On 9 April 1953, Shannon made the first flight of the XF2Y-1.

SEADART

U.S. Navy XF2Y-1 and YF2Y-1 Experimental Supersonic Seaplanes

by B.J. Long
Former CONVAIR Engineering Test Pilot

E.D. "Sam" Shannon, Convair's Chief of Engineering Flight Test, taxis the XF2Y-1, Bu. No. 137634, up the ramp after the first test operation.

Seadart No. 3, Bu. No. 135763, with Engineering Test Pilot B.J. Long, who made the first flight on this aircraft on 4 March 1955.

Seaplanes played a major role in the development of aircraft and their application to man's needs for more than four decades of aviation history.

In 1910, a Frenchman made the world's first seaplane flight. The next year the U.S. Navy took delivery of their first hydroaeroplane to found Naval Aviation.

In 1914, the "St. Petersburg-Tampa Airboat Line" became the world's first scheduled airline. In 1916, the Curtis H-12 flying boat became the first American-built aircraft ever used in aerial combat. In 1934, an Italian racing seaplane set the then-incredible world speed record of 440 mph.

Seaplanes were developed by many nations because harbors were readily available and accessible as compared to airfields. Seaplanes pioneered international airline operations through the 1930s.

The U.S. Navy relied heavily on seaplanes from 1911 through World War II and beyond. Martin P5M flying boats were used extensively in the early days of Viet Nam for coastal and shipping patrols.

However, the worldwide development of airfields and aircraft during WW II helped spell the demise of the seaplane.

In the late '40s, the U.S. Navy studied a naval mobile base concept using a family of seaplanes that would be supported by suitable naval vessels anchored or buoyed in sheltered water. Convair Division of General Dynamics Corporation in San Diego, California, under contract to the U.S. Navy, studied the "mobile base" system and made conceptual designs of water-based aircraft required to perform such naval operations.

Convair's Hydrodynamic Laboratory for several years studied many subsonic jet seaplane designs, some called "SKATE." Jet-powered, radio-controlled models were tested in San Diego bay along with dozens of models and hydroski configurations towed by high-speed boats.

On 19 January 1951, Convair received an order from the U.S. Navy's Bureau of Aeronautics for development of two XF2Y-1 aircraft to be equipped with twin hydroskis. They were to be prototypes of a definitive waterbased supersonic interceptor fighter.

This action resulted in an experimental flight test program that began in December 1952 and continued through most of 1957, or for almost five years. A total of five aircraft, named Seadart, were built. Only three aircraft were ever flown. The last two were completed except for engine installation.

The first was the XF2Y-1 aircraft, Bu. No. 137634. The remaining four were YF2Y-1 aircraft, Bu. Nos. 135762 through 135765 consecutively, and built in that order.

There were four Convair engineering test pilots involved with the testing of the three aircraft plus several U.S. Navy test pilots from Naval Air Test Center, Patuxent River, who made evaluation taxi tests and flights in San Diego.

The Seadart aerodynamic design is best illustrated by the No. 3 aircraft, YF2Y-1, Bu. No. 135763. Unfortunately, these aircraft were designed, built and flown before the supersonic "area rule" was first embodied in aircraft designs. Also high-thrust engines were not available at that time.

On 14 December 1952, E.D. "Sam" Shannon, Convair's Chief of Engineering Flight Test, took the XF2Y-1 Seadart out into San Diego bay for its first taxi tests. The aircraft taxied up the seaplane ramp under its own power after the first test operation. Small wheels at the aft end of the skis plus a small tail wheel provided this land taxi capability. The same technique was used to enter the water.

Shannon emerging from the cockpit after an early test on the XF2Y-1.

The twin hydroskis were planing skis and derived their lift the same as a person using water skis. They were not hydrofoils that provide lift in the same manner as airfoils.

The initial and early taxi tests in San Diego bay revealed serious vibration and pounding of the aircraft created by the blunt or boat-tail afterbody of the skis traversing wave patterns. The rougher the water the more serious the vibrations. Vibrations were amplified by the skis flexing between the front and main oleo struts. These excursions acted like a tuning fork and set up a resonant frequency in the aircraft structure.

The front struts for the skis were mounted directly below the pilot. The combined vibration and pounding reaction loads on the front struts created completely unacceptable conditions for the pilot and equipment during takeoff and landing.

The immediate engineering action was to solve the vibration problem without drastic and major ski design changes.

On 9 April 1953, Shannon made the first flight of the XF2Y-1. The dark-blue paint with yellow markings provided aircraft attitude reference in instrumentation photos of taxi tests including takeoff and landing. This aircraft had the Westinghouse J34 engine installations that were soon replaced by the J46.

Charles E. Richbourg, Convair Engineering Test Pilot, soon had joined Shannon in the taxi tests and evaluation of the XF2Y-1 twin-ski aircraft. This aircraft was refitted with J46 engines and continued to be used as the primary testbed for twin-ski configuration changes directed towards reducing vibration and pounding loads in the aircraft and specifically the cockpit. Such tests on the XF2Y-1 with twin skis continued through 1953 to mid-1954.

In September 1953, the author asked for release from active duty in the Navy to join Convair as a Flight Test Engineer on the Seadart project. My duties included flight test operations planning, test conductor, and flight test data analysis. In this position I became very familiar with all aspects of the Seadart program and test operations.

