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Canada's Avro Arrow

A Presentation by

Doug Hyslip – Oct 2003

References / Authors:

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With special thanks to:

Palmiro Campagna – P.Eng – Researcher & Author
James Floyd – P.Eng, C.Eng, FRAeS, FAIAA, FCASI, AMCT
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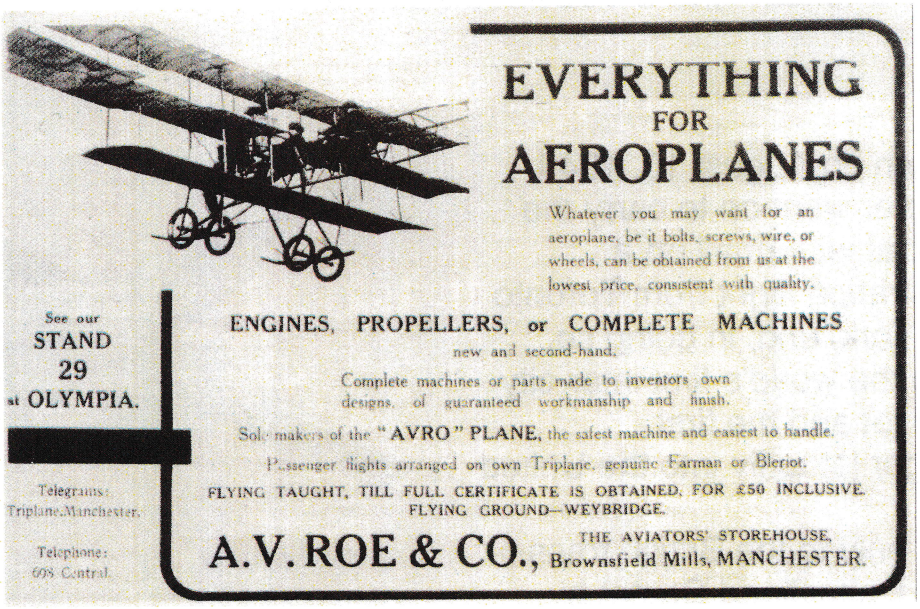
The story of Canada's legendary Avro Arrow of the 1950's can only properly be told in some context of world events of the day, and Avro's many other projects and accomplishments. It's an inspiring historical account of technological achievement that made A.V. Roe and Canada a world leader in aviation. It's also a twisted tale of world events and political decisions that led, not only to the premature loss of the aircraft, but the eventual demise of the company, and decimation of the Canadian aviation industry in 1959.



A.V. Roe & Company was a British corporation started on New Year's day 1910 by aviation pioneer, **Alliott Verdon Roe**. Although Canada later built Avro designed aircraft such as the Anson trainer and Lancaster bomber during World War II, it was in December of 1945 that the company itself came to Canada to rekindle the aviation industry and post war employment.

A.V. Roe Canada began operations in the wartime Victory Aircraft plant at Malton Ontario – now Toronto's Pearson International Airport. Post war Canada was a huge expanse of thinly populated country. Canada's national airlines were only just developing and used propeller driven aircraft. It was a time when most Canadians relied on the railway system, traveling the country by steam locomotive powered train.
Looking to seize on an exceptional opportunity, Avro Aircraft, the company's aeronautical division, immediately began the design and construction of what was to become the first jet powered transport aircraft in North America – the **C-102 Avro Jetliner**.

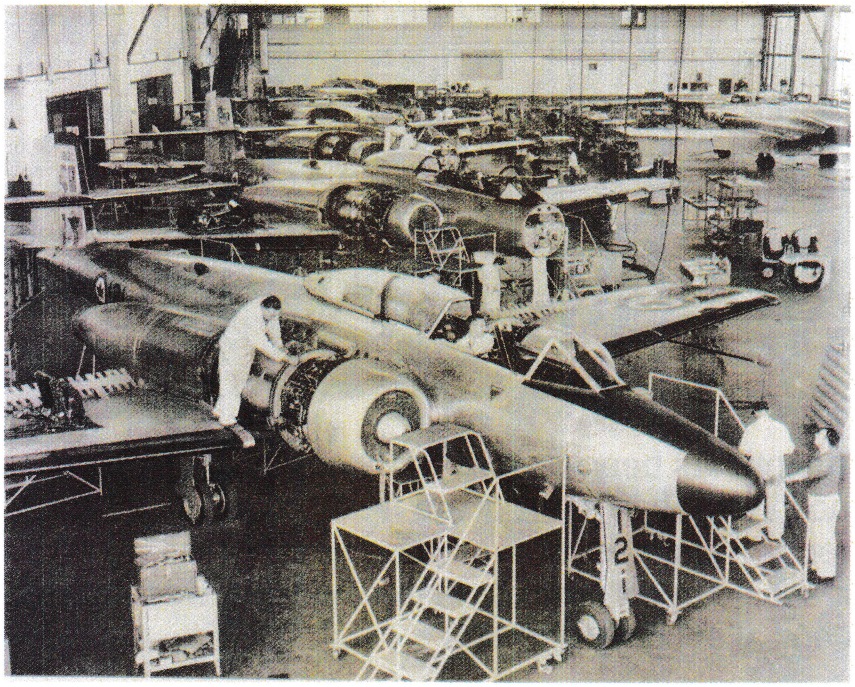
First flown on August 10, 1949, the Jetliner went on to carry the first official jet airmail on a demonstration flight from Toronto to New York, and, in doing so, became the world's first inter-city regional jet and the first passenger jet to fly into the United States.
Second only to the British trans-oceanic Dehaviland Comet by thirteen days, this innovative design, with a top speed of 500 miles/hour, was able to more than double both the speed and altitude of conventional transport aircraft – it was meant to be the first of an entire family of passenger and cargo jets.

The advent of jet transportation has been described by some involved, as the most significant advance in aviation short of the first manned flight. In that the Jetliner represented the first design of a brand new aircraft company, in a country not considered dominate in the industry, was, in and of itself, a tremendous technical accomplishment.

The Jetliner received rave reviews wherever it traveled, and U.S. National Airlines and Howard Hughes' Trans World Airlines amongst others, looked to contracting fleets of the aircraft. In fact, the American Air force approached the Canadian Department of National Defense in 1951 to purchase twelve Jetliners for military training. But the Canadian government never advised Avro of this all-important first order and instead instructed the company to stop all development of the aircraft.
In the end, the hand built prototype Jetliner was ordered destroyed after some seven years of corporate service to AVRO. Cut to pieces in December 1956, all that remains of this beautiful aircraft today is the cockpit section in the Canada Aviation Museum in Ottawa.

The Canadian Government had given economic priority to the urgent development of Avro's all-weather **CF-100 Avro Canuck fighter** with the intent of using them in the Korean war effort. Conceived in 1946, the Canuck was first flown in January 1950. It remains the only Canadian designed fighter aircraft ever to be mass-produced - some 692 were built.

