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Notes on Arrow Project.

Questions most often asked and some notes on these items.

1 What was the Arrow designed to do?

The Arrow was designed to fulfil a performance specification issued by the RCAF in 1953. This called for a supersonic interceptor to destroy any enemy threat to the Northern reaches of North America likely to be employed within the next decade and beyond.

It was to be a twin-engined aircraft with a crew of two and be able to operate in an entirely automatic mode of target interception and kill.

Prior to instructing Avro to proceed with the design, a top level RCAF evaluation team had visited all of the countries in the Western alliance to determine whether any of them were developing or contemplating the development of an aircraft to meet their stringent requirements. Their report confirmed that there was not.

Specific performance recorded on the Arrow Mk1 aircraft,equipped with J75 interim engines, which more than accomplished the RCAF specified performance, was as follows;

Over 70 hours test flying was logged in the 66 flights carried out on the five Mk 1 aircraft, most of which was at supersonic speeds up to close to twice the speed of sound (M = 1.98.) . Jan Zurakowski, the first pilot to fly the Arrow, went supersonic on the third test flight and exceeded 1000 miles per hour on the seventh flight while still climbing and accelerating, at 50,000ft.

Climb speeds of up to 40,000 ft.per minute were recorded by Spud Potocki, Avro's other Arrow development pilot.

T.O. Speed 170 kts (11°) Approach 165 (15°)

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Jack Woodman, the RCAF evaluation pilot assigned to the Arrow reported prior to cancellation that he had carried out 95% of the performance evaluation on the Mk 1s and that "The Arrow was performing as predicted and was meeting all guarantees". (see attached report from Woodman)

Peter Cope was the third Avro test pilot to fly the Arrow, but Zurakowski and Potocki carried out most of the test flying.

The first Arrow Mk 2 aircraft, powered by the more powerful Orenda Iroquois engines, was due to fly within days when cancellation came and since the Iroquois had approximately 30% more thrust than the J75, the performance on the Mk 2 Arrow would have been increased substantially. In the words again of Woodman, "I believe the Arrow Mk 2 had sufficient performance capability to set a new world speed and altitude record, and I believe it would have easily met all performance guarantees" (Ref. 'Flying the Avro Arrow' by S/L Jack Woodman. May 16 1978 CASI Journal)

The specification called for a manoeuvre capability of at least 2g at Mach 1.5 at 50,000ft. at combat weight with all missiles aboard, with no loss in speed or altitude during that manoeuvre. This was a requirement which has not to my knowledge been exceeded by any in-service combat aircraft even today. It was the reason for having to put the enormous power in the aircraft and having to stow all of the missiles inside the aircraft to cut down the drag.

Range specified was a radius of 200 nautical miles with five minutes combat at Mach 1.5, but Avro considered this range was low and the aircraft was designed for ranges up to 650 nm.radius. while still retaining the specified performance. (A projected reconnaissance version was to have a range of more than 2000nm.)

2 Why was it cancelled?

The two specific reasons given for cancellation were;

a. Obsolescence.
b. Cost.

Taking the first reason given, obsolescence, it was at that time stated that manned aircraft were becoming obsolete and that missiles would soon take their place for the defence of North America. In the face of that information, the Arrow would be obsolete before it even got into the squadrons. It is ironic that 30 years later all of the Air Forces of the world are purchasing new manned fighters and the RCAF have bought 3 or 4 generations of American aircraft since the cancellation of the Arrow project, none of which came even close to the overall capability of the Arrow.
So that reason for Diefenbaker's decision was obviously invalid, short-sighted and proved to be absolutely wrong, in every respect!

b Cost.

This is the most misunderstood of the factors surrounding the Arrow cancellation. Those who like to use it as an excuse for the cancellation apply all of the costs of the Arrow and Iroquois programs against the small number of test aircraft on contract at that time.

The $180 M already spent on the Arrow program and the $120M spent on the Iroquois program included the design, development, tooling and extensive testing for a full production run of both aircraft and engines. 100, 200, 300, 400 or 500 Arrows could have been produced from those designs and tools and similarly with the engines. It is therefore patently ridiculous to allocate those costs on a per--aircraft basis for the small number then on contract.

The whole philosophy on the Arrow program was to go for full production from scratch, with no prototypes to 'suck it and see'. This was necessary because the RCAF were breathing down our necks to get the aircraft into squadron service in double quick time. That procedure was not only an engineer's nightmare, but it required very extensive and costly testing programs prior to flight, to ensure the safety and performance of the aircraft. As an example, over four thousand hours of wind tunnel testing and the firing of eleven free-flight models launched over Lake Ontario on rocket-boosters, along with thousands of hours of structural and systems testing, had been completed prior to the first flight of the first Arrow.

