FALL 2023 - Volume 70, Number 3
WWW.AFHISTORY.ORG

Journal of the Air Force Historical Foundation

A Mount for the Iroquois: A USAF TB-47B Serving with the RCAF

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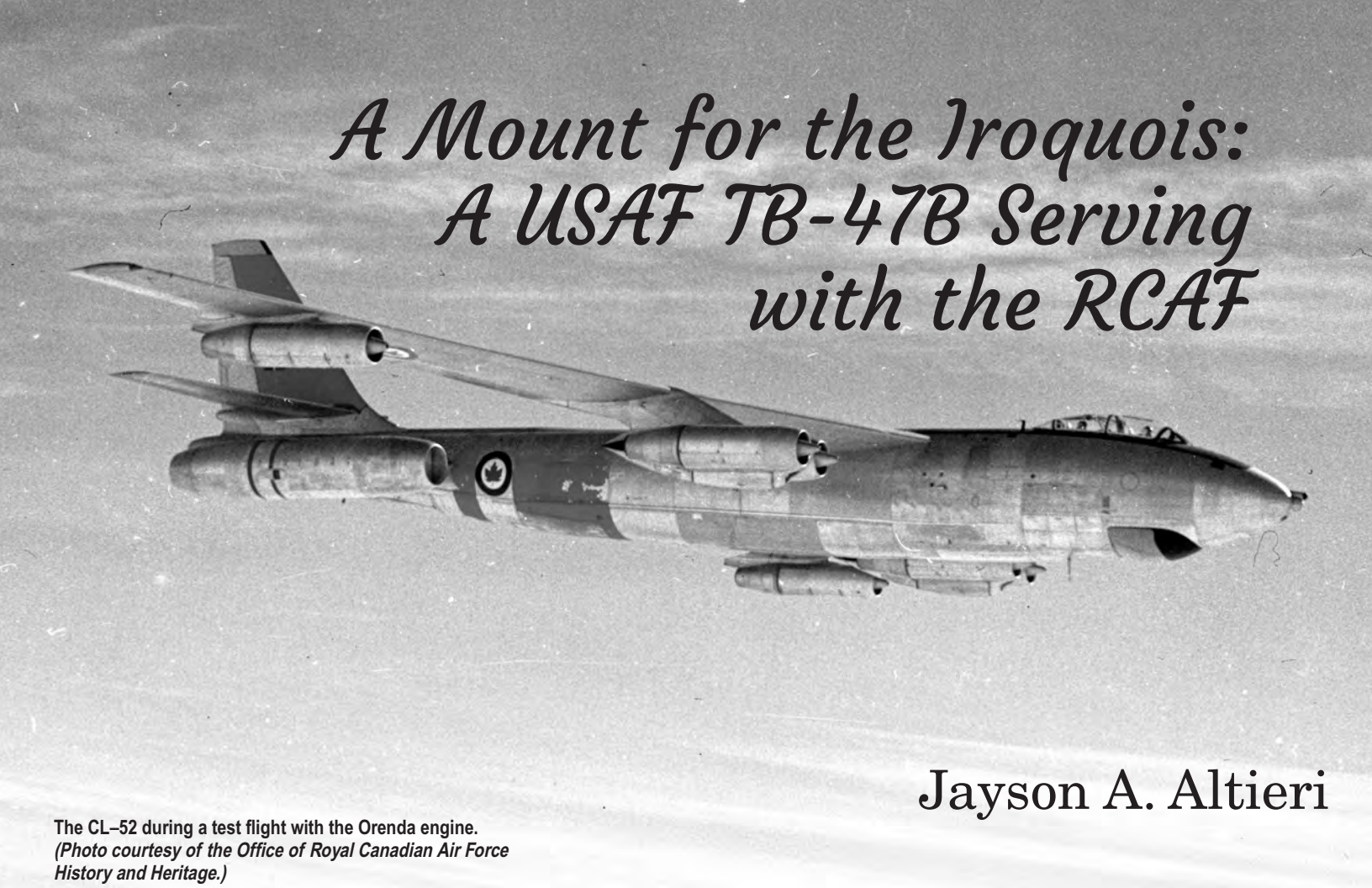

The CL–52 during a test flight with the Orenda engine.
(Photo courtesy of the Office of Royal Canadian Air Force History and Heritage.)

Since the successful development of the airplane in the early twentieth century, aircraft have become not only part of our daily life, but also a key part of many nations' popular culture and image. Examples of such aircraft include France's Dassault F–1 Mirage fighter and joint Aerospatiale/British Aircraft Corporation Concorde supersonic airliner, Great Britain's Sopwith Camel and Supermarine Spitfire fighters, and the United States' (US) Ryan Aeronautical Company's NYP monoplane (Charles Lindbergh's The Spirit of St. Louis) and Boeing 747 airliner. One aircraft, while it never entered full production, but became part of Canada's aviation heritage and cultural image, was the short-lived and revolutionary, 1950's A. V. Roe (Avro) Canada Limited's CF–105 Arrow supersonic delta-winged interceptor.[1] While the Arrow, both in fact and legend, has assumed a historical significance in Canada's distinguished aviation history, what is less well known, is the important role a Florida based US Air Force (USAF) TB–47B Stratojet bomber played in the Arrow's development.

The Avro Canada CF–105 Arrow program, whose demise in 1959 was a classic case of the right airplane at the wrong time – was deemed obsolete as a weapons system due to the competing technologies of intercontinental ballistic and surface-to-air missiles.[2] Still the ability of Avro Canada, the Royal Canadian Air Force (RCAF), and the USAF to successfully combine a diverse range of resources and talents to test a key component of the Arrow Interceptor – the revolutionary Orenda Engines Limited (an aeronautical subsidiary of Avro Canada) Project Study 13 (P.S. 13) Iroquois turbojet engine, demonstrates the successes of international cooperation in advancing new aerospace technologies.[3]

The development of the Orenda Iroquois engine was an essential part the Arrow's ability to perform its planned role as a high-altitude, high-speed interceptor against the then Union of Soviet Socialist Republic's (USSR) long-range nuclear armed bombers designed to attack North America. Worried that Soviet bombers could attack via the North Pole, the US and Canada needed aircraft that, when combined with a defense-in depth early warning radar system, could intercept the Soviet bombers close to the Arctic Circle.[4] The whole objective of the Arrow development was as a flying weapons system capable of intercepting and destroying a highspeed Soviet bomber invading North American airspace.[5] To do this, the Arrow needed an engine capable of pushing the aircraft to altitudes and airspeeds not previously seen in the current cohort of 1950's era western interceptors. Such an engine would require a large aircraft capable of carrying one of the late 1950's most innovative jet engines. This need led to the Avro Arrow program engineers acquiring an USAF TB–47B bomber as the platform on which to evaluate the Arrow's powerful Iroquois engine – another milestone in the Arrow's radical design program.