Nine squadrons were stationed in Canada, four served with NATO Command, and 53 aircraft purchased by the United States under its Mutual Aid Program were delivered to Belgium in 1957. None were ever sent to the Korean conflict.

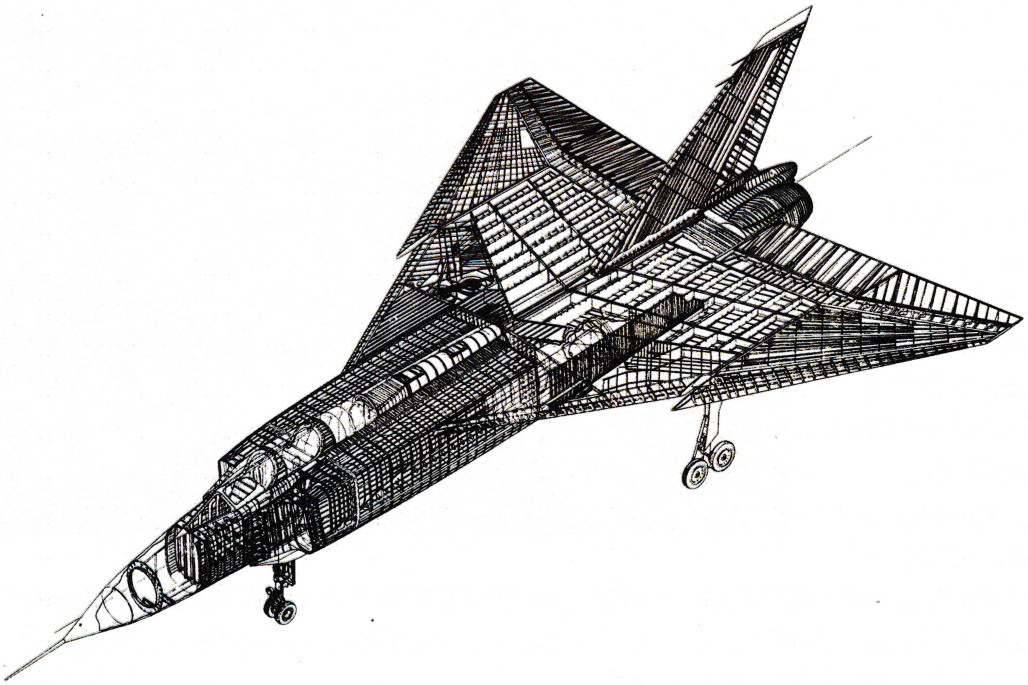


Decommissioned by NATO in December of 1962, the Canuck continued in selective service in Canada until 1981. Examples of the CF-100 Canuck are exhibited by museums across the country.

This 600-mph Canuck served as Canada's primary all-weather defense in the early 1950's, even as the escalating Global Cold War gave rise to the threat of Russian bombers attacking North America across the Canadian arctic.

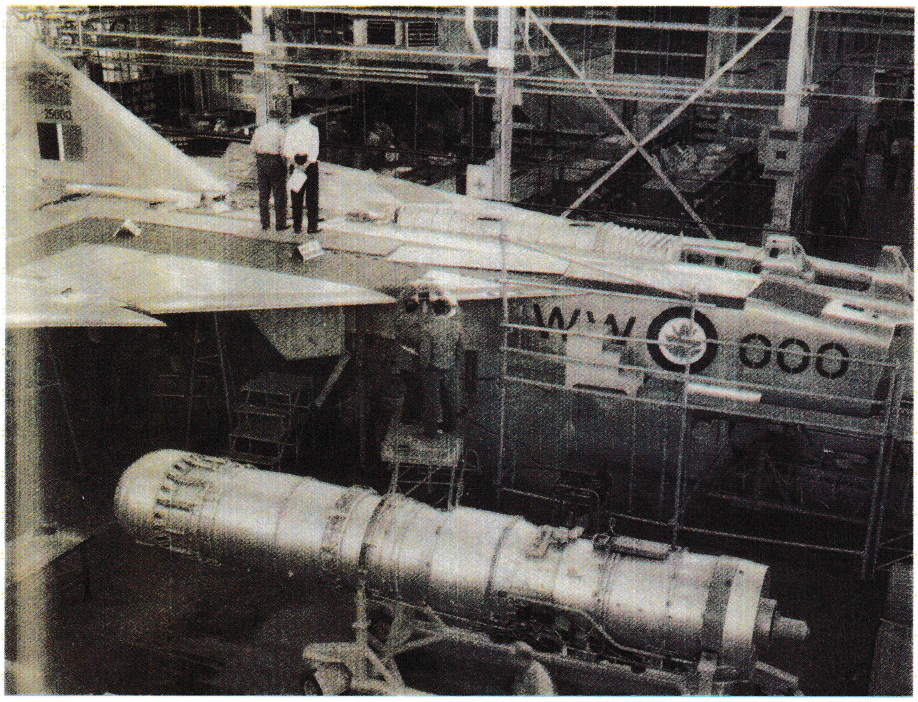
The Royal Canadian Air Force responded with specifications for a new interceptor aircraft so demanding that they exceeded all existing military aircraft. A search of manufacturers around the world revealed that no other country had a project, or design concept that would meet the Canadian requirements. Convinced of the need for such an aircraft, Canada undertook to produce the plane itself.

In April 1953, the Canadian Government commissioned Avro Aircraft to design and build a long-range interceptor capable of the high altitudes and supersonic speeds necessary to challenge, what was now, a growing threat of nuclear attack by supersonic Russian bombers.



With Cold War tensions building rapidly, Avro chose to forego the usual hand built prototype approach to aircraft design – it moved from the drawing board directly into the complex development of the test rigs, production tooling, assembly jigs and a new plant layout that would allow construction of even the first test aircraft.

Avro's unique approach had taken them straight into the production of 37 air force test aircraft to be followed by another 83 squadron aircraft.



There were however, obvious and substantial front-end costs associated with building the production tooling first. Regrettably, these facility costs were perhaps, never properly understood by government, as there was ongoing and contentious political debate over escalating "development costs" being attributed to Avro's supposed mismanagement of the project.

