National Aeronautics and Space Administration

Citizen Report

A look at the work and impact of the Dryden Flight Research Center for Fiscal Year 2011

Dryden Flight Research Center

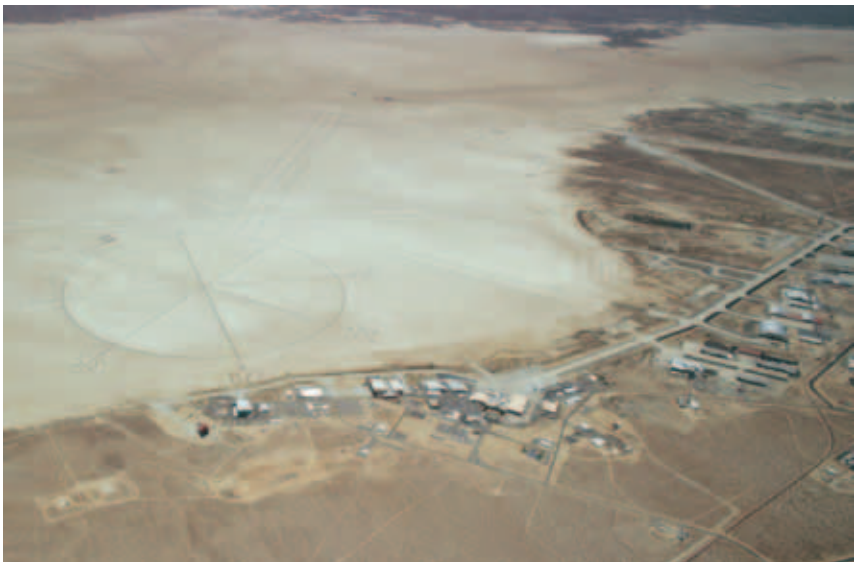
Citizen Report Fiscal Year 2011

Introduction to the Dryden Flight Research Center

Dryden Flight Research Center, located on the western edge of California's Mojave Desert, has made many significant contributions to NASA's mission since the agency was established more than five decades ago.

Dryden's history dates to late 1946, when 13 engineers and technicians arrived at what is now Edwards Air Force Base from the National Advisory Committee for Aeronautics Langley Memorial Aeronautical Laboratory. Their goal was to prepare for the first supersonic research flights by the X-1 rocket plane in a joint NACA/U.S. Army Air Forces/Bell Aircraft program. The NACA was the predecessor organization of today's NASA.

Dryden continues to pioneer programs that contribute to technological advances, access to space at reduced cost, human spaceflight, space exploration and Earth and space science. Dryden completes that work with less than .014 percent of the annual federal budget (approximately $262.7 million) and about 1,210 contractor and civil servant employees.



This bird's eye view shows the expanse of Edwards Air Force Base and Rogers Dry Lake.

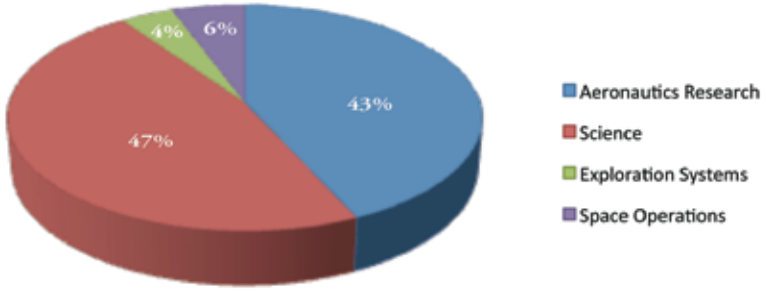
Our Vision

To fly what others only imagine

Our Mission

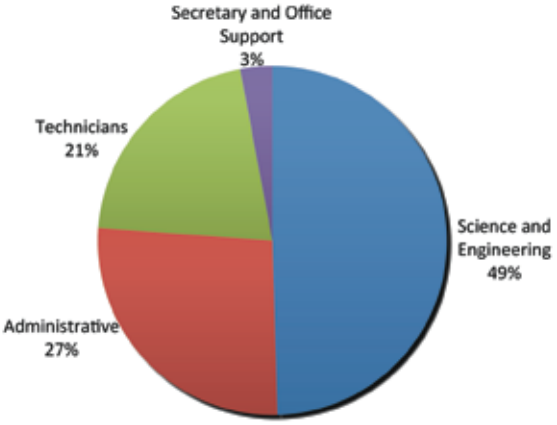
Advancing technology and science through flight

