CANADA AVIATION AND SPACE MUSEUM AIRCRAFT

RYAN KDA-4 FIREBEE TARGET DRONE
RCAF SERIAL KD4788

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Canada

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ROYAL CANADIAN AIR FORCE SERIAL KD-4788

INTRODUCTION

The Ryan *Firebee* began as a series of target drones (now more commonly referred to as unmanned aerial vehicles or UAVs) [1] developed by the Ryan Aeronautical Company (later Teledyne Ryan), beginning in 1951.

It was one of the first jet-propelled drones, and, eventually, one of the most successful and widely used target drones ever built. Generally referred to as the *Firebee I*, the initial versions possessed high subsonic speed, and were primarily intended for use in ground-to-air and air-to-air gunnery training. Later versions were developed into reconnaissance vehicles, as well as into attack and multi-mission platforms. More than 7,000 *Firebee* vehicles were built, with many variants being introduced.

A Ryan publicity photo illustrating the first customers for the Ryan Firebee: the United States Air Force, the United States Navy, the United States Army and the Royal Canadian Air Force. - (Ryan Aeronautical Company Photo)

The Royal Canadian Air Force (RCAF) became one of the first customers for the *Firebee* intending the target drone to be used in particular for the planned weapons testing and training on the Avro Canada CF-105 *Arrow* fighter program. The *Firebee* has the distinction of being the first UAV in the RCAF.

Cover Photo Caption - The Ryan Firebee was launched from a modified Lancaster bomber in RCAF service. - (RCAF Photo)

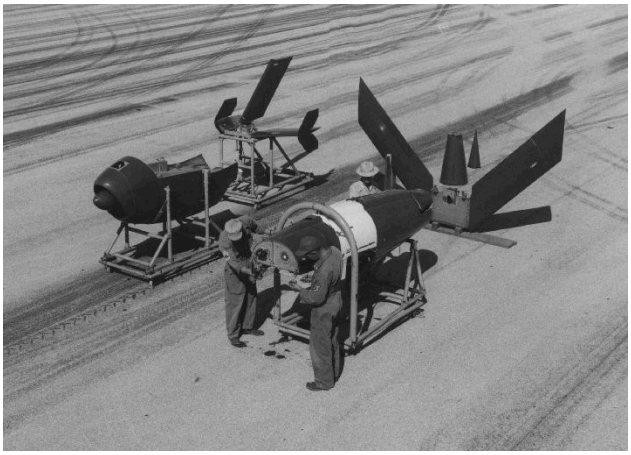
FIREBEE DESIGN HISTORY [2]

Q-2 / KDA-1 Firebee

The *Firebee* was the result of a 1946 United States Army Air Force (USAAF) request for a jet-powered gunnery target. Sensing the potential magnitude of this project, thirty-one companies responded to the first request for quotation, but after analysis by the Air Force, none was accepted and the project was opened for rebids with a due-date of January 1948. Eighteen of the nation's top aircraft manufacturers responded, and 14 actual designs were submitted.

In August 1948, the Ryan Aeronautical Company was awarded the first contract for a subsonic, jet-propelled target drone. The first flight of the XQ-2 *Firebee* prototype took place in early 1951. The drone featured swept flight surfaces and a circular nose inlet. The initial models had distinctive "arrowhead" shaped endplates on the tailplane.

A early model KDA-1 Ryan Firebee is shown here in US Navy markings - (Ryan Aeronautical Company photo courtesy of the San Diego Air and Space Museum Archives)



The modular construction of the Ryan Firebee is clearly shown in these two images. - (Ryan Aeronautical Company photos courtesy of the San Diego Air and Space Museum Archives)

The Firebee is shown here mounted under the wing of a USAF A-26 Invader. - (USAF Photo)

The original specification for the XQ-2 called for both an air and ground launch capability. The early launching aircraft for the XQ-2, as well as the launching vehicle for the parachute recovery tests, were many and varied. The first launching of the (unpowered) Q-2 took place from the wing of a Boeing B-17 *Flying Fortress* bomber, and a Boeing B-29 *Superfortress* was also used for a short period for recovery parachute tests. Eventually, the Douglas B-26C *Invader* medium bomber was adopted as the standard launch vehicle. Actually, the US Navy was the pioneer in this phase, using their JD-1 version of the B-26 with a single target on one wing with water ballast on the other. The final configuration with a target under each wing was tested at Holloman Air Force Base with the United States Air Force (USAF).

In 1952, the United States Research and Development Board Panel for Target Drones, including representatives for the United States Air Force, Navy and Department of the Army convened at Holloman Air Development Center in New Mexico to witness the formal demonstration of the Ryan XQ-2 drone. At least 32 XQ-2 drones had been built for the test and evaluation program. In December of that year, Ryan received a letter contract for the production of 35 XM-21 (US Army designation) targets.

Ground-launch experiments initially started with a 1,219 meter (4,000 ft) set of rails to determine the effect of acceleration on the target during and after launching. All of these tests were captive, with the trolley-held drone being propelled down the rails under both rocket and engine power. Decelerations were accomplished with a scoop attached to the trolley which was dragged through a series of reservoirs containing water.

From the 1,219 meter rails, the tests proceeded on to a catapult launcher with 30 meter (99 ft) rails. The catapulting force was initially obtained from a powder charge fired from the breech mechanism of a standard

15 centimeter (6-inch) naval gun. Unfortunately, powder with the desired burning characteristics was not generally available, and use of a standard guided takeoff launcher with a 4,990 kg st (11,000 lbs) rocket assisted take-off (or RATO) [3] bottle for the initial boost was subsequently adopted.

