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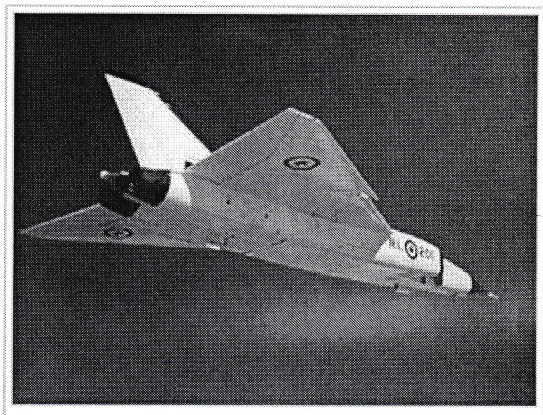

Avro Arrow

The **A.V.Roe CF-105 *Arrow*** was a delta-wing interceptor aircraft, designed and built in Toronto, Ontario, Canada by Avro Canada during a short period of time in the 1950s. The design was entering the middle stages of testing when it was cancelled in 1959, after a long and bitter political debate. The prototypes were then destroyed, and the blueprints were burned, creating an enduring piece of Canadian mythology. Many of the workers moved to the US in a massive "brain drain" to become lead engineers, program managers, and heads of engineeringin NASA's Mercury, Gemini, and Apollo programs. There is a persistent myth that one of the prototypes was spirited away after the cancellation and remains intact, but the evidence supporting this is weak at best.

"Avro CF-105 Arrow has given Canada a serious contender for the top military aircraft of the next several years. The large, decidedly advanced delta-wing fighter was rolled out of the Malton plant a few days ago...The Arrow's power, weight and general design leave little doubt of its performance potential." From: "CF-105 Displays Advanced Engineering In Rollout", Aviation Week, 21 October 1957.

"Arrow, []...the biggest, most powerful, most expensive and potentially the fastest fighter that the world has yet seen..." From "Arrow: A World-Leading Interceptor" by Avro Aircraft, *Flight*, 25 October 1957.

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The plane

Purpose

In the post-World War II period, the Soviet Union began developing a fleet of long-range bombers capable of delivering nuclear weapons to North America and Europe. To counter this threat, Western countries began the development of interceptor aircraft which could engage and destroy these bombers before they reached their targets.

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A. V. Roe Canada Limited had come into being in 1945, and within the short period of four years, had developed and flown the first commercial jet transport to fly in North America, the C102 Jetliner. A comparable American regional jet would not fly until well into the mid 1950s. Avro's first military aircraft development was the subsonic Avro CF-100 Canuck. Begun in 1946, the Canuck would not enter service until 1953 but due to the lead times in building new aircraft and the advances that were thought to have been made in the Soviet Union, the RCAF began looking for a supersonic replacement. In March, 1952, the RCAF's *Final Report of the All-Weather Interceptor Requirements Team* was submitted to A. V. Roe.

Initial design

The CF-100 was a very conventional design, similar to most World War II heavy fighters in layout, with the exception of the introduction of jet engines mounted close to the fuselage. This sort of design encounters a strong form of drag in the transonic

speed range, wave drag, as air "piles up" on the leading edge of the wing. Overcoming this drag proved to be difficult given conventional designs, and led to the concept of a "sound barrier".

German research during WWII identified a number of solutions to this problem. It was known that the onset of the drag was greatly reduced by using thinner airfoils with much longer chord, but these were impractical because they left little internal room in the wing for weapons or fuel. Instead they introduced the swept-wing design, which "fooled" the airflow into believing it was flowing over a long, thin wing. Almost every fighter project in the post-war era immediately copied the concept, which started appearing on production fighters in the late 1940s.

Avro engineers had already explored a number of paper projects on modifications to the CF-100 using swept wings (and tail) as the C-103. Although it theoretically bettered the CF-100 in terms of performance, the small performance gain was not worth the extra development costs.

To meet the requirements, the engineers considered the delta. The delta offers many of the same advantages (and disadvantages) as the swept wing, but is much larger, allowing for more internal storage. The only downside to the design, compared to the swept wing, was that at low speeds it suffered from much greater drag. This was of little concequence for an aircraft which would primarily be flying at high altitudes and speeds.

In the words of designer Jim Floyd, "At the time we laid down the design of the CF-105, there was a somewhat emotional controversy going on in the United States on the relative merits of the delta plan form versus the straight wing for supersonic aircraft...our choice of a tailless delta was based mainly on the compromise of attempting to achieve structural and aeroelastic efficiency, with a very thin wing, and yet, at the same time, achieving the large internal fuel capacity required for the specified range." (Floyd, James, Journal of the Royal Aeronautical Society, December 1958.)

