# MADE FOR CANADA

## The Story of Avro's Arrow


by Joan Dixon
and Nikolas Dixon Kostyan
with the A.V. Roe Canada Heritage Museum

DEAR DOUG N DONETTE,

OCT 11/2001

HOPE THE COMMENTS ON THE BOOK ARE O.K. AND IN THE RIGHT PLACE!

GOD BLESS.

Jim

# MADE FOR CANADA

## The Story of Avro's Arrow

*Dedicated to the Canadian men and women*
*who accomplished the seemingly impossible.*

A great book for young Canadians to be made aware of a special period in Canadian history in which their parents, grandparents and other family members and their colleagues took on the world to become acknowledged leaders in the field of aviation technology.

**by Joan Dixon and Nikolas Dixon Kostyan**
**with the A. V. Roe Canada Heritage Museum**

Congratulations to all who contributed to the production of this excellent book.

Jim Floyd. Oct 11th/2001

Former V.P. and Director of Engineering
Avro Aircraft
Canada.

MADE FOR CANADA
The story of Avro's Arrow

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(Some of the Avro employees hoping to see the Arrow fly.)

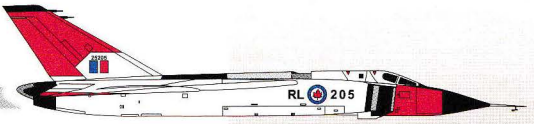
# CANADA IN THE 1950'S


Flying across the North Pole is the shortest route between the Soviet Union and the United States. This route puts Canada in between the two major enemies of the Cold War.

In the 1950's, Canada had two of the world's most powerful countries as neighbours—the United States and the Soviet Union. After World War II ended in 1945, these two countries became enemies in a different kind of war, the Cold War.

The Cold War was not a "real" war with armies and battles but a time of extreme tension and poor relations between the governments of the two countries. One side, the Western powers (including Canada, Britain and led by the US), believed in capitalism and democratic government. On the other side of the so-called Iron Curtain was the Eastern European bloc of countries, dominated by the Soviet Union. They followed a communist style of government and economy. Each side wanted to impose their beliefs on the rest of the world by propaganda or force. Relations between the sides were cold—neither side trusted the other. Spies lurked everywhere, trying to find out the other side's military plans.

By the mid-1950's, a new kind of warfare was expected to break out at any time. The recent invention of the nuclear bomb, which could wipe out an area as large as Ottawa in an instant, had added a frightening new dimension to war. No country was safe when the possibility of world destruction seemed so real. Canada was in the direct line of fire if the Soviets flew the shortest route, over the North Pole, to drop bombs on the United States. How would Canada




defend its own people, its vast land and its independence?

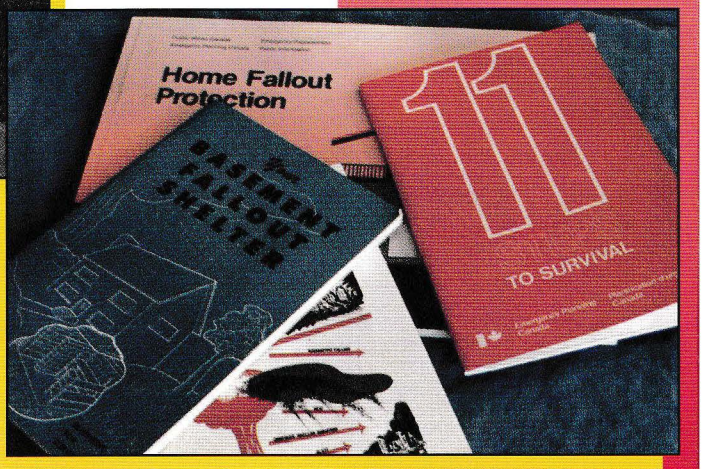
In this Cold War, the key strategy was "deterrence." Both sides raced to build more effective weapons and bombs, to discourage the other side from starting a real war. Air supremacy during World War II had been won by extraordinary planes such as Spitfires, Hurricanes and Avro's Lancaster bomber. Canada's air force, the Royal Canadian Air Force (RCAF), argued to the Canadian government that it needed its own extraordinary airplane to be prepared for the next war—one made especially for Canada.

### *We could be bombed!*

*Imagine being startled in class by the loudest siren you've ever heard. It wails for five minutes, not just at your school, but across town, everywhere. You don't know if the alarm is just a drill or for real this time, so you duck under your desk to protect yourself from the debris of exploding bombs. Pressing your head into your lap, you cannot breathe or see, but you can feel ... pure fear. Believe it or not, in the 1950's, these "duck and cover" exercises were routine in Canadian schools.*

An aerial view of
empty and unprotected northern Canada

During the Cold War, the Canadian government advised people to protect themselves by building bomb shelters and stocking them with battery-operated radios, blankets, mattresses, clothes and enough canned food for two weeks.



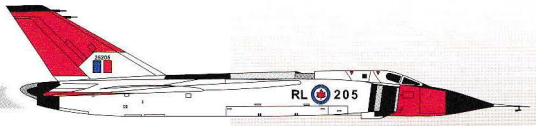
# "WE CAN DO IT!"

Lancasters (above) and Spitfires (below) were aviation heroes in World War II but they weren't equipped to fight the new kind of war brewing in the 1950's.

Canada's 10 million square kilometres (4 million square miles) of land and weather extremes have always made defence strategy complicated. Its vast territory stretches from sea to sea to sea, and much of the north is unpopulated and has no facilities for aircraft. The variety in temperatures—it can be 35°C in the south and -60°C in the north on the same day—is hard on aircraft.

In the early 1950's, most military planes were still designed for smaller and milder combat zones. Planes were able to travel at high speeds or for long distances, but not both. In Canada, the RCAF needed a plane that could do both—an attack plane that could travel long distances quickly to catch and destroy enemy bombers coming over the North Pole—a combination fighter-interceptor plane.

When the RCAF told the major aircraft companies in North America and Europe what it wanted, most aeronautical engineers said "Impossible!" A new Canadian company believed it could meet the challenge. A. V. Roe Canada had formed after the war, and it was ambitious. Jim Floyd, A. V. Roe's vice president of engineering, and his team decided that they could design and build their own Canadian super-plane.




"The Royal Canadian Air Force have asked for the 'moon', but we can do it." Inspired by Jim Floyd's words, A. V. Roe's aeronautical designers and engineers tackled their assignment. This was Canada's chance to lead the world and, at the same time, defend North America from attacking bombers. The super-plane, officially designated CF-105, was going to be called the Arrow because of its shape and purpose. It would be years ahead of its time. So in 1952, A. V. Roe Canada began designing the most famous plane in its history.

### *The impossible*

*The RCAF wanted a plane that*

- *could fly in all kinds of Canadian weather, day or night*
- *could take off and land on a short runway (not specially built longer military runways)*
- *could fly long distances without refueling or needing ground support (there were no airports in the Arctic!)*
- *was supersonic (faster than the speed of sound) to cover long distances in the shortest time possible*
- *could fly high enough to intercept the next generation of Soviet bombers*
- *could make steep turns at supersonic speed without losing speed or altitude (even fighter planes today have trouble with this)*
- *could carry and operate its own sophisticated radar and weaponry*

1959 AVRO ARROW

*18,300 m (60,000 ft)*
*2100 km/h (Mach 2)*

1954 AVRO CANUCK

*13,700 m (45,000 ft)*
*1000 km/h (Mach 0.94)*

MODERN PASSENGER JET

*10,600 m (35,000 ft)*
*870 km/h (Mach 0.82)*

MOUNT EVEREST

*8,800 m (29,000 ft)*

CN TOWER

*610 m ( 2000 ft)*

Comparisons of altitudes and maximum speeds (approximate numbers)

# THE A. V. ROE STORY

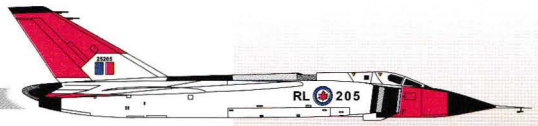
"Avrotown" was what people called Malton, a small town and railway station about 35 km north of Toronto. It was where Avro's plant was located, along with its hospital, fire hall, mini-city of houses, even schools for children of Avro workers. Now it's the site of Toronto's international airport.

During World War II, the Canadian government's Victory Aircraft had helped the British aircraft company A. V. Roe keep up with the demand for the Avro Lancaster bombers. The Lancaster was one of the planes credited with helping win the war. By the time the war was over, the Canadian plant had built 430 Lancasters. A. V. Roe recognized the high quality of the planes built in Canada, so, in 1945, it bought Victory Aircraft.

A. V. Roe Canada was in the perfect position to become a world-leading builder of aircraft. It had the experience, the plant and, best of all, easy access to materials, such as aluminum, in Canada. The company could also hire the best engineers in the world because many were available now that the war was over. Jim Floyd, one of the designers of the Lancaster, was recruited from A.V. Roe in Britain to join the fledgling Canadian aviation scene.

By 1955, A. V. Roe had grown and split into several divisions. Its aircraft division became known as Avro Aircraft. Avro employed about 14,000 people (known as Avroites) at its Ontario plant and built almost a thousand houses in the Malton area that was often referred to as Avrotown. When shifts changed, the plant created the worst traffic jams in Canada. Working for A.V. Roe was exciting and rewarding. Avroites never wanted to be late!

A. V. Roe's first project in Canada had been converting its Lancaster bombers into propeller-driven Lancastrians for passenger travel after the war. It soon bought the engine research company that became its Orenda engine division. A.V. Roe was then able to combine Orenda's recently developed jet engine with Avro Aircraft's new airplane design, the Canuck.



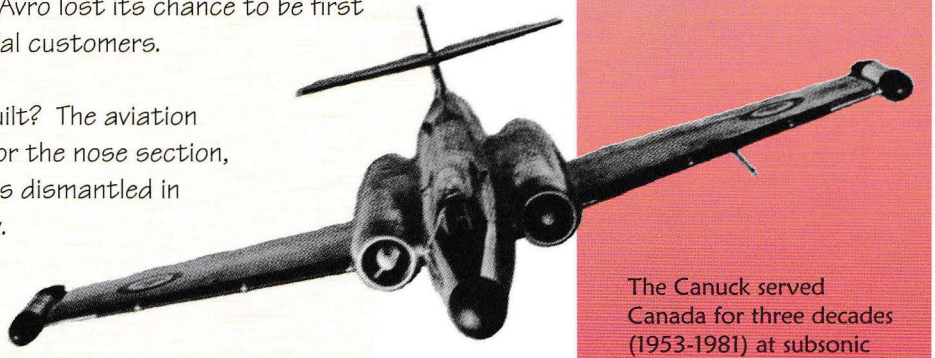

## The Jetliner (C-102)

Avro Canada's remarkable Jetliner, an older cousin to the Arrow, was a plane of many firsts. It was Avro' s first aircraft design project as a Canadian company and the first jet transport designed, built and flown in North America. The Jetliner was also the first passenger plane in North America to fly faster than 800 km/h (500 mph)—incredible for its time. On April 18, 1950, the Jetliner became the world's first jet to carry airmail, taking just half the time it took a propeller-driven aircraft from Toronto to New York. And there was only ever one prototype made.

On August 10, 1949, the Jetliner became the world's first regional passenger jet.

Unfortunately, the Korean War broke out in 1950 and the Canadian government demanded that Avro concentrate on finishing the CF-100 Canuck fighter jets for this war. Jets for civilians could wait. But by waiting, Avro lost its chance to be first in the world as well as its commercial customers.

What became of the only Jetliner built? The aviation museum in Ottawa only had room for the nose section, so the rest of the historic plane was dismantled in 1957—a Canadian aviation tragedy.



The Canuck served Canada for three decades (1953-1981) at subsonic speed. It was the first military jet to be completely designed, developed and produced in Canada.

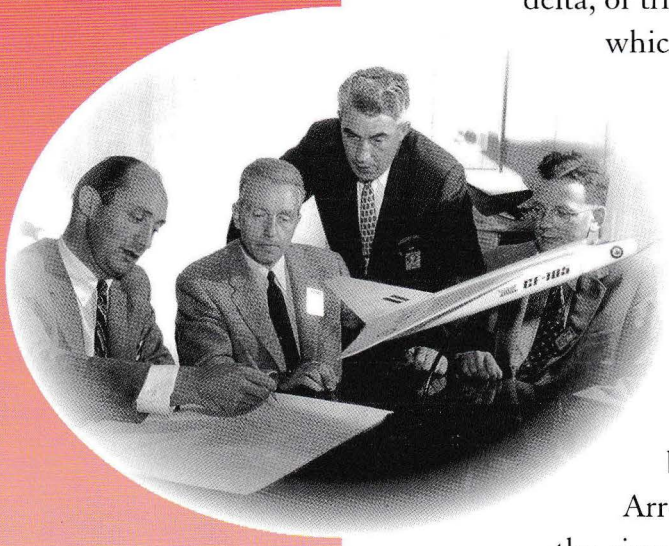
## The Canuck (CF-100)

The path to the Arrow started in 1946, with the Canuck, Canada' s first attempt at building a fighter interceptor. It was a traditional straight-wing, heavy airplane, but it was fast for its day, with the powerful new jet engines built by Orenda.