Two spectacular images of the Ryan XM-21 Firebees being ground-launched using a rocket booster (later jettisoned). - (Ryan Aeronautical Company photos courtesy of the San Diego Air and Space Museum Archives)

One of the first attempts to “zero-length” launch the *Firebee* from a standard road vehicle produced a truly spectacular flight. Shortly after takeoff, the target commenced a slow roll. The RATO continued to burn until the XQ-2 was in an inverted position, at which time the RATO separated. The drone completed its slow roll and reassumed level flight. Had not confusion occurred in the control station, the flight might have been a success, but the drone impacted the ground almost immediately thereafter. This initial crash proved to be a minor setback and the Army, which was responsible for the tests, later conducted successful take-offs from just 2.4 meter (8 ft) rails; a technique was subsequently adopted by many other users .

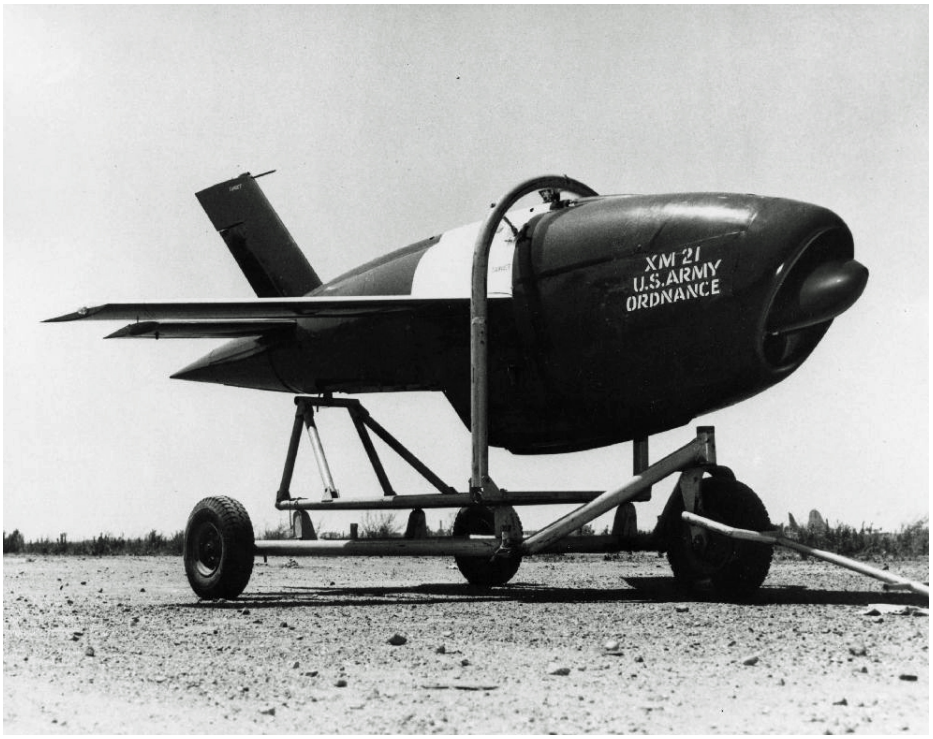
Following successful evaluation, the target was ordered into production for the USAF as the Q-2A, powered by a Continental J-69-T-19B turbojet engine with 481 kg (1,060 lbs) of thrust. The USAF later obtained small numbers of the Q-2B variant which featured a more powerful engine for better high-altitude performance.

The USAF’s Q-2A Firebee drone is illustrated in the above photo. Note the absence of a nose inlet centre body and the radar reflector pod on the wing tip. The Q-2 A , B and C variants were all powered by Continental J-69 jet engines. - (USAF Photo)

The United States Navy (USN) instead bought the *Firebee* KDA-1 variant, with much the same appearance as the Q-2A, differing mainly in that the powerplant was a Fairchild J-44-R-20B turbojet, providing just 453 kg (1,000 lbs) of static thrust. The KDA-1 could be visually distinguished from the Q-2A from the fact that the KDA-1 had an inlet centerbody.

