NASA Facts

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MD-11 PCA Landing: First jet transport propulsion controlled aircraft landing at Edwards, CA. *EC95 43247-3*

PCA Emergency Landing System May Make Air Travel Safer

You're flying a large transport plane carrying hundreds of passengers and instantly you are unable to control the airplane. The controls system has failed. As a pilot or a passenger, you hope that this scenario never presents itself, but if it did, what if there was a way to safely land the airplane by using only the thrust of its engines? With a Dryden-developed system known a Propulsion Controlled Aircraft (PCA) this concept has become a reality.

Propulsion Controlled Aircraft is a computer-assisted engine control system that enables a pilot to land a plane safely when its normal control surfaces such as elevators, rudders, and ailerons are disabled. If used on commercial aircraft, PCA and follow on projects could help reduce the number of aircraft accidents.

NASA's Dryden Flight Research Center, Edwards, Calif., initiated research into this Propulsion Controlled Aircraft technology in 1989 following a series of about ten military and civilian incidents over a 20-year period in which there were some 1,200 fatalities caused by the loss of the primary flight-control system in the aircraft. NASA sought to develop a backup system for landing a jet using only the throttles for control.

The PCA system uses standard autopilot controls already present in the cockpit, together with the new programming in the aircraft's flight control and engine-control computers. The PCA concept is simple — for pitch control, the program increases thrust to climb and reduces thrust to descend. To turn right, the autopilot increases the left engine thrust while decreasing the right engine thrust. Since thrust response is slow, and the control forces are relatively small, a pilot would require extensive practice and intense concentration to do this task manually. Using computer-controlled thrust greatly improves flight precision and reduces pilot workload.

From Idea to Flight-Proven Innovation

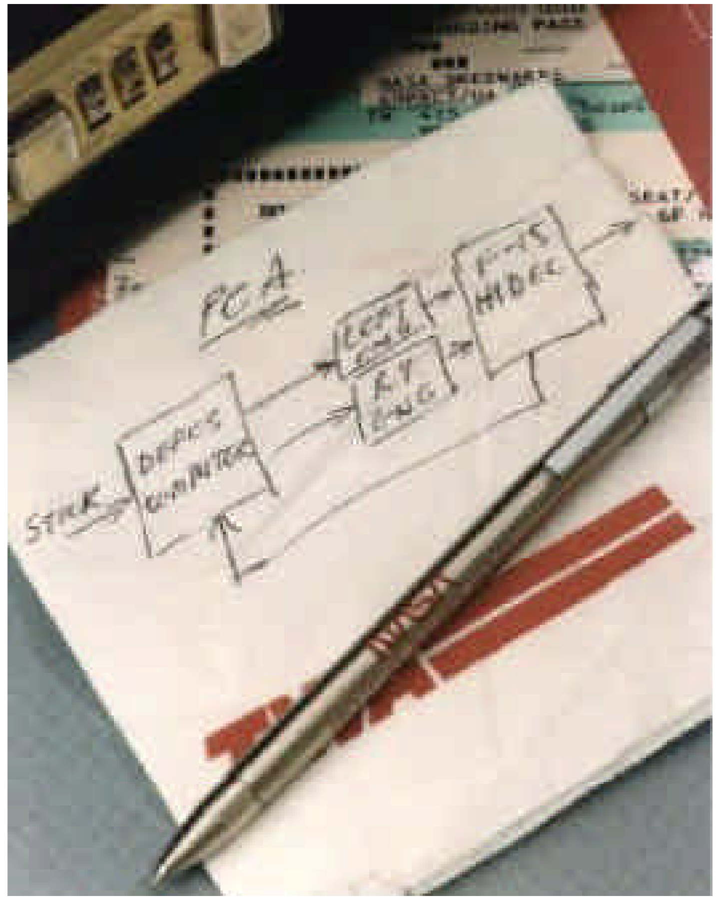
In August 1995, NASA pilot Gordon Fullerton performed the first-ever engine-only landing in an actual airliner — the widebody MD-11 that replaced the earlier DC-10. An earlier version of the PCA system had already been validated using both flight simulation and a NASA F-15 research aircraft, which twice landed successfully.

For the MD-11, the PCA system used standard autopilot controls already present in the cockpit, together with programming in the aircraft's flight control computers. The aircraft demonstrated software used in the flight control computer that essentially landed the MD-11 without a need for the pilot to manipulate the flight controls after activating auto-land control.

The success of the program was the result of a partnership between NASA and McDonnell-Douglas Aerospace, St. Louis, Mo. (now Boeing), Pratt & Whitney and Honeywell. Honeywell designed the software used in the aircraft's flight-control computer, while Pratt & Whitney modified the engine-control software. NASA Ames Research Center, Mountain View, Calif., assisted in the program by performing simulations.

The PCA technology is capable of being used on current, production and future aircraft with digital flight systems but not on older aircraft with analog or mechanical flight

Gordon Fullerton



systems. Aircraft manufacturers have decided that a PCA system will be valuable for use in the design of future airplanes. When they incorporate this for future design, it will eliminate the need for a less capable hydraulics-dependent backup flight control system.

Safety for the Future

Development on the Propulsion Controlled Aircraft system continues at NASA. One of the Agency's main goals is to reduce the aircraft accident rate by a factor five within 10 years, and by a factor of 10 within 20 years.

Two new versions of the system, dubbed "PCA-Lite" and "PCA-Ultralite" have been tested using a NASA Ames/ Federal Aviation Administration motion-based Boeing 747 simulator. The newer concepts are cheaper and can be used on more aircraft, as they do not require changes to the airplane's engine-control computer.

PCA-Lite allows the pilot to use an aircraft's existing autothrottle and engine trim commands to perform engines-only landings. Pilots have made about 50 landings using PCA-Lite on the 747 simulator. Early results show that PCA-Lite is almost as effective as the full system, although it does require that the airplane have digital engine controls. This system could possibly be used on Boeing 757s, 767s and 777s, as well as 747-400s.

PCA-Ultralite again uses an airplane's existing autothrottles to control pitch (climb and descent). Unlike PCA and PCA-Lite, however, PCA-Ultralite does not require digital engine controllers. Thus, the pilot must manually control the throttles (thrust) of the left and right engines for turning right and left. This is a more difficult piloting task, and it is probably too difficult for a pilot who has not been trained to use the system. However, results showed that if the pilot's flight director display was reprogrammed to provide cues for moving the throttles, that PCA Ultralite worked very well.

Simulation research has tested PCA Ultralite on B-747, B-757, MD-11, and C-17 airplanes. NASA Dryden pilots participated in tests of the system in August 1998, using the NASA Ames Advanced Concepts Simulator. The tests, which involved 10 pilots total, resulted in 20 out of 20 successful landings using the PCA Ultralite system.

Further testing is needed to see how many airplanes can successfully use PCA Ultralite.