Nicknamed "the clunk," the Canuck wasn' t pretty to look at, but it was functional. Heavily armed and indestructible, it could fly in all weather. In 1952, the Canuck became the first straight-wing fighter to manage supersonic speed, but that was in a dive only. The Canuck was the only aircraft to be in full production at Avro and see active service—692 planes were built and 53 of these were flown by Belgium's air force.

# BREAKING THE RULES

The young, creative engineering team at Avro used a combination of art and science to come up with the Arrow's unique-looking, aerodynamically fast design. Jim Floyd remembered saying, "The Arrow will make the Canuck look like it is standing still." To most people, the triangular design of the Arrow made it look more like a spaceship than an airplane. Huge delta, or triangular, wings blended into the body of the plane, which had no tail just a fin, to maximize speed.



The team coordinating the Arrow project:

Bob Lindley, Chief Engineer;
Jim Floyd, Vice-President and Director of Engineering;
Guest Hake, Project Designer;
Jim Chamberlin, Chief of Technical Design.

"Gentlemen, this has never been attempted before. But sometime in the future, it will be done. Let us do it now."

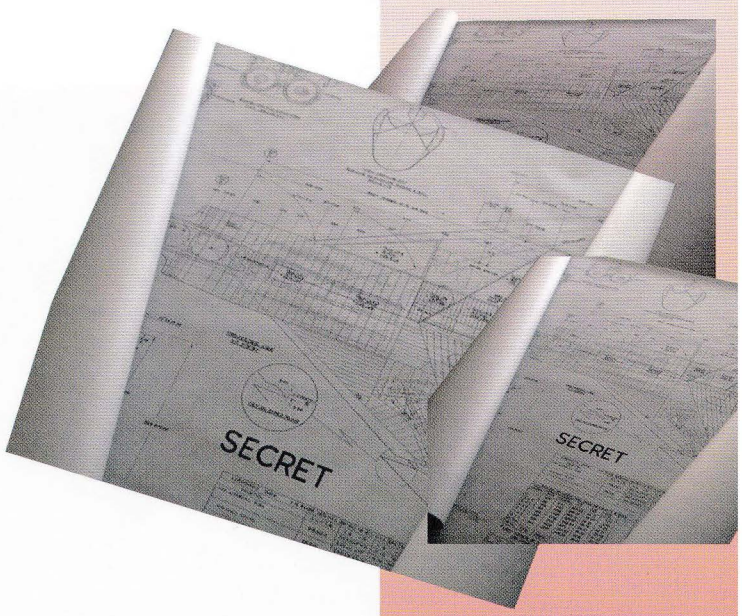
Flying supersonic had long been the dream of aircraft builders. Research in Europe and the US at the time showed that the Arrow's supersonic tail-less, delta-wing design might be radical but it would work. The Arrow was going to be one of the first planes to test the design.

Not only did Avro's aeronautical engineers have to break the generally accepted rules in designing the Arrow, they had to bend others when it came to building the aircraft. They had to find stronger and lighter-weight materials to build tougher and thinner wings. They also had to think up new methods for machining and bonding such new materials. At every stage, Avroites had to ask themselves not "Can it be done?" but "How can we do it?"

The traditional way to test new designs was to build one or two prototypes (sample planes) with simple tooling, then correct the design if problems showed up—all before producing the final planes in a factory. With the Cold War heating up, the RCAF was in a hurry so Avro decided to skip this prototype step. It would go directly from drawings to actual flying aircraft. This was considered a huge risk. "Everything had to be dead right the first time," said Jim Floyd.

Floyd's team carefully planned and tested all structures and systems at every stage. More than 17,000 technical drawings were needed at a time when the engineers didn't have sophisticated computers to assist them.

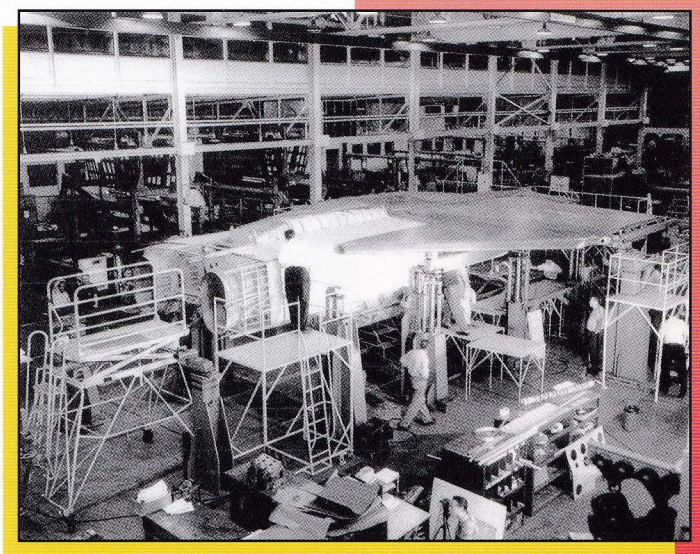

Calculations were done painstakingly with simple calculators and primitive computers. Full-size mock-up models of the plane made out of wood and metal were built in the hangars to test tools, check fittings and train production crews. Avroites were like their Canadian pioneer ancestors, leading the way in the aircraft industry.




Blueprints for the Arrow were classified "secret".

### Different Arrows?

The first five planes built were numbered 201 to 205. Partly because Avro expected the sophisticated engine and weaponry to take longer to develop than the airframe, these five aircraft would use temporary engines for flight testing. The sixth aircraft, #206, incorporated changes to design based on results from testing the first five. More importantly, #206, and all the 500-600 planes to be built after that, were to be equipped with the more powerful engines and sophisticated weaponry that would make the Arrow the aircraft of the future and all-Canadian.



Avro designed a fighter-interceptor with a superior combination of speed, range and weaponry. What was special about the Arrow was its aerodynamic shape, the materials it was made from, and its power.

# STARSHIP OF THE 1950'S

The tail-less design helped to reduce drag (the resistance to the air that slows speed).

Large, thin delta wings reduced drag while storing plenty of fuel.

Because of the Arrow's size and weight, it needed two engines to help it fly high and fast, and safely.

The wings were on top of the fuselage, rather than under it, to allow easy access to the engines and weapons bay for quick maintenance or change of missions. (The Arrow could, for example, switch its weapons for spying equipment or for more fuel tanks.)

The long landing gear was angled and housed in the wings.

To reduce drag, the Arrow's weapons bay and engines were inside, instead of outside, the fuselage.

The Arrow was huge! With a 15.2 m (50 ft) wing span, it was 24.6 m (80.8 ft) long, and weighed 31,000 kg (69,000 lb). It was longer than the Lancaster Bomber (imagine 3 school buses end to end!).

The stretched Coke bottle shape of the fuselage helped to reduce drag.

The Arrow had two seats because the RCAF believed that a second person was needed for operating the sophisticated radar and weaponry and helping the pilot in bad weather or at night.

The cockpit blended into the fuselage and trailed off into a spine that ran the length of the aircraft. This streamlined shape made for good aerodynamic performance.

The Arrow was one of the first aircraft to use an on-board computer in its advanced fly-by-wire control system. In a fly-by-wire system, the aircraft's controls are computerized and power assisted. At supersonic speed, a pilot does not have the strength or reactions to manually move the plane's controls.

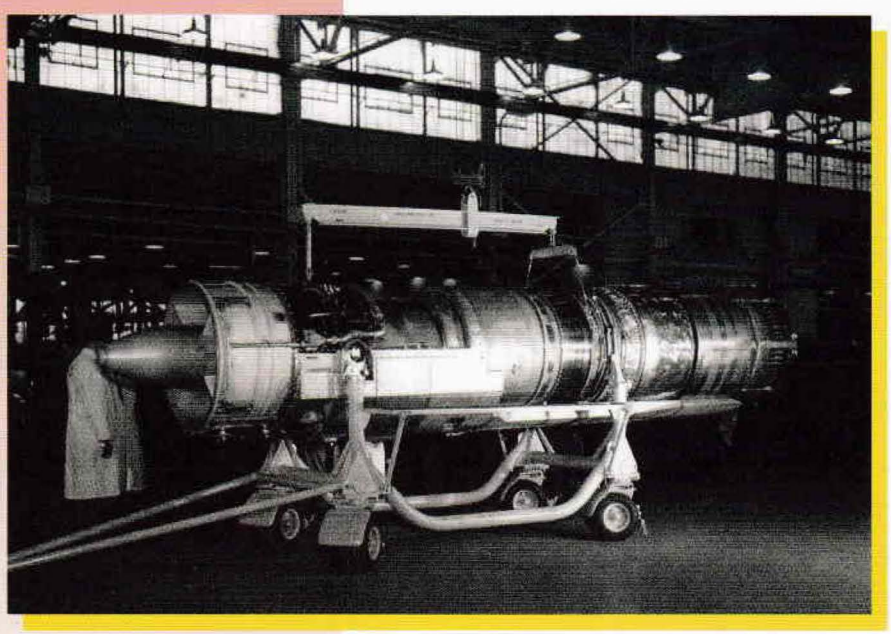
Artist: Brett Reid

# "WE DIDN'T KNOW IT COULDN'T BE DONE..."

What had started as "simply a new airframe" soon became a much more complicated project. Besides the airframe (the outer shell or structure of an aircraft without the engine), there are three other important components of a military aircraft—the engine, the weapons and the electronic systems to fire the weapons. These were all expected to be obtained from experienced specialty manufacturers outside Canada. But there were problems.

Every suitable engine that Avro wanted to use was unavailable. Either they were still "classified" (officially secret), or not ready in time or their production had been discontinued. Orenda, A.V. Roe's engine division, decided to create a brand-new one. But, for safety reasons, an untested airframe is not normally paired with an untested engine. So, until the Orenda Iroquois engines were ready and tested, the first five Arrows built would have to use temporary, less powerful engines, Pratt and Whitney J-75's from the US.

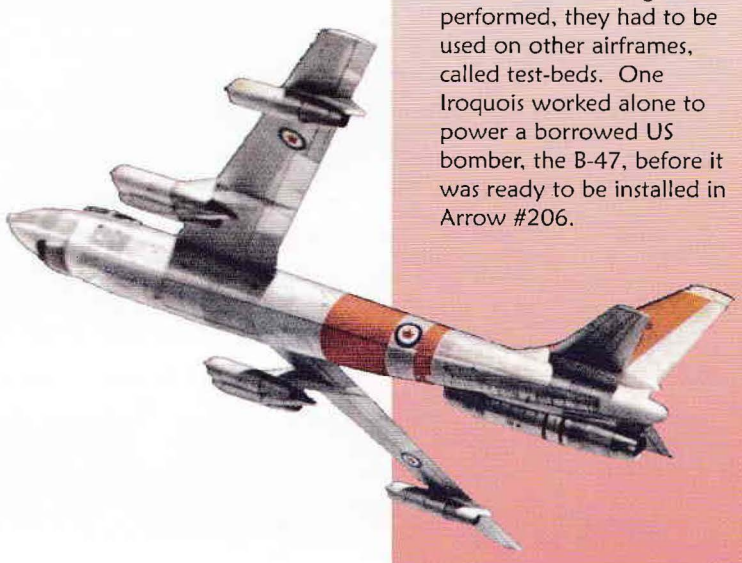
Two Iroquois engines were powerful enough to lift an aircraft vertically off the ground.



The weapons and the complicated electronic systems used to fire them suffered from the same kinds of problems. Both were difficult to get from manufacturers in other countries because of the secrecy in weapon design. Eventually, the RCAF decided that these expensive components would have to be designed and built from scratch by subcontractors. Avro knew the RCAF was taking a huge risk that could


drive the costs of the Arrow up, but the RCAF insisted on only the best for its super-plane.

The risks and costs of building, testing and fitting together so many critical parts made the project seem impossible at times. But as Jim Floyd said, "It was a time when we didn't believe it couldn't be done." Avro and Orenda recruited 650 other firms, most of them Canadian, to produce almost 40,000 parts needed for the Arrow. The whole country seemed to be involved in building the Arrow. Already the biggest aviation company in Canada, Avro had become the third largest employer in the country.