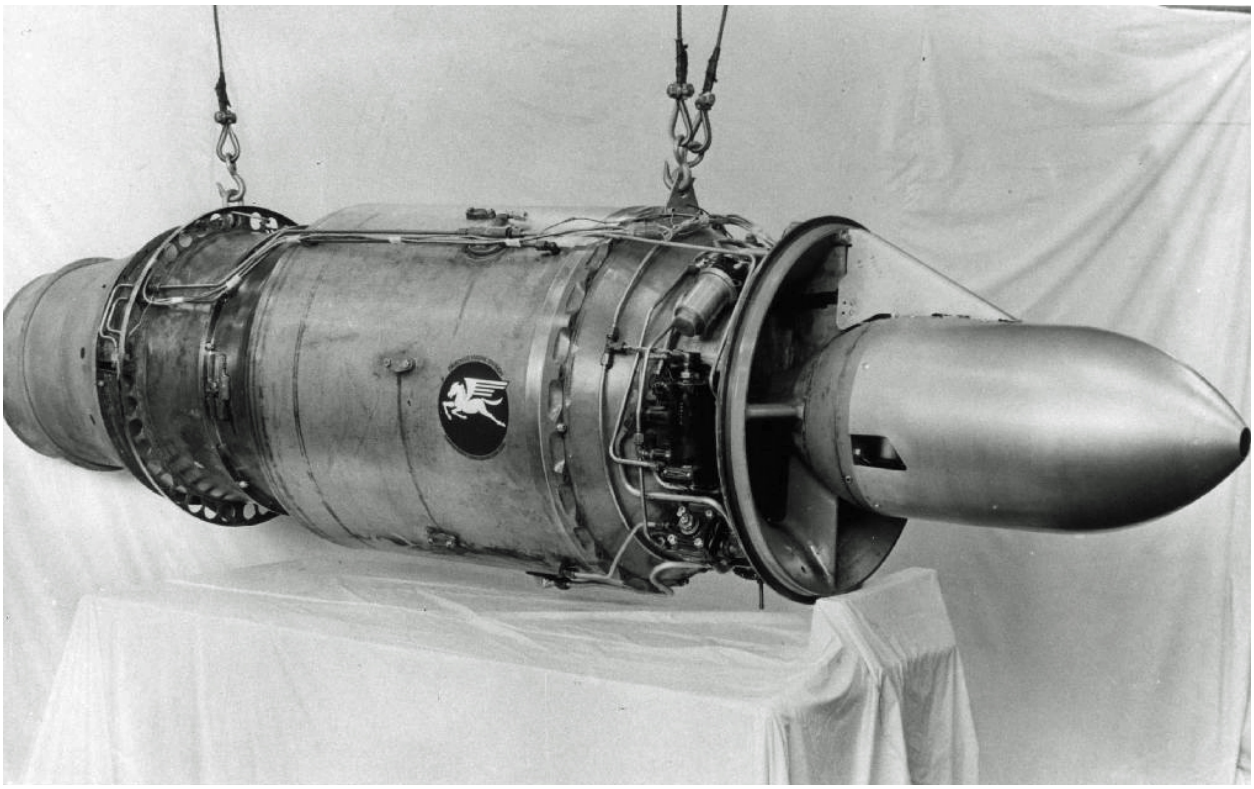
A colorfully decorated USN KDA-1 Firebee is illustrated here being prepared for an air launched mission. - (Photo courtesy of the San Diego Air and Space Museum Archives)

The United States Army also obtained yet another version, designated the M-21, that differed from the KDA-1 variant in only minor (internal) details. All of the Army's drones were ground launched.



The US Army's M-21 variant was externally indistinguishable from the KDA-1 variant . - (Photo courtesy of the San Diego Air and Space Museum Archives)

The USN went on to procure several improved variants of the KDA-1, including the KDA-2 and KDA-3 series, which were not built in quantity, and the KDA-4, which became the main production version for the type. These variants were hard to externally distinguish from the KDA-1, differing primarily in having successively uprated J-44 engines and other minor internal changes.



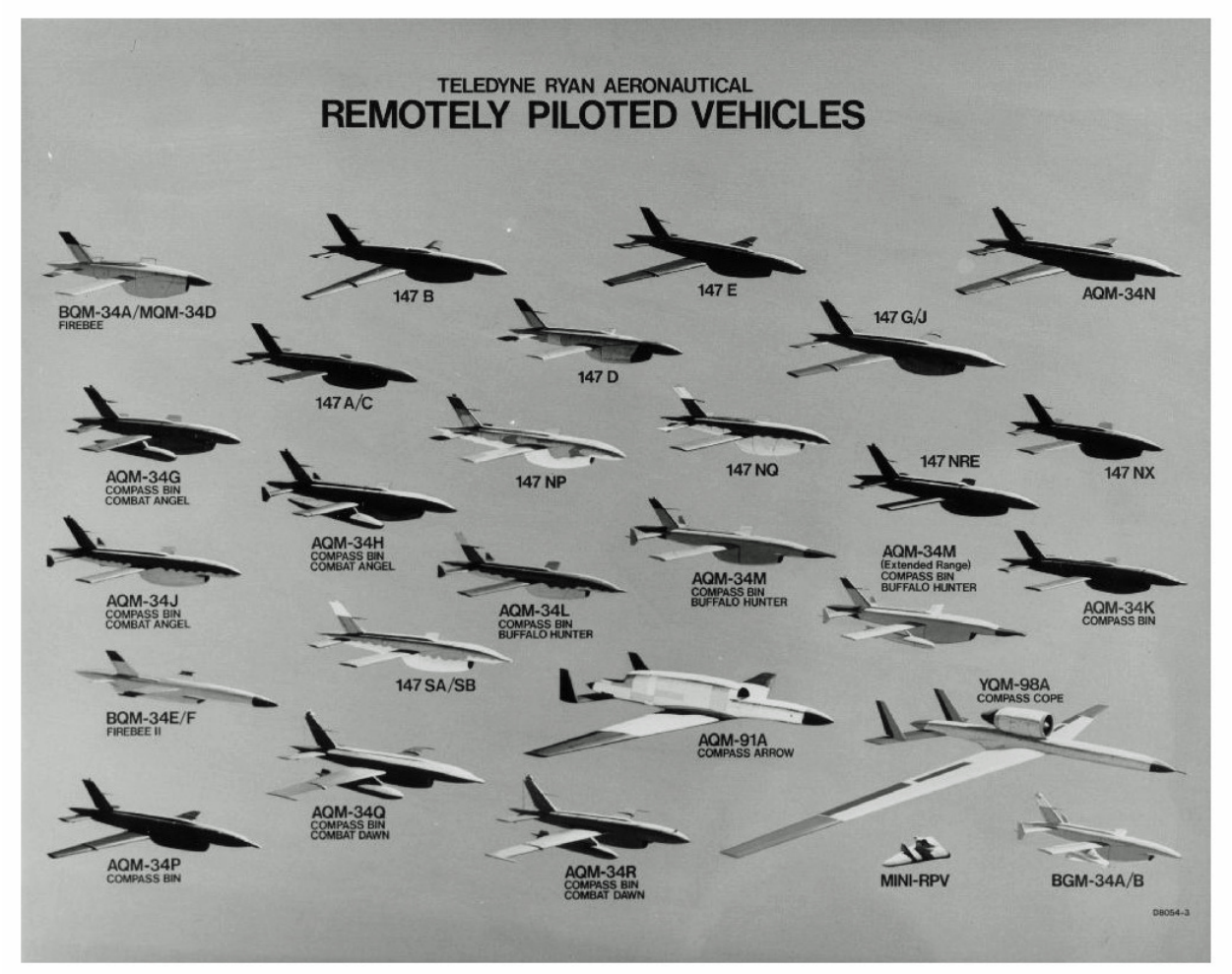
A view of the very compact J-44 turbojet engine which powered the KDA-1, 2,3 & 4 and M-21 variants of the Ryan Firebee. - (Photo courtesy of the San Diego Air and Space Museum Archives)