Seadart No. 2, YF2Y-1, Bu. No. 135762, rolled out in early 1954. Aircraft No. 2 and No. 3 were the same except for the twin-ski afterbody configurations. Richbourg made initial flights on the No. 2 aircraft and then began to explore high-speed performance plus aerodynamic stability and control characteristics. He continued limited twin-ski configuration testing on this aircraft but on a non-interference basis with aerodynamic testing. He and Shannon began open sea tests several miles south of Pt. Loma with this No. 2 aircraft.

Open sea tests became quite involved with support and standby rescue boats and auxiliary craft plus aircraft. At least one helicopter and one chase aircraft were required for safety, chase, and photo coverage. Recovery tests were conducted with a large Navy Landing Ship Dock vessel (LSD) to evaluate possible open sea support and service for Seadart-type aircraft.

In June 1954 the author was assigned pilot duties in engineering flight test and began to train as backup pilot for J.F. "Skeets" Coleman on the Navy XFY-1 Pogo, Convair's cruciform tail-setter vertical takeoff and landing experimental aircraft. I began flying chase on Pogo, Seadart, and R3Y Tradewind tests with a Navy AD-5 aircraft. I also flew copilot for Lou Hoffman on Convair 340 and 440 engineering flights.

Richbourg continued flight and twin-ski tests on the No. 2 aircraft and on 3 August 1954 exceeded Mach 1.0 in a shallow dive at 34,000 feet. Flight testing continued on this YF2Y-1 aircraft through the fall of 1954.

During the summer and fall of 1954, the XF2Y-1 had been reconfigured with a large single hydroski that was not fully retractable. It was to become the hydrodynamic test vehicle for the single ski and to fully demonstrate its practical and suitable use as an operational configuration. There was no need or intention to use this aircraft again for high-performance aerodynamic testing.

Shannon and Richbourg began initial taxi tests in the late fall of 1954 on the XF2Y with the new single ski and immediately encountered unacceptable hydrodynamic stability and control characteristics.

On 4 November 1954, Richbourg was killed during a flight demonstration for the press in the No. 2 aircraft, YF2Y-1 Bu. No. 135762. During a low-altitude pass, at about 500 knots, the aircraft went into a divergent longitudinal pitch oscillation and structurally broke up during the second nose-down pitch.

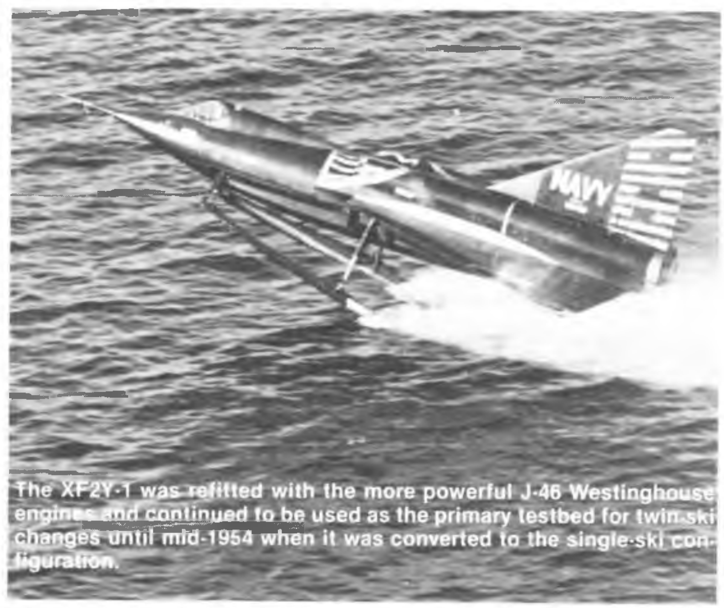
This accident was a classic example of the divergent pitch oscillation caused by combinations of high speed at low altitude (high dynamic pressure), early full power flight control system characteristics and pilot inducement of "PIO" (pilot induced oscillation). This accident had no bearing on the fact that the Seadart was a seaplane or that it had any unusual design deficiencies.

All Seadart operations were temporarily suspended after the crash of the No. 2 aircraft until the Navy accident board had completed its investigation.

The author volunteered to assist Shannon on the Seadart program and was accepted primarily because of my WW II seaplane experience. Shannon felt that prior seaplane experience was essential in order to satisfactorily conduct hydrodynamic demon-

YF2Y-1 at idle power. Note spray rails near water line below cockpit.

YF2Y-1, twin-ski configuration, at idle power. Note flotation characteristics and water line.



The XF2Y-1 was refitted with the more powerful J-46 Westinghouse engines and continued to be used as the primary testbed for twin-ski changes until mid-1954 when it was converted to the single-ski configuration.

YF2Y-1, No. 3 aircraft, during takeoff with four 1000-lb. RATO bottles firing. Naval Air Station North Island is in background.

Charles E. Richbourg, Convair's second Engineering Test Pilot assigned to the Seadart program, was killed in the No. 2 aircraft, YF2Y-1, Bu. No. 135762, on 4 Nov. 1954.

strations and evaluation required during the remainder of the program. My clearance to operate Seadart aircraft was requested from the Navy's Bureau of Aeronautics in Washington.