Avro Canada's CF–105 Arrow

The development of the Avro Canada's CF–105 Arrow was the result of the west's immediate Cold War needs of protecting both North America and Europe from the threat of the USSR under dictator Joseph Stalin. While Canada, Britain, the US, and USSR had been allies against the twin threats of German National Socialism and Japanese Imperialism during the Second World War, at the end of the war the USSR was the dominant military power in eastern Europe and the main power rival of the United States – the Cold War had begun.[6] The Cold War era also brought the proliferation of nuclear weapons by both sides – a significant existential military threat not seen until the end of the Second World War. As a result, in the early 1950's American and Canadian political and military leaders rightly feared nuclear weapons, delivered by Soviet bombers or missiles, might fall on their own cities. Based on western closed and open-source intelligence reporting (which later proved to be inaccurate and led to the "Bomber Gap" debate), Soviet aircraft like the jet powered M-4 Bison and the turboprop powered Tu–95 Bear long-bombers seemed the biggest nuclear threats to North American economic, military, and political centers of gravity.[7]

To counter the Soviet bomber threat, in the mid-1950's both the US and Canada relied on late first and early second-generation jet fighter aircraft like Convair's F–102 Delta Dagger, the Northrop F–89 Scorpion, North American F–86 Saber (known in Canada as the Canadair CL–13 Saber with an Orenda 10 engine), and Avro Canada's CF–100 Canuck to protect the continent. While all these aircraft were technologically more advanced than their late 1940's predecessors, many were single engine aircraft (except for the F–89 and CF–100) that lacked the range and maintenance reliability to operate in the extreme low-temperatures found over northern Canada.[8] Due to the fact that none of the existing US and Canadian fighter aircraft could address these performance concerns, the RCAF issued Operational Requirement (OR) 1/1-63, "Supersonic, All-Weather Interceptor Aircraft," in November 1952.[9]

Orenda Iroquois Engine Mounted on the CL–52. ***(Photo courtesy of the Canadian Air and Space Museum.)***

Avro Canada's Chairman Sir Roy Dobson and President/General Manager Crawford Gordon received from the RCAF in April 1953, Specification AIR-7-3 "Design Studies of Prototype Supersonic All-Weather Interceptor aircraft" based on the RCAF's 1952 OR.[10] This RCAF specification led the development on what was to become the CF–105 Arrow, an aircraft that would help revolutionize fighter development into the Cold War and beyond into the Space Race.[11] In accordance with the AIR-7-3 requirements, the proposed CF–105 aircraft would be a twin-engine interceptor capable of maximum level speeds of Mach 2.0; a combat ceiling of 60,000 feet; a maximum mission range of 200 Nautical Miles on a supersonic mission (1,500 Nautical Miles Ferry range); and could be flown day, night and all-weather by a crew of two (Pilot and Radar Operator).[12] Additionally, the Arrow would include a number of innovative design features that became common for future generations of advanced combat aircraft including: an Automatic Flight Control System or "Fly-by Wire" system (a feature not seen in production aircraft until the late 1960's), a fully-integrated Hughes MX-1179 Fire Control System which was completely automated and controlled from a ground control station, and a removable internal weapons bay pack capable of firing either eight Hughes AIM-4 Falcon or

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USAF TB–57B conversion to CL–52 Canadair November 25, 1956 at Cartierville, Quebec, Canada. ***(Photo courtesy of the Office of Royal Canadian Air Force History and Heritage.)***

four Raytheon AIM-3 Sparrow Air-to-Air missiles.[13] The total cost of this advance technology was estimated at nearly $400 million (Canadian), a considerable sum for the time when the entire Canadian defense budget was $2 billion with the RCAF having a larger budget than those of the Canadian Army and Royal Canadian Navy combined.[14] The cost of the CF–105 development, due in part to unplanned cost overruns driven by changing RCAF requirements, would come to haunt Avro Canada's leadership by 1958.[15]

What was even more impressive for the time, in an era (even today) when high-profile military aircraft programs take decades to simply get a contract in place and many more years before actual delivery starts, Avro Aircraft Canada (now an aviation subsidiary of Avro Canada Limited and led by President Fred T. Smye), took the initial 1953 design to the Arrow's first flight by 1958.[16] A total of six production model Arrows were built using the Cook-Craigie approach to aircraft development which meant none of the six aircraft were prototypes.[17] In order to meet production timelines, all the initial Arrows flew with the US designed Pratt and Whitney J-75 engine while the Orenda Iroquois was in development. According Palmiro Campagna author of *The Avro Arrow: For the Record*,

Five Arrows flew by the end of 1958 and early 1959, achieving some 95 percent of the designed flight envelopes. On its third flight, [an] Arrow went supersonic at Mach 1.1, at 40,000 feet…on its seventh flight, using Pratt and Whitney J-75 engines, not the more powerful [and lighter weight Canadian designed] Iroquois engines specifically [built] for [the Arrow], it achieved Mach 1.52 at 50,000 feet, while still accelerating and climbing, with excess thrust available.[18]

Clearly the Arrow with an interim power plant like the J-75 engine could achieve all the designers promised, but the "Holy Grail" of merging the Arrow airframe with the Iroquois engine still lay ahead.[19]

RCAF CL–52 X059 during a test flight with the Iroquois engine mounted. ***(Photo courtesy of the Office of Royal Canadian Air Force History and Heritage.)***

Orenda's Iroquois

The Arrow's powerplant, the P.S. 13 Iroquois engine, was developed in coordination with the Arrow airframe by Avro Canada's Orenda subsidiary also located at a multi-million-dollar facility in Malton, Ontario (today the home of Toronto's Pearson International Airport). The Arrow's engine requirements were for a high performance, axial flow, two-spool turbojet engine with an integral afterburner, and was specifically designed for operations under supersonic flight conditions.[20] In order to provide the new interceptor with the required maximum performance of 6-minutes from a runway standing start to reach Mach 1.5 at 50,000 feet, the engine would need to have a thrust-to-weight ratio of better than 5:1 and to produce a sea-level dry thrust of 20,000 pounds or 25,000 pounds with afterburner.[21] The Iroquois weighed only 4,680 pounds, a remarkable achievement when compared to the 5,960 pound J-75 which was nearly 1,280 pounds heavier and produced about the same thrust weights.[22] This cost savings in weight was due in part to Orenda's innovative use of titanium on many components (approximately 60% of the basic engine), rather than steel, saving as much as 20% on engine weight.[23] This thus allowing the Arrow to achieve the climb speeds needed for a high-altitude interceptor aircraft.[24]

The Orenda team spent a considerable amount of time and resources evaluating the engine at the Malton plant, which put the engine development program over budget and behind schedule from the Arrow airframe development.[25] Ground tests for the Iroquois were a noisy and labor-intensive procedure that took place inside a special sound-proof chamber with the engines firmly bolted to struts embedded in the floor.[26] According to an engine production team member, when first tested the powerful engine nearly pulled the whole test stand out of its mounting sockets.[27] The testing proved successful and after four years of development, by 1957 nine of the originally planned nineteen Iroquois engines had been completed, with nearly 1,400 hours of development running on six of

The RCAF CL–52 X059 during ground tests of the Orenda Iroquois engine . ***(Photo courtesy of the Office of Royal Canadian Air Force History and Heritage.)***

the engines accumulated.[28] A special unveiling of one of the new engines was held on July 22, 1957 at the Orenda Engine factory, with federal, provincial, and municipal civilian and military leaders (many from other NATO nations) in attendance including the RCAF Chief of Staff Air Marshal C. R. Slemon, Canada's Minister of Defense George R. Pearkes, and Orenda Engines Limited President and General Manager Walter R. McLachlan.[29]

Still, for all the success Orenda engineers were having with the ground tests, high-altitude performance evaluations were necessary to prove the reliability of the new engine. In 1957 Orenda began conducting altitude performance investigations at the US National Advisory Committee for Aeronautics (NACA) supersonic wind tunnel facility in Cleveland, Ohio, with additional cold weather tests held at the Canadian National Research Council laboratories in Ottawa.[30] The success of the Iroquois' NACA engine tests led to the next phase of development, which required the engine be mounted on an airborne test platform and given the size of the engine, the Orenda engineers faced a challenge finding a suitable aircraft mount for testing. To meet the demands of an airborne platform capable handling both an extra engine of the Iroquois size and the power that the engine produced, Orenda engineers solved this problem by using an aircraft from outside the Canada and the Commonwealth and turned to the USAF for help.[31]

