NASA Facts

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D-558-1

The D-558-I "Skystreaks" were among the early transonic research airplanes like the X-1, X-4, X-5, and XF-92A. Three of the single-seat, straight-wing aircraft flew in a joint program involving the National Advisory Committee for Aeronautics (NACA), the Navy-Marine Corps, and the Douglas Aircraft Co. from 1947 to 1953. In the process, the Skystreaks set several world speed records.

The division of responsibility among the partners was that Douglas flew a contractor program on the first Skystreak to investigate its performance, handled major maintenance and performed any modifications. The NACA's Muroc Flight Test Unit, redesignated the High-Speed Flight Research Station in 1949 and now named the NASA Dryden Flight Research Center, purchased fuel and oil from the Army Air Forces (Air Force after September 1947), provided and installed instrumentation, performed the flight research on the number two and three aircraft, and took care of routine flight maintenance and inspection on them. The Navy paid the expenses of Douglas Aircraft, including engine overhaul and replacement, and its pilots did some of the flying.

The (Roman numeral) I in the aircraft's designation referred to the fact that the Skystreak was the phase-one

version of what had originally been conceived as a three-phase program, with the phase-two aircraft having swept wings. The third phase, which never came to fruition, would have involved constructing a mock-up of a combat-type aircraft embodying the results from the testing of the phase one and two aircraft.

Douglas pilot Eugene F. May flew the number one Skystreak for the first time on April 14, 1947, at Muroc Army Airfield (later renamed Edwards Air Force Base) in Calif. The goals of the program were to investigate the operation of a straight-wing configuration in the lower third of the transonic speed range (which extended from roughly 0.7 to 1.3 times the speed of sound) and to obtain data about flight in that speed range that were not available from existing wind tunnels.

The three aircraft, equipped with Allison J-35-A-11 turbojet engines, gathered a great deal of data on handling qualities, tail loads, buffeting, pressure distribution, plus static and dynamic longitudinal as well as lateral stability and control and the effects of vortex generators on undesirable handling characteristics. Together with other transonic research airplanes, the D-558-I research results validated the data from wind tunnels then being developed by the NACA, which required basic data for comparison to ensure there were no unforeseen errors in their development. Both kinds of data were then available for use by designers of new military aircraft, such as those in the century series of fighters (F-100, F-102, and so forth.)

Design

The need for transonic research airplanes grew out of two conditions that existed in the early 1940s. One was the absence of accurate wind tunnel data for the speed range from roughly Mach 0.8 to 1.2. The other was the fact that fighter aircraft like the P-38 "Lightning" were approaching these speeds in dives and breaking apart from the effects of compressibility—increased density and disturbed airflow as the speed approached that of sound, creating shock waves. People in the aeronautics community—especially the NACA, the Army Air Forces (AAF), and the Navy—agreed on the need for a research airplane with enough structural strength to withstand compressibility effects in the transonic region. The AAF preferred a rocket-powered aircraft and funded the X-1, while the NACA and Navy preferred a more conservative design and pursued the D-558, with the NACA also supporting the X-1 research.

The Navy contracted with Douglas to design the airplane, and in the course of the design process, the D-558 came to be divided into two separate phases, with phase one being a straight-wing turbojet aircraft and phase two consisting of a swept-wing design with turbojet and rocket propulsion. The Douglas design team, headed by Edward H. Heinemann, used NACA information and airfoil shapes. It tested its models in NACA and California Institute of Technology wind tunnels. And it relied on NACA recommendations, such as putting the horizontal stabilizer of the D-558-I high on the vertical tail to avoid the wake from the wing. As with the X-1, the D-558-1 also featured, at NACA suggestion, a horizontal stabilizer that was thinner than the wing so as to avoid simultaneous shock wave effects for the wing and horizontal tail. Also at NACA suggestion and like the X-1, the stabilizer was movable in flight to provide pitch (nose up or down) control when shock waves made the elevators ineffective.

What the Skystreak lacked was an ejection seat. The design team had considered one, but given the technology of the day, the team discovered that the force necessary to propel the seat and pilot higher than the vertical tail exceeded the pilot's physiological limits. Hence, Douglas provided instead a jettisonable nose capsule from which the pilot could bail out if the airplane were high enough.

When Commander Turner F. Caldwell set the world's speed record in the D-558-1 (NACA140), the Navy Bureau of Aeronautics stated in a message to the NACA, "A great measure of the credit for the success of the D-558 airplane speed record flight is due to the NACA. The highly important introductory research and investigation program leading to recommendations on airplane configuration problems was essential in the development of this airplane."

Instrumentation

The NACA-Muroc instrumentation section under Gerald M. Truszynski installed a 12-channel oscillograph to record the data from strain gauges; a 60-

capsule manometer to record pressure distribution; transmitters for data on control-wheel and pedal forces; recorders for the positions of ailerons, elevators, and rudder-controls; an accelerometer; a telemeter and switch to transmit airspeed, altitude, normal acceleration, and the positions of ailerons and elevators; an airspeed-altitude recorder; a sideslip-angle transmitter; and a camera to record the instrument readings on the pilot's control panel. All of this instrumentation—some 634 pounds—was ready on Skystreak number two by the late fall of 1947.