They created two versions of a design known as the **C-104**: the **C-104/1** with a single engine, and the **C-104/2** with twin engines. The planes were otherwise similar, using a low-mounted delta-wing, powered by the new Orenda TR.9 engines, armed with Velvet Glove missiles (an RCAF design) stored in an internal bay, crewed by a single pilot, and guided with a completely automatic interception system that would track down and attack the target after it was selected by the pilot (similar to the F-86D). The primary advantage of the twin-engine /2 version was that it was larger overall, including a much larger weapons bay, and had the advantage of twin-engine reliability. The results were submitted to the RCAF in June, 1952.

Final design

Intensive discussions between Avro and the RCAF examined a wide range of possible sizes and configurations, culminating in RCAF *Specification AIR 7-3* in April 1953.

AIR 7-3 called specifically for twin engines, since no single engine then available could lift the fuel load needed for the long-range missions the RCAF demanded. This was to be 300 nautical miles (556 km) for a normal low-speed mission, and 200 nautical miles (370 km) for a high-speed interception mission. It was to fly at Mach 1.5, cruise at an altitude of 50,000 feet (15,000 m), and be able to pull 2 g in maneuvers with no loss of speed or altitude under those conditions. The time from a signal to start the engines to the aircraft's reaching 50,000 feet (15,000 m) and Mach 1.5 was to be less than five minutes. Turn-around time on the ground was to be less than ten minutes. The new specification also called for a crew of two, as it was considered unlikely that even a fully automated system would reduce pilot workload enough to allow a lone pilot. An RCAF team led by Ray Footit visited US aircraft producers and concluded that no existing or planned aircraft could fulfil these requirements.

In response to the updated requirements, Avro returned their modified **C-105** design in May 1953, a two-man version of the C-104/2. It was decided to move the wing to the upper part of the fuselage from its former low-mounted point, in order to improve access to the plane's internals, weapons bay, and engines. The high-wing design also allowed the wing to be a single structure across the plane, which simplified construction and added strength. However this also required long landing gear that still had to fit within the thin delta-wing — an engineering challenge. Five different wing sizes were outlined in the report, from 1,000 to 1,400 ft² (93 to 130 m²). The 1,200 ft² (111 m²) version was eventually selected. Three engines were considered as well: the Rolls-Royce RB-106, the Bristol B.0L.4 *Olympus*, and the Curtiss-Wright J67 (a license-built version of the Olympus); the RB-106 was selected with the J67 as a backup.

The weapons bay was larger than the 104/2, situated in a large thin box running from the front to the middle of the wing. The weapon system originally selected was the Hughes MX-1179, which was a pairing of the existing MA-1 fire-control system with the AIM-4 Falcon missile of radar-guided and heat seeking variants. This system was already under development for proposed use in the US's WS-201 *1954 Interceptor* (dating from 1949, which would lead to the F-102 Delta Dagger). The Velvet Glove radar-guided missile had been under development with the RCAF for some time, but was considered unsuitable for supersonic launch, and further work on that project was cancelled in 1956.

In July 1953 the proposal was accepted and Avro was given the go-ahead to start a full design study. In December, $27 million was provided to start flight modelling. At first the project was limited in scope, but the introduction of the Soviet Myasishchev M-4 *Bison* jet bomber and their testing of a hydrogen bomb dramatically changed priorities. In March 1955, the contract was upgraded to a $260 million contract for five **Arrow Mark 1** flight-test aircraft, to be followed by 35 **Arrow Mark 2**s with production engines and fire-control systems.

Production start

Most aircraft designs start with the construction of a small number of hand-built

prototypes. These are test-flown, and the inevitable problems are discovered and fixed. Once satisfactory results are achieved, a set of *jigs* for production construction is laid out in the assembly hall. This is a slow and expensive process, but a safe one.

For the Arrow project it was decided to adopt the Cook-Craigie plan. Developed in the 1940s, Cook-Cragie skipped the prototype phase and built the first test-airframes on the production jigs. Any changes could be incorporated into the jigs while testing continued, so production started as soon as the test program was complete. As Jim Floyd noted at the time, this was a risky approach but together with the RCAF, "...it was decided to take the technical risks involved to save time on the programme...I will not pretend that this philosophy of production type build from the outset did not cause us a lot of problems in Engineering. However, it did achieve its objective.." (Floyd, Journal of the Royal Aeronautical Society, Decmber 1958).

In order to mitigate the risks, a massive testing program was started and by mid-1954, the first production drawings were issued and wind tunnel work began. In another program, 9 instrumented free-flight models were mounted on solid Nike rockets and launched over Lake Ontario while 2 more were launched across Wallops Island in the United States. These models were for aerodynamic drag and stability testing and achievied a maximum speed of Mach 1.7 before intentionally crashing into the water. Ongoing efforts have been made to search for the models in Lake Ontario but none have been found to date. What has been found is a Velvet Glove booster and possibly a Nike booster but not the scale models themselves.

Experiments showed the need for only a small number of changes to the design, mostly involving changes to the wing profile and positioning. In order to improve high-alpha performance the front of the wing was drooped, especially on the outer sections, a dog-tooth was introduced to control spanwise flow, and the whole wing was given a slight negative camber to help control trim drag and pitch-up.

