An Aviation Chapter in Canadian History

Paul Campagna, P.Eng.

In 1958, the heroes of every Canadian boy (and probably quite a few girls) were the test pilots flying the CF-105, known as the Avro Arrow. Behind the test pilots were the engineers, creating what was to be the fastest, most powerful aircraft yet conceived. 1988 marks the 30th anniversary of its first flight, 1989 the last. Many articles have been written about the Arrow, some true, many false. Here, for the first time, are the engineering facts, painstakingly researched by a young Canadian engineer as a testament to the integrity of the team which created the Arrow.

"The biggest, most powerful, most expensive and potentially the fastest fighter that the world has yet seen . . ."

—Flight Magazine, 1958

Four years of excellence in Canadian engineering, research and design culminated in the maiden flight of the CF-105 Avro Arrow all-weather, supersonic jet interceptor from Malton, Ontario, on March 25, 1958. The world watched Canada's major contribution to aerospace engineering—but not for long. On Friday, February 20, 1959, the Canadian government ordered all work on the Arrow cancelled.

Some 14,000 employees were fired immediately. Within two months, five superb flying machines and a more powerful sixth, which had been within days of takeoff, were ordered reduced to scrap. Also, 31 others in various stages of assembly, along with all parts, drawings, accessories, blueprints and photographs were ordered destroyed.

Even today, some Canadians are unaware of the aircraft's existence, yet it still ranks as one of the most technically challenging projects ever undertaken in this country. Design of a supersonic interceptor with the parameters of the Avro Arrow presented colossal engineering problems which were systematically overcome. However, less than 30 years later, much misinformation exists about the Arrow, such as the number of aircraft that actually flew, what speeds were reached and technologically just how far ahead it really was.

The Company

A.V. Roe Canada Limited was established as a subsidiary of the British Hawker-Siddeley Group in 1945. On purchasing the Malton-based Victory Aircraft Ltd., which was producing Lancaster bombers for the war effort, A.V. Roe turned its attention to commercial jet transports and military jet aircraft. On August 10, 1949, some two weeks after the British Comet made a short hop from its runway, Avro flew the C-102 Jetliner on its maiden flight to 13,000 feet, becoming the first commercial jet transport to fly in North America.

Unlike the Comet, the Jetliner was not plagued with catastrophic fatigue failure. Despite meeting the Trans-Canada Airlines specifications to which it was designed, the Jetliner never went into production. Instead, the company was told to focus on producing the CF-100 all-weather fighter, partly to support the Korean war effort. After flying for seven years, the lone Jetliner, a milestone in aviation, was cut to scrap, forcing Canada to depend on foreign markets for jet transport aircraft.

Although the CF-100 project was a success, it was decided that a new all-weather, supersonic jet interceptor would be required to meet Canada's expanding defence needs. In May, 1953, in response to an RCAF specification, A.V. Roe Canada submitted its report which examined five possible delta winged configurations, with varying wing sizes and engine types. In July, 1953, the Department of Defence Production chose the 1,200 square foot version, thus launching the CF-105 program.

The Aircraft

To set the record straight, the first production CF-105 aircraft, dubbed the Arrow, was rolled out on October 4, 1957, only four years after the start of the program—a major achievement in itself. Its first flight was March 25, 1958. On its third flight, the aircraft was flown supersonically at Mach 1.1. On its seventh flight, it exceeded 1,000 mph while climbing. Four more production aircraft were flown. Eventually, the Arrows would fly to Mach 1.98 (approximately 1,300 mph), although they were never pushed to their performance limit.