Later Variants

The later generation BQM-34 Firebee is shown here mounted under the wing of a USN Neptune. - (USN Photo)

A substantially improved, second-generation *Firebee*, the AQM / BQM / MQM / BGM-34 series of variants, first flew in 1958 and then went into production in 1960. This improved version ultimately became the dominant *Firebee* variant, featuring a larger airframe, longer wings, and a chin type inlet under a pointed nose. Additionally, a supersonic version, generally known as *Firebee II* (BGM-34E/F/T), was contracted for in 1965. These later variants evolved far beyond their target drone origins and evolved into multi-purpose UAVs used for battlefield and maritime reconnaissance and even for attack missions. More than 7,000 *Firebees* have been built, with 1,280 of these being the first-generation variants.[4]

The 2nd generation variant of the Firebee has become the dominant series of this very successful design. - (Photo courtesy of the San Diego Air and Space Museum Archives)



The Firebee design has gone on to span an impressive series of modification and further development as illustrated by the above family of variants. - (Photo courtesy of the San Diego Air and Space Museum Archives)

THE Q-2 / KDA-4 TARGET DRONE IN DETAIL

Q-2 / KDA-4 *Firebee* Details

The *Firebee* Q-2A, Q2-B and Q-2C versions from the USAF and the USN's KDA-4 variant were generally very similar. The fuselage was of metal monocoque construction, carrying either a Continental J-69 or Fairchild J-44 turbojet underslung at the forward end of the fuselage. The swept wings and tail surfaces were untapered, and the command-guidance system controlled the drone through conventional ailerons, elevators and rudder.

The optional wing-tip mounted electronic reflector pods show up well in this head-on aerial view. - (Photo courtesy of the San Diego Air and Space Museum Archives)

For target applications, electronic pods could be mounted on the wing tips. These pods transmitted a special radar signal to an oncoming missile; the reflection from which (at a higher frequency) modified the transmission from the *Firebee* by pulsing in direct proportion to the missile / target distance. These modified signals were then transmitted to a ground station and recorded on moving tape to give a continuous running record of miss-distance.

The *Firebees* were also equipped with S-band beacons for response to ground control radar and L-band beacons to provide a Ground Control Intercept (GCI) station with a positive position for the vectoring in of fighter aircraft. In addition, cameras could also be installed in *Firebees* to photograph incoming missiles.

The vast majority of first generation *Firebees* in service were Q-2As with the USAF. These were powered by J-69-T-19B (Turbomeca-Marbore) turbojets manufactured under license. The stabilization system consisted of a RAPS-4A autopilot. The tracking and control system comprised an MSQ-1 or 1A ground station along with an APW-11A airborne radar, all using a four-channel telemetering system.