The area rule principle was also applied to the design. This resulted in several changes including the addition of a tailcone, sharpening the radar nose, thinning the intake lips and reducing the cross-sectionial area of the fuselage below the canopy. (James Floyd, Royal Aeronautical Journal.)

The aircraft used a large measure of magnesium and titanium in the fuselage, the latter limited largely to the area around the engines and to fasteners. Titanium was still expensive and not widely used, because it was difficult to machine. The construction of the airframe itself was fairly conventional, however, with a semi-monocoque frame and multi-spar wing.

The Arrow's thin wing demanded aviation's first 4000 lb/in² (28 MPa) hydraulic system that could supply enough power while using small actuators and piping. Use of a rudimentary fly-by-wire system resulted in the problem of the lack of control "feel" for the pilot, and to solve this the control stick input was "disconnected" from the hydraulic system. The pilot's input was sensed by a series of force transducers in the stick, and their signal was sent to an electronic control servo that operated the

valves on the hydraulic system to move the various flight controls. In addition, the same box fed pressure back into actuators in the stick itself, making it move. This happened quickly enough that it appeared as if the pilot were moving the stick directly. An advanced stability augmentation system was added as well, as long, thin aircraft have a number of coupling modes that can lead to departure from controlled flight if not damped out quickly. Since the centre of lift moved with speed, the flight control system also assisted stability and manoeuvre.

In 1954 the RB.106 program was cancelled, so plans were made to use the backup J67 instead. In 1955 this engine was also cancelled, leaving the plane with no engine. At this point the new Pratt & Whitney J75 was selected for the initial test-flight models, while the new TR.13 (soon PS-13 *Iroquois*) engine was developed at Orenda for the production Mk.2s. Eventually it was only the rejected Bristol Olympus design that would actually go into production.

In 1956, the RCAF demanded an additional change, the use of the advanced RCA-Victor *Astra* fire-control system in place of the MX-1179, firing the equally advanced US Navy Sparrow II in place of the Falcon. Avro objected to this choice on the grounds that neither of these were even in testing at that point, whereas both the MX-1179 and Falcon were almost ready for production. The RCAF planners felt that the greatly improved performance of the Sparrow was worth the gamble.

The Astra proved to be a serious problem in the Arrow design. The system ran into a lengthy period of delays, and the US Navy eventually cancelled all work on the Sparrow II in 1956. This left the Arrow weaponless, although Canadair was quickly brought in to continue the Sparrow program in Canada.

A rush study looked at alternatives, including resurrecting the Velvet Glove for use with the Astra, or the use of the original MX-1179 system with its Falcons. Even the MX-1179 had run into difficulties, and the F-102 eventually settled on the older MG-1 system originally used in the F-86D. Work was continuing on the MX, however, as it was planned to be used in the upgraded F-102B (later renamed as the F-106 Delta Dart), so this was selected for the Arrow as well.

Mark 1

Go-ahead on the production was given in 1955, and the rollout of the first prototype, RL-201, took place October 4 1957, quite an achievement for a company that had never built a supersonic aircraft. Unfortunately, the roll-out was dwarfed by the launch the same day, of Sputnik.

The J75 was slightly heavier than the PS-13, and therefore required ballast to be placed in the nose to move the centre of gravity back to the correct position. In addition, the Astra fire-control system was not ready, and it too was replaced by ballast. The otherwise unused weapons bay was loaded with test equipment. This makes the Arrow one of the few aircraft to actually grow lighter during service entry.

RL-201 first flew on March 25, 1958. Four more J75-powered Mk.1s were delivered

in the next two years. The test flights went surprisingly well; the plane demonstrated excellent handling at all extremes of the flight envelope. Much of this is due to the natural qualities of the delta-wing, but an equal amount is due to the stability augmentation system. The aircraft flew supersonically on only its third flight and on its seventh flight, achieved a speed of over 1,000 miles per hour at 50,000 feet, while climbing and still accelerating. A top speed of Mach 1.98 would eventually be reached at three quarters throttle.

No major problems were encountered during the testing phase. There were some issues with the landing gear, flight control system, and the stability augmentation system needed considerable tuning.

The former problem was partly due to the gear being very thin, in order to fit into the wings. In order to achieve gear stowage upon retraction, the landing gear was of the tandem arrangement (two tires); one in front of and one behind the gear leg. The leg shortened in length and twisted as it was stowed. During one landing incident, the chain mechanism used in the Mark 1 gear jammed, resulting in incomplete rotation of the gear. In a second incident, the flight control system commanded elevons full down at landing, resulting in little weight being on the main landing gears and ultimately resulting in brake lockup and gear collapse.

The stability augmentation system was a matter of tuning, tuning and more tuning. Although the Arrow was not the first plane to use such a system – the Arrow used this system for all three axes, other aircraft did not – it was one of the first, and the concept had not yet developed into the science it is today.