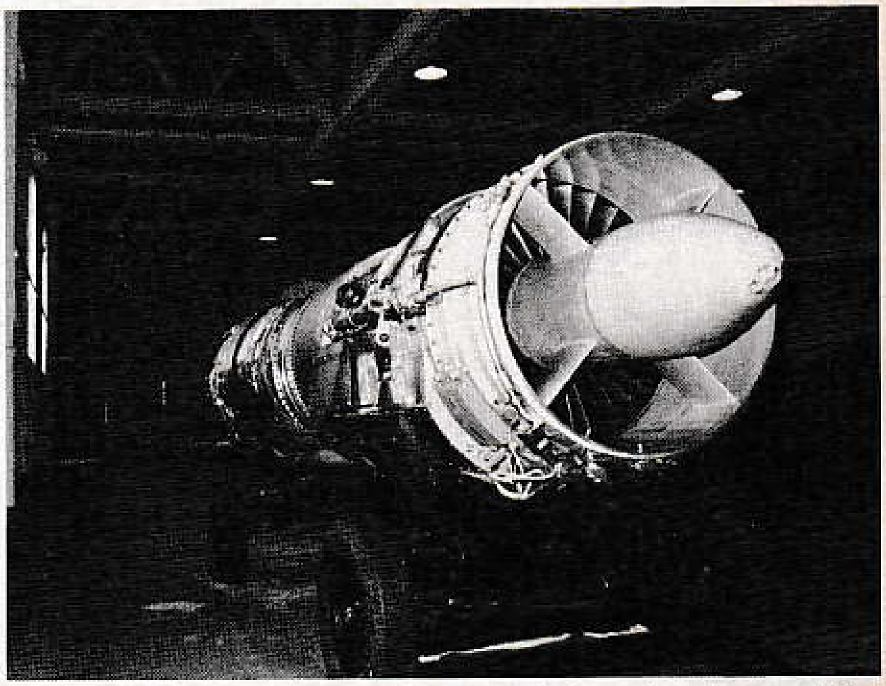


Photo: Orenda Engines, Toronto

Flight tested in a B47 but never in an Arrow, the Iroquois engine was 19 feet long, four feet in diameter and composed of some 20% titanium alloys overall. With a 1:1 weight to thrust ratio, it would have given the Arrow better than Mach 2 speed.

All five aircraft were equipped with two Pratt and Whitney J75 engines, each with approximately 18,000-lb static thrust and 26,000-lb with afterburner. A sixth aircraft was produced and ready for roll-out at the time of cancellation on February 20, 1959. This aircraft was equipped with the more powerful Iroquois engine, at 23,000-lb static thrust and 30,000-lb with afterburner.[1] Arrow number six was expected to break all speed records.

No "prototype" Arrow was ever built, only production aircraft. To move from drawing board to production line, one of the most extensive programs of wind tunnel, structural and systems testing ever undertaken on any aircraft was conducted. In addition, detailed mockups were built for checking system installation.

Part of the test program involved the use of fully instrumented one-eighth scale free-flight models launched on Nike rocket boosters. These models would telemeter information concerning various flight parameters including drag and stability. Today, those stainless steel models rest in Lake Ontario, approximately 13 miles off Point Petrie, waiting for some enterprising underwater enthusiasts to retrieve them.

The Wing

A striking feature of the Arrow was its large delta wing. It was determined that the delta was the most aerodynamically efficient platform for high speed and high altitude performance, while providing a large internal fuel capacity for the required range. To permit higher angles of attack and greater stability, the leading edge of the wing was extended, drooped and slotted, creating more favourable airflow conditions over the wing. These features had been used singly on other aircraft, such as the notch on the English Electric F-23, the leading edge on the Grumman

F-9 and the droop on the F-102, forerunner of the F-106 Delta Dart. Today, combinations of these are used on most fighters, including the Russian MIG series and the F/A-18 Hornet. An early prototype of the F/A 18 incorporated the notch. At the time, the combination of notch, droop and leading edge extensions made the Arrow unique and aerodynamically superior.

Another addition was negative camber, a slight concavity in the upper surface of the wing that helps to reduce the amount of elevator deflection required for stability and control (trim) during supersonic flight. This, in turn, reduces the amount of drag that would otherwise be created with greater elevator deflections.

The Fuselage

The aircraft was extensively "area ruled." This concept involves aerodynamic shaping of the cross-sectional area of the fuselage along its length, to reduce drag to a minimum. Also called the "Coke bottle" design, the fuselage is characteristically pinched at the waist at the wing joint, although this was not immediately noticeable on the Arrow.

Similarly, the cockpit was deigned as an extension of the fuselage rather than as a separate bubble, again for good aerodynamic performance. The cockpit canopy itself was of unusual design, opening and closing in clam-shell fashion due to its size and weight, as well as for ease of entry and exit. The canopy was made of a magnesium alloy with partly glazed glass. In back, drag was reduced by trailing the canopy off into a spine running the length of the aircraft to the tail. This also doubled as a conduit for controls and wire cabling. In short, everything possible was done to reduce aerodynamic drag, including the internal carriage of weapons.

The Weapons Carriage

The concept of internal weapons carriage has spawned several misguided criticisms about an aircraft that would destroy itself if the weapons package were lowered during supersonic flight. In fact, the weapons package was designed to be lowered and removed only while on the ground. In this way, a fully loaded package could be "snapped" into place, considerably reducing the turnaround time per aircraft. This concept also allowed easy reconfiguration for other roles, including reconnaissance and bomber. The pack was never designed to be lowered in flight; since it was 16 feet long and nine feet across, lowering in flight would have been ludicrous. At no time were any of the completed aircraft fitted with weapons.