A Mount for the Iroquois

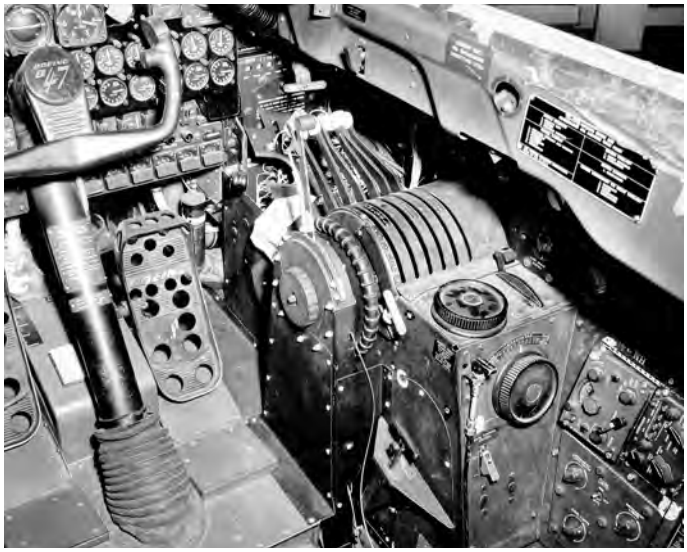
The mount chosen to flight test Orenda's Iroquois engine, the USAF's Boeing B–47 Stratojet bomber, seems like an unusual choice for a Canadian company with strong ties to the parent United Kingdom based Avro Limited, the same company that was building the Type 698 Vulcan bomber. But when viewed from a purely engineering perspective, the USAF's primary strategic jet bomber was the best choice to meet the company's needs. First, Orenda's then current airborne engine test platform was a war-surplus Avro Lancaster Mk 10O (Tail #FM209) which served as the testbed for the Orenda 11 engines used in the CF–100.[32] With the increase in altitude, speed, and thrust of the proposed P.S. 13 engine, a stronger platform, different from the venerable Lancaster was needed. Additionally, by 1956, the USAF had stopped buying the B–47 and was replacing them with the B–52 Stratofortress, meaning 2000 B–47's would soon be available for other duties.[33]

Orenda engineer's specific choice of the B–47 as the Iroquois engines flying test platform was based on six design factors. It had to be immediately available, reliable, big enough to carry the necessary measuring equipment, with a speed approaching that of sound, capable of climbing to 45,000 feet with sufficient structural strength to take the high thrust of the Iroquois, and with sufficient air resistance to take the engine's high power output without entering dangerous speed ranges.[34] Orenda engineers studied eleven other US and British aircraft (like the Avro Vulcan and Boeing B–50) before tentatively deciding on the B–47.[35] With approval from the US and Canadian governments, on February 19, 1956, the Orenda team went first to the Boeing Airplane Company headquarters in Seattle, Washington, then to the Boeing B–47 production plant in Wichita, Kansas to discuss with the B–47 designers and engineers the Orenda team's assumptions of the aircraft test role.[36]

The Boeing and Orenda engineers then met to consider methods of mounting the Iroquois for testing. The usual practice of mounting the test engine beneath a wing or above or below a fuselage, often so the test pilot could retract the engine when it was not operating, was impossible on the B–47 due to the tandem undercarriage installed in that area.[37] The B–47 wings were calculated to have sufficient strength to absorb the power of the Iroquois engine if installed anywhere on the aircraft, although the Iroquois developed more thrust than four of the B–47s own engines.[38] The Orenda and Boeing engineers finally settled on mounting the Iroquois engine on a 29.4 foot x 6 foot pylon fasted to the starboard rear side of the B–47's fuselage beneath the horizontal stabilizer, with a 5 degree off set from the aircraft's pitch axis (which would later contribute to a noticeable yaw during the actual test flights).[39] This installation would require changes internally to airframe to compensate for the weight changes on the B–47s bicycle undercarriage, gave adequate clearance off the ground, was easily accessible for service, and provided the test engine with an almost undisturbed airflow.[40] Canadair Limited of Montreal, was contracted by Orenda to begin the detailed engineering for the conversion of a production model B–47 into the proposed flying test platform configuration.[41]

While the Boeing B–52 Stratofortress is the aircraft most associated with the Cold War and despite its iconic station, its success is owed much to its lessor known predecessor, the Boeing B–47 Stratojet. First proposed during the Second World War as a highspeed propeller driven aircraft, the B–47 morphed into the world's first six-engine, swept winged, medium jet bomber that dominated the Strategic Air Command's (SACs) fleet for over a decade with over two thousand built between 1947 and 1956.[42] While SAC relied heavy on the B–47 in the transition period from the hybrid Piston/Turbojet B–36 Peacemaker to

Avro Arrow 201 during a test flight with the US designed Pratt and Whitney J-75 engine while the Orenda Iroquois was in development. ***(Photo courtesy of the Edenvale Aviation Heritage Foundation Museum.)***



The CL–52 Cockpit-Throttle quadrant with Iroquois throttle lever on the far left of the quadrant. ***(Photo courtesy of the Office of Royal Canadian Air Force History and Heritage.)***

the all turbojet B–52, the B–47 was never popular with SAC's Commander, General Curtis LeMay.[43] LeMay despised the B–47 due to its inadequate range, myriad of technical shortcomings, and inability to fulfill its mission. Over time, LeMay grudgingly accepted the B–47 as an interim solution pending delivery of the B–52 in the late 1950s.

TB–47B #51-2059 to CL–52 #X059

B–47A tail #51-2059, which became the only aircraft powered by the Orenda Iroquois engine, began its life as Production Model 450-11-10/Construction 4500112, with a rollout date at the Boeing Wichita, Kansas plant on November 20, 1951 and its first flight date on May 12, 1952.[44] The USAF Material Inspection Report date (the day the aircraft became US Government property) was June 18, 1952 and the aircraft left the plant for its future SAC assignment on June 30, 1952.[45] Tail #51-2059's first assignment with SAC was on December 10, 1953, after processing through the USAF's Air Material Command (AMC), Tinker Air Force Base (AFB), with the 3540th Flying Training Wing (later redesignated the 4240th Flying Training Wing) at Pinecastle AFB, Orlando, Florida, serving as a training aircraft for personnel flying the B–47A model in bomber units.[46] Later the aircraft was transferred to the 321st Bombardment Wing, 813th Air Division, also at Pinecastle AFB to serve in an operational nuclear deterrent role on 27 May 1954.[47]

The 321st Bombardment Wing began as the 321st Bombardment Group (Medium) on June 19, 1942 and activated on June 26, 1942. Prepared for overseas duty with B–25 Mitchell bombers, the unit moved to the Mediterranean theater and served with the 12th Air Force from January 1943 to April 1945 in North Africa, Sicily, and Italy, and finally deactivated on September 12, 1945.[48] Established as the 321st Bombardment Wing, Medium, on March 23, 1953 and reactivated on December 15, 1953, at Pinecastle AFB, the newly formed 321st absorbed the resources of the 4042nd Flying Training Wing in late 1954, thus acquiring its B–47As and KC-97s. The Wing conducted bombing training and air refueling operations to meet SAC's global commitments from 1954 - 1961.[49] Once transferred to the 321st Bombardment Wing, tail #51-2059 was assigned to the 446th Bombardment Squadron where the aircraft served as a SAC alert bomber until it was sent back to Boeing on July 14, 1955, as part of the USAF's *Ebb Tide* modification program converting B–47As to TB–47B training models.[50]