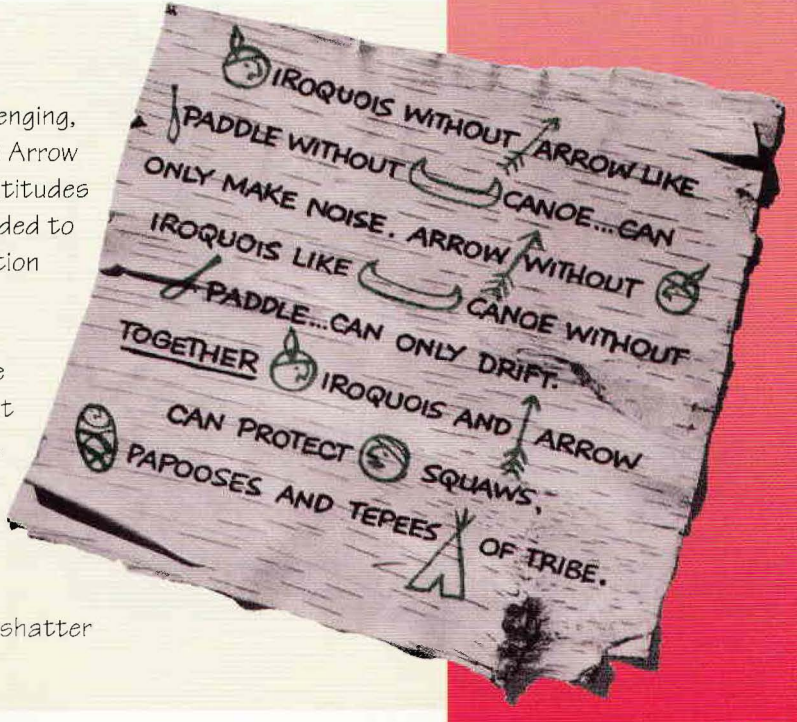


To see how new engines performed, they had to be used on other airframes, called test-beds. One Iroquois worked alone to power a borrowed US bomber, the B-47, before it was ready to be installed in Arrow #206.

## Iroquois power

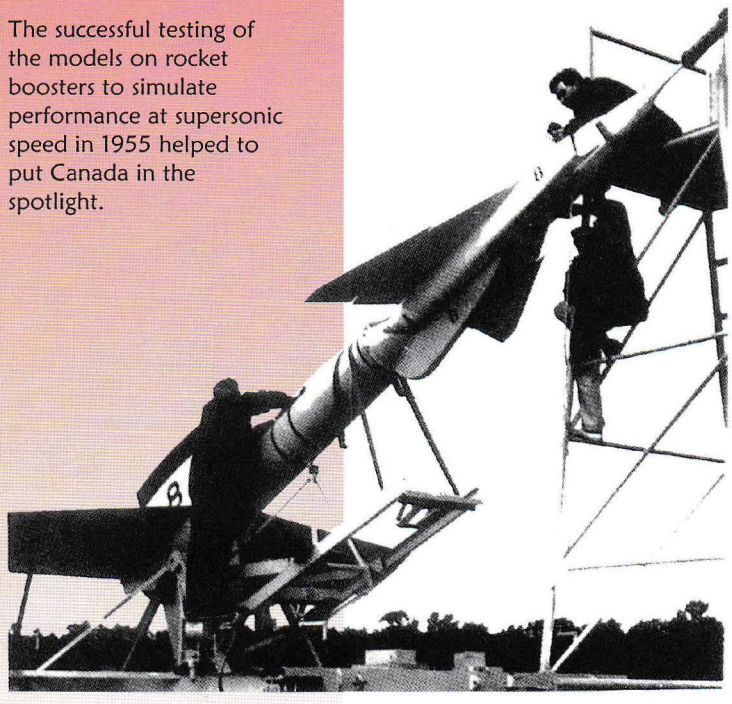
Designing a revolutionary new airframe was challenging, but so was designing the engine to power it. The Arrow needed an engine that could operate at higher altitudes and faster speeds. New materials were also needed to survive the high temperatures of supersonic friction and drag forces.

The Iroquois engine that Orenda designed for the Arrow met all these needs. It was lightweight but strong because a new, lighter material, titanium, replaced some of the steel. It was the most powerful and fuel-efficient engine in North America at the time. The Iroquois engine's combination with the Arrow airframe in the sixth plane built (Arrow #206) was expected to shatter all records of speed and altitude.



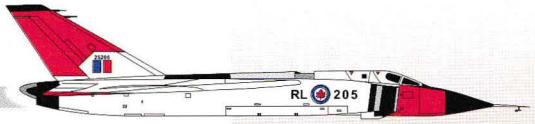
# UNDER THE MAGNIFYING GLASS

Because it was a military project, the building of the Arrow was supposed to be carefully guarded with restricted access. Avro had a security force that was larger than police forces in many towns in Canada. All Avro employees were issued specially coded identity cards to show to the security guards. They had to swear an oath of secrecy, promising not to talk even to their families about their classified work. Much work had to be done at night and behind screens to keep anyone driving by the plant from taking photographs. Avro didn't want to take any chances. Both sides in the Cold War had spies trying to obtain the other side's secrets. If any of the advanced Arrow technology leaked out to its enemies, the Canadian advantage would be lost.



The successful testing of the models on rocket boosters to simulate performance at supersonic speed in 1955 helped to put Canada in the spotlight.

At the same time, the whole program was "in the shop window," as Jim Floyd liked to say. Canadians wanted to know what was happening in Avrotown. People were fascinated with all the technological advancements in this time of 'technomania'. Newspapers and media from around the world gobbled up any news from the plant. In Canada, the Arrow was front page news because it was being designed and built in Canada. The Arrow was becoming a symbol of what was possible, and was capturing the hearts and imaginations of Canadians.




# ... AND UNDER TIME PRESSURE

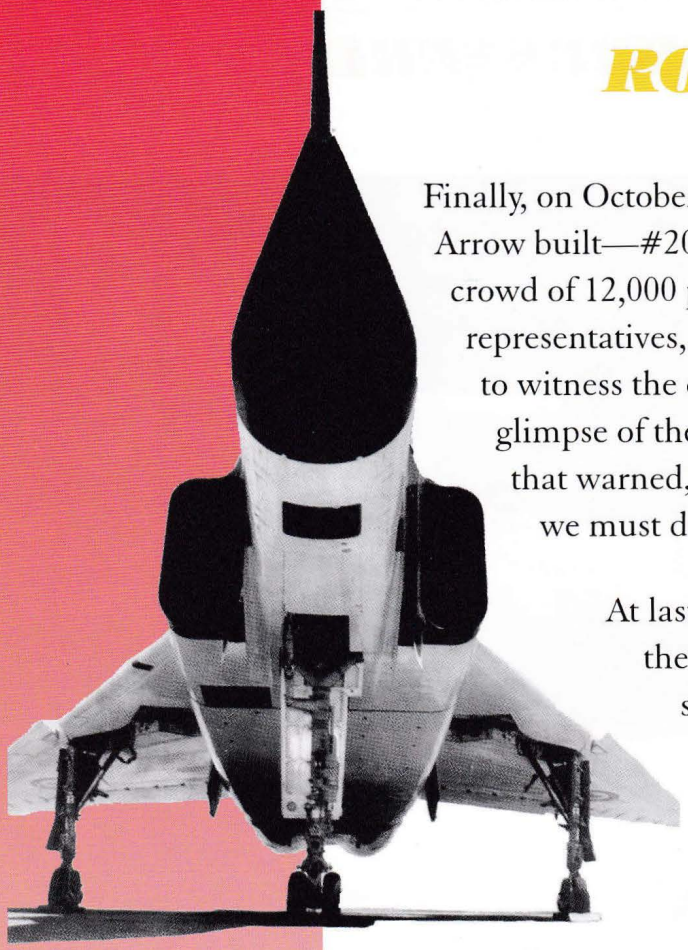
But the clock was ticking. The whole world was going supersonic. The US and Britain were racing ahead on similar but less complex supersonic aircraft projects. In Canada, unfortunately, production on the Arrow was often stopped because Avro didn't have a vital new part or material. Many times, someone would have to invent what was needed. It was exciting to be on the leading edge, but the delays and competition worried everyone at Avro.


The US was modifying its single pilot, single engine Delta Dagger interceptor to fly supersonic.

## The Man Who Started The Cold War

*Did you know that the Cold War was said to have started in Canada? In 1945, Igor Gouzenko, a clerk and message decoder in the Soviet embassy in Ottawa, decided he would rather live in Canada than return to Russia as ordered. He stole more than 100 documents from the embassy and decoded them for the Canadian government to prove that the Soviets were trying to steal military secrets. Because the Soviets had been on Canada's side in World War II, nobody believed Gouzenko at first. But eventually his information led to Soviet spies being caught and prosecuted. In return, Gouzenko and his family were given a new identity and protection in Canada.*

# ROLL OUT DAY

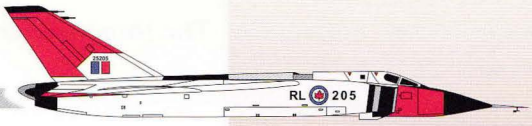


"The Avro Arrow has given Canada a serious contender for the top military aircraft of the next several years." (from a speech at the roll out ceremony)

Finally, on October 4, 1957, Avro was ready to show off the first Arrow built—#201—and lifted its top-secret restrictions. A huge crowd of 12,000 people, including Avroites, their families, RCAF representatives, government officials and the media, gathered to witness the event. Waiting impatiently to get their first glimpse of the future, the guests first had to listen to speeches that warned, "The concept of war is becoming so terrifying we must do our utmost to prevent war."

At last, the excited onlookers heard the introduction they were waiting for: " … the Avro Arrow—a symbol of a new era in the air for Canada …". A tiny truck towed the enormous #201 out from behind the gold curtains hiding Avro's hangar. Thousands of flashbulbs popped, a military band played a rousing march, and an Avro Canuck swooped past in a noisy salute. The gigantic #201 was immediately mobbed by the admiring crowd on the ground beneath.


Although the Arrow was not yet ready to fly, this roll-out was important to show Canadians and enemies alike the futuristic-looking plane that was going to be Canada's impressive defense weapon. It was a proud moment in Canada's aviation history and it was broadcast later around the world.




Unfortunately, it was overshadowed by the launch of the Soviet Union's Sputnik, the world's first artificial satellite.


The Globe and Mail

TORONTO, SATURDAY...OCTOBER 5, 1957.

Partly Cloudy; High 60

10 Cents Per Copy

158 PAGES

RUSSIA LAUNCHES FIRST SATELLITE

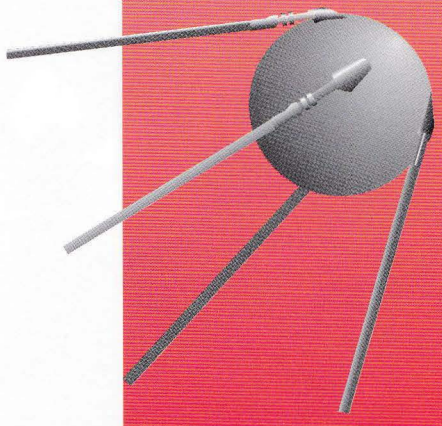
Hear Signal Loud, Clear Over Toronto

Paves Way To Planets, Soviets Say

On the same day as the Arrow's roll-out, an even newer air traveler stole the attention that should have belonged to the Arrow. Sputnik was launched into space with rockets by the Soviet Union. Sputnik was a 84 kg (185 lb) aluminum sphere smaller than a basketball that circled Earth like a moon every 95 minutes. As it beeped across the sky, Sputnik transmitted radio signals back to the Soviets, proving space was finally in reach of mankind.

Even though the US was working on a similar project, the Soviet launch caught the Western world off guard. Now the possibility of a different kind of war—one that didn't use piloted planes like the Arrow—seemed much closer. If pilotless satellites could be launched into space and controlled from earth, would it be long before bombs could be dropped from them? Sputnik had begun the space race, suggesting rockets and missiles might become more important than airplanes. No wonder some people were asking if the Arrow was obsolete before it had even flown.

Sputnik became the symbol of the upcoming missile age.



# WILL THE ARROW EVER FLY?

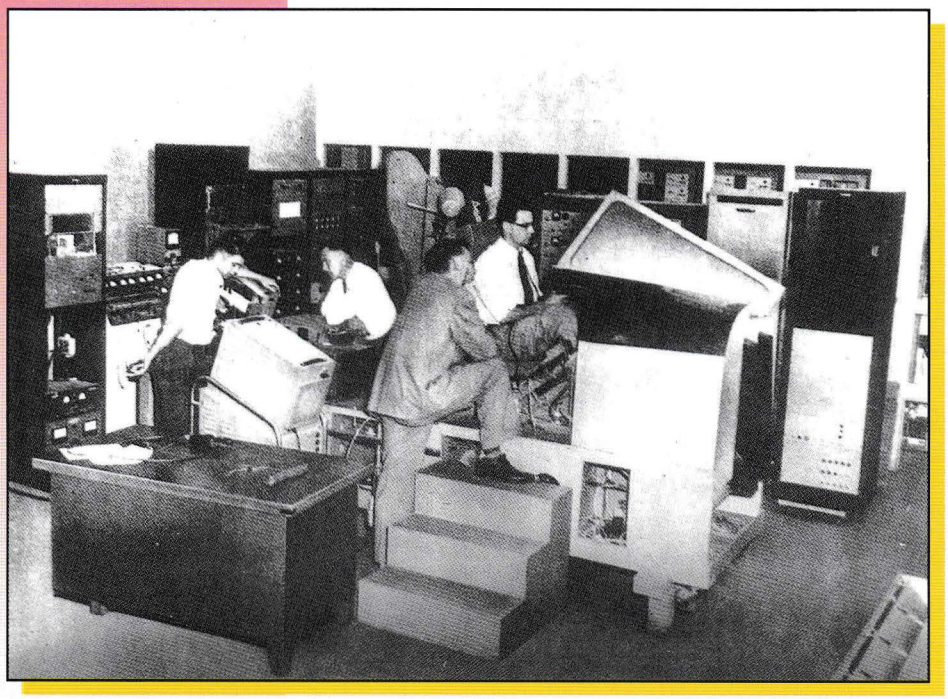
After rolling out the Arrow in record time, Avro took longer than it hoped to get the Arrow into the air. There were technical delays, political setbacks and still plenty of testing to be done.

