The AVRO ARROW

The story of the AVRO ARROW has taken on a life of its own, with a level of interest greater now than during the brief span of its conception, development, and destruction.
There are a great many myths about this profound achievement, both pro and con, and this page will hopefully demonstrate the absurdity of some of them. There is no need to inflate what the ARROW was, it was quite impressive enough on its own merit. Any figures on this page are based on actual flight data,with projections based on Avro Canada's actual figures for follow on and improved versions. There is, sadly, no absolute final word on the ARROWS ultimate potential, as the poor great beast was destroyed, and projected figures are muddied by the perpetually odd state of affairs in our political system, combined with the malevelant destruction of valuable test data.

Most of the data is in table form, in considerably greater than average depth. Tables on various pages.

Perhaps the most annoying of the anti-ARROW myths would be
1) Performance shortcomings and 2) Out of control costs.

Pro ARROW myths... (anti-anti-ARROW myths????)
1) ARROW sacrificed to protect U2?? : 2) Was Diefenbaker guilty of ordering the scrapping??.
3) Firsts NOT achieved by the ARROW.

In what ways was the ARROW advanced, what would the ARROW have actually cost, and what would have been realistic performance figures, how did it compare to its contemporaries, and more modern aircraft??
1) In what ways was the ARROW advanced??
2) Actual cost of the machine and industry.
3) What would have been realistic mid 60's performance for the ARROW?
4) Comparisons of the ARROW to its contemporaries.
5) Comparisons of the ARROW to more modern aircraft.
6) Comparisons of the ARROW to paper projects.

Performance Shortcomings???

Whenever a member of the anti-ARROW lobby offers up suggestions that the ARROW was defective, they will usually refer to absurdly low range, or refer to the ARROW being a machine that would not have even been capable of supersonic flight.
These absurdities have their roots in the minority view offered up by the NAE (contradicted by NACA and the RAE), specifically the suggestion that Avro was wildly off base in its drag calculations (insisting to this day that they were "100% off").
These pessimistic souls seem to have a near magical ability to forget one rather important point in the story of the ARROW.

It actually flew.

If the great white beast (actually, great white beauty) had remained a paper airplane or had never passed beyond the mockup stage, any performance figures would have been estimates, and the anti-ARROW lobby would have had a weak case. But without actual flight data, the pro-ARROW lobby figures would also just be a matter of faith (or probabilities}.
Since the ARROW flew, these myths can be quite happily laid to rest.

The specification for the ARROW required that it be capable of a supersonic mission radius of 200 NM. Avro produced a machine with greater than specified fuel capacity, and the ARROW MK II with off the shelf weaponry was capable of well over 350 NM radius for this mission. For a subsonic mission, the ARROW was proving capable of a radius of well over 500 NM. If the 500 gallon external tank is added, the radius would be over 800 NM. And remember that a nautical mile is larger than a statute mile, the unit quoted for aircraft performance in most civilian oriented references.

I can't really see how exceeding the required performance, amounts to failure.

Whenever one of the anti-ARROW faction deride the ARROW's supersonic intercept range (420+ stat miles for the Mk II), ask them how that compares with the F-14's SUPERSONIC intercept range.... (it is actually better then the Tomcat's, or the Tornado's as well.)

- *High Speed Intercept Ranges page..*

for various aircraft, will be added to, time and data permitting.

The ARROW MK 2a which Avro had developed with an eye to the future (and which the MK 2 could easily have been upgraded to) incorporated minor structural changes (approximately 1,569 lbs) to enhance the internal fuel load (additional 9,300 lbs), which would have given an increase in range of up to 90% (for certain mission profiles).
(Once you get off the ground, range estimates based on internal fuel are not hard to make, with very high levels of confidence. The confidence is due to lack of changes in drag with internal fuel, though climb rate and acceleration to maximum speed would suffer, until the extra fuel was burned off.)