On 29 December 1954, Shannon was scheduled to resume taxi tests on the XF2Y-1 with the new single ski; however, a mild illness prevented him from making the test. I was cleared by the local Bu Aer rep at Convair to make the test rather than have any delays. I continued to test this single-ski aircraft for over two years, until my last test on 8 April 1957.

On 4 March 1955, the author made the first taxi and takeoff tests in the new YF2Y-1 Bu. No. 135763, or No. 3 aircraft.

With this new aircraft the final twin-ski configuration was installed, with wheels that rotated along with the tapered afterbody of the skis.

All high-performance aerodynamic testing of the Seadart was canceled after the crash of No. 2. The prime purpose of this No. 3 aircraft was the final evaluation of the "optimized" twin-ski design changes and to demonstrate possible operational feasibility of the twin-ski configuration including open-sea operations.

The cockpit and canopy arrangements were similar to the X-15. Visibility out of the small V windshield was acceptable but was poor for permitting outside light on the cockpit consoles and panels. The prospects of ejecting even at low airspeeds with this canopy seemed unacceptable. Cockpit layout was acceptable except that the beaching wheels did not use conventional toe brakes on the rudder pedals. Instead were two side-by-side handles on the right console that had to be hand pulled separately or together for steering or braking. This beach braking arrangement was unacceptable and unnecessary.

Taxi down the ramp into the water was made with the ski oleos in the beach position for attitude purposes. Upon attaining flotation the main wheels on the ski afterbodies were rotated 90° by electrical switch and hydraulic action to place the tapered afterbody of the ski in the proper hydrodynamic position.

At idle power the aircraft speed was 2 to 3 knots. If speed brakes on the lower fuselage afterbody were opened and the skis fully extended the aircraft speed was reduced to 1 or 2 knots. The speed brakes could be cycled differentially by a switch and use of rudder pedals for steering at low speeds in the water. Asymmetric power was also effective for steering at low speeds.

Ski positions were selected by an electrical switch on the left console aft of the throttles. For takeoff, the skis' oleos were initially placed in the fully extended position and military power applied. This high-trim angle of the skis caused the leading edges of the skis to unport or break the water surface at 8 to 10 knots. Immediately, the ski oleos were placed in the intermediate position for hydrodynamic drag reduction and afterburner power applied to commence the takeoff run. It was best to let the aircraft assume a natural or normal pitch attitude up to about 40 or 50 knots then select the fully extended position of the oleos. From this point, optimum pilot technique was used relative to pitch attitude and directional control. Up through 100 knots the best attitude for the twin skis was slightly nose up, say 2° to 5° nose up. At about 125 knots the aircraft was sharply rotated nose up to an attitude of 17° to 19° for lift-off and positive separation from the water. The skis could be immediately retracted like any retractable landing gear.

Takeoffs using four 1000-lb. thrust RATO bottles were tried. These rocket bottles were used in open-sea tests to reduce takeoff distances and the associated undesirable vibration and pounding loads on the pilot and airframe.

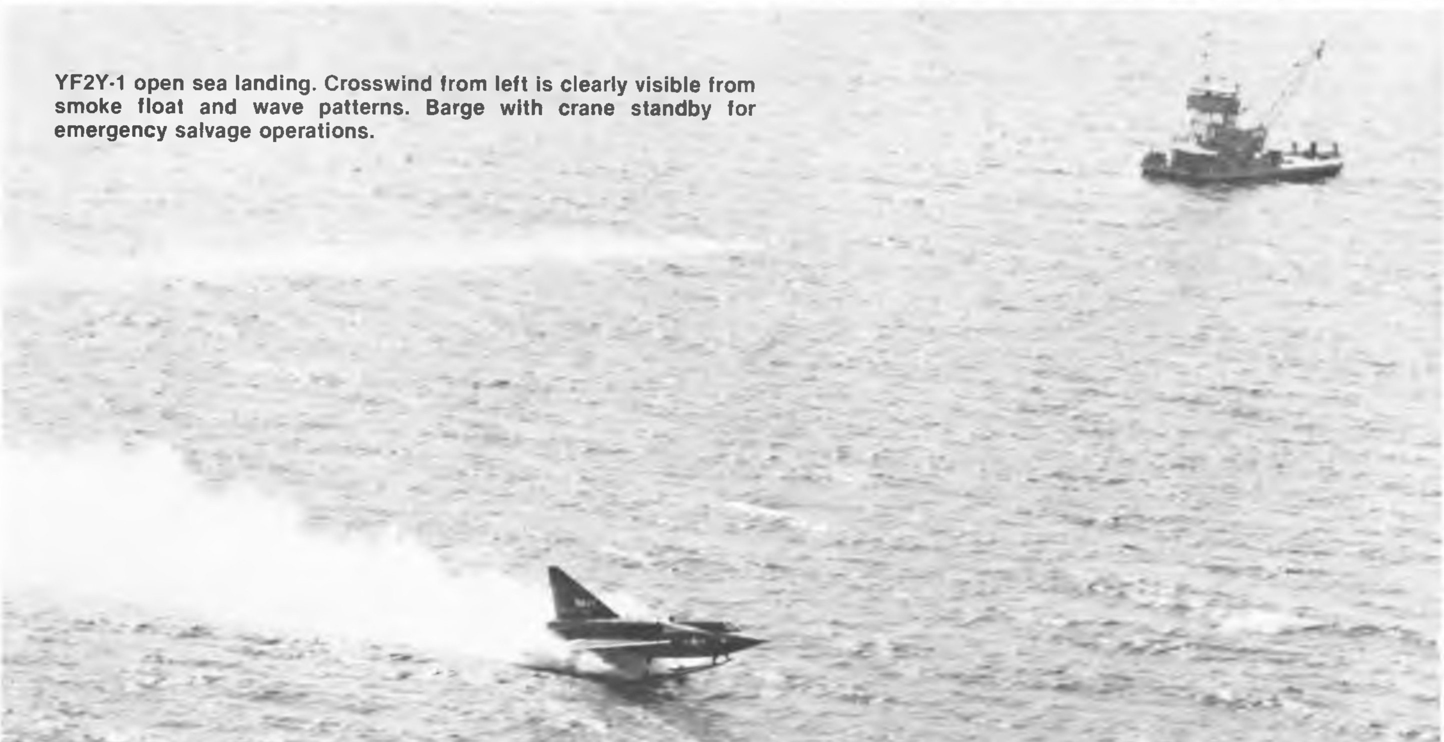
The author never accepted even this best twin-ski configuration as being suitable for an operational aircraft. The pointed afterbody of the skis did give penetration relief when traversing rough water but the flat planing surfaces, rather stiff oleo actions, and the flexing of the ski midbodies all added up to an unacceptable system with respect to vibration and pounding loads. Hydrodynamic stability and control, however, were excellent.