Initially, the Arrow was to have carried the Hughes Falcon guided missile. The Falcons were to be replaced by Sparrow 2D missiles, with a sophisticated weapons control system known as ASTRA. However, Avro engineers judged the Sparrow missiles to be inferior for use in a high performance aircraft without further development.

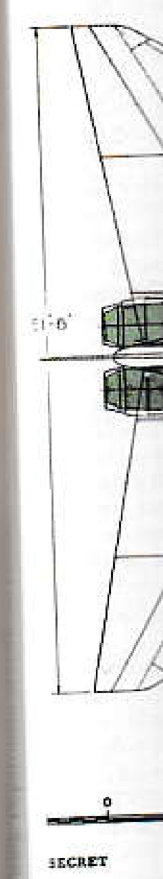
Each missile was to be mounted on its own hydraulically actuated retractable launching mechanism. Because of their large fins, Sparrows would sit partially within and partially outside the belly of the aircraft. (This is similar to the manner in which missiles are carried on the Tornado aircraft: they are recessed into the underbelly; however no retractable launcher is required.) The smaller Falcon missiles would have been fully internal to the aircraft. Missiles would extend from their own individual bay doors. Aft missiles would be fired first, followed by forward missiles.[2] A sliding bay door arrangement was being considered for the Sparrows. Door opening and closing was to have been completed in 0.35 seconds; extension was to have taken another 1.25 seconds or less.

It has been argued that no other fighter has duplicated this internal weapons carriage. This is simply not the case. The CF-101 Voodoo aircraft, for example, employed a rotating platform, which carried some of the weapons internally and the remainder externally. The F-106 Delta Dart used an almost identical internal missile system to that of the Arrow. Internal weapons carriage may also become the future norm.

As calculated by Avro engineers, externally mounting four missiles could have increased drag by some 20% at Mach 1.5. Bill Gunston[3] states that the move towards faster, more agile fighters is slowly forcing the removal of externally mounted weapons in order to take every advantage of the resulting reduced drag. He states it will simply no longer be good enough to hang missiles on pylons. One solution is to use the recessed method of missile carriage and the other is to place weapons in an internal bay.

A recent article[4] describes stealth design techniques to reduce radar cross-sectional (RCS) area. These include using aerodynamic shapes such as delta wings, blending cockpit and wings into the fuselage and, of course, carrying weapons internally. Aerodynamic and stealth efficiency appear to be complementary design requirements. The Arrow was not a stealth aircraft, but obviously the

Photo: Department of National Defence



concept of a "clean" aircraft could have several inherent advantages.

The Landing Gear

The requirement for such a large weapons bay necessitated stowage of the main landing gear in the thin delta wings. This caused a number of engineering difficulties, overcome by Dowty Engineering Limited. On retraction, the main gear would be shortened, angled forward and then twisted in order to be accommodated. Given the 30-ton weight of the aircraft and resulting 200,000-lb compressive load on the main gear on landing, ultra-high-tensile steel with an ultimate tensile strength of 260,000-280,000 psi was required. Use of aluminum was obviously precluded, as was the use of butt and gas welding techniques. Instead, large forgings were made, using a die process. For example, the main outer leg was the largest forging, weighing 1,000 lb. After machining this would be reduced to 167 lb. Solutions to the problem put Dowty and Avro engineers at the forefront of metallurgical research.

Likewise, the engineers at Jarry Hydraulics were obtaining patents for their steering mechanism in the nose gear arrangement, among others. In fact, Avro engineers and their subcontractors made enormous strides in developing high temperature alloys, high pressure and high temperature systems, fuel technology for supersonic flight and human engineering, in terms of cockpit layout and design. These techniques pushed the world aircraft industry further ahead. In support of these advances, Avro maintained a huge metal-to-metal autoclave, a special heat treat furnace, a giant skin mill and a 15,000-ton rubber pad forming press (then the largest in the world).

Fly-by-wire

Early in the design, it was decided that some form of power assist would be required to help control and fly the aircraft during supersonic flight. The chosen result was fly-by-wire. In conventional systems, the pilot's stick and rudder controls are mechanically linked via steel cables or rods to valves which control high pressure fluid flow to the actuators. These powerful hydraulic actuators, in turn, operate the aircraft's control surfaces, such as elevators and ailerons. In military aircraft, automatic flight control systems, gyroscopes and position sensors are also mechanically linked to the actuators through the control rods.

In the Arrow automatic flight control system (AFCS), in automatic mode, the pilot's stick and positioning sensors were linked electrically to electro-hydraulic actuators. Hence, stability, command and control were effected almost instantaneously in all three axes. Analogue computers with a mix of vacuum tube and transistor technology were used, together with autostabilization of the tail fin and artificial feel, to give the pilot some sense of force on his control stick.

