

On the 'Wing... #119

The AVRO CF-105 "Arrow"

We recently had the opportunity to watch "The Arrow," a Canadian Broadcasting Corporation film depicting the history of the AVRO Canada CF-105. Originally presented as a two part series on Canadian television, the film is now available on video tape. Starring Dan Aykroyd as Crawford Gordon, president of AVRO Canada during Arrow development, the movie presents the technological and political circumstances leading to the cancellation of the Arrow development program on "Black Friday." Doug Clark, a Canadian, wrote,

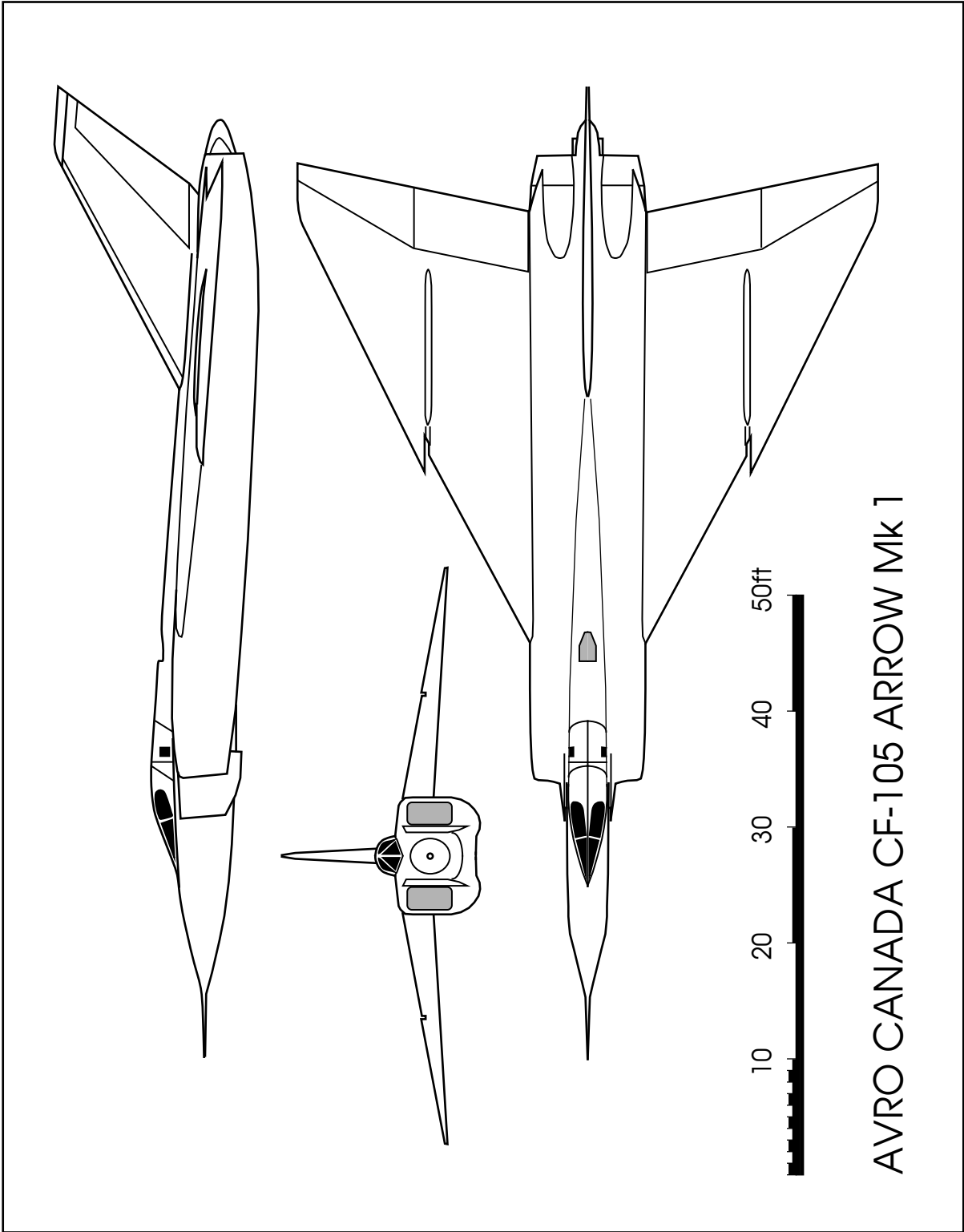
"I just watched the Arrow miniseries and I must say that it brought me to tears. I am 32 years old and I grew up in a country without a space program believing that we were second best. I never knew that we built such a machine. I had heard stories all my life from my father, but until now they didn't have an effect on me... ...seeing how we as Canadians once led the world makes me so terribly sad. I can't express what knowing the truth has done to me. I am going to learn all that I can about the Arrow and I will not be in the dark any longer."