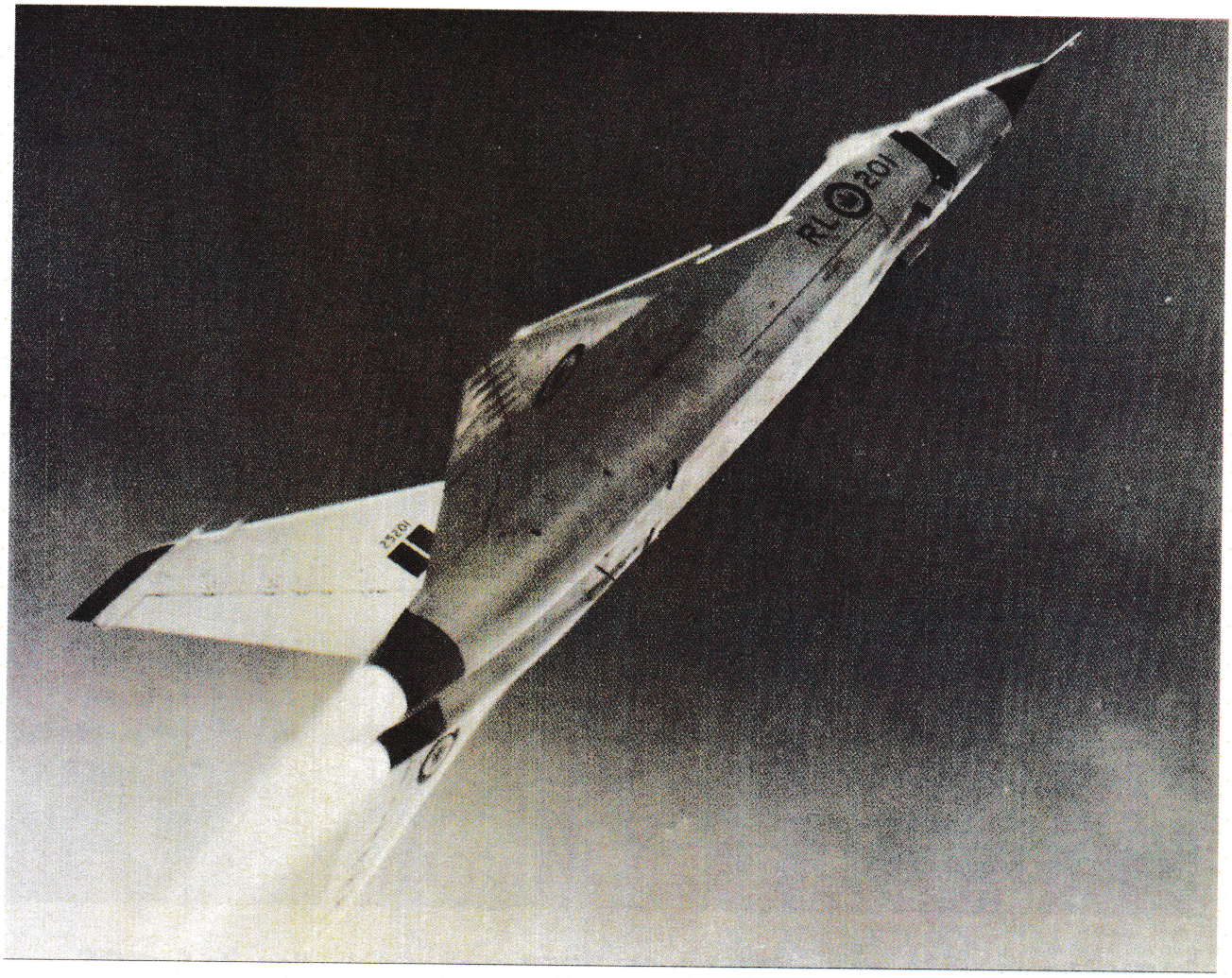
Historical records now show that Avro's apparent cost over runs were in fact, due more to an ever-changing national defense strategy and revised aircraft specifications by the RCAF - changes that required costly re-design and scheduling of not only the aircraft but the entire production facility.

It would appear that there was also seemingly endless political discussion of the supposed future cost of putting the aircraft into production after testing, when in fact, the test aircraft were actually production aircraft.

AVRO persevered, and on March 25, 1958 successfully flew its first **CF-105 AVRO ARROW**, an aircraft capable of speeds in excess of Mach 2 at 50,000 feet, or twice the speed of sound. The snow white Arrow, with it's delta wing, long clean lines and sparkling performance, has since become an icon of Canadian legend.

Although a mere corporate infant, Avro had proven it was able to compete with the development costs and schedules of even its most well established competitors.

The huge fuel requirement of the Arrow's interceptor role resulted in the aircraft being the size of a conventional bomber. With supersonic flight requiring the equivalent power of two Queen Mary steamships, the aircraft consumed a quarter ton, or some 100 gals of fuel per minute in supersonic flight.



Despite weighing some 60,000 pounds, the Arrow could climb from sea level at an astonishing rate of 35,000 feet per minute and on November 11, 1958 achieved a recorded speed of Mach 1.98 or some 1320 mph at only three quarter throttle.

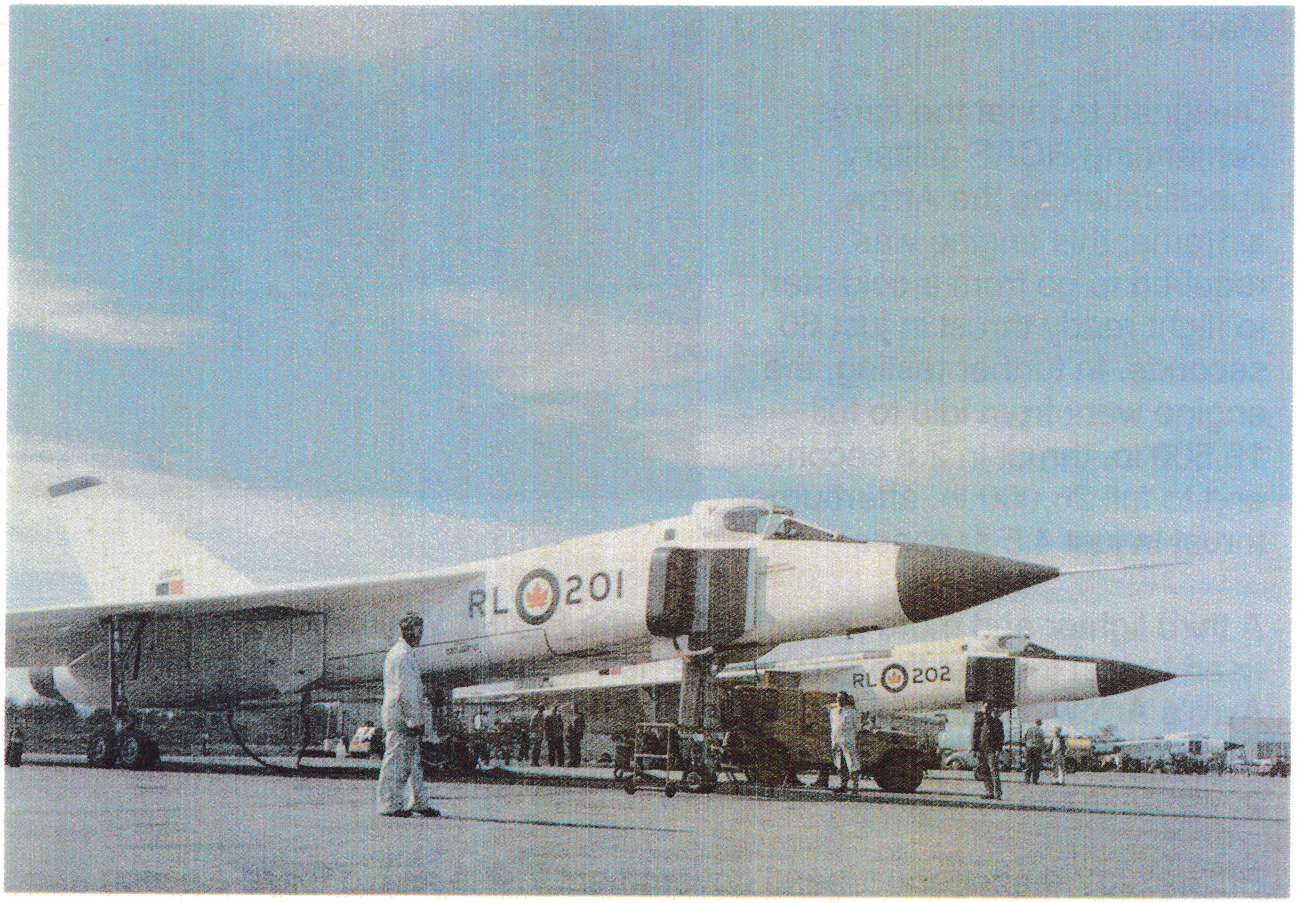
The Arrow embodied the best technology of the day and set new standards for design, testing, metallurgy, tooling, and production. Avro's Arrow had made Canada a world leader in aeronautical development.