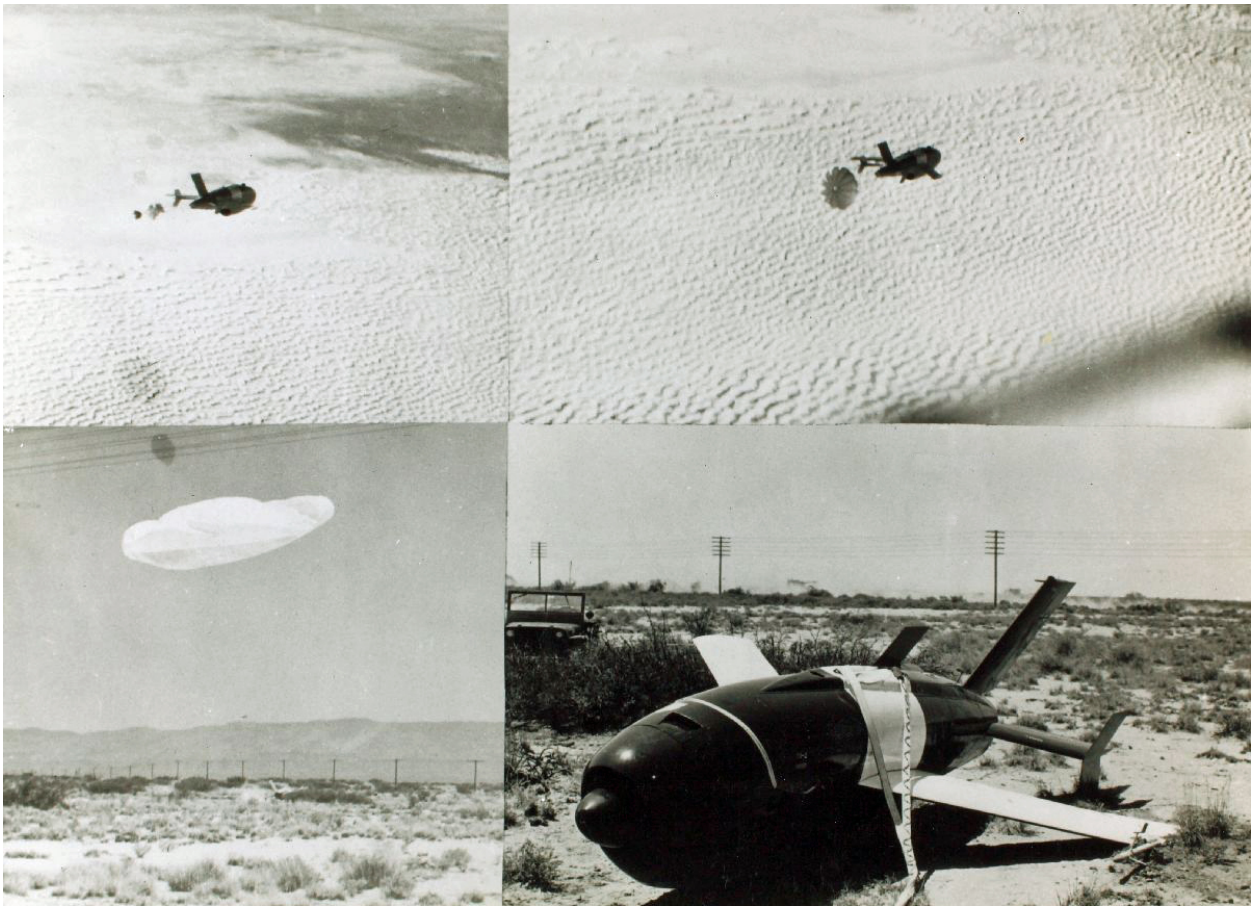
In contrast, the KDA-4 version was powered by a Fairchild J-44-R-20 turbojet engine and its equipment included the RAPS-7B stabilization system, command control by UHF radio and an S-band radar beacon. The Fairchild J-44-R-20 was designed as a special-purpose turbojet. It possessed a diagonal-flow (centrifugal eye and axial periphery) compressor and an annular combustion chamber with 12 burners and a single-stage turbine.

First planned in 1947, this small and simple engine bore little similarity to any previous aircraft jet powerplant. Its monocoque construction was particularly innovative. The first “short-life” version of the engine was first run in 1948 and then service-tested in 1949. It was first flown in a US Navy missile test vehicle in 1950. Many hundreds of flights followed, and “short-life” versions [5] of the J-44 were then successfully employed on the KDA-1 version of the *Firebee*. At least one J-44 was recovered from the sea after eleven successive flights without needing overhaul or major parts replacement.

Typical Firebee Operations

In the USAF, the Q-2 *Firebee* became the standard target at the “Project William Tell” intercepter weapons meet used to train USAF and RCAF North American Air Defence interceptor crews. Typically during the meet’s ten-day program from 80 to 120 *Firebees* were launched to act as interception targets operating between 4,250 - 15,250 meters (14,000 - 50,000 ft) at speeds of around Mach 0.79 - 0.87.

The mean flight duration of the *Firebees* was normally of the order of 30 minutes, one hour being near the normal maximum in USAF operations. The peak distance from the ground controller could be as high as 240 kilometers (150 miles), and recovery was effected by a parachute system including a 21-meter (70-foot) canopy.



The recovery sequence for the Firebee is shown in this series of photographs and the next. The recovery system was a two-stage parachute system; a drogue chute first slowed down the drone and then a much larger parachute deployed to lower the drone to the ground. - (Photo courtesy of the San Diego Air and Space Museum Archives)

Air Launch Details

The airborne launch routine can be described as follows: the drone carrier aircraft took off and climbed to its launching height on a rectangular course. While carried by the aircraft, the *Firebee* was connected to it by an "umbilical cord," through which a onboard crew member carried out full control checks during the climb. When these were completed, the link was disconnected and all subsequent control was carried out by a drone controller from a command post on the ground. As the drone carrier came up to the launching point, it was joined by a "chase plane" which observed and reported on the drone's manoeuvres. If the drone for some reason got badly out of control, the chase plane's duty was to shoot it down. But this was unlikely to happen because an automatic device within the *Firebee* ensured that, should ground control be lost, a recovery parachute would automatically deploy and safely lower the drone to earth. The ground controller typically directed a planned series of manoeuvres and finally, when the *Firebee* ran out of fuel, he would command its recovery by a two-stage parachute. Because of its high speed and altitude, it was not normally possible to keep the *Firebee* in sight from a ground position and mission progress was therefore plotted on a board.

The Firebee design employed a two-stage parachute system; a drogue chute to slow the drone and a much larger canopy, as seen here, to safely lower it to the ground - (Photo courtesy of the San Diego Air and Space Museum Archives)

ROYAL CANADIAN AIR FORCE USE

The RCAF purchased the KDA-4 variant of the Firebee as shown here - (RCAF Photo)

The RCAF became one of the first operators of the *Firebee* drone in 1957 with an order for thirty KDA-4s. The first examples were subjected to cold weather testing at Fort Churchill, Manitoba.

The Ryan *Firebee* drone was originally acquired by the RCAF to provide training for CF-100 interceptor crews and primarily in anticipation of the procurement of the CF-105 *Arrow* interceptor and its proposed future weapon systems.

