ASOS Research Brief

Research Request:

Recommended Use of the Aircraft Autopilot

Research Response:

Autopilot systems differ between each aircraft; however, the basic principle of reducing workload is the same. By relieving workload, errors may be reduced during the approach-to-landing phase, IMC, or other high workload situations. By not using an autopilot system, the margin for error is typically increased due to amplified workload. Autopilot systems are also especially vital during in-flight emergencies, as they allow the crew to concentrate on troubleshooting. Use of autopilot in any flight condition, especially cruise, may reduce pilot fatigue as well.

There are also varying levels of automation use. Depending upon the situation, a lower or higher level of automation may be required. For example, for take-off and initial departures the aircraft is typically hand-flown with only flight director guidance. In the case of cruise, STAR, or a departure procedure, automation may be used to the fullest extent to prevent errors. This is assuming the automation was programmed correctly, and aircraft performance and path are properly monitored. The level of use is also dependant upon the flight crew's familiarity with the type of automation being used. This places special emphasis on training. In many cases, for example, flight crews will use new equipment such as Electronic Flight Bag's, without being fully familiar with their operation. Too much automation use during high-workload situations may actually be counter-productive and distract the pilot from the task at hand– flying the aircraft. The following are suggested times when autopilot/automation would not likely be used:

- **During a breakout**– The Aviation Information Manual states a breakout must be hand flown. (Per the AIM, a breakout is a technique to direct aircraft out of the approach stream. In the context of close parallel operations, a breakout is used to direct threatened aircraft away from a deviating aircraft.)
- **While in icing conditions**– According to Advisory Circular 91-51A the FAA recommends the autopilot be disengaged during icing conditions. The autopilot may mask important cues or disconnect and present unusual attitudes/control conditions.
- **GPWS Warning**– a timely recovery may be required that exceeds the response capability of an autopilot.
- **Aircraft Upset**– autopilot systems do not have the capability to recognize unusual

attitudes, requiring immediate recognition and manual input.

- **TCAS Warning**– an immediate reaction is required, exceeding the capability of most autopilot systems.
- **Wind Shear Recovery**– again, this is a situation requiring immediate recovering exceeding the capability of the autopilot.
- **Automation not functioning properly**– monitoring should be constant, instruments cross checked, and position verified in order to maintain situational awareness. If one indication does not agree with another, the autopilot may be malfunctioning.
- **Taxiing**– only one crewmember should be "head-down" performing functions such as programming the FMS.

A study completed by the Langley Research Center found the heading select mode was foremost in decreasing workload and simplifying approach tasks. The largest amount of mistakes were made with the highly automated, Heading Select with Lateral NAV Coupling and Altitude Hold with Vertical NAV Coupling (HAC) Mode. The mistakes on the HAC mode may be due to autopilot training deficiencies (training was concluded when test subjects stated they felt comfortable) or the pilots may have become complacent and had a false sense of security.

The only way to stay ahead of the autopilot is to consistently scan and monitor the system, train for the specific autopilot system, and stay current with hand flying the aircraft; you never know when autopilot might fail.

Publication Excerpts

Aeronautical Information Manual

5-4-13. ILS/MLS Approaches to Parallel Runways

c. The close proximity of adjacent aircraft conducting simultaneous parallel ILS/MLS and simultaneous close parallel ILS PRM approaches mandates strict pilot compliance with all ATC clearances. ATC assigned airspeeds, altitudes, and headings must be complied with in a timely manner. Autopilot coupled ILS/MLS approaches require pilot knowledge of procedures necessary to comply with ATC instructions. Simultaneous parallel ILS/MLS and simultaneous close parallel ILS PRM approaches necessitate precise localizer tracking to minimize final monitor controller intervention, and unwanted No

Transgression Zone (NTZ) penetration. In the unlikely event of a breakout, ATC will not assign altitudes lower than the minimum vectoring altitude. Pilots should notify ATC immediately if there is a degradation of aircraft or navigation systems.

5-4-16. Simultaneous Close Parallel ILS PRM Approaches (Independent) and Simultaneous Offset Instrument Approaches

f. Differences between ILS and ILS/PRM approaches of importance to the pilot.