Mark 2

The Mk.2 version was to be fitted with the Iroquois engine. The Astra/Sparrow fire control system had been terminated by the government in September 1958 and all aircraft were to have the Hughes/Falcon system installed. At the time of cancellation of the entire program, the first Arrow Mk.2, RL-206, was nearly complete. It was expected to break the world speed record but never had the chance.

Top speed would have been limited by frictional heating but as Jim Floyd has said, "The alluminum alloy structure which we favoured was good for speeds greater than a Mach number of 2..." (Floyd, Journal of the Royal Aeronautical Society, December 1958).

Other versions

Avro Canada had a wide range of Arrow derivatives under development at the time of project cancellation. Frequent mention is made of an Arrow that could have been capable of Mach 3 – this was not the production version, but one of the design studies, and would have been almost a completely different aircraft from the Arrow Mk.1 and Mk.2, featuring revised engine inlets, and extensive use of stainless steel or titanium to withstand airframe heating.

The politics

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Until 1955, the Arrow project had been quite cost effective. Only $27 million had been earmarked for the studies, and $260 million for the initial production line. However in September 1955 Avro told the Canadian Cabinet that it needed an additional $59 million to keep the program on schedule. In December 1955, Cabinet limited Avro to eleven prototypes and put a spending cap on the overall program of $170 million over three years.

It was around 1955 that the notion began to surface, not only in Canada but most of the western world, that the era of the manned interceptor was over, and that the age of guided missiles had arrived. The United Kingdom and the US both scaled back most of their interceptor development programs, leaving only one in the UK (the English Electric Lightning) and only two in the US, the F-102 (later evolving into the F-106) and the recently started North American F-108 *Rapier*.

In February 1957, the Cabinet ordered the spending cap increased to $216 million. There is some evidence that the Liberals were losing faith in the project, but it would be impossible to cancel it in an election year. In June the Liberals lost the election, and a Conservative government under John Diefenbaker took power.

In August 1957 Diefenbaker signed the NORAD (*North American Air Defence*) agreement with the United States, which required the subordination of the RCAF Air Defence Command to American command and control. The USAF was in the process of completely automating their air defence system with the SAGE project, and insisted that the RCAF had to use it as well. One aspect of the SAGE system was the BOMARC nuclear-tipped anti-aircraft missile, which when intercepting bombers over Ontario and Quebec would be exploding right over major Canadian cities. This led to studies on basing BOMARCs in Canada in order to push the line further north, away from the cities. The Canadian politicians seemed to come to the conclusion that they could not afford SAGE, Bomarc *and* Arrows.

On October 4, 1957, when the first full-sized prototype was rolled out to a crowd of 12,000 in front of the Avro plant, Sputnik 1 was launched. Now the age of the missile was clear even to the public, and soon the outcry over the cost of the project was being reported in the press. The Arrow program was already the most expensive in Canadian history, representing a considerable fraction of all government spending, and was seen by many outside Ontario as an industrial welfare program.

Arrow Costs

Many have contended that the cost of the Arrow was simply too much for the Canadian economy to handle. While it is acknowledged the cost of the program was high, both the Prime Minister and Minster of National Defence noted that cost was not the reason for the cancellation of the program. In 1955, the findings of a special government committee on the Arrow stated, "The greater effectiveness and greater range of the CF 105 results in the need for less aircraft and fewer bases. Aircraft for aircraft the F102B is less costly but, dollar for dollar, the CF 105 provides significantly more defence...The burden of cost involved in this course of action is in inherent in an air defence system which is kept abreast of the developing threat." (From files at the Directorate of History, Department of Natioal Defence, Canada, 73/1223) As a side note, the Arrow was originally to be a one-for-one replacement for the CF 100 but because of the reason stated here, fewer aircraft were needed.

Historians have maintained the cost per aircraft would be $12 million dollars. Audit Records revealed in Storms and Requiem show that the total cost of the program when complete was going to be $1.111 billion. This figure included all of the development cost, all of the production and tooling, support equipment, combat stocks of Falcon missiles and finally, the aircraft themselves at a fly-away cost of $3.75 million each, not $12 million. Too often fly-away cost is confused with overall program cost. As more aircraft were produced, the fly-away cost was going to drop to below $3 million, more than comparable to the less capable single-engine F106 for example.

Requiem details the reasons why costs escalated. Much of it is attributable to rising labour and material costs. What the documents also show though is that parts of the program were progressing faster than anticipated hence costs not expected until months or years later, were appearing earlier on. In addition, costs were fluctuating due to the numerous redesigns the RCAF was imposing on Avro. World conditions were also playing apart in that when the Soviets unveiled new aircraft, the program was accelerated accordingly, by the RCAF. The afformentioned file contains the relevant documentation supporting this scenario.

