engaged in the production of transport," Bell told the Australians in mid-September 1943, but "we are not in a position to give any precise specification of what will be built in Canada in the transport field."[71] The Australians made no further enquiries about the project.

As work continued on the VAL transport, the CPMA moved forward with the design and development of the two trainers and three transports agreed to on 30 June 1943. At its third meeting held on 15 October 1943, the committee sent two recommendations to C.D. Howe. First, the government should take immediate steps to grant contracts for the preliminary design and development of the five aircraft types previously selected by the CPMA. The committee noted that Boeing, CCF, Canadian Vickers, DHC, Fairchild, Fleet, and Noorduyn were capable of doing this work. Second, that upon satisfactory completion and approval of preliminary designs, contracts be immediately issued for the construction of a sufficient number of prototypes. The CPMA also asked that the government take necessary steps to maintain adequate design and engineering staffs in the country for a period of ten years.[72]

The CPMA was presented with a list of the types of aircraft each Canadian aircraft manufacturers was willing to design and develop. Noorduyn was interested in pursuing three types of aircraft: a single engine medium weight transport, a twin-engine medium weight transport adapted to Canadian conditions, and an advanced trainer. DHC wanted to work on a twin-engine feeder line transport of 6,500 lbs. gross weight and a five-seat single engine aircraft of 3,500 lbs. gross weight, whereas Fleet was interested in a trainer similar to the Cornell and a twin-engine transport adapted to the requirements of the Canadian north. For its part, Fairchild was interested in a light twin-engine transport and a twin-engine inter-city or feeder line aircraft. Finally, CCF remained committed to Burnelli type aircraft. Boeing and Canadian Vickers had still not made any decision as to what type of aircraft they hoped to design and produce.[73]

The CPMA's decision to concentrate on trainers and small transports, and to postpone the development of a four-engine transoceanic transport, caused some resentment in military circles, namely among the air staff. To make matters worse, the Canadian press announced in mid-October 1943 that the British Ministry of Aircraft Production (MAP) had approved specifications for the construction of a very long-range transoceanic transport of more than 316,000 lbs gross weight (capable of carrying a 30,000 lbs payload over a range of more than 5,000 miles) to be built by the Bristol Aircraft Company. The British specification called for a transport aircraft similar in size to the one originally suggested in the Canadian Air Staff draft specification of 15 April 1943, which was said to be "quite beyond the capacity of Canadian industry to build" and was rejected in favor of the smaller TCA proposal. Air Commodore K.M. Guthrie, Deputy AMAS, pointed out that the original RCAF proposal was "in line with probable postwar developments, as indicated by the MAP proposal." Guthrie commented: "If Canada is to enter into international aviation as the fifth ranking airpower of the world and is to produce her own aircraft, we have to prepare and pay for the development of a heavy transport aircraft of a more advanced design than those now contemplated by TCA et al. The alternative is, of course, to manufacture small types for our domestic use and trust, as poor relations must, to others to provide us with the large long range type necessary for transoceanic flying. I am afraid these may be obsolescent when we get them."[74] He concluded: "I still think that a very long range transport type with a payload of 35,000 to 40,000 lbs. will be required in the future for both service and civil air transport work."[75]

Ferrier replied that Ralph Bell, who recently returned from a trip to Great Britain, had indicated that the British transoceanic transport project "is still hardly out of the dream stage" and that its engines "are in the most embryonic stage of development." He explained that although he never considered the aircraft described in the Canadian air staff specification to be impossible to build, he supported the opinion of the CPMA that "Canadian technical resources are not yet sufficiently developed to justify consideration, in the next few years, of anything beyond the inter-city transport of the order of 50,000 lbs all-up weight." Ferrier added that an arrangement had been made between the DMS and VAL for the development of a large four-engine transoceanic transport aircraft design; however, the progress of this project had, "up to now, been very small." The problem was that VAL had been unable to augment its small design staff with competent recruits to accelerate the development process, as few experienced American or British aircraft designers were willing to abandon their prosperous careers to come to Canada to work on the VAL transport project without a guarantee of future work.[76] Bell told Ferrier a few days later that "arrangements are presently in a very fluid state" and that "very little progress has been made with this deign, mainly because the DMS and VAL have been unable to secure the necessary technical staff to push the project with any speed."[77] Ferrier concluded that "the important thing is to get hold of a design staff which can be kept and employed continuously in Canada and such an object cannot be achieved by confining attention to one type."[78]

At the same time, VAL was manufacturing under-license an A.V. Roe York transport prototype. The York had been originally designed to meet British Air Ministry specifications and had a capacity for carrying troops and cargo. Ferrier believed that the

York might be better suited to meet RCAF needs than an aircraft designed to meet the requirements of commercial operators, as was the case with the TCA transport aircraft project. If the AMAS agreed, he proposed to place an order for a certain number of Yorks, which could be delivered much sooner than the proposed TCA transport aircraft expected in four or five years. If, however, the design and manufacture in Canada of a transport aircraft of more than 100,000 lbs. gross weight, such as the one laid out by the TCA specification, was a firm requirement for the RCAF, Ferrier recommended that the DND (Air) immediately issue a contract demand for the construction of a prototype to cost between $1.5 and 2 million.[79] In the end, the RCAF did not adopt the York and, as a result, the DMS suspended the production of this aircraft in Canada.[80] Nonetheless, VAL was asked to complete the prototype, which only flew in November 1944.[81]

Ferrier felt that the CPMA's decision to concentrate on the development of five different types of aircraft was sound. After all, the British government had done essentially the same in the spring of 1943 when the Brabazon Committee delivered its first report. This group of experts, working under the leadership of former Minister of Aircraft Production Lord Brabazon of Tara, had been asked to draw up proposals for various types of transport aircraft likely to be required by British civilian airlines in the postwar years. The committee called for the development of four different types: a 200,000 lbs. gross weight long-range transoceanic transport (with a parallel bomber program); a 120,000 lbs. gross weight medium-range transport; an inter-city feeder line transport similar in size to the Douglas DC-3; and a smaller transport resembling the De Havilland Flamingo for local service.[82] The committee later added a large jet-powered

transport and a small general-utility aircraft. The activities of the Brabazon Committee resulted in several British postwar transport projects.[83]

Conclusion

In the end, wartime frustrations with the licensed production of American and British-designed aircraft in Canada, combined with an increased realization that the war might be over soon, led the Canadian government to consider ways of strengthening the Canadian aircraft industry and improving its design and development capabilities. This was particularly important if Canadian aircraft companies were to successfully compete against foreign manufacturers in postwar markets. The creation of the CPMA in early 1943 and the decision to go ahead with the design and development of indigenously designed aircraft, showed the determination of government officials to prepare the industry for postwar years, namely by initiating projects such as trainer and transport aircraft that could have both commercial and military applications.

NOTES

1 "Hawker Siddeley Buys Victory Aircraft: Canadian Firm will Operate Malton Plant," *Commercial* Aviation, Vol. 7, No. 7 (August 1945), p. 22.

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16 LAC, RG-28, Vol. 156, File: 3-P-12-11, "Alfred Sewart (VAL) to Ralph P. Bell," 10 February 1943.

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34 LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to C.P. Edwards (Deputy M of T)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to A. Ferrier (AMAE)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to J.H. Parkin," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell toH.J. Symington (President, TCA)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to L.B. Unwin (President, CPA)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to R.B.C. Noorduyn (Vice-President and General Manager, Noorduyn)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to Stanley Burke (President, Boeing Canada)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to V.M. Drury (President, CCF," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to David Boyd (General Manager, VAL)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to H.M. Pasmore (President, Fairchild)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to P.C. Garratt (Managing Director, DHC)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to B.W. Franklin (Assistant General Manager, Canadian Vickers)," 8 April 1943; LAC, RG-28, Vol. 155, File: 3-P-12-1, "Ralph P. Bell to W.N. Deisher (General Manager, Fleet)," 9 April 1943.

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CHAPTER FIVE

THE DOMINION OF THE AIR

> The demands of war have telescoped into four or five years the growth that might normally have taken air transport a generation to achieve. Canada's size is shrinking, while our long 3,000 miles frame is filling out as air transport opens up the Canadian north. All Canadians are becoming neighbours, and Canada is being given a new basis for unity. What is true of relations between the various parts of Canada is true also of relations between the nations of the world. These, too, are being brought closer together. Moreover, new regional connections are being developed, and the boundaries of old regions washed away. Because of the geographical location of the land masses of the earth ... Canada occupies a strategic position, for it stands athwart most of the air routes linking North America with Europe and Asia. This position carries with it great responsibilities and great opportunities.[1]
>
> – C.D. Howe, Minister of Munitions and Supply

The creation of the CPMA illustrated the Canadian government's willingness to encourage the design and development of aircraft in Canada, as a strong postwar Canadian aircraft industry was deemed essential for economic, industrial, political, and military ends. Most government officials believed that Canada's postwar needs were for large transoceanic transports, which could have both military and civilian applications. The Canadian government gave the task of designing and developing such aircraft to one of its Crown Corporations, VAL, which came up with several conventional designs.

Private aircraft companies such as CCF and Fairchild also worked on similar projects, and proposed more unorthodox aeronautical concepts, such as lifting fuselages and flying wings. None of these aircraft were ever built, but they nonetheless provided the Canadian aircraft industry with valuable experience in the aeronautical design and development field. This chapter examines the work undertaken on the design and development of large transoceanic transports between 1943 and 1945.

The Victory Transports

For more than six months, VAL had been working to design and develop a four-engine transoceanic/transcontinental transport of about 100,000 to 120,000 lbs gross weight that met TCA's specification of 15 February 1943 (Chapter 5). Moreover, since early 1943, the company had been working on the conversion of Lancaster bombers into civilian transports for TCA. This was an interim project pending delivery of the first 100,000 to 120,000 lbs gross weight transport to the airline. The re-engineered aircraft, dubbed the Lancaster XPP, incorporated a new nose section with front-loading doors, a revised interior for carrying passengers, long-range fuel tanks, and a redesigned rear fuselage. The Lancaster XPP prototype made its maiden flight on 9 September 1943.[2] The DMS was impressed with this aircraft and, in early October 1943, asked VAL to abandon its 100,000 to 120,000 lbs gross weight transport aircraft project "and in lieu thereof to investigate the possibility of designing a [new] transport based upon Lancaster bomber wings and other parts, but having a pressurized fuselage." This owed largely to the CPMA's recent decision not to proceed with the immediate design and development of a large transoceanic transport. The proposed hybrid aircraft, which was to be "in all

respect modern," was clearly meant as a temporary project. The advantage was that it could be produced faster and cheaper than a completely new aircraft design, as it would use existing Lancaster components. Since parts of the aircraft could be build on the same assembly line as Lancaster bombers, there would be no need to re-tool the VAL plant, meaning huge savings in time and money. Furthermore, the production and distribution of such an aircraft could likely be done before the end of hostilities, thereby filling the needs of TCA, CPA, and the RCAF. Finally, from a military standpoint, this aircraft would ensure a degree of standardization, which would facilitate logistics in the field.[3]

W.U. Shaw, VAL's chief aeronautical engineer, examined the proposal and commented in a 14 October 1943 report. He proposed two distinct variants of a 61,000 to 63,000 lbs. gross weight aircraft that would incorporate many of the Lancaster's components, and named the new aircraft the Victory 5 because it was the fifth design laid out by VAL (after the Anson, the Lancaster, York, and the large transport designed for TCA). The first Victory 5 version was to be used for transcontinental flights with a maximum range of 2,400 miles. It would carry 33 passengers, a crew of six, and up to 6,500 lbs of extra cargo. The second version of the Victory 5 was to be used for transatlantic operations. It would carry 15 passengers, a crew of five, and 1,525 lbs. of luggage. Its maximum range would be 3,000 miles. In the end, Shaw did not recommend the second version, pointing out that its range would be far below the ideal required for transatlantic travel. He added that operators of a transatlantic aircraft would insist on a fuel capacity sufficient for a 4,500 miles range, which could not be obtained with a sensible payload for any aircraft of less than 80,000 lbs gross weight. Shaw maintained

that VAL's original 100,000 to 120,000 lbs gross weight transport, which the DMS had recently requested abandoned, "was ideal for transatlantic operations."[4]

David Boyd, General Manager at VAL, supported this conclusion. He told Ralph Bell that "investigations and studies made to date indicate that it will be necessary to have an aircraft of at least 40-tons gross [88,000 lbs] to operate a transatlantic service with reasonable economy and safety and it would appear further than an even larger aircraft of approximately 50 tons gross [110,000 lbs] would be desirable."[5] After much discussion, the DMS granted VAL authority to continue work on its transatlantic transport, which became known as the Victory 7, and to initiate the development of a smaller inter-city/transcontinental commercial transport for domestic service to be called the Victory 9. This aircraft would be somewhat similar to the transcontinental Victory 5 and would similarly incorporate Lancaster wings and components.[6] VAL began working intensively on both design projects.

In early December 1943, W.U. Shaw told Ralph Bell that he had just completed the design of the Victory 9, which he described as "a high mid-wing Lancaster with [a] ... cylindrical fuselage and extended centre section." Bell immediately requested an official VAL design proposal and sketches, as the DMS wanted to forward these as soon as possible to Roy Chadwick, chief designer at A.V. Roe in Great Britain, for "comments and criticism."[7] This decision illustrated the government's mistrust of Canadian design and development capabilities. Many officials believed that Canadian projects needed British supervision given Canadian companies' lack of aeronautical engineering experience. At the same time, C.D. Howe and Bell had previously discussed the design of a cylindrical transport fuselage with Chadwick and top A.V. Roe officials, and they

felt obliged to keep them informed of all Canadian developments, especially since the British company was also working on civilian variants of the Lancaster. "We should be working together and not separately," Bell told VAL's general manager, "unless, of course, you have good reasons for wanting to keep quite independent on this thing and are thoroughly satisfied that Shaw and his group are competent beyond any shadow of doubt to set up such a structural change in the machine without Chadwick's approval."[8] Shaw did not entirely agree, as he replied to his general manager: "The policy of sending information to the chief designer at A.V. Roe, of course, will rest with yourself. I have no objection personally to you doing so, but I should like to know if this company [VAL] is going to stand on its own feet no matter how difficult that will be, or are we going to take dictation on future design problems from the parent firm [A.V. Roe]."[9]

On 13 December 1943, Shaw issued his design proposal for the 63,000 lbs gross weight Victory 9 inter-city/transcontinental transport. The aircraft was to use a number of Lancaster components, namely the outer wing panels, wing tips, power plants with nacelles, undercarriages, fins and rudders, as well as a large percentage of the flight and engine controls. New components in the design included the fuselage, wing outer sections, tail plane, and elevators. The proposed fuselage was to be circular to enable the cabin to be pressurized, and a continuous floor was to run the full length. The proposal called for two rows of double passenger seats on each side of the cabin. The maximum number of passengers that the Victory 9 could carry was 33 in seats, or half this number in berths, and crew of six. Accommodation inside the aircraft included two washrooms and adequate stowage space at each end of the cabin. The cargo space, to be located

below the cabin floor, was to carry 3,100 lbs of cargo; the aircraft's cargo version could transport a payload of up to 7,650 lbs.[10]

The Victory 9 was to be fitted with mid upper wings to "allow all passengers to have a downward view without wing interference, since all windows are below the wing level." In addition to this scenic advantage, the wing concept proposed to bring the fuselage closer to the ground upon landing, which would ease the loading of passengers and cargo and facilitate maintenance. Powered by four Rolls Royce Merlin engines, the aircraft would be capable of reaching speeds of up to 250 mph at an altitude of 16,000 feet, and have a range of 3,624 miles. Although intended primarily for inter-city and transcontinental operations, transatlantic operations "could be achieved by adding extra fuel tanks in the lower cargo compartment of the fuselage and reducing the payload accordingly." A transatlantic version of the Victory 9 would be crewed by only five people and would carry a maximum of 12 passengers and 635 lbs of cargo, but fuel capacity would be raised from 15,000 lbs to 21,000 lbs.[11] Shaw's Victory 9 design proposal was sent to the DMS' Aircraft Production Branch on 14 December 1943.[12]

The Victory 7 design proposal was only issued on 5 January 1944. It called for a 105,000 lbs. gross weight four-engine transatlantic transport based on TCA's specification. The Victory 7 would be a four-engine all-metal monoplane powered by four 2,000 hp engines, which would enable the aircraft to reach up to 225 mph and a range of 4,500 miles. It would be fitted with mid-upper wings, said to provide "for superior aerodynamic qualities, a fuselage close to ground level for ease in loading cargo and passengers ... [and] all passengers [enjoyed] ... an uninterrupted window view downwards." The pressurized fuselage was to be circular, except for the center portion,

which deepened at the cargo compartment. The aircraft was to have a crew of five, located in the flight compartment in the nose of the aircraft. This compartment's windows would have double safety glass and be equipped for anti-icing, de-frosting and anti-glaring.[13]

The Victory 7 was to transport 48 passengers. For overnight travel, the aircraft could carry a maximum of 24 passengers, each provided with individual berths that could easily be converted into seats during flight. It was also possible to arrange a combination of berths and seats. The cabin was to be air-conditioned, insulated for heat, sound and vibration, and have sufficient stowage space for personal luggage. The passenger entrance door was to be sufficiently wide to permit loading bulky freight (when cargo is to be carried inside the cabin) and the space under the passenger compartment floor would be available for cargo. Overall, every effort was to be made "to produce an aircraft which is efficient and yet simple in construction, provides the maximum amount of serviceability for the operator, and safety with comfort for the passengers."[14]

The Victory 7 design proposal was submitted to the Aircraft Production Branch on 10 January 1944.[15] The CPMA acknowledged receipt of the Victory 7 and Victory 9 design proposals at its fourth meeting held on 20 January 1944,[16] but in the months that followed, VAL halted all further work on these projects to concentrate on re-engineering the York to a new specification laid down by TCA.[17]

The Victory 7 and Victory 9 design proposals completed, Ralph Bell felt optimistic about the future of the Canadian aircraft industry. Such was evident in an article he wrote entitled, "Great Opportunities Lie Ahead of Canada in World Aviation" published in the *Montreal Gazette* on 5 January 1944.

> Geographically Canada is the keystone of the arch of aerial transportation between the most important centers of the world. For our population we probably have the greatest background of knowledge and experience in 'northern' flying of any country on the globe. Relative to our population we will come out of this war with the largest proportion of trained airmen of the Allied nations. Our aircraft industry has conclusively demonstrated that it is capable of building the largest and most complicated types of operational aircraft in the world today ... Canada had an aircraft industry in the last war, but it was allowed to die. A similar situation must not be allowed to develop this time. Now is the time to start thinking, planning and working to prevent it ... Given a fair field and a reasonable chance, I believe ... our aircraft industry will once more demonstrate that we Canadians possess the ingenuity, resourcefulness, determination, and skill to successfully compete against all comers. But we must invest ourselves in the fields of design and increased efficiency for competition in aircraft in the postwar era is going to be of the most intense character imaginable and the Canadian aircraft industry can compete successfully only if it builds cheaper and better than its competitors.[18]

Bell felt that Canada was approaching a crossroads: "Are we at war's end to allow the valuable technique and experience thus acquired to lapse, and become dependent on other countries for the planes to supply our transportation needs and provide the defence of the Dominion? Or will we this time seize the opportunity that fate has offered us and forge ahead to still greater accomplishments in what promises to become one of the greatest fields of industrial development in the decade that lies ahead?" He concluded by stating that "the part that Canada will play in the field of aerial world transportation and the position our aircraft industry maintains in the postwar economy will in large measure determine the relative position we continue to maintain in world trade."[19]

Meanwhile, in January 1944, the RCAF examined the proposed development of postwar transport aircraft in Great Britain and the United States. The general observation was that large high-speed aircraft were popular, though this attraction may have stemmed more from nationalism than from concrete commercial requirements. Air Vice-Marshal Stedman reported that "it is quite possible that a country determined to capture air trade

might be prepared to operate the air lines at a loss for reasons of national prestige or for purely strategic reasons." On the British aircraft industry, he noted that with the exception of the York, there had been little progress in regard to future civil transports up to the summer of 1943. At that time the British government realized that the United States had made tremendous advances in the field of air transportation thereby placing it in a leading position in postwar aviation. The British government was determined to protect its aircraft industry so it began to pay greater attention to civil aviation. In September 1943, the British initiated a program for the design and development of four types of postwar transports aircraft. This included a very long-range "luxury" transport, an empire trunk line transport, a feeder line or intercity transport, and a smaller transport. In the winter of 1943-1944, a technical mission headed by Sir Roy Fedden visited American and Canadian aircraft industries leading the RCAF to expect that British work on transport aircraft would increase in the near future.[20] As for the United States, Stedman reported that it "is rapidly placing itself in an unassailable position of importance in the aircraft industry." He drew attention to the magnitude of American aeronautical research facilities, which included the government-owned NACA facilities, those of the USAAF, and the work conducted in the field of aeronautics by American aircraft companies, universities, and institutes of technology. Stedman noted that in the past years, a great number of large transports had been designed for postwar applications in the United States, ranging in size from 50,000 lbs to 400,000 lbs gross weight.[21]

In order to successfully compete with American and British aircraft manufacturers in postwar markets, Stedman claimed that Canada would need to develop a 200,000 to 250,000 lbs gross weight transatlantic transport, a 100,000 to 120,000 lbs gross weight

transcontinental transport, a 62,000 lbs gross weight intercity transport, helicopters, and transport gliders. He thus pointed out that "it seems undesirable to restrict our Canadian air lines to the use of aircraft manufactured in Canada when there will be a much bigger choice available from elsewhere." He suggested that Canada concentrate on the design and development of military aircraft for security reason. As he explained:

> There is some doubt whether the demand for civil aircraft of types manufactured in Canada would be great enough to enable us to compete with other countries manufacturing in greater quantities and probably with a better product to sell. Therefore, it seems undesirable for us to manufacture civil aircraft, except such types as are peculiar to Canadian condition, for example the Norseman and small or local aircraft. Experience at the beginning of the war showed that it was impossible for us to obtain aircraft when they were most required, from Britain because they were attacked, or from the USA because they had a Neutrality Act. If there is another war in Europe, and I have no doubt that there will be, then there is every reason to believe that England will be suddenly attacked and her industries crippled. This will leave Canada the manufacturing task of providing for her own defence and contributing to the defence of the Empire. These arguments point to the necessity for Canada to retain the art of building service aircraft, and to develop the art of designing new types of service aircraft.[22]

Stedman recommended that the Canadian industry produce new types of fighters and bombers with all their equipment to supply the needs of the RCAF during peacetime and to continue to regularly produce new aircraft designs: "We would at least have an established industry, producing warlike aircraft, that could quickly change to a new imported design if necessary, but could in the meantime provide us with something to go on with."[23]

To this, Bell replied that the Canadian aircraft industry had the capacity to provide for any RCAF requirement. The challenge, however, was to maintain strong aircraft design staffs in the country in peacetime:

> There is no reason why Canada cannot, and should not, design outstanding types in spheres other than that to which the Norseman caters, and the crux

> of the whole question of the postwar future of the aircraft industry in this country lies in that one point, the establishment and protection of adequate design staffs in this country. If we look only to the market within Canada, this country can never support an aircraft industry; if we look to the world, and plan accordingly, there is no reason why we should not establish for ourselves a vanguard position in the aircraft field ... We have definitely proven that the Canadian aircraft industry can manufacture the most highly complicated types of aircraft used in this war, and that the quality of workmanship is fully the equal of anything turned out in the United States, or England. The disadvantage that we labor under during the war is that the orders to the United States plants are from five to ten times the size of orders received by us, and the rate of production is on a similar basis ... When you come to the postwar era, when orders for aircraft will be on the basis of 10, 20, 50, 100, and rarely more than 200 planes of a type at a time, then, in my opinion, Canada will have a decided advantage. Our plants are all new, and are equipped with the most modern tools in the world, and are of far better size for orders such as I envisage in the postwar period than are the enormous plants in the country to the south of us.[24]

Bell felt that the Canadian aircraft industry could compete, but the challenge lay in maintaining itself in the forefront: "The only thing it requires ... is designs of its own, that will compete with United States or British designs, and, to that end, it is imperative, from the aspects of national defence, transportation, and trade and commerce, that Canada take immediate steps to establish a policy which will enable the industry to create and maintain the requisite design teams."[25]

In the meantime, the DAE investigated the Victory 7 aircraft project thoroughly to determine its suitability for the RCAF. The report he submitted in February 1944 was not good, as he concluded that the "range performance of the aircraft would be rather less than that estimated by the company." The report emphasised that "an aircraft of the proposed layout, designed from a gross weight of 105,000 lbs., would not carry the desired payload (8,000 lbs.) over the specified still air range (4,500 miles)." The DAE estimated that the maximum range for an aircraft of this size, carrying 36,000 lbs. of gasoline, would hover around 4,000 miles. The major problem was that the aircraft's high

wing configuration would create too much drag and increase tare weight. The configuration also made the landing gear's undercarriage legs excessively long, making them heavy and difficult to store. Moreover, the ten-foot long engine nacelles, which had been designed to provide enough room for the stowage of the undercarriage legs, seemed too high. The DAE explained that if the nacelles were longer than needed to accommodate the power plant and engine accessories, the propellers would be too far ahead of the center of gravity, creating a destabilizing effect on the entire aircraft. The only way to resolve this problem was to lengthen the fuselage or increase the size of the horizontal and vertical tail surfaces, but either option would increase tare weight and parasite drag.[26]

The DAE therefore recommended a low wing configuration for three key reasons: the undercarriage would be shorter and lighter; there would be increased safety in the event of a crash; and the tail surfaces would be better located with regard to the wing wake. He noted with implied sarcasm: "It is not considered that the improved passenger vision in a high wing monoplane is an important factor in transoceanic aircraft flying at altitudes of 20,000 to 25,000 feet." The DAE also recommended that the undercarriage legs be shortened to lower the fuselage closer to the ground. Acknowledging that "this would tend to make stowage of mail, express and freight, in the luggage compartment, somewhat more difficult," he suggested that "in the case of very long range aircraft, this inconvenience is more than balanced by the decreased undercarriage weight that would result from the use of shorter legs." Finally, the DAE requested a review of the tail volume coefficient of the aircraft, an increase in the aspect ratio of the wings, and a revision of the gross weight of the entire aircraft.[27] The DAE's report was discussed at

the next meeting of the CPMA's Technical Subcommittee, which took place on 28 February 1944. [28] The Subcommittee felt that the information and data supplied by VAL "is insufficient to permit any useful appraisal of the possible merits and shortcomings of the proposed aircraft." It largely concurred with the DAE, pointing out that based on the limited information at hand VAL had overestimated the range of the aircraft and underestimated the tare weight. It also suggested that VAL consider increasing the aspect ratio of the wings, as well as the tail surface area. Finally, it recommended the making of a scale model of a revised aircraft for testing.[29]

VAL was not at all pleased with these two bodies' conclusions. David Boyd reported to Ralph Bell in March 1944 that the Victory 7 and Victory 9 design proposals should be seen as VAL's "preliminary exploration of the problem placed before us" under Order-in-Council PC 1720 to design and build a prototype transport aircraft that met the TCA specification. He noted that in the absence of any clear direction from the DMS, TCA, and even the Privy Council Office, VAL prepared two design proposals as "a very general outline of two possible aircraft, with a view of obtaining some direction as to what we were expected to produce. Neither of the reports referred to were intended as a summary design and it is unfortunate that the Committee on Postwar Aircraft Manufacture erroneously assumed that they were complete submissions." He stressed that both the Victory 7 and Victory 9 conformed to the basic specification laid down by TCA. Boyd offered to have his company prepare a more detailed design report on the two transports, but the issue was not pursued.[30]

The CCF Transoceanic Transports

Other Canadian aircraft companies were planning their postwar operations, specifically looking into the possibility of designing and developing their own lines of transport aircraft. CCF was the most ambitious as it planned to develop an entire line of large transoceanic transports that would use the Burnelli lifting fuselage principle. The company was not dissuaded by the failure of its CB-34 and MB-2 projects, and decided to pursue work on an even bigger aircraft. The project began in 1941, when CCF's Charles Villiers unveiled two large six-engine transoceanic transport designs of 220,000 lbs gross weight: the more conventional V-1000, and the B-2000, a Burnelli-type lifting fuselage aircraft. CCF hoped to manufacture the B-2000 in the near future and designed the V-1000 as a possible alternative should they encounter problems with the former.[31]

The B-2000 was a high wing monoplane with an air-conditioned pressurized cabin, thin outer wings, and empennage supported on twin booms. This long-range transport was to be capable of carrying 160 passengers and 22,000 lbs of freight, and of flying over a range of 4,500 miles. It was to be powered by six 3,300 hp Pratt & Whitney Super Wasp engines (to be replaced with four 5,000 hp engines when available), enabling the aircraft to reach a maximum speed of 310 mph. To meet transoceanic requirements, the B-2000 would be equipped with deluxe reclining chairs or convertible sleeping berths. The aircraft's windows would allow excellent passenger visibility. Freight loading and passenger entry was to be effected by a ramp situated at the center section of the body trailing edge.[32]

CCF even proposed to produce a heavy transoceanic bomber version of the B-2000, known as the B-2000-B. The aircraft was reportedly designed in response to a

USAAF 1941 requirement that was meant to compete with the huge American-designed 265,000 lbs gross weight six-engine Consolidated XB-36.[33] The 220,000 lbs gross weight B-2000-B super bomber, designed by Charles Villiers, was to be a high wing lifting fuselage monoplane with multi-spar outer wings and empennage supported by twin boom. A crew of twelve would operate the aircraft that was to carry up to 80,600 lbs of bombs, which was considered high compared to existing heavy bombers (for example, the A.V. Roe Lancaster and A.V. Roe Lincoln could only carry a 14,000 to 22,000 lbs bomb load). The bomb load at normal range of 2,000 miles was to be 72,000 lbs and 35,000 lbs at maximum range of 4,000 miles. In other words, the B-2000-B could carry six 12,000 lbs Block Buster bombs on a mission of about 2,000 miles. The aircraft could also carry depth charges and torpedoes in lieu of bombs for long-range ocean patrol and convoy protection. The B-2000-B's bomb load could also be replaced by military equipment or troops for special transport missions. In addition, the center of the lifting body would provide space for additional fuel tanks or freight. Bombs would be loaded in the usual way, that is by internal power-driven winches or external hoists. Freight would be loaded using the central edge ramp at the body's trailing edge, specifically by lowering its bottom portion to drive in Jeeps or small tractors carrying freight. The aircraft's defensive armament would consist of seven power-driven gun turrets — one in the nose, two amidships in the top of each boom, two belly turrets amidships in the bottom of each boom, and two in the rear ends of the booms — each capable of accommodating four machine guns or two canons. In comparison, the Lancaster and the Lincoln bombers had only three gun turrets. The B-2000-B was to be powered by six 3,300 hp Super Wasp engines (to be replaced by four 5,000 hp engines when available),

and was to be capable of a maximum speed of 300 mph. CCF officials described the aircraft a "formidable offensive weapon,"[34] but in the end, the USAAF chose to go with the heavier XB-36, which made its maiden flight in the summer of 1946 and became the backbone of its Strategic Air Command (SAC) in the early Cold War.[35]

The V-1000, on the other hand, was a mid-wing monoplane with elliptical wings, cantilever tail plane, twin rudders, and a tricycle landing gear. Its fuselage was to have a clean aerodynamic form with a circular cross section for pressurization divided into two floor levels with rest rooms and refreshment facilities. It was to be capable of transporting 160 passengers and 13,300 lbs of freight, and of flying over a range of 4,500 miles. The aircraft was to be powered by six 3,300 hp Pratt & Whitney Super Wasp engines and capable of a maximum speed of 300 mph. To meet the requirements of transoceanic transportation, the V-1000 would be equipped with sleeping berths or deluxe reclining chairs convertible to berths.[36]

CCF wrote of the inherent difficulties encountered in conventional aircraft design that it hoped to overcome by building aircraft that used the Burnelli lifting fuselage principle.

