HD **Pilot React to The Automated Cockpit Glass Cockpit Study Reveals Human Factors Problems --- DAVID HUGHES**

WC 1,753 words
PD 7 August 1989
SN Aviation Week & Space Technology
SC AW
PG Pg. 32
VOL Vol. 131, No. 6
LA English

LP BOSTON -- The results of a three-year NASA study of 200 Boeing 757 pilots indicate disagreement over whether **automated cockpits** actually reduce workload and whether they might cause some safety problems.

NASA's Ames Research Center recently published the findings of its study, directed by Earl L. Wiener, professor of management science and industrial engineering at the University of Miami. Wiener, who has conducted similar studies, surveyed 200 line pilots from two airlines. The pilots, who had varying levels of Boeing 757 experience, answered questionnaires on two occasions. Wiener, a former military pilot, also rode the jump seat on the Boeing 757 to make personal observations.

TD While the majority of pilots expressed pride in flying the most advanced aircraft in their company's fleet, many had reservations about safety issues related to so-called glass cockpits, which rely on cathode ray tubes driven by computers. At least half said they felt automation actually increases workload and, one year later, these pilots showed no shift in their opinion, despite having gained more experience in the cockpit. (The study defined automation as primarily flight path guidance including power plant control and warning and alerting systems.)

Nearly half of the pilots were concerned about the possible loss of aviation skills with too much automation. About 90% of the pilots said they hand-fly part of every trip to keep up their skill level.

One key safety concern was that there is too much programming going on below 10,000 ft. and in the terminal area. Slightly more than half of the pilots surveyed agreed this was a problem while only about 30% disagreed.

The Boeing 757 and other automated airline aircraft are equipped with flight management computers that can program a flight almost from takeoff to touchdown. The Honeywell computer in the 757 provides both lateral and vertical navigation capability. In addition, Collins electronic flight instrument systems (EFIS) displays can be used by the pilot and copilot to display a wide variety of navigation information generated by the computer. The 757 pilots enter data into the flight management computer using an alphanumeric keyboard on the control display unit.

The computerized cockpit is designed to reduce workload, and it does in ideal conditions. As one pilot said, the system works well flying into a North Dakota airport at 3 a. m. However, in the current air traffic control environment, it is common for an assigned route to be changed frequently, particularly in a busy terminal area. The assigned runway is often changed after an aircraft descends below 10,000 ft., which calls for a pilot to either reprogram the flight management computer or turn off the automatic flight guidance. The aviator can then fly the aircraft on autopilot heading and altitude hold or by hand.

Many pilots voiced concern about the tendency of some crews to go to a "head-down" operation to reprogram the computer. "During departures and arrivals, the workload became excessive with the slightest change to our flight plan," one pilot said. "It was difficult to make the copilot leave the flight management computer alone below 10,000 ft. Both problems have been cured by experience."

Others in the study contend heads-down operation is still a problem, depending on how the crew handles a particular situation. Older captains tend to rely more on their basic flying skills in such situations while younger first officers tend to use the computer. "Thus far, my mind/hand/feet combination is faster than my monitoring-programming capabilities," an older pilot said.

One particularly difficult aspect of programming a computer while in flight is that it takes the undivided attention of one pilot, Delta pilot Richard Stone said. Stone, a member of the Air Line Pilots Assn. human performance committee, has flown more than 23,000 hr. in his 32 years with Delta, including 3,000 in the Boeing 757 and 767 in the past six years.

Stone said the "intellectual attention required by programming makes it hard to do anything else." Researchers have also noted that in automated aircraft, the division of roles between the cockpit crew members tends to break down. Crews must guard against the tendency of one pilot to look over the shoulder of the other who is entering data into the computer.

Jack Gray, a striking Eastern Airlines pilot who has about 2,000 hr. in the 757/767 and nearly 10,000 hr. total time, disagrees with those who believe the flight management computer is difficult to use below 10,000 ft. Gray points out that rerouting below 10,000 ft. requires a pilot in a nonautomated aircraft to dig out the charts and start over, which is also a head-down sort of operation. Reprogramming the flight management computer does not take much time and it can be done by one pilot and checked by the other one before it is activated, he said.