Not until the 1970s did fighter planes use a similar AFCS, although variations had been employed in experimental aircraft and the SR 71 Blackbird. The F-16 and Panavia Tornado both used analogue fly-by-wire.

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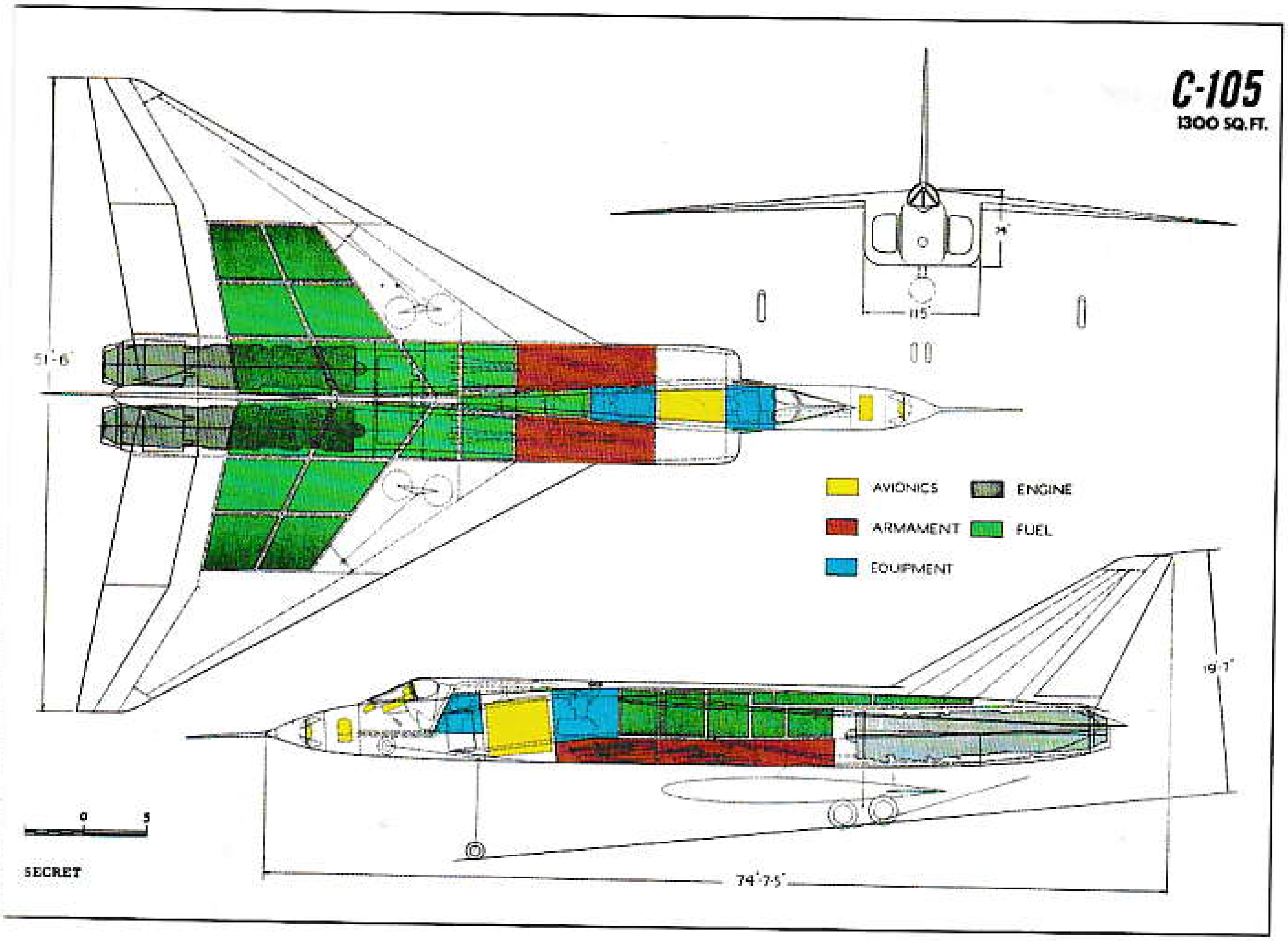

"A Flawed Plane and an Inept Corporation"? The Historian's View

Margaret McCaffery

Thirty years ago, the Canadian public was cheering the launch of an aircraft that made headlines around the world. Three years ago, one of Canada's foremost historians, Dr. Desmond Morton, principal of Erindale College, University of Toronto, described the Avro Arrow as "a fatally flawed weapon, on a par with those earlier monuments to our military-industrial blundering, the Ross rifle or the MacAdam shovel." In an article in the *Toronto Star*, he said: "Politicians, our professional scapegoats, took the blame for aborting a design whose imperfections should have been obvious to a first-year engineering student."