> As conventional aeroplanes become larger in size, it is necessary to go to greater wing loadings to keep wing proportions and structure weights within practical limits. This results in high landing speeds, lower safety of operation and requires excessive skill in piloting. One of the greatest technical difficulties encountered in the design of large aircraft is that the undercarriage, when if built to required safety factors, exceeds in dimensions the space available in the wings. Designers are up against the big problem of retracting the wheels somewhere. This state of affairs is being accentuated on projected large aeroplanes. The installation of power plants in the comparatively thin wings of conventional aeroplanes has inherent disadvantages. Engine accessibility in flight is impractical in all but giant planes. The installation of primary engine controls, which should be directly connected, is very difficult. These factors result in lower reliability, increased maintenance and higher first cost. When the Burnelli 'flying wing'

> principle is utilized, engines and landing gear are housed in the aerofoil center section, and the above difficulties are eliminated. Wing loading and landing speed are inherently lower.[37]

In order to demonstrate the advantages of the Burnelli lifting fuselage principle, the company decided to undertake a comparative analysis of its two transoceanic transport designs. The B-2000 lifting fuselage was dubbed Project B and the more conventional V-1000 was referred to as Project V. In early 1943, CCF sent the basic layout and characteristics of both aircraft to two American aeronautical experts for review: Max Munk, NACA aerodynamicist in Washington DC, for comparative performance calculations, and Dr. Alexander Klemin of New York University for technical advice on design and stability. Since both aircraft had the same gross weight, engines, and wingspan, it was believed that any performance differences would relate to the basic design principle.[38]

After careful analysis of both projects, Munk concluded that Project B was much superior to Project V. His March 1943 report noted:

> The B project has a smaller drag. This is the natural consequence of the substitution of two small booms for a large fuselage. The total wing area is larger, but there still remains a balance in favour of the B project, although the difference by itself is not striking. Both projects having the same weight and span, and both projects having a wing plane view reasonably close to an elliptical one, it can be confidently expected that both projects will give equal induced drag under equal conditions. The B project requires furthermore a lighter structure only, thus having a larger capacity for freight. Since the B project exceeds the V project in every respect, in smallness of drag, in smallness of weight of the structure, and also in some other ways that are not within the scope of this report, but tend to decrease the drag farther, it results that the B project is the better one. It exceeds the V project in all performance items. The superiority is particularly pronounced in its cargo carrying capacity over long distances. This is aided by the smaller structural weight, and to a lesser degree by the somewhat smaller drag. The B project carries more than one and half times the freight of the V project over 4,500 miles. It is well to keep in mind that the superior performance of the B project is not in any way obtained by sacrificing a small landing

> speed, but on the contrary: the B project has a smaller wing loading and in consequence will definitely land much slower than the V project. It is doubtful whether the high landing speed of the V project will make it suitable for commercial operations. Increasing the wing area of the V project for the purpose of bringing its landing speed down to the landing speed of the B project will further increase its drag and its structural weight. A comparison between such modified V project and the B project would be more fair to the B project. It would show even larger superiority of the B project over and in comparison with the conventional design.[39]

According to Munk's calculations, the lifting fuselage design required a lower take off run, could climb faster and attain higher speeds than the conventional design. It also benefited from a lower drag coefficient because of its greater wing-lifting surface and could, therefore, carry a much heavier payload over greater distances. Klemin concurred with Munk that Project B was more advantageous, but admitted that Project V was "aerodynamically in line with the best practice of the day." In his opinion, Project B exceeded Project V in every respect, and its superiority was particularly pronounced in the load-carrying capacity over long distances: Project B could carry more than one and a half times the payload of the other (49,000 lbs versus 29,500 lbs for Project V) with less fuel (66,000 lbs compared to 70,500 lbs for Project V) over a 4,500 miles range. Moreover, when carrying no payload, Project B could reach a greater distance than Project V (9,000 miles versus 6,800 miles).[40]

CCF officials seriously considered Munk and Klemin's comments, as well as the advice of Vincent Burnelli and the NRC's J.H. Parkin and G.S. Levy. All parties favoured the lifting fuselage design. In its report, CCF agreed that the "design of the aeroplanes of the order of 100 tons [224,000 lbs] gross weight involves a step into new territory" but noted, however, that "the most eminent authorities and practical experts ...

agree that the flying wing with span wise weight distribution holds great promise, and is a logical way to construct large aircraft." CCF concluded:

> While it is confidently expected that the structure weights quoted for the B-2000 can be realized in practice, it should be pointed out that even if the 'lifting fuselage' structure weights are little better than conventional weights, it still has the following tremendous advantages: (1) Lower wing loading, resulting in greater climb, and lower landing speed; (2) improved performance due to reduced absolute drag; (3) increased passenger space, permitting greater flexibility in day and night accommodation; (4) as a military aeroplane, it has the obvious advantage of versatility in use as a freighter, troop transport, long range reconnaissance aircraft, or heavy bomber. This is a primary consideration when such a large amount of productive capacity is invested in each aeroplane.[41]

CCF was definitely interested in pursuing work on the B-2000, which offered great possibilities as a long-range transport and heavy bomber. The company estimated the initial cost of engineering and producing a B-2000 prototype would be $487,500 (US).[42] In the end, however, both projects were abandoned as the company decided to concentrate its efforts on a more advanced Burnelli lifting fuselage transport known as the B-1000, which it planned to market in the immediate postwar.

The B-1000 project, initiated in early 1942, was a large four-engine semi-tailless lifting fuselage transport aircraft. The project used an advanced application of the lifting fuselage principle, and tried to avoid mistakes made in the B-2000 program. CCF officials reported that the "suppression of extraneous booms and empennage components, while locating as much weight as possible span wise in the body, gives very low structure weights with increased cabin volume. Due to the low horizontal tail volume, inherent longitudinal stability is built into the aircraft by automatic means."[43] The B-1000 was to have a 264,000 lbs gross weight and carry 88,000 lbs of cargo. It was to be powered by four 5,200 hp engines, which were not yet in production.[44] In May 1942, CCF built a

small scale model of the B-1000 for testing in the NRC's wind tunnel, but it was relatively small with a span of only 4 feet. As the NRC considered this to be too small a model for the aircraft in question, a new model with a span of 6 feet was made.[45] The delay pushed advanced aerodynamic research in the NRC wind tunnel to February 1944.[46] The wind tunnel test report, issued in June,[47] noted that it would be desirable to carry out flight research on a quarter size version of the B-1000 powered by four 500 hp engines.[48]

As the B-1000 represented the wave of the future, CCF wanted the aircraft forefront in its publicity. One CCF advertisement published in the pages of *Canadian Aviation* in the fall of 1943 and entitled *Can-Car Wings Over Canada: A Glimpse into the Future - Planning Today for To-Morrow's Airway*, pictured a B-1000 in flight above Canada. As the publicity explained: "Cancar is planning and preparing so that when victory comes, its immense accumulated resources of plant, equipment and personnel will swing without pause, into production of aircraft for world-wide passenger and cargo operation ... For it is recognized that to-morrow's wings over Canada will be revolutionary. Commercial flying must step in one stride from swaddling clothes to maturity. Air-minded and air-staffed, Cancar is working to that end."[49] Then, in January 1944, the B-1000 was publicized as a "refrigerated fruit express" for service by Colonial Airlines in the United States in postwar years.[50] Surprisingly, CCF abandoned the B-1000 program before the end of the war and decided to concentrate on a smaller twin-engine lifting fuselage transport. The reason for this decision is unknown, but anticipated high costs and postwar competition from American and British aircraft manufacturers in the field of large four-engine transoceanic transports likely played a role.

CCF was already working on a twin-engine transport when the B-1000 was cancelled. The project had begun in early 1943 when CCF reached an agreement with Nicaragua's Transportes Aeros Centro-Americanos (TACA) for the construction of ten lifting fuselage aircraft that met the requirements of the airline. The aircraft, which was designed by Vincent Burnelli for CCF and known as the CBY-3 Loadmaster, was intended for operation in the bush country of Central and South America.[51] The new 27,000 lbs gross weight twin-engine aircraft was to be powered by 1,200 hp Pratt & Whitney R-1830 Twin Wasp engines and be capable of carrying up to 24 passengers.[52] It was to rival the highly popular American-designed Douglas DC-3 twin-engine transport,[53] and was to incorporate some of the best features of the cancelled CB-34 and MB-2 lifting fuselage transport projects.[54] In late June 1943, CCF made arrangements with the NRC to build a scale model of the new lifting fuselage aircraft and to undertake wind tunnel tests.[55] In December, work slowly began on the CBY-3 prototype at the CCF St. Laurent plant in Montreal.[56] In the summer of 1944, tests were carried with a CBY-3 scale model in the NRC wind tunnel. Soon, problems surfaced with the design. The NRC reported that the aircraft was "hopelessly unstable," that "the tail area had to be increased by 120% to produce adequate stability," and that "modification to the rudder and fin, the cockpits, the tail booms, the flaps, and the dihedral angle of the wings are also ... necessary."[57] In August 1944, CCF nevertheless applied for a Canadian government certificate of airworthiness for export of the CBY-3.[58] Before the prototype was completed, however, TACA cancelled its contract.[59]

The setback did not stop CCF from continuing work on the CBY-3.[60] In March 1945, a revised scale model underwent testing in the NRC's wind tunnel; the results were

much more positive.[61] The aircraft prototype, completed in early 1945, was first flown on 17 July 1945.[62] A few days later, the NRC was asked to try and improve the aircraft structure to increase its performance.[63] Flight tests were carried out with the CBY-3 prototype in Montreal from August to October 1945 to determine the performance characteristics of the aircraft.[64] Since the original CBY-3 that had flown with Twin Wasp engines was underpowered, it was decided to install the more powerful 1,450 hp Pratt & Whitney R-2000. The CBY-3 flew with these new engines for the first time on 10 May 1946, but it was still not successful on the civilian markets.[65] Attempts to offer military versions of the aircraft to the RCAF and USAF also failed.[66] In late 1945, CCF began working on more advanced Burnelli-type aircraft designs, including a 63,000 lbs gross weight four-engine transport capable of carrying 72 passengers known as the CBY-7, but none of these machines were ever built.[67] The CBY-3 project was finally abandoned a few years later. The main problem was that the CBY-3 had been originally designed to compete with the DC-3 or similar aircraft, whose designs dated back to the late 1930s. The immense technological progress that accompanied the Second World War had spawned new commercial transport aircraft designs that rendered the CBY-3 obsolete.[68]

An Unorthodox Concept: Tailless Aircraft

Aeronautical engineers around the world devoted much time and energy to the development of new and more radical aircraft designs during the war, the most important of which was the tailless aircraft or flying wing. Work in this field was undertaken in countries such as Germany, Great Britain and the United States, and Canada expressed some interest in following suit. The war history of the NRC's mechanical engineering

division described the advantages and disadvantages of the flying wing concept: "The suppression of the tail and conventional fuselage of an aeroplane offers certain aerodynamic advantages in the reduction of drag, particularly for very large aircraft types. On the other hand, certain difficulties in stability and control are introduced which, although not insuperable, offer a fruitful field of study that must be undertaken before the 'all wing' aeroplane can become a proven type."[69] The NRC undertook much of the Canadian work on flying wings, although efforts were also made by private industry, such as Fairchild. With little experience in the design and development of sophisticated aircraft, these groups took a serious gamble in deciding to work on this type of aircraft. Indeed, the cost of failure was high and ultimately impacted on the future of Fairchild and the NRC.

In the summer of 1943, Fairchild became interested in tailless aircraft. The company proposed to work on an experimental light tailless aircraft of its own design. If successful, it hoped to initiate the production and commercialization of larger tailless transport aircraft for both civilian and military markets. The proposed small experimental aircraft, known as the X-1, was to be powered by a 90 hp engine and have a gross weight of 1,722 lbs. Work immediately began on scale models of the X-1.[70] In the fall of 1943, company representatives asked the NRC to conduct wind tunnel tests with the scale models of the new aircraft, but they faced obstacles. G.S. Levy of the NRC explained that "the main difficulty with any extensive work is that the tests may take a very long time. If your tests are not backed by some government department, they would have no priority. This would mean that the model would only be put in the wind tunnel after other work was completed, and since the tunnels are fairly busy at present the work might take a long

time to complete."[71] Nevertheless, a model of the X-1 was tested in the NRC wind tunnel in January 1944, but the results were inconclusive and further tests would be required.[72]

Fairchild went to work on a new version of the aircraft, known as the X-2, which was to be powered by a more powerful engine — a 130 hp De Havilland Gipsy Moth — and have a gross weight of 1,768 lbs.[73] A scale model of the X-2 was tested in the NRC wind tunnel facilities in July 1944, with promising results. In the end, however, the Fairchild X aircrafts were never built as the company abandoned the idea of tailless aircraft owing largely to high costs.

Although Fairchild refused to move ahead on the design and development of tailless aircraft, the NRC pursued work in this field in ensuing years.[74] In 1942, Professor G.T.R. Hill, a British aeronautical expert renowned for his work on tailless aircraft, came to Canada as a British liaison officer.[75] Hill had done important work for Westland Aircraft and, in the 1930s, had designed a whole line of flying wing aircraft, dubbed Pterodactyls after the prehistoric bird of prey, that included transports, flying boats, and even fighters and bombers.[76] Upon arrival, Hill proposed to conduct work with the NRC on a flying wing transport aircraft of his own design.[77] The machine, to be known as the Pterodactyl Mk. VIII, was derived from a large high-performance long-range flying wing bomber that he had designed a few years earlier but had never been built.[78] Hill had already tried to pitch his project to the British Ministry of Aircraft Production (MAP), but the problem was that such a project would divert men and resources from more important and pressing wartime projects. Only four British aircraft companies had the necessary experience and all were busy with other urgent projects. British authorities suggested that Hill propose his project in Canada to determine if any large company there could produce

the aircraft. Hill collected the work he had done on tailless aircraft with Westland, and left for Canada.[79]

Hill explained to NRC officials that work on flying wings was already taking place in Germany, Great Britain and the United States, and tried to convince them that Canada should initiate work along similar lines. The NRC was interested. J.H. Parkin noted that this project "could easily be done here in Canada." Parkin liked Hill's tailless aircraft design as it lent itself to pusher propellers, a concept that he had always favoured. More importantly, the project offered Parkin the opportunity to have the NRC design and develop aircraft, something he had unsuccessfully attempted to initiate on several occasions earlier in the war. In September 1942, Hill began constructing a scale model of his proposed aircraft for wind tunnel trials. If the tests proved successful, the intention was to have the NRC build a full-scale prototype.[80] The wind tunnel test was drawn up on 1 October 1942,[81] and Hill attempted to spark the DMS' interest. In mid-October 1942, he discussed the issue with C.D. Howe and Ralph Bell, who were at the time very interested in jet engine developments in Great Britain and were exploring the possibility of Canada conducting research in this field. Hill therefore told the two government officials that his tailless aircraft could be fitted with jet engines, and explained that the flying wing concept lent itself much better to jet engines than conventional aircraft designs, but neither man was impressed with Hill's proposal.[82] Howe reported in his diary: "Bell and I thought very little of it; he has no real knowledge of jet propulsion, which we believe to be a worthwhile development."[83]

Despite this setback, the NRC tested the scale model of Hill's tailless aircraft in its wind tunnel in January 1943. Hill was pleased with the trials, which revealed that a

"fair maximum lift coefficient" could be obtained with such a design. Shortly afterwards, he explained the advantages of the Pterodactyl as a potential transport to the NRC Associate Committee on Aeronautical Research (ACAR).

> The Pterodactyl does not have a swept back wing, but a swept forwards center section with swept back tips ... In conventional aircraft types the long fuselage behind the wing is a great temptation as regards loading space with the result that the C.G. [center of gravity] always tends to wander backwards. In the Pterodactyl the C.G. is at the middle of the loading space and additional loading is not so likely to cause it to move appreciably from this position.[84]

At this point, the RCAF showed interest in the project. Air Vice-Marshal Stedman told the ACAR that it definitely "had to proceed with this project."[85] NRC officials were pleased with the decision. After all, the only way Canada could justify the development and production of such an aircraft was if the British MAP or the RCAF was ready to place large orders. Yet, the Air Council would still have to decide whether this project was sufficiently important to warrant an interruption of some war programs. Hill was confident that the Pterodactyl would be "extremely useful in the future developments" of flying wing aircraft. He thought it would be a simple matter to produce a flying model of the aircraft since there was no fuselage and tail unit to construct.[86]

In order to proceed rapidly, Hill suggested that the model be a glider, as this would further simplify the project given the absence of power plants and associated equipment, and the undercarriage could be a simple skid or one wheel and two skids. Hill explained that such a glider could be towed to a considerable height before being cast loose. "A glider would be a good approximation to the powered aircraft because with pusher propellers and no tail there is no slipstream interference on controls." The model

would also use wood, making the weight less critical and simplifying structural problems.[87]

Hill asked the ACAR to consider building this glider version. Air Vice-Marshal Stedman responded asking whether the glider should be made to an accurate scale model of the contemplated full-scale aircraft. Hill responded that this was not important "since the geometry does no change with size for a Pterodactyl." What he envisioned was a single seat glider model and he firmly believed that the NRC could do the job. The alternative, Hill noted, would be to ask a Canadian company to design and build the aircraft, but the RCAF did not favour this option for fear that the project might affect more important wartime programs. In the end, the glider would be built in the NRC shops.[88]

The NRC thought it important to keep a close eye on developments in tailless aircraft in other countries, particularly in the United States, where several companies were working on this kind of aircraft.[89] The most important was Northrop. In March 1943, the NRC attempted to obtain data on the Northrop flying wings — the XB-35 bomber, the XP-56 fighter and the XP-79 jet fighter — but the RCAF pointed out that "the patent situation concerning the use of Northrop's data for design purposes at present precludes Canada from using it."[90] In May 1943, Hill visited Northrop and reported that the company was still "far from the solution of a satisfactory tailless aircraft." Meanwhile, Stedman had several discussions in Great Britain on the subject of tailless aircraft and noted that though the British were "moderately interested," they did not have enough design staff to undertake the project.[91] In early 1943, wind tunnel tests were done

in the NRC laboratories on the 1/24 scale model of the Pterodactyl Mk. VIII tailless aircraft,[92] and in May of the same years, a second scale model was built for more tests.[93]

On 19 November 1943, the ACAR accepted to build two Pterodactyl Mk. VIII gliders. The construction of the aircraft was to be made by the NRC Structures Laboratory. The gliders were to be one-third scale flying models of the proposed Pterodactyl transport aircraft and were to be made of moulded plywood. In mid-July 1944, the ACAR agreed to pursue the Pterodactyl project. Wartime wind tunnel experiments were to be followed by flight tests with a full-scale tailless glider, and eventually all Canadian aircraft manufacturers would have the opportunity to work on this aircraft. The Subcommittee on Aerodynamics therefore requested that "work be continued as important research with great possibilities for future developments." In fact, the future prospects of the Pterodactyl program were bleak. Squadron Leader F.S. Nowlan of the RCAF noted that most Canadian aircraft companies "plan on staying in production after the war with their own more or less standard designs" and that it was unlikely that the Canadian government would invest much money in a transport aircraft of unconventional design.[94]

The 3,730 lbs gross weight tailless glider prototype was built in the NRC Structures Laboratories during the summer and fall of 1945.[95] In February 1946, the completed aircraft was shipped to Namao, Alberta, an RCAF Station near Edmonton,[96] where it made its maiden flight on 22 April 1946. The tailless glider program was terminated in the fall of 1948 after certain design flaws were found.[97] In the end, however, the NRC flying wing glider only served for research purposes and never led to the design and development of full-scale powered aircraft. It should be noted that in a last

effort in 1944, Professor Hill issued a design proposal for a large-scale Pterodactyl VIII transatlantic flying wing airliner with pressurized cabin powered by five pusher engines. He took the design with him when he returned to Great Britain after the war and made arrangements to have the aircraft built by Shorts Brothers, but the project was quickly abandoned on the grounds that the design was too unorthodox to be considered by airlines.[98]

A Time of Frustration and Anger

In the early months of 1944, the design and development of aircraft in Canada generated much debate and caused discontent in some government circles. DMS and DND representatives disagreed over the role the Canadian government should play in the preservation of a strong Canadian aircraft industry in postwar years. The issue surfaced at the CPMA's fourth meeting on 20 January 1944. In the course of discussions, the committee reiterated the two recommendations it had submitted to C.D. Howe for approval at its previous meeting, namely to initiate the preliminary designs of the five different types of aircraft that the committee had selected for design and development in Canada and to issue contracts for the construction of a sufficient number of prototypes. It also repeated its recommendation that the Canadian government take steps to provide for continuity and maintenance of adequate design and engineering staffs for an initial period of ten years. Ralph Bell indicated that Howe had sent a letter to him on 1 November 1943, wherein he approved the committee's two recommendations and noted that he was prepared to authorize "the various [aircraft] companies to undertake work of this

character." At this point, the CPMA completed its original survey work, thereby fulfilling its mandate.[99]

Yet, in his memorandum, Howe had not commented on the lingering problem of establishing strong aircraft design staffs with the support of the Canadian government. The committee discussed the issue thoroughly and, in the end, unanimously agreed to send a new recommendation to the Minister of Munitions and Supply requesting the immediate appointment of "a permanent board to advise the government in connection with the aircraft industry." The committee argued that such an organization could contribute more actively to the production of indigenous aircraft and to the establishment of aircraft design staffs.[100] Bell told Howe on 1 February 1944:

> [The aircraft] industry should be organized as a compact, efficient and progressive nucleus, capable of speedy and adequate expansion in an emergency. It must be based on keen, able, and highly trained design staffs, and the development of such staffs should be commenced immediately and pushed energetically. Ordinary postwar business to the Canadian industry will not be sufficient to cover the cost of the creation and maintenance of this nucleus. In Britain and the U.S. the governments have long since established the policy of providing contracts from time to time as required that furnish the necessary support for the maintenance of such design staffs ... To support her airlines, and the general commercial demand of industry, Canada must commence at once the development of suitable aircraft. It is believed that a Canadian aircraft industry, when properly organized, will be able to compete successfully in the postwar market. In order that the Canadian government may have a source to which it can look for considered opinion and advice on this matter, the committee recommends that at the earliest possible moment a board, known as the Canadian Aircraft Board, comprising representatives of the same interests as constitute this committee be appointed as a continuing committee to advise the government in connection with these matters.[101]

In line with this idea, a few days later, Bell proposed the creation of an Advisory Committee on Aircraft Manufacture to be run by the DMS. Its role was summarized in a draft order-in-council:

> To examine the requirement of the government commercial operators for aircraft and associated equipment; to recommend to the ministers the means to be employed to develop and maintain a creative aircraft industry; to recommend to the ministers the types of aircraft and associated equipment, the development of which will be most advantageous to Canada; and to investigate and report upon such other matters as may be referred to it by either minister.

Bell recommended that the Advisory Committee take over the functions of the CPMA and DND's Technical Advisory Committee on Aeronautics, which had been set up in May 1924.[102] However, Howe did not approve. While he agreed that the Canadian aircraft industry should proceed with the design and development of aircraft for the postwar years, in spite of the fact that the Canadian government had not adopted an official postwar policy, Howe was of the opinion that the government would only be on the market for a few civilian type aircraft after the war. As such, he firmly believed that the government should not supervise or coordinate any efforts by industry to design and develop aircraft in Canada. He suggested instead that Canadian aircraft companies obtain their support for all non-military types of aircraft from TCA, CPA, and private aircraft owners. Howe told Bell: "The airplane business in the postwar period must not expect to find itself a ward of the government. In that position it will be no different from any other peacetime industry." In the end, Howe saw no need to set up another body to oversee aircraft manufacturing; this decision was congruent with his pro-business approach. [103]

Howe's decision generated much debate at the CPMA's fifth meeting held on 2 March 1944. Bell proposed that the committee meet with the Minister of Munitions and Supply, which was done that same afternoon. Howe explained that the CPMA should continue to exist and advise the government on commercial aircraft developments, but made it explicitly clear that military aircraft "were a matter for the Department of

National Defence for Air." He did note that if the DND (Air) so wished, the committee could also "act in an advisory capacity for that department in connection with design and construction by the industry of [civilian] as well as military types." He added that he was "prepared to consider any proposal for the design and the construction of a specific type of aircraft that the committee was prepared to recommend to him, but that such submission must be referenced to some particular company, and the committee must be prepared to make a statement as to the prospective demand in Canada for the type of aircraft in question." Clearly, Howe wanted to leave the postwar aircraft industry entirely in the hands of the aircraft manufacturers, meaning that the individual companies, and not the Canadian government, would be responsible for design staffs and aircraft designs. Howe added that as long as he had anything to do with the policy of VAL, it "would not engage in the design field except for the largest type of transport aircraft and then only if private industry had shown itself incapable of producing satisfactory designs in this field." Howe then informed the committee that the Canadian government had negotiated a contract with the Douglas Aircraft Company for the licensed production of the American-designed Douglas DC-4 four-engine transport in Canada. There would therefore be no need to design and develop large transports such as the Victory 7 and Victory 9.[104] On 15 March 1944, Bell asked TCA if, in light of the decision to proceed with the DC-4, the air line still wanted the DMS to proceed with work on a preliminary design to meet their original specification for a four-engine transport; the answer was a simple "no."[105]

News of the DC-4 deal came as no surprise. Since September 1943, TCA president H.J. Symington had been telling C.D. Howe that it would be impossible for

Canada to compete with the Americans and British in the design and development of large transoceanic transports in the postwar period, and suggested instead that the Canadian aircraft industry secure a license to manufacture the American DC-4. TCA was very interested in operating that type of aircraft.[106] So in early February 1944, Howe asked the Cabinet War Committee to accept a proposal to have the DC-4 manufactured under-license in Canada. He originally suggested Boeing Canada, VAL or Canadian Vickers for the job. The selected company was to build fifty aircraft for TCA. Howe strongly believed that the DC-4 "was pre-eminently the best plane of this type in existence." The Cabinet agreed with the project and Canadian Vickers was selected for the job shortly after.[107]

But not everyone was happy with the decision to have Canada produce the DC-4. For example, Escott Reid of the Department of External Affairs was sceptical of Douglas' intentions, claiming that the American company was only willing to have the DC-4 produced under-license in Canada "in order to establish a base from which to take advantage of the British preferential market in the postwar period."[108] The British government was also opposed to the Canadian DC-4 project. A few months earlier, it had put pressure on Canada to increase its output of A.V. Roe Lancaster bombers, and suggested to have both VAL and Canadian Vickers assemble the aircraft.[109] At the time, Canada had already been contracted for the production of 600 Lancasters.[110] British Prime Minister Winston Churchill protested the decision to have DC-4 transports built at Canadian Vickers instead of Lancaster bombers.[111] In a letter to Canadian Prime Minister William Lyon Mackenzie King, he said "it is gravely disappointing to us that we should not receive these invaluable aircraft which you had promised to make for us and on

which we were counting, but that we should receive this notification without any warning and consultation."[112] But Churchill was also particularly concerned by the fact that Canada intended to manufacture an American-designed transport aircraft for possible postwar use rather than a British-designed one. Work was progressing in Great Britain on the development of large four-engine transport aircraft, and Churchill had one particular aircraft in mind for eventual production in Canada: the British-designed A.V. Roe 688 Tudor. Churchill said that Canadian Vickers could manufacture the Tudor as soon as the need for bombers was relaxed.[113] C.D. Howe and Prime Minister King stuck by their decision to have the DC-4 made in Canada and remained convinced that VAL could handle the entire Lancaster program. Canadian officials told the British that Canada was also "greatly interested" in the Tudor and was willing to have VAL produce the aircraft under-license after the war.[114]

Meanwhile, the RCAF grew increasingly impatient with the CPMA's seeming in-activity and lack of results. The disappointing conclusions on the Victory 7 merely added fuel to the fire. The RCAF was also upset with C.D. Howe's decision not to go ahead with the creation of an Advisory Committee on Aircraft Manufacture, as the benefits of such a technical advisory committee were well accepted in military circles. It was further concerned with the DMS' intention to manufacture the DC-4 in Canada instead of a Canadian-designed transport, and with recent discussions of converting existing Canadian-made military aircraft types for civilian usage, particularly the American-designed Consolidated PBY Canso and the British-designed A.V. Roe Anson.[115] The RCAF was particularly anxious to initiate the development of aircraft of indigenous design as soon as possible. The military situation in Europe and the Pacific was changing

rapidly and all signs seemed to point to an Allied victory, so it seemed increasingly important to prepare the aircraft industry for the postwar.[116] Dissatisfaction grew when Air Vice-Marshal Ferrier received a copy of Howe's earlier letter to Ralph Bell that noted: "We should not undertake the design of military aircraft until we are asked to do so by the Department of National Defence for Air." Ferrier saw this as a sign that the Minister of Munitions and Supply believed that "the postwar aircraft industry is not a sufficiently vital element of our national defence as to warrant special support by the government."[117] He told the Chief of the Air Staff that the CPMA's efforts "have virtually come to nothing as we are no nearer the Air Council objective than we were a year ago. If the axiom be upheld that a sound creative aircraft industry is an essential element of our national defence," it was necessary for the DND (Air) to obtain funds and place orders to enable the industry to survive incoming years. "I am strongly of the opinion that the commercial users in this country are not in a position to furnish significant support, nor will they be for a good many years."[118] Ferrier added a few days later: "I think it can be accepted that the Department of National Defence will remain the overwhelmingly major support of the future industry."[119] The Chief of the Air Staff agreed: "Canada must prepare to take a greater part in the creative aspect of armament for war."[120] Shortly thereafter, DND (Air) initiated requirements for the design and development of two indigenous military aircraft: a twin-engine aircrew trainer and a jet fighter.

