Full-Scale Wind Tunnel

After the Variable Density Tunnel (VDT) of the National Advisory Committee for Aeronautics (NACA) was put into operation in the 1920s, it was recognized as a breakthrough accomplishment in wind-tunnel testing technology. By using higher than atmospheric pressure in its airstream, the VDT provided aerodynamic conditions more representative of those experienced in flight. However, the relatively small size of its test section required the use of relatively small aircraft models and severely limited testing of full-scale airplane components. Powered models could not be accommodated, and the aerodynamic effects of real aircraft construction such as rivets, fabric, and other component details were difficult or impossible to simulate. Of even more concern, however, was the recognition that significant aerodynamic turbulence was present in the tunnel air flow due to the geometrical shape of the VDT. As the concern over results from the VDT began to grow, several research leaders at Langley began to advocate for a new large wind tunnel capable of conducting tests of full-scale aircraft at that time.

The NACA authorized the construction of the Full-Scale Tunnel (FST) at Langley in February 1929 and design work started immediately. Smith J. DeFrance led the design team, which also included Abraham Silverstein, Clinton H. Dearborn, and Harry J. Goett. Significantly, three of these NACA researchers later became Directors of NACA or NASA field centers: DeFrance (Ames), Silverstein (Lewis), and Goett (Goddard). The timing of the Full-Scale Tunnel project was fortunate: the initial appropriation of $900,000 was made before the onset of the Depression; and by the time work began in the spring of 1930, labor and material costs had fallen, and the project directors could draw from a large pool of unemployed engineers.

Since the FST was to be the first wind tunnel constructed with an elliptic throat and two drive propellers mounted side-by-side, the designers had a 1/15-scale model of the FST constructed for studies of the flow circuit. The model tunnel was subsequently used for years as a small-scale test facility, after which it was given to Portugal in the late 1950s. It was returned to NASA in the 1970s for additional studies of the flow properties in the FST.

Work on the FST proceeded rapidly, and it was completed and ready for operation in May 1931, when it was the NACA centerpiece of the Sixth Annual Aircraft Engineering Conference. The largest wind tunnel in the world at that time, the FST had a unique design, with the building's steel framework visible on the exterior of the building. The enormous facility measured 434 feet in length, 222 feet in width, and 97 feet in height, and immediately became a recognizable landmark at Langley. The semi-elliptical test section measured 30 feet high by 60 feet wide with an open jet (that is, no walls immediately adjacent to the test section) and allowed the installation of aircraft with wingspans up to 40 feet. The tunnel was powered by two 35 feet 5 inch diameter propellers, each driven by a 4,000-horsepower electric motor, which could circulate air through the test section at speeds between 25 and 118 mph. The air circuit was of the double-return type, in which the airflow from the propellers was split right and left into two streams, doubling back between the test section and the building's walls, then reuniting before entering the throat of the test section. Extensive tuning of airfoil-shaped turning vanes in the tunnel circuit resulted in satisfactory flow properties in the test section. In addition to testing full-scale aircraft the FST had considerably lower turbulence than the VDT.

Full-scale aircraft were mounted to a 6-component strut support system which used linkages connected to dial-type force scales to measure air loads on the test subject. Early calibrations were

conducted with aircraft that also underwent flight tests permitting correlation with FST results. After successful initial operations, the tunnel became a national asset for testing and its contributions to aeronautics and space research continued for 78 years.

Early testing in the FST focused on the aerodynamic effects of aircraft geometry and construction methods on aerodynamic drag and engine cooling. Results of exploratory testing indicated unexpectedly high performance penalties from seemingly negligible aircraft protrusions and construction methods. Aware of the value of such tests, in 1938 the Navy sent its Brewster XF2A Buffalo to Langley for analysis of the aircraft's aerodynamic performance which had resulted in a disappointing top speed of only 250 mph. After a number of drag-producing items such as the landing gear, exhaust stacks, gun installations, and other details were analyzed, recommendations for modifications to the design were made by the FST staff that were subsequently adopted and resulted in a 31-mph increase in top speed. The tests were such a success that both the Navy and the Army quickly sent a steady stream of military aircraft to Langley for "drag cleanup tests." In the next 18 months, 18 different aircraft were tested and improved in the FST. The FST operated around the clock, seven days a week, during WWII conducting not only drag cleanup tests, but engine cooling methods, stability and control, and unexpected operational problems. Early versions of virtually every high-performance fighter aircraft were evaluated in the FST, allowing for countless design improvements that gave American pilots a critical edge in combat.

Following WWII, the FST was used in the 1950s to explore emerging new concepts such as wing sweep, delta wings, and boundary-layer control for improved low-speed performance. A remarkable variety of other subjects were also tested in the FST, including dirigibles, submarines, radar antennae, gliding parachutes, inflatable airplanes, and even another wind tunnel complex.

Although the performance of jet aircraft in the postwar period outpaced the relatively low speed capabilities of the FST, the facility remained an important test facility for NACA and its successor, the National Aeronautics and Space Administration (NASA). After the creation of NASA, changes in the tunnel's backlog of tests and transfer of key NACA personnel to the new NASA Space Task Group (STG) preparing for Project Mercury provided an opportunity for a new type of testing—remotely-controlled free-flying models. These tests had previously been conducted in the Langley 12-Foot Free-Flight Tunnel to determine the flight characteristics of radical aircraft designs, but the availability of the FST and its huge test section was perfect for the flight models by providing much more room to maneuver the model as well as use larger models with more realism.

The influx of free-flight models brought a decade of intense research on unconventional vertical takeoff and landing (VTOL) aircraft. Numerous types of civil and military VTOL designs were tested, including the British P.1127 fighter which ultimately led to the current Marine Corps Harrier jump-jet.

In the 1960s new types of aerospace projects were conducted to evaluate the low-speed characteristics of parawing/capsule combinations, advanced supersonic transports, lifting body configurations for spacecraft, and breakthrough concepts such as variable sweep. The tunnel was also used to test the tubular Lunar Landing Training Vehicle to assist in an investigation of the cause of an accident during the training of astronauts in late 1968.

In 1969, the FST began a research program on high-angle-of-attack behavior of fighter aircraft using free-flight models. The program began an integral part of the development process for all new military high-performance aircraft for over 25 years. An upgrade to the FST in 1977 (and later in

1984) improved the operation of the electric fan motors, and allowed the facility to continue testing aircraft designs whose technology and performance could not possibly have been envisioned in the biplane era in which it was built.

The historical significance of the FST and its many contributions to aerospace technology were recognized when it was designated a National Historic Landmark in 1985. The oldest operating wind tunnel at Langley when NASA finally decommissioned it in October 1995, the facility gained a new lease on life when it was transferred to Old Dominion University (ODU) under the terms of an innovative privatization program. ODU began operations at the FST in October 1996, providing engineering research facilities for graduate students and private customers in the field of aircraft and automotive transportation.