What was revealed in Storms, was the Top Secret brief prepared for George Pearkes, then Minister of National Defence, for his July 1958 meeting with officials from the US. The NORAD agreement had been signed in 1957 and the American were requesting that Canada install Bomarc bases along with SAGE and gap filler radar. From the Top Secret brief, "The introduction of SAGE in Canada will cost in the neighborhood of $107 million. Further improvements are required in the radar... NORAD has also recommended the introduction of the BOMARC missile...will be a further commitment of $164 million.... All these commitments coming at this particular time...will tend to increse our defence budget by as much as 25 to 30 percent..." Pearkes was also concerned about funding a defence against ballistic missiles. From an American brief of the meeting with Pearkes, "He [Pearkes] stated that the problem of developing a defence against missiles while at the same time completing and rounding out defence measures against manned bombers posed a serious problem for Canada from the point of view of expense..." Eisenhower Library, File: DDE Trip to Canada, Memcons, July 8-11, 1958, Canada-U.S. Defence Problems. See Requiem

So, the problem was a combination of costs that Canada could not afford. What was revealed in the late 1990s, was a taped interview Pearkes gave to his biographer. In that recording Pearkes discusses these problems and then reveals that he was advised by an American oficial, while en route to Colorado, that Canada did not need to build aircraft because the US had plenty and could make them available at any time. On tape Pearkes states that this is when he made his decision. His dilemma though was how to fill in the defence gap from cancellation of the Arrow to the time when Bomarc bases would be operational. On tape he reveals a secret deal he struck to allow American training in Goosebay and Labrador and Cold Lake, in exchange for protection. By August 11 1958, Pearkes requested cancellation of the Arrow.

It has been stated that the Army and Navy were upset with the cost of the Arrow as their own programs might be jeopardized. This is not borne out by the documentary record. When Pearkes tabled his memo to cancel, the Cabinet Defence Committee refused. He tabled it again in September and recommended installation of Bomarc etc. The latter was accepted but again the CDC refused to cancel the entire program. The CDC wanted to wait until 31 March 1959, to better examine world conditions. What was cancelled in September 1958 was the Sparrow/Astra system. Ill advised from the start, Avro and others had recommended against this system.

The onset of Sputnik had also raised the spectre of attack from space and as the year wore on, word of a missile gap began spreading. Money would be needed for a defence against ballistic missiles. At the same time, the manned bomber threat was perceived to be diminishing. Noted Pearkes in a document after the cancellation, " We did not cancel the CF 105 because there was no bomber threat but because there was a lesser threat and we got the Bomarc in lieu of more airplanes to look after this." Department of National Defence, Directorate of History, File 79/469 Folder 19 see Requiem. We now know the missile gap was a fabrication and just a few months after the cancellation, the Americans were advising Canada to purchase interceptors, like American Voodoos.

Canada tried to sell the Arrow aircraft to the US and Britain but had no takers. Storms revealed that Donald Putt, AFRDC wanted to purchase the Arrow for the American inventory but the Secretary of the Air Force said no as did John Foster Dulles. In other words, while it is true that many Americans supported the Arrow, those that mattered did not, for various reasons not the least of which was pressure from American industry to purchase American made goods. Dulles said as much to Canadian officials, at the Paris summit in 1958.

The French government, prepared to buy some 200 Iroquois engines, cancelled the order in 1958, being advised by persons unknown that the Arrow was going to be cancelled.

On February 20, 1959 Diefenbaker announced to the Canadian House of Commons that the Arrow and Iroquois programs were to be immediately cancelled. The telegrams sent to Avro were very clearly and precise on the meaning of immediate.

With no work available, this left the A.V. Roe Company no choice but to lay off some 14,000 workers in one afternoon. Declassified records show Avro was caught unprepared by the suddeness of the anouncement by the government. Some 25,000 were laid off due to cancellations of contracts with various subcontractors. These numbers are from declassified government records.

Within two months, all aircraft and engines, production tooling and technical data, were ordered scrapped. Contrary to popular belief, the scrap orders did not include photos or film of the aircraft in flight. An attempt was made to provide the completed Arrows to the Canadian National Research Council. The latter refused noting that without a company to provide spare parts and maintenance, as well as pilots, the NRC could make no use of them. As a static test bed, the NRC could not guarantee security around the aircraft. Remember, this was the cold war.

Why is the Arrow such a volatile subject in Canada?

There may be several reasons. Firstly, as noted from the above discussion, most of the information and records were kept in secret for over 30 years. Many thought the records had been destroyed until discovered and declassified for Storms and later Requiem. This secrecy allowed much erroneous information to be propagated over the years. For example, the discussion on cost remains a major sticking point although now the audit records have been revealed.

Crawford Gordon was vilified for allegedly having argued with the Prime Minister at length and so the project was cancelled because of this. The two men met once. Writing in his memoirs, Diefenbaker made light of the encounter. It occurred long before the cancellation. Also, Gordon is accused of firing everyone out of spite. Again, the facts do not support this.

For his part, Diefenbaker has been vilified for ordering the physical destruction of the Aircraft. This too has been laid to rest as the paper trail of the decision was revealed in Storms. It leads to Pearkes and the Chief of the Air Staff.