So the $300M already spent at Malton on the aircraft and the engine was a production investment which could only be justified or assessed on the basis of future production. If the aircraft was never produced that money could never be amortised and had to be considered as nonrecoverable.

Having made that point, it is obvious that when the sums were being done on the cost of the Arrow against the cost of an American alternative, after it was later 'discovered' that the RCAF would need another manned aircraft anyway, the only basis on which the cost-effectiveness of continuing with the Arrow could be measured was to equate the 'fly-away' price offered by Avro on the Arrow Mk 2, which was $ 3.5M per aircraft complete with engines, Fire Control System, (MG3-not Astra) and all support, based on a run of 100 aircraft, against the cost of the American aircraft, bearing in mind the performance and effectiveness of the aircraft to meet or not meet the RCAF requirement.

The 'red herring' excuse that Canada could only afford the aircraft if the Americans bought it, was naive and ridiculous. No foreign aircraft has been bought by any country before the country offering

it has equipped its own forces with it and proved its effectiveness in squadron use.

A prime example of what I am talking about is the French Mirage aircraft. That was two years in service with the French Air Force before the first foreign order was received, yet that aircraft was later in service with many foreign countries and is still in use today, having been developed to considerably higher performance, as the Arrow would have been had the project been pursued.

I believe that, at the price that the government was offered the Mk 2 Arrow complete, and bearing in mind the unique performance of that aircraft, which to my knowledge has not been surpassed today, the Arrow was the bargain of the century, and if the project had been continued, it would have been in use today in the major air forces of the world.

The real problem of the cost of the Arrow was that the government of the day knew nothing about the cost or worth of high technology.

If the Arrow was to be cancelled at all, the best time would have been when we saw the RCAF specification, because they had asked for the moon and for an aircraft which was so far ahead of anything else in existence that it was sure to be expensive. Anyone who imagines that high-technology runs cheap has to have his head in the sand!

The ultimate way to save money is to do nothing, the next is to do something mediocre, which has already been done before. If the name of the game is hi-tech, which is what the RCAF asked for, then somone has to 'pay the shot', there are no free lunches!

In hindsight, the cancellation costs on the Arrow and the Iroquois and the cost of laying down the useless Bomarc should also be accounted against Diefenbaker's decision.

3 What did we lose when the Arrow was cancelled?

During the halcyon days of A.V.Roe Canada, This country had risen to be counted with the great aerospace countries of the world, with the first intercity jet transport flying all over North America and as the Americans put it;

"The fact that our massive but underpopulated good neighbor to the North has a mechanical product that licks anything of ours is just what the doctor ordered for our overdeveloped ego. The Canadian plane's feats accelerates a process already begun in this nation-- a realization that Uncle Sam has no monopoly on genius; that our products are not necessarily the best simply because we made them." (Rochester Democrat and Chronical. Jan 12.1951.)

Later, with the Arrow, Canada earned the expressed respect and admiration of the rest of the aviation world, and the aviation press in the UK and the US described the Arrow as 'the most advanced and sophisticated military aircraft in the free world.'

Canada had come out of it's shell and shaken off the self-defined status of 'second best in everything' We had proved that, given the right opportunity, Canadians could rise to the 'top of the heap' and compete with the best in the world. .With the demise of the Arrow and Iroquois projects we were once again lulled into the notion that we could never retain our status as the leaders in anything and went back into semi-consciousness.

We also lost the best engineering team ever assembled in this country. The measure of the capabilities of the Avro team is what they went on to do after being rejected in their own country.

Many of them went into the US space programs and played a major role in all of the American space projects. Others went to the UK to

contribute to the early work on the UK supersonic transport which later became Concorde. Almost all of the ex-Avro and Orenda engineering teams went on to frontier-of-technology jobs, in most cases using the advanced technology learned on the Arrow program, but to the advantage of foreign countries instead of where it belonged, in Canada.

That is what we lost with the demise of the team at Malton. The unique opportunity to retain our position as a leader in world aerospace, an opportunity that is never likely to be available to us again unless we shake the cobwebs out of our hair and take pride in our heritage and encourage our younger generation to make Canada the best in the world again.