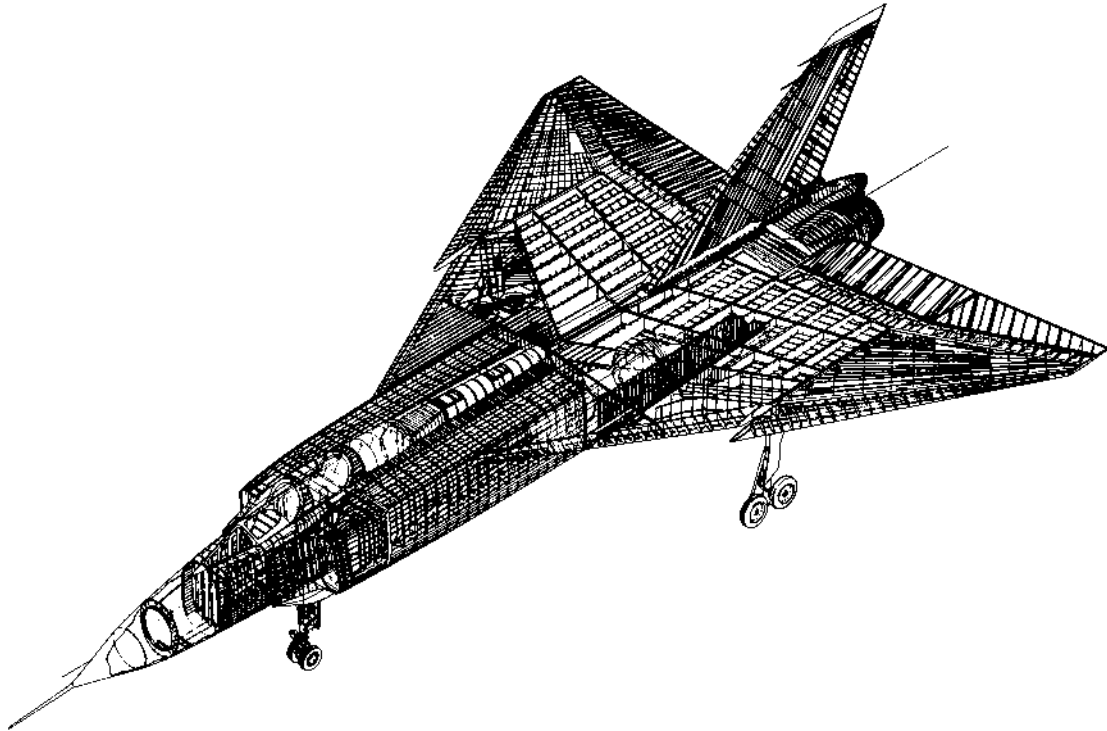
The Arrow project began when the Royal Canadian Air Force issued specification Air-7-3 in April 1953. The document called for a twin engined interceptor with a crew of two which would be capable of Mach 1.5 with a range of 1000 km. The RCAF had studied several alternative designs, and found them lacking. Rather than purchase a compromise design, the RCAF began looking for a manufacturer which could produce an aircraft which would meet all the stated criteria.

AVRO Canada, builder of the Lancaster bomber during WWII, the CF-100 "Canuck," and the C-102 "Jetliner" (almost the world's first jet powered passenger aircraft) was a nearly perfect choice to design and manufacture what would become the most advanced aircraft of its time. AVRO Canada not only had the facilities to manufacture the airframe, it was also owner of Orenda, manufacturer of aircraft jet engines.

Several advanced concepts became part of the Arrow design. First was the Automatic Flight Control System (AFCS). This was not a true fly-by-wire design, but was a sophisticated control system which assisted the pilot by maintaining stability, acting as an autopilot, and preventing the aircraft from entering dangerous flight attitudes in case of engine failure or other serious difficulty. All control surfaces were driven by hydraulic actuators powered by a special high pressure system.