The *Ebb Tide* TB–47B models (tail #49-2642 thru #51-2091) lacked weapons and air-to-air refueling capability, but now included a fourth seat in the cockpit for an instructor used for pilot and navigator training, internal bomb bay tanks, and a solid nose with a bomb site perturbance; these modified aircraft were designed to turn out B–47 trained pilots and navigators as quickly as possible.[51] It was during this time, due to US aircraft manufacturer and defense interest in the Arrow program, that the USAF agreed to loan tail #51-2059 to the RCAF as part of the Orenda Iroquois engine test while the aircraft was undergoing the *Ebb Tide* conversion at Boeing's Wichita plant.[52] While tail #51-2059 was modified to a TB–47B, air and ground crews from Canada were designated to fly the bomber during the Orenda engine tests. Avro Canada Chief Test Pilot T.P.M. "Mike" Cooper-Slipper, Test Pilot Leonard "Len" Hobbs (from the United Kingdom), and Flight Engineer Johnny McLaughlin became the first non-US citizens to fly the B–47, spending ten-weeks training under B–47 Instructor Pilot USAF Captain Mike "Slim" Drew at McConnell AFB, Kansas, where USAF SAC aircrew qualified; while the ground crews trained at the Boeing Plant, Wichita.[53] At McConnell AFB, the Anglo-Canadian airmen earned the admiration of their SAC counterparts, especially when word got around the McConnell AFB Officers Club as to the reason why Cooper-Slipper, Hobbs and McLaughlin were attending the B–47 transition course. Said one USAF pilot from Texas, "Do you mean, that you little old Canadians have got the biggest jet engine in the world? And you are going to put it in the tail of the B–47? Man, you're crazier than we are."[54]

Avro Arrow Test Pilot T. P. M. "Mike" Cooper-Slipper at the controls of the CL–52. ***(Photo courtesy of the Canadian Warplane Heritage Museum.)***

During the Anglo-Canadian team's stay in Kansas, in what was a public relations coup for Avro Canada, the US and Canadian governments allowed *MacLean's* magazine reporter June Callwood to report on the Arrow Development and fly with Cooper-Slipper, Hobbs, and McLaughlin in a B–47 during their check-out at McConnel AFB.[55]

After their B–47 check out in Wichita, Cooper-Slipper, Hobbs, and McLaughlin returned to Canada and USAF Colonel Robert E. Lee and Major Jay Brown delivered tail #51-2059 to the Canadair Plant at Cartierville Airport, Quebec, on February 16, 1956.[56] Over the following 14-months, Canadair engineers and mechanics would convert the TB–47B to a CL–52, tail #X059.[57] The modifications to the newly designated CL–52 included, besides the previously mentioned Orenda engine pylon, additional internal airframe structural stiffening, a dorsal fin extension for 100,000 feet of test wiring, an additional throttle for the Orenda engine, a removable test rack for monitoring instruments in the bomb bay, and two methyl bromide fire extinguishing systems (one for the engine and one for the test monitoring equipment).[58] To counterbalance the Iroquois engine and the pylon, 10,000 pounds of ballast was added to the front of the aircraft which comprised of two layers of canvas bags filled with lead shot and held in place with wooden planks.[59] Additionally, surface plating was added to the fuselage in case the Iroquois engine self-destructed.[60] With the modifications completed, and now sporting the distinctive RCAF Red Maple Leaf roundels on the fuselage and wings; RCAF tri-color fin flashes; and Orange painted bands and tail fin, the CL–52 (without an actual Iroquois engine in the pylon) with Cooper-Slipper, Hobbs (in the pilot and co-pilot positions), and McLaughlin (occupying a position in nose of the aircraft) at the controls departed from the Canadair Plant to the Malton Plant on April 15, 1957.[61]

The Iroquois Takes Flight

Of the planned original nineteen Iroquois powerplants (series X101 thru X118 and X121), engine X106 was selected for testing on the CL–52.[62] X113 and X114, designed

321st Bomb Group patch.

Avro Lancaster Mk 10O (Tail #FM209) which served as the testbed for the Orenda 11 engines used in the CF–100. ***(Photo courtesy of the Canadian Warplane Heritage Museum.)***

to incorporate the latest development changes and be capable of passing a 50-hour preliminary flight rating test at full power, were also slated for testing on the CL–52, these two engines were never completed before the Arrow program's cancellation.[63] Developmental changes to future engines would be based on ground, altitude tunnel, and CL–52 flight tests.[64] With modifications to the CL–52 complete, based on previous test flights with a dummy engine and X106 installed on the pylon, the first flight and start of an Iroquois engine aloft with the engine running for a total of 6-minutes at 77% power took place on November 13, 1957.[65] When the Iroquois was operating at a high-power setting, it was necessary for three of the CL–52's General Electric J-47 engines on the starboard side of the aircraft to be reduced to idle thrust, the #1 J-47 on the port side operated at full throttle to countermand the yaw induced by the Iroquois, another port side J-47 was kept running at low power to keep the aircraft hydraulic systems operating, and the third port side engine was kept at idle.[66] While flight tests proceeded well, there were a few minor problems with the Iroquois and the CL–52.

On one occasion, there was an explosion in flight about 50-miles north of Malton, near Barrie, Ontario on March 26, 1958.[67] The problem began when the CL–52 started to climb with full Iroquois power on, this was the only recorded occasion that the Iroquois was put to full throttle while in flight test.[68] As the Iroquois was operated at full afterburner it threw turbine blades, caught fire, and caused extensive damage to the engine's nacelle and horizontal stabilizer.[69] The first indication to the aircrew of a problem was an enormous bang and the whole aircraft shook, followed by a deadly silence.[70] The pilot/co-pilot positions were a long way from the Iroquois but dust flew up in the cockpit.[71] The Iroquois was immediately shut down and its fire extinguisher activated.[72] The vibrations diminished as the engine came to a stop.[73] A CF–100 chase plane, which was following the CL–52, flew up to the right side of the aircraft and the chase pilot noted lots of smoke, but no fire.[74] Upon landing at Malton, a second fire occurred in the engine, which was quickly put out by the airfield's fire department. After an inspection by the Orenda engineers, it was determined that an engine blade had failed and broken into pieces.[75] The damage to the aircraft and engine resulted in a redesign of the powerplant and a general beefing up of the CL–52 structure with "chain mail" sheeting paced inside the nacelle.[76] These changes allowed the Iroquois to obtain a total of 31 flight hours on the CL–52 before the Arrow program was cancelled.[77]

The performance of the Iroquois during the CL–52 airborne tests completely justified the faith of those who put the project in motion, albeit with some "unserviceability arising from common or garden mechanical faults, many of which had been experienced long before on the test bed".[78] It should be noted that only today are jet engines routinely achieving the same thrust and performance as the Iroquois did in the late 1950s.[79] There were plans for future Iroquois engine tests until 1960 that would have increased the rated thrust by nearly 34%, possibly making the Iroquois suitable for a fighter, bomber, cruise missile, and possibly a civilian jet airliner.[80] Finally, Orenda's future tests in their high altitude facilities were scheduled to push the Iroquois performance at speeds of Mach 3 at 100,000 feet.[81] But while the Arrow and Iroquois programs were proving the reality of a Canadian built high-speed/high-altitude interceptor, military and political changes were coming. First, the Soviet Union launched the world's first artificial satellite into earth's orbit in 1957, signaling that the USSR was leading the race in terms of intercontinental ballistic missiles. Second, because of this, there was a perceived diminished bomber threat. Third,

Iroquois Engine mock-up prior to mounting on the CL–52 at the Canadair Plant, Cartierville, Quebec, Canada. ***(Photo courtesy of the Office of Royal Canadian Air Force History and Heritage.)***

CL–52 Model during wind tunnel test in 1956 at the Canadair Plant. ***(Photo courtesy of Bill Upton.)***

Progressive-Conservative John Diefenbaker, who eventually cancelled the Arrow program, was elected Prime Minister in June of 1957 and again in 1958.