4 What if the Arrow and Iroquois had not been cancelled?

I believe that if the team had remained intact, instead of being scattered all over the globe, to the benefit of everyone else, Canada would still be one of the leading nations in the world in aviation technology. We would be exporting these high-tech. products in aerospace to the rest of the world, instead of importing most of them from the States.

In the project research group at Avro we were studying more than 20 exportable projects, from monorails to a space threshold vehicle. Unfortunately the cancellation of the Arrow, resulting in the demise of the company, flushed all of those projects down the drain also.

Spar Aerospace broke the ground with Canadarm and if the Avro/Orenda teams had been allowed to continue in their well-earned role as among the best in the world, I believe that today we would be exporting transport aircraft, military aircraft, gas-turbine engines and a galaxy of other space products all over this planet.

Jim Floyd. Feb. 10th 1989.

APPENDIX.

ARROW AND IROQUOIS PROGRAM COSTS TO CANCELLATION.

ARROW.	MILLIONS.
DESIGN AND DEVELOPMENT	67.70
TOOLING (HARD TOOLING FOR MASS PRODUCTION)	30.50
PRODUCTION + SUPPORT	81.90
ARROW TOTAL	180.10

IROQUOIS.	
DESIGN AND DEVELOPMENT	55.40
TOOLING (PRODUCTION).	13.60
PRODUCTION AND SUPPORT	58.40
IROQUOIS TOTAL	127.40

COMBINED ARROW + IROQUOIS $307.50M.

AVRO OFFER TO CANADIAN GOVERNMENT, PRIOR TO CANCELLATION.

FOR 100 Mk 2 AIRCRAFT, WITH ENGINES, FIRE CONTROL SYSTEM AND TECHNICAL SUPPORT — $3.50M PER AIRCRAFT.
(NOTE — THE $3.50M PER A/C DID NOT INCLUDE AMORTICATION OF THE NON-RECOVERABLE COSTS SHOWN ABOVE — IT WAS A STRAIGHT 'FLY-AWAY' PRICE TO COMPARE WITH ANY ALTERNATIVE).

THE GOVERNMENT HAD SPENT $61.00M ON THE ASTRA/SPARROW PROGRAMS PRIOR TO THEIR CANCELLATION.

SUMMARY FROM PAPER 'FLYING THE AVRO ARROW' — PRESENTED TO THE CANADIAN AERONAUTICS + SPACE INSTITUTE. MAY 16. 1978 — BY S/L JACK WOODMAN — RCAF CHIEF EVALUATION PILOT.

There is not much I can add to the performance picture. As I mentioned, approximately 95% of the flight envelope was investigated, and while the MK I Arrow never did quite reach max speed of Mach 2.0, there is no reason to believe that the production aircraft with Iroquois engines would not have reached Mach 2.0 quite easily. The Iroquois engine had approximately 30% more thrust than the J-75, and the airplane would have weighed approximately 5000 lbs less. I believe the Arrow MK II had sufficient performance capability to set a new world speed and altitude record, which was held at that time by the United States. The first MK II Arrow was scheduled to fly at the end of February, and I believe it would have easily met all performance guarantees.

HANDLING

As I mentioned earlier, the Arrow, at certain speeds and altitudes, flew as well as any airplane I have ever flown; at other points control was very sensitive and the aircraft difficult to fly.

Reading from some of my old flight reports, on my first flight I reported that at low and high indicated airspeeds the airplane behaved reasonably well, the controls being effective, with good response, and the aircraft demonstrated positive stability. However, due to the sensitivity of the controls the aircraft was difficult to fly accurately. At high Mach numbers, I reported the transition from subsonic to supersonic speed to be very smooth, compressibility effects negligible, and the sensitive control problem experienced at lower speeds and altitudes eliminated. The aircraft, at supersonic speeds, was pleasant and easy to fly. During approach and landing, the handling characteristics were considered good; approach speed was 190 knots, touchdown was at 165 knots, drag chute was deployed at 155 knots, and the aircraft rolled the full length of the runway. Attitude during approach was approximately 10°, with good forward visibility.

On my second flight, I reported that the general handling characteristics of the Arrow MK I were much improved. The yaw damper is now performing quite reliably, although turn coordination is questionable in some areas. The roll damper is not optimized as yet, and longitudinal control is sensitive at high IAS.