As for the suggestion that the Avro drag estimates were so far off that the ARROW would not be capable of supersonic speed.... Well, even with the lower powered and heavier PW engines, carrying excess weight for ballast, the ARROW MK I was continuing to *ACCELERATE*, in a climb, at 3/4 throttle, reaching Mach 1.96/1.98 when the throttle was eased off.(A1)
Far from being optimists, Avro was actually being pessimistic in their expectations for the ARROW. Avro suggested that the first 20 ARROWS would not be capable of meeting speed and altitude requirements as the PS 13 would not be developed enough and the ARROW's weight was increasing. However, even with the lower powered PW engines at less than full throttle, the ARROW was meeting or exceeding even the very demanding specifications laid out for it.
Two examples of how removed from the truth the more extreme elements of the anti-ARROW faction can become in their efforts to discredit AVRO and the ARROW follow:

On February 20th 1979 a former Diefenbaker cabinet minister {George Hees}was interviewed (on CBC's "Morningside" radio broadcast) on the anniversary of the destruction of the ARROW. He actually suggested that the ARROW had become so sadly obsolete, that its original specification to intercept bombers at an altitude of 25,000 feet had been replaced with a need to intercept bombers at an altitude of 50,000 feet, and if it tried to, it would fall out of the air, killing its crew. (A2)
Spitfires out of the second world war could as a matter of routine intercept bombers at a 25,000 foot altitude, and on occasion did so at over 40,000 feet. Post war F-86 Sabres had a service ceiling of 50,000 feet, the Canadair Sabre MK 6 improved over even this. The CF-100 in its last versions was capable of reaching and maintaining this altitude.
To suggest that an aircraft designed decades after the Spitfire was incapable of matching its altitude performance, is outright pathetic. It ignores the performance specifications the ARROW

was required to meet, and ignores the flight data, which indicated that far from being deficient, the ARROW was exceeding its design specifications.

On February 2,1998, another former Diefenbaker cabinet member {Pierre Sevigny, previously known mainly for his involvement in the Munsinger affair), had the gall to suggest the the destruction of the ARROW was not the result of government orders, but was done by Crawford Gordon of AVRO.. tellingly, most of his comments consist primarily of attacks on the less than lovable Crawford.(A3) Since the identity of the guilty parties has been known for several years, with relevant documents still in existance
(Was Diefenbaker guilty of ordering the scrapping??),
is any comment really necessary??

What would have been realistic mid 60's performance for the ARROW?

Cost overruns??

Even though there was no public suggestion that the ARROW was going to be too costly for Canada at the time of its cancellation, this is the usual reason (combined with performance shortcomings) trotted out to justify the end of the entire program.
The ARROW was scrapped, as those who did it claimed, because it was obsolete. {That the MK 2a, with armament upgrades, would be among the best weapons systems in the world fourty years later, is the only reply this comment deserves}
Diefenbaker did concoct an absurd figure of some $12 million per copy, but even if that price (which he never explained) was valid, Pearks went on record saying that Canada could afford the ARROW, but not the ARROW with SAGE and Bomarc.
Actual cost of the machine and industry.

A pro ARROW myth or two.

Was the ARROW sacrified for the U2?

As much as I love the ARROW, the efforts to demonize the Yanks in the story of its destruction are tiresome. Not always without merit, but frequently outright silly.
It has been suggested that the CIA was involved with the destruction of the ARROW in order to destroy the only aircraft capable of reaching or beating the U2 at altitude.
Even though I personally reguard the best translation of CIA as 'caught in act', the thought that the ARROW was sacrificed for the U2 is is just plain wrong. The Brits would not have been allowed to get the Lightning into service, because this machine was also capable of scaring U2 pilots, and did so on numerous occasions (sustained flight of 77,000 feet, and controlled {if delicate} flight at 87,000 feet, with the Avons still turning over...).
Actually, the CF-104 that Canada ended up buying, was controllable in a zoom climb to 90,000 feet. The U2 was hardly the icon that some would make it out to be.

The Russians were also in possession of aircraft that would have been capable of taking out the U2, such as the Ye-150 (airframe constructed in 1958, first flight 1961), and Ye-152-1 (1961), both of which were capable of sustained flight at 75,000 or so feet. These were more experimental than front line fighters, and were not viable for various reasons (engine reliability), but could have easily been adapted for sprint flights against the U2, if the Russians really wanted

to.
If the suggestion was made that other countries would be alarmed by, or jealous of, Avro Canada's growing stature and high-tech expertise, that might be another matter altogether.