Complete instrumentation recorded vibratory loads and accelerations at various points on the aircraft including the most important point, being under my seat. During a typical bay takeoff, in a 2-inch wave condition caused by wind, the author experienced ±5.5 g's at 15 to 17 cycles per second just prior to lift-off. In this environment I experienced "shotgun" vision and my only facilities were pulling back on the stick and trying to break the throttles off in the afterburner position. Nothing was visible in the cockpit because of vibration.

Water ingestion in the engines was not a particular problem if proper pilot techniques were used. The J46 engines were sensitive to salt particles being baked on the inlet compressor and stator blades. This buildup occurred even with salt particles in the atmosphere and would quickly cause thrust decay and eventual compressor stall when attempting high power and afterburner settings.

A small fresh-water tank of about 20-gallon capacity was installed in both the XF2Y-1 and the YF2Y-1 (No. 3 a/c). At idle power and just prior to takeoff, small amounts of fresh water were pumped into the engine air-inlet areas to sanitize the compressor sections of salt contamination. This "power restoration"

YF2Y-1 at 1500-ft. altitude prior to open sea landing off San Diego. Note RATO bottles, under right wing, used for open sea takeoff. White caps are clearly visible on ocean surface.



YF2Y-1 open sea landing. Crosswind from left is clearly visible from smoke float and wave patterns. Barge with crane standby for emergency salvage operations.

YF2Y-1 open sea touchdown at 120 knots during relative calm sea conditions.

Open canopy on YF2Y-1, Bu. No. 135763, with B.J. Long. All Seadarts had the same canopy arrangements.

method was very successful and useful after salt-water ingestion during open-sea landings when needing all available power for takeoff. It could make the difference in getting off or being towed home.

Seldom were engines flamed out from water ingestion. Again, this could usually be prevented by aircraft and engine handling techniques; however, if an engine was lost, taxi was impossible because directional control could not be maintained with the asymmetric thrust condition of one engine out.

Initially this twin-ski aircraft would uncontrollably turn downwind during strong crosswind conditions such that the takeoff had to be aborted. The strong hydrodynamic directional stability characteristics would turn the aircraft into the relative water or downwind. This was corrected by installing small skegs of water on the bottoms of both skis just forward of the estimated center of water pressure for the speeds or wetted length involved. These acted to reduce the hydrodynamic directional stability allowing the aerodynamic stability and control to have the greater directional forces.

Normal landing and takeoff procedure for both the twin-ski and single-ski aircraft was a heading parallel to the major wave or swell condition and into the wind as much as possible. Usually this involved a crosswind condition of 30° to 60°. Landing or takeoff directly into any sizable wave patterns or swells was unacceptable and not attempted. During open-sea tests a smoke float indicated crosswind conditions. The author conducted the final twin-ski test on 28 April 1955, which was the last operation for this particular aircraft and twin-ski evaluation.

Single-ski tests with the YF2Y aircraft had continued simultaneously with the twin-ski aircraft No. 3, the author testing both aircraft.

The single ski was slowly but surely being improved. Initially the oleo damping qualities produced uncontrollable and divergent hydrodynamic pitch oscillations or porpoising to the point that taxi runs had to be aborted as early as 40 to 50 knots. Directional stability and control were unacceptable but became excellent by doubling the lateral control deflection of the elevons. This provided very positive directional control by banking the aircraft at all speeds in the desired direction of turn. This looked like "motorboating" in effect. During strong crosswind takeoff and landing conditions the author actually dragged the "into the wind" wing tip at lift-off or touch-down at airspeeds of 125 and 120 knots respectively with no adverse results. Therefore, the wing low method for handling crosswinds was best for this aircraft. The wing tip was at a positive trim angle (angle of attack in water) at all times with no submerging tendencies.