The decision to produce the American DC-4 in Canada instead of the Victory 7 or Victory 9 put an end to the Canadian government and aircraft industry's aspirations of designing and developing large four-engine transports domestically. In the summer of

1944, Canadian Vickers (which became Canadair in November 1944) was officially awarded the DC-4 contract.[121] The Canadian government briefly considered manufacturing the larger American-designed Douglas DC-6 as well as the Lockheed Constellation and Lockheed Constitution four-engine transports that summer,[122] but decided to stick with the Canadian version of the DC-4, which was expected to be faster and capable of flying at higher altitudes than these three aircraft.[123] In the months that followed, the Canadian company completely re-engineered the American aircraft to meet the needs of TCA. The result was an aircraft powered by Rolls Royce Merlin (instead of Pratt & Whitney Twin Wasp) engines with pressurized fuselage and incorporating some of the best features of the DC-4 and DC-6.[124]

In December 1944, the RCAF began expressing interest in the Canadian DC-4 project after the Cabinet War Committee authorized it to form three long-range transport squadrons for operation in the war against Japan in the Pacific theatre.[125] The RCAF proposed to equip these squadrons with a military variant of the Canadian DC-4.[126] The RCAF originally planned to purchase as many as 120 of these aircraft.[127] The RCAF considered several names for the Canadian-made DC-4. Among the suggestions were Dominator, Depositor, Dominion, Wanderer, Canuck, Argo, Eros,[128] and Beaver.[129] In the end, after much debate, air force officials selected the name Dominion.[130] The prototype of the Dominion made its maiden flight after the war, on 15 July 1946,[131] and was re-christened North Star ten days later.[132] In the end, Canadair went on to produce 71 North Star transports for the RCAF, TCA, CPA, and the British airline BOAC (which dubbed the aircraft Argonaut) between 1946 and 1950.[133]

Returning to the Roots

When the Canadian government awarded the DC-4 contract to Canadair in early 1944, the Canadian aircraft industry had no other government-sponsored commercial transport aircraft programs to work on. Concerned about their postwar future on the civilian market, several manufacturers started contemplating the development of small and medium size transports. The production of general utility bush transports had been quite popular during the interwar years, and the wartime success of the Noorduyn Norseman had further demonstrated the high demand for suitable bush aircraft both in Canada and worldwide. For many Canadian aircraft makers, the design and construction of such aircraft seemed the cheapest and easiest route to developing a postwar Canadian aircraft industry. Accordingly, several Canadian aircraft manufacturers began developing general utility transports between 1944 and 1945. Such was the case for DHC, Fairchild, VAL and Fleet.

DHC was among the first to contemplate the design and development of general utility transport aircraft for the postwar period. In March 1944, W.J. Jakimiuk, the company chief aeronautical engineer, and another DHC engineer named W.Z. Stepniewski, prepared a preliminary design proposal for a small 4,100 lbs gross weight transport aircraft capable of carrying five passengers and up to 937 lbs of freight. The machine was to be powered by a 295 hp De Havilland Gipsy engine and capable of operating on wheels, floats or skis.[134] Being the third aircraft manufactured by DHC after the British-designed Tiger Moth and Mosquito, it was simply baptized the DHC.3. The company also studied the possibility of designing a twin-engine general utility transport powered by 160 hp De Havilland Gipsy Major engines that would use the same wings

and fuselage as the DHC.3, and would be fitted with a retractable tricycle undercarriage. Its performance and payload capacity would be slightly greater than the DHC.3.[135] In the end, DHC did not produce the DHC.3 or its twin-engine counterpart, for in the summer of 1945, it was asked by De Havilland, the parent company, to abandon its bush transport project and to concentrate instead on the development of a small elementary training aircraft for the military market. The design of the new aircraft, designated the DHC-1 Chipmunk, started in the fall of 1945 under the leadership of W.J. Jakimiuk. The trainer's prototype made its maiden flight on 22 May 1946 and was a success on the military markets.[136] But work done on the DHC.3 was not totally lost. In the spring of 1946, Jakimiuk initiated the development of a new general utility transport, the DHC-2 Beaver, which incorporated some of the best design features of the DHC.3. The Beaver flew for the first time on 16 August 1947.[137]

In May 1945, Fairchild began work on its own general utility transport designs. J.A. Butler, the company's chief aeronautical engineer, developed two basic designs powered by 700 hp Wright C-7 engines and capable of operating on wheels, floats or skis: the single-engine Fairchild F-3 and the twin-engine Fairchild F-7. The twin-engine aircraft was to be fitted with retractable undercarriage and was to be capable of carrying 21 passengers and a payload of up to 1,150 lbs. The single-engine machine was essentially a smaller version of the F-7 with fixed undercarriage, and had the same general outline and design features as its twin-engine counterpart.[138] While the F-3 and F-7 never left the drawing boards, Fairchild remained particularly interested in the capabilities of the single-engine layout. In late 1945, J.A. Butler designed a new general

utility transport known as the Fairchild F-11 Husky, which made its maiden flight on 14 June 1946.[139]

In June 1945, VAL initiated the development of a 13,000 lbs gross weight twin-engine general utility transport known as the Canadian Freighter. Designed by W.W. Shaw, the company's chief aeronautical engineer, the aircraft was powered by Pratt & Whitney R-1340 engines and was capable of operating on wheels, floats or skis. It could carry 12 passengers and up to 3,657 lbs of freight. However, the project never left the drawing boards.[140]

Fleet also became actively engaged in the design and production of general utility transports. By early 1945, the company felt that there was a market for a simple and rugged light civilian aircraft suitable for flying clubs, private owners and light cargo work. Fleet prepared a specification and found that the aircraft best suited to meet these needs was one designed and built by a small Canadian aircraft company, Noury Aircraft Limited. This was the Noury N-75, a 1,200 lbs gross weight two-seat light aircraft powered by a 75 hp Continental A-75 engine that flew for the first time in late 1944. In May 1945, Fleet purchased the design rights to the N-75. The Noury prototype was shipped to the Fleet factory, where it was test flown on 4 June 1945. George E. Otter, Fleet's chief aeronautical engineer, made modifications to the aircraft, including a new fin and rudder, relocating the fuel tank, lowering the engine and installing a more powerful 85 hp Continental C-85 engine. The aircraft was to be capable of operating on wheels, floats or skis. The revised prototype, which was re-designated the Fleet Model 80 Canuck, was test flown on 26 September 1945.[141]

Conclusion

The 1943 decision to go ahead with the design and development of indigenously designed aircraft, particularly transport aircraft that could be used by both civil and military operators, showed how determined government officials were to prepare the industry for postwar years. Good intentions, however, could not mend the divisions between different interest groups. The RCAF had certain requirements that did not correspond to those of civilian airlines such as TCA or CPA. Some officers in the DND (Air) felt that Canada should design and develop combat aircraft to lessen the RCAF's reliance on foreign sources in the event of an emergency, but DMS representatives remained committed to a more commercial approach. C.D. Howe's decision to ask VAL to proceed with the design and development of the Victory 7 and Victory 9 projects was not well accepted in air force circles, as neither transport aircraft was suitable for military or even commercial applications without considerable re-designing. Frustration grew when the CPMA's work came to end, and the DMS decided to license manufacture the American DC-4 transport in Canada rather than pursue the development of indigenous transports. Consequently, DND (Air) immediately decided to take matters into its own hands and launched the design and development of two ambitious indigenous aircraft projects. As government responsibility for the design and development of aircraft in Canada shifted from the DMS to the DND (Air), Canada's focus shifted from transports for civil airlines to military type aircraft.

But the Canadian government's intention to design and develop military aircraft in Canada worried the British government, which perceived such projects as a threat to British Commonwealth standardization policies and the British aircraft industry. The

British preferred that Canada continue to manufacture British-designed aircraft in the postwar period.[142] As Sir Charles F.A. Portal, the British Chief of the Air Staff, told Air Marshal Robert Leckie, the Canadian Chief of the Air Staff, in April 1945:

> At the end of the war, Canada will have in existence a well-established aircraft industry, and I am sure it will be the policy of your government to keep it in existence by ordering from it the aircraft needed for the RCAF. It will certainly be of great value to all British Commonwealth countries after the war, as it has been during the war ... It will, of course, be for the government of Canada to decide what aircraft to order for the RCAF, but it will naturally be the aim of the Air Ministry here to make it possible for Canada's needs to be met by aircraft of British design, and I hope and believe we shall succeed in having fully suitable designs to offer. I need not elaborate the advantages to the general war potential of the British Commonwealth of the closest possible knitting together of our aircraft industries, or the advantages of our air forces using the same types of equipment.[143]

But the DND (Air) remained committed to Canadian-designed military aircraft.[144] As Leckie told Portal in May 1945:

> It is our desire to retain some units of the aircraft industry and to manufacture in Canada the aircraft required by the Royal Canadian Air Force. With this object in view we have already issued two specifications for aircraft to be designed in Canada; these are a twin-engine trainer and a high-performance jet fighter ... We feel that instead of continually exporting trained men we should encourage them to stay in our own industry and it is hoped that new design work will prove attractive to these men."[145]

The DND (Air) clearly wanted the Canadian aircraft industry to be more self-sufficient and less dependent on foreign technology and expertise. As an aviation expert once said, "money spent on Canadian design does leave Canada a residue of skill, experience and knowledge valuable in time of war."[146] Still, despite such efforts, many Canadian aircraft manufacturers remained committed to the civilian market and, as a result, initiated the development of small general utility transports in 1944 and 1945 to assure their postwar survival.

NOTES

[1] Canada, "Canada's Air Future," *Canada at War*, No. 35 (Ottawa: Wartime Information Board, April 1944), p. 3.

[2] LAC, RG-25, Vol. 2718, File: 72-RX-40, "Secretary of State for External Affairs to the High Commissioner for Canada in the United Kingdom," 23 April 1943; LAC, RG-28, Vol. 156, File: 3-P-12-11, "A. Stewart (A.V. Roe and Company Representative, British Air Commission) to Ralph P. Bell (DGAP)," 14 October 1943; Molson and Taylor, *Canadian Aircraft since 1909...*, pp. 74-77.

[3] Library and Archives of Canada [LAC], RG-28 [Records of the Department of Munitions and Supply], Vol. 156, File: 3-P-12-11, "Report on VAL Transport Design Number 5 by W.U. Shaw (CAE, VAL)," 14 October 1943.

[4] *Ibid.*

[5] LAC, RG-28, Vol. 156, File: 3-P-12-11, "David Boyd (General Manager, VAL) to Ralph P. Bell (DGAP)," 15 October 1943.

[6] LAC, RG-28, Vol. 156, File: 3-P-12-11, "Ralph P. Bell (DGAP) to David Boyd (General Manager, VAL)," 11 November 1943; LAC, RG-28, Vol. 156, File: 3-P-12-11, "Report of a Telephone Conversation between Ralph P. Bell (DGAP) and David Boyd (General Manager, VAL)," 12 November 1943

[7] Roy Chadwick was the designer of several A.V. Roe aircraft, including the Lancaster bomber. See LAC, RG-28, Vol. 156, File: 3-P-12-11, "Ralph P. Bell (DGAP) to David Boyd (General Manager, VAL)," 9 December 1943.

[8] *Ibid.*

[9] LAC, RG-28, Vol. 156, File: 3-P-12-11, "W.U. Shaw (CAE, VAL) to David Boyd (General Manager, VAL)," 14 December 1943.

[10] LAC, RG-28, Vol. 156, File: 3-P-12-10, "VAL Engineering Report No. 31 – Design Proposal for Victory 9," 13 December 1943.

[11] *Ibid.*

[12] LAC, RG-28, Vol. 156, File: 3-P-12-11, "W.U. Shaw (CAE, VAL) to David Boyd (General Manager, VAL)," 14 December 1943.

[13] LAC, RG-28, Vol. 156, File: 3-P-12-10, "VAL Engineering Report No. 32 – Design Proposal for Victory 7 Transport," 5 January 1944.

[14] *Ibid.*

[15] LAC, RG-28, Vol. 156, File: 3-P-12-11, "David Boyd (General Manager, VAL) to Ralph P. Bell (DGAP)," 10 January 1944; LAC, RG-28, Vol. 156, File: 3-P-12-11, "Ralph P. Bell (Chairman, CPMA) to V.W. Scully (President, VAL)," 6 March 1944.

[16] LAC, RG-28, Vol. 155, File: 3-P-12-3, "Minutes of the Fourth Meeting of the CPMA," 20 January 1944.

[17] LAC, RG-28, Vol. 156, File: 3-P-12-11, "David Boyd (General Manager, VAL) to Ralph P. Bell (DGAP)," 7 March 1944.

[18] LAC, RG-28, Vol. 156, File: 3-P-12-8, "Ralph Bell to Montreal Gazette," 31 December 1943; LAC, RG-25, Vol. 2718, File: 72-RX-40, Ralph P. Bell, "Great Opportunities Lie Ahead of Canada in World Aviation; Vast Wartime Growth," *The Montreal Gazette*, 5 January 1944.

[19] *Ibid.*

[20] LAC, RG-28, Vol. 155, File: 3-P-12, "Memorandum by A/V/M E.W. Stedman (RCAF) for Presentation to the Cabinet Subcommittee on Air Transport Policy," 19 January 1944.

[21] The largest American transport aircraft project at the time was the eight-engine 400,000 lbs gross weight Kaiser-Hughes H-4 Hercules flying boat developed by Howard Hughes, capable of carrying a payload of 120,000 lbs. Next in line was the six-engine 265,000 lbs. gross weight Consolidated C-99 (85,000 lbs payload and 400 troops); the four-engine 186,000 lbs gross weight Lockheed C-89 (35,000 lbs payload); the four-engine 120,000 lbs gross weight Boeing C-97 (30,000 lbs payload); the four-engine 125,000 lbs. gross weight Douglas C-74 (120 passengers); and the four-engine 94,000 lbs gross weight Lockheed C-69 Constellation (67 passengers). See *Ibid.*

[22] *Ibid.*

[23] *Ibid.*

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[33] "Chalmers H. Goodlin to Martin F. Auger," 4 September 2002.
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[37] *Ibid.*, p.2.
[38] *Ibid.*
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63 NAM, File: CCF CBY-3, "G.S. Levy (NRC) to J.H. Parkin (NRC)," 24 July 1945.

64 NAM, File: CCF CBY-3, "CCF Report on the Flight Test of the CBY-3," 6 December 1945.

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66 LAC, RG-24, Vol. 5053, File: HQ 938-1-3, "H. Murray Semple (Assistant to the President, CCF) to the DND," 14 November 1945; Molson and Taylor, *Canadian Aircraft since 1909...*, p. 172.

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71 NAM, File: Fairchild X, "G.S. Levy (NRC) to R.D. Richmond (Stress Engineer, Fairchild)," 2 November 1943.

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postwar research and development work on several innovative civilian and military aircraft designs, including helicopters, jet aircraft, gliders and remotely controlled rocket-propelled aircraft "for rapid mail delivery and for obtaining meteorological data at high altitudes." The ACAR also wished to work on tailless aircraft, pusher-propeller aircraft (aircraft with the propeller behind the wing or at the tail-end of the fuselage) and canard, or tail-first, aircraft (layout in which the tail assembly is eliminated and an extra lifting surface is attached to the nose of the aircraft for extra stability and control). It also wanted to undertake studies on jet propulsion, supersonic speeds, new types of undercarriages (multiple wheel and track types) and new types of wings. Having the NRC work on such unorthodox aircraft concepts seemed justifiable at the time. As one government official noted, the NRC "has first class facilities ... which should be used to full capacity ... Canada must be bankrupt of brains and equipment" not to take advantage of this. See LAC, RG-28, Vol. 155, File: 3-P-12, "*The Canadian Aircraft Industry – Past, Present, Future*, by Richard J. Moffett," December 1943; LAC, RG-77, Vol. 249, File: LM4-A3-R13, "List of Suggestions for Postwar Research to ACAR by A/V/M E.W. Stedman," 16 December 1943; LAC, RG-77, Vol. 249, File: LM4-A3-R13, "J.L. Smith (Aeronautical Engineer, Federal) to G.S. Levy (ACAR), 3 February 1944; LAC, RG-77, Vol. 249, File: LM4-A3-R13, "Group Captain A.O. Adams (RCAF) to ACAR," 24 February 1944.

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82 LAC, RG-28, Vol. 5, File 9, "Diary of Visit to Great Britain by C.D. Howe (MMS)," 13 October 1942; LAC, RG-77, Vol. 243, File: BM4-A-3-37, "G.T.R. Hill to Dean C.J. Mackenzie," 28 October 1942.

83 LAC, RG-28, Vol. 5, File 9, "Diary of Visit to Great Britain by C.D. Howe (MMS)," 13 October 1942.

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85 *Ibid.*

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[143] LAC, RG-24, Vol. 6179, File: HQ 60-1-59, "Marshal of the Royal Air Force Sir Charles F.A. Portal (CAS, RAF) to Air Marshal Robert Leckie (CAS, RCAF)," 25 April 1945.

[144] DHH, AIR 8 853, "Air Vice-Marshal W.F. Dickson (ACAS (P)) to Air Marshal Sir W.A. Coryton (Controller of Research and Development, Ministry of Aircraft Production)," 6 January 1946.

[145] LAC, RG-24, Vol. 6179, File: HQ 60-1-59, "Air Marshal Robert Leckie (CAS, RCAF) to Air Marshal Sir Charles F.A. Portal (CAS, RAF)," 23 May 1945.

[146] "What's Worrying our Engineers?," *Canadian Aviation*, Vol. 26, No. 5 (May 1953), pp. 28-29, 36-50.

CHAPTER SIX

THE FUTURE OF AIR TRAINING

> Sometime in the fall of 1948, prototypes of a new training aircraft completely designed and built in Canada, will undergo first flight trials. The twin-engine machines, required by the RCAF for the crew training of all members of aircrew except pilots, will ultimately be produced in three subtypes: a navigation trainer, a bombing and gunnery trainer, and a radar and radio trainer ... The project was initiated by the RCAF in 1944, when the Department of National Defence for Air issued Preliminary Specification AIR-4-10 to ten Canadian manufacturers ... The specification was the end result of some long term planning by the Aeronautical Engineering Division, which had recommended this step as the most practical means of encouraging Canadian firms to maintain adequate design staffs ... The firms ... submitted competitive preliminary designs, two of which were selected for further development ... Each firm has been authorized to produce three prototypes and these will represent one of the most progressive steps yet taken by Canada's aviation industry.
>
> — *Canadian Aviation*[1]

In early 1944, the DND (Air) decided to take matter into its own hands and to issue a formal postwar requirement for a twin-engine aircrew trainer to be designed and developed in Canada. The decision was owed largely to the fact that the RCAF was disappointed that no government-sponsored aircraft project had yet been issued for postwar work in the industry. The RCAF had first issued a requirement for a suitable twin-engine aircrew trainer in early 1943, when it was asked to prepare a list of aircraft

needed for the future that could be manufactured in Canada. Work proceeded at an extremely slow pace, that is until 1944, when the RCAF decided to accelerate the process to provide the Canadian aircraft industry with a viable postwar project. The initial goal was to have the proposed aircraft designed and developed in Canada by private aircraft companies. Crown Corporations such as VAL or Federal were excluded from the program. Yet, pressure from C.D. Howe and the DMS paved the way for these two corporations to play an extremely active role in the evolution of the twin-engine trainer project. While VAL was allowed to bid against other Canadian aircraft manufacturers for the contract, Federal was asked to supervise and coordinate the entire project after it took over the responsibilities of the DMS' Aircraft Production Branch. In the end, however, the aircrew trainer was a failure as none of the design proposals submitted by Canadian aircraft companies were adopted. The RCAF specification was simply too ambitious and complex and, as a result, officials decided to cancel the program altogether in 1947. This chapter will analyze the evolution of the RCAF twin-engine trainer program, and its impact on the Canadian aircraft industry.

The "Ideal Twin-Engine Trainer" Project

The roots of the RCAF twin-engine aircrew trainer program went back to February 1943, when the Air Council met to discuss the need to design and develop aircraft in Canada in order to prepare its aircraft industry for postwar years. The Air Members were asked to recommend aircraft types for future RCAF use that could be manufactured in Canada, "with the objective of establishing a continuing postwar aircraft industry, producing aircraft indigenous to Canada, and give Canadians experience in

design." The requirement was for trainers and transports.[2] Air Vice-Marshal R. Leckie, the Air Member for Training (AMT), was asked to provide specifications for the "ideal" elementary single-engine trainer, advanced single engine trainer and multi-engine trainer. The AMT solely expressed interest in a universal twin-engine trainer, an aircraft suited for training both multi-engine aircraft pilots and aircrews.[3] On 11 March 1943, the RCAF notified the British Air Ministry that it was working on a general specification for a modern twin-engine trainer to be designed and constructed in Canada as an A.V. Roe Anson, Airspeed Oxford, and Cessna Crane replacement.[4]

The AMT's report on the "ideal twin-engine trainer," as the aircraft came to be known, was issued in mid-March 1943. The basic aircraft was to be developed for three separate functions: flight, navigation and armament training. Each model was to be designed and fitted to perform all three roles with the appropriate equipment. The basic aircraft design was to be used for flight training. The two other versions were to be essentially the same, except that they would incorporate specific components, such as navigation, bombing and gunnery equipment. The basic aircraft was to be a low-wing or mid-wing monoplane with retractable tricycle undercarriage powered by two 600 hp engines. It was to be capable of carrying a crew of five and of six hours. The criteria for training multi-engine aircraft pilots dictated that the machine be representative of the larger operational types, particularly bombers, and be suitable for converting pupils having just completed their formation on single-engine elementary trainers. As such, the aircraft was to be fitted with advanced instruments, such as dual controls and night and formation flying equipment.[5]

But Air Vice-Marshal A. Ferrier, the AMAE, did not share the AMT's interest in a universal trainer. He firmly believed that the training of multi-engine aircraft pilots should take place on a different type of aircraft, preferably a single-engine trainer, which could be a "good deal lighter" and with "better performance." In his opinion, it was better to continue using the Harvard for advanced pilot training, even in twin-engine training schools. Ferrier told the AMT that a universal trainer designed to meet both requirements of pilot and aircrew training would be impractical "in view of the rapid changes in the types of aircraft that are liable to occur in the near future," which will make it "necessary to change the type of aircraft used for flight training rather more quickly" than one for navigation or armament training.[6] "It seems that we are not yet ready to crystallize ideas concerning advanced multi-engine pilot training into a specification to govern design and manufacture," he added. "On the other hand, requirements for a crew trainer boiled down essentially to the provision of a good flying platform." Ferrier recommended that the AMT concentrate his efforts on a twin-engine general utility aircrew trainer.[7] But work on the project moved at extremely slow pace in the months that followed, since the Committee on Postwar Manufacture of Aircraft (CPMA) preferred to have the Canadian aircraft industry work on the development of transport aircraft adapted for both civil and military applications.[8]

In March 1944, Ferrier was fed up and frustrated with the activities of the CPMA. He concluded that the time had come for the RCAF to initiate the design and development of an indigenous aircraft. To get the ball rolling, he recommended to the Chief of the Air Staff that the RCAF issue at once a specification for a general utility twin-engine aircrew trainer. "It is fully realized that we are faced at this moment with an

embarrassing surplus of such aircraft," Ferrier admitted, "but they are all of an obsolescent type, and my fear is that, if the Canadian industry does not get something creative to do soon, the technical staffs will just fade away and we shall lose the new generation of aeronautical engineers to the United States and United Kingdom." Estimating the manufacturing cost of the first prototype at about $300,000, Ferrier recommended that at least two Canadian aircraft companies should compete for this project and that each should build at least three prototypes. Under such an arrangement it would be necessary to allot approximately $1 million for the aircrew trainer program.[9]

The Air Council discussed Ferrier's proposal on 27 March 1944 and agreed that a sound aircraft industry, capable of producing its own aircraft designs, was an absolutely essential element of Canada's national defence.[10] There was a realization that the Canadian aircraft industry had achieved a position of prominence in world aviation during the war by producing modern combat and training aircraft types. Canada's enhanced status, achieved at considerable expense, should not be weakened in the postwar period. Yet, the Air Council stated:

> With the exception of Noorduyn Aircraft Limited, which is building a general utility single engine transport of its own design [Noorduyn Norseman], the Canadian aircraft manufacturers are engaged in building aircraft, which were designed either in the United Kingdom or the United States of America. No industry can continue to exist in a healthy state under such circumstances because competitive industry in foreign countries will not be willing to license its most up-to-date designs for manufacture in Canada except under the peculiar conditions of war. Furthermore, an aircraft industry engaged in building to other people's designs cannot hope to attract to itself nor to retain the best class to technical personnel, and the inevitable result would be that, for lack of creative opportunity, existing technical staffs will be dissipated to other more vital fields and, worse still, Canada will lose the oncoming generation of ambitious and capable young technical men educated at her expense.[11]

The Air Council concluded that steps should be taken to retain necessary technical personnel to promote the establishment of a Canadian aircraft industry capable of successfully creating and producing aircraft comparable in design, quality of workmanship and performance to those of other countries. Canadian-designed aircraft had to be capable of competing on the international market. Indeed, the major challenge in operating a successful aircraft industry was to make it economically self-sustaining by assuring a market for its product in sufficient volume to recoup the designing, engineering and production costs. It was therefore becoming increasingly clear that if Canadian manufacturers were to survive in the postwar period, the production and distribution of indigenously designed machines would require government support.[12]

According to the Air Council, the twin-engine aircrew trainer proposal offered an excellent opportunity for the DND (Air) to contribute to the maintenance of a strong Canadian aircraft industry.