While Arrow #201 was being tested on the ground with temporary engines, Orenda was trying to catch up with its Iroquois engine development. In November 1957, the Iroquois finally had its own roll out with a demonstration for the government. Meanwhile, Avro was completing tests of the ejector seats and other important details. The computerized flight simulator that the test pilots, Zura and Waldek "Spud" Potocki, were training in, was not working well. Because the engineers programming the computer could only guess at what the radical Arrow would do in the air, Zura wasn't lasting more than ten seconds before he crashed.

In the same period, the government announced to the RCAF and Avro that it would continue funding the project, but it reduced the number of Arrows it wanted built. Avro made efforts to sell the plane to other countries but until it proved it could fly, the Arrow couldn't be taken seriously.

"Judgement Day," came on March 25, 1958. At last, Zura got his chance to take the Arrow up for its first flight and show it off to a country anxious with anticipation.

A flight simulator is a mock–up cockpit and aircraft controls that are manipulated by a computer. Engineers give the computer their best estimates of what the aircraft and the controls would do in flight. When the test pilot "flies" the simulator on the ground, he gets an idea of how the real aircraft will fly in the air.






## Toy Arrows!

*The joke making the rounds Christmas 1957 was that Soviet spies would be lining up at toy stores to sneak a look at Canada's new secret weapon. That year, for the first time in history, a Canadian plane was produced as a model kit. An American company, Aurora, produced 250,000 toy Arrows and sold them for $1.95 each. And nobody knew yet whether the Arrow could fly!*

# JUDGEMENT DAY

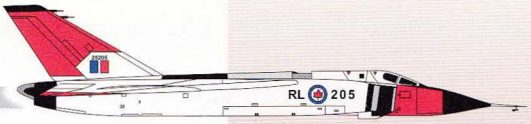
*(continuation from Prologue)*


An estimated million Canadians saw the first Arrow takeoff on TV that night. At least ten million read about it in the newspapers.

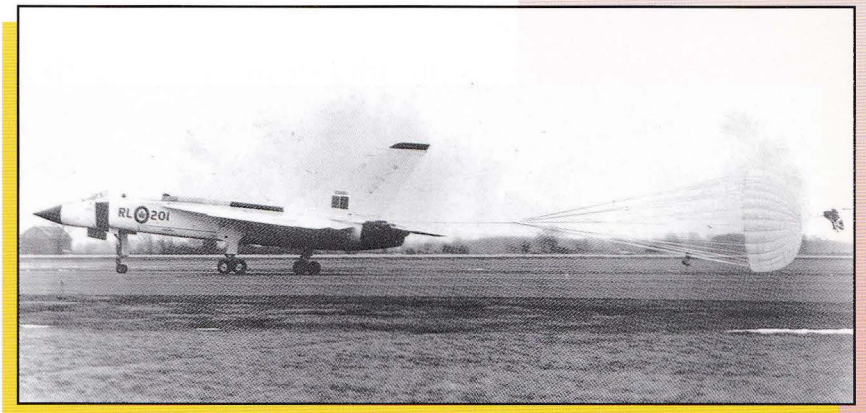
*Accelerating now, the Arrow is airborne less than halfway down the runway. At 1500 m (5000 ft) in the air, Zura retracts the spidery landing gear and feels it stow away as the Arrow climbs higher. A red warning light in the cockpit immediately attracts Zura's attention. Over the radio, he discusses the warning calmly with the control tower. He asks chase pilot Spud Potocki to close in and check whether the Arrow's nose-wheel landing-gear door is properly closed. Satisfied with Spud's report that the door is closed, Zura says a crisp "thank you" before moving on to other basic manoeuvres of a first test flight. After a while, he reports formally, "The controls are behaving quite nicely." He hears Spud add, "The engines also, except for occasionally giving some black puffs of smoke."*

*Before Zura knows it, the tower interrupts, advising him to land. No one wants to take too many chances on the first flight. Zura glances at his watch, slightly annoyed there is no clock in the cockpit. He has been in the air for only 35 minutes and did not attempt supersonic speed. He does one last circuit around the airport and lines up with the end of the long runway for his approach. The tower comes on the radio again. "Number 201. You are cleared for runway 32. Winds are northeast, 10 to 20 knots."*

*Putting his hand on the landing-gear lever, Zura wonders about the warning light earlier. Will his wheels go down? He catches a glimpse of the fire trucks and ambulance standing by on the runway below. The landing is as critical as the takeoff, and he suspects that his fellow Avroites must be collectively holding their breath. Zura lowers the aircraft onto*




*the runway. The tires touch the concrete, and Zura feels a jolt as the tail parachute fills with air, slowing down the plane.*




*"Wonderful," he hears someone (was it him?) blurt out. Through his thick windshield, he cannot hear but can only imagine the crowd's cheers. Once Zura has taxied back to the plant, members of the ecstatic support crew surround his plane and hoist him off the ladder onto their shoulders.*

*Later, Zura tells the press in his usual quiet way that the flight had been "fine". "I have never test flown an aircraft with so few problems." The snag (problem) sheet was framed and a Canadian aviation legend was born.*

" ... the biggest, most powerful, most expensive ... fastest fighter the world has yet seen." (Flight Magazine)

Zura as the hero of the day.

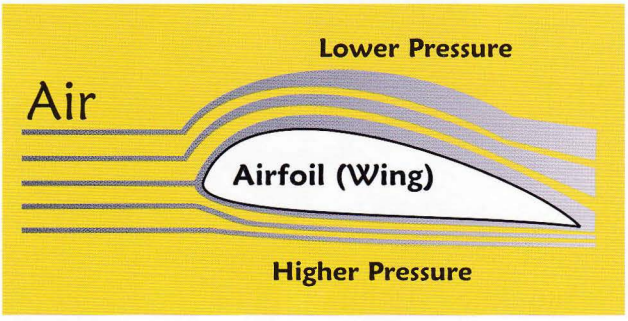
# FLYING LESSONS

Avro test pilot Peter Cope explains to some young fans how planes like the Arrow, and the Canuck behind him, fly.

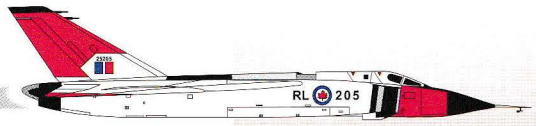
All planes—including the Arrow—fly in much the same way. Airplane designers must keep in mind the four forces of flight—**weight**, **lift**, **drag** and **thrust**.

➤ Materials used to build the plane must be as light as possible to reduce the **weight** that the air must lift. The Arrow used new materials such as titanium and magnesium, which are light yet strong.

➤ How do wings work to overcome the weight of an airplane? Airfoil shapes (such as wings) are generally curved at the top and flatter at the bottom. Air flows faster over the curved top of the wing when in flight, creating low air pressure above the wing, while the air flowing under the wing is deflected downward, creating higher air pressure under the wing. The result of these pressure differences is called "lift".

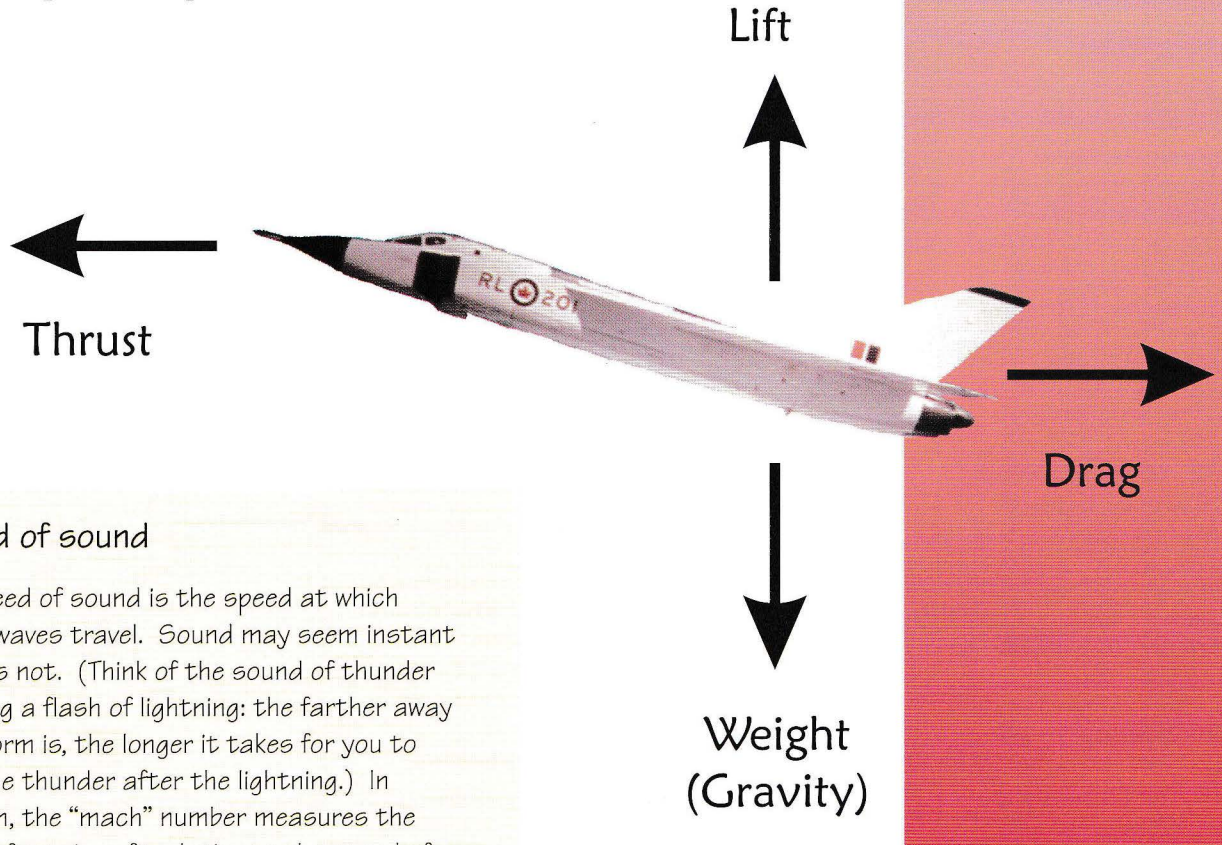



The Arrow's large wing surface provided lots of lift. Avro used wind tunnels and small scale models to come up with the best shape for supersonic flight.




The faster a plane goes, the more drag, or resistance to the air, it experiences. The amount of **drag** is also affected by the shape and smoothness of a plane. The Arrow's aerodynamic design reduced drag at every opportunity—thin wings, internal weapons bay and fuel storage, no horizontal tail.

Jet engines drive a large amount of air backward, pushing the plane forward and overcoming drag. In the Arrow, this **thrust** was to be provided by two Iroquois engines, the most powerful jet engine of the day for supersonic speed.




### Speed of sound

The speed of sound is the speed at which sound waves travel. Sound may seem instant but it is not. (Think of the sound of thunder following a flash of lightning: the farther away the storm is, the longer it takes for you to hear the thunder after the lightning.) In aviation, the "mach" number measures the speed of an aircraft relative to the speed of sound, with Mach 1 being the speed of sound. The Arrow was designed to fly faster than Mach 2 or twice the speed of sound. That's about 20 times faster than your car travels down the highway!

# UPS AND DOWNS

Arrow Test Pilot Club (from left to right) Waldek "Spud" Potocki flew the Arrow the most and the fastest. Peter Cope flew the only Arrow that had to land somewhere else (Trenton, when another aircraft was blocking the runway at Malton). Jack Woodman was the only RCAF pilot to fly the Arrow. Janusz "Zura" Zurakowski was the first to fly an Arrow. Only #202 and #203 were flown by all four pilots! Missing from this photo is the test pilots' boss—Don Rogers, Manager of the Flight Test Program.