This single ski was very rigid with no midpoint deflecting. The bottom was a shallow V in cross-section with a 10° deadrise. The afterbody was tapered in plan form at a 60° included angle for water penetration. The final oleos' characteristics were excellent with a stroke-rate sensing device that would vary the hydraulic orifices and give excellent damping qualities. Excellent hydrodynamic stability and control characteristics were finally realized. These oleos required three positions during takeoff: fully extended for unporting the ski, back to intermediate position for acceleration up to 40 to 50 knots, then fully extended for acceleration through lift-off. Landings were of course made in the fully extended position.

Except for being underpowered, the open-sea handling qualities of this single-ski aircraft were excellent considering the touch-down speeds of 120 knots and lift-off speeds of 125 knots.

Vibration was not experienced in this final single-ski configuration. Pounding loads were considered acceptable and were proportional to the roughness of the water.

The Navy required high rate of sink landing tests. In San Diego bay I demonstrated rates of sink up to and including 19 feet per second with no unacceptable impacts felt in the cockpit and with no damage to the aircraft.

The final open-sea test of the XF2Y-1 single-ski aircraft was on 16 January 1956. The purpose of this test was to demonstrate an upper limit of rough seas for operating this aircraft.

Special hydrodynamic instrumentation from support vessels provided an accurate plot of the wave patterns during this landing to full stop, taxi back to a near touch-down position, then take off for return to San Diego bay.

The waves varied from 6 to 10 feet in height with a separation of 50 to 100 feet. Small 1 to 2-foot waves were superimposed on the major wave patterns. A few waves measured 12 feet in height just prior to landing. This sea condition approached a rating of Seastate 5.

Landing and takeoff were made parallel to the major wave pattern with the 15 to 20-knot wind line about 45° to the right of the aircraft heading.

Deceleration after a touch-down at 120 knots was rapid. Vertical and lateral motions experienced in the cockpit were severe. The author's hard hat struck the V windscreen with such impacts in lateral motion that I suddenly tasted what I thought was blood. After forward motion was stopped I removed my oxygen mask and realized that the impact had forced mucous from my sinuses into my mouth.

Takeoff bordered on the catastrophic. I over-rotated prematurely because of heavy pitching motions which made it appear that I might "trip" or dive into the heavy sea condition.

This nose-high attitude kept me from simulating a torpedo but it also delayed my acceleration such that I kept ricocheting off the tops of waves. The resulting impacts experienced in the

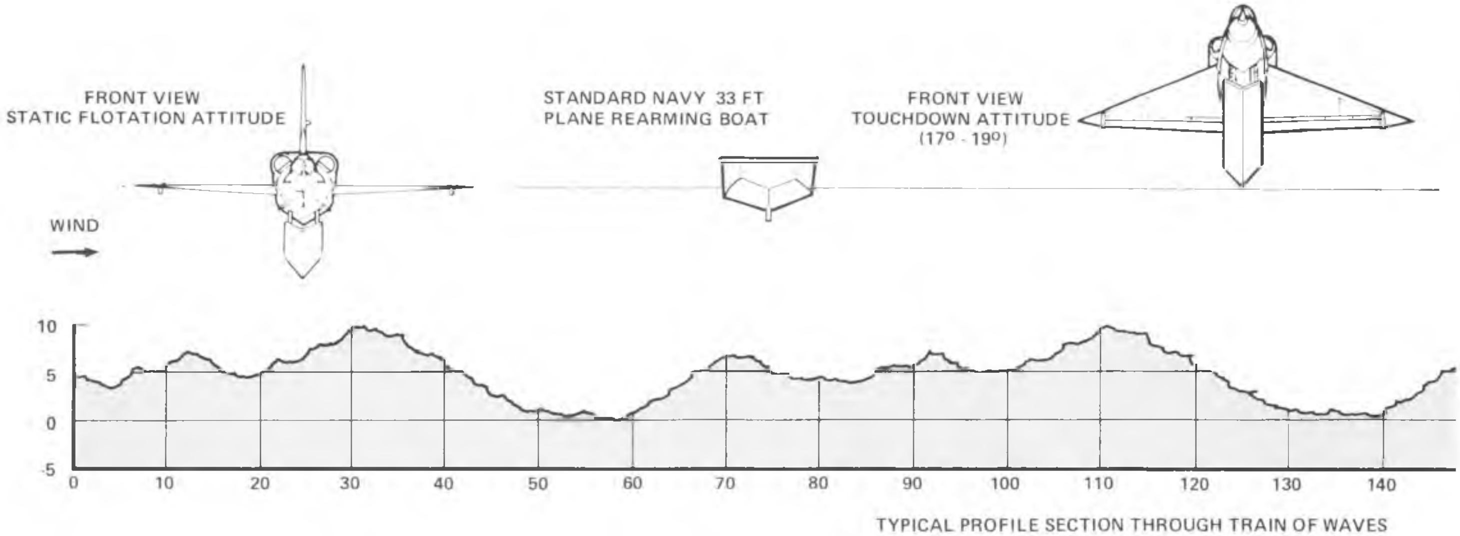
XF2Y-1 with single-ski decelerates rapidly during landing "run-out" in rough water open sea test.

XF2Y-1, single ski fully extended in lift-off or landing position during approach to open sea landing.