Some facts about the Arrow:
- It was a true all weather interceptor
- Required only a two man crew
- Was the first rapid turn-around interceptor
- Had a fully computerized fly-by-wire flight control system
- Had aerodynamically clean internal weapons and propulsion systems

- It was designed for computerized weapons control systems
- It was the first intensive use of computers for stress analysis
- It was the first to use wing skins milled from billet material
- led to the development of new alloys and methods of working titanium
- Used an advanced flight simulator for training and flight testing
- Had jet engines capable of in-flight restart

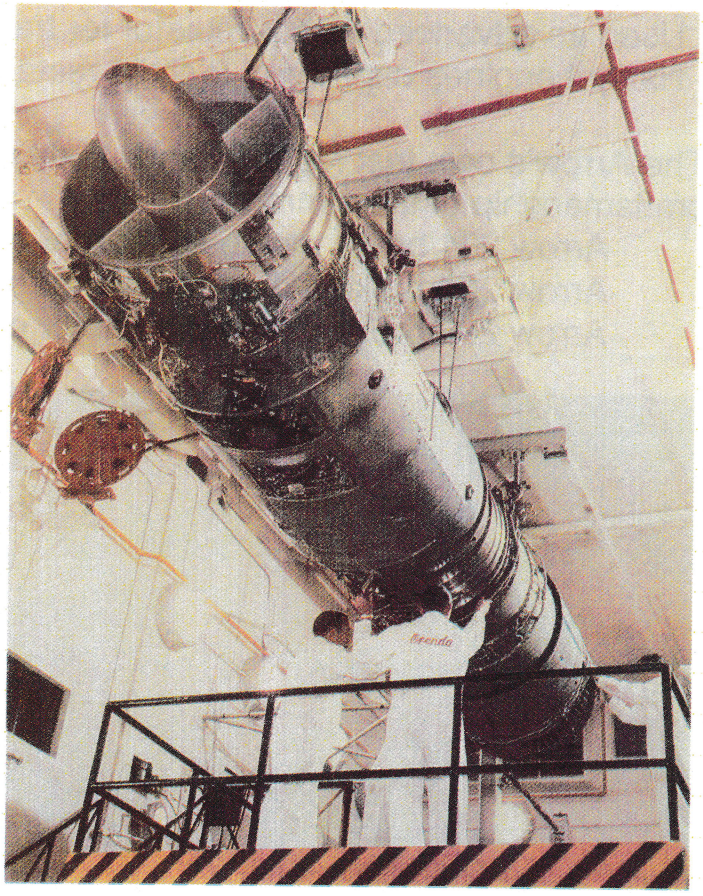
The Arrow's own test record stands testament to the superb design and craftsmanship of the aircraft:

Arrow 201 broke the sound barrier on only its third flight
Arrow 202 broke the sound barrier on its second flight
Arrow 203 broke the sound barrier on its maiden flight



At the same time, Orenda, Avro's sister company, was having similar success in building new turbine engine designs for aircraft and industrial use.

Although some Orenda industrial turbines may still be in use in the oil and gas industry even today, the ultimate Orenda aircraft engine was the Iroquois high mass turbojet, an engine capable of operating in the 350 degree Fahrenheit heat generated by flight in excess of Mach 2.



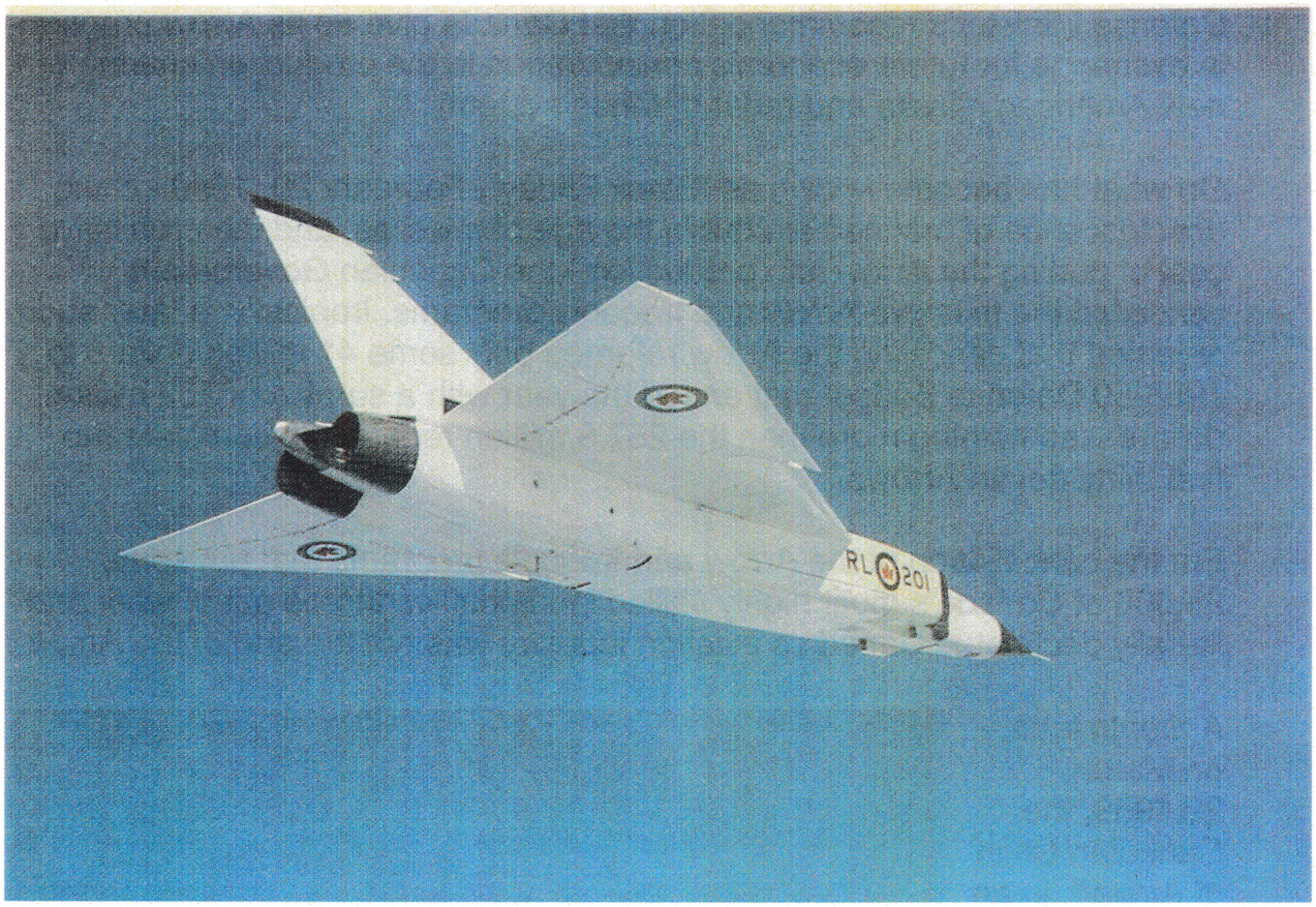
Designed to meet the same demanding RCAF military specification as the Arrow airframe, this engine was required to go from a cold start to flight ready thrust in just 60 seconds. In further testing, the engine went from idle to full 19,500 lb. thrust in 2.8 seconds and to full 26,000 lb. afterburner thrust in just 4.5 seconds.