Dryden 2011
Program Funds Distribution*

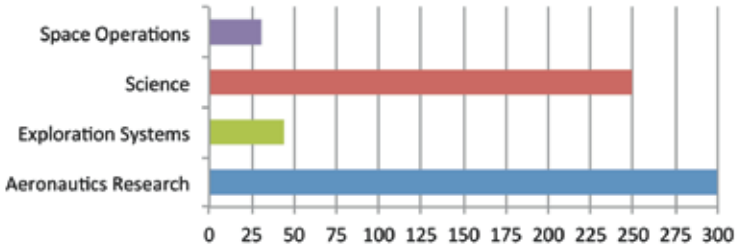


*Percentages based on total program budgets
Chart includes all projects

Occupational Distribution



Dryden 2011
Number of Employees by Mission



Aeronautics

NASA conducts cutting-edge research in traditional and emerging disciplines to help transform the nation's air transportation system, and in support of future aerospace vehicle development. NASA Dryden's world-class flight research capability is built on a tradition of expertise in aeronautical engineering and its core research disciplines, including aerodynamics, aero-acoustics, materials and structures, propulsion, dynamics and control, sensor and actuator technologies, advanced computational and mathematical techniques, and experimental measurement techniques.

Dryden supported the Aeronautics Research Mission Directorate in 2011 with four sonic boom experiments and exploration of engine design hardware attached to a research aircraft in flight.

NASA used supersonic aircraft to produce amped-up, super-loud sonic booms to understand how to minimize the startling impact caused when an aircraft exceeded the speed of sound. The idea is to calibrate computer prediction tools to the louder booms so future aircraft designers can create quiet supersonic aircraft.

Researchers are working to reduce the impact of sonic booms created by the shock waves propagating from supersonic aircraft that are an annoyance to many and can damage private property. By reducing the noise, researchers hope to help lift severe restrictions currently in place on supersonic flight over land.

Researchers used a two-mile long string of microphones to record the thunder of an accelerating F/A-18 jet for the Superboom Caustic Analysis and Measurement Program, or SCAMP, project that wraps up in 2012. The initial data included 13 flights that generated 70 sonic boom events. Airborne microphones also were mounted on a Dryden TG-14 motorized glider equiped with sound recording devices that flew between the booming F/A-18 jet and the ground. Additionally, a 35-foot-long blimp was tethered at 3,500 feet above ground with two microphones along its tether. The flights were flown in the remote Black Mountain Supersonic Corridor north of Boron, Calif., in restricted military testing airspace near Edwards Air Force Base over which supersonic flight is allowed.

Partners include Dryden, NASA's Langley Research Center in Virginia, Wyle Laboratories, The Boeing Company, Northrop Grumman, Cessna, Gulfstream, Central Washington University, Pennsylvania State University, Eagle Engineering, MetroLaser Inc. and Seismic Warning Systems Inc. SCAMP was funded by NASA's Aeronautics Research Mission Directorate in Washington and managed by the Supersonics Project in the directorate's Fundamental Aeronautics Program.

Dryden also flight tested two supersonic shockwave probes to determine their viability as research tools in air-to-air analysis of shockwaves. The probes were designed by Eagle Aeronautics of Hampton, Va., under a NASA Research Announcement and manufactured by Triumph Aerospace Systems of Newport News, Va. The probes were first tested in a wind tunnel at NASA's Langley Research Center, also in Hampton.

The new probes were flown on the centerline instrument pylon located under Dryden's F-15B research test bed aircraft. Sonic boom researchers intended for the Eagle Aero probes to aid their understanding of supersonic shockwaves. The two probes are mounted beside each other on the pylon, one wedge-shaped and the other conical. Both are designed to make very accurate measurements of supersonic airflow, improving the quality of the shockwave data engineers can obtain.

ED11 0339-12 **NASA Photo by Tom Tschida**

From left, Larry Cliatt, Christopher Hobbs, Joseph Salamone and Erin Waggoner install one of 13 remote sonic boom sensors. The sensors remotely measured sonic booms for the Waveforms and Sonic boom Perception and Response, or WSPR, project.

EC02 0224-1 **NASA Photo by Jim Ross**

Dryden F/A-18 mission support aircraft were used to create low-intensity sonic booms during the WSPR project.

Rounding out Dryden's sonic boom research was the Waveforms and Sonic boom Perception and Response, or WSPR, project that involved gathering information from a select group of more than 100 volunteer Edwards Air Force Base residents on their attitudes toward sonic booms produced by aircraft in supersonic flight.

WSPR was funded by NASA's Aeronautics Research Mission Directorate and managed by the Supersonics Project in the directorate's Fundamental Aeronautics Program.