At the same time, two *Lancaster* Mk 10 aircraft were reactivated from storage to act as “mother” ships for the drones. The *Lancaster* modifications were carried out by Fairey Aviation Company and included fitting of *Firebee* launch racks under each wing along with the associated electrical wiring and control

units. Initial training was conducted in cooperation with the USN at their China Lake Naval Air test facility in California. The *Lancasters* were then operated by the Central Experimental Proving Establishment (CEPE) using a purpose-built facility at RCAF Station *Cold Lake*, Alberta. The first flight took place on 21 October 1956 and by the end of that year another 11 flights had occurred. The KDA-4 was used in various trials of the Canadian-built *Sparrow* air-to-air missile and also in cooperative tests with the US Army on the *Nike Hercules* surface-to -air missile in Churchill, Manitoba and with the US Navy on firings of the their *Sparrow III* missile.

A fine close-up of the RCAF KDA-4 Firebee mounted on the wing launch rack underneath a Lancaster. Note the white mission markings on the centre fuselage. A protective cover has been installed over the jet engine inlet. - (RCAF Photo)

After release from the *Lancaster* launch aircraft, the *Firebees* under remote control could climb to 40,000 feet in approximately 10 minutes and could be made to perform any manouevre of which contemporary high performance aircraft were capable. An airborne duration of 1 hr 20 minutes was typical. The drones could also be fitted with wingtip mounted radar reflector pods to ensure optimum radar energy reflection. Assuming the drone was not shot down, recovery was then effected by means of a two-stage parachute, which also had a built-in flotation system. The *Firebees* would be parachuted for recovery over the air weapons range associated with RCAF Station *Cold Lake*. The airframes were then typically airlifted by helicopter back to the station for refurbishment. Re-use of the drones for up to 15 operational flights was found to be possible in RCAF service.

The KDA-4 *Firebee* drone program proved to be very successful until it was concluded in 1961. The demise of the CF-105 *Arrow* program before the commencement of weapon's testing likely precluded any

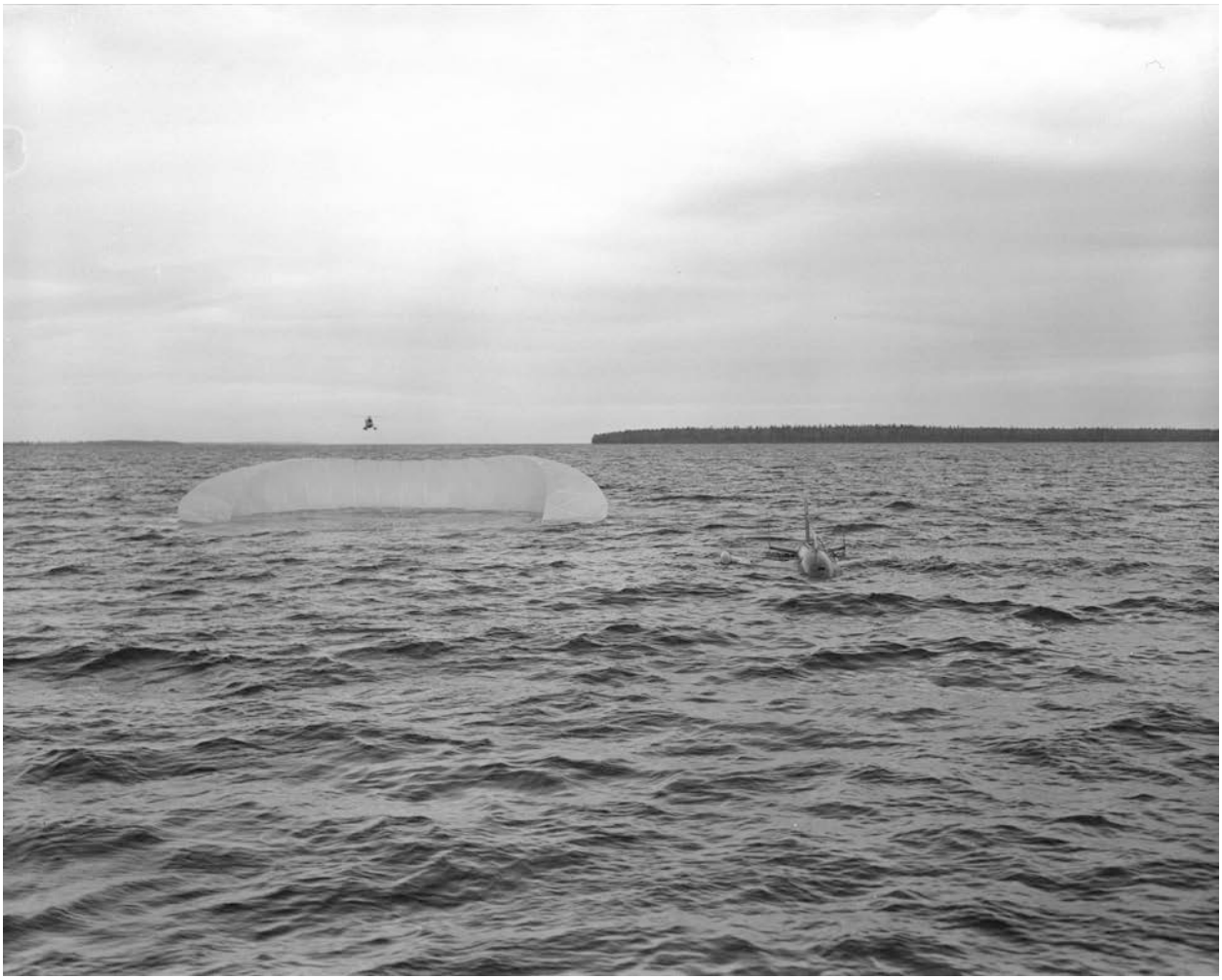
further replacement procurement program for the *Firebee* in the RCAF. Although now largely forgotten in history, the Ryan *Firebee* has the distinction of being the first operational UAV in the RCAF.