A third lighter and more powerful than the Pratt & Whitney J75 engines used to test the first five Arrows, the new Iroquois engine was to make Avro's Arrow capable of setting new world speed and altitude records for Canada. France was going to place an order for some 400 of Canada's powerful Iroquois engines for its new Mirage fighter aircraft.

But in 1957 the federal Liberal government lost in its bid for re-election and the Progressive Conservative Party took power with a new political social platform and yet another defense strategy against nuclear attack.

In September of 1958, the Prime Minister of Canada announced plans to acquire the new, but yet unproven, American made Bomarc missile in a combined defense of North America. In reality the Bomarc missile system

with a range of only 350 miles, was but an extension of the defense of the United States, as the nuclear-armed enemy was to be intercepted by nuclear Bomarc missiles over Canadian territory. Records show the RCAF still wanted the Arrow interceptor with its 700-mile subsonic range.
But Canada's Defense Minister of the day soon came to realize that Canada could not afford both the Arrow and the Bomarc. He was later to recount how, while traveling with the U.S. Undersecretary of Defense, his lament about the high cost of developing the Arrow was met by an assurance by the Undersecretary, that the U.S. had lots of fighters, and that Canada could rely on the United States for interceptor defense if required.



Over time, this thinking led to a new Canadian defense policy - one that required convincing Canadians that Bomarc missiles would be cheaper than the Arrow, and manned interceptors in general, were obsolete in the supposed "new age of missiles".

This new position was at total odds with the strategic defense plan of it's North American ally – the American Secretary of Defense having publicly declared on January 22, less than a month before Canada's cancellation of the Arrow, that their own Cold War defense strategy would, by priority, include:

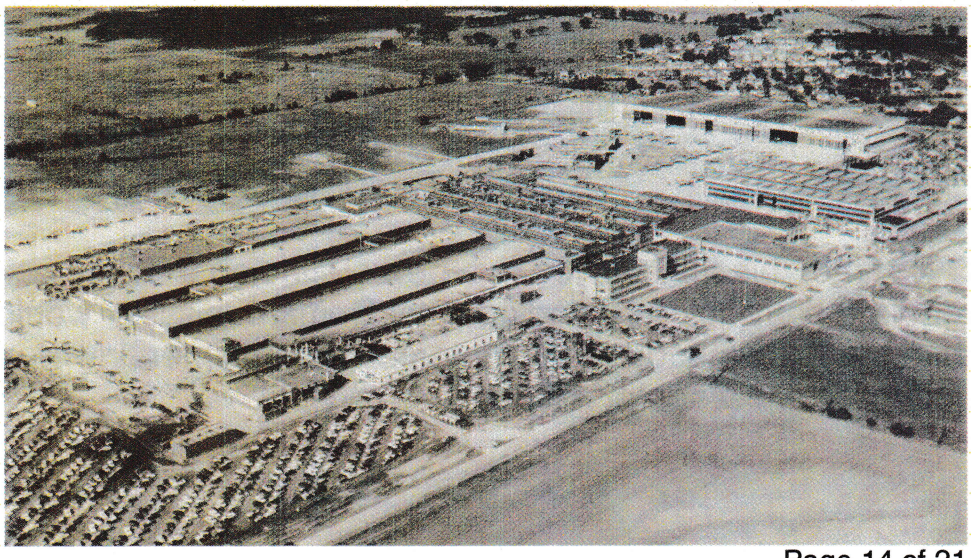
1 – Manned interceptors,
2 – Bomarc missiles and
3 – An expanded radar net (to later be known as the Dew Line)

Embroiled in a multitude of international defense agreements also looking to missiles, Canada was to apparently forego any credible analysis of its own defense needs and/or strategy – government ultimately accepting the Defense Minister's recommendation that Canada give up its Arrow program in exchange for future economic consideration in the production sharing of new American missile and radar defense systems.

On what has become known as "Black Friday", February 20, 1959 - citing obsolescence of manned aircraft in the age of missiles, and the prohibitive cost of putting the Arrow into production - the Canadian Government cancelled the massive Arrow and Iroquois programs. Ironically, a later audit revealed that canceling the Arrow returned only some 41 million dollars to a 1958-59 Defense Budget that ended the year with a surplus of 262 million dollars – something more than the 257.8 million required to complete the first thirty-seven Arrows.

But the cancellation of the Arrow and Iroquois programs that put some 25,000 of Canada's most highly skilled industrial workforce out of work and literally decimated Canada's aviation industry was not the end of the Arrow.