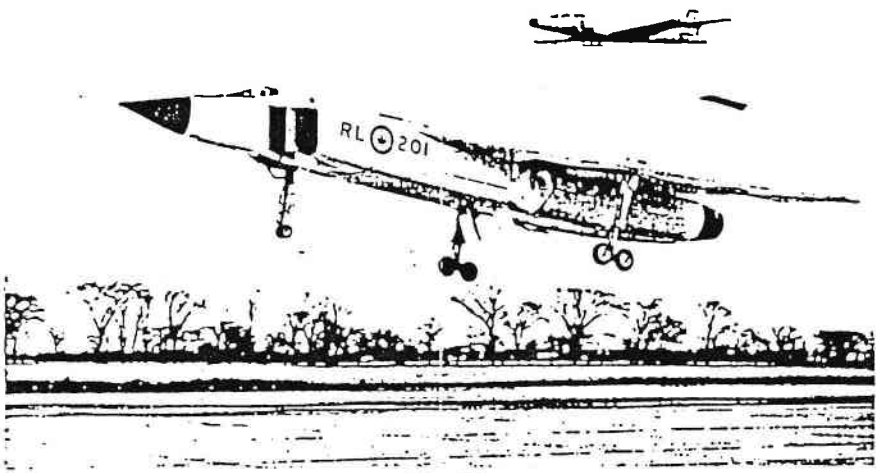

Figure 24

On my 6th and last flight, I reported longitudinal control to be positive with good response, and breakout force and stick gradients to be very good. Lateral control was good, forces and gradients very good, and the erratic control in the rolling plane, encountered on the last flight, no longer there. Directionally, slip and skid was held to a minimum. At no time during the flight was there more than 1° of sideslip, and the problem of turn coordination appears to be eliminated at this point. Final approach to landing was at 175 knots and a 3° glideslope; attitude was approximately 12°, touchdown was at 160 knots, and the landing roll was estimated at 6000 to 6500 ft, with little or no braking.

To me, it appears obvious that excellent progress was being made in the development of the Arrow.

Comments made by some of the other pilots who flew the Arrow include:

- "The nosewheel can be lifted by very gentle movement of the stick at just over 120 knots."
- "Unstick speed is about 170 knots with an attitude of about 11°."
- "Acceleration is rapid, with negligible correction required and no tendency toward swing."
- "Typical touchdown speed is a little over 165 knots."
- "There was no indication of stalling at maximum angle of attack at 15°."
- "Stability steadily improved with speed."
- "Change of trim was negligible except in the transonic region, where small changes of trim were required."
- "In turns, stick force was moderate to light, but always positive, with no tendency to pitch up or lighten."
- "In sideslip, the aircraft was a little touchy without the damper, but excellent with the damper engaged."

SUMMARY

In closing, I would just like to say that the handling and performance characteristics of the Avro Arrow were shaping up very nicely. There were many problems still to be resolved at the time of cancellation, but from where I sat the Arrow was performing as predicted and was meeting all guarantees.

The decision to cancel the Arrow program was, in my opinion, very poorly founded. Nothing has happened since 1959 to support that decision as being correct. In fact, just the opposite happened.

Several months before the cancellation announcement, there was a lot of bad publicity in Toronto newspapers about the Arrow. It was like an anti-Arrow campaign was being waged. Retired Army officers and self-proclaimed aviation experts, and others, were implying that the day of the manned interceptor was over. They said missiles would be the first line of defense, and the Arrow would be obsolete before it could enter squadron service.

Ironically, not too long after the program was cancelled, an announcement had to be made concerning the decision to scrap the Bomarc missile program due to obsolescence. The Bomarc just never got off the launching pad, and the Canadian Government had been "led down the garden path." Ground-to-air missiles can be effective weapons, and a combination of missiles and manned aircraft is probably a good way to go, but one certainly does not replace the other.

The decision to scrap the Arrow program could not logically have been based on money, because since the cancellation, the RCAF has purchased at least 400 new aircraft, if not more. This includes the F-101, the F-104, the F-5, and the present-day evaluation of the F-14 and F-15 as a replacement fighter for use in the 1980's, which run about 15 to 20 million dollars per copy. This new manned interceptor is intended for the 1980's, approximately 30 years after the Arrow was cancelled, and the idea of the manned interceptor declared obsolete.

Cancelling the program was one thing, but to make matters worse, everything was destroyed — all the aircraft, the records, and all the work that was accomplished, almost as if to hide all the evidence. I think one of the aircraft, at least, should have been assigned to the NAE and kept as a research vehicle. Also, I'm sure other aircraft manufacturers could have benefitted from Avro's experience — makers of the Concorde, for example.

Cancelling the Arrow program denied A.V. Roe, and Canada, the opprotunity of developing their technological expertise and to be world competitors in the field fo high-performance aircraft.