"Black Friday"

The Avro Arrow had "as a weapons system…become virtually obsolescent" in the minds of many Canadian officials just after the aircraft was displayed for the first time at the Malton Plant on October 4, 1957.[82] This line of thinking was all due to the 184-pound Sputnik 1 passively orbiting 139 miles above the earth challenging the purpose of the 57,000-pound innovative interceptor. Launched on the same day as the Arrow inauguration, the Soviet's Sputnik 1 suddenly forced western defense planners to reassess their assumptions, creating a perceived "Missile Gap" that now replaced the so-called "Bomber Gap". If the Soviets could launch a rocket with a satellite, why could they not do the same with a nuclear weapon? Canadian leaders looked at missile interceptors like Boeing's CIM-10 Bomarc nuclear armed surface-to-air missiles to deal with the perceived challenges of a reduced manned bomber threat, in lieu of continuing with the Arrow program. The latter it was now assumed was an "outmoded weapon."[83] These missile interceptors, which were "state-of-the-art" for the late 1950's, were cheaper to produce than manned aircraft interceptors like the Arrow.

Due to the Canadian Military and Civil government's public reassessment of Canada's manned interceptor aircraft needs following the launch of Sputnik, Avro Canada's Arrow cost in the face of a diminished manned bomber threat and during an economic recession, Canada's Army and Navy Chiefs needs to modernize their own Post-Second World War forces with potential funding available if Arrow was cancelled, and the possibility of a joint informal agreement between Canada and the US to "share in the productions of defense items of mutual interest", the Prime Minister formally cancelled the CF–105 program on Friday, February 20, 1959.[84] Known as "Black Friday" to many in the Canadian aerospace industry, the cancellation decision had the immediate impact of laying off 14,000 Avro Canada workers, with an additional 25,000 subcontractors also losing their jobs.[85] In addition to shutting down the Arrow production line, which had already produced six aircraft and three more still on the Malton assembly line, all completed, and nearly assembled aircraft were ordered by the Canadian government to be scrapped or destroyed along with all engines, drawings, jigs, and tools.[86]

Captain Brian Jones, a 36-year retired veteran of Air Canada with experience flying bush planes to Airbus 340 airliners and a Canadian Warplane Heritage Museum docent, vividly remembers "Black Friday" and the impact it had on his father, the late Captain Gordon E. Jones. The elder Jones, an RCAF C-47 Pilot who flew missions during 1944's *Operation Market Garden*, was then currently employed with Trans Canada Airlines (later renamed Air Canada). Brian recalls,

I was 11-years old and sitting in our kitchen eating breakfast before school listening to Montreal radio station, CJAD, on a small plastic radio. As announcer Bill Roberts read the 8:00 AM news, my father [Gordon] came downstairs and heard Roberts announce that Prime Minister Diefenbaker had just canceled the Arrow program and 14,000 Canadian workers would be laid off. My father, a levelheaded man, was so angry at the news, he smashed the radio on the kitchen floor, announcing "He [my father] would never vote for the Progressive Conservatives again!"[87]

Broken Men and Mounts

Prime Minister Diefenbaker's decision to cancel the Arrow program and buy the nuclear-armed Bomarc missile would eventually lead to his parliamentary government falling, with Canadians deciding the Progressive-Conservative party had mishandled the entire issue, electing the

The CL–52 X059 with Arrow 201 at the Malton Plant, Ontario, Canada. ***(Photo courtesy of the Office of Royal Canadian Air Force History and Heritage.)***

Liberal Lester B. Pearson Prime Minister on April 8, 1963.[88] Additionally, while costing less than the Arrows, Bomarc missiles would eventually prove to be an operational failure and the limited threat of Soviet bombers to Canada and the US remained.[89] As a result of this reality, in 1961 the Canada government was forced to buy sixty-six of the McDonnell Aircraft Corporation's F–101B Voodoo (renamed the CF–101B) all-weather interceptor to fill the gap created by the cancellation of the Arrow program and the failure of Bomarc.[90]

Another impact of the project cancellation was the eventual financial failure of Avro Canada, which depended heavily on Canadian government contracts since the Second World War. In July 1962, Avro Canada Limited was dissolved by Hawker Siddeley Aviation in Britain and what at one time had been the third-largest company in Canada ceased to exit.[91] Avro Canada President and General Manager Crawford Gordon left Canada a broken man and never returned, dying nearly bankrupt in New York City in 1967.[92] Sir Roy Dobson would continue as a leader in the aviation industry until his death in 1968.[93]

Following Prime Minister Diefenbaker's cancellation of the Arrow program, Avro Aircraft's leadership directed Cooper-Slipper and his crew to return the CL–52 (now once again TB–47B tail #51-2059), with the test pylon and Iroquois engine removed, to the USAF's AMC at Tinker AFB on May 28, 1959.[94] The following day, in a fate similar to the Avro Arrows and as a result of both Canadair Limited extensive airframe modifications and the Orenda Iroquois engine's thrust on the right side of the TB–47B that deformed the airframe, the USAF decided to scrap the aircraft.[95] AMC elected to transfer the aircraft to the Arizona Aircraft Storage Branch, Davis-Monthan AFB, near Tucson, Arizona where the Iroquois' last mount was broken up and melted down for metal ingots on August 12, 1959.[96] The last USAF B–47 bomber was retired at the end of 1969 (with two US Navy EB–47E finally retiring in 1977), and the entire fleet was dismantled at Davis-Monthan AFB except for about 30 Stratojets which were saved for display at air museums around the United States.[97]

Today, little remains of the original Avro Arrows except for the forward cockpit of aircraft RL-206, an ejection seat, two wing panels, landing gear, some blueprints, and photographs in places like the Canadian Air and Space Museum, Ottawa. Two Arrow replicas were eventually built by Arrow enthusiasts, one of the most detailed is aircraft RL-203 at the Edenvale Aviation Heritage Foundation Museum in Stayner, Ontario. Three Iroquois engines of the ones completed survive today.[98] Engine X106 used on the CL–52 and the only one that ever flew, is located at the Canadian Warplane Heritage Museum, Hamilton, Ontario.[99] The impact of the Arrow program, and the cooperation given by the USAF, demonstrates how combined international aerospace development can push the envelope of aircraft and engine development. Finally, the Arrow-Iroquois technology lived on in America's warplane and space program development. Following the cancellation decision, twenty-five ex-Avro engineers found work with NASA in the 1960s developing the successful Mercury, Gemini, and Apollo Space programs.[100] ■

NOTES

1. According to the 1956 A. V. Roe Canada Limited Stock Prospectus, "[Avro Canada] was incorporated under the laws of Canada on September 1, 1945, as a wholly owned subsidiary of the Hawker Siddeley Group Limited, the largest aircraft organization in the British Commonwealth and a major producer of aero engines, diesel engines, motor cars and other industrial products. The [Avro Canada] company sought to establish in Canada a self-sufficient enterprise based on Canadian resources and personnel, capable of undertaking original aeronautical research and design." *500,000 Shares, A. V. Roe Canada Limited, Common Shares without Nominal or Par Value*. (Toronto: Wood, Gundy & Company, September 28, 1956), 1, Canadian Warplane Heritage Museum, Hamilton, CN.