A month later, on March 29,1959, the Canadian Chief of Airstaff, in an extraordinarily simple memo, recommended to the Defense Minister that the entire Arrow

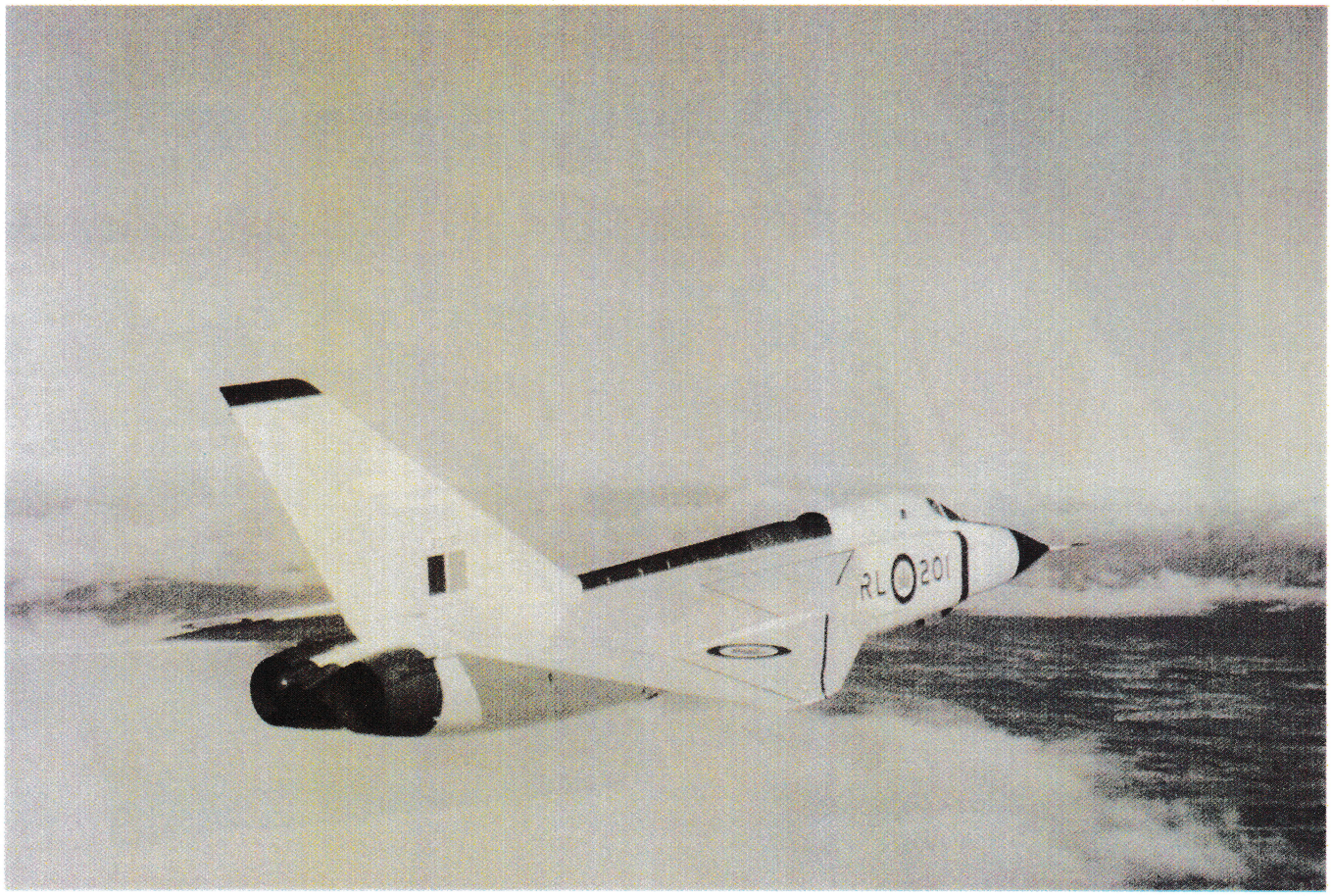


program be immediately reduced to scrap to “avoid the embarrassment of the airframe and engine being placed on public view or even, in fact, used as a roadside stand”.

In April 1959, the five Mark 1 Flight Test aircraft, the five Iroquois powered Mark 2’s in final assembly, and the 27 other Arrows in major sub-assembly were ordered destroyed, along with all production tooling and engineering and test data.

The only recognizable remains of Canada’s Arrow, arguably the world’s most advanced military aircraft of the time; was, like the Jetliner before it, reduced to a single cockpit section in the National Aviation Museum in Ottawa.

Two years after the Arrows were physically destroyed, C.A.R.D.E – the Canadian Armament Research and Development Establishment released its study of the Arrow test program. They found that the Arrow had indeed met 95% of its specification in only 72 hours of actual flight-testing. This can only be considered a remarkable feat of design engineering and manufacturing.

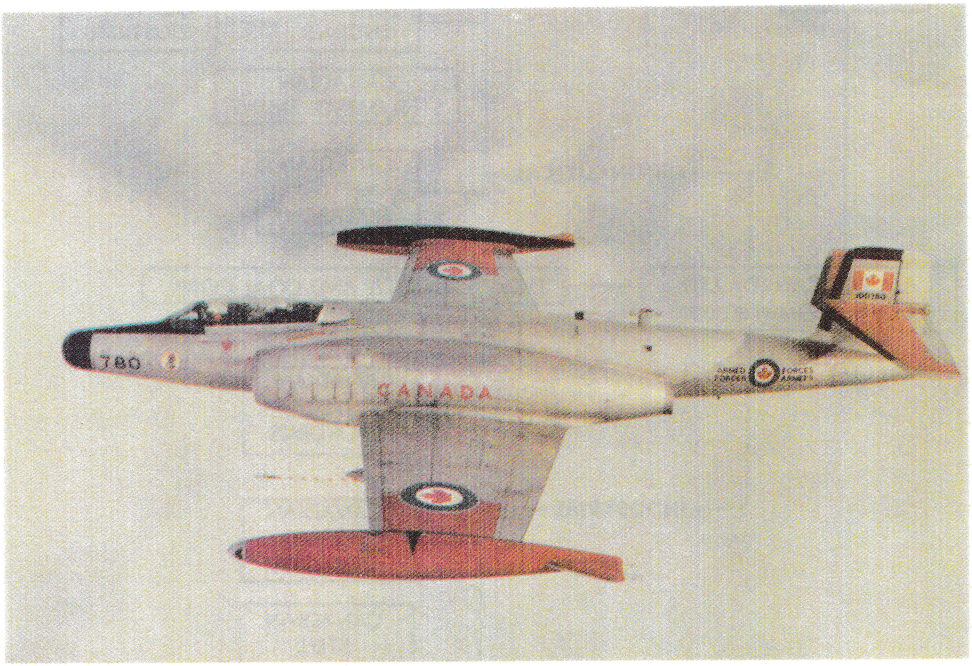


But the reality was that after canceling the Arrow, the country was essentially defenseless without a supersonic interceptor or working missile system. Now under intense pressure in Cabinet, the Prime Minister admitted, that to turn around and immediately buy American aircraft after trying to convince the Canadian public of the wisdom of canceling the Arrow would be a tremendous political embarrassment.

So, as a stopgap measure, the Defense Minister announced that the Americans were to be allowed to conduct military aircraft exercises in Canada. Although the political defense agreement was common knowledge, no one was ever meant to know the reason for this agreement

was that the Bomarc missile system was still failing in testing and that Canada, without it's supersonic Arrow interceptor, was essentially defenseless. For some 2½ years during the height of the Cold War with Russia, Canada was in effect, being defended by the United States.

While the cancellation was a fatal blow to the company, the termination of the Arrow program led to a multitude of situations and decisions that would affect the country and the aviation industry.