> The difficulty in establishing an aircraft industry in Canada that will be capable of designing its own products is to assure a market volume which will give a reasonable distribution of engineering and development costs. It may be taken as an accepted fact that the aircraft industry in every nation today has been and is maintained by the government of that nation to create actual and potential air power and, in no country has the aircraft industry reached a position of being self-supporting in the true sense of the term. It can, therefore, be stated that, in Canada, the Department of National Defence must assume the financial burden of supporting the future Canadian aircraft industry. Such sales as may be made to customers other than the Canadian government will serve merely to reduce to some extent the burden of the industry on the government. In the existing situation, the Canadian aircraft industry has no specific, officially supported, design projects in hand, with a firm promise of orders to follow.[13]

Consequently, the Air Council proposed that the DND (Air) issue specifications for a general utility twin-engine crew trainer aircraft for training all kinds of aircrew except pilots. This trainer would replace the types in use, "none of which are entirely satisfactory

and all of which are of obsolescent design."[14] The twin-engine aircrew trainer project was all the more interesting due to its potential civilian applications as such an aircraft shared many features of a small transport. The Air Council explained that "much of the design and construction work involved could also be applied to an aircraft of a generally similar type, which would have an excellent chance for a market in the 'feeder line' transport field in civil aviation." The intended outcomes were higher marketability and lower production costs. Overall, the aircrew trainer seemed to be an ideal choice.[15]

The Air Council proposed that arrangements be made through the DMS for competitive proposals, from which would be selected the two best aircrew trainer designs. A contract not exceeding $500,000 would then be negotiated with the two chosen Canadian aircraft companies. Each company would build at least three prototypes to be delivered to the RCAF for trials. The best design would be approved for production at a later date, although it was pointed out that no "promises should be made at this stage, the main object of the project being to afford a specific task for the design staffs of the infant industry which will enable part of the industry, at least, to accumulate technical personnel, retain their services, and give them practice and experience, in design and preparation for production."[16]

On 18 April 1944, the Air Council recommended that $1 million be allocated by the Treasury Board following approval by the Cabinet War Committee "for the production of three prototypes of each of the two most suitable designs for a twin engine general utility crew trainer." The AMAE and AMT were asked to produce specifications embodying as much as possible all the desired features of the ideal twin-engine trainer aircraft, and prepare the necessary submissions.[17] In early May 1944, the AMEA and

AMT discussed their requirements for the all-purpose twin-engine aircrew trainer with the DAE. It was agreed that the aircraft be used for target towing, bombing and air gunnery, navigation, wireless and photography training. It was to have a gross weight of 12,000 to 14,000 lbs and be powered by two Pratt & Whitney engines, either the Wasp or the R-1340. Moreover, it was to be equipped with power-operated tail and mid-upper gun turrets, and be capable of carrying 500 lbs. bombs on as many as twenty-five suspension points under the wings and fuselage.[18] The DAE prepared the aircraft specification in the weeks that followed.[19]

On 24 June 1944, the DAE made available a draft of the proposed RCAF Specification AIR-4-10. The 12,000 to 14,000 lbs gross weight aircraft was to be powered by two 600 hp Pratt & Whitney R-1340 engines and capable of a maximum speed of 200 mph. It was to be designed for the training of bombardiers, air gunners, navigators, and wireless and radar operators. In order to properly fill these functions, it was suggested that the basic aircraft design be converted into three variants: Type "A" navigation trainer, Type "B" armament trainer, and Type "C" wireless trainer. The three variants were to be as similar as possible, and to be readily convertible from one type to another in minimum time and with minimum workshop facilities. In general, the variation between the three types was limited to the different equipment. It was noted that it was the intention of the DND (Air) to encourage the designer to be as creative as possible, and to exploit the latest advances in the fields of aerodynamics, structures and materials.[20]

The Type "A" navigation trainer would be used for the training of pupil navigators. The exercises to be performed were to increase in difficulty, from elementary

map reading flights to the most advanced navigational flights required before allowing the pupils to operate on service aircraft such as bombers. The aircraft would have a crew of five, composed of a pilot, a wireless operator, and three pupils; a pilot, a wireless operator, an instructor, and two pupils; or a pilot and four pupils.[21]

The Type "B" armament training aircraft was to be used for training bomb aimers and air gunners. While it was impossible to predict the future direction of bombing and sighting, it was noted that some thought and consideration should be given to the use of radar controlled bombsights and gun sights. The DND (Air) was to keep contractors informed of space and mounting required for such possible future equipment during the construction of the prototypes. The normal crew was to consist of a pilot, an instructor and two pupils. Armament training was to be divided into two categories: air bombing and air gunnery. Only bombing exercises were to be conducted during the training of bomb aimers. As elementary bombing instructional methods were not expected to change fundamentally within the next few years, advanced training was to be done on operational aircraft. The Type "B" aircraft required a maximum forward view, and the bomb aimer's position, located in the nose of the aircraft, was to allow side-by-side seating for an instructor and a pupil. Space provision was to be made for a chart table and bombsight. The bomb aimer's instruments were to include an altimeter, an airspeed indicator and an outside temperature indicator. Provision was to be made to permit the release of bombs under the following conditions: single bomb drops, salvo release, jettison of all bombs, and stick release including any combination of bomb stations in any sequence.[22]

In regards to air gunnery, the aircraft was to be used to teach the elementary principles of gun sighting. For this purpose, an enclosed sighting station in the aft portion

of the aircraft was to accommodate a pupil seated. A power-operated mid-upper gun turret and an observation station from which the instructor could observe the results obtained by the pupils were to be provided. The mid-upper gun turret installation was to be located so that clear view and firing without wing damage could be carried out with full depression of the guns. The mid-upper turret was to be capable of rotating 360 degrees and was to be easily removable from the aircraft; a contoured blanking off plate was to be provided to cover the opening. A totally enclosed rear gunner's position was also to be provided in the aircraft, consisting of an upright seating position for the gunner. The tail and mid-upper gun turrets were to be fitted with twin .303 or twin .50 caliber machine guns. The Type "B" armament trainer was to be crewed by a pilot, an instructor, and two pupils.[23]

Type "C" was to serve as a wireless trainer for the training of radio personnel. The normal crew was to consist of a pilot, an instructor, and three pupils. The first student was to operate the main wireless installation, the second the direction finding and/or radar equipment, while the third monitored the first pupil, did map reading for the direction finding equipment operator, and visual signaling. Simultaneous operation of all equipment while airborne was necessary, except that simultaneous operation of the pilot-operated radio-transmitting equipment and the main wireless installation was not required.[24]

The proposed basic twin-engine trainer configuration was to be designed for satisfactory operation of all instrument, armament and equipment at very high and low air temperatures. Each component of the airframe assembly had to be easily removable from the main body. The maximum size of any single components — wings, tails, cabin —

was not to exceed 8 x 10 x 36 feet in order to permit transportation on a standard railroad flat car and storage in existing RCAF hangars. Most components were to be interchangeable, the only exception being the flaps. An astrodome was to be fitted in the cabin as near as possible to the center of gravity of the aircraft, readily accessible to the navigator stationed aft of the pilot's compartment. It was to be installed as to enable quick jettison in flight so as to provide an emergency exit. In addition to emergency exits provided by the astrodome and the cabin door, other exits were to be provided in the nose of the aircraft, in the roof of the pilot's compartment, and near the tail gunner's position. An internal bomb bay, which was to accommodate sixteen 30 lbs. practice bombs, was to have power-operated doors capable of opening and closing within ten seconds when the aircraft was in flight, and opening without obstruction when the aircraft was on the ground. The design of the bomb bay doors was to be such that the adverse aerodynamic effect due to their opening would be minimized. The bomb door controls were to be electrically interlocked with the bomb release circuit to prevent the release of bombs while the doors were closed. There would also be a suitable opening for the installation of cameras to be used to photograph and record bomb strikes. The tricycle landing gear was to be fully retractable and power operated. The design of the cabin was to allow successful emergency ditching on water, and time for crewmembers to escape. An automatic fire extinguishing system was to be operable from the pilot's compartment and from an external point on the aircraft, readily accessible for ground crew.[25]

Wind tunnel tests for the proposed aircraft were to be conducted as early as possible. The scale model was to be constructed by the NRC, or by a contractor to the NRC's satisfaction. The contractor was to construct mockups of the aircraft, true to scale

and comprising samples of each piece of equipment or accurately constructed dummies. The RCAF provided a list of all the pieces of equipment it required in the aircraft, which included radio, lighting, electrical, oxygen and fire-fighting equipment, navigation instruments, bombsights, practice bombs, gun turrets, machine guns, pyrotechnics, parachutes, dinghies, and cameras.[26]

The project was now ready for submission to the Cabinet War Committee and Treasury Board, but it was deferred for three months at the instruction of the Minister of National Defence for Air as per a ruling of the Cabinet War Committee that all postwar projects be held for that length of time and then reconsidered. The proposal put forward would only be pursued if it received favourable consideration.[27] In the meantime, the draft specification underwent careful study by the AMT and AMAE, who corrected certain small errors and clarified a number of clauses. Specification AIR-4-10 was officially issued a few days later, on 10 July 1944.[28]

After careful examination of the project in early September 1944, three months after the project's initial submission, the Minister of National Defence for Air gave his approval and forwarded the proposal to the Cabinet War Committee for approval.[29] On 27 September 1944, the Cabinet War Committee approved the Minister of National Defence for Air's request for up to $1 million for the design and development of six prototypes of a twin-engine trainer aircraft.[30] The Treasury Board approved the requested sum in early October.[31] Federal Aircraft Limited, a Crown Corporation under the jurisdiction of the DMS, was tasked to supervise and coordinate the project. Federal already had experience in that field, having coordinated the licensed production of the British-designed A.V. Roe Anson twin-engine trainer in Canada.[32]

The Problem Child

On 11 November 1944, Federal sent the RCAF's specification to selected Canadian aircraft manufacturers. The interested companies were to provide an answer before the end of the months and submit preliminary design proposals by 1 March 1945. Fairchild, Fleet, CCF, and Noorduyn indicated their intention to submit preliminary designs, and following preliminary investigations all of these aircraft companies were retained to submit design proposals. VAL believed that its considerable experience in aircraft design warranted its participation in such a project, so it asked to be allowed to submit a preliminary design. As the project was intended to prepare Canadian private industry for postwar, it was doubtful that VAL would be allowed to actually construct the aircraft given its Crown Corporation status and possible interference with its A.V. Roe Lancaster and A.V. Roe Lincoln bomber programs. However, W.A. Newman, president of Federal, saw no reason "why the air force should not benefit from any views they might have." In the end, VAL was allowed to participate in the project.[33]

On 2 December 1944, Newman told the RCAF that he had already began talking to the interested contractors, and that Federal was willing to act as the intermediary between the RCAF and the aircraft industry. All queries from contractors were to go through Federal's Engineering Department, which would confer with the RCAF on matters requiring their input.[34]

But problems soon emerged. Noorduyn president Robert Noorduyn had recently told Newman that he was greatly interested by the government's seeming desire to build up a "creative engineering potential, now lacking in this industry," but had certain reservations about the project. Noorduyn explained that "the whole matter brings into

sharp relief the handicapped position in which Canadian aircraft manufacturers find themselves, and the problems which will have to be solved if any such project is to be carried through successfully ... it is entirely beyond the present capacity of our engineering department to achieve the desired results within any period, such as two years, which we believe would be considered reasonable, and we probably have the largest and most experienced engineering department of any of the manufacturers." Noorduyn explained that there were 172 employees in his company's engineering department, less than ten per cent of whom had experience in layout and detail design work. He estimated that he would have to hire forty to fifty additional men for this project alone. Noorudyn also believed that the recent introduction of overseas conscription by the Canadian government in November 1944 would pose another problem, as "the Selective Service is threatening to conscript the majority of those we now have into the army. If this threat is realized, we will be forced to give up any further interest in the matter." Moreover, Noorduyn felt that the successful development of aircraft such as these "was only possible in a manufacturing organization which is continuously provided with productive work, possessing such a degree of stability and installing such faith in the future as enables it to attract and retain personnel of the necessary experience and skill. An engineering department coupled with an unstable factory condition can achieve nothing." Finally, Noorduyn thought it would be impossible to provide all the design data by the March deadline.[35] He also alleged that a great deal of data was missing from the RCAF specification, principally in regards to weight and location of military equipment.[36]

The RCAF discussed Noorduyn's complaints and requested that this latter provide proof of that his company was incapable of meeting the 1 March 1945 deadline, pointing out that "this project is for the purpose of giving all firms the opportunity to develop engineering staffs as well as to build prototype aircraft."[37] According to the Chief of the Air Staff, Noorduyn was too much concerned "over problems which may never arise." In the end, the RCAF wished to stay the course and "meet the problems as they arise."[38]

In early January 1945, the interested aircraft companies were working feverishly on their twin-engine aircrew trainer designs (Fairchild was even building a full-scale mockup of its trainer's fuselage),[39] but they had numerous problems with the RCAF specification. For example, all contractors experienced difficulty with the requirement for a heavy mid-upper gun turret, and inquired as to whether the RCAF would consider using a lighter turret instead.[40] The RCAF was amenable to the idea of discussing all non-confidential matters at a joint open meeting planned for the fourth week of January, and to holding individual private meetings with each contractor afterwards.[41]

In the meantime, the air force organized a trip for contractors to RCAF Station Mountain View in late January. The purpose of this "familiarization" tour was to provide designers with information on air force training exercises in bombing, gunnery and navigation, and to showcase equipment to be installed in the twin-engine trainer. The visit was described as a complete success. "It not only afforded a background in air exercises," reported an RCAF officer, "but also was beneficial inasmuch that it built up a more thorough understanding generally, by the aircraft industry, of the training procedures of the RCAF."[42] Then, on 25 January 1945, the RCAF held the meeting with contractors and Federal to answer the aircraft manufacturers' questions about certain

aspects of the specification and to review several dozen requests for a relaxation of the requirements. The RCAF said no to most points.[43]

But on 2 February 1945, the AMT complicated matters by requesting major changes to the twin-engine trainer specification with respect to performance and equipment. These were outlined in a memorandum to Federal, wherein it was noted that the rapidly increasing performance of operational aircraft, and concomitant addition of equipment, had altered aircrew training requirements.[44] As a result, two major revisions to the original specification were recommended. First, it was requested that the flight endurance requirement of 6½ hours at an air speed of 150 mph at 10,000 feet altitude be raised to 175 mph for the same time and altitude. This change required an increase in fuel load of up to 400 lbs. Second, provisions were to be made for the installation of new radio and radar equipment, resulting in a weight increase of 485 lbs for the Type A, 695 lbs for the Type B, and 575 lbs for the Type C aircraft.[45] This created certain problems. Air Commodore A.L. James, the DAE, noted that the net effect of these changes increased the gross weight of the aircraft to such an extent that it was "doubtful if a satisfactory aeroplane could be produced."[46] Wing Commander F.S. Nowlan, the DAD, further explained that after discussing the background of these recent requests with AMT officers, "there now is a somewhat prevalent opinion that aircraft designed to specification AIR-4-10 will not represent a sufficient advance over the Anson V in so far as suitability for present training requirements." Nowlan added that in order to meet the new AMT requirements, the aircraft would need to use more powerful types of engines.[47] As he explained:

> It is noted with some trepidation that the effect of recent operational development has apparently increased very materially the performance and

> useful load requirements necessary for training purposes in the short time since specification AIR-4-10 was originally conceived. Presumably, these performance and useful load requirements will continue to become more severe. The use of R-1340 engines for twin-engine aircrew training aircraft will not permit incorporation of all the presently proposed specification revisions, let alone cater to future expansion of requirements. It is suggested, therefore, that a meeting of branch heads of the Directorate of Aeronautical Engineering and of the various directors in AMT division, similar to those held during the original drafting of specifications, would be of value at this time to permit explanation of why further increases in performance and useful load capacity cannot be specified for the aircraft as presently visualized. If it is considered that the present specification no longer meets training requirements, consideration would have to be given to the design of an aircraft with larger power plants.[48]

The best way to meet the additional AMT requirements would be to further amend the aircraft specification to call for increased performance and load carrying capacity. Yet, since contractors had been working on competitive designs for some time at their own expense, Air Commodore A.L. James, the DAE, recommended that the AMT be asked to re-consider their new requirements and stick to the initial specification. As James stated: "I strongly recommend that the original specification be adhered to. If there are constant alterations we will never get delivery and costs will mount considerably."[49] In the meantime, the aircraft contractors submitted their design proposals based on the original specification to the Canadian government for the 1 March deadline.[50]

On 2 March 1945, top RCAF officials met to discuss the suggested AMT amendments to specification AIR-4-10. The meeting was called to discuss revised training requirements for the aircrew trainer and to make the compromises necessary to allow the design of this aircraft. Participants stood behind the project's original purpose, namely "to have produced as ideal a trainer as possible for the training of all aircrew other than pilots," and to "introduce to the Canadian aircraft industry a design project which will offer the opportunity of retaining trained design personnel in Canada, and to

create competent design staffs and to contribute to the economic development of a sound aircraft industry for national defence." The group examined the revised training requirements and, in the end, determined that the requested changes were not feasible for the aircraft's desired size. The major problem revolved around the engine, for the group found that "it is not possible to combine in a basic crew trainer all the current training requirements and use the specified power plant." The engine had been chosen because it was the only available one in the required power class. For this reason, the group decided to retain the initial engine. In regards to the revised training requirements, namely an increased cruising speed and weight, the participants reached a compromise. The group explained that "with the stipulated power plant, a good clean design could meet the requirements of the original specification but an inferior design would not. The increase weight proposed would therefore jeopardize the project. A compromise must be made either by limiting training to be done on the types originally proposed or by increasing the number of models of trainer required." It was agreed that the RCAF needs could be met if the aircraft had one basic design, but was fitted with equipment for specific tasks. The types of trainer versions would be readjusted to meet current requirements. Two different models of Type A navigation trainers were to be made, as well as one model Type B armament trainer and two models of the Type C wireless trainer. Finally, in regard to weight limitations imposed by the current specification, the group concluded that every effort was to be made "to reduce the all-up weight so that a successful aircraft will result."[51]

By April 1945, a group of RCAF engineers began working full time on analyzing data submitted by the contractors and comparing the aircraft designs. The results would

be reviewed by the Air Training Division, which had been given a month before responding to the contractors.[52] Unfortunately, it took much longer to assess the proposals; the results were not issued until early June (about a month after the war in Europe came to an end on 7 May 1945). Fairchild's design proposal obtained the highest marks,[53] followed by Noorduyn, VAL, Fleet, and CCF.[54] With the exception of Fairchild and Fleet, all other proposals contained errors in calculation or in basic assumptions. After thorough analysis of all design proposals the RCAF group concluded that none of the aircraft met the performance requirements set out in Specification AIR-4-10. While the manufacturers' structural gross weight estimates were deemed reasonable, the performance estimates were overly optimistic. In fact, all of the proposed aircraft would have inadequate speed and performance. Estimates indicated that none of the aircraft could meet the original requirement of 6½ hours endurance at 150 mph at 10,000 feet without an increase in fuel load and, therefore, gross weight. A solution lay either in reducing the aircraft's gross weight or endowing the aircraft with more powerful engines.[55]

In June 1945, a DAE study entitled *Improved performance of proposed twin engine trainer with reduced gross weight or with larger engines* was conducted to determine which option would best meet the highest assessed design proposal, which was that of Fairchild. The study compared two options: (Case A) a considerable reduction of gross weight from 14,200 to 12,000 lbs., and (Case B) a replacement of the 550 hp Pratt & Whitney R-1340 with more powerful 1,000 hp Pratt & Whitney R-1830 or Wright R-1820 Cyclone engines. The fuselage of the proposed aircraft was to remain unchanged, while the wing area would be modified as required to maintain Fairchild's proposed wing

loading. It should be noted that the proposed Fairchild twin-engine trainer could only reach a cruising speed of 169 mph and a maximum speed of 189 mph (Specification AIR-4-10 called for air aircraft capable of a cruising speed of 175 mph and a maximum speed of 200 mph). The report concluded that a reduction in gross weight would not sufficiently improve the performances of the aircraft so as to meet the standard of the RCAF's specification; it would only be capable of a cruising speed of 177 mph. The gross weight would have to be further reduced, but this was not feasible as it would limit the aircraft's endurance and payload. The study recommended instead the installation of higher-powered engines, which promised to give the aircraft a performance superior to that outlined in the specification. Whereas the R-1830 engines would permit the aircraft to reach a cruising speed of 202 mph and a maximum speed of 237 mph, the R-1820 would enable a cruising speed of 208 mph and a maximum speed of 245 mph.[56]

The RCAF concurred that it would not be advisable to reduce gross weight, and concluded that the use of more powerful engines would enable the construction of an aircraft similar to the one proposed by Fairchild with excellent performance and the ability to cater to increased training requirements in the future. The consensus was that the performance in Fairchild's aircraft would be good, and an increase in speed could also be achieved through the use of larger and more powerful engines. The RCAF was also interested in a low-wing aircraft. In the end, the RCAF decided to award contracts to the two companies that had submitted the best designs, namely Fairchild and Noorduyn, for complete development of twin-engine trainer designs. It was noted, however, that the DND (Air) reserved the right to approve or commend design changes to the aircraft.[57]

The staff of the DAE studied extensively all aspects of the twin-engine trainer design proposals submitted by Canadian aircraft companies. The RCAF recognized the noteworthy efforts that were undertaken by the industry on this project. An officer observed: "It is apparent that the firms in the industry tackled this job most enthusiastically and sincerely, and under considerable pressure of time." He also stressed the problems encountered along the way. "At no time in the past has the Canadian aviation industry found itself in such a position; nor has so much been at stake – namely the industry's future. It has tried to lift itself from a 'production' function to a 'design and production' function. The results have been most creditable but the restrictions of horsepower and the essentials required by the specification have made the problem very difficult." In the end, the RCAF decided not to adopt any of the design proposals. Work was not to proceed on any of the proposed aircraft, as none were deemed satisfactory. The RCAF offered two alternatives: first, to increase engine power to maintain current training requirements, or second, to modify training requirements by either reducing the number and kind of exercises on the practice schedule or limiting the applications within the different training phases. After considerable thought, the RCAF chose to undertake a complete review of future training requirements "considering the more recent technical advancements in air warfare and with future developments in mind."[58]

The fact that none of the design proposals met the requirements of Specification AIR-4-10 caused serious problems. It became clear that an aircraft of less than 14,000 lbs gross weight "will not be realized" and that this "precludes meeting the minimum performance requirements." Consequently, the DAE recommended that the RCAF re-think the twin-engine trainer project. He explained that the June 1945 DAE report had

showed that the installation of more powerful engine would produce an aircraft that could easily meet the specified performance. The downside was that the size of the aircraft would have to be increased to about 18,000 lbs gross weight. The DAE explained that a decision would have to be taken if the project was to continue: either the RCAF agreed to replace the R-1340 engines with the more powerful R-1830 or R-1820, or it would have to revise the specification and concentrate only on a navigational trainer that met the performance requirements of specification AIR-4-10.[59]

The DAE preferred the second option. He noted that the larger aircraft fitted with more powerful engines would probably be too large for adaptation as a feeder line commercial aircraft, which was problematic since the project's premise was to help assure a future for the Canadian aircraft industry by pursuing development of an aircraft that could be adapted both as a trainer and a feeder line transport. The navigation trainer option, on the other hand, could be readily adaptable to civilian use. The DAE warned that it would be inadvisable to proceed with the project unless there was some assurance that the industry could produce a good aircraft. "If the first postwar endeavour on the part of the industry was a failure," he explained, "there would be rather serious repercussions on the reputation and possible future development of the industry in Canada ... I suggest that consideration be given to the design and production of a straight transport aeroplane powered with the R-1340 engine, as a possible future replacement for the present Beechcraft Expeditor." In other words, he recommended that the RCAF abandon the twin-engine trainer aircraft project and use the design proposals submitted by the contractors as the basis to develop a small transport aircraft adapted to both commercial and military use. The DAE was clearly impressed by the quality of the designs, which he

claimed "indicate that the present Canadian design staffs are capable of producing good designs and the firms concerned deserve great credit for the designs which they submitted under the restrictive terms of the present specification."[60]

Air Vice-Marshal Stedman did not agree with the sudden course change, replying that "we must not lose sight of the fact that the industry has been put to considerable expense in preparing these proposals and would hardly welcome a new specification on the same terms." While he shared the DAE's opinion that the RCAF needed "a good aeroplane," he thought it wiser to simply make necessary modifications to the current specification. Air Vice-Marshal F.S. McGill, the AMSO, agreed with Stedman. "It would be wrong to issue new specifications for a larger aircraft with more powerful motors," he said, pointing out that the industry had already devoted considerable time, money and effort to arrive at the present stage. He strongly recommended that an immediate decision be made to adopt the aircraft proposed in Specification AIR-4-10, but to remove the turrets and convert it into a straight instrument and navigation training aircraft. He felt that the American-designed Lockheed Ventura and Lockheed Hudson twin-engine bombers, or even larger four-engine types should be used for bombing and gunnery training given the required additional horsepower to carry the heavier loads. He also strongly recommended that orders be placed with Fairchild and Noorduyn for three prototypes of their respective trainer designs.[61]

In late June 1945, Air Vice-Marshal Stedman met with the DAE and the AMT to discuss the proposals submitted for the twin-engine trainer and to collect enough information to make an informed recommendation to the Chief of the Air Staff. In the course of discussions, it was pointed out that the original Treasury Board submission had

stressed the importance of the aircraft's dual role as a training aircraft and as a possible feeder line transport. While several interesting propositions had been received from Canadian aircraft manufacturers, their review had shown that the initial Specification AIR-4-10 would not provide a satisfactory training or feeder line aircraft. It became necessary to reconsider the specification in one of two ways. The first option was to reduce the load requirements of the present specification and fit the aircraft with two 600 hp engines, in order to enhance performance. The disadvantage was that by reducing the load requirements, the aircraft would become unsuitable for its original aircrew training purpose; however, it would be useful as a transition aircraft from single engine to multi-engine service types, and for training transport aircraft crews. It would also be suitable as a transport aircraft. Alternatively, the second option was to increase engine power to meet requirements for aircrew training, which could be done by doubling the aircraft's horsepower and relying on two engines of about 1,200 hp.[62]

One of the key underlying problems was that requirements for aircrew training were in a constant state of flux; indeed, they had already changed a good deal since the specification was first written and issued. The proposed aircraft would not be used for RCAF training purposes for at least three years, and no precise determination could be made as to what the air force requirements for crew training would be in upcoming years. It was reported that "under these circumstances it is felt that to go into the heavier aeroplane a good deal of expenditure would be involved, which would be better employed for service types and we might still not have an aeroplane suitable for our requirements."[63] The problems encountered with the proposed twin-engine aircrew trainer design were discussed at the 12 July 1945 meeting of the Air Council. Members

acknowledged that the key problem related to the fact that the RCAF had tried to incorporate too much equipment, such as gun turrets, astrodomes, radar domes, and other sophisticated pieces, into the original design in order to produce an all-purpose aircrew trainer.[64]

A Solution to a Major Problem

Amidst mounting frustration toward the RCAF specification, and growing doubt that the same structure could be used for a satisfactory aircrew trainer and feeder line aircraft, Canadian aircraft companies became increasingly disillusioned with the project. Stedman decided that the time was propitious to call a joint meeting of concerned parties.[65] On 17 July 1945, representatives of the five interested aircraft firms (CCF, Fairchild, Fleet, Noorduyn, and VAL), Federal, the Department of Transport, the Air Transport Board and the RCAF met to discuss the issue and talk about possible next steps. Interestingly, a good portion of the conversation centered on the twin-engine trainer's civilian version, which was to be slightly smaller than the actual trainer but large enough to carry sixteen to twenty passengers. All agreed that priority was to be given to the trainer, and then to possible commercial applications. The problem, however, was that the twin-engine trainer was already overweight. Canadian aircraft manufacturers suggested a considerable increase of aircraft's horsepower by adopting engines of 700 hp, 950 hp or 1,000 hp, preferably the latter two. It was noted that unfortunately the use of such powerful engines would not only make for a more expensive commercial aircraft, but would also increase the gross weight of the trainer considerably. The adoption of a

950 hp engine such as the Wright R-1820, for instance, would raise the gross weight of the aircraft to more than 18,500 lbs.[66]

In the end, the group agreed to have the RCAF revise its twin-engine aircrew trainer specification. It was also said that the new RCAF specification should be submitted to Federal, which would study it and pass it along to the two aircraft companies best suited to fill the task.[67] The Minister of National Defence for Air summarized the process as such:

> As a result of discussion with the aircraft manufacturers it was recently decided that the RCAF should revise the specification for a twin-engine trainer. At that meeting it was also decided that in order to avoid unnecessary expenditure of time and money in preparing designs the new specification should be only sent to two firms. It was the intention of the RCAF officials to send the revised specification to Federal Aircraft, together with a technical assessment of the proposals already submitted, indicating our order of preference. Technical considerations are, however, not the only ones to be taken into account, and particularly as there were very wide differences in cost. It was assumed that Federal Aircraft would themselves select the manufacturers to whom the revised specifications would be sent.[68]

Once again, VAL was initially excluded from the competition because of its Crown Corporation status. The decision shocked C.D. Howe, who had just announced on 24 July that VAL was being sold to A.V. Roe, a British aircraft company owned by the Hawker Siddeley Group, one of the largest aviation organizations in the world and a leader in the British aircraft industry.[69] Howe reminded the Minister of National Defence for Air that "Victory Aircraft has been sold to a British company that probably has more experience than any one in the world in the design of aircraft of the type desired by the RCAF."[70] More importantly for the twin-engine trainer project, the sale conditions dictated that A.V. Roe establish a strong design, research, and development organization in Canada so that its new Canadian-owned subsidiary, to be known as A.V. Roe Canada Limited, be

responsible, on its own, for the design and development of any new types of military and commercial aircraft.[71] Howe went on to say "the sales agreement includes a proviso that the new purchasers will send a top designing team to Canada for the purpose of developing distinctive Canadian designs for combat aircraft. In the circumstances, it seems to me that Victory should be given another chance under its new management and with its strengthened designing team."[72] Howe vowed to involve A.V. Roe Canada in the project.[73] The Minister of National Defence for Air agreed with Howe, noting that "the acquisition of Victory Aircraft by A.V. Roe certainly changes the picture, and it is agreed that it would be desirable to give them a new opportunity to quote."[74] A.V. Roe Canada was officially formed on 1 September 1945, but did not take possession of the VAL facilities until 1 December.[75]

The RCAF specification was finally rewritten around a more powerful engine, the 1,200 hp Pratt & Whitney R-1830 Twin Wasp, and was issued on 28 September 1945 as Specification AIR-4-10 Issue 1.[76] It was decided to have the top two contenders from the first competition — Fairchild and Noorduyn — submit design proposals. The RCAF also agreed to allow the newly formed A.V. Roe Canada to issue a design proposal.[77]

In September 1945, Sir Roy Dobson, managing director of A.V. Roe and first president of A.V. Roe Canada, indicated his willingness to travel to Canada in coming weeks with one of A.V. Roe's chief aircraft designers to work on the twin-engine trainer project, which he found "very interesting." Dobson was quite impressed with the RCAF specification, particularly by the possibility that it could be converted into a first class commercial aircraft capable of carrying between 20 and 22 passengers. "In view of the present scarcity of designs of this type it is possible that this aircraft, built in Canada,

could find a ready market in [Great Britain] and other countries," he explained, adding that, "we are also bearing in mind the chances of eventually fitting turbine power units in place of the piston engines, which of course should give a very much increased performance."[78]