2. The CF-105 Arrow was not the first organic fighter designed and built in Canada. In 1938, Canada Car & Foundry Limited produced the Gregor FDB-1 biplane fighter. Like the Arrow nineteen years later, the FDB-1 was overcome by strategic and technological changes and the Canadian government terminated the program. Graham Chandler, "Cancelled: The Gregor FDB-1," Smithsonian *Air and Space Magazine, September 2014*. https://www.smithsonianmag.com/air-space-magazine/cancelled-gregor-fdb-1-180952402/ (accessed, October 11, 2022).

3. Randall Whitcomb, *Cold War Tech War. The Politics of America's Air Defense.* (Burlington, Ontario: Apogee Books, 2008), 61.

4. In the 1950s, US and Canadian defense planners depended on a three-layered air control and warning system consisting of the Distant Early Warning (DEW) line located north of the Arctic Circle from Baffin Island west to Alaska, the Mid-Canada line which ran from Newfoundland and Labrador west to British Columbia, and the Pine Tree Line which ran from the Gulf of Saint Lawrence west along the 50th parallel to the Pacific Ocean. Lloyd H. Cornett and Mildred W. Johnson, *A Handbook of Aerospace Defense Organization, 1946 – 1986.* (Peterson Air Force Base, Colorado: Office of History, Air Force Space Command, 2015), 7; Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents.* (Toronto: James Lorimer & Company Limited, Publishers, 2014), 10.

5. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*. (Erin, Ontario: Reprint, Boston Mills Press, [1980] 1998), 133.

6. Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents,* 5.

7. Soviet Second World War era bombers, including the Tu-4 Bull (a copy of the Boeing B-29 Superfortress), did not have the range from Russia for a round trip to reach targets in the West. It was not until the development of aircraft like the Tu-95 Bear, with speeds approaching 600 mph and a range of 9320 miles, did western leaders believe the need for faster and higher-flying interceptors to deal with these new threats was necessary. *Ibid*, 9-10; Sherman Kent, *Memorandum for the Intelligence Advisory Committee, SUBJECT: Validity of Heavy Bomber Estimate in NIE 11-4-57*. (Washington, D.C.: Central Intelligence Agency, April 11, 1958), 1-3.

8. Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents,* 36.

9. James Dow. *The Arrow*. (Toronto: James Lorimer & Company Limited, Publishers, 1997), 86.

10. *Design Study of Supersonic All Weather Interceptor Aircraft In Accordance with RCAF Spec. AIR-7-3, Report No. P/C-105/1, May 1953.* (Malton, Canada: A.V. Roe Canada Limited, May 1953), 1, https://nrc-digital-repository.canada.ca/eng/view/ft/ ?id= 9a63e8b4-6dd5-442a-b78f-16aeedb947fd (accessed, September 20, 2022).

11. Avro Canada's experience building aircraft began in November 1942 when the Canadian Government acquired the National Steel Car Company plant in Malton, Ontario to build Avro Lancaster bombers, Lysander Army Cooperation aircraft, and Anson twin-engine training aircraft for the RAF and RCAF, changing the name of the company to Victory Aircraft Limited. As part of the post-war changes in the Canadian aviation industry, the company's leadership placed a greater emphasis on both commercial and well as military aviation programs. As a result of these change, on December 1, 1945, Victory Aircraft Limited became A. V. Roe Canada Limited. Palmiro Campagna. *The Avro Arrow: For the Record*. (Toronto: Dundurn, 2019), 15.

12. *CF-105 Supersonic All-Weather Fighter: U.S.A.F. Presentation, August 1954.* (Malton, Ontario: A. V. Roe Canada Limited, August 1954), 3, Canadian Warplane Heritage Museum, Hamilton, Ontario.

13. Before the program was cancelled, the RCAF was considering the nuclear-tipped AIR-2A Genie rocket as potential armament for the CF-105 Mark 2 aircraft. This massive rocket, equipped with a 1.5 kiloton warhead, would have required a considerable redesign of the weapons bay and only two rockets could be carried. T.F.J. Leversedge, "Avro Canada CF-105 Arrow, RCAF Serial 25205 (Nose Sections and Components," *Canada Aviation and Space Museum Aircraft,* n.d., https://documents.techno-science.ca/documents/CASM-Aircrafthistories-AvroCanadaCF-105Arrownose.pdf (accessed November 2, 2022), 31; *Arrow 2: Twin Engine Supersonic All-Weather Fighter, Standard Aircraft Characteristics, Issue 2, March 1958*. (Malton, Ontario: Avro Aircraft Limited, March 1958) n.p.; Richard Organ, Ron Page, Don Watson, and Les Wilkinson. *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 137.

14. James Dow, *The Arrow*, 88-89.

15. Fred Smye, *Canadian Aviation, and the Avro Arrow*. (Oakville, Ontario: Randy Smye, 1985), 74-75.

16. "Business Trends: A.V. Roe Management." *Canadian Aviation*, *January 1958.* (Toronto: McLean-Hunter Publishing Company Limited, January 1958), 3; Palmiro Campagna, *The Avro Arrow: For the Record*, 21.

17. The Cook-Craigie production model, developed in the US during the Second World War, reduced the time needed to bring a new aircraft design into service. Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents,* 52.

18. The CF-105 Arrow's fastest recorded speeds in were Mach 1.90 in level flight and Mach 1.95 in a dive. *Ibid*, 21.

19. The Avro Arrow's closest western hemispheric rival on the drawing board was the North American XF—108 Rapier. The company's engineers designed the Rapier as an extremely high speed (Mach 3) interceptor and escort fighter for the B-70 Valkyrie bomber under development at the same time. The delta wing Rapier, in its pre-mockup phase, was to have a canard (forward-mounted pitch-control surface) and three vertical stabilizers: one on the fuselage centerline and a pair at the halfway point on the wing trailing edge for high-speed stabilization at speeds above Mach 2. Like the Arrow's fate, The XF-108 program was canceled by the US Government on Sept. 23, 1959, but never getting past the mockup phase. "North American F-108 Factsheet," *National Museum of the US Air Force,* n.d., https://web. archive.org/web/20141228184033/http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=2319 (accessed September 5, 2022).

20. *Iroquois 2 System Data, October 1958, B21-58.* (Malton, Ontario: Orenda Engines Limited, October 1958), 1, Ingenium, Canada Aviation and Space Museum Archives, Ottawa, CN.

21. "Comparison of Large Turbojet Engines," *CF-105 Development Programme, Iroquois Gas Turbine Development Programme.* (Malton, Ontario: Orenda Engines Limited, 1956), n.p., Ingenium, Canada Aviation and Space Museum Archives, Ottawa, CN.

22. For comparison, the heavier Pratt and Whitney J-75 engine could produce 16,800 pounds at sea-level dry thrust and 26,000 pounds with afterburner. "Comparison of Large Turbojet Engines," *CF-105 Development Programme, Iroquois Gas Turbine Development Programme,* n.p.