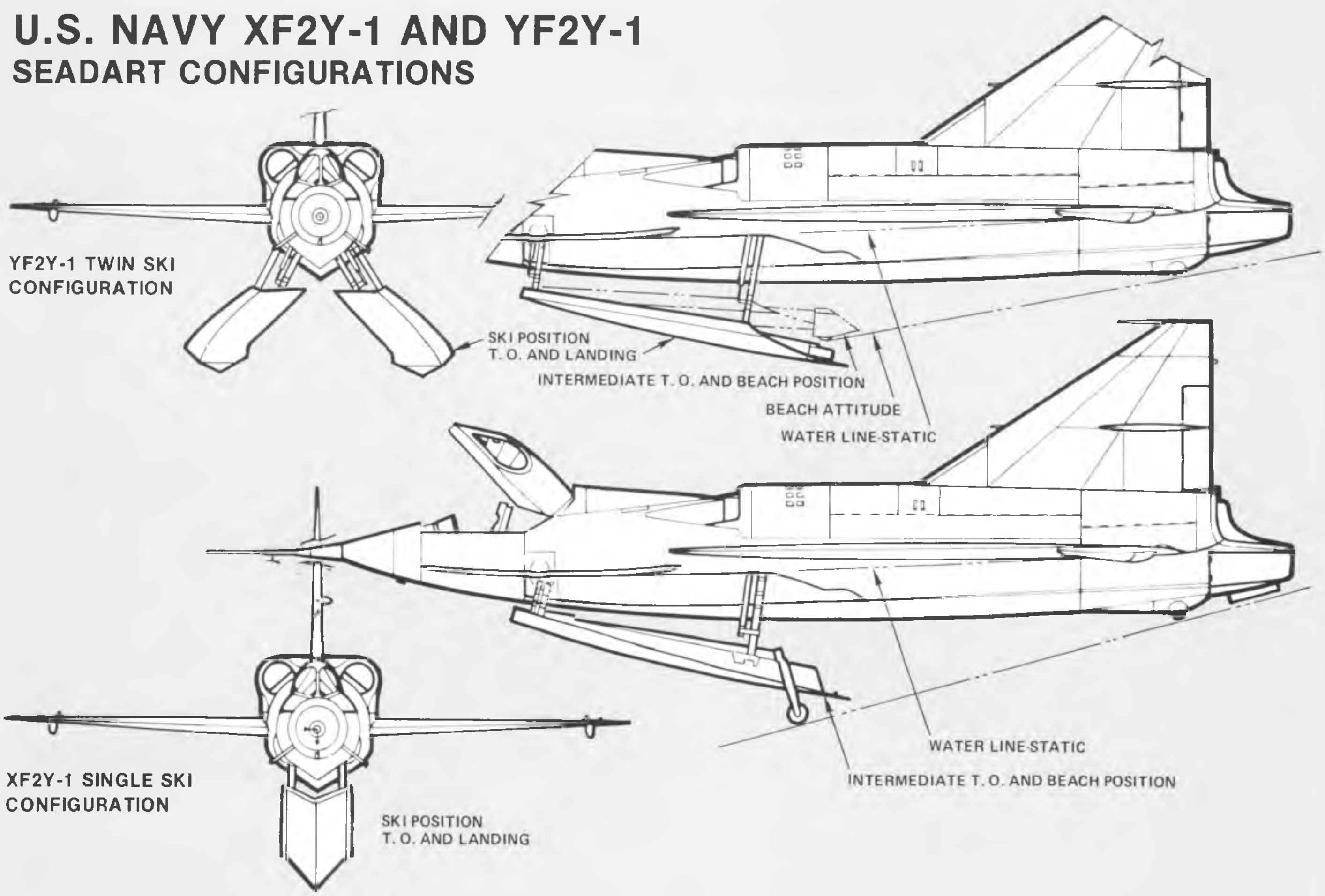
XF2Y-1 with single ski in "stowed" position during slow cruise to open sea test site. This hydrodynamic test configuration was not made fully retractable. Note beaching wheels in retracted position.

XF2Y-1, single-ski configuration, taxiing up Convair seaplane ramp.