It should be noted that a few months earlier, in January 1945, A.V. Roe, had worked on a preliminary design for an aircrew trainer that met RCAF Specification AIR-4-10, to be known as the A.V. Roe 702, but the project never left the drawing boards.[79] Moreover, A.V. Roe had also worked on a 12-seat twin-engine transport aircraft known as the A.V. Roe 700, which was suitable for conversion as a twin-engine trainer.[80] In the fall of 1945, one of A.V. Roe's design offices proposed to the British Ministry of Aircraft Production (MAP) a more advanced version of the A.V. Roe 700, to be powered by two turbojet engines. Dobson noted that this "could be the first aircraft fitted with turbines for the civil markets." The plan called for the original 12-seat twin-engine transport to evolve into a 14-seat twin-engine jet transport, which could possibly also be used as an aircrew trainer. Dobson originally wanted the VAL design staff to go to Great Britain to work jointly on this aircraft with the A.V. Roe design staff, and then to return to Canada and to take over and complete its design and production. Dobson envisaged the project would thereafter be left in Canadian hands. "I think the design team at Victory can be brought on comparatively quickly in order to make that plant self-contained and capable of building aircraft, not only for Canada but possibly for export, even to this country [Great Britain]," Dobson said. However, the idea was not pursued, as the Canadians preferred working on an independent project.[81] In the end, the British company abandoned its projected 14-seat turbojet version of the A.V. Roe 700.[82]

In October 1945, all three Canadian aircraft companies submitted their twin-engine aircrew trainer design proposals to Federal. A.V. Roe Canada was the first to submit and was anxious of initiating the construction of the three prototypes as early as possible.[83] The proposed trainer, known as the A.V. Roe Canada C-101, was to have a maximum gross weight of 20,294 lbs.[84] Fairchild's proposal for a twin-engine trainer, known as the Fairchild F-8, called for an aircraft with a maximum gross weight of 19,886 lbs.[85] Meanwhile, Noorduyn's proposal called for a twin-engine trainer having a maximum gross weight of 18,166 lbs known as the Noorduyn Model N-38.[86]

The RCAF assessed the three proposals later that same month. All aircraft were found to be satisfactory, despite the fact that each required minor changes to the cabin layout. According to the RCAF, Fairchild submitted the best design, followed by Noorduyn and A.V. Roe Canada. While Fairchild and Noorduyn submitted a modified version of their original submission, A.V. Roe Canada had risen to the challenge by proposing a completely new aircraft design.[87] However, Noorduyn pulled out of the competition a few weeks later, as it no longer felt comfortable with the project; it also turned its attention to the design and development of a feeder line aircraft for operations in Canada. The Norseman's commercial and military success certainly contributed to this decision. A few months earlier, Noorduyn had forwarded a copy of a general specification for a small commercial aircraft of its own design known as the Noorduyn Model N-20 to the Air Transport Board for inspection.[88] With only Fairchild and A.V. Roe Canada left in the competition, the RCAF immediately ordered full-scale mock-ups of both the A.V. Roe Canada C-101 and Fairchild F-8 twin-engine trainers.[89]

In February 1946, new armament requirements for the twin-engine trainer project, namely the installation of a remotely controlled barbette, forced a complete revision of the aircraft's gunnery equipment. A number of RCAF officials were against such a change for fear that this could further delay the project. Indeed, this new equipment requirement could set back the A.V. Roe Canada and Fairchild program considerably and increase costs. Air Vice-Marshal A.L. James, the Air Member for Research and Development (AMRD), claimed that it "may not be possible to install more modern equipment than originally specified without further design changes, due to alterations in size, weight, and location." Yet, some of the requested changes could easily be made; the dorsal gun turret could be replaced by a barbette, the tail sighting station could be converted to a remote control gunnery station, and another remote control position could be made in the astrodome without serious difficulty. The new aircraft might also require a ventral barbette.[90]

On 8 February 1946, RCAF officials visited the Fairchild factory to examine the progress made on the twin-engine trainer mock-up. Fairchild was informed of the possible change in requirements for gunnery equipment. Fairchild said that it could meet these new requirements. It was then agreed that three types of twin-engine trainers be designed and developed: Type A for navigation and bombing training, Type B for gunnery training, and Type C for wireless training. The company requested a conference with RCAF officials during the first week of March 1946 to finalize the aircraft design.[91]

In early May 1946, Fairchild sent a letter to RCAF authorities informing them that none of the trainer versions could meet the new requirements in regards to performance.[92] The problem was that the latest RCAF revisions in equipment had resulted in an increase

in wing area and profile drag, which was particularly serious in the armament trainer version.[93] The replacement of the mid-upper gun turret with two gun barbettes in the gunnery trainer version, and one barbette in the bomber trainer, led to significant increases in overall weight: over 2,500 lbs in the Type B bomber trainer and about 3,000 lbs in the gunnery trainer. Meanwhile, Type A and Type C weights increased almost 2,400 lbs. In total, the gross weight of the Type A aircraft rose to 21,946 lbs, the Type B (bomber) to 22,405 lbs, the Type B (gunner) to 23,028 lbs, and the Type C to 20,852 lbs.[94] It became clear to the RCAF that the armament version was "imposing limitations on the design which precludes interchangeability and which will definitely reduce the performance of the navigation and wireless trainers." This would translate into a considerable increase in the cost of the twin-engine trainer program. Indeed, air force officials reported than an additional $940,000 would be needed to supplement the $1 million that had already been approved by the Treasury Board. The RCAF needed to find a solution to this problem.[95]

The RCAF indicated that it would in all likelihood have to reduce the cost of the twin-engine trainer contract. One solution was to reduce the number of aircraft versions to two, or even possibly one, and lower the number of subcontractors involved in the project. To complicate matters, however, an additional requirement was being put forward for the installation of radar gun sighting in the gunnery version. It was apparent to Wing Commander C.W. Crossland, the DARD, that the gunnery version should be separate from the others: "It is now considered that the requirement that all versions of this aircraft be interchangeable by the removal and replacement of equipment be abandoned, since it must inevitably lead to such serious compromises that none of the

versions are likely to be satisfactory." He further explained that while the gunnery version would have the same engines and undercarriage as the others, its wings would be longer, and its fuselage and empennage would be of an entirely different design. According to Crossland, the RCAF had good aircraft available for navigation, bombing, and wireless training, but no existing service aircraft was suitable for a proposed gunnery training program using remotely controlled barbettes and radar gun sighting. He therefore recommended that the Type A and Type C versions be dropped, and that the aircraft be designed primarily as a gunnery trainer with bombing training as a secondary role.[96]

In June 1946, the RCAF decided to ascertain the changes it needed to make to the specification to meet its new requirements. The ultimate goal was to modify the specification in such a way to minimize impact on design work already completed, and prevent any delays that would result in further increased costs. The RCAF looked into several options. A first was to call for two non-interchangeable versions of the aircraft, one for navigation, bombing and wireless training, and the other for gunnery training only. This course of action would involve major revisions to design calculations, but the resulting delays would not be great since designs were still at preliminary stages. Moreover, since the two versions would have different performance characteristics it would be easier to incorporate equipment to respond to future requirements. Finally, it was noted that although the aircraft would not be interchangeable, many of the components could still be such as engines, nacelles, fuselages, nose sections, cockpits, undercarriages, fuel tanks, and controls. This degree of interchangeability would lessen cost as well as the number of spare parts. A second option was to revise the specification to increase engine power. This would involve a complete re-design of the aircraft,

resulting in an increase in weight due to necessary structural strength and fuel capacity. A third option was to revise the specification to call for two non-interchangeable versions; one for navigation and wireless training, and the second for bombing and gunnery training.[97] Other options were to ask contractors to revise their estimates for one or two types of aircraft instead of three, or increase RCAF estimates for the project. In the end, the RCAF decided to follow the first option.[98]

Like Fairchild, A.V. Roe Canada was experiencing difficulties. In early July 1946, the company reported that certain aspects of the twin-engine trainer design powered by two Pratt & Whitney R-1830, as requested in RCAF Specification AIR-4-10, gave rise to difficulties "if we are to attempt to incorporate all the required versions in one basic type." A.V. Roe Canada proposed to subdivide Type B into two distinct versions: a bombing and a gunnery trainer. The main reason for wanting to do so was because the gunnery version's performance was very different from the others, especially in regards to drag and weight.[99]

The twin-engine trainer program came under intense scrutiny in the summer of 1946 owing largely to its high costs. The DRS requested Fairchild and A.V. Roe Canada to provide a breakdown of their estimated costs. Fairchild reported $1,603,535 for three prototypes,[100] while A.V. Roe Canada reported significantly more at $2,310,900. These estimates did not include the engines, propellers and all loaned instruments and pieces of equipment.[101] This discrepancy caused suspicion and concern in government circles, and led to discussions of abandoning the twin-engine trainer program altogether. On 23 July 1946, the DRS asked the DND (Air) "whether the funds would be provided in accordance to the Fairchild and A.V. Roe Canada estimates or whether, has had been suggested, the

project could be abandoned in part or in total."[102] Several weeks later, the RCAF responded that the estimate submitted by A.V. Roe Canada for three twin-engine aircrew trainer prototypes "would involve an excessive expenditure for this program" and, as such, requested the DRS "to take any necessary steps for the cancellation of contract arrangements with A.V. Roe Canada for these aircraft."[103]

In early August 1946, the DRS asked Fairchild to issue a revised estimate of the cost of developing and building three prototypes of the navigational trainer version only instead of one aircraft for each version. After careful analysis, company officials reported that this initiative would cost a total of $1,709,746, which was higher than estimates for the initial project because the company included the cost of work done on the project thus far. Undoubtedly anticipating concerns, Fairchild proposed to produce only one or two prototypes to reduce costs. The company estimated that the cost of producing a single prototype would bring down the overall cost to $1,245,525. This was still fairly expensive for the production of a twin-engine trainer, but the new estimates were nonetheless submitted to the DRS and the RCAF in early September 1946.[104]

Shortly thereafter, Fairchild reported that the requirements of Specification AIR-4-10 were inadequate in regards to gunnery training equipment and was such that "the aircraft would be unsuitable for any use other than as an aircrew trainer." Fairchild's chief engineer, J.A.T. Butler, explained to the AMRD, "assuming that it now your intention to eliminate the gunnery provisions, we have considered the possibility of altering the fuselage shape to provide an airplane that would not only be suitable for navigational training, but also have additional utility." The company told the RCAF it had several ideas in mind, and the latter requested additional information.[105]

On 30 September 1946, Fairchild submitted a report outlining four ways to expand the utility of the twin-engine trainer without additional cost. The first method was to abandon the gunnery trainer version. Fairchild noted by eliminating gunnery equipment, the aircraft could not only meet all the remaining training requirements, but also fulfill additional functions without major modifications. It would be suitable for bombing, navigational, wireless, pilot and paratroop training, and could serve as a military transport to be used on operational missions for paratroop carrying, material transportation, aerial supply dropping and medical evacuation. To meet additional transport requirements, an upswept rear fuselage with a large rear hatch was proposed. The interior of the aircraft and the rear cargo door dimensions were to be adequate for rapid loading of freight, such as artillery guns, rocket launchers, mortars, jeeps, tractors, and military equipment. Moreover, an overhead rail and winch was to be installed above the loading door to permit the efficient handling of any RCAF engines.[106] The second proposal went even further, namely to abandon both the gunnery and bombing training versions. According to company officials, the elimination of gunnery and bombing equipment would result in a lighter and more efficient aircraft that could fill all of the additional functions outlined in the first proposal. This 21,000 to 22,000 lbs gross weight aircraft could also have some commercial utility as a small passenger transport capable of carrying up to 24 passengers, or as a cargo carrier.[107] The third proposal was to scale down training and other requirements to the capacity of a 12,000 lbs gross weight aircraft powered by two 800 hp Pratt & Whitney Wasp engines, or a 16,000 lbs gross weight machine with the 800 hp Wright C-7. This proposed aircraft's major advantage other than reduced cost, was that it would be suitable for commercial use as a feeder line aircraft or

military transport.[108] The final proposal was to eliminate all training requirements. Fairchild officials observed that if RCAF training requirements could be fulfilled by other aircraft types, a cargo-type aircraft designed with ability to land and take-off on unprepared ground, water or snow surfaces could fill a defence function. Fairchild noted that such an aircraft could be used to supply troops in remote areas where other means of rapid transportation was not possible. It could also be used for material transport for ground forces, medical evacuation, and the transportation of airfield construction crews and equipment to selected areas to prepare landing strips for operational combat aircraft. It could also serve as an aerial communications-mobile command post, mobile kitchen, machine shop, and radio and radar transmitting platform. The proposed aircraft would require a low landing speed, a wide range of approach path control, high energy absorption in the wheel and ski undercarriages, high initial rate of climb, a high degree of ground stability and control, short landing and take off runs, and provision for the rapid changeover of floats, skis, and wheels. The commercial version called for a single-engine aircraft of 7,000 to 10,000 lbs gross weight, or a twin-engine aircraft of 10,000 to 20,000 lbs gross weight.[109]

On 24 October 1946, the RCAF met with Fairchild representatives to discuss the proposed new version of the twin-engine trainer, referred to as Project F-13-X. The AMAS was requested to decide whether the air force should proceed with the twin-engine trainer as originally specified, or to adopt the new Fairchild F-13.[110] RCAF technical officers reviewed the entire project thoroughly, and on 7 November 1946, the AMAS, Air Vice-Marshal W.A. Curtiss, recommended that neither the original twin-engine trainer nor the Fairchild F-13 be pursued. Curtiss explained that when the initial

requirement for the twin-engine trainer was issued, the RCAF foresaw the need for a substantial number of trainers as the war was still underway. Now, the demand for trainer requirements had dropped considerably. He added that the RCAF had a number of twin-engine Douglas DC-3 Dakota transports available to meet navigation and wireless training requirements for at least the next five years, noting that "with present rapid and varied development in aircraft and armament, signals and navigation equipment, it is difficult to foresee at present what equipment will be needed, say in 1950, to fit in with the trend of development ... At present, the designs submitted by Fairchild would not permit the same flexibility in fitment of equipment [as the Dakotas]. Therefore, the usefulness of the aircraft proposed by Fairchild would be limited." He concluded that it was "not considered sound to proceed with the twin-engine trainer project until it is determined firstly when a replacement type will be required (we don't known exactly when Dakota stocks will be retired) and secondly that the Fairchild design fills a requirement which cannot be met by purchase, at lesser cost, of other aircraft existing at that time."[111]

Air Vice-Marshal A.L. James, the AMRD, agreed with this assessment. "It has become increasingly apparent during the past few months that the twin-engine trainer to specification AIR-4-10 could not be successfully developed to keep pace with increasing requirements of equipment for aircrew training and also that the cost of the project would be far in excess of that originally contemplated." He recalled that the initial program, which was perhaps overly optimistic, had proposed the construction of three interchangeable aircraft for different roles at a cost of only $500,000, or one-third the cost of Fairchild's latest cost estimate. Therefore, "since the twin-engine trainer is unsuitable

for all training requirements and since other aircraft are available for training purposes, the expense of continuing the twin-engine trainer project cannot be justified on the grounds of training requirements." The fact was that the project's first objective — to provide an aircraft suitable for the training of all aircrew other than pilots in the postwar period — could be met by other means. The second objective — to stimulate and encourage original aircraft design in Canada in order to assist in the preservation of the Canadian aircraft industry in postwar years — had already been achieved with the creation of Canadair (1944) and A.V. Roe Canada (1945), both of which were engaged in original design projects for the RCAF.[112]

On 23 December 1946, the Deputy Minister of National Defence for Air told the Deputy Minister of Reconstruction and Supply that the "expense of continuing this program cannot be justified on the grounds of training requirements. It was found that the twin-engine trainer will be unsuitable for all training requirements. Coupled with excessive cost, there is not suitable alternative but to request the abandonment of the twin-engine trainer project."[113] A few days later, the RCAF wrote the DRS that it was "unwise to continue the development of a twin-engine trainer along the lines proposed by Fairchild since the cost had developed considerably in excess of that first estimated and the design produced is not as suitable to the variable training demands as some aircraft which have become surplus from wartime operations." The air force requested that the contract with Fairchild be terminated and that the development of a twin-engine trainer be deferred for two to three years until there were clearer peacetime training requirements.[114] The DRS took immediate action, canceling the project in mid-January 1947.[115] In the end, only the nearly completed wooden mock-ups of the A.V. Roe Canada

C-101 and Fairchild F-8 twin-engine trainers were built.[116]According to aviation historian K.M. Molson, "the problem with the project was the RCAF had done two things. Not only did they specify the power plant they wanted ... but they also specified all the equipment they wanted on board so, consequently, they had anyone who was working on the project trapped." It was a harsh lesson in aircraft design and development, and as Molson added, "from then on ... whenever the RCAF issued a specification, all they did was to tell the manufacturer what they wanted done and that's it; that way, the engineers can go and make the best possible airplane powered in the best possible way."[117]

Conclusion

The RCAF twin-engine trainer project proved to be a failure. The goal of initiating a twin-engine trainer project to provide Canadian aircraft manufacturers with a suitable indigenously designed aircraft to produce in the early postwar was not met. No Canadian designed aircrew trainer was ever built or adopted by the RCAF, and no manufacturer continued work on such an aircraft following the government's decision to cancel the project. The discarding of the twin-engine trainer program also coincided with general, and deep, military budget cuts in the immediate postwar era. As a result, the Canadian aircraft industry was forced to rely on its own resources to survive, leaving many companies to turn to the civilian market and rely on privately sponsored programs. In the absence of government support, Canadian aircraft companies found it safer to stick to the design and development of small transport aircraft or to continue the licensed manufacture of foreign-designed aircraft than to initiate new products. The only positive outcome was that the program enabled the government and aircraft companies to start

actively preparing the postwar aircraft industry. The program gave many contractors valuable experience, not to mention added confidence in their abilities to design aircraft, and proved to many that there was a capability to design and develop aircraft in Canada.

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CHAPTER SEVEN

INTO THE JET AGE

> We have a contract to supply the government with jet-propelled fighters ... Our products will be on par with the best in England and the US. We are going to build aircraft designed to suit Canadian conditions. Canada has always built the other fellow's product; now we are going to have aircraft that are Canadian from the drawing boards to the stars.
>
> — Walter Deisher, President of A.V. Roe Canada[1]

The Canadian aircraft industry did not manufacture any aircraft engines during the war, the bulk of production consisting of airframes and aircraft equipment. Canada had to import aircraft engines from Great Britain or the United States as there were no facilities that could produce them at home. The country remained entirely dependent on foreign sources to power all Canadian-made aircraft until the end of the war. This situation placed Canada in an extremely vulnerable situation, for if the supply of engines from American or British sources was suddenly cut off, the Canadian aircraft industry would have faced serious problems. Moreover, engines destined for the Canadian market were often re-oriented towards American or British production lines to meet urgent requests. The importation of engines was often delayed as American and British engine makers not only had to cope with Canadian orders but also those of their own governments and other Allied countries. It was relatively easier for Canada to obtain engines in the United States because of geographical proximity. British engines had to be

shipped across the Atlantic, where many were lost as a result of enemy submarine attacks on Allied merchant ships.

The strategic importance of initiating the construction of aircraft engines in Canada was not a new subject. The issue had been discussed on several occasions before and during the war, but it was felt that there were too many difficulties in launching such production. Many Canadian government officials believed it was simply too late for Canada to begin producing aircraft engines on an equal footing with other Allied engine producers. The situation only changed with the advent of jet and rocket propulsion towards war's end. Canada wanted to partake in this new venture. As a result, the Canadian government launched an important jet engine program during the war, the ultimate aim being to provide Canada with the necessary tools, resources and knowledge to undertake the mass production of such products. Ottawa also decided to initiate the design and development of jet aircraft, including a twin-engine jet fighter. This was an ambitious project for a country like Canada, especially given its record on conventional aircraft. Why did Canada want to venture in the uncharted waters of jet engine production when it had absolutely no knowledge or experience? And why did Canada initiate the design and production of such a complex machine as a jet fighter when it had not developed a single combat aircraft since the unsuccessful FDB-1 in the late 1930s? This chapter will attempt to answer these questions and explain why Canada decided to design and develop its own line of jet engines and jet aircraft in the later stages of the war.

A Wartime Deficiency: Canada and Aircraft Engines

Efforts to initiate the manufacture of aircraft engines in Canada go back to the beginning of the century. In 1910, W.W. Gibson of Victoria, British Columbia, produced Canada's first aircraft engine. It was an indigenous 60 hp design that was never mass-produced.[2] In 1916, Canadian Aeroplanes Limited obtained the manufacturing right for the production of the American-designed Curtiss OX series of aircraft engines, and planned to share production with Canadian Vickers, but there were no orders.[3] The only successful endeavour was Willys-Overland Limited's of Toronto, which built more than 125 Sunbeam Arab aircraft engines of 200 hp for the British government in 1918, but production ceased with the end of the war.[4] In 1924, the newly-created Royal Canadian Air Force (RCAF) investigated the possibility of initiating aircraft engine production in Canada, but these efforts proved fruitless. It was concluded in a Department of National Defence report that, "the manufacture of aircraft engines is expensive and can only be conducted efficiently on a production basis" and that "the demand for aircraft engines in Canada will not justify the establishment of a special industry for this purpose for many years."[5] It is thus not surprising that in 1936, the Navy, Army, and Air Supply Committee noted that production of aircraft engines in Canada would be very difficult. In a special report, it explained that "the art of manufacturing aero engines is unknown in this country. Suitable materials are not produced and the majority of the machinery required is not available. There are no firms equipped for this work at the present time and it is estimated that at least two years would elapse before any aero engines could be produced, even with the assistance of imported materials."[6]

However, in this same period, CCF was planning to design and develop its own line of aircraft engines. In 1937, the company told the Canadian government that its Pointe St. Charles factory in Montreal was about to manufacture a 175 to 200 hp aircraft engine of its own design, and it was considering the eventual production of more powerful ones.[7] CCF had in fact converted a portion of its Montreal plant into an aircraft engine-manufacturing unit complete with technicians, skilled workers, engineers and designers. In August 1938, *Canadian Aviation* reported that the CCF factory was " in production on an aircraft engine designed, processed, fabricated and assembled in the shops of the company" and was "now in a position to produce aircraft engines from the raw material to the test stand." The factory was not only able to produce the engines, but also propeller hubs and blades.[8] In late 1938, CCF completed the prototype of its small indigenously designed 200 hp seven-cylinder radial engine, known as the R-500 Maple Leaf. Unfortunately, the project was unsuccessful as the company did not receive any orders.[9]

As a result, when the Second World War began in September 1939, Canada had no engine-making capabilities.[10] This was a serious problem, so the Cabinet War Committee discussed the possibility of initiating the production of aircraft engines in Canada. But in the end it decided not to pursue this endeavour because it would be expensive and would take about two years for such a factory to become operational.[11] As C.D. Howe explained:

> The manufacture of aeroplane engines involves an enormous capital expenditure, a heavy drain on available supplies of machine tools, and a very large number of highly skilled workmen. Production cannot be obtained in less than a period of eighteen months, and, when production is obtained, it will be for only one size and type of engine, whereas Canada uses some ten sizes of engines and two different types ... In the present state

> of our industrial production we would be well advised to purchase aeroplane engines outside Canada, rather than to attempt to build them.[12]

The successful German strike against Scandinavia and Western Europe in the spring of 1940, the ensuing Battle of Britain, and the growing possibility that Germany might invade the British Isles raised fears that Canada could be cut off the supply of British engines. The Canadian government investigated the possibility of initiating the construction of British or American-designed engines. In May 1940, Canadian authorities discussed the possibility of building the British-designed 2,100 hp Bristol Centaurus engine in a factory in southern Ontario, possibly Toronto or Hamilton. The rationale for this initiative was that Canadian factories were far less vulnerable to enemy bombing, and had the necessary facilities and machine tools to undertake such a task. Moreover, Canada was close to the American market for special engine parts and tools.[13] The Centaurus project failed, as did the later proposal to produce British-designed 1,600 hp Rolls-Royce Merlin engines.[14] The British government decided instead to negotiate a contract for the licensed manufacture of Merlins with the Packard Motor Corporation of Detroit, Michigan. The first Packard Merlin engines came off the assembly line in 1941 and many of them were supplied to Canada for Hurricane, Mosquito, and Lancaster production.[15]

In September 1940, the Canadian Pratt & Whitney Aircraft Company Limited of Longueuil, Quebec, proposed to manufacture the American-designed 600 hp Pratt & Whitney R-1340 Wasp engines, or the more powerful 2,000 hp R-2800 Double Wasp. A license agreement was made between Pratt & Whitney Aircraft of Hartford, Connecticut, and its Canadian branch plant. Unfortunately, American neutrality laws affected the deal as many of the components and parts to be used in the construction of Pratt & Whitney

engines in Canada were to be provided by the American parent company, representing an infringement of United States neutrality. The license was withdrawn.[16]

The DMS was particularly disappointed by the turn of events and it was suggested, as an alternative, to contact other American aircraft engine manufacturers. In early September, Ralph Bell suggested that the Wright Aeronautical Corporation of Patterson, New Jersey, or the Jacobs Aircraft Corporation of Pottstown, Pennsylvania, be approached for the licensed manufacture of their engines in Canada.[17] At about the same time, Fleet was planning to assemble Jacobs engines in Canada at a factory to be built in London, Ontario.[18] Bell supported the Jacobs option, but the RCAF preferred the more powerful Wright engine. Still, the idea of going with an American engine could be problematic, as there was always the possibility of encountering the Pratt & Whitney difficulties again.[19] As a top RCAF official added: "Wright will be in a similar position to Pratt & Whitney and its commitments are so great that it cannot undertake to pay the proper attention to the development of an aircraft engine factory in Canada."[20] The RCAF suggested to look instead at British engine manufacturers, particularly the Bristol Aeroplane Company, which had reportedly already approached the British Air Ministry concerning setting up a factory in Canada.[21] According to C.D. Howe, Bristol was "most anxious" to establish a branch plant in Canada.[22] Many in the RCAF also believed Bristol engines to be far superior to their Pratt & Whitney or Wright counterparts. In the end, both the Bristol and Wright propositions were investigated.[23] Canadian officials immediately looked into the possibility of producing several types of Bristol engines, namely the Aquilla, Taurus,[24] Perseus and Hercules.[25] In December 1940, the DMS discussed the establishment of a Bristol branch plant in Canada with the British, but

nothing transpired.[26] Meanwhile, Canadian authorities expressed an interest in manufacturing Wright engines, namely the 350 hp R-760, the 450 hp R-975 Whirlwind, the 1,000 hp R-1820 Cyclone, and the 2,000 hp R-2600, but the Wright proposal never came through either.[27]

In the meantime, the Canadian aircraft industry and the RCAF grew impatient and frustrated as both required a stable supply of aircraft engines. On 5 September 1940, Prime Minister William Lyon Mackenzie King told the Cabinet War Committee that the production of aircraft engines in Canada "might have been a sound insurance against the possibility of being unable to obtain adequate supplies of engines from British and American sources" and that Canada should begin this production "at once."[28] He later added that "he had always felt that Canada should adopt a policy of self-sufficiency in this respect" and that the events of the past year had shown that "we could not rely on outside sources."[29] In January 1941, the Cabinet War Committee noted that the problem of engine production was a difficult one and that many obstacles had been encountered in negotiations with American and British companies. Plans were contemplated for the small-scale production of a 1,200 hp engine solely for Canadian requirements. However, it was noted that "were it not for public opinion it would be more efficient to continue to obtain engines for Canadian aircraft from US and UK sources."[30] Indeed, the initiative seemed costly: the only way for such an operation to be financially sound was if Great Britain placed large orders in Canada, and this seemed highly unlikely as the British preferred to have their combat aircraft engines manufactured at home. For this reason, when the issue of building the Bristol Centaurus engine in Canada was revived in March 1941, a disillusioned Air Vice-Marshal E.W. Stedman told Ralph Bell that "it is apparent

that we in this country can do nothing in the matter without a direct order from the British government for engines of this type" and added that he had "given up the hope that we may manufacture engines in Canada ... of such a large size as the Centaurus."[31] The production of engines of more than 1,000 hp was clearly out of the question, at least for the foreseeable future.

In February 1941, the Menasco Manufacturing Company of Burbank, California, contacted the DMS with a proposal to set up a factory in Canada to make the 125 hp Menasco D4 Pirate engine.[32] The Canadian government was interested in the proposal because it would offer it an opportunity to produce its own engines for the elementary trainers of the BCATP, thereby relieving pressure upon British engine manufacturers, and it would also increase self-sufficiency in engine production. The manufacturing of a small and simple engine such as the Pirate would provide an appropriate stepping-stone, before moving into the production of larger and more powerful power units. Menasco was also developing more powerful engines of up to 4,500 hp, and indicated that it would be willing to grant license production of all of these engines to a Canadian branch plant.[33] The Menasco proposition had to wait until a decision was made regarding the adoption of a new type of elementary trainer for the BCATP.[34] The choice fell on the Fairchild PT-26 Cornell elementary trainer, powered by an American-designed Ranger engine. The Menasco idea came to an end.