In *The Illustrated History of Canada*, a text which most Canadian schoolchildren will read, Professor Morton claims that then Prime Minister John Diefenbaker cancelled the Avro Arrow, not because guided missiles had made it obsolete, but because it was "a flawed plane and an inept corporation."

In *A Military History of Canada*, Dr. Morton refers to "crippling design flaws in a reputed triumph of Canadian engineering. The Arrow's Mach-2 speed depended on carrying its missiles in a belly pack. Opened for action at high speeds, the rocket pack acted like an air brake—or threatened to tear off."

The basis for Dr. Morton's claims of technological flaws are the presumed effects if the Arrow's weapons pack had been lowered during flight. Yet, as several engineers have since informed Dr. Morton, it was never designed to be lowered in flight, only on the ground. Engineer Paul Campagna comments: "The scenario of instability previously described (by Dr. Morton) in fact occurred on the CF-100, Mark IV prototype. The author seems to have gotten the two aircraft confused."

Were the engineers who designed the Arrow no better than Dr. Morton claims they were—or was he himself the victim of misinformation? And if he was misinformed, why? Like any journalist, Dr. Morton won't name his Ottawa sources, who, he says, "believed there was a lot more to the story than they were able to tell." He admits that he "was misled" about the design for the weapons pack, but contends that there were other problems which would still justify the description of the Arrow as "a magnificent airplane that had major flaws." He maintains that since the plane's weapons and avionics systems "were being bought off the American shelf" and had not been tested in flight, their incorporation would have caused major problems "that would have involved considerable redesign."

In this interview with **Engineering Dimensions'** editor Margaret McCaffery, Professor Morton explains why the story of the Arrow is itself flawed.

ED: *Do you think you will change your account of the Avro Arrow in subsequent editions of your books?*

Morton: I may reflect on this controversy. Particularly when you're dealing with contemporary history, you've got a very partial access to sources. You have people alive with very strong feelings and knowledge, which they may or may not share.

ED: *Would it be fair to suggest that your sources wanted to see an opinion expressed that the cancellation of the Arrow was the fault of the company and the engineering?*

Morton: They may have, although that wasn't how I approached them. I simply wanted to know if there was more to this than defenders of the Arrow have said. The problem with the Arrow is that it has become another myth of absolute perfection. When the politicians came to make their decision about the Arrow, though they had a lot of faulty information, they also had some facts, some of which we know, some of which we don't know. When I look at the story of the Arrow, which was only a quarter of a century ago, there's a great deal that's hidden. I'm denied access to what went on in Cabinet, in the Prime Minister's Office, in the Department of National Defence. What I'd like to see come out of this, and what I suspect my sources would like, would be access legislation being used to open up all the records related to the Arrow, including the decision to destroy the prototypes.

Who precisely ordered the destruction of the existing prototypes and why? It was an act of extraordinary vandalism and vengefulness and no one has formally taken responsibility for it. I'm told there were American arguments that the aircraft was flawed—although that may be the same sour grapes attitude that you've suggested. I think it was a tragedy that the opportunity to perfect it was never achieved.

ED: *Did you ever speak with Mr. Floyd, who was vice-president of engineering at Avro during this time?*

Morton: No.

ED: *What do you think his response would have been?*

Morton: Oh I know what it is, because I've received a copy of the letter he and a group of engineers sent to the *Toronto Star*. That's one of the reasons why I wrote the *Star* article—to see what response I'd get, who was willing to talk. I've learned a great deal since then.

ED: *It's been suggested that there's more on file in Washington about the Avro Arrow than there is in Ottawa. With the U.S. Freedom of Information Act, wouldn't it be easier to get information from Washington?*

Morton: Yes, but I was led to believe that if I saw what was on file in Washington I would have an even more hostile view of the Arrow. Arguments were certainly put up for the U.S. not to buy it. It would be inherently improbable that they would try to suppress a good aircraft to produce an inferior one. They would be more likely to try and acquire the technology for themselves.

ED: *In an ideal world, what kind of access to information would you want?*

Morton: Our Access to Information Act is a very imperfect document; in fact, it's worse than no access legislation. At several points in the '70s, beginning with the first cabinet order on access and ending with the Access to Information and Privacy Act, researchers found themselves pushed out of information sources that they had been able to use before. While the government of the day could proclaim in glowing terms that they had opened the books, in each case they had not.