The Arrow was to be armed with missiles only, and all were to be stored internally to reduce drag to a minimum. Thus it had a very large weapons bay





<<http://www.totavia.com/arrow/images/archive/more/cutaway.gif>>

— more than 16 feet long, 9.5 feet wide, and 3 feet deep; more voluminous than the bomb bay of either the AVRO Lancaster or the Boeing B-29. The bay doors, on the fuselage bottom, could be opened at Mach 1.5 in just 0.3 seconds.

The twin engines were mounted at the rear of the airframe. This made maintenance extremely simple. Engines could be removed and replaced in less than 30 minutes by sliding them rearward out of the fuselage. Long ducts lead incoming air from the forward inlets to the aft-mounted engines. Special boundary layer fences mark the entrance ramps of the air intakes.

Because of the thin wing section (just 3% thick), a lot of fuel had to be stored in the fuselage, and the main landing gear had to use a tandem tire arrangement. The size of the weapons bay, and engine and fuel tank locations, dictated the Arrow be a very large aircraft. Its size relative to the Grumman F-14 Tomcat and Dassault-Breguet Mirage 2000 can be judged by the accompanying graphic comparison.

The Arrow Mk.1 was powered by Pratt and Whitney J-75 engines. Despite being somewhat underpowered, RL-201 achieved Mach 1.1 on its maiden flight, and Mach 1.54 on its seventh flight. The Mk.1 version eventually reached Mach 1.97! Performance of the Mk.2, with the substantially stronger and lighter

	AVRO CF-100 Canuck Mk.5	AVRO CF-105 Arrow Mk.1	AVRO CF-105 Arrow Mk.2	McDonnell F-101B Voodoo	Grumman F-14A Tomcat	Dassault-Breguet Mirage 2000
Engine	(2) Orenda 11	(2) Pratt & Whitney J75-P-3 or J75-P-5	(2) Orenda PS-13 Iroquois	(2) Pratt & Whitney J57-P-55	(2) Pratt & Whitney A - TF30-P-412A	(1) SNECMA M53-P2
Thrust, dry afterburner	3300kg /7275lbs	5670kg/12500lbs 8390kg/18500lbs	8390kg/19250lbs 11790kg/26000lbs	5438kg/11989lbs 6705kg/14782lbs	5670kg/12500lbs 9480kg/20900lbs	5600kg/12346lbs 9000kg/19842lbs
Wing span	17.75m/58' 0"	15.24m/50' 0"	15.24m/50' 0"	12.09m/39' 7"	19.54m/64' 1.3" 11.45m/37' 6.8"	9.0m/29' 6.3"
Wing area	54.9m ² /391ft ²	113.8m ² /1225ft ²	113.8m ² /1225ft ²	34.19m ² /368ft ²	52.5m ² /565ft ²	41.8m ² /450ft ²
Aspect ratio	8.6	2.04	2.04	9.28	2.58 — 7.2	2.04
Length	16.7m/54' 2"	23.715m/77' 9.65"	23.41m/76' 9.65"	20.54m/67' 4.7"	18.9m/62' 0"	15.0m/49' 2.5"
Height	4.76m/15' 6.5"	6.477m/21' 3"	6.477m/21' 3"	5.49m/18' 0.1"	4.88m/16' 0.1"	5.3m/17' 4.7"
Empty weight	10478kg/23100lbs	19935kg/43960lbs		12680kg/27995lbs	18112kg/39930lbs	6400kg/14110lbs
Max. weight	16800kg/37000lbs	3117kg/68600lbs		21170kg/46672lbs	33724kg/74348lbs	15000kg/33070lbs
Wing loading	94lbs/ft ²	56lbs/ft ²		126lbs/ft ²	131lbs/ft ²	73lbs/ft ²
Cruise speed		1128km/h/700mph		950km/h/590mph	925km/h/575mph	
Max speed	1046km/h/650mph Mach 0.97	2103km/h/1307mph Mach 1.98	2549km/h/1584mph Mach 2.4	1678km/h/1043mph Mach 1.58	2549km/h/1584mph Mach 2.4	2495km/h/1550mph Mach 2.35
Climb rate		3082m (10112')/min	3464m (11365')/min	5184m (17008')/min	8784m (28819')/min	3750m (12303')/min
Ceiling	16461m/54000'	18290m/60000ft		15850m/52000'	15250m/50000	19800m/65000'
First flight	01-19-50 (Mk.1) 10-12-55 (Mk.5)	03-25-58	not flown	03-27-57	12-21-70	03-10-78

Data from various sources, at times conflicting. Some information estimated or not available.