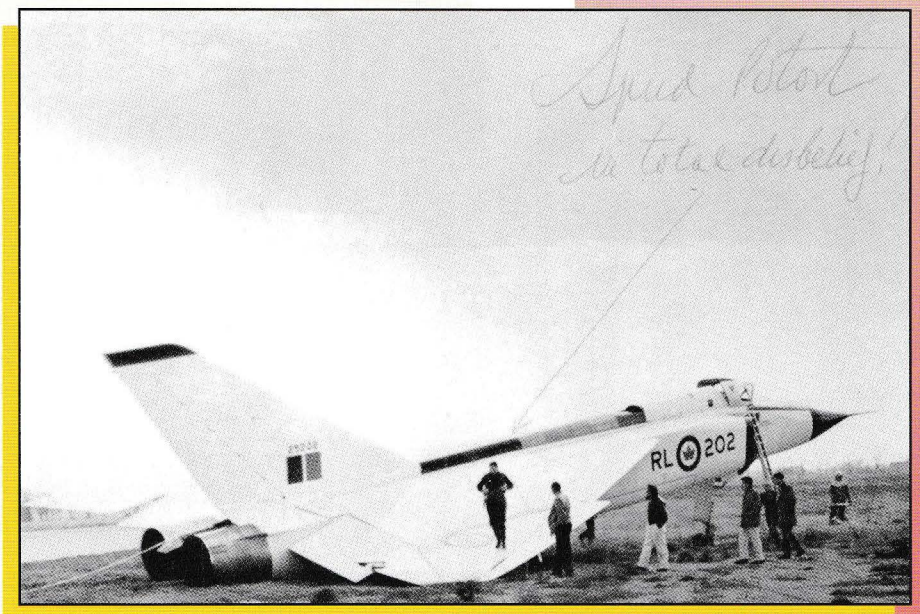
At Avro, spirits rocketed after #201's successful debut flight. They knew they had a winner. Hopes were confirmed a week later on April 3, when Canada officially entered the supersonic race on #201's third test flight. Doors and windows rattled as the plane broke the sound barrier for the first time even with its temporary, less powerful engines. Zura flew up to Mach 1.1, but still did not attempt the Arrow's maximum speed on this test. He did notice that the stability of the plane improved with speed. Considering there had been no prototype aircraft to work out the bugs of design and production, the results of subsequent flight tests seemed "too good to be true," said Jim Floyd.

Then two rough landings during test flights indicated that the Arrow did have some problems. At first, both were attributed to pilot error, but that changed with closer inspection. The radical design did need some minor adjustments, which is normal with any new aircraft.


## Crash landing ??

On November 11, 1958, almost eight months after "Judgement Day", three teenage aviation buffs apparently snuck onto the Avro airfield to take photos of the Arrow. By chance, it was the day of the biggest problem in all the test flights.

As Arrow #202 was coming in for a landing, test pilot Spud Potocki applied the brakes, but the plane skidded off the runway and the landing gear collapsed. Smoke billowed out from the tires, but fortunately no fire resulted. Avro confiscated and processed the teens' unauthorized photos which documented what had happened. Spud was really lucky. If the same thing had happened earlier in flight, he may have lost control - and his life. The problem was fixable and the teenage spies likely received thanks instead of a stern warning against trespassing!



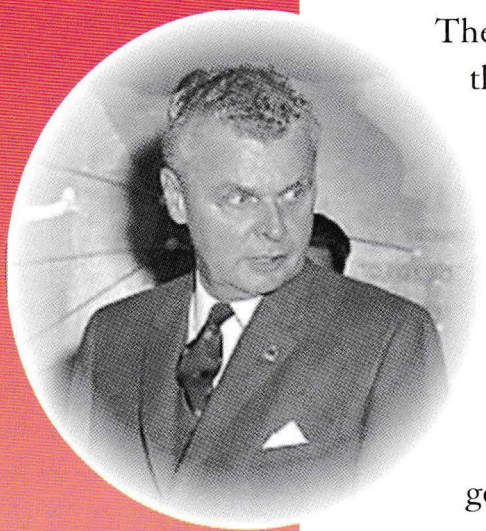

With no ladder handy, the surprised Spud had to quickly crawl out onto the wing to get down.

## Breaking the sound barrier

One gas station owner close to the Avro plant would stop pumping gas if he knew the Arrow was going to fly. He could see only its white vapour trails 15000 m ( 50,000 ft) up in the sky, but he could hear the sonic "boom" whenever an Arrow broke the sound barrier.

As an airplane flies, it displaces air. The air forms disturbances called pressure waves, which, like ripples in water, move away from the plane in all directions. At the speed of sound, the airplane and pressure waves are moving at the same speed. When the airplane exceeds the speed of its own pressure waves, it is said to "break the sound barrier." On the ground, this produces a sonic "boom", which sounds like a distant explosion.

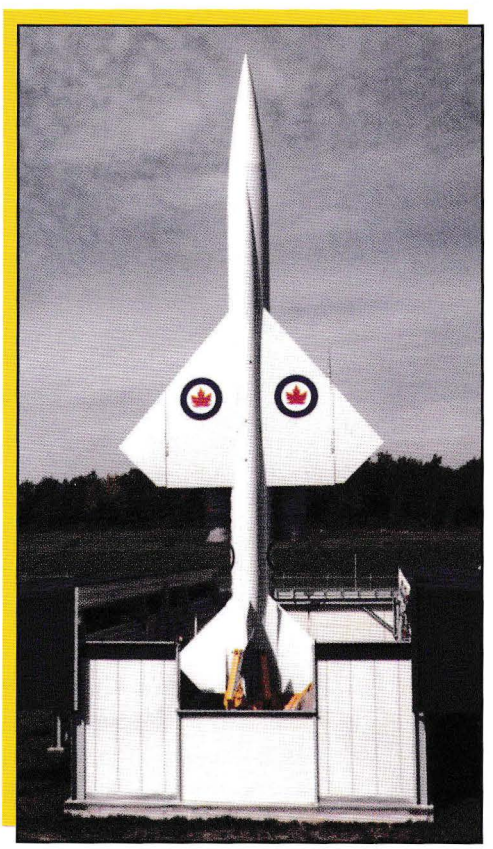
# WELFARE OR WARFARE?



Prime Minister Diefenbaker, not known as a fan of the Arrow, did call it "an impressive aircraft" in his autobiography.

The problems experienced in the test flights were fixable but the Arrow's bigger problems were in Parliament. Politicians were asking questions: was this kind of military plane really needed? Was it worth all the money it was costing?

While Avro had been concentrating on its testing program in 1957, Canada had held an election to decide who would form the next government. The Conservative Party's John Diefenbaker ("Dief") was elected prime minister because he promised to reduce government spending; the post-war years of prosperity were over. He also believed that most Canadians wanted programs like welfare for the unemployed more than they wanted expensive military planes. The times had changed and Canada needed a different defence strategy, Dief argued persuasively in Parliament.



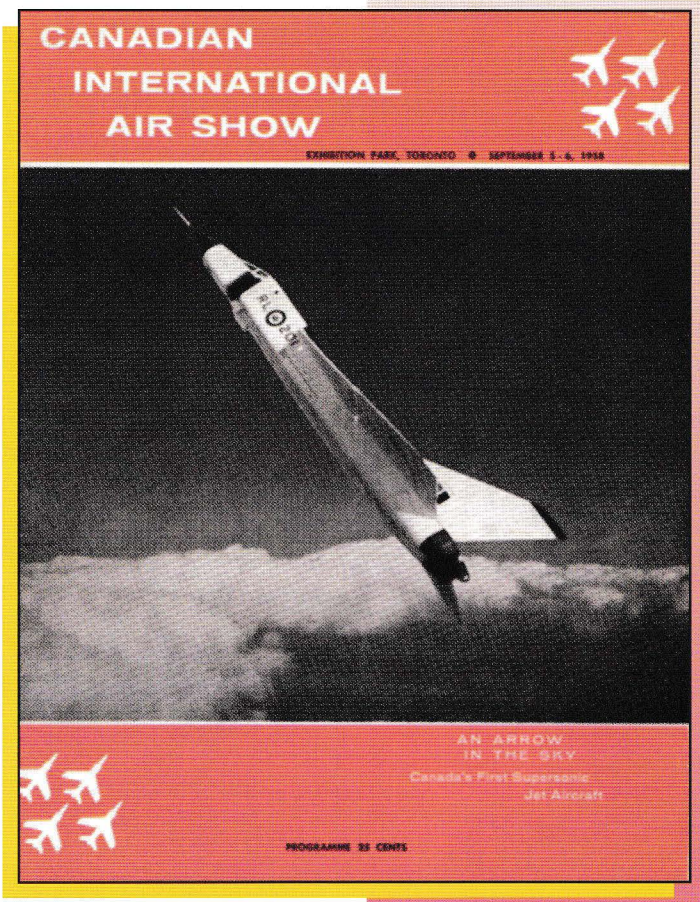
The strategy Dief chose was cooperation with the US in the North American Air Defence Command (called NORAD). NORAD's plan to use inexpensive US Bomarc missiles would reduce the number of interceptors needed. Interceptors designed especially for Canada would be less necessary.

Diefenbaker's opponents argued that the Bomarc system was unproven and that Canada still needed its own interceptors. They

**The competition to the Arrow?**
The US's Bomarc was a pilotless winged missile that could be launched from the ground to attack enemy bombers. Some people hoped that the less expensive Bomarc would make interceptors like the Arrow obsolete but the two were supposed to work together.


wondered if he understood the investment and risk that was part of high tech. The government had already reduced the number of Arrows ordered. Fewer Arrows built meant even higher costs for each plane, because of expensive research and development costs.

Avro was still determined to prove how indispensable its Arrow could be. Number 206, the first of the improved version of the Arrow design, was being readied to test fly with the Iroquois engines. This would be the first time that the Arrow and the Iroquois engines were paired—making it an all-Canadian aircraft. Avro expected #206 to break all speed and altitude records, impress the world and maybe interest other buyers. Diefenbaker wouldn't dare cancel production then, they reasoned. The 1958 International Air Show at the CNE in September was supposed to showcase the Arrow to the world but bad weather cancelled the show.




Featured on the 1958 International Air Show program—to show the world!

More dark clouds followed. Dief's new government decided that same month to further reduce the number of Arrows it had ordered. It also halted the most expensive part of Avro's project—the development of the custom-made weapon and firing system—in favour of a simpler, cheaper US-made system. Dief warned Avro that the Arrow had six more months before the government would conduct a final review of the whole project. Because a huge Canadian industry and so many jobs were at stake, Dief didn't want to make an unpopular decision so quickly.

# BLACK FRIDAY—

On Friday, February 20, 1959, production stopped at the Avro plant. Not even a typewriter or a rivet gun could be heard as workers stood stunned, listening to Diefenbaker's decision over the radio: "The government has carefully examined the probable need for the Arrow and Iroquois ... The conclusion arrived at is that the development should be terminated now." The government had not waited six months as promised to do their final review or to see how the wonder plane, Arrow #206, would perform.

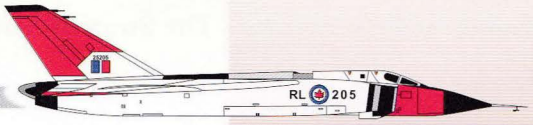
Headlines in the newspapers:

**Diefenbaker Decides: "SCRAP ARROW"** *February 20, 1959*

**Body Blow to Aircraft Industry!**
**Can't Ever Again Boss Own Defence—**
**Fear at Ottawa** *February 20, 1959*

This time the whole Arrow program was cancelled, not just scaled back. Jim Floyd remembered feeling sick as Avro cancelled the much-anticipated test flight of #206. Some Avro workers wept, some just threw down their tools and left the factory, never to return. Across Canada, about 25,000 people working in jobs that depended on the Arrow project were suddenly out of work. The president of Avro Aircraft remembered his response to the government's message. "How do you tell people that the job they have been dedicated to for years has been cancelled? How do you tell them that the product of their minds and hands has been eliminated?" Most of his employees were naturally devastated.

Some politicians and newspapers called it a national tragedy, especially because of the huge job losses. Others breathed a sigh of relief, still not convinced that Canada needed a custom-made warplane with costs still spiraling upwards. Prime Minister




# "SAY IT AIN'T SO!"

Diefenbaker tried to defend his decision by saying, "There is no purpose in manufacturing horse collars when horses no longer exist." Had his advisors convinced him that the manned bomber was no longer a threat to Canada?

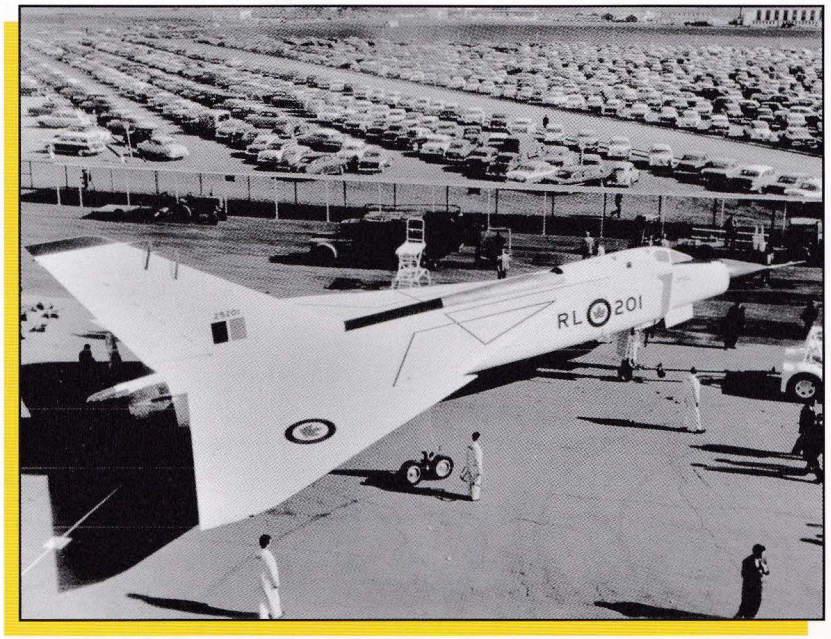
## Reactions from Avroites ...