The downside of a freedom of information act is the fear that people will prune the records. As a historian, in contrast to journalists, I would rather have the record complete and postponed for 20 years, than have it destroyed and available tomorrow.

The first fighter to replace the analogue system with digital electronics was the F/A-18 Hornet.

How effective was the Arrow fly-by-wire automatic flight control system? According to test pilot Spud Potocki, in a 60-degree climb, with full afterburner, he would shut down one engine and experience no expected sideslip or roll. The AFCS would compensate instantaneously. Automatic approaches and takeoffs were also successfully completed. The Arrow was the most modern interceptor in the world, clearly over 20 years ahead of its time.

The Engines

Due to problems in acquiring a suitable engine, Avro decided to fit the first five aircraft with the Pratt and Whitney J75, which would give the Avro subsidiary, Orenda Engines, time to complete development of the lighter yet more powerful Iroquois engine. The Iroquois was approximately 19 feet long and four feet in diameter. To reduce weight, it employed fewer compressor stages and was composed of some 20% titanium alloys overall. In producing the rotor blades from titanium, Orenda's subcontractor, Canadian Steel Improvements, patented a process of precision casting.

At a combined 60,000-lb thrust for an approximate 60,000-lb aircraft, the Iroquois would have provided a 1:1 thrust to weight ratio. This would have given the Arrow a better than Mach 2 speed and perhaps Mach 3, limitations due to structural heating, not lack of power.[5] On November 1, 1957, dry thrust runs at over 20,000-lb were demonstrated. Twelve days later, the Iroquois was flight tested on a four-engined B47 and proved that it alone could have powered this aircraft. Like the airframe, the Iroquois pushed the state of the art in engine technology. Unfortunately, it was never flown in the Arrow.

The Problems

As good as it was, the Arrow was not without some problems. During the flight test program, two significant accidents occurred. The first, on flight number 11, involved failure of the left main landing gear to extend properly, causing the aircraft to veer off the runway. During an approach landing of the second Arrow, all wheels on the main gear skidded, with subsequent tire burst. The aircraft again veered off the runway.

The resulting investigation showed that on this touchdown, the elevator had moved down, causing some backlift. This caused the pilot to overcorrect by applying too much braking pressure too soon, locking the wheels.

Other problems included failure of the nose gear door to retract and malfunctions with indicator lights and switches. Each was corrected in turn as the Arrow continued to meet and exceed specifications.

Jan Zurakowski, principal test pilot, stated that handling characteristics and performance agreed well with estimates. In flight number seven, he flew at 47,000 feet at Mach 1.52, while climbing. He indicated he was still accelerating and showing excess thrust available, and that handling was good. Pilot Jack Woodman, the only military pilot to fly the Arrow, said the aircraft was "...performing as predicted and meeting all guarantees."

The Consequences

In 1958, Canada had an aircraft industry that was among the best in the world. Many foreign engineers emigrated to Canada specifically to become part of "The Team." After cancellation, both Britain and the United States eagerly sought to get the Avro Arrow for research purposes.

In 1959, the brain drain reversed. Many Avro engineers went to NASA, including John Hodge who became associate flight director, Project Mercury, flight director, Gemini, and later flight director, Project Apollo. Likewise, Jim Chamberlin became head of the Space Task Group's Engineering Division. Jim Floyd, P.Eng., the man who largely conceived the overall program and who was vice-president of engineering at Avro, returned to Britain where he was consultant on the Concorde and other leading edge, high technology projects. Others went to McDonnell, Boeing and other aircraft manufacturers.

Back at Avro, the remaining 2,000 engineers continued on in various projects. One of these was the Avrocar, an experimental all-wing vertical take-off vehicle, completed for the U.S. Air Force. In 1962, Avro closed its doors, leaving a legacy of concepts and ideas, including a vertical take-off CF-100, a supersonic transatlantic transport, a spaceplane concept, and a monorail—testimony to the advanced thinking of one of the best engineering teams ever assembled.

Recently, some newspapers carried a story of one reporter's flight in an F/A 18. In it, he exclaims how far Canadians have come in aircraft technology, just 79 years after J.D. McCurdy's first flight in Nova Scotia. We were there 30 years ago—with a wholly Canadian product, the most powerful aircraft in the world.

Why Was the Arrow Cancelled?

A recently declassified U.S. Deputy Secretary of Defense memorandum dated June 1, 1960 says:

"Prior to the NSC (National Security Council) paper (December 1958) and following a visit of the President to Canada in July 1958, Canada took the following actions with the undertanding that her defense industry depended largely upon the U.S. channelling defense business into Canada; cancelled the CF-105 and related systems contracts; decided to make maximum use of U.S. developed weapons, integrated into NORAD; worked with U.S. toward a fully integrated continental defence."