Was Diefenbaker Guilty??

Frequently, and of numerous things. But not of ordering the destruction of the ARROW. He was fool enough to cancel the project, and dishonest enough to NOT address the issue in his too numerous writings. But who to blame for the ARROW being reduced to scrap has been known for several years. Foulkes had decided to push for the Bomarc in 1958, in order to keep Canada's "air defence" in the hands of ground forces (Pearkes had hardly done an impressive job of standing up for Canada in his contact with the U.S., or for the Air Force while in Canada for that matter). With only the air force standing up for it, Foulkes was able to sacrifice the ARROW, and Campbell ordered its scrapping on the 26th of March, 1959, with Pearkes concurring on April 8th.(A4)

Firsts NOT achieved by the ARROW??

Ocassionally (well okay, more than occasionally) claims are made in the ARROW's favor that are without merit. These would include the claim that the ARROW was the first delta winged aircraft to fly, that Avro developed the delta, that the ARROW was the only threat to the U-2. These are nonsense.

Delta wing aircraft were given very serious consideration in the late 1930's, and Fairey (in England) as well as Convair (in the U.S.) had delta winged aircraft flying years before the ARROW. England, Russia, France and the U.S. all were developing aircraft that would be able to challenge the U2 at altitude (though not with the stability of the ARROW). The claim that that ARROW would be the first aircraft to pull 2G's at 50,000 or more feet, is wrong, but only because it is incomplete. ANY machine that made it to 50,000 feet, could pull 2G's (as long as it wasn't a balloon..). What made the ARROW out of the ordinary, in its ability to pull 2G's at this altitude and at speed, would be the provision "without loss of speed or altitude". THAT is definitely out of the ordinary, at the present time, let alone in the late fifties.

The ARROW was not the first aircraft capable of supercruise, as both the FD2 and EE Lightning were also capable of this. The English Electric P.1, the forerunner of the Lightning, was designed to be capable of supersonic flight without reheat. A feature its offspring retained. The first fighters to attain a TWR of unity at combat weight, were later models of the MIG-19 (1954), a very much under-rated machine.

The ARROW was not the first aircraft to carry its air to air missiles internally, or to have a "rechargable weapons pack". The F-102 (and later F-106) both carried their missiles internally, as did the F-101 (with part of its weapons load). A time saving "rechargable weapons pack" was used as early as the Hawker Hunter, which had everything short of the barrels of its 4 X 30mm cannon set up to be removed and replaced in a matter of minutes.

The ARROW was unusual in the amount of weaponry that it carried in its weapons pack, as well as the variables in weaponry, reconansance equipment, fuel, and anything else that could be reloaded or swapped in a matter of minutes. That is rather impressive, and still a watermark.

So in what ways *WAS* the ARROW advanced???

It was a pioneer in the area of fly by wire, even though its opponents will adamantly insist it was not.

Definitions of FBW: no direct mechanical linkage between controls and control surfaces (ARROW meets the definition in the same manner that the F-15 does, electronic signal with mechanical backup).

Change the definition, to include computer input into the system. ARROW meets the definition.

Change the definition, to include computer input over-riding pilot input, so that the control surfaces could actually move in the OPPOSITE direction to pilot input. ARROW meets the definition.

Another bone of contention with the anti-ARROW faction would be about thrust to weight ratio. The ARROW would have been one of the earlier jets to attain a TWR ratio of unity, at COMBAT weight, while being one of the heaviest armed aircraft in any air force. Quoting all up takeoff weight, only confuses the issue. Which is probably why the anti's do it. (I didn't say I wouldn't get nasty.)

In its original incarnation, the ARROW had a combination of speed (due to internal fuel and weapons carriage), range and weight of weaponry that none of its contemporaries could match. With the small changes to bring it up to MK 2a standard, it had a combination of range, speed and weight of weaponry that no other machine of its era could even come close to... Add enough fuel to match the ARROW's range, and its competators would have their performance cut so drastically, that they would often not even be capable of supersonic speed. Add in super-cruise, FBW, TWR of unity at combat weight, power of manouver at high altitude, and the ARROW was in a class of its own.