*"We are all very young ... newly married, young children, large mortgages, not too much time to plan or think about the future, except getting the job done—the Arrow."*

*"I have two things to say to Mr. Diefenbaker. Be a Canadian. Buy Canadian."*

*"What a birthday present! I was 21 that day and my hopes of continuing in aerospace were dashed."*

While many Avroites had hoped for the best, others had seen what was coming. Some had already accepted aerospace jobs in the United States. Even Zura, the "good old father of the Arrow", had retired from flight testing a few months earlier to become an advisor. More than a thousand Avroites had to uproot their families to move to new jobs. But many of the 10,000 others had to change their professions so they could stay in Canada.



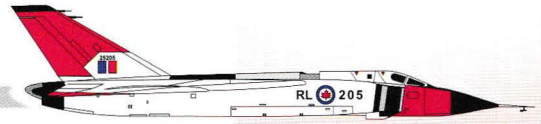

Obsolete? Once hidden from enemy spies, now in full view sitting near the Avro parking lot, a lone Arrow awaits its fate. Notice the contrast in car and plane design.

# SCRAPYARD BOUND

For fans of the Arrow, things got worse. All the planes—six finished and 31 others nearing completion—materials, drawings and even the engineering and test data were ordered destroyed soon after the cancellation. The few dejected Avroites still around had to watch strangers take away all their hard work. The papers and photos were dumped into large wheeled garbage cans for shredding or burning. Some Avroites couldn't resist saving a piece of their work—a blueprint, a photograph, a model—but they had to do it illegally.

In April of 1959, the aircraft waiting outside the hangar on "Death Row" were ordered to be cut up. Some Avroites tried to fight the order, but it was no use. Going home one day, Zura had to pass a truck with pieces of #201 on its way to the scrapyard. Another Avroite recalls, "The thing that always bothered me was the way it was done, the cold, callous, deliberate way it was cancelled. We salvaged nothing ... let's face it, the Arrow was the most advanced aircraft of its day. Yet all that knowledge, all that development, years and years of study, was wiped out. Deliberately wiped out. No salvage." Avro had requests from England, the US and Canadian sources to salvage some of the planes. The only large piece officially saved was #206's cockpit, which was needed for research.

A sad ending: Arrows being cut up on "Death Row".




Why the destruction? Was it standard operating procedure, or was there more to it? Why would a plane that had been called out of date still be classified secret? The Cold War was not completely over. The government probably did not want any of the new technology to leak to enemies. Dief might have also believed that if everything to do with the Arrow project was completely destroyed, people would forget about it more quickly. Did this happen? No. Instead, the Arrow became a Canadian legend.

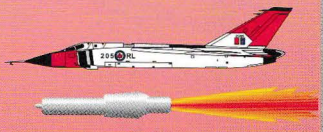
## Still a Mystery?

There are lots of opinions about why the Canadian government cancelled the Arrow, but no simple answers. Was the Arrow a victim of politics, its costs, or the times? It was a specialized warplane whose original purpose may in fact have been outdated, as Diefenbaker argued. Or maybe Avro's Arrow was too expensive and ambitious for a country just getting used to large-scale industry and advanced technology. What do *you* think?

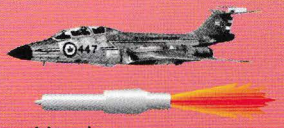

## Voodoo Replacements

Two years after the Arrow was cancelled, the RCAF acquired 66 second-hand American interceptors along with Bomarc missiles. In 1953, the RCAF had rejected these CF-101 Voodoos partly because they could not fly fast enough or high enough.

Thrust:



Arrow #206
23,500 kg (52,000 lb)



Voodoo
15,300 kg (34,000 lb)

Altitude:

Arrow #206
18,300 m (60,000 ft)

Voodoo
13,100 m (43,000 ft)

# AFTER THE ARROW


The Avrocar didn't 'fly' either, but it advanced the technology of the day.

After the cancellation of the Arrow, the Canadian aerospace industry did not recover for many years. Avro tried to continue with other innovative projects, including a flying saucer (Avrocar), which was the beginning of hovercraft technology, but the company had to shut its doors in 1962. The Iroquois engine died with the Arrow, despite interest from other countries, and Orenda had to slow down its operations for a while.

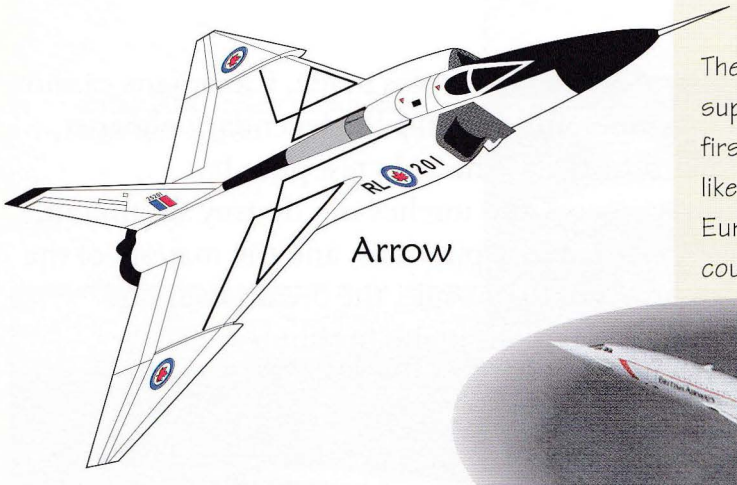
What really suffered, however, was research and development in Canada. Many Avro aeronautical experts, such as Jim Floyd, left for projects in other countries. These experts were welcomed with open arms at aerospace companies in the United States and England.

In 1969, former Avro thinkers and dreamers helped put man on the Moon. As well, former Avroites consulted on the supersonic passenger jet, the Concorde, in Europe and the F-4 Phantom and F-18 military jets in the US. Contrary to what Dief had predicted, supersonic piloted interceptors like the Arrow are still in use today, although the planes now also have jobs other than interception. Many of them benefitted from Avro advances. Out of Canada's loss came technological collaborations with the rest of the world. What might have happened if all that talent had stayed in Canada—if the Arrow had lived?

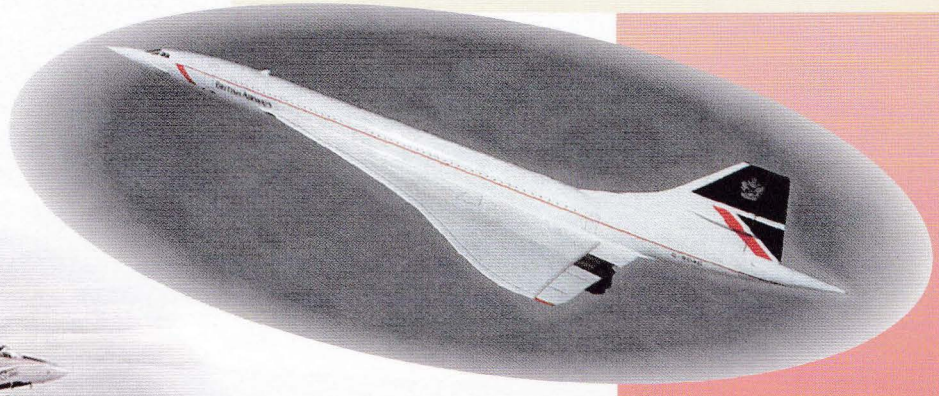
> "If it's worthwhile, but obviously impossible, do it anyway!"
>
> (Motto over the desk of "Avroite" Jim Floyd)


## Arrow legacies

The Arrow's legacies benefitted the Concorde (the first supersonic passenger jet) and the Space Shuttle (the first re-useable spacecraft) as well as military planes like the CF-18 currently in use by the RCAF, and the new Eurofighter Typhoon 2002, being developed for European countries.

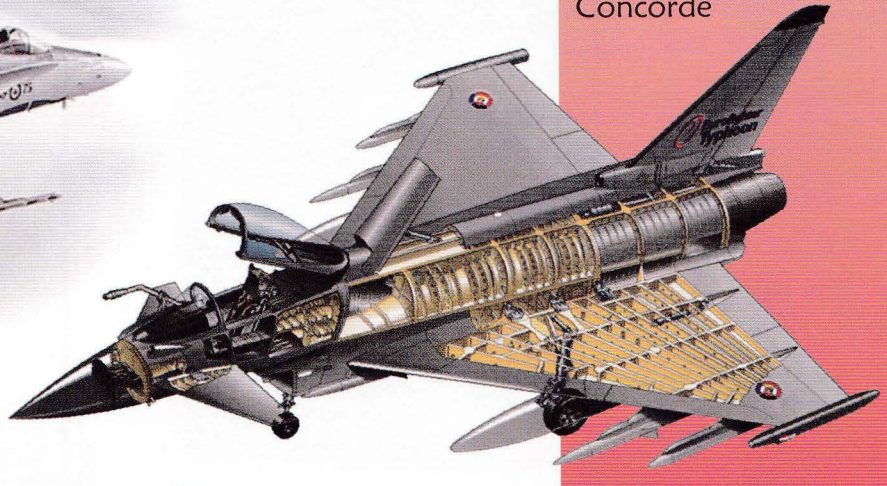



Arrow

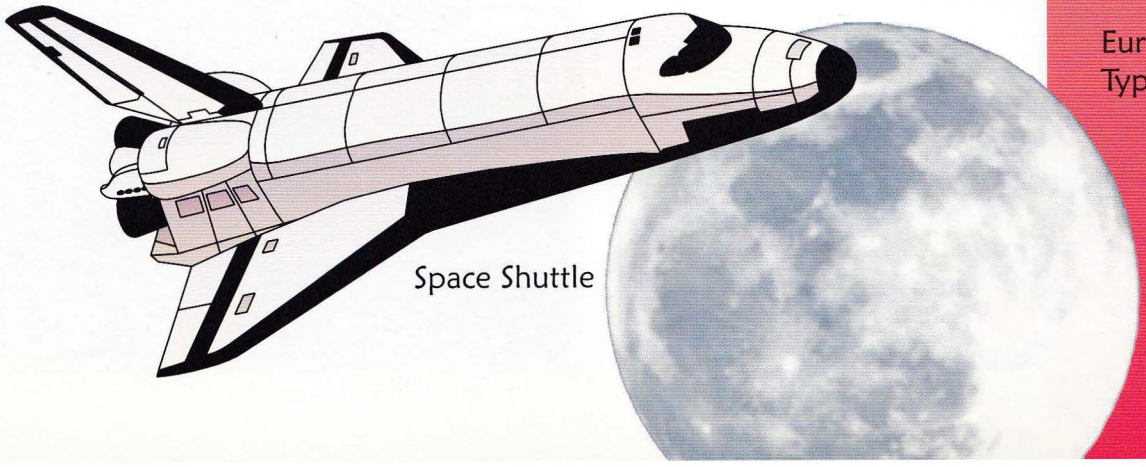


Concorde

CF-18 Hornet



Eurofighter Typhoon 2002



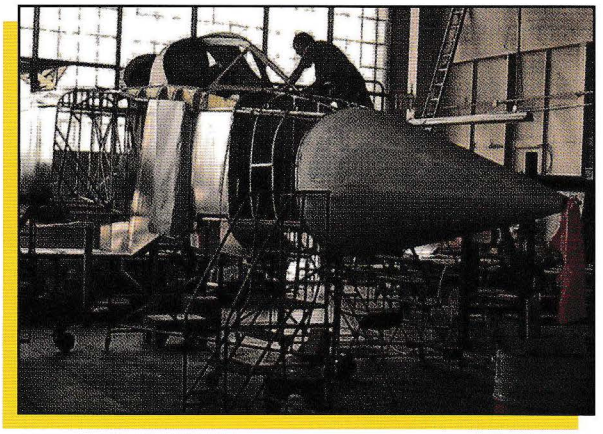
Space Shuttle

# REBUILDING THE ARROW!

Today, five decades after the first Arrow was made, Canadians cannot forget the phenomenal plane. Instead, like the legendary phoenix, the Arrow is being reborn from its ashes. As test pilot Jan Zurakowski said, "Governments and torches can destroy an aircraft, but they cannot destroy hope, and aspirations, and the majesty of the questing spirit. In the hearts of the people, the dream lives on." Canadians are rebuilding the famous plane in tribute.

One full-scale model was started in a garage in Wetaskiwin, Alberta. Allan Jackson abandoned his plans of an aerospace career when the Arrow was cancelled. But he couldn' t get the Arrow dream out of his head. His life-size model was used in the TV movie, The Arrow. It is now housed in the Reynolds-Alberta Museum in Wetaskiwin. Here the Jackson model shares the tarmac with RCAF planes flying today—a CF-18 and a T-33 at CFB Cold Lake.

