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Information Summary

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Aerospace Careers: Instrumentation Engineers

The work by instrumentation engineers is essential to the success of every aeronautical research project flown at NASA's Dryden Flight Research Center.

The basic product of aeronautical research is data, used primarily to investigate and validate new ideas and theories, and to monitor aircraft, engine, and systems performance during flight. Designing the sensors and instruments used to collect and record data during research flights at Dryden are the engineers of the Instrumentation Branch.

What is Instrumentation?

Every research project at Dryden uses instrumentation to collect in-flight data and transmit this information back to a mission control room. Many parameters are measured such as aerodynamic loads, pressure distribution, shear forces, flutter, temperatures, speed and the position of control surfaces at specific points on a timeline.

These data points are obtained by sensors, strain gauges and accelerometers. When installed on a research aircraft they are collectively called a data acquisition system. The instrumentation converts mechanical energy into electrical signals that are then processed on the aircraft into radio signals (telemetry), transmitted to a mission control center where the information is monitored, and analyzed by engineers and researchers.

The number of sensors on NASA research aircraft range from hundreds to thousands, based on the complexity of the project and the number of parameters that need to be studied. During the first phase of the X-29 Forward Swept Wing research project, flown at Dryden from 1984 to 1991, the aircraft had several thousand sensors, most of them on and in its unique wings just to measure pressure, loads and deflection while the aircraft maneuvered at different speeds.

Instrumentation engineers use many kinds of sensors to collect data. Probes called pitot-static systems extend into the airstream to measure pressure and convert it into airspeed. Electrical resistance strain gauges measure how much an aircraft component such as a wing or rudder is deflected during certain loads or maneuvering. This information is vital for flight safety and to establish operational limitations.

Thermocouples and resistance temperature detectors are used to gather information about heat generated by the propulsion and exhaust systems of the aircraft. The X-31 research aircraft was flown at Dryden to study thrust vectoring as a way of improving agility and maneuverability at extreme angles of attack. Important to the project were sensors on and near the thrust-vectoring paddles used to deflect the engine exhaust stream for directional control. The sensors measured temperatures of the paddles and the aircraft structure, paddle deflection and differential pressures between the paddles. Instrumentation is also used to record thermal heating on exterior surfaces of an aircraft due to the friction of air at high speeds.

Instrumentation is used in the flight control systems of Dryden research aircraft and also the Center's support aircraft. These measuring units feed the flight control computer basic information about speed, attitude, engine functions, exhaust temperatures and pressures, and movements of flight control surfaces. Without these data points the flight control system cannot function properly and the aircraft cannot be used as a stable research platform. Instrumentation serves as the researchers' eyes and ears.

The Work of Instrumentation Engineers

Instrumentation engineers work closely with project engineers, researchers and aircraft crews in the design and development of data acquisition systems to make sure that the equipment will meet their needs and can be installed on the aircraft safely and efficiently. Elements to be considered during the development process are the scope of acquisition, such as the number of sensors and telemetry systems to be installed, and the temperatures, altitudes and aerodynamic forces at which the instrumentation must operate. Complete understanding of these factors is necessary or data generated during a flight can be inaccurate or lost entirely.

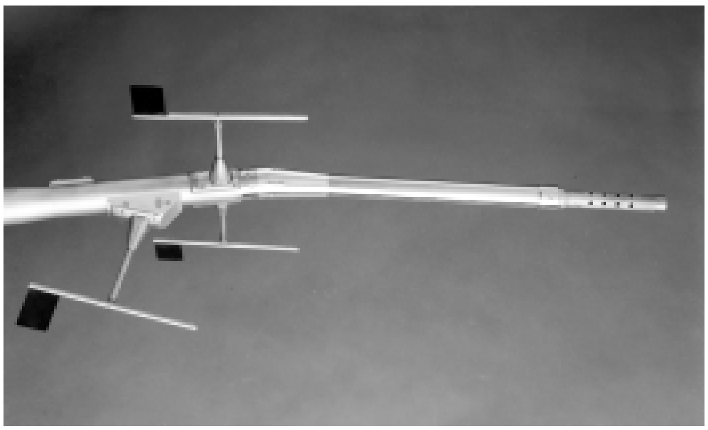
Close cooperation with test facilities personnel is also necessary for the smooth transfer of telemetry from the aircraft to the mission control center on the ground. During most research flights, data are being received in the mission control center in real time, while the aircraft is flying. To ensure that all research and performance parameters are displayed during the missions, instrumentation engineers must be familiar with the capability of the telemetry transmission

The Linear Aerospike Experiment (LASRE) program (using a linear aerospike rocket engine mounted on the back of an SR-71) was a complex project involving instrumentation engineers.