The fact of a mole in Avro was revealed in the 70s in a book called, "For Services Rendered," about the RCMP. The fact of the mole was confirmed by RCAF personnel to the author of Storms. Later this fact was confirmed in a book called the Mitrokhin archives. The mole issue was given in Storms as the reason why the aircraft and plans were destroyed. This was further supported in Storms in quoting an Aviation Week article from 1959 that stated government officials had said the plans were destroyed as they could aid a potential enemy.

The engineers have been castigated by historians for building a flawed aircraft but this was proven incorrect by the documented record. Some Canadian historians have since changed their comments about a technically inferior plane as a result. Note that magazines of day such as Aviation Week in the US and Flight magazine in Britain, hailed the technical advances being made in the design of the Arrow and Iroquois engines.

So, given the lack of information and the fact that over 25,000 Canadians, their friends and families were affected, it is easy to see how this has become a volatile subject.

Although almost everything connected to the program was destroyed, the forward fuselage and some sections of the wings and control surfaces of the first Mark 2 Arrow were saved and are on display at the Canadian Aviation Museum in Ottawa.

In 1961, the RCAF purchased 66 CF-101 Voodoo aircraft to serve in the role originally intended to be filled by the Arrow. The controversy surrounding this acquisition, and Canada's acquiring nuclear weapons for the Voodoos and Bomarcs eventually led to the collapse of the Diefenbaker government in 1963.

There is a belief, held by many people, that one lone Arrow was flown away before it could be destroyed, and is now stored in some remote location in Canada. This is, most likely, a myth, kept alive by the wishes of those who would like to have seen the project continue.

The controversy

The Avro Arrow aircraft program, many say, was cancelled by short-sighted political leaders. Many Canadians consider these leaders to have had little vision or understanding of the technological world unfolding at the time.

Reality is less clear on the fate of the Arrow. As the defence world had expected, the strategic bombing role was passed onto the missile – albeit at a slower rate than initially suspected. The interceptors designed to fight a potential Soviet bomber attack were all retired in the 1980s. Today the only remaining pure interceptor is the Soviet MiG-31, built to counter a USAF bomber attack. Nevertheless the Arrow would have filled an important role in the 1960s before the bomber finally passed away, a fact that forced the RCAF into purchasing the CF-101.

Many have also suggested that the aviation industry in Canada was destroyed with the cancellation of the Arrow. This claim is suspect, considering that Canada is currently the 3rd largest aircraft producer in the world (behind the US and France). It is true that design of fighter aircraft in Canada ended with the Arrow, but the same is true for most countries of similar means. The rapidly rising costs of fighter aircraft have led to rationalisation in the industry, and there are now only a few companies in the Western world designing military aircraft today, when at the time there were dozens.

From the Declassified Records

Here is a summary of some questions that have been posed over the years, as answered by just a few of the declassified documents themselves. These documents are discussed further in Storms and Requiem:

a. On Cost: "Arrow costs compare favourably with the somewhat less sophisticated aircraft in the USA..."(RCAF Memo March 28, 1958 RG 24 Box 6430)

"If this (Arrow) were the only requirement for our air defence, we could perhaps make provision for it in our succeeding defence budgets..."(Pearkes to Dulles in explaining how adding SAGE/Bomarc would stress the defence budget TOP SECRET brief July 8 1958 from RG 49, Vol. 427, File 159-44-B, part 1)

b. Did the Arrow even have a mission? "What was so wrong with countering the Soviet threat...with alternate weapons such as the superb F-101 Voodoo?":

"With the object of economy and to avoid unnecessary duplication, every effort has been made to determine whether future U.K. or U.S. aircraft could meet our requirements...In the U.K. the only aircraft for consideration is the Javelin whose performance falls far short of the requirement. In the United States there is the Convair F-102...does not meet the range requirement...The RCAF, therefore have had A.V. Roe Canada work out an engineering proposal for an aircraft to meet our specification." (the Honourable Brooke Claxton to cabinet November 30 1953 from RG 24/83/84/167 Box 6426)

Major General G.E. Price "...did not foresee the day of the phasing out of the manned interceptors as he felt there would always be a need for judgement and mobility in a weapon system." (General Price to the RCAF after a two day review of the entire project, in October 31 and November 1 1955, in which the USAF team concluded that the Arrow was superior to their F101, that Falcon should be the weapon of choice and that Iroquois would improve the performance of their own aircraft from RG 24/83/84/167, Box 6426)

The mission would be, "...primarily in peacetime to expose violation of national airspace...In wartime, reconnaissance aircraft are targets the same as any other enemy aircraft...an alternative supersonic two-place all-weather interceptor that generally meets the operational requirement is defined in OCH 1/1-63. This aircraft would have to be equal to or superior to the Arrow Weapons System."(RCAF review of the project late 1958 from RG 24 Box 6430)

c. When the Arrow was terminated, was it really a disaster for Canada's aviation industry?:

"...It has been our experience in the past that the potentialities of the Canadian aircraft industry and its allied companies have not always been appreciated...Lack of an immediate and long-range programme will result in a deterioration of the industry's effective operating capacity...We believe the industry at the moment to be in serious jeopardy."(Air Industries and Transport Association to the Prime Minister in December 1957. Arrow was the largest single ongoing project at the time therefore its termination would be disastrous. From The Scientific and Industrial Resources of the Canadian Aircraft Industry J.H. Parkin files NRC Ottawa)

d. Was Avro capable of delivering a first-class weapons system in the first place?