3. Hand-flown Breakouts. The use of the autopilot is encouraged while flying an ILS/PRM or LDA/PRM approach, but the autopilot must be disengaged in the rare event that a breakout is issued. Simulation studies of breakouts have shown that a hand-flown breakout can be initiated consistently faster than a breakout performed using the autopilot.

5-5-16. RNAV and RNP Operations

6. For RNAV_1 DPs and STARs, pilots must use a CDI, flight director and/or autopilot, in lateral navigation mode. Other methods providing an equivalent level of performance may also be acceptable.

Federal Aviation Regulations

Sec. 135.93

Autopilot: Minimum altitudes for use.

(a) Except as provided in paragraphs (b), (c), (d), and (e) of this section, no person may use an autopilot at an altitude above the terrain which is less than 500 feet or less than twice the maximum altitude loss specified in the approved Aircraft Flight Manual or equivalent for a malfunction of the autopilot, whichever is higher.
(b) When using an instrument approach facility other than ILS, no person may use an autopilot at an altitude above the terrain that is less than 50 feet below the approved minimum descent altitude for that procedure, or less than twice the maximum loss specified in the approved Airplane Flight Manual or equivalent for a malfunction of the autopilot under approach conditions, whichever is higher.
(c) For ILS approaches, when reported weather conditions are less than the basic weather conditions in Sec. 91.155 of this chapter, no person may use an autopilot with an approach coupler at an altitude above the terrain that is less than 50 feet above the terrain, or the maximum altitude loss specified in the approved Airplane Flight Manual or equivalent for the malfunction of the autopilot with approach coupler, whichever is higher.
(d) Without regard to paragraph (a), (b), or (c) of this section, the Administrator may issue operations specifications to allow the use, to touchdown, of an approved flight control guidance system with automatic capability, if--

(1) The system does not contain any altitude loss (above zero) specified in the approved Aircraft Flight Manual or equivalent for malfunction of the autopilot with approach coupler; and

(2) The Administrator finds that the use of the system to touchdown will not otherwise adversely affect the safety standards of this section.

(e) Notwithstanding paragraph (a) of this section, the Administrator issues operations specifications to allow the use of an approved autopilot system with automatic capability during the takeoff and initial climb phase of flight provided:

(1) The Airplane Flight Manual specifies a minimum altitude engagement certification restriction;

(2) The system is not engaged prior to the minimum engagement certification restriction specified in the Airplane Flight Manual, or an altitude specified by the Administrator, whichever is higher; and

(3) The Administrator finds that the use of the system will not otherwise affect the safety standards required by this section.

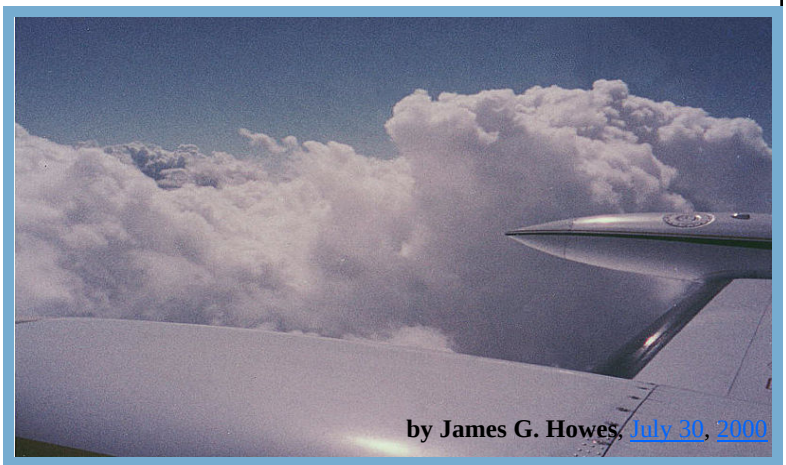
(f) This section does not apply to operations conducted in rotorcraft.