Another project called the Sonic Boom Resistant Earthquake Warning System, or SonicBREWS, investigated an earthquake early warning system.

Dryden and Seismic Warning Systems Inc. of Scotts Valley, Calif., began evaluating the company's QuakeGuard earthquake warning system to determine if sonic booms caused the devices to register false alarms. Vertical accelerometers in the devices, using the company's proprietary algorithms, are designed to detect precursor or "P" waves that travel ahead of the primary, destructive "S" shockwaves of earthquakes.

Missions by supersonic aircraft did not cause the system to generate false alarms. However, three F/A-18 aircraft intentionally dived to create sonic boom shockwaves directed at the building to mimic P waves. A system like SonicBREWS could provide up to five minutes warning prior to the arrival of a distant quake. Closer to the epicenter, time would be much less, but long enough for people to duck and cover, for gas company automated pipe valves to be shut off, and for fire station garage doors to open.

Dryden's Innovative Partnerships Office helped establish the Space Act Agreement that is the foundation for the partnership. In addition, the IPO and NASA's Airborne Science program funded the seismometers used in the study.

In addition to sonic boom investigations, Dryden Aeronautics researchers completed flight tests of a unique experimental jet engine inlet design in the Channeled Center-body Inlet Experiment, or CCIE. The experimental inlet was checked out on Dryden's F-15B aeronautics research test bed aircraft used to evaluate innovative and advanced propulsion concepts.

Six flights at speeds of up to Mach 1.74 were flown with two interchangeable center bodies installed in an air inlet tube to measure airflow around them. Both structures are designed to direct and compress airflow internally through the engine. Flight data from the standard smooth center body will be used to benchmark performance data for the channeled center body. The slots cut along the length of the channeled center body simulate a simple device that in an actual inlet would allow optimization of the amount of air flowing into the engine. The result is improved airflow efficiency at a wide variety of speeds and fuel efficiency.

Potential future applications for the simplified inlet design include its use on a new generation of supersonic cruise aircraft, reducing the complexity and weight of this important component of supersonic propulsion systems.

TechLand Research Inc. of North Olmsted, Ohio, developed the CCIE inlet through a NASA Small Business Innovation Research contract. The CCIE project was funded by NASA's Aeronautics Research Mission Directorate and managed by the Supersonics Project in the directorate's Fundamental Aeronautics Program.

Science

Dryden's Science Mission Directorate provides unique or highly modified aircraft, flight operations for scientific data collection and the development of advanced aeronautical capability to support the NASA Earth Science and Astrophysics programs.

Dryden supports the scientific community through airborne science research and operation of aircraft appropriate for program execution. Two ER-2s, a DC-8, two Global Hawks and a Gulfstream III aircraft are used in Dryden's Airborne Science program.

The Global Hawks' 11,000-nautical-mile range and capabilities for large payloads and flight duration in excess of 32 hours enable the scientific community to measure and monitor locations not easily accessible using piloted aircraft.

In the NOAA-led 2011 Winter Storms and Pacific Atmospheric Rivers mission, scientists successfully evaluated the capabilities of an automated dropsonde system. The Global Hawk Mobile Operations Facility, a portable ground control station, was acquired and will allow project aircraft to be deployed and operated from locations other than Dryden.

NASA's DC-8 flying laboratory is used to gather data for scientific studies in archeology, ecology, geography, hydrology, meteorology, oceanography, volcanology, atmospheric chemistry, soil science, biology and cryospheric science. The aircraft was based in Punta Arenas, Chile, for a second year of flights over Antarctica as part of the Operation IceBridge study of glaciers and ice thickness.

During the summer 2011 Active Sensing of CO_2 Emissions over Nights, Days and Seasons II campaign, the DC-8 was used in a test of four laser techniques for remote measurements of atmospheric carbon dioxide. Flights covered a variety of land surfaces to test surface-reflectance effects on instrument

Photo courtesy of Chris Miller

NASA's DC-8 flying laboratory flew a low-level data collection flight over George VI Sound on the Antarctic Peninsula.

ED10-0132-13 **NASA Photo by Tony Landis**

NASA's Global Hawk soars aloft on a functional check flight of the aircraft payload system and science instruments.

performance. Future applications will include the instruments' use on a space-borne laser that would overfly the same type of surfaces when used to study Earth's atmospheric components from space. This research will contribute to advanced development of laser-based, Earth-observing satellite instruments designed to measure atmospheric carbon dioxide.