Another Ontario group, called the Arrow Alliance, is collecting original parts that were forgotten or secretly saved to help reconstruct another full scale reproduction Arrow for the 100th anniversary of flight in Canada—in 2009.



At the Toronto Aerospace Museum, a full-scale static model, built by former Avroites and other volunteers, will be on display at air shows and in parades in Canada.


Arrow 2000 Project's 1/5th scale flight test model.

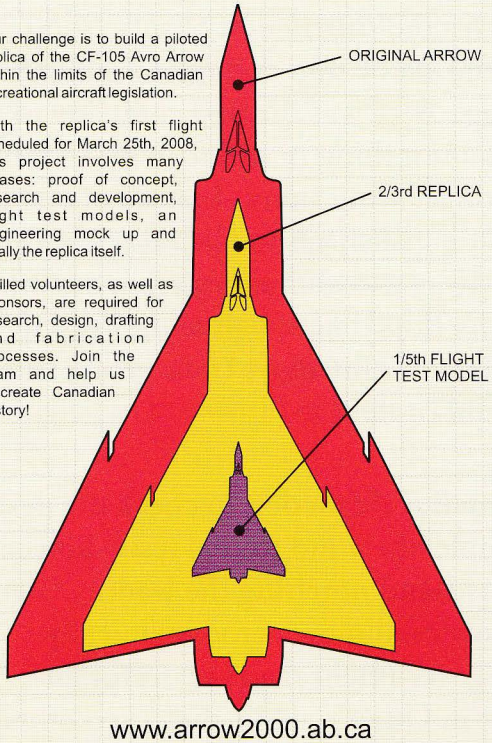

In Calgary, volunteers at the Arrow 2000 Project have been preparing to build a piloted 2/3 scale flying replica aircraft by first building smaller 1/5th scale flight test models. The project is aiming for a subsonic flight on the Arrow' s 50th anniversary in 2008.

ARROW
2000 PROJECT

Our challenge is to build a piloted replica of the CF-105 Avro Arrow within the limits of the Canadian recreational aircraft legislation.

With the replica's first flight scheduled for March 25th, 2008, this project involves many phases: proof of concept, research and development, flight test models, an engineering mock up and finally the replica itself.

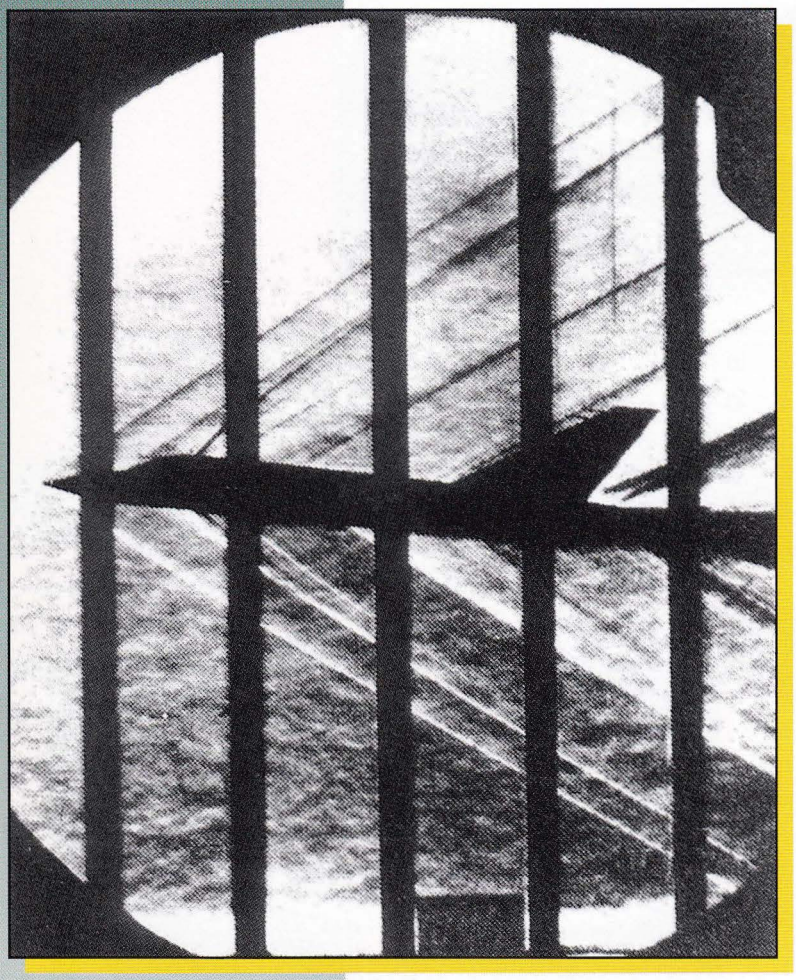
Skilled volunteers, as well as sponsors, are required for research, design, drafting and fabrication processes. Join the team and help us re-create Canadian history!




www.arrow2000.ab.ca

**Will Canada's Arrow fly again?**

# AVRO PIONEERING



One of the many wind tunnel tests of small-scale Arrows that checked the design.

Avro had to, and did, accomplish a lot in a short time. First Avro had to build a special plant for manufacturing the Arrow, and then it had to build all the machinery and unique tooling for constructing such an advanced aircraft. Avro took the best technology of the times and improved upon it. In the process, the creative engineers managed to solve a lot of aerospace problems. New standards were set in manufacturing, testing, computerization and training.

## Manufacturing

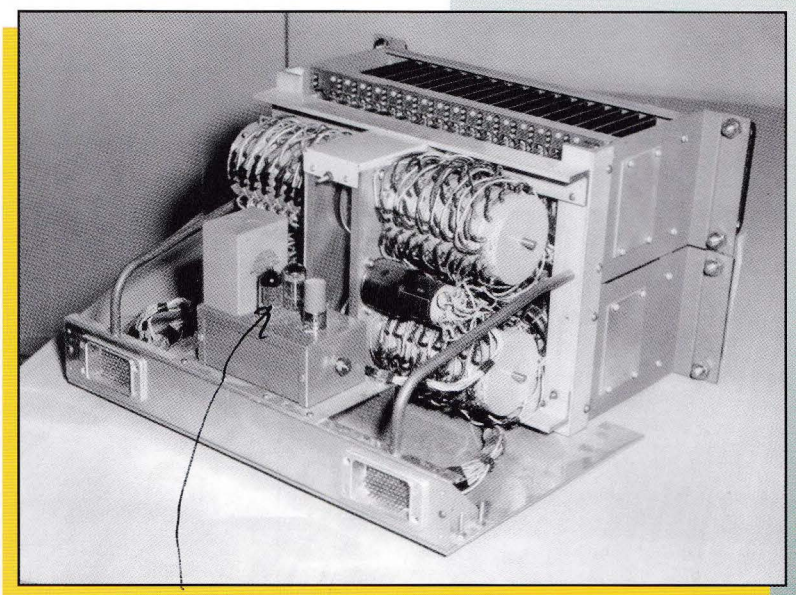
Wings, for example, are always a challenge to make strong enough to withstand the friction of supersonic speed yet be thin enough to minimize drag. Avro was the first company to use a giant milling machine to make much stronger wing skins. Instead of bending thin metal sheets to form the wing shape, this machine could carve away excess material from one huge thick piece of metal. They also developed new, lighter and stronger, materials such as titanium and magnesium alloys (mixtures).

## Testing

Avro used wind tunnel tests of small scale models to check the design early on in the project. For example, the wind tunnel tests showed how **drooping** (bending downward)and **notching** the leading edges of the wings could make the Arrow even more aerodynamically efficient. The company and the government made plans for an advanced wind tunnel to be built in Ottawa, while they used other

available tunnels in the US for their innovative testing program.

To simulate the Arrow delta-wing design's performance at supersonic speed, Avro also built large free-flight scale models and tested them by firing them off rocket boosters over Lake Ontario. They used data from these flights to modify the design and work out problems before the real airplane could be built.




An electromechanical computer looked different in the days before microchip technology.

## Computerization

Avro rented the most powerful computer available for some of its testing and training. Computers in the days before microchips were the power hungry ~~transistor~~ kind. They filled up almost an entire room but were able to rapidly do calculations that used to keep engineers busy with calculators for days.

## Successful

Most importantly, Avro Canada's high performance Arrow challenged a long standing myth—that Canada didn't have the skills, capabilities and resources to build a world class aircraft and aviation industry. Inspired by genius and determination, Avro had indeed succeeded in the world of high technology.

# MILESTONES IN AVRO TIMELINE

1938 Avro begins life as National Steel Car Corporation's aircraft division

1942 The Canadian government takes over the aircraft division and names it Victory Aircraft

1943 First Lancaster bomber built in Canada for England

1945 World War II ends; Cold War begins
A. V. Roe (part of Hawker-Siddeley, England) buys Victory Aircraft

1949 First flight of C-102 (Jetliner), Avro's first design project in Canada

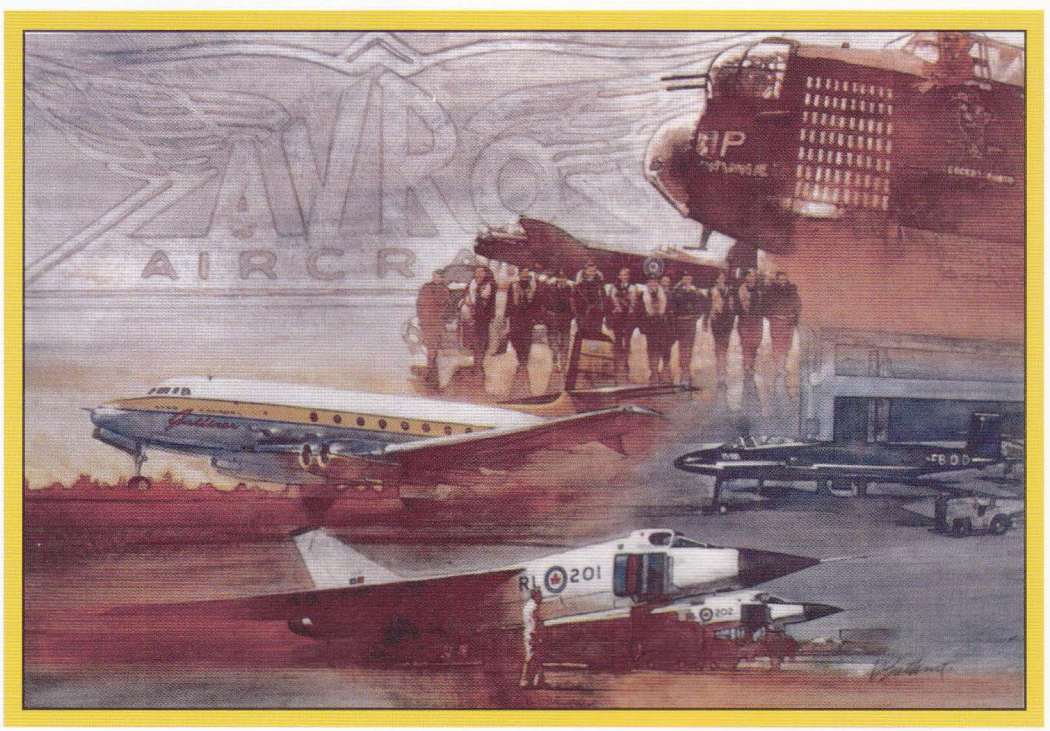
1950 Korean War starts
First flight of Avro's second project, CF-100 (Canuck)

1952 RCAF releases its wish list for a fighter-interceptor plane
A. V. Roe Canada responds with proposals for the CF-105 (Arrow)

1953 Wind tunnel testing of small-scale Arrow models

1954 A.V. Roe divides into Avro Aircraft and Orenda
Iroquois engine has first successful start at Orenda

1955 Full-sized engineering mock-ups of Arrow are built out of wood
Rocket testing of Arrow small scale models in Canada and US




Half a century of Avro Aircraft

(Artwork by David Bathurst, Poster courtesy: Norm Etheridge & Adlin Group Inc.)


| | | |
|---|---|---|
| 1956 | | Decision made: no prototype Arrow to be made<br>Last flight of Jetliner |
| 1957 | June | Diefenbaker elected prime minister |
| | August | NORAD defense agreement signed between US and Canada |
| | October | Official roll-out of Arrow; Sputnik launched the same day |
| | | Government authorizes continuing Arrow project for one year |
| | December | Testing of Arrow #201 on ground |
| 1958 | March | First test flight of #201 |
| | April | Arrow #201 supersonic (Mach 1.1) for first time |
| | | Diefenbaker re-elected prime minister |
| | June | First test flight problem |
| | September | Last CF-100 completed and delivered |
| | | CNE air show demo of #202 cancelled due to weather |
| | | Zura flies Arrow #202 to Mach 1.86 at 15 km (50,000 ft) |
| | | Diefenbaker reduces orders for Arrow and Iroquois, cancels special order for weapon and control systems and announces that Arrow development will continue until March 1959, when final review will be conducted. |
| | | Zura's last flight, retires to consulting for Avro |
| | October | Government orders Bomarc missiles from US |
| | November | Second test flight problem |
| | | Spud flies #202 to Mach 1.98, the fastest recorded speed of any Arrow |
| 1959 | February | Cope lands at Trenton, the only time Arrow does not land at Malton |
| | | First of two Iroquois engines is installed in #206 |
| | | Last flight of the Arrow (Spud flies #201 to Mach 1.7) |
| | | Black Friday: Dief announces cancellation |
| | April | Arrows waiting on "Death Row" are ordered disassembled |
| 1961 | | First test of Avrocar by Spud Potocki |
| 1962 | | RCAF acquires US-made Voodoos<br>A. V. Roe Canada shuts down |
| 1984 | | Plaque with Jim Floyd's name carried on the Challenger space shuttle to acknowledge incredible contribution to aerospace |


Fifty years before the Arrow, a very different looking airplane, the Silver Dart, launched the era of powered flight in Canada. The Arrow was supposed to have launched the supersonic era.