Actual costs of ARROW??

If you enter in to a discussion of the costs of the ARROW with a member of the opposition (thats the anti-ARROW faction, of course), you will be told

(1)the ARROW costs were completely out of control,

(2) that ASTRA and the Sparrow II were breaking the bank,

that Canada should never have begun the ARROW, since

(3) it was beyond our technical capabilities, that

(4)we could not afford it since we are such a small (in population) country...

(5)there was no role for the ARROW to fill...

(6)no one else wanted to buy it...etc.

With the exception of the reference to ASTRA and the Sparrow, which is valid, the rest are, to use one of my favourite phrases, cods-wallop.

(1)The costs were definitely increasing to levels much higher than the original estimates. Which is normal for a high tech project. The ARROW and PS-13 were breaking new ground in several areas, such as machining techniques, and use of and working with titanium. The machinery used to produce the ARROW had to be created, as AVRO were literally creating an industrial technology that either didn't exist before or didn't exist on the needed scale.

Diefenbaker at one point demanded that General Foulkes produce a dossier on the whole project from 1952 onward. It showed that the major causes of high costs were:

The decision to develop the engine (which had been accomplished at a VERY reasonable cost for such a project),
the RCAF'S insistence on Sparrow and ASTRA, and
several stretch-outs and cut-backs due to insufficient funding.(A5)

As a basis for comparison, the (C)F-18 was projected (1979) to have a unit price of US $5.9 million. In 1982, the actual cost was US $32 million. The F-16 experienced a similar increase in price.. the contract for the F-14 was renegotiated, to prevent Grumman from selling Tomcats at a loss... The F-111 is a horror story almost beyond belief.

(2)The ASTRA and Sparrow programs were entered into AGAINST the advice of AVRO, who had advocated a common sense approach of gradual upgrades of these packages, to keep costs under control, and keep to the hoped for delivery schedual.... They had already taken a beating on redesigning for several different potential engines. They learned.
(3)The testing procedures employed to confirm the validity of the theories AVRO was using to develop the ARROW, were as intensive as they were extensive. AVRO was not just assembling parts. Which is the role that some seem to think Canadians should be content with. The cost of the ARROW included the cost of bringing into functional existence a world beating, leading edge, high tech industry. Which in its younger incarnation, had already produced the CF-100, the finest aircraft in its class.
(4)Sweden is a country with about 1/2 the population of Canada, and a GNP also about 1/2 that of Canada. Sweden has been capable of producing its own cutting edge aircraft(usually designing the airframe while importing and improving the engine, electronics etc), so unless people suggesting (3) or (4) can explain the implication that Canadians are in some way inherently incompetent or inferior to the Swedes, this argument really isn't valid, or much of an argument at all (especially since Canada had already developed an excellent firm in the Aero-engine field...).
(5)If there was no role for the ARROW, then Canada would have had no need to purchase secondhand F-101s from the U.S., or the U.S. air force would not have used F-101s themselves, or F-102s and F-106s for that matter, or purchased F-4s to bolster their interceptor capability.
(6)I'm trying to find a single example of the purchase of an aircraft outside the country of its origin, prior to it being used in squadron service in the country of its origin (outside of being in the unfortunate position of being in a state of war, in which case, you buy anything you can get your hands on... even if its an unknown, or a second rate load of rubbish). The closest I've come to it so far, would be the Canberra, which had the U.S. making *inquiries* about license production prior to it beginning its 50 year and counting career with the RAF. The U.S. did *not* begin production, until after it actually did fly with the RAF.
The massive NATO purchase of F-104's did occur (thanks in large part to the British government of the time.....) with a model of the Starfighter that did not yet exist, but earlier variants did have a (short) career in the US. As a point of interest, at one point a British purchasing commission did suggest that the ARROW be purchased for RAF use..
*** Well, there was one machine ordered off the drawing board by a foreign government. The Austrailians did order the F-111 from the Americans in the early '60's.... *VERY* uncommon event. And the Aussies had a long wait, and a much higher price to pay for them. **** Pity we were not offering them ARROWS, as intermediate bombers.... (6000 lb weapons capacity)... but then, trying to sell them to the Americans seemed to be the only route the government was able to think of.