Gray also said that whenever he is the pilot doing the programming, he doesn't try to do it all at once. He enters some of the information on the keyboard, then looks outside for traffic before finishing the programming task. In many cases, the rerouting can be handled initially by entering the waypoint identification, calling it up from the computer data base and typing in a direct-to command. Gray, who also flies transport aircraft in the Air Force Reserves, said that not all flight management systems are as easy to use as the system in the 757.

One interesting point the study made was that pilots who left nonautomated aircraft to fly the Boeing 757 often expect to return to nonautomated aircraft. Thus, a pilot faces the transition from the nonautomated cockpit to an automated one and then back again where manual flying skills are of paramount importance. "I was somewhat concerned with the 'I-can't-fly-anymore-but-I-can-type-80-words-a-minute syndrome,' " one pilot said.

Pilots were also concerned that the first few days of transition training focus on operation of the computer equipment rather than basic operation of the aircraft.

Stone recalls one incident in a busy terminal area where the first pilot, flying the aircraft, was flying a base leg to intercept an ILS approach. The pilot asked Stone to activate a computer feature that extends the runway centerline on the electronic map display. Even though it requires only a few keystrokes to activate, Stone declined because he did not feel there was enough time. He told the first pilot to fly the approach using raw data. Stone later explained to the first officer that the procedure did not relate to the ILS and was not needed. But the first pilot had been instructed in training to use it.

"Pilots trust automation too much and don't depend on their own airmanship," Stone said.

Pilots even work around aspects of the computer program that do not provide the desired performance. For example, crews who want to start vertical navigation descents earlier than the computed top-of-descent point simply tell the computer they plan to use anti-ice when, in fact, they do not, or they program in a fictitious tail wind. The computer then refigures a new top-of-descent point to the pilot's liking. This procedure is often needed because the Boeing 757, considered an aerodynamically clean aircraft, does not descend as readily as earlier models. Pilots like to avoid using speed brakes to conserve fuel and avoid disturbing passengers.

Renwick Curry, a human factors consultant from Palo Alto, Calif., who has worked on previous NASA studies with Wiener, said another area of major concern in automation is complexity. In previous studies when pilots were asked if they have ever been surprised by the automatic features in an advanced aircraft, they responded with what Curry described as "a floodgate of answers." Nearly 70% of the pilots in Wiener's study responded that they have been surprised. The number dropped to about 60% by the time the second questionnaire was answered. OVERALL IMPRESSIONS It is important to note that the overall impressions pilots have of the glass cockpit environment are still positive. About 90% of the pilots surveyed said the glass cockpit instruments and displays are a big step forward. Many pilots said if they leave the Boeing 757 they will miss the electronic HSI map mode (on the Collins EHSI) and many said they would miss the Honeywell flight management computer.

Most pilots praised the warning and alerting systems on the Boeing 757, particularly the engine indication crew alerting system (EICAS) from Collins. Wiener said the number of warnings a pilot has to cope with on transport aircraft has been spiraling up to 400-500, and that EICAS simplifies things by reducing the number on the Boeing 757 to below 200.

Wiener concluded that additional automation can solve many of the problems uncovered in his study. He said computers can be designed to anticipate future problems rather than just issue a warning when they occur. Wiener proposed a concept of an "electronic cocoon" or "shell" around the aircraft. As long as the aircraft stays within the cocoon, the crew can operate as it sees fit. If the aircraft penetrates the cocoon, the crew would be alerted by the computer. It should also be possible to trap human errors as they are automatically entered into the system.

The next step in NASA's research will be an attempt to measure pilot performance in simulator missions. The same Line Oriented Flight Training (LOFT) mission profile will be used in a DC-9-30 and an MD-88 simulator to measure how crews perform the same tasks in automated

and nonautomated aircraft. LOFT training attempts to realistically portray a line mission. The study, which begins next month, will last for several years. Wiener and Curry will collaborate under contract to NASA-Ames.

ART Graph: Pilot Reactions to Glass Cockpit Source: NASA Ames Research Center Photograph: Boeing engineers are working on a software change to allow for automatic computer entry of any altitude selected on the Boeing 757 mode control panel. Photograph: Pilots on the Boeing 757 enter data into the flight management computer using this pedestal-mounted control display unit with an alpha numeric keyboard. Photograph: Automatic lateral and vertical navigation is provided on the Boeing 757 by the Honeywell flight management computer processor. The company has an enhanced version of this processor.

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