# LOOKING FOR


Canada Aviation Museum's display

## Museums

*A. V. Roe Canada Heritage Museum* in Calgary is dedicated to honouring the achievements of A.V. Roe, including the Avro Arrow.

6802 Ogden Road SE
Calgary, Alberta T2C 1B4
(403) 279-7791
www.arrow2000.ab.ca

*Canada Aviation Museum* in Ottawa has a display, "Pushing the Envelope", which features the nose section of #206 and an Iroquois engine.

Box 9724, Station T
Aviation & Rockcliffe Airport
Ottawa, Ontario K1G 5A3
(1-800-463-2038)
www.aviation.nmstc.ca

*Toronto Aerospace Museum* in Toronto has built a replica.

Downsview Park, 65 Carl Hall Road, Toronto, Ontario M3K 2B6
(416) 638-6078 www.torontoaerospacemuseum.com

*West Parry Sound District Museum* in Ontario created an exhibit, The Avro Arrow: A Dream Denied, that will travel to museums across Canada.

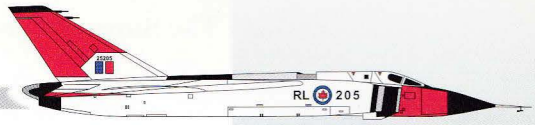
17 George Street, Box 337, Parry Sound, Ontario P2A 2X4
(705)746-5365 www.zeuter.com/~wpschin/

*Western Canada Aviation Museum* in Winnipeg has wooden mock-ups of the cockpit and other artifacts.

958 Ferry Road, Winnipeg, Manitoba R3H 0Y8
(204) 786-5503 www.wcam.mb.ca

*Reynolds-Alberta Museum* in Wetaskiwin, Alberta, has the first Arrow replica, and Canada's Aviation Hall of Fame also located there has tributes to many Avroites.

Box 6360, Wetaskiwin, Alberta T9A 2G1
(1-800-661-4726) www.gov.ab.ca/mcd/mhs/ram/ram.htm




# MORE INFORMATION?

## Books

### *For young readers*

*Avro Aircraft Arrows: Canada Built Them ... You Can Too!* (6 easy to build paper models) by Mark Robbins and Brian Smith (Aviation Heritage Foundation of Canada)

### *For advanced readers*

*Arrow* by the Arrowheads (Boston Mills Press 1980)

*Storms of Controversy: The Secret Avro Arrow Files Revealed* by Palmiro Campagna (Stoddart, 1997, 2nd edition)

*The Arrow* by James Dow (James Lorimer & Co., 1997)

*Fall of an Arrow* by Murray Peden (Stoddart, 1978)

*Shutting Down the National Dream: A. V. Roe and the Tragedy of the Avro Arrow* by Greig Stewart (McGraw–Hill Ryerson, 1996)

*The Arrow Scrapbook* by Peter Zuuring (Arrow Alliance/Boston Mills Press, 1999)

## Websites

*Canada Aviation Museum & Discovery Canada* (www.exn.ca/flightdeck/arrow/)

*Arrow Web Ring* (www.odyssey.on.ca/~dmackechnie)

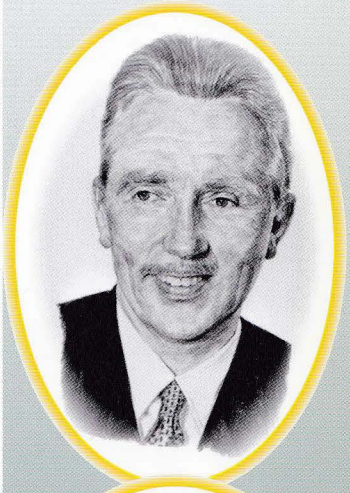
*Arrow Recovery* (www.avroarrow.org)

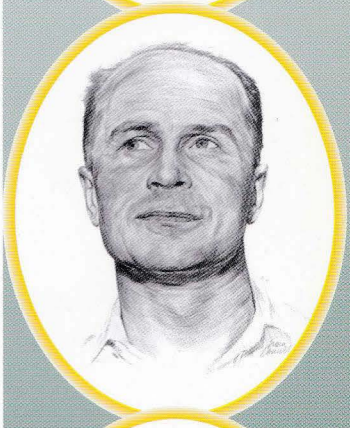
*Avroland* (www.avro-links@avroland.ca)

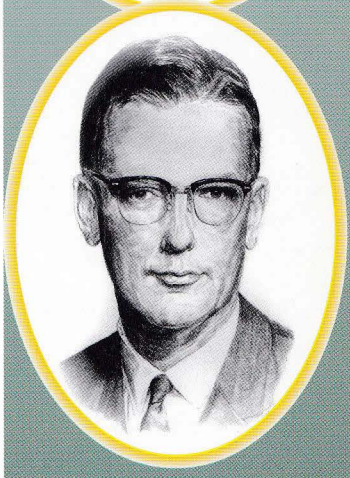
## Videos

*"The Arrow"* Dramatization (Northland, 1997)

*"Too Good To Be True—The Arrow, The Jetliner, & James C. Floyd"* Documentary (Rudy Inc.., 1993)







Some of the Avroite portraits at Canada's Aviation Hall of Fame: James Floyd, Jan Zurakowski, Jim Chamberlin
© Irma Coucill

# SPECIFICATIONS AND FACTS

## CF-105 Avro Arrow:
## Long range, all-weather interceptor

**Dimensions:**
Length with probe:
24.64 m (80.83 ft)

Height:
6.5 m (21.25 ft)

Wing span:
15.24 m (50.0 ft)

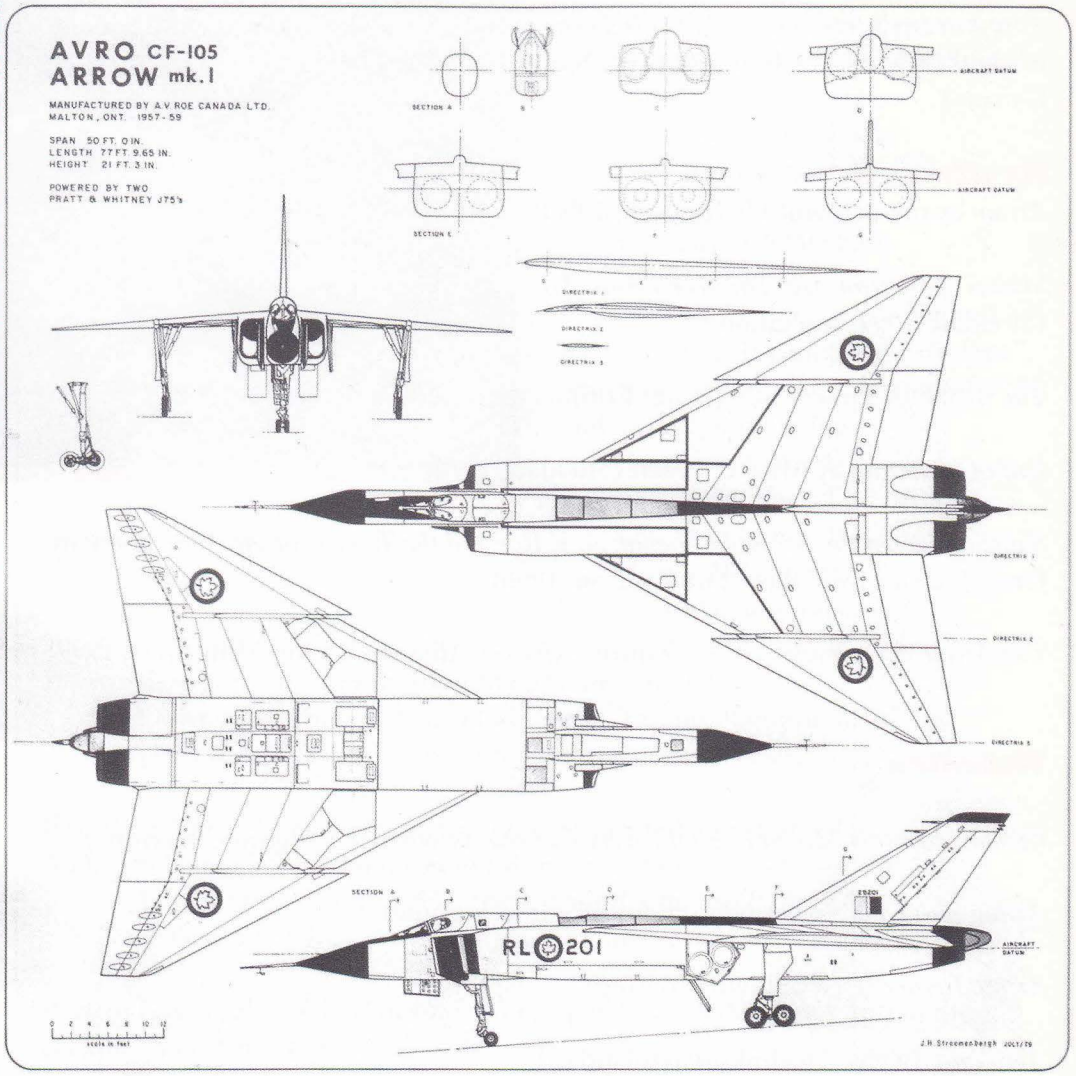
Wing area:
113.70 m² (1224 ft²)

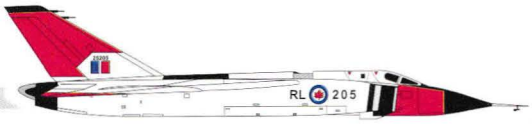
**Weight:**
Gross: 31,117 kg
(68,602 lbs)
Empty: 22,244 kg
(49,040 lbs)

**Power:**
2 Pratt-Whitney J-75
turbojet engines,
each with 8392 kg
(18,500 lbs) of thrust
with afterburner

**Performance:**
Maximum speed
(Mach 2.0):
2132 kph (1325 mph)
Combat speed
(Mach 1.5):
1599 kph (993mph)
Cruise speed
(Mach 0.92):
981 kph (610 mph)
Service ceiling:
16,154 m (53,000 ft)
Climb rate from sea level:
11,719m/min
(38,450 ft/min)

(These numbers are from the first Arrow built – #201 – and some are estimations.)



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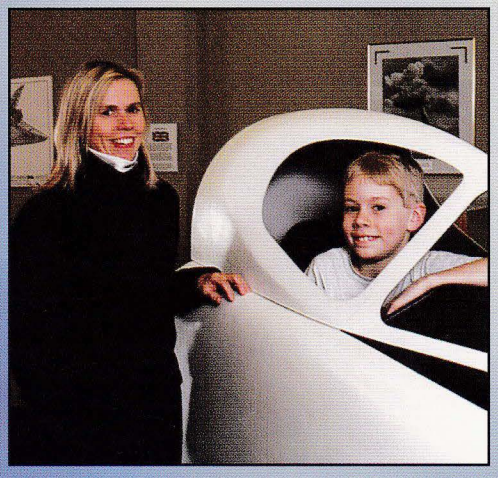
RL 201

***MADE FOR CANADA - The Story of Avro's Arrow*** **brings a fascinating period of Canadian history alive. Find out why this extraordinary 1950's military plane is still a modern legend—a symbol of Canadian pride and innovation.**



Joan Dixon is a writer and researcher with a Master's degree in Canadian Studies. Her son Nikolas's fascination with aviation, and especially the amazing Arrow story, inspired this book. The A.V. Roe Canada Heritage Museum in Calgary made it possible.

**"This excellent book is presented in language that will appeal to a younger readership, while still providing the accuracy essential for the preservation of Canada's aviation history.**

**It is a book that I will be delighted to present to my grandchildren in the knowledge that they can learn the true facts about a period in Canadian history which has been described by many as the 'golden age' of Canadian aviation."**

**Jim Floyd**
**Vice-President and Director of Engineering, Avro Aircraft**
**July 2001, Toronto**

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A.V. ROE CANADA HERITAGE MUSEUM

ARROW 2000 PROJECT

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