23. Victor Koby, "Orenda to fly its Power Giant," *Canadian Aviation*, *April 1956*. (Toronto: McLean-Hunter Publishing Company

Limited, April 1956), 33.
24. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 123.
25. June Callwood, "The Day the Iroquois Flew," *MacLean's: Canada's National Magazine*, *February 1, 1958*. (Toronto: MacLean-Hunter Publishing Company Limited, February 1, 1958), 11.
26. The Iroquois engine design team did additional testing at another Orenda plant at Nobel, Ontario. Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents,* 47.
27. *Ibid*, 46.
28. *CF-105 Development Programme, Iroquois Gas Turbine Development Programme.* (Malton, Ontario: Orenda Engines Limited, 1956), 1, Ingenium, Canada Aviation and Space Museum Archives, Ottawa, CN.
29. Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents,* 56.
30. *CF-105 Development Programme, Iroquois Gas Turbine Development Programme,* 1.
31. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 125.
32. W.E. "Ted" Jones, "The Big Trust," *New Horizons, Winter 1956-7.* (Toronto: Avro Canada Limited, 1957), 21, Ingenium, Canada Aviation and Space Museum Archives, Ottawa, CN.
33. June Callwood, "The Day the Iroquois Flew," *MacLean's: Canada's National Magazine*, *February 1, 1958*, 13.
34. W.E. "Ted" Jones, "The Big Thrust," *New Horizons, Winter 1956-7*, 21.
35. *Ibid*, 21.
36. As a result of this agreement between the USAF and RCAF, Canada became the only country outside of the United States to operate the B-47 aircraft. There was discussion between the Australian and United States governments in 1963 to loan 24 B-47s to the Royal Australian Air Force (RAAF) as a stopgap measure until the RAAF's General Dynamic's F-111 Fighter Bombers were brought into service in 1968. This loan proposal was never accepted by the Australian government. *Ibid*; C. Mike Habermehl and Robert S. Hopkins III, *Boeing B-47 Stratojet: Strategic Air Command's Transitional Bomber*. (Manchester, UK: Crecy Publishing Limited, 2018), 239.
37. Finding suitable and reliable airborne test platforms for prototype aircraft engines was not a new challenge. The German Luftwaffe, for example, used the twin-tailed Dornier 17 bomber as a test bed for early ram jet engines, with the test engine mounted on struts above the bomber fuselage, allowing the exhaust to pass between the bomber's twin tail configuration. "WWII Lorin Ramjet Experiments," *Engine History*, 2022. http://enginehistory.org/Rockets/LorinRamjet/LorinRamjet.shtml (accessed September 9, 2022); W.E. "Ted" Jones, "The Big Thrust," *New Horizons, Winter 1956-7*, 21.
38. *Ibid*, 21.
39. *Ibid*, 22; C. Mike Habermehl and Robert S. Hopkins III, *Boeing B-47 Stratojet: Strategic Air Command's Transitional Bomber*. (Manchester, UK: Crecy Publishing Limited, 2018), 84.
40. *Ibid*.
41. *Ibid*
42. C. Mike Habermehl and Robert S. Hopkins III, *Boeing B-47 Stratojet: Strategic Air Command's Transitional Bomber,* 247, 273.
43. Paramount Studio's 1955 *Strategic Air Command*, starting Jimmy Stewart, June Allison, and Frank Lovejoy (the latter playing a very thinly disguised version of General LeMay) portrayed a "Hollywood" version of this transition period. "Strategic Air Command," *Turner Classic Movies*, 2022. https://www.tcm.com/tcmdb/title/4246/strategic-air-command#overview (accessed September 8, 2022).
44. The B-47 was built at the government-owned Boeing Plant II at Wichita, Kansas, since the Seattle plants were all committed to the manufacture of B-50 and C-97 aircraft, and the conversion of obsolescent B-29s to tankers. C. Mike Habermehl and Robert S. Hopkins III, *Boeing B-47 Stratojet: Strategic Air Command's Transitional Bomber,* 248.
45. *Individual Aircraft Record Card, Type Model B-47B, A.A.F. Serial Number 51-2059, Contract Number AF 21-407*. (Washington, D.C.: US Government Printing Office, n.d.), 1, U.S. Air Force Historical Archives, Maxwell AFB, AL.
46. Pinecastle AFB (renamed McCoy AFB on May 7, 1958) closed in 1975 and became what is known today as Orlando International Airport. "Airport Profile 2015 by the Numbers, Orlando International Airport," *Florida Department of Transportation*. https://www.florida-aviation-database.com/library/filedownload.aspx?guid=873b1bbd-7c98-4f57-8178-d72a7cda260c (accessed September 8, 2022), 1; *Individual Aircraft Record Card, Type Model B-47B, A.A.F. Serial Number 51-2059, Contract Number AF 21-407*, 1.
47. *Individual Aircraft Record Card, Type Model B-47B, A.A.F. Serial Number 51-2059, Contract Number AF 21-407*, 2.
48. "321st Bombardment Group," *Army Air Corps Library and Museum*. https://www.armyaircorpsmuseum.org/321st_Bombardment_Group.cfm (accessed September 9, 2022).
49. "321st Bombardment Wing," *Strategic Air Command.Com*, 2003. http://www.strategic-air-command.com/wings/0321bw.htm (accessed September 9, 2022).
50. "Flying and Periodic Maintenance Schedule," *History of the 321st Bombardment Wing (M) (SAC), Pinecastle Air Force Base, Orlando, Florida, July 1955.* (Pinecastle AFB, Florida: 321st Bombardment Wing, July 1955), n.p., U.S. Air Force Historical Archives, Maxwell AFB, AL.
51. *T. O. 1B-47B-1, Flight Handbook: USAF Series TB-47B Aircraft.* (Saint Louis, MO: Universal Printing Company, August 31, 1956), iv, 10.
52. C. Mike Habermehl and Robert S. Hopkins III, *Boeing B-47 Stratojet: Strategic Air Command's Transitional Bomber,* 196.
53. Avro Canada's Test Pilots were both veterans of the Second World War. T.P.M. "Mike" Cooper-Slipper was a former RAF fighter pilot who received a Distinguished Flying Cross during the Battle of Britain for ramming a German Do 17 Bomber and for a short while was a POW with the Japanese following the Fall of Singapore. Len Hobbs, a former RAF bomber pilot, flew combat missions in B-24s in the western Pacific. June Callwood, "The Day the Iroquois Flew," *MacLean's: Canada's National Magazine*, *February 1, 1958*, 13.
54. *Ibid*.
55. "Writer Joins Crew," *The Wichita Beacon, November 14, 1958*. (Wichita, Kansas, The Wichita Beacon, November 14, 1958), 7.
56. "B-47 Arrival Heralds New Stage In Orenda Design, Development," *The Orenda*, Volume. 2, Number 4., February 24, 1956 (Malton, Canada: Orenda Engines Limited, February 24, 1956), 1, Ingenium, Canada Aviation and Space Museum Archives, Ottawa, CN.
57. While in possession of Avro Canada, the TB-47B was redesignated CL-52 by Canadair Limited and the aircraft operated with the Canadian aircraft registration X059. Had the Boeing bomber been fully integrated into the RCAF inventory, it would have received the Canadian military designation CB-47 (B for Bomber). C. Mike Habermehl and Robert S. Hopkins III, *Boeing B-47 Stratojet: Strategic Air Command's Transitional Bomber,* 196; Fred Paradie, RCAF Historian. Email to the author, Office of Royal Canadian Air Force History and Heritage, July 16, 2022.
58. *Ibid*.
59. *Ibid*, 196-197.
60. *Ibid*.
61. The departure was a one-time deal as the Canadair plant's runway left little room to abort a takeoff. Fortunately, the lift-off was uneventful, unlike the landing at Malton, where the aircrew discovered the new pylon created additional lift, thereby dramatically changing the aircraft landing characteristics when in ground effect. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 127.