The Gulfstream III carries the Jet Propulsion Lab-developed Unmanned Aerial Vehicle Synthetic Aperture Radar, or UAVSAR, in a pod attached to the aircraft's belly. In May 2011 the UAVSAR imaged volcanoes in Alaska's Aleutian Islands chain to detect and measure small changes of geophysical interest in the Earth's surface. En route to Alaska, the radar imaged volcanoes in the Cascade Range over California, Oregon and Washington.

NASA's high-altitude ER-2s enable researchers to carry out experiments that gather data about our surroundings, including Earth resources, celestial observations, atmospheric chemistry and oceanic processes. The aircraft are also used for electronic sensor research and development, satellite calibration and satellite data validation.

The ER-2 deployed to Offutt Air Force Base, Neb., for the six-week Mid-latitude Continental Convective Cloud Experiment. The study focused on convective cloud and precipitation activity, including observation and measurement of the entire process as it occurs from ice that forms near the top of clouds to rain that falls to the ground. Acting as a satellite simulator, the ER-2 carried instruments that sampled the entire column of atmosphere below the aircraft to verify that data collected produced a consistent summary of precipitation physics. These data will improve the accuracy of future satellite instruments.

Dryden supported the agency's astrophysics research through management and operation of the Stratospheric Observatory for

ED10-0182-01 **NASA Photo by Jim Ross**

The SOFIA's aft door is open during flight, exposing the high-tech, German-built and infrared telescope.

Infrared Astronomy program, a partnership between NASA and the German Aerospace Center.

The SOFIA made its initial science flight on Nov. 30, 2010, when Cornell University's Faint Object Infrared Camera for the SOFIA Telescope, or FORCAST, imaged Comet Hartley, star-forming nebulae Messier 42, W3 IRS5 and Sharpless 140. In 2011, the SOFIA team began the Airborne Astronomy Ambassadors program when six U.S. and two German educators had the opportunity to participate in science missions alongside SOFIA researchers.

Human Exploration and Operations

The Human Exploration and Operations Mission Directorate is responsible for the leadership and management of NASA space operations including human exploration in and beyond low Earth orbit. The directorate also oversees low-level requirements development, policy, and programmatic oversight. The International Space Station, currently orbiting the Earth with a crew of six, represents the NASA exploration activities in low Earth orbit.

Exploration beyond low Earth orbit includes the management of Commercial Space Transportation, Exploration Systems Development, Human Space Flight Capabilities, Advanced Exploration Systems, and Space Life Sciences Research and Applications. The directorate is similarly responsible for Agency leadership and management of NASA space operations related to Launch Services, Space Transportation, and Space Communications in support of human and robotic exploration programs.

Dryden celebrated almost 40 years of support of NASA's space shuttle development and operations when shuttle flights

ED11-0165-016 **NASA Photo by Carla Thomas**

Dryden F/A-18 No. 852 makes a 40-degree dive towards Rogers Dry Lake with the Mars Science Laboratory's landing radar during verification and validation flights. Project flights included vertical 90-degree dives.

concluded in July 2011. Dryden's Shuttle Flight Operations Support office provided management and coordination of facilities, systems, and ground servicing equipment to support

space shuttle launch, on-orbit, landing, recovery, and turnaround operations.

Dryden was the main landing site for early shuttle missions and remained an alternate landing site when weather at Kennedy Space Center, Fla., did not permit a shuttle landing there. In all, 54 shuttle landings occurred at Edwards, beginning with STS-1 on April 14, 1981, and ending with the last shuttle Dryden hosted when STS-128 concluded at Edwards on Sept. 11, 2009. Dryden began wrapping up space shuttle operations at the center following the last shuttle mission and disposition of specialized shuttle support equipment continues this year.

The center ensured the preparedness of the Dryden and Edwards Air Force Base landing sites in 2011 and supported the final two shuttle landings at Kennedy. The Western Aeronautical Test Range also provides ongoing communications tracking support for the International Space Station, including preparedness training and emergency on-board support.

Out-of-this world research by Dryden and the Jet Propulsion Laboratory of Pasadena, Calif., included flight-tests of the Mars Science Laboratory's landing radar, using an F/A-18 aircraft. The aircraft carried a Quick Test Experimental Pod that housed the MSL test radar underneath its left wing.

The MSL rover, named Curiosity, is on its way to Mars and is estimated to arrive in August 2012. After Curiosity lands on Mars, researchers will use the rover's 10 science instruments during the following two years to investigate whether the landing area at one time had environmental conditions favorable for microbial life.

The F/A-18 made a series of subsonic, stair-step dives over Rogers Dry Lake at angles of 40 to 90 degrees in order to simulate what the MSL's radar will see during entry into the Martian atmosphere. Flight data then was used to calibrate the MSL's landing radar software. If any unexpected challenges are uncovered, the JPL team can make adjustments leading up to the rover's landing.