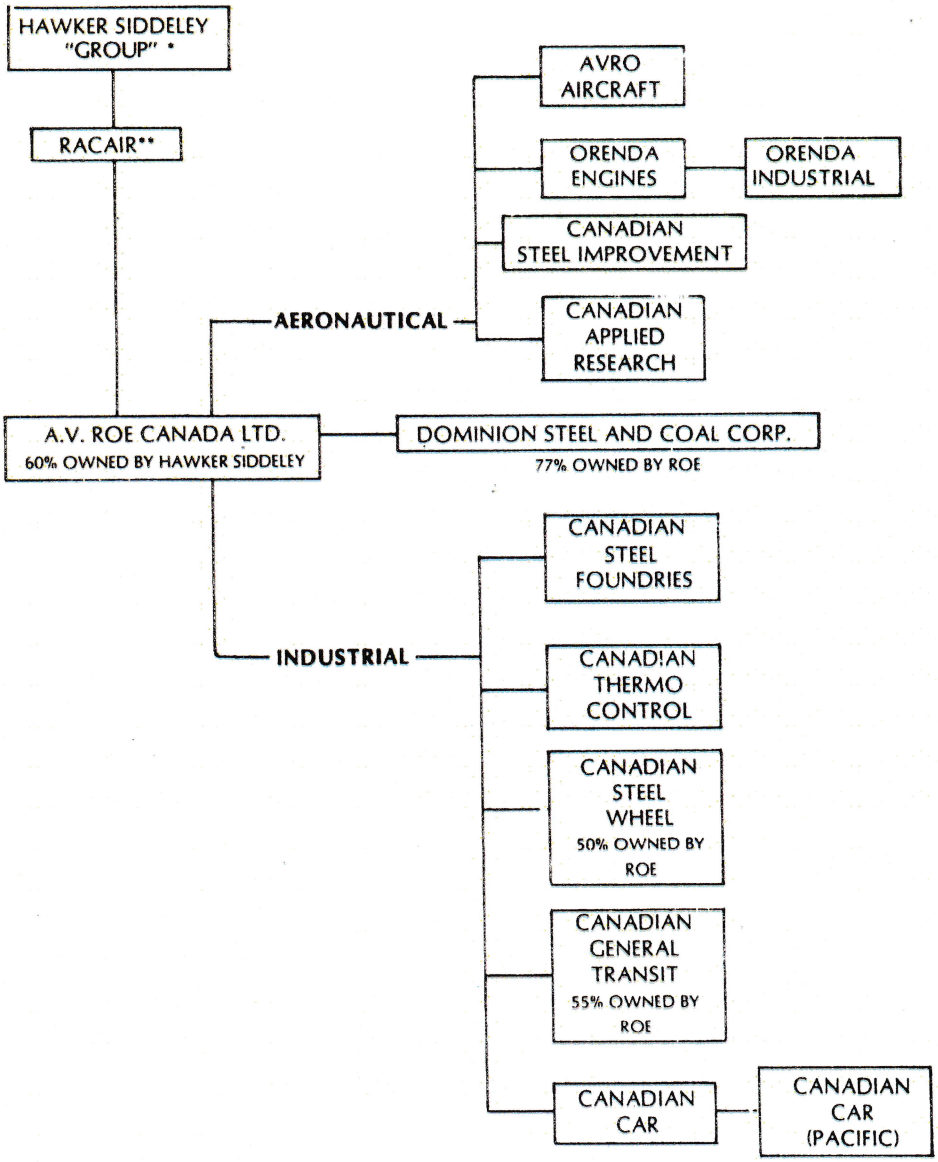
Ironically, Canada had chosen to destroy its only supersonic defense aircraft (Arrow) to keep the subsonic Canuck, which, only months later in 1960, reportedly struggled to intercept Boeing's new 480-mph 707 passenger jet.

Only months after canceling the AVRO Arrow because manned interceptors had been deemed obsolete in the so called missile age, the Canadian Government awarded Canadair in Quebec a contract to build 214 American F-104 Starfighters under license.

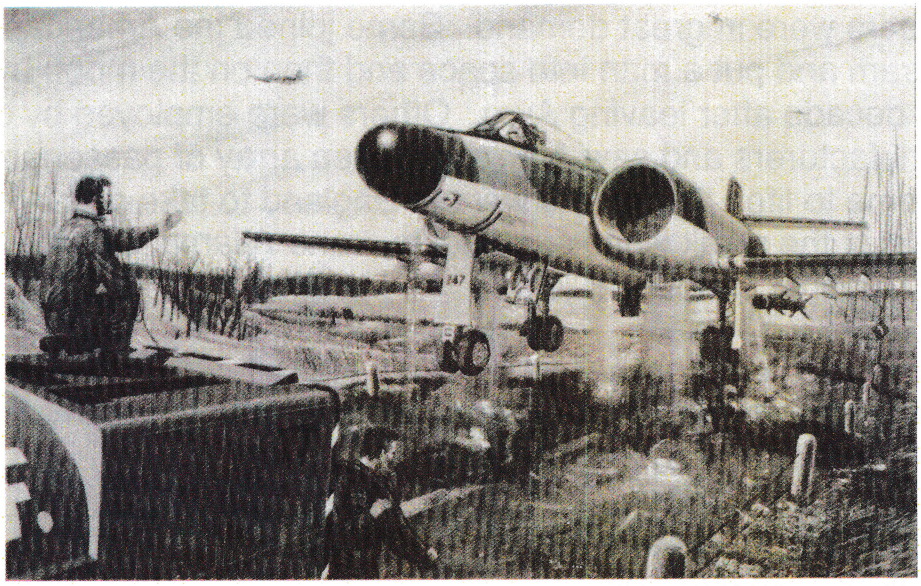
In June 1961, some two years after canceling the Arrow, Canada agreed to buy an additional 66 surplus American F-101 Voodoo aircraft.

Regrettably, the American Bomarc missile technology that presumably forced the cancellation of the Arrow program continued to fail in testing and was abandoned by the United States by 1964, even as Canada's two Bomarc bases were becoming operational.

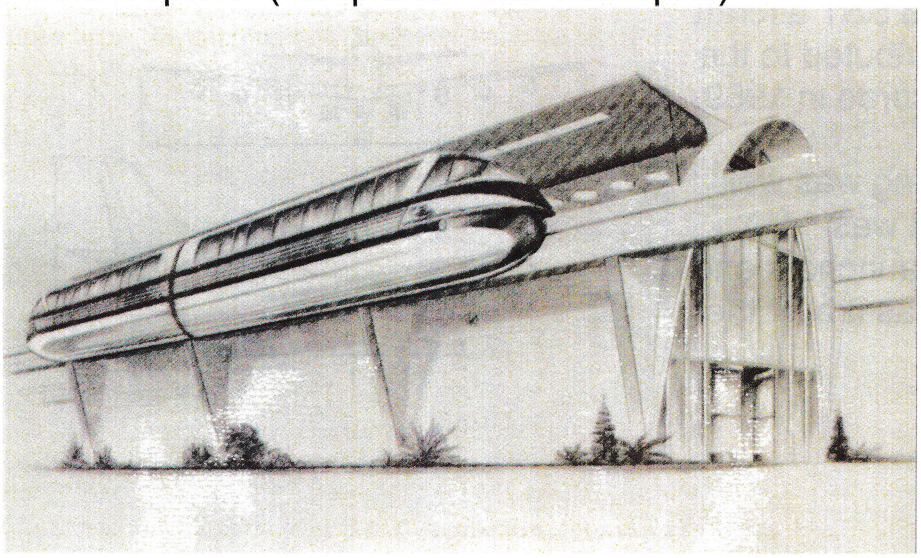
The promised Canada-US economic agreement on joint defense production never materialized because the Americans believed that Canada did not have the industrial base or national security to protect American advanced military technology from enemy spies.