In the fall of 1941, the DND (Air) decided to explore the feasibility of producing in Canada small aircraft engines for BCATP training aircraft.[35] On 30 October 1941, the Air Council met to discuss the possibility of manufacturing the 250 hp Ranger VI engine.[36] The Minister of National Defence for Air explained to the Cabinet War

Committee that if "if this proved practicable, it not only would provide engines for trainer aircraft, but also a Canadian source of spare parts, to assist in meeting the serious overhaul and repair problem of the Joint Air Training Plan." C.D. Howe supported the idea, pointing out that the project would be manageable, cheap, helpful, and different from the larger projects previously considered. More importantly, it would help reduce Canada's dependence on the United States for engines.[37] In January 1942, the Minister of National Defence for Air submitted a proposal to the Cabinet War Committee for the licensed production of Ranger engines by the Chrysler Corporation of Canada Limited in Windsor, Ontario. He said the Air Council was concerned with the serious shortage of trainer engines, which United States production could not meet alone. He explained that the Ranger engine would be used for the new Cornell, which had just been adopted as the standard elementary trainer of the RCAF, the RAF, and the USAAF. C.D. Howe approved the project. In mid-January 1942, the Cabinet War Committee agreed to refer the proposal for further examination,[38] and to negotiate a license agreement with the Ranger Aircraft Engine Division of Farmingdale, New York. The Ranger was to be the first aircraft engine mass-produced in Canada.[39]

Unfortunately, in March 1942, American members of the Joint War Production Committee concluded that the manufacture of Ranger engines in Canada would not be undertaken due to changed circumstances. The USAAF had decided to use another type of trainer engine, the Continental, which now allowed the Ranger factory in the United States to provide for Canadian requirements. Moreover, the United States would not release the drawings and tools for Ranger engine manufacture in Canada. In light of time, C.D. Howe pointed out that there was no need to proceed with this project and added "on

general grounds, engine manufacture in Canada was unsound, provided our needs could be met by the United States where large capacity and mass production methods could be used."[40] When the Cabinet War Committee revisited the issue of building Ranger engines, Howe noted that Canadian requirements would be met by American production and that "manufacture in Canada, would, in the circumstances, be unwise, indeed impossible, as machine tools would not, in present circumstances, be released from the United States."[41]

By 1942, Canadian officials interested in the future of the Canadian aircraft industry expressed concern about the country's dependence on foreign countries for aircraft engines. The issue was raised at the CPMA's first meeting of 7 June 1943. The group agreed that no aircraft industry could be considered absolutely complete without an engine manufacturing component, but realized that Canada could not embark upon the design and manufacture of aircraft engines.[42] Important to note is that Ralph Bell was against initiating the construction of aircraft engines in Canada on the basis that American and British engine manufacturers would provide too much competition in postwar years.[43] He thought it was simply "too late to attempt designing engines in Canada in this war." In his opinion, Canada should concentrate exclusively on the design and development of airframes. As he asserted, "we already are building [under-license] the largest and most complicated types in the world to as good or better standards of quality than the United States or England." He added that given adequate design staffs, Canada had "just as good chances of designing 'winning' types as England or the United States." Bell used the Noorduyn Norseman as an example, claiming it was the most outstanding type of its class in the world.[44]

Yet, not everyone in government supported this opinion. W.C. Clark, the Deputy Minister of Finance, told Bell in February 1944 that his argument against building an aircraft engine industry in Canada could also be applied against the airframe industry. "I have seen nothing to convince me that we can produce in Canada aircraft, with the possible exception of one of the smaller types, such as the Norseman, at anything like the prices which United States plants will be able to turn them out for after the war. Nor can I see our being able to compete with the vast new facilities for research and design which the United States has been building up." Furthermore, it would be difficult to create and sustain design teams in Canada capable of competing with those of Great Britain and the United States.[45] Bell stood his ground, replying that at this juncture, "it is far better to wait until the war is over and then see what it will pay us to do in that respect." He argued that it was best to continue to buy aircraft internal combustion engines from outside sources, and to concentrate on new types of engines, such as jet or diesel.[46] Bell seized the opportunity to promote the development of indigenous aircraft, stating:

> Canada will have the advantage after the war because our facilities being more compact are far better adapted to the size of orders that will be available in that era than are the enormous plants in the United States. Furthermore, the personnel will boil down to a point where we will have only the most highly skilled of our aircraft mechanics, and our wage scale will probably remain on a basis approximately one-third lower than it is in the United States. We possess all the products in Canada, or practically all the raw materials necessary for aircraft manufacture, and I am personally thoroughly satisfied that we will be able to compete and compete well.[47]

Bell believed that "we must compete, and that if we do not, we relegate Canada forever to a subservient position in the realm of transportation that will dominate the world for the next century.[48]

The RCAF was particularly in favour of initiating the construction of aircraft and engines in Canada from a national security standpoint. In January 1944, Air Vice-Marshal Stedman reported that the Canadian aircraft industry was "sadly handicapped" by a lack of engine manufacturing facilities. He pointed out that many small aircraft manufacturing countries such as Australia, Finland, Poland, Romania, Spain, Sweden, and Switzerland, produced aircraft engines prior to the war, and there was no reason why Canada should not do the same, "if only for the purpose of establishing and retaining the art for defence purposes." In his opinion, a 3,000 hp piston engine built under license would provide a good starter project after the war. Stedman also recommended that work be initiated in Canada on the new, more powerful, jet engine. As large aircraft require a huge amount of horsepower, "we are forced, at the present time, to use more engines than desirable, resulting in extra weight for nacelles, control, piping, and additional complication. Some years ago a large German seaplane was fitted with twelve engines, and we are approaching similar absurdities today due to lack of large power units." He noted that jet propulsion engines would be extremely useful to power huge transport aircraft in the near future, despite reporting that such engines were said to be "quite unsuitable for commercial use." This was mainly due to the fuel consumption of jet engines, which was excessively high for long distance flights.[49] Ralph Bell maintained his position in regards to aircraft engine manufacturing in Canada, telling Stedman:

> I would have been happy, in the earlier stage of the war, to see Canada embark on the manufacture of one aircraft engine, merely to get a start on this particular branch of the industry; but that we could ever make ourselves independent of outside sources of engines is obviously impossible, at least for twenty years. Furthermore, if we did go into the manufacture of aircraft engines of present types, it would have to be done under license from one or other of the big companies, such as Pratt and Whitney, Wright, Bristol, Armstrong Withworth, Rolls Royce, General Motors or Ranger, and the

> result would be that, in the postwar era, the only market we could hope to have would be in Canada, and that market would never support any aircraft engine manufacturing industry since, because of the volume of business available, our costs would inevitably be tremendously out of line with those of United States or British manufacturers. The suggestion that a suitable commencement would be a 3,000 hp piston-type engine is, to me, industrially and economically, thoroughly unsound. If we are going to start construction under license, of any of the conventional types, from a business point of view it seems to me that we should start in the lower horse-power ranges, with some engine for which there is likely to be a maximum demand in Canada.[50]

It normally took up to four years of experiment to develop a new type of aircraft engine. Considering the rapid wartime advances made in the field of aircraft propulsion, a Canadian engine could easily become obsolete before it reached the production stage. Moreover, such work would prove extremely expensive.[51] On the question of developing jet engines, Bell concurred, stating "I believe that Canada should go 'all out' on this type of propulsion unit, and not only set up engineering and research teams, but actually engage in design and manufacture, confident that we can hold our own in the front rank of the development of this type of power plant."[52]

The design and development of jet engines in Canada offered numerous possibilities to the Canadian aircraft industry. Canadian government officials quickly realized that this type of engine was the wave of the future, and that Canada should get involved if it wanted to be a player in postwar aircraft design and development. By 1944, it became clear that Canada needed to get in the game for both commercial and military reasons. As all countries would be embarking on this venture at the same time, Canada could make a name for itself in this field while simultaneously becoming more self-sufficient in aircraft propulsion. Luckily, work in the field of jet propulsion had been

initiated in Canada earlier in the war, facilitating the creation and success of a national jet engine industry as well as the design and development of indigenous jet aircrafts.

Several branch plants of American and British aircraft engine-making firms operated in Canada before and during the war, including Canadian Pratt & Whitney Aircraft Company Limited of Longueuil, Canadian Wright Limited of Montreal and Vancouver, and British Aeroplane Engines Limited of Montreal and Vancouver,[53] but none produced engines. Pratt & Whitney and Canadian Wright did, however, assemble a few aircraft engines from parts and components made by their parent plants in the United States.[54] Pratt & Whitney assembled over 150 American-made Pratt & Whitney R-1340 Wasp and R-985 Wasp Junior engines.[55] Canadian Wright assembled close to 250 American-made Wright engines.[56] The branch plants were used mainly for the repair and overhaul of existing aircraft engines: together, they overhauled over 10,000 engines during the war.[57] A dozen or so other Canadian companies also undertook this work, as did the RCAF in its repair depots. In all, close to 31,000 British and American aircraft engines were overhauled and repaired in Canada between 1939 and 1945.[58]

In the end, all the engines used in Canadian-made aircraft during the war were imported from either Great Britain or the United States. The United States was the Allies' largest supplier of aircraft engines. There were in fact more than nineteen major manufacturers of aircraft engines in the United States alone, the largest being Pratt & Whitney, Wright, Allison, Packard, Continental, Lycoming, Jacobs, and Ranger.[59] Meanwhile, Great Britain possessed about sixteen important engine manufacturers, the most notable being Bristol, Rolls-Royce, Napier, Armstrong-Siddeley, and De Havilland.[60] During the war, the United States manufactured 812,615 engines[61] and Great

Britain 572,209.[62] This production was more than enough to meet both domestic and British Commonwealth needs.[63]

Canadian Research on Jet Propulsion

The jet engine was without doubt one of the most important and interesting technological developments of the war. Since the 1930s, scientists and aeronautical engineers in Germany, Great Britain, Italy, and the United States had studied ways to propel aircraft by thrust reaction from the exhaust of a gas turbine. Among the British pioneers was an RAF officer named Frank Whittle. An ardent proponent of jet propulsion, Whittle received little recognition until he built his first jet engine in 1936 and founded Power Jets Limited with the financial assistance of private sponsors. The British Air Ministry took an active interest in his project, and in 1939, the Gloster Aircraft Company was commissioned to design and build an aircraft powered with Whittle's W.1 gas turbine.[64] The result was the single-engine Gloster E28/39 Pioneer, Britain's first jet aircraft, which made its maiden flight on 15 May 1941 (almost two years after the world's first jet-powered aircraft was flown in Germany on 24 August 1939).[65] This aircraft's performance far exceeded that of the Spitfire, the fastest propeller-driven fighter in Great Britain at the time.[66] The British immediately shared information with the American government, the latter having been secretly told of British jet engine developments the previous year by a British scientific mission led by Sir Henry Tizard.[67] The Americans were interested in developing their own version of the Whittle engine at the General Electric Company factory in Lynn, Massachusetts. In September 1941, a small team of Power Jet engineers visited the United States and brought with

them a Whittle engine. The American government proceeded to ask the Bell Aircraft Corporation to design a fighter using the new engine. This arrangement led to the development of the first American jet aircraft, the Bell XP-59 Airacomet, which flew for the first time on 1 October 1942.[68]

A select group of Canadian officials were also made aware of British advances in jet engines. Classified as top secret, the British jet aircraft project was known by only a handful of high ranking RCAF officers and NRC aeronautical engineers, who became very interested in the possibilities of jet propulsion. It is perhaps surprising that Canada was interested in jet engines. After all, it possessed no aircraft engine factories, and had virtually no experience in engine manufacturing. Its aircraft industry was still small, but expanding, and had not developed one single indigenous modern combat airframe. In this light, it seemed unlikely that the inexperienced Canadian aircraft industry would be capable of successfully undertaking an ambitious endeavor such as designing and developing jet engines and, possibly, jet aircraft. Yet, as the wartime history of the NRC Division of Mechanical Engineering explained, Canadian officials wanted to forge ahead:

> This development was of particular interest to Canada by reason of her complete lack of an aircraft engine industry. It had long been considered that the establishment of an aircraft engine industry in Canada, though desirable, would have proven prohibitive in cost because of the highly competitive nature of engine development. Furthermore, an embryo Canadian company would have to compete with British and American firms having a vast background of experience and well-established markets. The advent of the gas turbine as an aircraft power plant appeared, however, to provide Canada with an opportunity of entering this field on a more equal footing with other competitors. In addition to this, the Canadian aircraft industry had experienced severe difficulties in obtaining sufficient engines following the fall of France and the bombing of British aircraft factories in 1940 and 1941. For these reasons it was considered advisable to explore the possibility of creating a Canadian industry for development and possibly manufacture of gas turbine aircraft power plants as a safeguard to the country in future times of national emergency.[69]

In short, jet aircraft development offered Canada an opportunity to innovate and built a reputation in aircraft and engine development. It was generally believed that jet aircraft would become the dreadnoughts of the skies and would revolutionize aeronautical design and render all other aircraft obsolete.

The story of the jet engine in Canada began at the NRC. In late 1941, Malcolm Kuhring, head of the NRC Engine Laboratory, and J.J. Green, head of the NRC Aerodynamics Laboratory, went on a scientific mission to Great Britain to investigate British wartime aeronautical science and technology. The men reported that a radically new aircraft engine concept under development at Power Jets Limited could be of interest to Canada.[70] At the same time, Flight Lieutenant D.G. Samaras, a RCAF technical officer attached to the NRC Engine Laboratory, conducted work on the theoretical aspects of jet propulsion. His activities were reported at the meeting of the NRC Subcommittee on Internal Combustion Engines on 5 January 1942, where it was recommended that Samaras complete a detailed report of his work. Three months later, he submitted his document, entitled *Thermodynamic Performance Considerations of Jet Propulsion*, in which he proposed two modified cycles of operation for jet engines. Written with only meager knowledge of the Whittle developments in Great Britain, and without the benefit of the latest technical information on jet propulsion, Samaras' report was sent to the British MAP's Director of Scientific Research (DSR) for further examination by British jet engine experts.[71]

The DSR, already familiar with the document's basic premise because of months of research on jet propulsion in Great Britain, was much impressed "by the degree of interest demonstrated by Samaras, by his knowledge of thermodynamic and aerodynamic

theory and by his mathematical aptitude." The DSR felt strongly that Samaras' "enthusiasm and ability should be applied directly to the many jet propulsion problems there are still to solve," and told the NRC that he "should very much like to have him" in Great Britain. The MAP immediately requested the RCAF to lend it Samaras' services to aid in development work in Great Britain. In May 1942, the DSR told the NRC's J.H. Parkin: "The sooner he comes, the better."[72] Samaras' report was sent to the RCAF during the summer,[73] and shortly thereafter, the technical officer was sent to work on the British jet engine program. It was reported that "he produced a considerable amount of theoretical work of high value to the development of gas turbines."[74]

In this same period, the RCAF Chief of the Air Staff assigned Air Vice-Marshal Stedman, the DGR, to investigate jet engine developments in Great Britain. The RCAF was trying to find a solution to a chronic shortage of American and British engines.[75] In the spring of 1942, Stedman had the opportunity to have lengthy discussions with Frank Whittle of Power Jets Limited while on a visit to Great Britain. Whittle told him about his top secret jet engine project. "I learned a great deal about the early work, of the disappointments and triumphs that had marked the first years of this development ... I learned of the development of the W.1 and other experimental engines," said Stedman.[76] He was told that British firms such as Armstrong Siddeley, Bristol, De Havilland, Rolls-Royce and Vickers were all developing their own jet engines, although they were lagging behind Power Jets Limited. More importantly, he was allowed to examine the Gloster E28/39 jet aircraft. Stedman recalled "it was watching this aeroplane fly that convince me that here was something of the greatest interest to Canada."[77] He also learned of the progress of other British experimental jet aircraft programs, such as the single-engine De

Havilland D.H. 100 Vampire and the twin-engine Gloster F9/40 Meteor fighters, and of American developments on the General Electric jet engine and the Bell XP-59 jet fighter.[78] "I felt that, by now, I had a good picture of the development of jet propulsion as far as it had gone and that if we entered the field now we would be nearly as far advanced as any of the others, with the exception of Whittle who was leading the others as the result of his prewar experience."[79] On 1 October 1942, he informed the Air Council of what he learned and advised that the Canadian government should begin work in the jet propulsion field.[80]

A week later, C.G. Power, the Minister of National Defence for Air, forwarded Stedman's recommendation to C.D. Howe, who was then visiting Great Britain with Ralph Bell.[81] "The Air Council is interested in undertaking research and development work on jet propulsion in Canada under-license from Whittle, with the view to production in Canada at a later date. I suggest you and Bell visit Power Jet Limited to let me have your opinion of this proposal. Arguments are that we would be starting at the same level as other countries and that this development has postwar value." The suggestion did not fall upon deaf ears. Howe immediately assigned Bell and Charles Banks, the DMS representative in Great Britain, to make preliminary inquiries into jet propulsion work in Great Britain.[82] The MAP authorized Banks and Bell to visit Power Jet Limited to see the latest developments in jet propulsion. They were told that jet aircraft would supersede existing propeller-driven aircraft, would become the wave of the future, and would be used militarily and commercially within the next four years.[83] Bell was impressed and conveyed his enthusiasm to the Minister of Munitions and Supply. Howe immediately told Power on 12 October that jet propulsion "has a great future" and thought "Canada

should take part in development."[84] A few days later, he explained to C.J. Mackenzie, president of the NRC, that "as Canada had not gone in for aeroplane engine construction, we might well attempt to pioneer in jet propulsion."[85] Top DMS officials were clearly interested.

On 21 October 1942, Ralph Bell told the Air Council that jet propulsion would revolutionize both military and commercial aviation in coming years and, accordingly, Canada should undertake work in that field. In regards to combat aircraft, Bell noted that the Gloster Aircraft Company was leading the way with its single-engine E28/39 and twin-engine F9/40 Meteor fighter. He told air force officials that "the balance of opinion in the United Kingdom is that in two to three years a substantial number of [jet-propelled] combat types will be in operation" and that jet engines "will be suitable for combat at high altitudes." Bell added that jet propulsion would probably not have significant commercial appeal for another seven to ten years, but that overall, jet engines offered great possibilities. In regards to costs, he said that the people he consulted were of the opinion that an expenditure of $3.5 million would be necessary for developing in Canada a jet engine prototype and that an additional $15 to $20 million would be required to bring the project to mass production. Bell concluded that "it was improbable that Canada could contribute very much by immediately undertaking research work in this country, since it would be necessary to do a great deal of ground work already covered in Great Britain," so he recommended the creation of a small three-men team of the highest scientific caliber to be sent to Great Britain to investigate the matter. If the Canadian government agreed to carry out research work, a team of ten top-notch engineers and forty to fifty draughtsmen would have to be formed to design and develop a jet engine

prototype. The Air Council decided to refer the question to a special committee, which would ultimately report back to it on what action should be taken in regards to jet propulsion.[86]

The special committee composed of Air Vice-Marshal E.W. Stedman and Air Vice-Marshal A. Ferrier of the RCAF, C.J. Mackenzie and J.H. Parkin of the NRC and Ralph Bell of the DMS, met on 29 October 1942.[87] Bell told his colleagues that he had discussed jet propulsion with Sir Roy Feddon of the MAP during his visit in Great Britain, and that Feddon had indicated that "there was little concern about infringement of the Whittle patents because everybody was going ahead in England, knowing that the patent situation would be cleared up after the war." Bell reiterated his suggestion that a three men scientific team composed of a businessman, an internal combustion engineer and a research engineer, be sent to Great Britain on an information-gathering mission. The committee retained the names of P.B. Dilworth and K.F. Tupper of the Aeronautical laboratories of the NRC Mechanical Engineering Division.[88] Dilworth had joined the NRC in the summer of 1939, and was selected due to his knowledge of thermodynamics and his experience in the aircraft engine laboratory. Tupper, who had been at the NRC since 1929, was a specialist in the fields of aerodynamics, hydrodynamics, propulsion and mechanics.[89] Charles A. Banks of the DMS was selected as the team's business member. The mission's terms of reference were as follows:

> (1) To study and report upon the historical record of the development of jet propulsion in England to date; (2) To investigate and report on the present state of development of jet propulsion engines in the United Kingdom; (3) To make recommendations upon what way Canada can usefully contribute to the development of jet engines, and to report on the facilities, staff, machinery and cost involved for this program of research; (4) To report in a qualitative manner upon the organization, facilities, and machinery required for the manufacture of jet propulsion engines.[90]

Later that same day, the committee forwarded to the Air Council its recommendation to send a small Canadian mission to Great Britain to survey and report on the whole British jet propulsion program.[91] The DND (Air) and the DMS were also made aware of the decision.[92]

The Air Council considered the recommendation, which was approved by the Minister of National Defence for Air on 19 November 1942. All agreed with the mission's membership,[93] but the Air Council wanted an RCAF representative on the team. It pointed out that Stedman would be in Great Britain at about the same time as the mission, and could easily join it, but this proposal fell through. One week later, the Air Council notified RCAF Overseas Headquarters in Great Britain of the upcoming mission.[94] The British government authorized the Canadian delegation to visit a number of British industrial plants and government research facilities working on aircraft engines, having engine research and development divisions, or involved in the field of jet propulsion.[95] The delegation went to the National Physical Laboratory (NPL) at Teddington, the Royal Aircraft Establishment (RAE) at Farnborough, the Admiralty Experiment Station in Haslar, the research and development sections of aircraft and engine companies such as Armstrong Siddeley, Bristol, De Havilland, Fairey, Napier, Rolls Royce, Rotol and Shorts, and the laboratories of the Anglo-Iranian Oil Company and the Shell Oil Company petroleum companies. During those visits, the mission was to study jet engines, as well as research and development on high-speed subsonic and supersonic aerodynamics, rockets, internal combustion and exhaust turbines, air scoops, nozzles, exhaust heat and de-icing.[96]

Charles Banks, who was already in London, was particularly happy to act as the mission's business manager.[97] On 3 December 1942, he notified the MAP that the "Air Council in Canada is anxious that a small team of two carefully selected technical men from the National Research Council, together with myself as business manager, should make an intensive study of jet propulsion in England." Banks stated that the work would take about three months, and he requested the MAP to allow the team "complete freedom of access" to all jet engine developments facilities in Great Britain. As he explained: "The main object would be to study developments to date and then decide what contribution Canada might make towards this development."[98] The MAP responded enthusiastically to the idea, indicating that it "warmly welcomes the Air Council in Canada to help with the jet propulsion project."[99]

Unfortunately, there were serious misconceptions as the British were under the impression that the Air Council was interested in cooperating on the British jet engine program, and not intending to launch its own parallel one. Interestingly, Banks supported the British position. In a 22 December 1942 report to the Chief of the Air Staff, he indicated that the British were developing four separate and very different types of jet propulsion methods, but it was too early to say which was most promising because each had "difficult problems to be worked out. Canada could perhaps help best by advancing ideas and by trying to solve in Canada some of the many problems." In his opinion, Canada could develop a special type of steel or a nickel alloy that could withstand the extremely high temperatures involved in jet propulsion. This line of action, he maintained, would keep Canada "well in the picture," would be "most useful" to jet engine development in Great Britain, and "might suit Canada better than setting up an

extremely costly parallel development at this time." In closing, he proposed that Tupper and Dilworth remain in Great Britain to work on the British jet engine program.[100]

NRC President C.J. Mackenzie did not agree with Banks, as he pointed out that the "fundamental purpose of sending Dilworth and Tupper to England was to have them report upon the feasibility of establishing a development program in Canada." Mackenzie did not want the two men to "stay over there indefinitely" as their work was vital at the NRC in Canada. Mackenzie was not at all pleased with Banks' proposal as it was not in line with the mission's original goal.[101] The RCAF sided with Mackenzie and asked that it be made explicitly clear to Banks "that he should follow to the letter" the terms of reference that had been established by the special committee and agreed upon by the Minister of National Defence for Air.[102] Ralph Bell added that he wanted Canada to learn about jet engines and "get that experience in the shortest possible time and at the lowest possible cost."[103]

The issue having been resolved on the Canadian end, Tupper and Dilworth arrived in Great Britain in mid-January 1943 and joined Banks.[104] Still, the British authorities thought the team was "to assist" with the British jet engine program and not "to study exhaustively the present work so that the Canadian authorities would have future guidance on policy." Dilworth and Tupper were very upset by the attitude of MAP representatives, particularly by the fact that they were told not to conduct visits of industrial and research facilities or make enquiries on any subject without first specifying to the individuals interviewed that they were only collecting information and that Canada might possibly derive future commercial benefit from any such information. It was noted that the jet engine had reached "a very high state of development" in Great Britain and

that it will "almost certainly be put to full use before the present war is over; in fact, it should become operational early in 1944."[105]

The Canadian mission conducted a thorough survey of the British jet engine program and consulted with the MAP and various British firms engaged in this field on ways in which Canada might usefully contribute to the field of jet propulsion. The Canadians were shown the latest British jet engines under-development by such firms as Armstrong-Siddeley, De Havillland, Power Jets, Rolls-Royce and Metropolitan Vickers, and were also allowed to examine in great detail the Gloster E.28/39 experimental jet aircraft and the twin-engine Gloster F9/40 Meteor jet fighter.[106] In late May 1943, after several weeks of compiling information, the three men completed their *Report on Development of Jet Propulsion Engines in the United Kingdom.* Banks sent copies of the report to C.D. Howe and Ralph Bell, who in turn forwarded copies to the Chief of the Air Staff, the Minister of National Defence for Air, and the President of the NRC.[107] The "Banks Report," as it came to be known, recommended the following:

> (a) That Canadian personnel be sent to England to aid in the various jet propulsion development already in progress; (b) That work be undertaken in Canada directed toward the development of high temperature resistant materials suitable for gas turbine construction; (c) That a cold weather ground test station be established in Canada and staffed for experimental operation of gas turbine engines; (d) That a fully staffed flight test establishment be created in Canada and equipped with a flying test bed aircraft, preferably a York or a Lancaster, with provision in the fuselage for the installation of gas turbine engines; (e) That an air compressor test rig be installed for testing gas turbine compressors, particularly under conditions of low air temperature.[108]

Representatives of the NRC, the RCAF and the DMS considered the recommendations. After preliminary discussion, the group decided to adopt the recommendation calling for the establishment of a cold weather ground test station in

Canada under the jurisdiction of the NRC. Action on the other recommendations was deferred because of the need to get the adopted project under way to make the facilities available for the following winter.[109] Eager to begin work, the NRC immediately started a survey of possible sites for its Cold Weather Test Station (CWTS) pending the project's final approval in mid-July. The site was to be reasonably accessible by rail and air. Several sites were considered, including Kapuskasing (Ontario), Edmonton (Alberta), Winnipeg and Churchill (Manitoba).[110] The choice fell on Stevenson Field at Winnipeg, a site adjacent to the BCATP No. 5 Air Observation School, then being constructed by the RCAF. [111] According to Dilworth, Winnipeg was chosen "because of its larger population centre and related larger pool of personnel and auxiliary facilities, such as machine shops and hardware stores upon which we could draw."[112] All that was left was to secure funds.[113]

On 4 August 1943, Howe explained to the Cabinet War Committee his intention to have Canada develop aircraft jet engines for postwar use. He asked for an appropriation of $300,000 to enable the NRC and the DMS to carry out secret research work related to jet propulsion of aircraft at low temperatures, explaining that "while unlikely to be of importance during the war period, it was certain to be of considerable significance after the war and Canada should profit from an early start in this new field." The War Cabinet Committee approved the request through Order-in-Council PC 6179.[114] A staff of mechanical engineers and skilled mechanics was quickly recruited for the project and promptly sent to the Great Britain to receive special training on jet propulsion. Work began on the construction of the buildings and facilities at Stevenson Field in early September.[115]

A few months later, the CWTS became operational as the British trained staff began returning to Canada. On 4 January 1944, the first jet engine to be tested on Canadian soil — an obsolete model of the Rolls-Royce W2B sent over by the British in December 1943 — was a success.[116] The British government was pleased with Canada's decision to set up a CWTS and told Canadian authorities that they hoped Australia, New Zealand and South Africa would soon contribute in a similar fashion to the British jet aircraft program.[117] Prior to ceasing operations in May 1946, the CWTS carried out close to 450 hours of testing on eight British-designed jet engines,[118] including the latest models of the Rolls-Royce W2B, the Power Jets W2-700 and the Armstrong-Siddeley ASX. Throughout the experiments, British technicians were present to observe first-hand and to assist with any mechanical problems.[119] Although there were discussions about sending the De Havilland H-1 Goblin and Metropolitan Vickers F-2 jet engines to Canada for trials,[120] none of these projects materialized.[121] Still, the tests performed on British jet engines at the CWTS were valuable. While the British seemed satisfied with the trial results, Canada was undoubtedly the major beneficiary. Dilworth recalled that the CWTS project "laid a foundation in recruiting, training and practical experience for the cadre of personnel who later formed the backbone of Canada's jet engine design and development team ... It also encouraged federal government officials ... to support the launching of Canada's jet engine design and development industry."[122]

In the meantime, the idea of developing a Canadian-designed jet engine and aircraft was making progress. The DMS was the driving force behind this scheme. On 31 May 1943, Banks wrote a secret letter to Howe on the manufacture in Canada of jet propulsion engines, in which he noted that the entire British jet engine program was

under the direction of a central organization, the MAP. He suggested that Canada copy this set-up, specifically that a Canadian jet program be coordinated by a secret section of the DMS' Aircraft Production Branch. Banks added that later on, "if Canada goes into production of engines, and of aeroplanes to suit, all of which would seem logical ... a government owned company would be the best way of keeping the whole development and information together, and of maintaining secrecy." Banks evidently believed that the NRC should not be entrusted with managing the jet propulsion project. He concluded by advocating the project:

> In the opinion of the people here [in Great Britain] ... the jet propulsion engines will have a very wide application in the future, for, apart from its use as a power unit for driving aeroplanes, it is quite possible that it will later on be used for stationary power plants, for driving high speed ships and for other purposes ... I strongly recommend that Canada enters this whole field, including the development and building of engines and aeroplanes in Canada, as rapidly as possible, and I think full support and cooperation would be given by the United Kingdom.[123]

Ralph Bell agreed with Banks, and a few weeks later, he suggested that immediate consideration be given to the building of jet engines in Canada. Bell wrote Howe recommending that the Canadian government negotiate a contract with Canadian Vickers and the Dominion Engineering Company to work on jet engines, but this was not pursued for unknown reasons.[124]

The establishment of a jet engine industry in Canada was discussed at the Air Council meeting of 10 November 1943. Bell reported that the DMS "would not support any project to build aircraft engines of any type presently used"; in other words, the intention was that American or British jet engines were not to be produced in Canada under-license. The DMS was more interested in the design and production of indigenously developed jet engines. Bell also explained that both single and twin-engine

jet aircraft were being successfully flown in Great Britain, so if Canada wanted to enter the field of jet propulsion and be competitive in the postwar years, it would have to do so as soon as possible. The Air Council raised the possibility of the RCAF preparing a specification for an experimental type of aircraft, such as a fighter or a small bomber, to use future Canadian-developed jet engines. It was agreed that RCAF personnel should be sent to Great Britain to obtain as much information as possible on their jet aircraft program.[125] Bell noted that if the RCAF required data on the flying characteristics of jet aircraft and engines, the DMS could temporarily fit up an aircraft for flight research purposes. This aircraft could also act as a flying test bed for the British jet engines that were to undergo trials at the CWTS in Winnipeg. Bell believed such a measure could provide the RCAF with lots of valuable information on jet aircraft and engines. Tupper disagreed as he felt that British authorities would not likely accept such a request, and that flight research should be undertaken at a later stage. "A program of flight research cannot be arranged in haste ... considerable time is required in recruiting [and training] suitable personnel ... In my opinion, one full calendar year would be required to undertake the design and execute the construction of the modifications required in a large aircraft for the work we have in mind."[126] In the end, the Air Council decided that the operation of a flying test bed should be borne in mind for consideration at a later date.[127]

A number of government officials grew impatient at the slow pace of work on jet propulsion in Canada and sought to accelerate the process. After visiting the CWTS in late January 1944, Bell expressed his desire to initiate the production of jet engines in Canada as soon as possible and explained that Canada would have to define its course of action in the near future. He proposed to arrange for two suitable Canadian companies to

undertake the manufacture of these engines.[128] Bell and other government officials felt that if Canada wanted to become a key player in the field of jet propulsion, it would have to do more than simply work on British jet engines at the CWTS. The Canadian government had to initiate its own jet engine program and the Cabinet War Committee had to provide the necessary funds.[129] On 16 March 1944, Order-in-Council PC 1854 authorized additional funds of $660,400 for work on jet propulsion, raising the total sum allotted to the project to $960,400.[130]

This decision put grist in the mill of proponents of jet propulsion work in Canada. In a letter to Howe, Banks reiterated that Canada should become increasingly active in jet propulsion research, for it had now been more than a year since he issued his first recommendations:

> I am satisfied that jet propulsion as a method of driving aeroplanes has a great future; also that the gas turbine which is part of the same development will later be used as a stationary power unit and, no doubt, for the driving of ships and trains. The whole development is in its very early stages, and its huge possibilities are not yet generally realized. It is quite possible that a gas turbine of the size of an office desk ... will later be capable of developing up to 10,000 hp. Ten of these would drive the *Queen Mary* – no boilers would be required and the engine room would be quite small ... I am convinced that the future of this development is of greater importance to Canada that I had indicated [in May 1943] ... So far, we have gone ahead with only one of the five recommendations of the report, the Cold Weather Test Station, and done it very well, but I think we are making a great mistake by not going full steam ahead on the other recommendations. Canada must not be left behind in this revolutionary development, which could mean so much to her in the future.[131]

Banks felt that the time had come to create a government-owned company with several million dollars working capital to take care of research, development and production of jet engines in Canada.[132] His proposal did not go unnoticed.