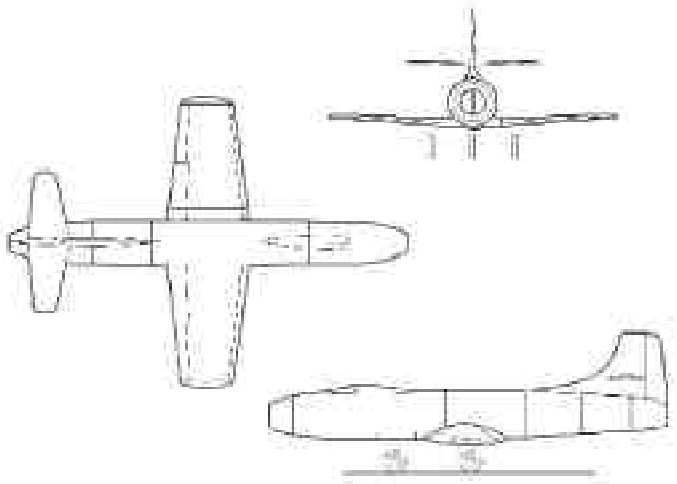
Program History

The three Skystreaks flew a total of 229 times from 1947 to 1953, including 101 contract flights in the number one aircraft (Bureau No. 37970—NACA 140), 46 by the Skystreak number two (Bureau Number 37971—NACA 141), and 82 by the number three aircraft (Bureau Number 37972—NACA 142). NACA 140's flights were all completed as part of the contractor program, although Caldwell flew it on four passes on August 20, 1947, averaging 640.663 miles per hour over a measured course, setting a new world airspeed record. Five days later, however, Marine Major Marion Carl surpassed the record, flying NACA 141 an average 650.796 miles per hour in four passes over the course. The NACA never flew the number one airplane, using it instead for spares support of the number three aircraft.

NACA 141 made 27 flights by Douglas, Navy and Marine pilots before being instrumented for NACA flights, all flown by Howard C. Lilly. Although both NACA 140 and 141 had been painted scarlet for improved visibility, in flying the aircraft both Douglas and NACA personnel discovered that the scarlet color was difficult to discern against the dark blue desert sky. During the winter of 1947-1948, NACA repainted NACA 141 with a white color.

In the spring of 1948, Lilly flew five research flights gathering data on directional stability. On April 29, he reached a speed of Mach 0.88 at 36,000 feet (roughly 580 miles per hour). Unfortunately, on his next flight, the compressor section of his J-35 engine disintegrated, severing the elevator and rudder cables and resulting in his loss of control over the airplane at a comparatively low speed and altitude. He died in the subsequent crash.

Following the recommendations of the accident board, Douglas technicians added duplicate control cables, armor plating around the emergency fuel pump and fuel lines, and wire-wound fuel hoses to NACA 142, repainting it white in the process.



In 1949, NACA pilots Robert A. Champine and John H. Griffith began flying NACA 142, gathering data about handling qualities, aileron effectiveness and pressure distribution. On November 29, 1950, following the conclusion in June of the extended pressure-distribution studies, NACA pilot A. Scott Crossfield began a series of buffeting, tail loads, and longitudinal stability investigations that lasted until October 1951. NACA pilots Walter P. Jones and Joseph A. Walker also participated in this series of flights.

Crossfield and fellow NACA pilots Stanley P. Butchart and John B. McKay flew a series of flights gathering data on lateral and dynamic stability from

June 1952 through April 1953. This was followed by McKay and Crossfield's investigation of the effects of tip tanks on the Skystreak's buffet characteristics. These concluded with Crossfield's final flight in the airplane on June 10, 1953.

Although it was slower and more conventional than the rocket-powered X-1 and D-558-II, the Skystreak performed valuable services as a first-generation transonic research airplane. Even the loss of NACA 141 and Howard Lilly served a purpose because it resulted in a greater appreciation for the dangers of research flying. As a result, the safety modifications to the Skystreak were also made to other research airplanes, especially the Northrop X-4 and the Bell X-5.

Together with the X-1 and the D-558-II, the Skystreak was one of the few sources of data on transonic flight conditions in the period 1947 to 1950 until the NACA developed better wind tunnels. These aircraft then contributed data to validate that derived from the tunnels by providing a reality check in the form of corresponding information from a real flight environment. Embodying the state of the art in aeronautics when built, these aircraft also tested whether the various components in their design operated together when flown. The data that resulted enabled the armed services and industry to advance the state of the art in the century series of fighters and other aircraft built in the 1950s, using data from the research airplanes in the areas of controllability, stability, changes in stability and in tailplane orientation. Like the X-1, D-558-I, and D-558-II, all the century series fighters employed movable hoizontal stabilizers because the research airplanes had shown that they provided excellent controllability near the speed of sound, whereas the elevator was ineffective in providing pitch control in that speed range.

The Aircraft

The Skystreaks were approximatley 35 feet long, 12 feet high, and 25 feet across the wing span. They were powered by one Allison J-35-A-11 engine (developed by General Electric as the TG-180), which was rated at 5,000 pounds of static thrust. The airplane carried 230 gallons of aviation fuel (kerosene).

NACA 140 is located at the Naval Aviation Museum in Pensacola, Fla. NACA 142 is at the Marine Corps Air Ground Museum, Quantico, Va.

For Further Reading

The best single source on the Skystreak is Richard P. Hallion's "Supersonic Flight: Breaking the Sound Barrier and Beyond, The Story of the Bell X-1 and Douglas D-558" (revised edn.; London and Washington, 1997). One of the Skystreak pilots, A. Scott Crossfield, has told about his own flying career in "Always Another Dawn: The Story of a Rocket Test Pilot" (Cleveland, 1960).