I could dispose of this entire theme with a short comment on the ORENDA PS-13 (actually, I am rather wordy when using a keyboard [did you notice??], so no I couldn't):

The development costs for the IROQUOIS had totaled approximately $90 Million, a *very* low figure for the time, to bring it through a very quick development program. Another $10 Million was needed, for final testing. The French government was trying to arrange purchase of 200 IROQUOIS, at a price of $200,000 each with possible eventual sales to the French of 300 units. The first foreign purchase, would have recovered almost half the development cost... The industry that AVRO had created, though the development of the ARROW, had cost approximately $300 million. The IROQUOIS would have added another $100 million. The supposedly hostile Yanks had offered the weapons systems at no cost (and even offered to pay for the production of several squadrons of ARROW's for use by Canada). Avro offered each of the first 100 ARROW's at a fixed cost of 3.75 million, including tax. We will assume that this was in addition to the development costs.**IF** we fail to amortize the development costs over other projects that AVRO would have applied them to, we would have a flyaway cost of $7.75 million per unit.... (and the research and technology, as well as industrial upgrades are paid for in one fell swoop). Which was much less than the figures created by Diefenbaker, and not much more then the $5 million per unit for the American F-106, which was not equal to the ARROW. It was a bargain at that price. But think for a moment. Even if no one else bought the ARROW (an unlikely event in light of the number of long range interceptors sold over the next several decades) the IROQUOIS would have begun generating sales and revenue. If you adopt a more realistic attitude towards the development costs and assume that AVRO would have been able to apply the technology, production tools and test data they had worked so hard for to other projects, figures of $4 to $6 million for the ARROW, would be realistic, or even high. Dependant on how long AVRO kept making the right technological choices. And the concepts they were developing suggest that they could have done so, for a very long time.

Realistic Performance of mid-sixties ARROW??

These figures are drastically at odds with what the anti-ARROW faction has embraced, and will startle even most ARROWphiles. Bear in mind that the distance figures are in statute miles, not nautical miles, and fuel is in imperial measure. Also bear in mind, that these are the figures (for the MK 2), that the people (Pearkes) who destroyed the ARROW, actually agreed were valid.

- ARROW Performance Table page.. Fasten your seat belts.

Comparison of ARROW with its contemporaries??

- ARROW & Contemporary Aircraft Comparison page..

About 50% complete, comparison with several aircraft of the fifties.

For those in a hurry, performance figures only at the following link, restructured, and about 90% complete.

Summary of Performance in Table Form

Comparison of ARROW with more modern aircraft.

- ARROW & Modern Aircraft Comparison page..

Post century series aircraft and European aircraft in table form, with configuration/range detail on F-16.

Comparison of ARROW with paper airplanes.

A few souls deride the ARROW in a most imaginative way. By comparing it with projects that never made it off the ground. Literally. Or by comparing it to aircraft begun after the ARROW was scrapped, aircraft having the advantage of following in the trail broken by AVRO (and others), with the advantage of the intervening years of technological developement. While most of us try to deal with aircraft that actually did fly, the occasional sad soul (who usually knows little or nothing about the ARROW) will display a similar lack of knowledge of the projects they claim make the ARROW "look foolish", as well as a lack of familiarity with logical reasoning.

- ARROW & Paper Airplane Comparison page..

Sources:

(A1) Shutting Down The National Dream p.227 - Greig Stewart
(A2) Short summary of quotation on p.204 Shutting Down The National Dream - Greig Stewart
(A3) CNEWS, WWW.CANOE.COM/CNEWSFeaturesArchive/Feb2_avro.html, or seek out 'The Ottawa Citizen' for February 2, 1998.
(A4) Storms of Controversy: Appendix, pages 209 and 211...
Copies of memos will be posted in near future.
(A5) Shutting Down The National Dream p.235 - Greig Stewart

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