"There is no doubt that the firm is capable with its present labour force and space of meeting the likely demands for the RCAF and in fact exceeding them considerably...Orenda Engines Ltd...is excellently equipped and there is no doubt whatever of its ability to match the aircraft programme in mind by Avro Aircraft Ltd."(Evaluation of the Canadian CF-105 as an All-Weather Fighter for the RAF, Report by the Joint Air Ministry/Ministry of Supply Evaluation Team 1956.)

e. Questions remain about the Arrow's airframe design, and its engine was still developmental.

"This aircraft is now in the test flying stage and flights to date indicate it will meet its design requirements. The engine for the aircraft, which is part of the Arrow programme, is also undergoing air tests. These tests indicate that it also will meet its design requirements."(RG 2, Cabinet Conclusions, August 1958)

"Very few engineering problems are expected in the production or flight testing of the Arrow 2 airframe..."(RG 24, Box 6433 Assistant for Arrow Weapon System Office, January 1, 1959)

f. Even its proposed weapon system was still on the drawing board.

"The adoption of the MA-1/Falcon/MB-1 fire control and weapons to the CF 105 programme has reduced the development time and will permit operational aircraft to be delivered for squadron use by September 1960 in place of the spring of 1961...The result of substituting MA-1/Falcon/MB-1 for Astra/Sparrow together with a close analysis of the programme has resulted in an overall saving of...$452.5 million saving on the programme for 100 operational aircraft."(Chief of the Air Staff to Pearkes January 12, 1959 from 73/1223 Series 1, File 12, Directorate of History DND)

CBC Docu-drama

In 1997, the CBC broadcast the two-part docu-drama *The Arrow* about the Arrow program, which remains one of the most-watched television programs in Canadian history. The docu-drama used a combination of archival film, remote-control flying models, and computer animation for the flying and action scenes. The flying models were built by Doug Hyslip of Calgary, but a full-scale replica of the Arrow was used in ground scenes. The docu-drama was intended as entertainment rather than a literal history, and the script differs considerably from the historical record. It should not be considered a canonical re-telling of the Arrow story, although it is frequently marketed as such.

Allan Jackson of Wetaskiwin was the original designer of the replica used in the CBC docu-drama. He had originally hoped to work on the original Arrow project, until it was cancelled. Years later, in 1989, he began building a full-scale replica of the Arrow. In 1996, the producers of the Arrow miniseries learned of Jackson's replica, then about 70% complete, and offered to finish it if they could use it for the movie. After several public appearances at air shows the Jackson replica was donated to the Reynolds-Alberta Museum in Wetaskiwin where it is being stored until it can be refurbished for display.

The Toronto Aerospace Museum, located at the former CFB Downsview has had another full-size replica Arrow under construction. Made of metal, it will be painted in the colours of Arrow 25203. It is scheduled to be completed and rolled out on October 4, 2006. It will be displayed with an Avro Lancaster bomber built at the same Malton plant that produced the Arrow. The museum ultimately hopes to acquire an Avro CF-100 to be exhibited alongside the Arrow replica and Lancaster.

Avro Museum of Calgary also has a Replica Arrow Project. Theirs is a 0.6-scale piloted replica aircraft being built for public flight demonstration — construction started in Sept/05 following eight years of research. Built of modern-day composite materials under Canadian Recreational Aircraft Legislation, construction is expected to take five years of volunteer labour and cost a half-million dollars in materials and parts.

Cultural Impact

Probably the most interesting thing about the Arrow today is the enduing fascination that many Canadians have with it. Certainly there is no comparable instance anywhere in the world of a nation continuing to lament the cancellation of a weapons platform half a century later, a fact which does not reflect well on the very delicate nature of Canadians' patriotic sensibilities.

Specifications (Arrow Mk.1)

Data from The Great Book of Fighters[1]

General characteristics

- **Crew:** 2
- **Length:** 23.71 m (77 ft 9 in)
- **Wingspan:** 15.24 m (50 ft 0 in)
- **Height:** 6.25 m (20 ft 6 in)
- **Wing area:** 113.8 m&sup2 (1,225 ft²)
- **Empty weight:** 22,245 kg (49,040 lb)
- **Loaded weight:** 25,820 kg (56,920 lb)
- **Maximum gross takeoff weight:** 31,120 kg (68,605 lb)
- **Powerplant:** 2× Pratt & Whitney J75-P-3 turbojets
  - **Dry thrust:** 55.6 kN (12,500 lbf) each
  - **Thrust with afterburner:** 82.3 kN (18,500 lbf) each