What exactly transpired at the July meeting with the President? The Defense Production Sharing Arrangements were signed at this time. Was the Arrow program, because of its rising costs, a bargaining chip for less expensive American goods? Was the program effectively cancelled shortly after this July, 1958 meeting?

Oddly enough, after its first successful flights, a media campaign attempted to discredit the aircraft.[7] Perhaps the reprieve until February 20, 1959, was to allow the flight test program to prove how poor the aircraft really was, making cancellation more palatable and logical. The opposite proved to be the case. Could this be why Arrow number six was never allowed to fly and break that speed record? Could this be why six of the most advanced aircraft ever built, along with all memory, had to be erased?

And how well did the defence sharing arrangements program work? The same memorandum continues:

"The last quarterly meeting of the Production Sharing Policy Group

was held on 25 May (1960). Despite all efforts, over the period 1 January 59 through 31 March 60, Canadian defense business in the United States almost doubled that placed in Canada. Canada is not satisfied with these results, nor do they appear acceptable from our view."

Whatever the reasons for cancellation, the loss to Canada's engineering community and aviation industry remains incalculable. It is clear from international reports of the day that the rest of the world was highly impressed with the Avro corps of engineers and the Arrow. Thirty years later, it is time for Canadians and Canadian engineers to look back and be proud of this magnificent engineering achievement.

Do you have any memories of the Arrow—facts, figures, reminiscences or photographs? If so, send them to The Editor, Engineering Dimensions, 1155 Yonge Street, Toronto, Ontario M4T 2Y5. We'll publish an A... Memorial in our January/Febru... 1989 issue.

Paul Campagna, P.Eng., is the ele... tromagnetic environmental effe... (E³) engineer for the Directorate of Avionics, Simulators and Photogra... phy of the Department of Nation... Defence, Ottawa.

Acknowledgements

Jim Floyd, P.Eng., designer of the Avro Arrow, provided valuab...

Setting the Record Straight: The Designer's View

Margaret McCaffery

"I feel for the youngsters. In our day you could get on with the job and not worry about going over the precipice." Those hardly sound like the words of a man who has known overwhelming disappointment in "getting on with the job," yet they capture the spirit of the man who designed the C-102 jetliner—which the New York press claimed "licks anything of ours" —was vice-president of engineering for Avro Aircraft when it was building the CF-105 (Avro Arrow), and ended up consulting on production of the Anglo-French Concorde.

James C. Floyd, P.Eng., epitomizes the cheery "mustn't grumble" attitude of his native Manchester, yet he's a proud Canadian, who retired to this country after spending 20 years working in Britain following cancellation of the Arrow and the crumbling of A.V. Roe Canada. His concern for "the youngsters" has led him on a concerted campaign to set the history books straight if possible, and if not, well, he's written one of his own.[1] He is currently helping to set up the Canadian Aerospace Heritage Foundation which aims to build a full-scale replica of the Arrow and other Canadian aircraft for permanent exhibit.

What does someone who was responsible for the design of the Avro Arrow think about the criticisms of its abilities? Jim Floyd and other Avro engineers have expressed themselves eloquently to the publishers of Professor Morton's books, but he se... kind of misinformation as par... larger picture:

"High technology is, by its nature, difficult for the layman to adequately assess, and its wort... impact can only be fully appre... even by those who have to ensure survival, if it is properly and com... hensively presented. In the past, Canadian engineers have tended to a... low profile in the political arena... have rarely been consulted abou... long-term effects of the decisions... by the 'captains of industry' and political counterparts. As an exam... firmly believe that had Mr. Diefe... exposed to a proper and full-scale engineering briefing on the Jetliner pro... he would not have made the ... erroneous statements about the al... technical shortcomings of the air... which must have influenced his ... sion to abandon the project and ... later caused him considerable em... rassment, even within his own par..."

Although he refers to himself (w... twinkle in his eye) as "just a p... engineer" who doesn't know any... about politics, he was embroiled in... Cold War politics of the late 1950s... involvement with the Arrow. In ... interview with **Engineering Dimen... sions'** editor Margaret McCaffery... relives those days at Malton.

ED: *Why do you think Diefenbaker can... celled the Arrow?*

Floyd: Diefenbaker had the wors... vice possible. His main advice ... from General Pearkes, who was a... old soldier, but he didn't know a... thing about airplanes at all. He ... hoodwinked by a visit to the ...

Avro Arrow design team, left to right: Bob Lindley, chief engineer; Jim Floyd, vice president, engineering; Guest Hake, Arrow project engineer, and Jim Chamberlin, chief, technical design.