Sample Events

ASRS reports

Narrative

This flight was day #4 for me and day #2 for the Capt. The day before we had an 18-hr duty day. I went to the hotel and I had a very good rest. Up to this flight, I was very fatigued. We were cleared for the BARRIN 1 Arrival and told to descend per the MARIN 1 Arrival. We were in moderate weather and icing conditions. I had ATIS and approach was set up for runway 19L both green source and in the FMS's. Next they told me to expect Runway 19R for landing. All VNAV info was in the FMS, He said 'Ok I understand.' Normally at this point I would arm the VNAV button so the jet will fly the arrival on its own, but this the Capt. doesn't believe in using this function of the jet, also you do have to monitor the system because it doesn't always capture the descents but it does tell you how many feet per minute you need to use to get down. So I proceeded to set up the other runway in the FMS's and green source for the ILS system. The next thing I heard was ATC asking if we were going to get down by BARIN and I said yes. The Capt. was for sure late, and I told him to start down. We needed around 4500 FPM to make the crossing restore, which is no problem in the Lear 60. I was still not totally focused on what was going on until ATC started yelling and TCAS was going off. For some reason the flight was off course and I told the ATC it was the computer, but come to find out the Capt. Was trying to hand fly a jet that is really an autopilot aircraft. We were headed about 60 degrees off course and we were pointed toward DC and oncoming traffic and the jet was saying bank angle with a steep descent angle. I dropped the approach plates and this is the point that I had to take over the airplane and started making yelling commands to the Capt., plus taking an immediate turn from ATC to turn to heading of 270 degrees to rejoin the


by James G. Howes, July 30, 2000

arrival and avoid the traffic, There is only a 4 degree turn after BARIN, I still don't know where he was trying to go. I never heard the autopilot tone when he turned it off due to the noise and everything that was going on. Also at this point due to the fatigue and me stopping the approach setup review, we missed an altitude before the initial approach and started to descend a too early. So the mistake was not the computer, but probably pilot error due to spatial disorientation leading from fatigue. I should have had ATC put us into a hold somewhere until we were ready to do the approach. There was just too much going on at once.

Narrative

We were cleared to an intercept heading for the LOC 23 and to descend and maintain 3000' until established on the approach. I descended through 3000' about 15 seconds prior to LOC alive on the approach. I stopped descent at 2650' and recovered to 2850' prior to becoming established on the approach. We are well trained and always fly with two pilots. All our pilots are very experienced. The other pilot (the Capt..) should have stopped me sooner (although I take responsibility) but he wasn't even sure what the clearance was. I was confused about what heading we were cleared to and while I was preoccupied with that I went through the altitude. I was probably close enough to the final approach course that was ok, but it was very sloppy flying on my part. Also, this particular day, the other pilot was preoccupied all day, forgetting checklists, and missing clearances. We were dealing with IFR and severe weather in the area all day and a typical multi-leg schedule, the completion of which was in doubt. I should have adjusted more quickly and completely to the lack of presence by the other pilot. Also, I should have relied more on the autopilot rather than hand flying.

Narrative

After takeoff from runway 24, TEB, started climb via the TEB 5 Departure to initial altitude of 1500 ft encountering turbulence in the climb, overshot level off altitude by 300 to 400 ft. Returned to assigned altitude. Altitude bust facilitated by lack of real currency in the aircraft with over 1,000 hours of G-4 experience, this was only the third flight for me in the G-450 after a 7-year gap in which I operated other types of aircraft. Could possibly have prevented this incident by engaging the autopilot after takeoff in the flight mode rather than hand flying.

NTSB Incident Synopsis:

During climb out at night over water, the airplane was straight and level and heading towards an intersection. The first officer was hand flying the airplane and the autopilot was not engaged. While climbing through 6,500 feet, the airplane rolled to the right and reached a maximum of 65.5 degrees. The first officer used left aileron, followed by left rudder input and returned to level flight. The crew declared an emergency, dumped 20,000 pounds of fuel and landed uneventfully at the departure airport. The captain reported there were no traffic collision avoidance system alerts or engine indication and crew alerting system warnings. The captain reported there was a thin deck of clouds at 6,500 feet, and it was a dark night with no moon. The international relief pilot stated there was no discernable horizon, and the first officer stated there was no horizon, stars, or moon, and all he saw was darkness. An examination of the airplane's systems revealed there were no mechanical or computer related discrepancies. The digital flight data recorder data revealed the rolls to the right were initiated by control wheel input.

The National Transportation Safety Board determines the probable cause(s) of this incident as follows:

The first officer's failure to maintain control of the airplane during climb out over water at night, which was a result of spatial disorientation. Factors in the incident were the cloud layer and dark night.