62. Palmiro Campagna, *The Avro Arrow: For the Record*, 246; "Part 1, Scope of Work," *SE 10-58-4, Statement of Work Iroquois Program for The Arrow Weapons System, Issue 4.* (Malton, Canada: Orenda Engines Limited, January 27, 1959), n.p., Ingenium, Canada Aviation and Space Museum Archives, Ottawa, CN; P.Y. Davoud, Vice President Sales and Service, Avro Aircraft Limited, "Iroquois Compressor Designed Standard," Letter to Group Captain H.R. Foottit, Assistant for Arrow Weapons Systems, December 8, 1958, 1-2, National Archives Canada, Ottawa, CN.
63. "Part 1, Scope of Work," *SE 10-58-4, Statement of Work Iroquois Program for The Arrow Weapons System, Issue*, n.p.
64. *Ibid*, n.p.
65. During this time engine X106 was designated model "A" and later "B" following post-flight modifications. W. E. Jones, *Flight Test Report – 65, Iroquois 106/6A and B Flight Testing and Ground Running while installed in B-47 Test Vehicle,* (Malton, Canada: Orenda Engines Limited, March 18, 1958), 5.
66. It was not possible for the CL-52 to fly with all seven engines at full power. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 131.
67. *Ibid*, 127; News article, n.p., March 28, 1958, Avro Arrow Museum, Calgary, CN.
68. *Ibid*.
69. C. Mike Habermehl and Robert S. Hopkins III, *Boeing B-47 Stratojet: Strategic Air Command's Transitional Bomber,* 197.
70. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 127.
71. *Ibid*, 127.
72. *Ibid*.
73. *Ibid*.
74. *Ibid*.
75. *Ibid*.
76. *Ibid*.
77. *Ibid*, 127, 131.
78. W. E. Jones, *Flight Test Report – 65, Iroquois 106/6A and B Flight Testing and Ground Running while installed in B-47 Test Vehicle*, 3; *Ibid*, 131.
79. *Ibid*.
80. *Ibid*; "Part 1, Scope of Work," *SE 10-58-4, Statement of Work Iroquois Program for The Arrow Weapons System, Issue 4,* n.p.
81. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 131.
82. Palmiro Campagna, *The Arrow: For the Record, October 6, 2020*, educational video, 1:08:27, https://www.youtube.com/watch?v=fdxum2OiBeQ.
83. Canadian Defense Minister George Pearkes stated during an August 4, 1958, meeting with US Secretary of Defense Neil McElroy, "Notwithstanding the political difficulties, the Canadian Government might decide to scrap the CF-105 program and perhaps turn to missiles. It would be better to take the loss than to tie up a large part of the [Canadian] defense budget for the next five years making an outmoded weapon." Although the following day, August 5, 1958, Pearkes seemed to have second thoughts about "closing down the CF-105 production." Palmiro Campagna, *The Avro Arrow: For the Record – Update USA 2021*, July 29, 2021., educational video, 37:19, https://www.youtube.com/watch?v=ulC Tf-KJ2Eo.
84. In recommending cancellation of the Arrow, the Chiefs of Staff stated in a February 6, 1959 Top Secret memo to Cabinet that "[The Chiefs of Staff] are still of the opinion that the changing threat and rapid advances in technology, particularly in the missile field, along with the diminishing requirements for manned interceptors in Canada create grave doubts as to whether a limited number of aircraft of such extreme high cost would provide defense returns commensurate with the expenditures." Palmiro Campagna, *The Avro Arrow: For the Record – Update USA 2021*, July 29, 2021; Fred Smye, *Canadian Aviation, and the Avro Arrow*. (Oakville, Ontario: Randy Smye, 1985), 75-76.
85. *Ibid*, 75; The number of subcontractors who lost their jobs is based on Diefenbaker's own cabinet documents, Palmiro Campagna, email to the author, October 30, 2022.
86. The Canadian government's decision to terminate and destroy all evidence of the Arrow program led to a variety of conspiracy theories ranging from the US Government's desire to eliminate Canadian aircraft competition (with some justification based on Palmiro Campagna's research) to a rumor that one Arrow, aircraft RL-202, was smuggled to the UK or hidden away at a secret location in Greenland. A likely explanation for the decision to destroy all Arrow aircraft and materials comes from a memorandum signed by the Canadian Chief of the Air Staff, Air Marshal Hugh Campbell, dated March 26, 1959, which states, "This course [of selling the aircraft as disposable property] could lead to subsequent embarrassment, that is… [the Arrow airframe] could be used as a public roadside stand [like a restaurant or car dealership]." Palmiro Campagna, *The Avro Arrow: For the Record*, 232; June Callwood, "Requiem for a Dream: A reporter remembers the glory days of the Arrow," *MacLeans: Canada's News Magazine,* January 13, 1997. (Toronto: MacLean-Hunter Publishing Company Limited, January 13, 1997), 56.
87. Brian Jones, Docent, Canadian Warplane Heritage Museum. Interview with the author, Canadian Warplane Heritage Museum, Mount Hope, Ontario, June 27, 2022.
88. "Bomarc Missile Crisis," *Parli: The Dictionary of Canadian Politics*, 2022. https://parli.ca/bomarc-missile-crisis/#:~:text=In%201958%2C%20a%20decision%20by,planes%20headed%20to%20North%20America. (accessed September 18, 2022); In a telegram from Prime Minister Diefenbaker to President Eisenhower, dated March 10, 1959, Diefenbaker stated, "[A] heavy tide of personal mail from all over Canada as showing far more bitterness towards the United States than he could previously recall, all in terms of the CF-105 decision." Palmiro Campagna, *The Avro Arrow: For the Record – Update USA 2021*, July 29, 2021.
89. Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents,* 98.
90. Fred Smye, *Canadian Aviation, and the Avro Arrow*. (Oakville, Ontario: Randy Smye, 1985), 93.
91. Palmiro Campagna, *The Avro Arrow: For the Record*, 149.
92. "Crawford Gordon Dies at 52; Ex-Head of A.V. Roe Canada; Director of Arrow Interceptor Program Resigned When Production Was Halted," *New York Times, January 28, 1967*. https://www.nytimes.com/1967/01/28/archives/crawford-gordon-dies-at-52-exhead-of-av-roe-canada-director-of.html (accessed September 20, 2022), 23.
93. "Sir Roy Dobson," *Flight International, 18 July 1968*. https://www.airfieldresearchgroup.org.uk/community/140282=15580-Sir%20Roy%20Dobson%20CBE.PDF. (accessed September 20, 2022), 83.
94. Richard Organ, Ron Page, Don Watson, and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow from its Evolution to its Extinction*, 131.
95. Lawrence Miller, *The Avro Arrow: The Story of the Great Canadian Cold War Combat Jet – In Pictures and Documents,* 76.
96 *Individual Aircraft Record Card, Type Model B-47B, A.A.F. Serial Number 51-2059, Contract Number AF 21-407*. (Washington, D.C.: US Government Printing Office, n.d.), 6, U.S. Air Force Historical Archives, Maxwell AFB, AL.
97. "Scrapping of the B-47 Stratojet Fleet," *Airplane Boneyards,* 2022. https://airplaneboneyards.com/davis-monthan-afb-amarg-airplane-boneyard.htm (accessed September 18, 2022).
98. The remaining Iroquois engines are X116, owned by a private collector in Fort St. Johns, British Columbia and X117, which is owned by the Canadian Aviation and Space Museum, Ottawa, Ontario.
99. Gilbert J. Hunt, Letter to the Canadian Warplane Heritage Museum Board of Directors, Mount Hope, Ontario, dated January 15, 1997, n.p., Canadian Warplane Heritage Museum, Mount Hope, Ontario.
100. Palmiro Campagna, *The Avro Arrow: For the Record*, 185-188.