U.S. NAVY XF2Y-1 SEADART BU NO. 137634
SINGLE SKI CONFIGURATION

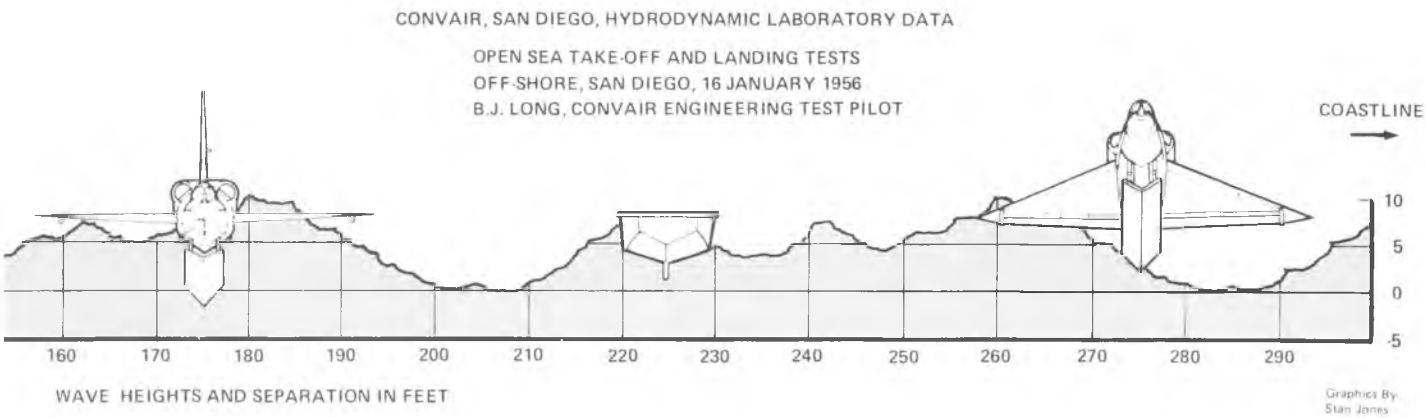


U.S. NAVY XF2Y-1 AND YF2Y-1
SEADART CONFIGURATIONS



Final YF2Y-1 twin ski configuration, Bu. No. 135763, and the best single-ski configuration on the XF2Y-1, Bu. No. 137634.

XF2Y-1 final open sea landing test data with single ski. Waves varied from six to ten feet in height with a separation of 50 to 100 feet. Small one to two-foot waves were superimposed on major wave patterns.



U.S. NAVY YF2Y-1 SEADART BU NO. 135763
BUILT BY CONVAIR DIVISION,
GENERAL DYNAMICS CORPORATION

MISSION: WATER BASED INTERCEPTOR

CONFIGURATION: TWIN SKIS

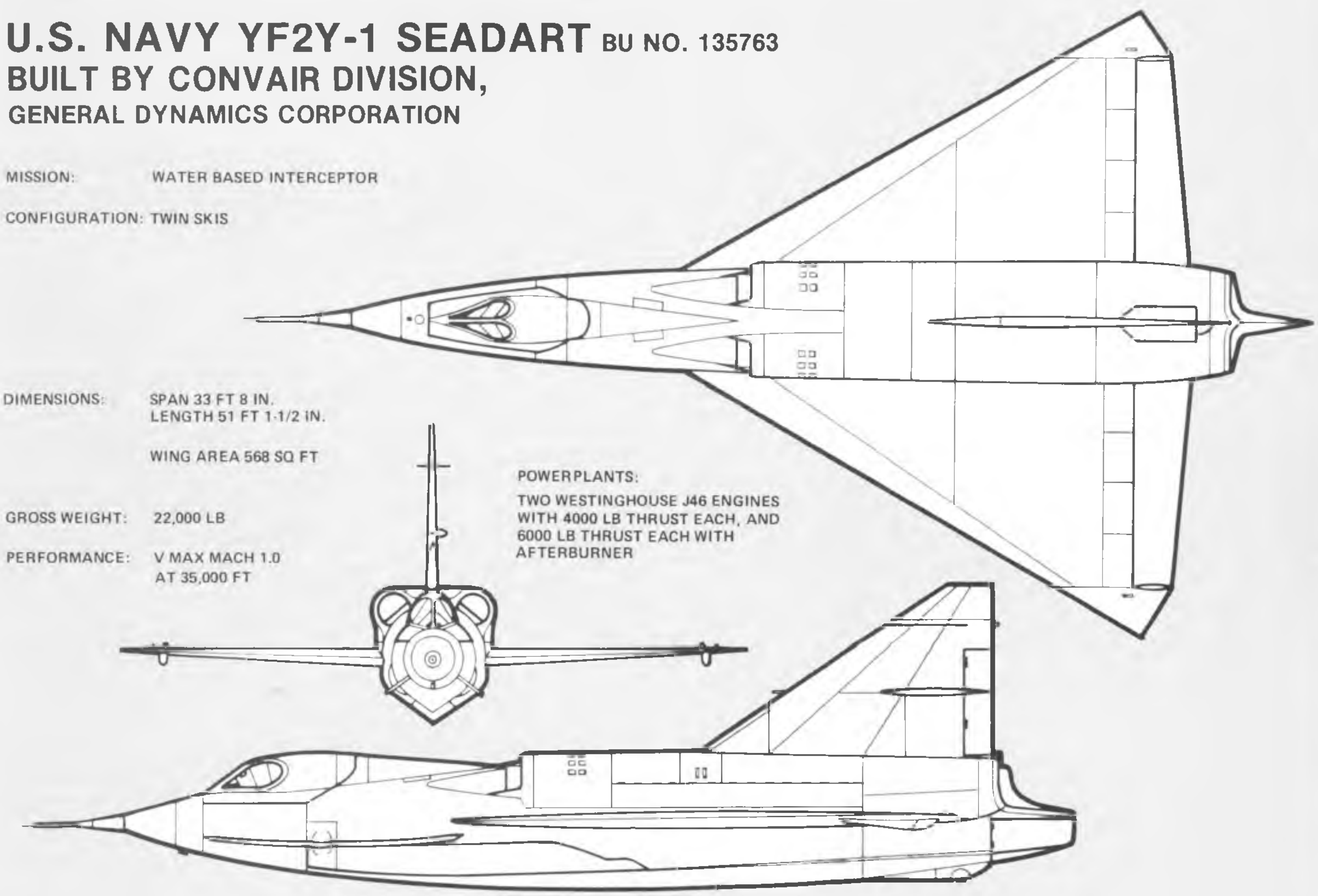
DIMENSIONS: SPAN 33 FT 8 IN.
LENGTH 51 FT 1-1/2 IN.

