60 Years of Flight Research at NASA Dryden

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(Editor's note: On Sept. 30, 1946, a small team of NACA engineers and technicians led by Walter C. Williams arrived at Muroc Army Air Field to support the initial powered flights of the Bell X-1 flight research program. While NACA had initially resisted the idea of conducting the flights at Muroc, Williams was extremely impressed with the incomparable flying conditions at the base. In this remote, almost primeval location, he caught a glimpse of the future and he predicted that the NACA would probably "have a large group out here for a very long time." There were "no two ways about it," he reported back to NACA headquarters at Langley, VA, "this is the place to test experimental airplanes or, for that matter, any sort of airplane." Walt Williams proved to be a prophet. The NACA and NASA have remained a major presence on Edwards Air Force Base ever since.)

The National Advisory Committee for Aeronautics Muroc Flight Test Unit in 1947. Walt Williams is in front row, third from left.

In late 1946, members of the National Advisory Committee for Aeronautics (NACA) arrived at the Muroc Army Air Field to help launch a new era in aviation. The NACA and its successor, NASA, have had a significant and uninterrupted presence in the high desert of Southern California ever since, leading to an unbroken chain of advances in aerospace.

That initial cadre of engineers, pilots, mechanics, and computers comprised the NACA's Muroc Flight Test Unit—forerunner of today's NASA Dryden Flight Research Center. They played a central role in determining whether an airplane could successfully exceed the speed of sound. That milestone was first accomplished in the famed Bell X-1 rocket plane, flown by Air Force Capt. Charles E. “Chuck” Yeager, in October 1947.

Over the past six decades, four major chapters in Dryden’s history emerged—speed and structures, access to space, the controls revolution, and efficiency and safety. To one degree or another, almost everything done at Dryden has fallen into one of these categories. And, while it is convenient to think of them as chapters, it is useful to remember that the chapters overlap, and some are not yet finished.

What drove the NACA’s research beside the dry lakebed in the high desert was the advent of the turbojet engine, which made the previous forty years’ experiences, technology, and understanding of aerodynamics almost irrelevant. The higher speeds and altitudes made possible by jet engines fundamentally altered aircraft design, construction, materials, control, and aerodynamics. Suddenly, the future of aviation drew little from the past; the NACA/NASA research efforts in the first two decades after WWII focused on these uncharted regions of flight.

The first- and second-generation of the X-1 series of aircraft demonstrated that one could successfully fly faster than twice the speed of sound and at altitudes above 90,000 feet. More questions about aircraft control at transonic speeds were tackled in the Douglas D-558-II Skyrocket, whose highly swept wings revealed difficulties at certain points in flight. Air Force and NACA researchers at the base jointly explored control in a swept wing jet with the X-4, an almost tailless aircraft. Its stability problems could only be solved with advances in computers that came decades later. The X-5 demonstrated that an aircraft’s wings could be swept fore and aft in flight, leading to subsequent combat aircraft that were optimized for both low-speed and supersonic flight performance.

But it was the X-15, the greatest rocket plane of them all, which caught the world’s attention. The X-15 explored hypersonic flight (above Mach 5), attaining a speed of 4520 mph on one flight; and exo-atmospheric flight, reaching an altitude of 67 miles, as well as conducting countless experiments on human physiology outside the atmosphere, control of a vehicle in near space, and dynamic heating, to list but a few. Eight of the twelve pilots who flew the X-15 received astronaut wings for reaching space in the vehicle.

By the 1960s there was a noticeable broadening in Dryden’s focus to include space-related activity, what has since been dubbed "access to space." The X-15's visits to space were almost coincidental, but they demonstrated the concept of a reusable space vehicle, as well as winged flight back to Earth from space.

In the mid-sixties Dryden began testing and validating the Lunar Landing Research Vehicle (LLRV) as a free flying tool to train astronauts for actually landing on the moon. From the testing done at Dryden came the Lunar Landing Training Vehicles that the Apollo astronauts flew as their launch dates approached.

At the same time, Dryden began validating the concept of lifting bodies, aircraft that had no wings but whose blunt shape made it possible to enter Earth's atmosphere from space and glide to a designated runway for a controlled landing. This was in marked contrast to the only method then in use (excepting the X-15): descending in a capsule under parachutes.