<<http://www.odyssey.on.ca/~dmackechnie/ARROW2.GIF>>

Orenda PS-13 engines, was predicted to be even better, with a maximum speed of Mach 2.4.

Flying at speeds of Mach 1.5 and above, friction heat was a significant problem. For this reason, a substantial number of key parts were made of titanium, and the crew required an environmental control system. On the ground, the airframe had to be able to withstand the extreme cold of the northern Canada winters.

The Arrow was truly an astounding achievement, as can be judged from the included table. It required a specialized hydraulic system which operated at extremely high pressures; the Iroquois engines, in addition to being extremely powerful for the time, made extensive use of titanium to save weight and handle high internal temperatures; the weapons and avionics systems utilized cutting edge technologies. Yet in just four years, and with around \$300 million, AVRO managed to incorporate all of these diverse systems, each with its own unique challenges, into five flying aircraft. A sixth (RL-206), equipped with the Orenda engines, was just days from completion.

Several governmental and political changes took place during Arrow development; the NORAD agreement in 1954, a change from conservative to liberal government in 1957, and promotion of the Bomarc missile defense system to name a few. Perhaps the major factor was the belief by many that the Soviet Union would not attack Canada and the U.S. by sending trans-sonic bombers over the North Pole. Rather, they believed missiles would rapidly become the "weapon of choice," making the Arrow an expensive and useless



<<http://www.achq.dnd.ca/archive/archiv40/gifs/arrow4.gif>>

artifact. Combined with the belief that Canadians were more interested in new social programs than an “expensive” national defense system, the new Prime Minister, John Diefenbaker, cancelled the Arrow program on 20 February 1959, now known as Black Friday.

The termination of the Arrow led to the loss of 14,000 jobs at AVRO Canada and roughly 35,000 at various subcontractors throughout Canada. The five fully operational aircraft, plus 30 in the process of being built, turned to scrap. Documents, manufacturing jigs and special tools were also destroyed. This despite the fact the first of the Mk.2 versions was less than two weeks from its maiden flight. Suggestions that a single Arrow should be kept as a testbed for the Orenda Iroquois engine were rejected.

A few ironies are worth noting.

- The cancellation of the Arrow forced the RCAF to eventually purchase American aircraft, the F-101 Voodoo. The RCAF purchased 64 copies of that relatively low performance fighter at a cost of \$260 million, near the expenditures already made on the cancelled Arrow program. The Voodoo was the option rejected in favor of development of the Arrow.
- The Bomarc missile system, envisioned to augment and eventually replace manned interceptors, did not achieve success, and was never fully deployed.
- The Tu-95 “Bear,” the most likely target of Arrow missiles, was still in operational status in 1995.

- The powerful Orenda PS-13 Iroquois engine, eagerly anticipated by a large and growing foreign market, was never put into production.
- Many of the senior engineers and designers within the Arrow program emigrated to the United States to work for NASA and major American aircraft manufacturers, while others moved to Europe where the Concorde program was just starting.

The forward fuselage of RL-206, the first of the Mk.2 series, and a few miscellaneous parts still exist. These items are currently stored at the National Aviation Museum (Canada) in Ottawa. Quotes from a couple of Canadians who have experienced that display firsthand:

“I have also been to the museum in Ottawa and I have seen the nose of 206... ..as well as right and left outboard wing sections. ...found it glorious and intensely saddening at the same time.” — Johon Stuart

“I don't have any special Arrow stories to share, but I just came back from vacation down east and... yes, I touched THE NOSE SECTION!! In one way I found it disgraceful how what little remains of the greatest technological achievement in Canadian history is relegated to a dingy little corner of an old hangar that no one deems important enough to visit. On the other hand, I thought that it was a perfect memorial to the unforgivable act of treason perpetrated upon this nation by one John Diefenbaker. By the way, I hadn't cried since I was in grade school, but I wept when I touched that metallic skin.” — Andrew Wilson



Photo by: Hugh Mackechnie (Avro Aircraft)

<<http://www.totavia.com/arrow/images/mackechnie/rl201-4.jpg>>

We often see requests for detailed 3-views of the Arrow within various newsgroups on the internet. Those requests, frequently posted by Canadians, often demonstrate an obvious pride in the tremendous accomplishment AVRO managed to achieve. Less obvious, but still inherent in each message, is the tremendous emotional tie between the Canadian people and what many consider to be the greatest airplane ever built.