A RCAF KDA-4 Firebee being displayed in the hangar during an Air Force Day open house - (RCAF Photo)

The following sequence of photos illustrates a Canadian *Firebee* mission from start to finish:

These two photos are courtesy of Ted Mahood who worked on in the Firebee while posted to the Air Armament Experimental Detachment of CEPE at Cold Lake. The Firebee on the left awaits another mission. Note the four mission markings just visible on the nose. On the right, Firebee sits fully loaded on its mothership just prior to a mission.

Getting airborne for the mission, the drone controller Lancaster lifts off the runway carrying a Firebee under each wing tip - (RCAF Photo - PL-120072)



The mission now complete, the RCAF Firebee has safely parachuted into the waters of Primrose Lake near Cold Lake. The main parachute provides a good visual cue to the H-34 helicopter arriving in the distance to pick up the drone. - (RCAF Photo - PL-120091)

A close-up of the RCAF KDA-4 Firebee being recovered. Note the water cascading from the drone. - (RCAF Photo - PL-120087)

Safely recovered from the lake, the KDA-4 Firebee is flown back to base slung underneath the helicopter - (RCAF Photo - PL-120088)

The KDA-4 Firebee is shown here being manhandled onto its ground handling cradle - (RCAF Photo - PL-120089)

Canadian winters necessitated the Firebees to also be parachuted onto frozen lake surfaces.- (RCAF Photo)

A fine close-up of a KDA-4 Firebee flying alongside a US Navy Demon jet fighter carrying both a Sparrow and Sidewinder missile. In 1960, the RCAF cooperated with the US Navy providing Firebees for test firings of the Sparrow III missile from Demon aircraft at Cold Lake in a test program known as Operation "Blue Tar". - (USN Photo)

Lancaster Mk 10DC (Drone Controller)

One of two RCAF Lancaster drone controller aircraft shortly after conversion. Note the drone pylon / carriage racks under each wing and the non-standard, high-visibility paint scheme. - (RCAF Photo)

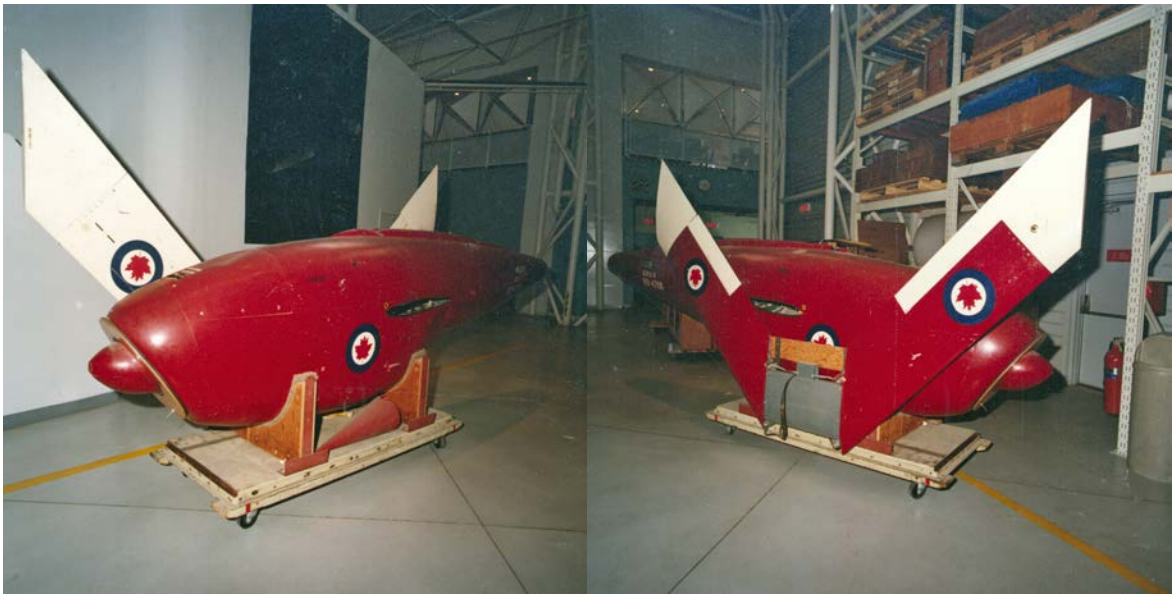
In 1957, Fairey Aviation modified two *Lancaster* airframes destined to act as a launch platform and controller for the RCAF's Ryan KDA-4 *Firebee* drone program. The two selected airframes, serial numbers KB848 and KB851, had both seen previous wartime service and were ultimately designated as the Mk. 10DC. Modifications to the 10DC airframes were essentially the same as those given to the post-war 10MR/MP *Lancaster* variant. However, the specific maritime patrol equipment was eliminated and drone controller equipment was substituted. A pylon capable of carrying the *Firebee* drone was added under both wings, outboard of the engines. Both 10DC airframes were retired from service at the end of the program. The front fuselage section of KB848 was then preserved and is currently part of the collection at the Canada Air and Space Museum (CASM) in Ottawa in Second World War colours.

