NASA's B-737 Flying Laboratory
From 'Glass Cockpits' to Windshear Detection

Since it first entered the NASA inventory in 1974, NASA 515 has been a testbed for research into a multitude of issues affecting aircraft safety, efficiency and capacity (see p.2). Called an "airborne trailblazer," it goes beyond the typical research facility in that it demonstrates new concepts in real-world situations. For example, government and industry decision makers could observe -- first-hand -- research pilots using innovations in computer-generated display formats and content while interacting with air traffic controllers in a busy terminal area. Other observers experienced flying through potentially hazardous windshears to prove that advance-warning devices really can give pilots precious extra seconds to avoid hazardous weather.

As a result, this flying laboratory and its supporting facilities have been responsible for rapid adoption of new aviation technology by U.S. industry.

NASA 515 is the first B-737 built. First used by Boeing to qualify the 737 for airline service, the prototype 737 has since been heavily modified by NASA. It has two separate cockpits -- a conventional B-737 forward cockpit providing operational support and safety backup, and an operational research flight deck positioned behind in what was the aircraft's first-class cabin section.

This national facility is maintained and flown by NASA Langley Research Center, Hampton, Va., as part of the center's Terminal Area Productivity (TAP) program.

---

**WELL TRAVELLED.** NASA 515 posed for this picture over NASA Langley Research Center in 1989. The 737 has taken part in flight research in several states in this country, in Canada and in South America.
1. Electronic Flight Displays [1974-75]. Boeing 757/767 aircraft have cathode ray tube electronic attitude indicators and horizontal situation displays. Technology developed and first demonstrated on the Langley B-737 research aircraft. These instruments have contributed to both safety and efficiency of flight through better comprehension by the pilot of airplane's situation relative to its environment.

2. Microwave Landing Systems (MLS) [1975-78]. Conducted flights with the FAA to evaluate the MLS performance as a precision landing guidance system. As a result of joint flight demonstrations, the U.S. MLS system was adopted as the international standard approach and landing guidance system.

3. Precision Flare Control [1978-80]. Aircraft landing-flare control computations, developed and flight tested to tighten touchdown area, demonstrated that improved touchdown accuracy could reduce time aircraft on runway. Technology adopted by Boeing.

4. Profile Descent Program [1979-80]. Conducted flights to evaluate aircraft descent procedures from high altitude using automation to achieve efficient descent paths for fuel and time savings.

5. Wing Surface Coating [1980-81]. Joint program with Boeing to evaluate advanced paints for improved laminar flow over wing surfaces. Flight tests pointed to net drag reductions for commercial airliners.

6. Digital Autonomous Terminal Access Communications (DATA)C [1983-88]. Joint program with Boeing to develop, flight test and demonstrate practical use of onboard computer network to communicate between aircraft electronic flight systems. NASA/Boeing DATA system adopted as industry standard.

7. Runway Friction Program [1984-85]. Conducted tests to improve and predict aircraft ground handling performance on slippery runways during bad weather. Technology used by FAA. Results adopted for use at most commercial airports worldwide.


9. Total Energy Control System (TECS) [1985-92]. Joint program with Boeing that validated, through flight tests, new computations to improve fuel efficiency during climb and descent maneuvers. Technology applied on "Condor," a remotely piloted vehicle built by Boeing for the Department of Defense.


12. Airborne Information Transfer System [1989-90]. Conducted flight tests to evaluate benefits of using electronic data link—vs. voice—as primary communications system between aircraft and air traffic control. Results used in developing government-industry design and operational standards. Technology adopted for use in newer B-747 and all B-777 cockpits.


15. Airborne Windshear Sensors [1990-93]. With industry participation, joint program with FAA to develop and flight-test airborne windshear detection sensors. B-737 flight tested five separate windshear measurement technologies. Results applied by industry to develop commercial windshear sensors. The windshear hazard index, developed as part of the flight program, is industry measurement standard and basis for FAA certification.

16. Advanced High-Lift Technologies [1991-Present]. Flight test data will support new NASA computer fluid flow and wind tunnel techniques for developing advanced wing designs. This technology will be a tool for designing more efficient high-lift wings.

17. Optical Propulsion Management Interface System [1991-Present]. Joint program with McDonnell Douglas to flight test and evaluate use of fiber optic lines as communication link between pilot and engine. McDonnell Douglas and Boeing planning to apply technology to next-generation commercial aircraft.
(Above) In addition to its unique two-cockpit arrangement, the NASA Langley B-737 includes rows of computer consoles and data collection stations where researchers monitor real-time flight results. (Below) With a length only one foot greater than its wingspan, the stubby aircraft earned the nickname, “Fat Albert.”

B-737-100 GENERAL ARRANGEMENT
**NASA B-737 FACTS & FIGURES**

- **THE PROTOTYPE BOEING 737**
- **DATE OF MANUFACTURE:** 1967
- **FIRST FLIGHT:** April 6, 1967
- **ARRIVED AT LANGLEY:** May 17, 1974
- **COST TO NASA:** $2.2 million
- **DESCRIPTION:** Twin-engine, short-range transport
- **TOTAL FLIGHT HOURS:**
  - Upon arrival at Langley: 978
  - As of May 1994: 2,968
- **GROSS TAKEOFF WEIGHT:** 97,800 lbs.
- **CRUISING SPEED:** 575 mph
- **RANGE:** 2,140 statute miles
- **CEILING:** 35,000 ft.

**TECHNOLOGY TRANSFER LESSONS:**

‘Getting personal’ and ‘seeing is believing’

Although the engineers who created the B-737 research program in the early 1970s did not set out to explore creative methods of technology transfer, their experience with the airplane and its numerous research projects contains some important lessons about how technology transfer can be accomplished and the difference a facility like the 737 research airplane can make.

In the 1994 book, *Airborne Trailblazer: Two Decades with NASA Langley’s 737 Flying Laboratory*, author Lane E. Wallace recounts some “technology transfer myths,” which include the idea that industry automatically “gobbles up” new technology as soon as it is received; that a “better mousetrap” is self-evident and doesn’t need setting, and that “exciting and valid” technology will “automatically” be transferred.

The reality, she explains, is that there are many factors that complicate and influence the transfer of technology from government research institutions like NASA to industry.

Forces that had little to do with the intrinsic worth of the concepts researched through the Langley B-737 flight research program had a tremendous impact on the eventual application of those technologies in commercial products. New ideas face a human and organizational tendency to resist change, and as companies grow in size, effectively communicating information about new innovations to all the necessary players becomes more difficult.

As new technology becomes more expensive to produce and incorporate into aircraft designs, it has to “earn its way” onto airplanes more than it has in the past. In other words, technological innovations have to offer significant economic or other tangible benefits to be incorporated into new airliners.

Gone are the days when successful technology transfer is as simple as writing a report on research results after the work is completed. There is a growing consensus, according to Wallace, that technology transfer efforts stand a much better chance of success if they occur as a part of the technology development process, through personal contact between NASA and industry engineers.

By involving industry earlier in the process, NASA Langley B-737 program managers have helped insure that their efforts are relevant to industry’s needs. Also, flight testing new concepts on the airplane has provided unassailable proof that the technology will work.

For instance, what made the 1989 B-737’s GPS-guided autoland flights so significant was not the technical performance of the system, but the fact that the airplane had actually completed automatic landings using satellite-based global positioning system (GPS) technology. The fact that the system used onboard radar to meet low-visibility landing criteria was secondary. The NASA-industry flight tests abruptly ended the debate about whether a GPS autoland was possible, and refocused the discussion and further research on what level of accuracy the technology could attain.


May 1994