WING AREA 568 SQ FT

GROSS WEIGHT: 22,000 LB

PERFORMANCE: V MAX MACH 1.0
AT 35,000 FT

POWERPLANTS:
TWO WESTINGHOUSE J46 ENGINES WITH 4000 LB THRUST EACH, AND 6000 LB THRUST EACH WITH AFTERBURNER



The Seadart aerodynamic design is best illustrated by the No. 3 aircraft, YF2Y-1, Bu. No. 135763.

XF2Y-1 with single ski at 120-knot touchdown in relatively calm open sea test.

cockpit were intolerable. I was stunned. Aircraft test instrumentation recorded one vertical impact of 8.5 g's at a very high rate of acceleration, under my seat.

Finally, after the last separation from the water, Lou Hoffman, my friend and chase pilot in an AD-5, yelled for me to come out of afterburner so he could stay with me. The return flight and landing in San Diego bay were routine.

This open-sea test was the last flight or actual lift-off and landing for any Seadart. The single-ski test program was considered completed and both the No. 1 and No. 3 aircraft were placed in storage.

In August of 1956, the author was assigned to Convair's engineering flight test operations at Edwards Air Force Base for the F102A and TF-102A.

The Navy's Bureau of Aeronautics in late 1956 decided to test a small rigidly mounted hydro ski on the XF2Y-1 aircraft. This new configuration had a hydrofoil shape in addition to having planing ski capabilities. The rigid mounting and placement made actual takeoff impossible because of the 17° to 19° nose-high attitude required for lift-off.

In April of 1957, I tested this new small rigid ski in San Diego bay. Severe pounding loading in the cockpit kept me from ever reaching more than 50 or 60 knots. Three test operations in 18 days concluded tests on this configuration.

At this point, the three test aircraft in the Seadart program had performed over 300 test operations. The XF2Y-1 or No. 1 aircraft had accounted for approximately 250 test operations.

The Navy's Bureau of Aeronautics decided to test one more small rigid ski configuration on the XF2Y aircraft in the fall of 1957. It was similar to the previous rigid hydrofoil shaped ski but was about half the size. This evaluation was conducted by Convair's Chief Engineering Test Pilot for Navy and Commercial Aircraft, Donald P. Germeraad, who was an experienced seaplane, flying boat pilot, test pilot, and SETP "Fellow." His tests proved the same as the author's on the previous rigid ski: i.e., unacceptable.

In summary, the large single-ski and oleo configuration finally derived on the XF2Y-1 aircraft was a very sound and satisfactory design for use on a delta-winged, waterbased supersonic aircraft. The Seadart test program also proved the feasibility of designing and developing supersonic waterbased aircraft for support of U.S. Navy Fleet Operations.

If the single-ski design could have been incorporated into a delta-wing aircraft with the aerodynamic refinement and power capabilities of the F-102A and F-106, then the U.S. Navy would have had a highly effective waterbased aircraft for use with a mobile base system. The utility and operational flexibility of such a system could have compensated for most of the supposed inherent and undesirable characteristics of waterbased aircraft.

Seadart development was not continued by the U.S. Navy because of the lack of an approved operational requirement for such an aircraft and the lack of funds.

ABOUT THE AUTHOR

Billy Jack Long, also known as B.J., was born and raised in Johnson City, Tennessee. Early aviation activities in the 1930s included airplane rides at the local cow pasture airports and winning several state contests for free flight gas model airplanes.

His first professional position in aviation was with Monocoupe Aeroplane and Engine Corporation, Bristol, Virginia, in 1941 as a draftsman, junior engineer, and stress analyst. He soloed in an early J3 Cub before entering the Naval Aviation Cadet Program in WWII.

Commissioned in 1944, B.J. chose single-engine seaplanes for operational training and followed with duty flying catapult floatplanes from a cruiser in the Pacific. In a few years, he had become qualified in a large variety of naval aircraft plus proficient as a control and chase pilot for large drone aircraft and target pilotless aircraft. Duty assignments included the Operational Development Force; Naval Missile Center, Point Mugu; and Fleet Utility and Drone Squadrons.

In 1953, he requested inactive duty to join Convair, San Diego, as a flight test engineer on the Seadart project and later assumed pilot duties in the engineering flight test group. In December 1954 he was assigned as Engineering Test Pilot on the Seadart. He completed the twin-ski evaluation on the Seadart and conducted over 90 percent of the single ski test operations for completion of the program. He attended the U.S. Navy Test Pilot School, Class 16, as a Convair pilot. In August 1956 he was assigned to Convair's F-102A Engineering flight test group at Edwards Air Force Base. In 1957, he left Convair to pursue a non-flying career.

B.J. retired as a Commander in the U.S. Naval Reserve and has logged 3,000 hours of pilot time in over 50 different types of aircraft. He majored in industrial engineering at the University of Tennessee.

B.J. has been associated with Rockwell International for over fifteen years and is a member of the management staff in the Space Systems Group public relations organization.