Performance

- **Maximum speed:** Mach 1.98, 2,104 km/h (1,307 mph) at 15,240 m (50,000 ft)
- **Cruise speed:** Mach 0.91, 977 km/h (607 mph) at 11,000 m (36,000 ft)
- **Range:** 660 km (410 mi)
- **Service ceiling:** 16,150 m (53,000 ft)
- **Wing loading:** 226.9 kg/m² (46.5 lb/ft²)
- **Thrust/weight:** 0.65:1

Armament

Projected

- 8x AIM-4 Falcon and 3-4x Sparrow II air-to-air missiles carried in the internal weapons bay. After Sparrow II was cancelled, the specifications were changed to 4x AIM-4 Falcon and 1-2x AIR-2 Genie unguided nuclear rockets.

Avionics

- Velvet Glove fire control system

References

1. ↑ Green, W; Swanborough, G (2001). *The great book of fighters*, MBI Publishing. ISBN 0760311943.

Further reading/viewing

- Palmiro Campagna, *Storms of Controversy The Secret AVRO Arrow Files Revealed*,1992, with Foreword by Major General Richard Rohmer based on declassified documents by Mr. Campagna that reveal for the first time who ordered the blowtorching of the completed aircraft.
- Palmiro Campagna, *Requiem for a Giant, A.V.Roe Canada and the Avro Arrow*, Dundurn Press, 2003 based on declassified documents by Mr. Campagna, destroying the myths about soaring costs and a flawed airplane.
- James Floyd, The Canadian Approach to All-Weather Interceptor Decelopment, The Journal of the Royal Aeronautical Society, December 1958. This article, from the designer himself, discusses the reasons for the Arrow and many of the intricacies of its design; why the tailless delta, choice of materials, RCAF requirements, aerodynamics, flight control and auto-damping etc. Jim's article is available online at the avroarrow.org site and is a must for anyone researching this topic.
- Ron Page, Richard Organ, Don Watson and Les Wilkinson, *Avro Arrow: The Story of the Avro Arrow From Its Evolution To Its Extinction* (Boston Mills Press 1979, reprinted Stoddart, 2004). Probably the best book on the subject of the Arrow program. It concentrates on the technical aspects of the program, and eschews the politics. Outstanding selection of plans, photos, diagrams, etc.
- Peter Zuuring, *The Arrow Scrapbook* (Arrow Alliance Press, 1999). Uncovers a lot of previously unknown information about the program.
- Randall Whitcomb, Avro Aircraft and Cold War Aviation, (Vanwell, 2002), also available through Arrow Recovery Canada.
- Chris Gainor, *Arrows to the Moon: Avro's Engineers and the Space Race* (Apogee, 2001) also has a great deal of material about the Arrow.
- *Dateline - There Never Was an Arrow* broadcast on the CBC in March 1980 (Available as an extra on the Arrow Docu-Drama DVD). Excellent, balanced documentary on the program, includes lots of interesting film clips, and interviews with key decision makers in the Arrow program. Clips from the program can be seen at [1]

- "Supersonic Sentinel" Rare Avro Arrow film footage. Available from Arrow Digital Archives (ARC). Also includes extra footage of the Arrow in Flight, and some footage of the Avro Jetliner. (1950).
- Peden, Murray - "Fall of an Arrow"

External links

- Avro engineers' contribution to NASA
- Avro Museum's Replica Arrow Project
- Homage to the Avro Arrow - the longest running Arrow website
- The Largest Archive of Factual Arrow Information
- Avro Arrow pictures on Discovery Channel Canada site
- Avro Arrow pictures on maverick2.com
- A site dedicated to the people and projects of Avro Canada and Orenda Engines Limited
- Avro CF-105 Arrow Mk.1 (Department of National Defence, Government of Canada)

Related content

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- Fighter aircraft
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Results from FactBites:

Avro Arrow (3981 words)

- The **Avro** CF-105 **Arrow** was a tail-less[?] delta-wing interceptor aircraft, designed and built by **Avro** Canada during a short period of time in the 1950s.
- **Avro** objected to this choice on the grounds that neither of these pieces were even in testing at that point, whereas both the MX-1179 and Falcon were almost ready to go.
- Although the **Arrow** was not the first plane to use such a system, it was one of the first, and the concept had not yet developed into the science it is today.

Avro Arrow - Wikipedia, the free encyclopedia (6344 words)

- The **A.V.Roe** CF-105 **Arrow** was a delta-wing interceptor aircraft, designed and built in Toronto, Ontario, Canada by **Avro** Canada during a short period of time in the 1950s.
- **Avro** objected to this choice on the grounds that neither of these were even in testing at that point, whereas both the MX-1179 and Falcon were almost ready for production.
- Although the **Arrow** was not the first plane to use such a system – the **Arrow** used this system for all three axes, other aircraft did not – it was one of the first, and the concept had not yet developed into the science it is today.

More results at FactBites »

COMMENTARY

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