The Canadian Jet Engine Project

The Canadian government was very interested in initiating the design and development of jet engines in Canada. In March 1944, Air Vice-Marshal Stedman issued recommendations concerning the establishment of an aircraft engine industry in Canada concentrated around new developments in jet propulsion. Air Vice-Marshal Ferrier agreed with Stedman's basic proposal.[133] The NRC also felt extremely confident in Canada's ability to design and develop jet engines. Paul Dilworth noted that the development, testing, and production of a successful jet engine design would take less time and work than was required for a piston engine because "the whole mechanism lends itself much better to rational design based on adequate information gained through research."[134] Dilworth believed jet engines should not only be used for aircraft propulsion, but also to drive motor generators, ships, and railway locomotives. Dilworth recommended that Canadian officials adopt a clear stance on the subject of jet propulsion and determine the best course of action, namely the licensed manufacture of foreign designs or independent and indigenous research and development work.[135] Dilworth suggested that great efforts be made to establish a jet propulsion research program in Canada and emphasized that the Canadian government had to take steps to obtain appropriate personnel, as "to my knowledge we have no suitably trained men" to work on jet engines. He suggested that Canada attract trained and experienced men from abroad, provide training for properly qualified Canadians, and encourage Canadian universities to promote study in these fields and provide relevant courses.[136]

On 13 May 1944, C.J. Mackenzie met with Bell and Banks to discuss how best to handle the design and development of jet engines in Canada. All agreed that the solution

laid in the formation of a government-owned company, which would be an offshoot of the NRC and be financed at the outset with $10 million. It was to work in close cooperation with British companies involved on jet propulsion research to avoid unnecessary duplication of work, and was to place orders with private companies in Canada on a royalty basis. The proposed Canadian Crown Corporation would only design jet engines, and then assign their mass production to Canadian aircraft companies. It was also agreed that it would eventually take on the design and development of jet aircraft. The royalties would supplement government funds and help cover the costs of on-going research and development. Mackenzie, Banks and Bell agreed to select a president and directors as soon as possible, and suggested that a special committee of technical experts be formed and trained without delay.[137] At a meeting held on 18 May with top RCAF, NRC and DMS officials, the name of the new company was chosen: Turbo Research Limited.[138]

Turbo Research was incorporated on 7 July 1944, and set up shop in the Toronto suburb of Leaside.[139] Its mission was to carry out experimental and scientific research and development work on jet propulsion.[140] This work extended beyond aircraft engines to encompass railway, automotive and ship propulsion as well as industrial applications such as electrical power generation and gas compression.[141] H.J. Carmichael, the DMS' coordinator of production, was name president, F.C. Wallace vice-president and general manager,[142] and Ken Tupper chief aeronautical engineer. One of the first things Turbo Research did was to recruit, train and organize an engineering staff.[143] The NRC jet propulsion project was transferred to Turbo Research Limited on 1 September 1944, including the CWTS.[144]

However, according to K.F. Tupper, it was not enough to merely develop and produce jet engines; the Canadian government also needed to adopt specific jet propulsion policies. Tupper first proposed a short-term policy, covering the period 1944 to 1947, during which Canada would provide facilities for research, design and construction of experimental jet engines, secure and train key personnel, embark on a scheduled development program to produce a jet engine of about 3,500 lbs thrust to suit a specific aircraft, and continue operation of the CWTS. Tupper's long-term policy, which extended to 1954, would see Canada undertake research work to find higher efficiencies, lower weights and greater reliability of jet engines, and pursue a program to guarantee that one jet bomber engine and one jet fighter engine of Canadian design was continuously available to the RCAF. Tupper explained that this should not be a war project.

> The British will likely be able to use jet propelled aircraft in the present war, and any work undertaken by Canada in their aid may fairly be termed a war project. Work done independently in Canada will take so long to complete that it is impossible to consider it as useful in the present struggle. Even production of existing designs would take 18 to 24 months to get well under way. A Canadian project started now will add to the demand for men and materials, which may be urgently required elsewhere. Therefore, it is essential to schedule the major expansion of the organization to be set up so that it can absorb surpluses of men and materials which will become available at the end of the war, or at a later stage in it.[145]

As a first step, Tupper suggested that Canada obtain as much information as possible on jet propulsion from the American and British governments during the war because of the spirit of scientific cooperation among the Allies. He suggested that a Canadian contingent of 50 to 100 men be sent to Great Britain to work on the British jet propulsion program, and though predicting that the "services of half of these ultimately become lost to us, we will get 25 to 50 well trained men." The second step was to gather all the necessary

equipment and tools to carry out jet propulsion research in Canada. "Some research equipment is slow to build and should be started a year to two years ahead of its completion state." The compressor test rig, for instance, would take approximately eighteen months to build at maximum speed. Third, he recommended that a design staff nucleus be formed as soon as possible to start work on the first jet-propelled engine. Finally, he suggested that the machine tools required for the experimental shop be acquired as soon as possible.[146]

Air Vice-Marshal Stedman requested the Chief of the Air Staff's authorization to allow the RCAF to draw up a specification for a jet engine to be produced by the new corporation. Stedman added that it was also "necessary for an aircraft specification covering a jet propelled aeroplane to be drawn up at the same time so that by the time the engine is in a sufficiently advanced stage to be flown a suitable aeroplane will be available for use for test purposes." In his opinion, it would be best for the RCAF to prepare a specification for both a jet engine and a jet aircraft, and to issue it to the DMS for a contract demand.[147] At a meeting of the board of directors of Turbo Research on 29 August 1944, Stedman reported that two of his associates in Great Britain recommended that a specification for a jet engine and jet aircraft be made as soon as possible.[148]

On 13 December 1944, the Cabinet War Committee approved the RCAF proposal to design and develop a jet engine and a jet-propelled aircraft in Canada. The decision emanated from a memorandum submitted by the Minister of National Defence for Air, which explained "that present conditions presented a favourable opportunity to develop gas turbine engines in Canada for RCAF purposes." The memorandum recommended that the DMS negotiate contracts for the design and manufacture of twenty such engines

in Canada, as well as three special airframes suitable for their use. The estimated cost of these projects was $150,000 in fiscal year 1944-45, $850,000 in 1945-46, and $1,060,000 in 1946-47. The Cabinet War Committee approved the negotiation of contracts for the design and development of jet engines and airframes, with the implicit understanding that the question of manufacturing would be reviewed at a later date.[149] In January 1945, the RCAF issued Specification AIR-7-1 Issue 1, calling for the design and development of a single-seat, single-engine, jet fighter, and Specification ENG-62-1, calling for a suitable jet engine to power this new aircraft. The RCAF invited Turbo Research to design the jet engine[150]

Turbo Research initiated preliminary design studies on two types of aircraft jet engines. Under the direction of Winneth Boyd, it designed a centrifugal type engine designated the TR-1 and an axial flow engine known as the TR-2.[151] Author James Dow summarized the main differences between both types of jet engines. As he explained, air brought into a jet engine is compressed before fuel is added for combustion. A centrifugal engine "achieves this by centrifugal force, throwing incoming air first outward then rearward in a process that exchanges velocity for increase pressure." Axial flow engines, on the other hand, "move air directly along the axis of the engine, from front to back through successive stages of increasing pressure."[152]

General arrangement drawings of Turbo Research's jet propulsion engine were inspected in March. The corporation pointed out that if the engine was intended for development purposes only, and not for flight, selection could be made independent of airframe considerations. It was noted, however, that if there were any thoughts of installing these engines in aircraft at a later date, it would be "essential to consult with the

airframe designer before finalizing the general arrangement." Turbo Research's Chief Aeronautical Engineer explained that the main concern related to mass distribution, "that is whether the engine shall be long with small frontal area, or short with comparatively large frontal area. If the aircraft is to have single power plant installed within the fuselage, the short type is permissible, and perhaps preferable. If, however, the aircraft is to be twin-engined, with units mounted in the cells, then the slim layout is the only logical choice." [153] On 14 March 1945, the RCAF gave Turbo Research its requirements for the single-seat jet fighter prototype.[154]

The Turbo Research Technical Committee met in late March 1945 to decide which of the two jet engine designs devised should be adopted for development. The first was a straight through centrifugal type engine, known as the TR-1. It would weigh 2,050 lbs and have a thrust of 4,200 lbs. It was noted that an engine of such dimension should be capable of more thrust than 4,200 lbs when fully developed. The second design was for an eight-stage axial compressor type engine, known as the TR-2. Like the TR-1, this 2,775 lbs engine would have a thrust of 4,200 lbs.[155] Boyd made a case for the TR-1 centrifugal type engine, pointing out that it had been developed successfully in Great Britain by Frank Whittle, and was most suitable for use in a high-speed fighter because of its relative simplicity. The committee was impressed, but felt that it was more specialized than the axial type, "as the aircraft for use with this engine was still a long distance in the future it was perhaps desirable to concentrate on a type of engine capable of more development and not restricted to aircraft." Both types of engines had their supporters. Reportedly, the British had produced successful centrifugal engines but had made very little progress with axial flow types. One American company was manufacturing

centrifugal engines while the rest of the manufacturers concentrated on axial engines. In the end, the committee decided that Canada should concentrate on the development of the axial flow engines, despite the fact that centrifugal engines were in a more advanced state of development.[156] It believed that the axial flow engine would likely supersede the centrifugal engine in the near future owing to its higher component efficiency.[157] In July 1945, work on a third jet propulsion engine design known as the TR-3 was undertaken.[158] This was to be a 2,000 lbs axial flow engine capable of a maximum thrust of 4,200 lbs.[159]

Turbo Research received important work from the RCAF, but it was held up by a lack of suitably trained personnel. In early 1945, the corporation noted that it had vacant positions for about thirty engineering graduates.[160] It also urgently required a number of mechanical draughtsmen, and asked the RCAF if some could be released to fill the gap.[161] To overcome this gap, Turbo Research initiated a training program in collaboration with the British government; by July 1945, eighteen men were in training or serving on special assignments in Great Britain, and the CWTS was also used as a training ground.[162] It also helped that secret exchange of information on jet propulsion between Canada and the United States continued regularly. Through such contacts, Canadians learned of important research work being conducted by the California and Massachusetts Institutes of Technology, NACA, OSRD, and the research establishments of the USAAF and USN.[163] Since the summer of 1944, Canadian delegations visited the General Electric Corporation plants in Schenectady, New York, and West Lynn, Massachusetts, where they were allowed to examine the latest American jet engines, including the I-40 with a thrust of 3,200 lbs that was to be installed in the Lockheed XP-80 Shooting Star jet fighter.[164] Moreover, after the end of hostilities in Europe, the

American and British governments allowed Turbo Research personnel to travel to Germany to examine its jet propulsion work, such as the BMW 003 and the Jumo 004 jet engines.[165]

In November 1945, the DMS informed Turbo Research that A.V. Roe Canada had been awarded the jet fighter contract, that the TR-3 jet engine would be used in the aircraft, and that it should collaborate with A.V. Roe Canada.[166] Unfortunately, Turbo Research was experiencing problems with its TR-3 jet engine design. In October 1945, discrepancies were found following some theoretical work on the performances of an aircraft powered by the TR-3. While the RCAF specification called for an engine with a thrust of 1,500 lbs at 35,000 feet altitude, the latest Turbo Research figures indicated that the TR-3 would only be able to provide 1,200 lbs thrust.[167] Moreover, in September 1945, two prominent British aeronautical experts from the Gloster Aircraft Company came to Canada and were reportedly horrified to learn that the RCAF planned to equip its squadrons with single-engine fighters powered by the TR-3. The experts persuaded the RCAF that a twin-engine fighter would be much more appropriate and that the Turbo Research design work should be revised accordingly. The TR-3 was seemingly too ambitious for an initial jet engine design project. As a result, by November 1945, Turbo Research decided to gradually abandon the development of the TR-3.[168] Winnett Boyd and the Turbo Research design team immediately began work on a much smaller axial flow jet engine of 2,450 lbs thrust known as the TR-4. The new design was suitable for a twin-engine fighter and was capable of developing a maximum thrust of 3,000 lbs.[169]

In early February 1946, RCAF officers visited Turbo Research to examine the state of progress. Although the corporation expressed great interest in the jet fighter, their

current jet engine design was in a state of flux pending the RCAF's decision as to the size of the required engine. At the time, the corporation had almost completed the drawings of their TR-3 jet engine and most of the major drawings on the TR-4. It was reported that Turbo Research preferred to build the smaller jet engine first, believing that the experience gained would lead to improvements on the TR-3. They also felt that design and manufacturing problems would be decreased with the smaller engine, particularly with respect to castings. In connection to installations, they agreed that fitting engines on the fuselage might be impracticable, and that slinging the power units under the wings was likely the best solution. In connection to manufacturing, Turbo Research stated that it had been handicapped to date by not having sufficient space or facilities to produce models, experimental assemblies or to test their designs. Yet, it was also reported that material was being purchased for the production of the prototype engine.[170]

At the request of the Deputy Minister of Reconstruction and Supply, V.W.T. Scully, a meeting was held on 13 March 1946 with top representatives of Turbo Research, Federal, the RCAF and the NRC to discuss the best means to encourage the design and development of jet engines in Canada. Air Vice-Marshal A.L. James, the Air Member for Research and Development (AMRD), opened the gathering by expressing the Air Council's view that jet engine research was necessary from a national defence standpoint. The group felt such a statement indicated "an acceptance of some financial responsibility on the part of the RCAF" for the project. Discussion then turned to possible applications in other fields, such as land and sea transportation, power generation, and mining. In the end, the group decided that Canada should adopt a long-range program for research, design, development and manufacture of jet engines for defence and industrial

purposes. The group recommended that the research functions of Turbo Research be transferred to the NRC, and that design and manufacture activities be delegated to private industry.[171] Now that the war was over, the Canadian government's position was to turn its jet engine development projects to private industry.[172] And yet, the meeting also concluded with a recommendation that the Canadian government invest $12 million over five years in Turbo Research to allow jet engine development work to continue.[173]

Upon learning of the recommendation, C.D. Howe was not impressed. "I'm confident that the government will not authorize twelve million dollars to be spent over five years by Turbo. This is development work rather than research work and should be undertaken by private industry." In April 1946, Sir Roy Dobson, President of A.V. Roe Canada, proposed buying Turbo Research and proceeded to negotiate an agreement with the Department of Reconstruction and Supply.[174] In May 1946, the Department of Reconstruction and Supply authorized the transfer of assets of Turbo Research to A.V. Roe Canada.[175] In the arrangement, the new owner was to continue the development of aircraft jet engines for the RCAF.[176] On 23 September 1946 Turbo Research shareholders agreed to dissolve the company, which was done in November.[177] Turbo Research became known as the A.V. Roe Canada Gas Turbine Engineering Division (renamed Orenda Engines Limited in 1951) and relocated to Malton.[178]

In the meantime, the RCAF reconsidered its jet fighter requirement. It now needed an all-weather twin-engine long-range jet fighter to be powered by two axial flow engines of minimum weight and diameter that could develop 6,500 lbs of thrust. "This was a pretty tall order in the spring of 1946, especially for a very green engine design team," recalled Winnett Boyd.[179] Knowing full well that Turbo Research had no jet

engine available to meet this new RCAF requirement A.V. Roe Canada decided instead to install British-designed Rolls-Royce AJ-65 Avon jet engines in the RCAF's twin-engine fighter. The Rolls Royce jet engines were chosen for fear that the engine designed by Turbo Research might not be sufficiently developed in time for the initial flight trials of the aircraft. Anticipating that the RCAF would probably re-write Specifications ENG-62-1 and AIR-7-1 in the near future, Turbo Research considered four possible courses of action. The first was to focus on building TR-3 jet engines, but the corporation chose not to pursue this option since the engine was no longer up to date. The second option was to redesign the TR-3 to conform to Turbo Research's latest design ideas, but it was noted that it was doubtful that such an engine configuration would meet the RCAF specification. The third option was to design a completely new jet engine that equaled the performances of the Rolls Royce AJ-65 Avon, but such a venture would likely take between six and seven months of research and could encounter difficulties. The fourth option was to pursue work on the TR-4. The company felt this was the wisest choice.[180]

In August 1946, work started on redesigning the TR-4 for experimental purposes, and on designing a second more powerful jet engine, the TR-5 with a thrust of 6,500 lbs for the planned twin-engine jet fighter. In January 1947, the RCAF placed an order for twelve TR-5 engine prototypes. According to the schedule, the first TR-4 was to commence tests in December 1947 and the TR-5 in December 1948 for preparation for flight trials by August 1949. At the same time, A.V. Roe Canada planned to work on a substantially larger and more powerful engine of 8,000 lbs thrust.[181] In the summer of 1947, it was decided to designate the Canadian jet engines after Amerindian names, so the TR-4 became known as the Chinook and the TR-5 as the Orenda.[182] Work on these

two jet engines continued into early 1948. On 17 March of that year, the Chinook was successfully started for the first time.[183] "The whole future of the company hinged on that little engine," recalled Fred Smye, assistant general manager of A.V. Roe Canada. "If it failed we might lose the contract for the big one," meaning the Orenda. The Orenda's first test run occurred on 10 February 1949. The engine flew for the first time in a specially converted A.V. Roe Lancaster flying test bed on 13 July 1950 and made its first flight in a fighter on 5 October 1950.[184] Several versions of the Orenda were made over subsequent years, the most powerful with a thrust of 7,400 lbs. Before production ceased in 1958, more than 3,800 Orenda engines were built. Orenda engines saw service in the Belgian, Canadian, Columbian, Pakistani, South African, and German air forces.[185]

The Jet Fighter Program

At about the same time as the Canadian jet engine project was initiated, the Canadian government expressed interest in designing and developing jet aircraft. In the summer of 1944, Paul Dilworth of the NRC emphasized that it was imperative that Canada venture into the development of jet aircraft.

> One all important point which must never be forgotten in the design and development of aero gas turbines is the necessity for the closest collaboration between aircraft and engine design and development. The basic design requirements for an aero gas turbine are by far more dependent on the particular aircraft application in which such engine is to be used than is the piston engine. It will not therefore be satisfactory to design an aero gas turbine engine and then decide what aircraft it is to be used in. Needless to say that it is no more satisfactory to design a new type of aircraft without at the same time giving careful consideration to what suitable aero turbine engines are available, or can be developed while development is proceeding on the aircraft.[186]

In his opinion, Canada should develop the engine and airframe simultaneously in order to maximize speed, range, weight, altitude and general performance. K.F. Tupper agreed with Dilworth that it was not enough to merely produce jet engines, noting that "there is very little use building aircraft power plants unless there are aircraft in which to fly them." He suggested that the Canadian government lay down an aircraft development policy so that the jet engines being designed and produced in Canada could be used.[187]

The RCAF shared the NRC's perspective. In July 1944, Air Vice-Marshal Stedman encouraged the Chief of the Air Staff to allow the RCAF to draw up a specification for a Canadian designed jet aircraft.[188] A series of high-level meetings followed to decide what type of aircraft was most needed for the defence of Canada. After much discussion, RCAF officials agreed to develop a day or night, all-weather, long-range heavily armoured jet fighter capable of operating in Canada's north and of flying higher and faster than the world's best bombers. Air Vice-Marshal W.A. Curtiss explained that "what we needed was a different type of aircraft; an aircraft which could operate over the vast distances of our country at all hours of the night and day and in all weather. This meant long range easy take-off, short landing, full instrumentation and navigation, and the capacity to carry the fuel and equipment, the arms and ammunition to destroy any invader." The RCAF made a complete survey of all aircraft known to be in production or in the planning stages in other countries, but as C.D. Howe explained to the House of Commons a few months later, "there was no plane in existence which, in the estimate of competent military authorities, would be suitable as an all-weather fighter that could be used in the defence of northern Canada. The only alternative was to produce one."[189] On 13 December 1944, the Cabinet War Committee agreed to provide the

necessary funds for the design and development of three jet fighter prototypes.[190] In January 1945, the RCAF issued Specification AIR-7-1 Issue 1, calling for the design and development in Canada of a small single-seat jet fighter powered by a 5,000 lbs thrust jet engine.[191]

In the summer of 1945, the RCAF discussed the proposed jet fighter with Canadian aircraft manufacturers. At the time, Sir Roy Dobson, managing director of the British aircraft company A.V. Roe, was in Canada negotiating the purchase of VAL with the Canadian government. When he learned of the RCAF's interest in developing a jet fighter, he proposed to have his future Canadian subsidiary — to be known as A.V. Roe Canada — undertake the task. "About the jet fighter," he told Air Vice-Marshal Curtis, "I know you are interested in one. I should like to have a go at designing and manufacturing it in Canada." Dobson also proposed to have his new Canadian company design and build a three-seat jet trainer for the RCAF, which could use the same jet engine being developed by Turbo Research.[192]

A.V. Roe Canada was officially formed on 1 September 1945,[193] and on 31 October, Dobson and representatives of the Canadian government reached an agreement to have the new company awarded a contract for the design and development of two prototype jet fighter airframes in accordance to RCAF Specification AIR-7-1. The total cost was not to exceed $1 million.[194] The DMS entered into negotiations with A.V. Roe Canada three days later.[195] On 1 December, A.V. Roe Canada took possession of the VAL facilities at Malton.[196] The DMS immediately announced its intention of ordering from the new company a jet fighter of indigenous origin equipped with engines designed and built in Canada by Turbo Research.[197]

Work on the jet fighter project started in early 1946 when A.V. Roe Canada's fighter project engineer, J.H. Millie, laid out three single-seat fighter design proposals, which were submitted to the RCAF for consideration.[198] After examining the submissions the RCAF revised its design requirements and, as such, re-wrote the original fighter proposal as Specification AIR-7-1 Issue 2. It now wanted an all-weather, twin-engine, two-seat jet fighter powered by two axial flow engines of minimum weight and diameter that could develop 6,500 lbs of thrust. A.V. Roe Canada prepared three new design proposals to suit the revised requirements and presented these to the RCAF in October 1946. The three designs were prepared under the leadership of chief aeronautical engineer Edgar Atkin. One was accepted, with certain modification, and resulted in a contract. The selected twin-engine jet fighter configuration received the designation of XC-100[199]

Work on the jet fighter proceeded slowly, that is until the arrival of a new project designer in May 1947, John C.M. Frost.[200] The XC-100's design was completed later that year and A.V. Roe Canada began tooling up for its production in early 1948.[201] The aircraft had a very conventional looking airframe design. Aviation author Larry Milberry wrote that "except for the jet engines near the fuselage, the airplane had a basic World War II look to it," as the design had straight wings and tail. A.V. Roe Canada clearly stuck to the tried and true. There were practical reasons for this. Even though company designers spent many hours debating whether or not to sweep the wings, too little was known about that aerodynamic form. A.V. Roe Canada could not gamble on its design failing, and the RCAF wanted a fighter as soon as possible. An unorthodox design would take much longer to produce and be much costlier as well.[202]

While these efforts were taking place, the RCAF tried to obtain as much information as possible on foreign jet aircraft developments. It recalled all the technical officers it had loaned the MAP for work on the British jet aircraft program.[203] These men returned to Canada with much knowledge about British jet aircraft developments, having worked on the De Havilland E6/41 Vampire, Gloster E1/44 Ace and Westland N11/44 Wyvern jet fighters, the Saunders-Roe E6/44 flying boat jet fighter, the Miles E24/43 supersonic experimental aircraft, the Armstrong Whitworth AW.52 jet-propelled flying wing, and several other projects.[204] The Canadians also kept abreast of American wartime jet aircraft developments. They paid particular attention to the evolution of American jet fighters, such as the Bell XP-59 Airacomet, Northrop XP-79, Lockeheed XP-80 Shooting Star, Consolidated XP-81, Bell XP-83, Republic XP-84 Thunderjet, and North American XP-86 Sabre.[205] Moreover, the end of the war in Europe gave Canada access to captured enemy technology. Germany had developed radically advanced aircraft designs and had played an active role in the fields of rocketry and jet propulsion. The Canadians wanted access to German aeronautical technology in order to conduct reverse engineering, particularly in regards to jet aircraft and jet engines. In the summer of 1945, the RCAF prepared an ambitious listing of the German aircraft it hoped to obtain: about forty different types of fighters, bombers, flying boats, transport and trainers, including several examples of the Heinkel He 162, Heinkel He 280, Messerschmitt Me 163, and Messerschmitt Me 262 jet fighters; the Bachem Bp 20, Heinkel P.1077, Junkers EF 127 and Messerschmitt P.1104 rocket-propelled fighters; and the Arado Ar 234 and Junkers Ju 287 jet bombers.[206] Moreover, the RCAF wanted German jet engines and thirteen different types of jet and rocket propelled flying bombs and guided missiles.[207] In the

end, only a few He 162, Me 163 and Me 262 jet fighters were shipped to Canada over the next two years and tested by technical experts with the NRC and the RCAF. This provided valuable information for the XC-100 program.[208]

A.V. Roe Canada was not the only Canadian aircraft company interested in developing jet powered military aircraft. In early 1948, DHC investigated the possibility of developing a jet trainer.[209] The RCAF was interested,[210] and drew up specifications for a 7,500 lbs gross weight jet trainer powered by Canadian-designed Chinook jet engines and capable of flying at a maximum speed of 500 mph. The aircraft was to be equipped with radar, radios and cameras, and if need be, canons and rocket launchers.[211] Two prototypes were to be built for testing.[212] Unfortunately, some senior RCAF officials opposed the jet trainer program on the grounds of high costs (fixed at $2 million for two prototypes) and the whole program was cancelled later that year.[213] At about the same time, Canacargo Aircraft Manufacturing (a CCF subsidiary formed in 1947 to develop Burnelli-type aircraft) developed a twin-engine canard jet fighter known as the SK. 5076, to be powered by two American-designed General Electric J-40 or British-designed Rolls-Royce Nene jet engines, but the project never left the drawing boards.[214]

Moreover, it should be noted that since January 1946 A.V. Roe Canada was also working on the development of a jet transport for TCA under the leadership of a young British aeronautical engineer named James C. Floyd. Benefiting from earlier jet transport studies at A.V. Roe in Great Britain, Floyd was quick to prepare a proposal, which was submitted to TCA in February 1946. The proposal outlined two designs capable of carrying 30 to 50 passengers. The first called for an aircraft of 40,000 lbs gross weight powered by four British-built Armstrong-Siddeley Mamba jet engines; the second was

for a 45,000 lbs gross weight machine propelled by two British-made Rolls-Royce AJ.65 Avon jet engines.[215] TCA chose the twin-engine aircraft in April 1946, [216] and A.V. Roe Canada proceeded to produce a detailed specification. The jet transport aircraft received the designation of C-102 Jetliner.[217] But bad news emerged in March 1947 when Rolls Royce told the Canadian company that no AJ.65 engines would be available for civil use anytime in the foreseeable future. Rolls Royce suggested instead replacing the two AJ.65 with four smaller Rolls-Royce Derwent jet engines. A.V. Roe Canada accepted the offer, but the new engines raised the gross weight of the aircraft to 65,000 lbs. TCA was not happy with the substitution, and lost interest in the C-102 project in early 1948. [218]

Still, the construction of the C-102 prototype moved forward,[219] and on 10 August 1949, it made its maiden flight.[220] This was the first jet transport flight in North America and the second in the world after the British De Havilland DH 106 Comet's flight two weeks earlier. The test pilot remarked that the aircraft "handles like a fighter" and achieved speeds in excess of 500 mph.[221] Several American, Australian, Canadian and European airlines showed interest in the C-102,[222] as did the RCAF, USAF and USN.[223] A.V. Roe Canada estimated the market for the C-102 to be between 400 and 500 aircraft.[224] Unfortunately, in December 1951, the Canadian government ordered A.V. Roe Canada to halt the C-102 program and concentrate instead on the jet fighter for the RCAF. A.V. Roe Canada had no choice but to follow the government's directive and put an end to marketing efforts and the construction of the second prototype of the C-102. In the end, A.V. Roe Canada built only one C-102 Jetliner.[225]

The jet fighter program was somewhat more successful. The XC-100 prototype, powered by two Rolls-Royce Avon jet engines of 5,700 lbs thrust, made its maiden flight

on 19 January 1950.[226] At the time, more than $140 millions had already been invested in the Canadian jet fighter program.[227] The XC-100, which was then described as the "most powerful fighter in the world,"[228] received the official designation of CF-100 Canuck on 21 June 1950.[229] The first CF-100 fitted with more powerful Orenda engines flew almost a year later, on 20 June 1951. A few preproduction aircraft were made thereafter and officially handed over to the RCAF on 17 October 1951.[230] On that occasion, C.D. Howe said of the CF-100 that "not only is this the first aircraft to be completely designed, developed, and produced in Canada, but the Orenda engine is the first airplane engine to be designed, developed and produced in this country. The aircraft as it stands before us is a notable Canadian achievement, marking as it does a new milestone in Canada's industrial advancement."[231] But the RCAF still had to wait until April 1953 before its first squadron equipped with CF-100 became operational.[232] In other words, the jet fighter program took more than eight years of development from the time the RCAF issued its specification in January 1945 to the delivery of the first production aircraft to the air force.