Photo: J.C. Floyd, P.Eng.

sistance in preparation of the article and supplied photographs of the Jetliner. Other photographs courtesy Department of National Defence and Arnold Rose, P.Eng.

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...re he was told that airplanes are ... and missiles are in and there'll ...er be another manned airplane ...ght by any air force.

ED: *Was it on the strength of that advice ... that Diefenbaker acted?*

...d: Oh no. It was such a complex ...ure, it was like a tree: even the ...es had something to do with it ...ng. There were four major reasons:

- ...iefenbaker could see the costs of ...Arrow rising. It isn't unusual for the ...s on high technology to be going ...ll the time; one of the prime ex...ples would be the Concorde, which ... the time it flew cost more than ...ble what it had been estimated at. ...e Arrow was going the same sort of ...y.
- ...eneral Pearkes had said we can ... justify this sort of a cost if we ...d sell it to the Yanks or the Brits. So ...went out, completely prematurely, ...ause you never sell an aircraft to a ...ign government before you've de...oped it yourself, and of course he ...e back with a no.
- ...hen there's this memorandum ...l Campagna brought back from ...shington (see p. 51). It's obvious that ...Americans had virtually insisted on ...e cancellation of the Arrow as part of ...s deal, long before Diefenbaker came ... and said that the Arrow was can...ed. That's a new one to me.
- ...hen the Americans were cutting ...n on their development of manned ...lanes. Although they'd put out a ...ification for the F-108, which was a ...y highly supersonic airplane, pro...ly as near to the Arrow as you can ... they'd cancelled it, because they ...en't too sure that manned aircraft ...ld be needed. The British govern...nt had put out a White Paper saying ... they didn't foresee that there'd be ... fighter aircraft designed from that ...nt on. So I really don't blame Diefenbaker for his uneasiness looking at the program. I would blame him, though, for the way he accomplished the cancellation.

ED: *Did you suspect that the program was going to be cancelled?*

Floyd: We suspected that there'd be some hiccup. In September 1958, we were told that the whole thing would be reviewed in March, so of course we were on tenterhooks. But the appraisal was done on February 20 and the cancellation came the same day. That was the biggest shock of the century. We were in a board meeting with John Plant (president of Avro Aircraft) trying to settle some very mundane union situation about seniority. Joe Morley (sales and service manager) came running down the corridor with a man from the DDP (Department of Defence Production) saying they'd heard on the radio that Diefenbaker had cancelled the Arrow.

ED: *So you heard about it at the same time as the general public?*

Floyd: Later than the general public—*they* heard it on the radio.

ED: *It sounds like the government had a gun to its head.*

Floyd: We were told to close everything down and that nothing would be paid as from that day. My first thought was to see if any of our other projects could be got into shape so I could keep my 1,500 engineers. I'd been pleading for years to get another project going at the same time as the Arrow, but Fred Smye (general manager), who was a most sincere man, felt we had a duty to do the best we could on that airplane.

ED: *I still find it very difficult to understand why it was ordered scrapped, especially when today we're all talking about technology transfer, joint ventures, etc.*

Floyd: You're in very good company. The first thing that I did was to get on to the RAE (Royal Aircraft Establishment) in the UK to see if they'd be interested in taking some of these airplanes and they said of course, provided we could back them up with parts. Well, we had 31 aircraft back through the plant in different stages of production, so we had plenty of parts. We'd even worked out a method of transportation over the northern route—and then the order to scrap came down. (This was mid-April 1959. Floyd had been ordered to scrap the Jetliner, his admitted favourite project, on November 23, 1956. Three years later, after setting up another first class design team at Hawker-Siddely, UK, where he led the feasibility study on the Concorde, Jim Floyd experienced the disappointment of seeing the design study for Concorde go to Bristol Aviation Corporation. Saying he didn't want to see another aircraft, he quit and took his family on vacation. On his return, his first call was from the minister in charge of the Concorde asking him to consult on the project. That one flew!)

ED: *What message would you have for today's engineers?*

Floyd: The best things I've learned have been about dealing with people to bring out the best in them. The old things I learned in England I rebelled against. I try to coax people rather than beat them over the head. Canadians are very flexible: treat them the right way and you can get anything out of them.

One of the things I'm trying to do with the Canadian Aerospace Heritage Foundation is to help young people get the incentive to do some of the things we tried to do. Today there seems to be an apathy, a sense of too many things in the way. I'd like to give the kids some hope.

Reference

1. Floyd, J. *The Avro Canada C-102 Jetliner*, Erin: Boston Mills Press, 1986.