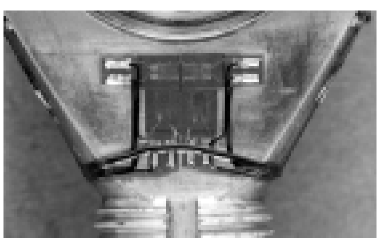
system on the aircraft and the requirements of the control room data display system on the ground.

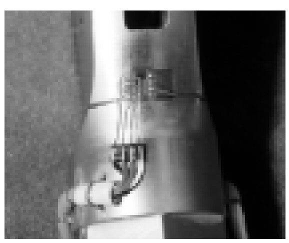
Tools of the Instrumentation Engineer

Data are also recorded by equipment aboard research aircraft on most flights. The selection of proper on-board recording equipment that can function accurately in a dynamic flight environment is an important job of instrumentation engineers.



The air data probe is a sensor that helps determine information including aircraft pitch, yaw, and airspeed.





Strain gauges are small enough to fit on many aircraft parts.

Occasionally instrumentation engineers design special sensors for special projects. Examples would be a researcher's need to have data that are more precise or sensitive than usual, or data that must be collected in an extremely dynamic flight environment. This requires the instrumentation engineer to generate his or her own research project by studying the needs of the researcher, and creating a new instrument or sensor that is adaptable to the aircraft that will produce the necessary data.

The People and the Projects

Instrumentation engineers are involved in many research projects at Dryden that are developing new technologies for future applications in aeronautics and space flight.

One of the most significant projects has been the testing of alternatives to wire bundles, which are multiple wires fastened together and span long distances inside an aircraft structure. They are difficult to troubleshoot when there are electrical problems, they are subject to wear, and they are heavy. Fiber optics are being studied by instrumentation engineers to replace conventional aircraft wiring, as well as the use of microwave transmissions to deliver electrical impulses in aircraft. Development of these technologies may drastically reduce the amount of wiring in future aircraft, while also reducing weight.

Instrumentation engineers were involved in the development of a laser system to detect clear air turbulence, which can cause severe injuries and aircraft damage. The system uses a laser beam to detect the movement of microscopic air particles excited by dangerous currents of air that are normally unseen by pilots and undetected by radar. The laser system can "see" the clear air turbulence at distances of up to five miles. It could be the forerunner of systems that will allow commercial airline pilots to either fly around the dangerous disturbances or warn passengers in time for them to fasten their seat belts.

One of the most complex projects involving instrumentation engineers in recent years at Dryden was the Linear Aerospike Experiment (LASRE). Flown on a NASA SR-71, LASRE was a scaled version of an advanced rocket engine that will power the X-33. The instrumentation included extensive measurements of air pressure and temperatures in the fuel feed systems of the test engine, mounted on the upper fuselage of the SR-71, and air data probes that monitored the aerodynamic conditions surrounding the rocket engine. The X-33 is under development to test materials and technologies for a Reusable Launch Vehicle (RLV).

Education and Experience

Most engineers in the Dryden Instrumentation Branch have a bachelor of science degree in electrical engineering or physics, with some possessing post-graduate degrees and doctorates. Education leading toward a bachelor of science degree should include all levels of mathematics, science, physics and computer operations.

Branch engineers should possess a broad working knowledge of aviation fundamentals and be able to communicate with researchers and engineers of all disciplines and at all levels of management, not only at Dryden but with individuals at other NASA centers, government agencies, and commercial aerospace firms.

Instrumentation engineers must have excellent problem-solving skills and the ability to understand the needs of his or her customer — the researcher — and translate this dialogue into the design and development of suitable hardware.

All major aerospace companies have flight test branches where engineers work in positions common to a NASA instrumentation engineer. Within the federal government, similar engineering positions can be found in the Federal Aviation Administration and also in the flight test branches of the U.S. armed forces.