The MSL mission follows the success of the twin Mars exploration rovers, Spirit and Opportunity, which explored Mars for the past seven years. The MSL mission is part of NASA's Mars Exploration Program, a long-term Mars robotic exploration effort. JPL manages the mission. Dryden has assisted with instrumentation integration, project planning, flight article environmental testing, airspace coordination, logistical support and flight test expertise.

Flight Opportunities Program

The Flight Opportunities Program is part of NASA's Office of the Chief Technologist. The Office of the chief technologist is responsible for advocating and advising on agency-wide technology policy and programs and maturing crosscutting technologies, or discoveries that are useful in a number of areas, to flight readiness status for future space missions.

The Office of the Chief Technologist, established in 2009, also is responsible for management of NASA's Space Technology programs. The Chief Technologist is responsible for developing and executing innovative technology partnerships, for technology transfer and commercial activities and development of collaboration models for NASA.

Dryden is helping NASA by managing the Agency's Flight Opportunities program. Seven companies were selected in August 2011 to integrate and fly a variety of technology payloads on commercial suborbital reusable vehicles near the boundary of space to help meet the agency's research and technology needs.

These two-year contracts, worth a combined total of $10 million, will allow NASA to draw from a pool of commercial space companies to deliver payload integration and flight services. Also referred to as indefinite-delivery, indefinite-quantity contracts, NASA intends to provide frequent flight opportunities for payloads on suborbital platforms.

The selected companies include: Armadillo Aerospace of Heath, Texas; Near Space Corp. of Tillamook, Ore.; Masten Space Systems of Mojave, Calif.; Up Aerospace Inc. of Highlands Ranch, Colo.; Virgin Galactic of Mojave, Calif.; Whittinghill Aerospace LLC of Camarillo, Calif.; and XCOR of Mojave, Calif.

Photo courtesy of Draper Laboratory

Masten Space Systems' Xombie rocket with Draper Laboratory's GENIE flight control system had its first untethered flight from the Mojave Air and Space Port, Calif.

Economic Impact

Dryden Flight Research Center is a big contributor

NASA has 10 centers across the nation that enable the agency to carry out its mission. Dryden is NASA's premier installation for aeronautical flight research for current and future aerospace vehicles. Dryden also plays a key role in NASA's development of next-generation access-to-space, reusable launch vehicles from commercial partners.

In past years, Dryden has employed hundreds of personnel in achieving the center's mission. In 2011, the center employed 1,210 people, about 557 civil servants and 653 private-sector contractors on or near the site.

A major source of U.S. economic output is generated from the procurements and expenditures made in support of NASA programs, including payroll, operating expenditures and construction totaling about $262.7 million.

Dryden strives to maximize benefits produced by activities conducted at the center while minimizing costs. In addition to technical and social impacts derived through these activities, the total benefit of business Dryden conducts also includes a significant economic boost in the location it operates in and among the community.

In 2011, Dryden's operations resulted in an estimated equivalent dollar value of $51.1 million in jobs created outside of the center, employing an estimated 1,646 individuals.

The combination of Dryden's annual expenditures and the estimated value of the jobs created outside of the center result in a total economic impact of $313.8 million.

Fiscal Year 2011: Indirect jobs created

Total personnel at the center:	1,210
Indirect jobs created *Using 1.36 multiplier	1,646
**Average annual pay for Local community:	$31.024
Estimated annual dollar value of jobs created:	**$51.07M**

(1,646 x $31.024 = $51.07M)

Fiscal Year 2011: Economic impact

- Annual expenditures **$262.7M**
- Estimated value of jobs created **$51.07M**
- Grand Total **$313.8M**

*Multipliers: LMI Economic Impact Database, Installations and Indirect/Induced Job Multipliers, February 1995

**Avg. Annual Pay: Current tables for Average Annual Pay Levels in Metropolitan Areas and Average Annual Pay by State and Industry are accessible at: http://www.bls.gov/cew/home.htm

Cover

NASA is using supersonic aircraft to produce very loud sonic booms in an effort to minimize their startling impact in future supersonic aircraft. NASA photo ED12 0034-17 by Jim Ross.

ED11 0258-53 **NASA Photo by Tony Landis**

NASA research pilot Jim Less checks out the Channeled Center-body Inlet Experiment mounted underneath NASA's F-15B prior to a test flight.

ED10-0383-013 **NASA Photo by Tony Landis**

A NASA high-altitude ER-2 environmental science aircraft descends on final approach to the runway at Air Force Plant 42 in Palmdale, Calif.