Table 7.1: Characteristics of CF-100 variants

Variants	Gross Weight (lbs)	Engine Thrust (lbs)	Armament	Numbers Made	Years Made
Mk. 1 (prototype)	31,877	5,700	None	2	1950
Mk. 2 (Preproduction)	33,100	6,000	None	5	1951-52
Mk. 3A	34,000	6,000	8 machine guns	74	1952-53
Mk. 3B	34,000	6,300			
Mk. 4A	37,000	6,300	8 machine guns and 58 rockets	279	1952-55
Mk. 4B	37,000	7,400			
Mk. 5	33,528	7,400	104 rockets	332	1955-58

Source: K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 85-93, 458.

In all, 692 CF-100 fighters were manufactured between 1950 and 1958. All of them went to the RCAF, except for 53 that were purchased by the Belgian Air Force.[233] Table 7.1

shows the different characteristics of the seven main variants of the CF-100. Operational CF-100 fighters carried a sophisticated radar and fire control system, and were powered by Orenda engines of 6,000 to 7,400 lbs thrust. Armament carried included eight .50 caliber machine guns installed in a completely self-contained retractable gun pack mounted into the aircraft's fuselage and/or rockets in wing tip pods. The total cost of producing the 692 aircraft and their jet engines was about $750 millions.[234] Overall, more than 40,000 people worked on the CF-100 program (10,000 at A.V. Roe Canada alone) in over 400 companies located across Canada.[235]

Conclusion

The design and development of jet engines and a jet aircraft in Canada was an ambitious undertaking on the part of the Canadian government. Given that no aircraft engines were produced in the country during the war, and that no combat aircraft had been conceived since the FDB-1 in the late 1930s, the decision to enter the field of jet propulsion was surprising. But jet propulsion promised to offer Canada numerous benefits in the postwar period. The design and production of jet engines would allow the aircraft industry to become increasingly autonomous. Wartime difficulties in obtaining vital power plants from American and British sources made self-sufficiency in the field of aircraft propulsion all the more essential. The advent of the jet aircraft led to a radical transformation in the international development of combat aircraft. In so many ways, jet aircraft could be compared to dreadnoughts of the skies, rendering all other aircraft types suddenly obsolete. The era of the propeller driven combat aircraft powered by piston engines was rapidly coming to an end. Jet bombers and jet fighters were the wave of the

future and Canadians knew all too well the importance of this air revolution for Canada. The postwar possibilities afforded by the jet engine therefore seemed endless.

The success of the CF-100 Canuck jet fighter and the Orenda line of jet engines in the 1950s testified to the fruitful efforts made by Canada in the field of jet propulsion during the Second World War. These projects marked the beginning of a truly self-sufficient Canadian fighter aircraft industry and enabled A.V. Roe Canada to emerge as one of the world's most important combat aircraft designer and producer during the early Cold War. In fact, as early as the summer of 1948, A.V. Roe Canada began work on a CF-100 successor and over the next decade designed several supersonic fighters, such as the C-103, C-104 and C-105. Although none of these projects ever left the drawing boards, they paved the way for the development of the twin-engine CF-105 Arrow supersonic interceptor, which made its maiden flight in March 1958. A.V. Roe Canada also pursued work on several new and more powerful jet engine designs in the 1950s, such as the 13,000 lbs thrust TR-9 Wakunda, which culminated in the Arrow's 19,000 lbs thrust (25,000 lbs thrust with afterburners) PS-13 Iroquois.

NOTES

1 "Walter Deisher (President, A.V. Roe Canada) to Malton Businessman's Association," February 1947, reproduced in Greig Stewart, *Shutting Down the National Dream: A.V. Roe and the Tragedy of the Avro Arrow* (Toronto: McGraw-Hill Ryerson, 1988), p. 69.

2 Kenneth H. Sullivan and Larry Milberry, *Power: The Pratt & Whitney Canada Story* (Toronto: CANAV Books, 1989), p. 12.

3 K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), p. 23.

4 David Carnegie, *The History of Munitions Supply in Canada, 1914-1918* (London: Longmans, Green and Company, 1925), p. 317; K.M. Molson, "Aircraft Manufacturing in Canada during the First Great War," *Canadian Aeronautical Journal*, Vol. 5, No. 2 (February 1959), p. 54.

5 J. Fergus Grant, "Canada's Aircraft Industry," *Canadian Geographical Journal*, Vol. 17, No. 2 (August 1938), p. 69.

6 LAC, MG-27 [Ian Mackenzie Papers], III B 5, Vol. 30, File: X-11, "Report of the Navy, Army and Air Supply Committee," 31 December 1936.

7 LAC, MG-27, III B 5, Vol. 30, File: X-11, "Eight Meeting of the Navy, Army, and Air Supply Committee," 3 November 1937.

8 "Canadian Car's Rapid Progress," *Canadian Aviation*, Vol. 11, No. 8 (August 1938), p. 43.

9 Ralph P. Bell, "Canada's Aircraft Industry," *Canadian Geographical Journal*, Vol. 24, No. 3 (March 1942), p. 119; C.G. Grey and Leonard Bridgman, *Jane's All the World's Aircraft 1939* (London: Sampson Low, Marston & Company, 1939), p. 77c; Ronald A. Keith, "Aircraft Manufacturing in Canada," *Canadian Aviation*, Vol. 13, No. 11 (November 1940), p. 21.

10 Several companies established aircraft engine plants in Canada during the interwar period, but these were only equipped for the overhaul and repair of foreign-made engines. Some of these factories, however, did assemble some American and British type engines from pre-fabricated parts and components made in Great Britain and the United States. Such was the case for Canadian Pratt & Whitney Aircraft Company Limited of Longueuil; Canadian Wright Limited of Montreal; Ottawa Car Manufacturing Company Limited of Ottawa; and Bristol Aeroplane Company Limited of Montreal. See J. Fergus Grant, "Canada's Aircraft Industry," *Canadian Geographical Journal*, Vol. 17, No. 2 (August 1938), p. 72, 78-79.

11 LAC, RG-2 [Records of the Privy Council Office], 7c, Reel: C-11,789, Vol. 1, "Minutes of Emergency Council, CWC," 28 September 1939.

12 C.D. Howe, "A Review of Canada's War Effort on the Industrial Front," *Industrial Canada*, Vol. 41, No. 8 (December 1940), p. 40.

13 LAC, RG-24 [Records of the Department of National Defence], Vol. 5404, File: HQS 60-5-9, "Proposed Scheme for Building Centaurus 18-Cylinder Sleeve Type Bristol Aero Engines," 20 May 1940. For more information on the Bristol Centaurus engine, consult Graham White, *Allied Aircraft Piston Engines of World War II* (Warrendale: Society of Automotive Engineers, 1995), pp. 151-153.

14 LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Wing Commander A. Ferrier (For CAS) to the DMS," 19 August 1940. See also White, *Allied Aircraft Piston Engines of World War II* ..., pp. 46-93.

15 White, *Allied Aircraft Piston Engines of World War II*..., pp. 54-57.

16 LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "James Young (President, Canadian Pratt & Whitney Aircraft Company Limited) to Ralph P. Bell (DMS)," 4 September 1940. See also LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Memorandum by Flight Lieutenant J.G. Goodenough (Power plant Adviser to AMES)," 22 October 1940. See also White, *Allied Aircraft Piston Engines of World War II*..., pp. 198-200, 222-232.

17 LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Ralph P. Bell (DGAP) to J.S. Duncan (Deputy MND (Air)," 6 September 1940.

18 LAC, RG-24, Vol. 5125, File: HQ 1021-9-72, "W.J. Sanderson (President and Managing Director, Fleet) to Ralph P. Bell," 11 January 1941.

19 LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Construction of Aero Engines in Canada," 10 September 1940.

[20] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Memorandum by Wing Commander A. Ferrier (DAE) to AMES," 12 September 1940.

[21] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Construction of Aero Engines in Canada," 10 September 1940.

[22] LAC, RG-28 [Records of the Department of Munitions and Supply], Vol. 5, File 9, "Diary of Visit to Great Britain by C.D. Howe (MMS)," 23 December 1940.

[23] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Memorandum by Wing Commander A. Ferrier (DAE) to AMES," 12 September 1940.

[24] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Wing Commander A. Ferrier (For CAS) to Ralph P. Bell," 26 September 1940.

[25] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "J.S. Duncan (Deputy MND (Air)) to Ralph P. Bell," 5 December 1940.

[26] LAC, RG-28, Vol. 5, File 9, "Diary of Visit to Great Britain by C.D. Howe (MMS)," 23 December 1940.

[27] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Proposed Technical Assistance Agreement between Wright Aeronautical Corporation and Government of the Dominion of Canada," 4 October 1940; LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Memorandum by Flight Lieutenant J.G. Goodenough (Power plant Adviser to AMES), 4 October 1940. For more information on the Wright R-1820 Cyclone engine, consult White, *Allied Aircraft Piston Engines of World War II...*, pp. 325-335.

[28] LAC, RG-2, 7c, Reel" C-11,789, Volume 2, "Minutes of the CWC," 5 September 1940.

[29] LAC, RG-2, 7c, Reel" C-11,789, Volume 2, "Minutes of the CWC," 3 October 1940.

[30] LAC, RG-2, 7c, Reel" C-11,789, Volume 3, "Minutes of the CWC," 29 January 1941.

[31] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "A/V/M E.W. Stedman (For CAS) to Ralph P. Bell," 17 March 1941.

[32] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Orville E. Mohler (Vice-President of Sales, Menasco Manufacturing Company) to DMS," 6 February 1941.

[33] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Squadron Leader J.G. Goodenough (CD/DED) to DAE," 20 February 1941.

[34] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "A/V/M E.W. Stedman (For CAS) to Ralph P. Bell," 21 February 1941.

[35] LAC, RG-2, 7c, Reel: C-4654, Volume 6, "Minutes of the CWC," 19 November 1941.

[36] LAC, RG-24, Vol. 5404, File: HQS 60-5-9, "Extract from Minutes of Meeting of the Air Council," 5 November 1941.

[37] LAC, RG-2, 7c, Reel: C-4654, Volume 6, "Minutes of the CWC," 19 November 1941.

[38] LAC, RG-2, 7c, Reel: C-4874, Volume 8, "Minutes of the CWC," 15 January 1942; LAC, RG-24, Vol. 2728, File: HQS 5199-W-9, "Digest of Minutes of Meeting of the Joint War Production Committee," 26 January 1942

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[41] LAC, RG-2, 7c, Reel: C-4874, Volume 9, "Minutes of the CWC," 1 April 1942.

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[44] *Ibid*

[45] LAC, RG-28, Vol. 156, File: 3-P-12-8, "W.C. Clark (Deputy M of F) to Ralph P. Bell," 11 February 1944.

[46] LAC, RG-28, Vol. 156, File: 3-P-12-8, "Ralph P. Bell to W.C. Clark (Deputy M of F)," 22 February 1944

[47] *Ibid.*

[48] *Ibid.*

[49] LAC, RG-28, Vol. 155, File: 3-P-12, "Memorandum by A/V/M E.W. Stedman (RCAF) for Presentation to the Cabinet Subcommittee on Air Transport Policy," 19 January 1944.

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53 Bell, "Canada's Aircraft Industry...," p. 129.

54 "With Aviation to Victory," *Commercial Aviation*, Vol. 7, No. 10 (November 1945), pp. 38-39

55 "With Aviation to Victory...," p. 38. See also White, *Allied Aircraft Piston Engines of World War II...*, p. 199, 201.

56 "With Aviation to Victory...," p. 39.

57 During the war, Pratt & Whitney overhauled 4,358 engines, British Aeroplane Engines 3,532, and Canadian Wright 2,537. See "With Aviation to Victory...," pp. 38-39.

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[207] Added to the RCAF list were duplicate samples of airborne equipment (radios, radars, cameras, sights, aircraft instruments) aircraft armament (canons, machine guns, rockets, aerial bombs, airborne sea mines, shells, fuzes); rescue material (emergency rations, airborne lifeboats, air-sea rescue equipment), and personal items (flight suits, helmets, headsets, microphones, oxygen masks, parachutes, small arms). Moreover, the RCAF wanted samples of jet and rocket propelled flying bombs and guided missiles (Hs-293 to Hs-298, X-1 to X-7, and V-1) as well as long-range rockets (V-2) and jet engines (BMW 003 and Jumo 004). It was also requested that the above items be provided with complete sets of drawings, instructional manuals, and other data. The NRC and Turbo Research were also interested in wind tunnels and other turbine test equipment. See LAC, RG-24, Vol. 4980, File: HQ 626-3-1, "Memorandum by Group Captain D.A.R. Bradshaw (Ops/J-2) on German Air Force Equipment," 6 July 1945; LAC, RG-24, Vol. 4980, File: HQ 626-3-1, "Memorandum by Air Vice-Marshal E.W. Stedman (DGR)," 6 July 1945; LAC, RG-24, Vol. 4980, File: HQ 626-3-1, "H.F. Gordon (Deputy Minister of National Defence for Air) to Under-Secretary of State for External Affairs," 11 July 1945; LAC, RG-24, Vol. 4980, File: HQ 626-3-1, "List of Equipment, Technical Data and Publications Required by the RCAF," 27 August 1945.

[208] LAC, RG-24, Vol. 4980, File: HQ 626-3-3, "Wing Commander A.H. Mielke (For Air Officer Commanding RCAF Overseas) to Department of National Defence for Air," 17 April 1946; LAC, RG-24, Vol. 4980, File: HQ 626-3-3, "RCAF Message Form by Group Captain J.A. Easton (RCAF Overseas Headquarters)," 26 April 1946; LAC, RG-24, Vol. 4980, File: HQ 626-3-3, "Squadron Leader J.M. Bridgman (For Chief of the Air Staff) to Department of National Defence," 27 April 1946; LAC, RG-24, Vol. 4980, File: HQ 626-3-3, "Group Captain G.E. McCormick (For Air Officer Commanding RCAF Overseas) to the Department of National Defence for Air," 27 April 1946; LAC, RG-24, Vol. 4980, File: HQ 626-3-3, "Major F.G.B. Maskell (Joint Committee on Enemy Science and Technology) to Wing Commander Gouin," 3 June 1946; LAC, RG-24, Vol. 4980, File: HQ 626-3-3, "Wing Commander C.H. Cotton (RCAF Member, Joint Committee on Enemy Science and Technology) to Officer Commanding Experimental & Proving Establishment (RCAF Station Rockliffe)," 9 January 1947; LAC, RG-24, Vol. 4980, File: HQ 626-3-3, "Memorandum by Wing Commander C.H. Cotton (RCAF Member, Joint Committee on Enemy Science and Technology)," 10 February 1947.

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[217] *Ibid.*, pp. 41-52

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CONCLUSION

> All equipment for a Canadian air force in being must be manufactured ... in Canada. This is most desirable in order to maintain control of production in Canada to the greatest extent possible, to avoid foreign exchange problems which would otherwise arise, and to reduce the cost to the Canadian taxpayer by ensuring that defence expenditures themselves are, to the fullest extent possible, made a part of the national income upon which taxes are levied ... It is in the national interest to encourage Canadian design and development of aircraft and equipment to the greatest possible degree in order to foster the higher engineering qualities which such work demands and so add to our national capacity. We should be prepared to pay a premium to encourage the growth of Canadian design and development teams and should plan to design and develop in Canada military aircraft and equipment ... It should be remembered however that to be of value such design and development in Canada must be able to compete with corresponding design and development elsewhere.
>
> — Fred T. Smye, Canadian Ordnance Association[1]

The Canadian aircraft industry made an important contribution to Allied victory during the Second World War. In the span of six war years, aircraft manufacturing plants across Canada produced an astounding 16,418 aircraft, including modern fighters, bombers, trainers, transports and patrol aircraft. In addition, about 3,200 American and British aircraft were assembled in Canada from parts and components imported from Great Britain and the United States. Much of this wartime industrial achievement came from Canadian factories that did not even exist at the beginning of the war. The wartime

growth of the Canadian aircraft industry was achieved at considerable government expense under the watchful eye and strict coordination of the Department of Munitions and Supply. When the Second World War ended in 1945, Canada ranked as the fourth largest Allied manufacturer of aircraft, surpassed only by the United States, the Soviet Union and Great Britain. The wartime Canadian aircraft industry had conclusively demonstrated, according to C.D. Howe, that it was "capable of building the largest and most complicated types of operational aircraft in the world."[2]

As this study shows, the bulk of Canadian aircraft production consisted of aircraft of American or British origin. Unlike the three larger and more powerful Allied aircraft manufacturing countries, which produced their own lines of products, Canada only produced a few aircraft of indigenous conception, namely the Fleet 60 Fort trainer and Noorduyn Norseman general utility transport. Indeed, little more than five percent of Canada's total wartime production consisted of domestically developed aircraft.

This situation was owed largely to the relatively small size of Canada's prewar aircraft industry and its inexperience in designing, and manufacturing, military aircraft. Indeed, almost all of the aircraft that were produced in the country during the interwar period consisted of small trainers and general utility transports. Most Canadian aircraft companies lacked the design staffs, skilled labour, machine tools, equipment, facilities, and funds to initiate the development of sophisticated military aircraft. Moreover, Canada acquiesced to the British Commonwealth policy of standardization in weapons and military equipment, which made it difficult for the country to develop its own types of military aircraft. Moreover, Canada simply found it easier and cheaper under wartime conditions to concentrate on the production of existing and well-proven American and

British aircraft types. The development of service aircraft was a complex and costly endeavour that generally required several years of development without any guarantees of success. It was simply easier to leave the creation of new military aircraft types in the hands of stronger and more experienced American and British design staffs. There was simply no point in running parallel programs in Canada. Winning the war was the priority, and manufacturing existing and well-proven aircraft designs quickly and in large quantities for the Allies — no matter what the origins of these aircraft were — took precedence over design and development efforts. This course of action, however, placed the Canadian aircraft industry in an extremely subservient position, as it had to constantly rely on foreign aeronautical expertise and technology to survive. The industry was all the more vulnerable owing to the fact that Canada did not manufacture aircraft engines, but rather imported them from Great Britain and the United States.

But the decision to focus on the production of American and British aircraft designs under-license was not unanimously accepted in Canadian government and industrial circles. A number of individuals felt that Canada could and should innovate in the field of aircraft design and development, especially following Germany's conquest of Scandinavia and Western Europe in the spring of 1940. With the looming possibility of Great Britain's defeat these sources promoted the need for Canada to be self-sufficient in aircraft production.

At the NRC's instigation, the wooden aircraft program was initiated in the summer of 1940. However, ultimately, the Canadian government opted to re-engineer and convert from metal to wood existing American or British aircraft designs already in production in Canada. Similarly, DHC's attempts to develop in Canada a whole line of

military transport gliders largely made of wood between 1941 and 1942 proved unsuccessful as the Canadian government preferred to use existing and well-proven American and British built gliders.

Early setbacks did not stop some Canadian aircraft manufacturers and government officials from encouraging the creation of indigenously designed aircraft during the war. Their initiative derived from a growing spirit of independence in the Canadian government and some elements of the private sector resulting from the massive wartime expansion of the aircraft industry and a rise in aeronautical engineering expertise in Canada, as well as from frustrations encountered in the production of licensed aircraft. Moreover, the series of important Allied victories in the European and Pacific theatres beginning in late 1942 led to a realization that the war might soon be over. The Canadian government had to begin considering ways to strengthen its aircraft industry by improving its design and development capabilities. This was particularly important if Canadian aircraft companies were to successfully compete against foreign manufacturers in postwar markets.

The creation of the Committee on Postwar Manufacture of Aircraft in early 1943, which operated under the auspices of the Department of Munitions and Supply, testified to the determination of some government officials to prepare the industry for postwar years. The committee's ultimate aim was to work on projects that could have both commercial and military applications. This was reflected in the decision to initiate the design and development of trainers and transport aircraft that could be put to both civil and military use. Unfortunately, there were many divisions between different interest groups, particularly the Department of National Defence for Air and the Department of

Munitions and Supply, as to where to devote time and resources. Frustration mounted when the work of the Committee came to an end in early 1944 and the Department of Munitions and Supply chose to have the American-designed DC-4 transport produced under-license in Canada instead of a Canadian-designed aircraft. As a result, the Department of National Defence for Air decided to take matters into its own hands and issued formal postwar requirements for two ambitious aircraft projects to be developed in Canada: a twin-engine aircrew trainer and a jet fighter. From this point, government responsibility for the design and development of aircraft in Canada shifted from the Department of Munitions and Supply to the Department of National Defence for Air, which chose to commit the Canadian aircraft industry to military types.

The twin-engine aircrew trainer project was initiated to provide Canadian aircraft manufacturers with a suitable indigenously designed aircraft to produce in the early postwar period. This objective was never met: no Canadian-designed aircrew trainer was ever built or adopted by the RCAF, and no Canadian manufacturer continued work on such an aircraft after the government pulled the plug on the project. However, the twin-engine trainer project led the government and aircraft companies to actively start thinking about postwar requirements. Moreover, while the proposed trainer never left the drawing board, the project provided the companies that participated in the program with additional confidence in their ability to design and develop aircraft in Canada.

The Canadian jet fighter program was somewhat more successful. The advent of jet propulsion marked the beginning of a new era, and in 1942, the Canadian government launched its own jet engine program. The decision to design and develop a jet fighter, as well as a suitable jet engine, was certainly an ambitious undertaking on the part of the

Canadian government, especially since no aircraft engines were made in Canada during the war and no combat aircraft had been conceived in the country since the 1930s. The ultimate aim of the jet fighter program was to provide Canada with the necessary tools, resources and knowledge to undertake quantity production of such engines and aircraft after the war. The postwar possibilities afforded by jet propulsion were tremendous, from both a military and civilian perspective. Although no Canadian-designed jet fighter was ready to fly before the end of the war, work on this project continued for many years thereafter and culminated in the CF-100 Canuck fighter of the 1950s.

Toward the end of the war, the Canadian aircraft industry had acquired considerable experience and, as a as a result of wartime industrial expansion, Canada came to possess huge state-of-the-art facilities in which to build the aircrafts of the future. This translated into increased research and development efforts. With wartime production subsiding, more thought could be given to postwar planning and the development of Canadian-designed aircraft. The survival of the industry and its capability to compete with foreign manufacturers in postwar years depended on such preparations. Fuelling this increasing desire to design and develop aircraft in Canada was the realization that the end of the war in Europe and Asia was fast approaching. On 7 May 1945, the war in Europe ended when the Germans surrendered unconditionally. On 6 and 9 August 1945, the United States dropped atomic bombs on the Japanese cities of Hiroshima and Nagasaki and on 14 August, the Japanese sued for peace.

With the end of the war, the Canadian government cancelled its wartime contracts in the summer of 1945. Only three government-sponsored aircraft programs were pursued: the jet fighter, the twin-engine aircrew trainer and the DC-4 transport. The

problem, however, was that these projects provided work to only three Canadian aircraft manufacturers (A.V. Roe Canada, Canadair, and Fairchild). Without government support, the other aircraft companies turned to the civilian market to assure their future. Most of them resorted to the design and development of small general utility transports that could be sold on both the civilian and military markets. The production of such aircraft had been quite popular during the interwar years, and the wartime success of the Norseman had further demonstrated the high demand for suitable bush aircraft both in Canada and around the world. However, only a few of these general utility transport aircraft projects proved successful on the international market and resulted in any large-scale orders. This created financial difficulties for several aircraft manufacturers, which forced some of them out of the aircraft-making business in the late 1940s.

The situation only began to improve in the early 1950s with the beginning of the Korean War and the intensification of the Cold War, which upheld demand for combat and transport aircraft on international markets, thus helping to keep the Canadian aircraft industry vibrant. A bright and promising future seemed just ahead for the industry. Some aviation experts even believed that Canada would become "the air arsenal for Britain and the United States."[3] While the licensed production of foreign aircraft types continued in postwar years, as Table 1 demonstrates, Canadian aircraft companies undertook more and more domestically developed projects. While many Second World War aircraft manufacturers left the aircraft-making business in the immediate postwar years, several others emerged as international aviation leaders, earning great reputations for their successful, sophisticated and highly complex civilian and military aircraft designs. Such was the case for A.V. Roe Canada, Canadair, and DHC.

Table 1: Foreign-Designed Aircraft Made in Canada, 1945-2000

Aircraft	Country of Origin	Type	Years of Production	Numbers Produced
Canadair				**3,099**
Convair CV-540 Cosmopolitan	United States	Transport	1959-60	10
North American F-86 Sabre	United States	Jet Fighter	1949-58	1,815
Lockheed T-33 Silver Star	United States	Jet Trainer	1952-59	656
Lockheed F-104 Starfighter	United States	Jet Fighter	1961-65	378
Northrop F-5 Freedom Fighter	United States	Jet Fighter	1968-73	240
CCF				**680**
Beech T-34 Mentor	United States	Trainer	1954-55	125
North American AT-16 Harvard	United States	Trainer	1951-53	555
Cub				**145**
Piper J-3 Cub	United States	Transport	1945-47	128
Piper L-4 Prospector	United States	Transport	1947	17
DHC				**153**
De Havilland DH 83 Fox Moth	Great Britain	Transport	1945-48	53
Grumman S2F Tracker	United States	ASW	1956-60	100
Fleet				**6**
Bay Super V	United States	Transport	1962-63	5
Helio H-391 Courier	United States	Transport	1955	1
TOTAL				**4,083**

Source: K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 458-464.

Table 2 shows how Canada's Second World War aircraft manufacturers built 6,862 aircraft of indigenous design (in addition to the 4,083 aircraft of foreign design built under license — see Table 1) before the end of the Twentieth Century. In other words, 63 per cent of the 10,945 aircraft made by these manufacturers between 1945 and 2000 consisted of domestically developed aircraft designs. In retrospect, the Second World War was a training ground for the Canadian aircraft industry. Although few aircraft of indigenous design were produced in Canada between 1939 and 1945, the war gave the Canadian aircraft industry the necessary resources and expertise to build a bright postwar future.

Table 2: Canadian-Designed Aircraft Made by Second World War Manufacturers, 1945-2000

Aircraft	Type	Years of Production	Numbers Produced
A.V. Roe Canada			**701**
C-102 Jetliner	Jet Transport	1949	1
CF-100 Canuck	Jet Fighter	1950-58	692
CF-105 Arrow	Jet Fighter	1958-59	6
Avrocar	Flying Saucer	1958-61	2
Canadair (Bombardier in 1986)			**1,533**
CL-2, CL-4 and CL-5 North Star	Transport	1946-50	71
CL-28 Argus	ASW Patrol	1957-60	33
CL-44 Yukon	Transport	1959-65	39
CL-41 Tutor	Jet Trainer	1960-67	212
CL-84 Dynavert	VTOL Aircraft	1964-72	4
CL-215	Flying Boat	1967-89	125
CL-415	Flying Boat	1991-2000	57*
Challenger	Business Jet	1978-2000	506*
Regional Jet	Business Jet	1989-2000	451*
Global Express	Business Jet	1991-2000	35*
CCF			**56**
CCF CBY-3 Loadmaster	Transport	1945	1
Noorduyn Norseman	Transport	1945-59	55
DHC (Bombardier in 1992)			**4,335**
DHC-1 Chipmunk	Trainer	1946-56	217
DHC-2 Beaver	Transport	1947-68	1,692
DHC-3 Otter	Transport	1951-67	466
DHC-4 Caribou	Transport	1958-73	307
DHC-5 Buffalo	Transport	1964-86	126
DHC-6 Twin Otter	Transport	1965-88	844
DHC-7 Dash-7	Transport	1975-88	113
DHC-8 Dash-8	Transport	1983-2000	570*
Fairchild			**12**
F-11 Husky	Transport	1946-47	12
Fleet			**225**
Fleet 80 Canuck	Transport	1945-49	225
TOTAL			**6,862**

* Remained in Production after 2000.

Source: K.M. Molson and H.A. Taylor, *Canadian Aircraft since 1909* (Stittsville: Canada's Wings, 1982), pp. 458-464; Paul Jackson, *Jane's All the World's Aircraft, 2001-2002* (Coulsdon: Jane's Information Group, 2001), pp. 34-51; Paul Jackson, *Jane's All the World's Aircraft, 2005-2006* (Coulsdon: Jane's Information Group, 2005), pp. 43-60.

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