Another fine view of the RCAF KDA-4 Firebee mounted on the wing launch rack underneath Lancaster KB851 . Note the wing-tip mounted electronic reflectors on this particular Firebee. - (RCAF Photo)

The forward fuselage of Lancaster KB848 is now preserved in the Canada Aviation and Space Museum. - (RCAF Photo)

Canada Aviation and Space Museum *Firebee* RCAF Serial Number KD-4788

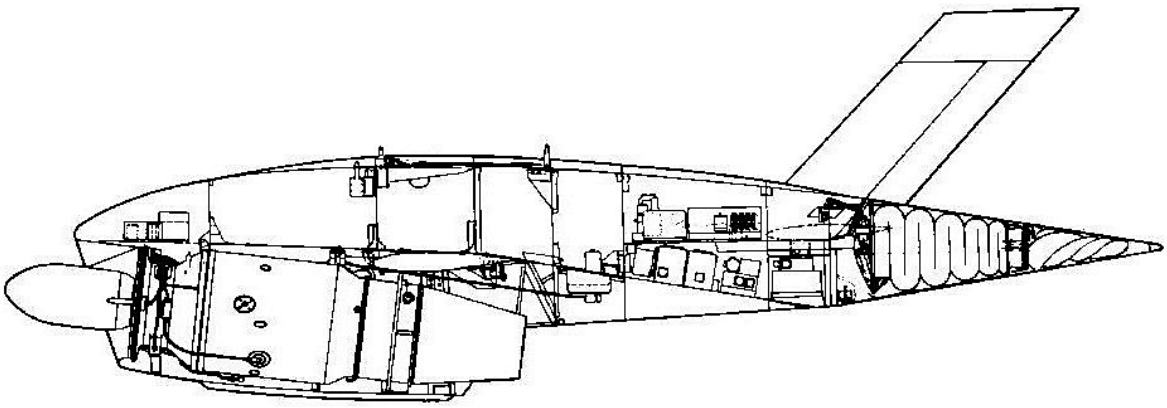
The Canada Aviation Museum (now CASM) obtained a surviving RCAF *Firebee* drone, serial number KD-4788. The engine is listed as a [Fairchild] J-44-R-20B. Few details of its operational history are known. It was delivered to RCAF Station Cold Lake, AB on 30 June 1959 and, after service, was transferred to Uplands, ON for preservation on 4 July 1963. It was transferred to the (then) National Aviation Museum on 6 February 1964. The *Firebee* is currently in storage awaiting restoration.



Several views of the Canada Aviation and Space Musuem's KDA-4 Firebee drone - (CASM Photos)

Several views of the Canada Aviation and Space Musuem's KDA-4 Firebee drone - (CASM Photos)

This final view of Canada Aviation and Space Musuem's KDA-4 Firebee drone shows both the designation and serial number painted on the aft fuselage of the drone. - (CASM Photo)



A cross-sectional view of the KDA-4 clearly illustrates the engine installation (note the inlet centre body) along with the avionics bay and parachute installations towards the rear of the fuselage. - (Ryan Aeronautical Company drawing courtesy of the San Diego Air and Space Museum Archives)

TECHNICAL SPECIFICATIONS [6]

Designation:	KDA-4
Role:	Target Drone
Powerplant:	Fairchild J-44 turbojet engine
Performance:	Max Speed: 976 km/h (610 mph)
	Cruising Speed: 920 km/h (575 mph)
	Stalling Speed: 259 km/h (162 mph)
	Service Ceiling: 12,960 m (42,500 ft)
Weights:	Empty: 536 kg (1,181 lbs)
	Gross: 839 kg (1,849 lbs)
Dimensions:	Span: 3.40 m (11 ft 2 in)
	Length: 5.36 m (17 ft 3 in)
	Height: 1.79 m (5 ft 10 in)
Cost:	$45,000 US

J-44 Specifications [7]

Basic diameter:	55.9 cm (22 in)
Length:	225 cm (88.5 in)
Dry weight:	152 kg (335 lb) with basic accessories
Mass flow:	11 kg / sec (25 lb/sec)
Pressure ratio:	2.5:1
Maximum thrust:	454 kg st (1,000 lbs) at 15,780 r.p.m.

LIST OF COMMON ABBREVIATIONS

RATO	Rocket Assisted Take-Off	UHF	Ultra High Frequency
RCAF	Royal Canadian Air Force	USAF	United States Air Force
UAV	Unmanned Aerial Vehicle	USN	United States Navy

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Acknowledgements:

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END NOTES

[1] The terminology of "target drones" was first superseded by the abbreviation "RPV" or Remotely Piloted Vehicle and RPV has since been superseded by "UAV" standing for Unmanned Aerial Vehicle and / or "UAS" for Unmanned Aerial System".

[2] This section is based primarily on the applicable chapter in the reference: *Lightning Bugs and other Reconnaissance Drones.*

[3] The term "RATO" was often used interchangeably with "JATO" or Jet Assisted Take-Off. The booster charge is actually a rocket motor so the term RATO is technically more accurate.

[4] See http://en.wikipedia.org/wiki/Ryan_Firebee

[5] Fairchild went on to develop a long-life (150+ hour) version of the J-44. The engine was also used in a variety of other applications: for added take-off assistance, J-44s were fitted to the wings / or fuselages of Fairchild C-82 *Packett* and C-123 *Provider* transports. The engine could also be found on missiles including on Fairchild's *Petrel* air-to-surface weapon designed for the U.S. Navy.

[6] Drawn from: Leversedge, T.F.J. *Canadian Combat and Support Aircraft* - Page 342.

[7] Drawn from: " Fairchild J44-R-20 "*Flight Magazine* 26 Jul 1957 Page 132