A full size model of the Arrow, composed of a 304L stainless steel frame with 0.063 aluminum skin, is scheduled for completion in April of 1999 at the Toronto Aerospace Museum in North York, Ontario.

As a power scale slope soaring (PSS) subject, the Arrow is nearly ideal. Lots of wing area for a given span and a relatively simple fuselage structure make it an attractive choice. But it's the story behind the CF-105 Arrow which will hopefully entice you to model it.

Special thanks to Monique MacNaughton's Terminal AVRO Arrow Obsession Syndrome "graffiti" page, <<http://studio.watertower.com/~coydog/shrine.htm>>, for the three quotes included in this article.

References (print):

Air Progress. Spring 1958, pp.82-83.

Angelucci, Enzo and Paolo Matricardi. *World Aircraft, Military, 1945-1960*. Rand McNally & Company, Chicago, 1978.

Wood, Derek. *Jane's World Aircraft Recognition Handbook, Fifth Edition*. Jane's Information Group Ltd., Coulsdon, Surrey, UK, 1992.

Krivinyi, Nikolaus, Editor. *Die Luftflotten der Welt, 3rd Edition*. Bernard & Graefe Verlag, Koblenz Germany, 1983.

Taylor, John W.R., Editor. *Combat Aircraft of the World from 1909 to Present*. G.P.Putnam's Sons, New York, 1969.

References (internet):

Aviation Videos Ltd., <<http://www.aviationvideos.com/avs/av-home.html>>

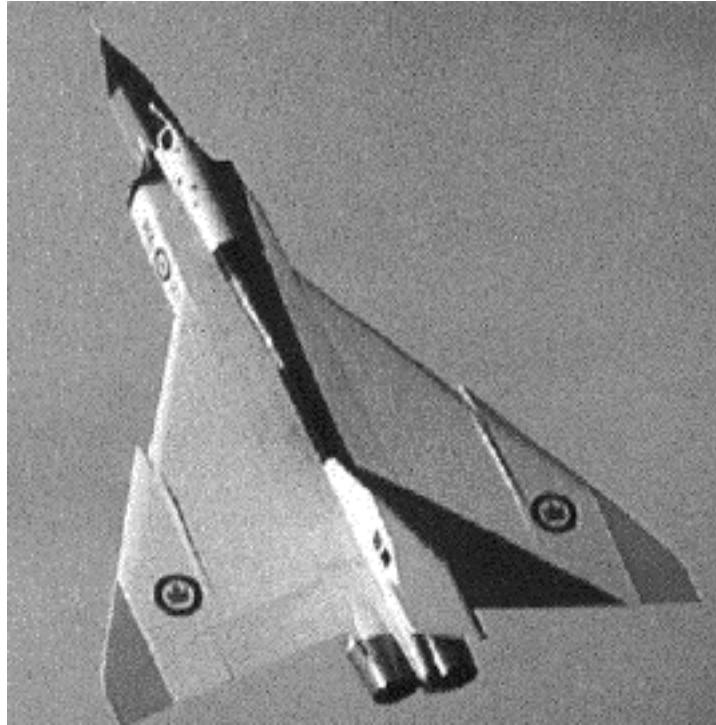
C.J. "Chip" Chapman's AVRO Arrow page, <<http://www.king.igs.net/~chapmanc/arrow.html>>

Monique MacNaughton's Terminal AVRO Arrow Obsession Syndrome, <<http://studio.watertower.com/~coydog/tpage.htm>>

Hugh Mackechnie, official AVRO photographer, <<http://www.odyssey.on.ca/~dmackechnie/CF-105.htm>>

The National Aviation Museum (Canada), <<http://aviation.nmstc.ca/exhibits/silverdart/sd015e.htm>>

Photographs of the Arrow, <<http://www3.sympatico.ca/lanmad/>> and <<http://www.angelfire.com/sc/avroarrow201/index.html>>



<http://www.geocities.com/CapeCanaveral/9581/climb.gif>

References:

Photographs of the full sized (motorized) model used in the CBC movie "The Arrow," <http://www.gray.mb.ca/gray/aviation.html>

R. Kyle Schmidt's Homage to the Arrow, <http://www.totavia.com/arrow/>

Rich Thistle's "Dream Machine," <http://www.richthistle.orc.ca/article13avroarrow.htm>

The Toronto Aerospace Museum, <http://tor-pw1.netcom.ca/~n.flight/small.html>