The success of the lightweight wooden M2-F1—the world's first lifting body—led to a family of heavier, all-metal and rocket-powered lifting bodies such as the M2-F2, M2-F3, HL-10, X-24A and B. The data from these programs was applied to the development of the space shuttle and to the design concepts for various future space vehicles. By the program's conclusion lifting bodies had flown supersonically and to altitudes in excess of 90,000 feet en route to proving their capability.

X-24B Lifting Body

The NASA center has continued its space-related activity over the decades, playing a key role in the space shuttle, and most recently, the unmanned X-43 hypersonic scramjet programs. Dryden has not only hosted nearly half of all space shuttle landings, it conducted essential research and testing for the shuttle, including the all-important validation of its unpowered approach and landing on return from space. And, in a pair of wonderfully symmetric events in 2004, Dryden successfully flew a pair of X-43s, the world's first airframe-integrated scramjet that combined an air-breathing engine with an airframe capable of hypersonic flight. The two research vehicles reached speeds of nearly Mach 7 and Mach 10 during their missions, making them the fastest air-breathing aircraft in the world.

F-8 Digital fly-by-wire demonstrator

Dryden's work with the LLRV led directly to a third chapter in its history—digital-fly-by-wire flight controls. The LLRV was entirely controlled by on-board analog computers: there were no mechanical control systems on the vehicle. This program gave Dryden engineers confidence to apply their experience to a highly modified F-8, from which they removed all mechanical and hydraulic controls. In their place, engineers installed a digital computer and small electric motors to drive the control surfaces of the wings and empennage. (The digital computer came from the Apollo 15 command module, and had a total of 38K of memory.) Successfully demonstrating an all-computer controlled aircraft not only benefited the space shuttle (itself a fly-by-wire aircraft using digital computers), it paved the way for computer controlled aircraft in the military and commercial aircraft fields, and is now the dominant means of flight control for high-performance aircraft.

Moreover, Dryden conducted follow-on research with digital electronic engine controls on a modified F-15, which, in turn, led to the development of self-repairing, and then intelligent flight control systems. The latter can enable an aircraft to remain flyable even after sustaining significant physical damage, because of its sophisticated computer system. Such digital controls also enable more precise and efficient operation of an aircraft.

Dryden engineers also pursued efficiency and safety in commercial and private aircraft, in what might be termed the fourth chapter in its history.

In the 1970s engineers at the center employed another highly modified F-8 to demonstrate the efficiency of a supercritical wing, a reshaped airfoil that allowed either higher speed or greater fuel efficiency at transonic speeds. Such wings are now found on many new military, commercial, and corporate jets, as well as the tips of helicopter rotor blades. At almost the same time, Dryden evaluated a pair of winglets on a modified KC-135 to validate a NASA assumption about improved efficiency. So effective were winglets that they, too, are now commonplace on business jets, commercial airliners, and military transports, and are being retrofitted on existing aircraft. Closer to Earth, Dryden conducted research with aerodynamic fairings on trucks, culminating in a redesigned long haul truck cab that looks very much like what manufacturers make today.

Dryden also tested the structural strength of general aviation aircraft, verifying (or not) their manufacturers' stated air worthiness. Sometimes failure is more instructive than success, and this was the case with the Controlled Impact Demonstration. To determine the value of an anti-misting additive to jet fuel (the better to reduce the chance of a post-crash fire) that the FAA was about to require in airliners, Dryden intentionally crashed an old Boeing 720 airliner, flown remotely, onto Rogers Dry Lake. To everyone's surprise, the airplane exploded in a ball of fire. The additive was never used again.

Now sixty years on, the Hugh L. Dryden Flight Research Center remains deeply involved in aeronautical testing and research. It is the site of emergency recovery testing for the new Orion capsule planned for the next lunar mission. A team of NASA and industry partners have recently started flying the X-48B blended wing body concept demonstrator, a design potentially capable of carrying far heavier loads with greater efficiency than today's aircraft can. And one of its F-15Bs serves as the test bed for the Intelligent Flight Controls System, which incorporates artificial intelligence in aircraft control. The aeronautical future continues to be seen first at Dryden.