At the height of the Arrow project, A.V. Roe Canada was a conglomerate of 12 companies and Canada's third largest employer. But in 1962, with the Jetliner, Arrow and Iroquois destroyed, and Canuck production ended, the AVRO plant at Malton, Ontario was sold and little of our AVRO heritage remains.



Regrettably, Avro's many concept projects died on the drawing board:
- vertical takeoff and landing aircraft
- business jets
- long range transport jets
- gyroplanes
- Avrocar – ground effect vehicle for the U.S. Army
- tank and anti-tank missile systems
- ship-borne missile systems
- Bola-Copters (half plane – half helicopter)



- mono-rail transit system,
- propjet conversion of aircraft (modern turboprop)
- air cargo studies
- subsonic jet trainer aircraft
- supersonic Transport
- supersonic trans-Atlantic transport studies
- Avro Orbiter (Arrow launched satellite)
- Space threshold and re-entry vehicles

Avro engineers were in great demand. Some joined the American NASA space program and put a man into space and then on the moon by 1969, less than a decade after leaving Avro. Others were employed by different aircraft manufacturers and saw Avro's forgotten array of passenger jet concepts come to life. Still others went to England to take part in the development of the sleek white supersonic, trans-Atlantic Concorde. The world's only Mach 2 passenger jet.

Avro's design engineers possessed a vision of the future. The aviation industry's modern, short range Regional Jet is but the re-incarnation of Avro's intercity Jetliner concept of 1949.

The 2002 announcement by a major aircraft manufacturer that they would build a huge double-decked, long-range passenger jet to fly the long routes such as New York to Paris or New York to Rome is but the conclusion of a project conceived in a feasibility study completed by Avro in March, 1956.

Avro's Super Sonic Trans-Atlantic Transport studies and SST aircraft concept of 1959 contributed to the first flight of the Concorde in 1969.

Obviously Avro thinking was well ahead of its time as it was envisioning satellite launchers and space vehicles even as it built the futuristic Arrow.

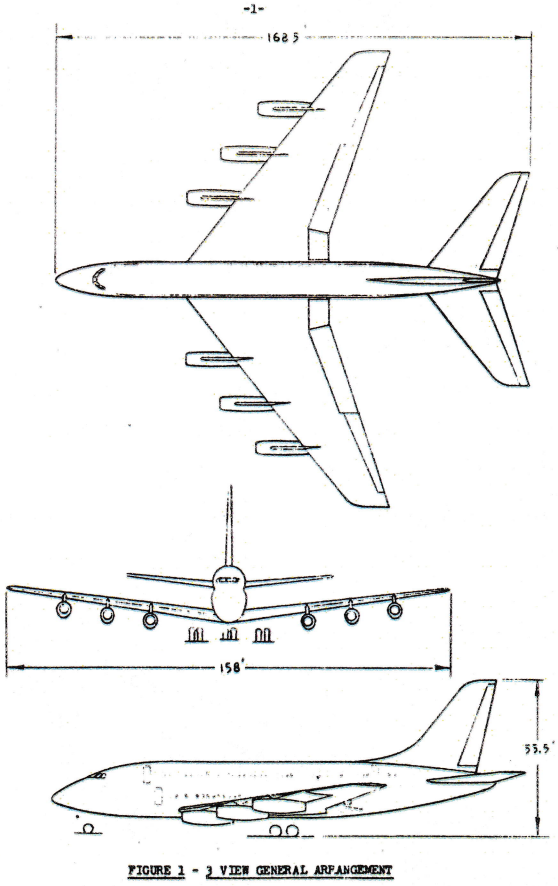
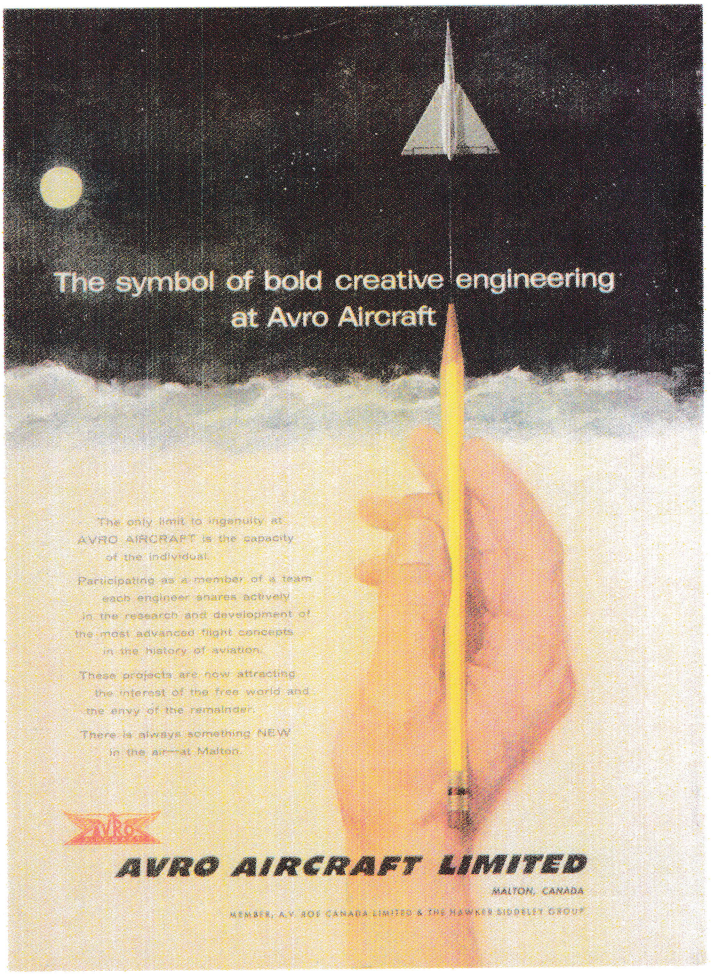


FIGURE 1 - 3 VIEW GENERAL ARRANGEMENT

Most of the people who worked on these projects recounted their time with AVRO and Orenda as the most challenging and exciting time of their careers, and for some – their lives.

Avro/Orenda succeeded by never accepting the notion that what they were attempting couldn't be done or that they wouldn't be able to do it.



It is the Avro Museum's hope, that by preserving this legacy of Canadian achievement, that the dream of extraordinary achievement will live on, and that it will inspire future generations of Canadians with the confidence to challenge themselves if not the world.