Flight Simulators: Lessons Learned from NTSB Accident Investigations

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Outline

- NTSB Basics

- Simulator Improvements
  • Takeoff in strong gusty crosswinds
  • Stall recognition and recovery, including in icing conditions and at high altitudes

- Proposed Additional Improvement
  • Events involving increasing automation
NTSB 101

– Independent federal agency, investigate transportation mishaps, all modes
– Determine probable cause(s) and make recommendations to prevent recurrences
– Primary product: Safety recommendations
  • Favorable response > 80%
– SINGLE FOCUS IS SAFETY
– Independence
  • Political: Findings and recommendations based upon evidence rather than politics
  • Functional: No “dog in the fight”
Simulators – Major Training Enhancement

- Flight simulators enable exposure to and practice of activities that may be dangerous in an airplane
  - Example: Late 1960s, several Part 121 training crashes during engine-out training
  - NTSB recommended using simulators for that training

- Increasing use of simulators for other training
  - Air traffic control
  - Maintenance
  - Cabin operations
Takeoff in Strong Gusty Crosswinds

- Continental 1404 on takeoff roll, Denver, CO (2008)

- Sudden very large (> 40kt) crosswind gust from left, airplane departed left side of runway

- Pilots had limited experience with gusty crosswinds on takeoff because simulators did not generate gusts below 50’ AGL

- NTSB recommendations (A-10-110, 111) re developing realistic gusty crosswind profiles for simulators, requiring gusty wind takeoff training for Part 121, 135, 91K pilots
Response From Congress, FAA

  - Congress mandated FAA to require improved training re “microburst and windshear weather events”

- FAA revised Part 60 to require, for Part 121, simulators to be able to include gusty crosswind takeoffs

- Per P.L. 111-216, FAA requiring gusty wind takeoff training for Part 121, effective 2019
Stall Recognition and Recovery

- Experience has shown that crews often respond to stalling by pulling back on stick, especially when the aircraft is descending in nose-low attitude

- Prompt stall recovery is especially important when aircraft is rolled or nose is below horizon

- Proper simulator training may be an excellent tool to teach pilots:
  - That the aircraft can be stalled with the nose below the horizon
  - To overcome the natural tendency to pull up when the nose is low
Need to Change Stall Recovery Training

- Stop emphasizing no loss of altitude
- Emphasize pitching down to lower AOA
- Stick pusher familiarization
  • NTSB Recommendation A-10-23, superseding Recommendation A-07-4
- Ability to identify natural stall cues, not just shaker and pusher
- Simulators to include fully developed stall
  • NTSB Recommendation A-10-22
- Nose low stalls
Elements of Stall Upset Recovery

- Pitch as needed for adequate reduction of AOA
- Level wings
- Then arrest descent
- Avoid re-stalling
- Avoid over-speed
- Avoid excessive load factor
Training Issue

- Stall training in airplanes not feasible

- Simulators could approach stall, e.g., buffet, but most could not simulate fully developed stall

- Hence, stall recognition training possible, but not stall recovery training
NTSB Recommendations

- A-97-47: Improve the fidelity of simulators re stalls, add training in recovery from stalls with pitch attitudes at or below the horizon

- A-10-22: Require training re fully developed stalls that are unexpected and involve autopilot disengagement

- A-10-23: Require stick pusher familiarization and simulator training (superseding A-07-4)

- A-10-24: Improve simulator fidelity requirements to enable training to recover from fully developed stalls
Response From Congress, FAA

  - Congress mandated FAA to require, for Part 121, improved stall recognition and recovery training, and to determine how to improve pilot response to stick pusher

- FAA revised Part 60 to require simulators to be able to simulate fully developed stall

- Per P.L. 111-216, FAA requiring improved stall recognition and recovery and stick pusher training for Part 121, effective 2019
Stalls in Icing Conditions

- AOA may be below shaker & pusher triggers
  - Hence, possibly no shaker/pusher warning before buffet (if any), stall and break

- Upset/roll damping & control effectiveness
  - Like non-iced stall, but at lower AOA
NTSB Recommendations

– A-11-46: Enhance simulator fidelity to include degradations from icing

– A-11-47: Require training re icing conditions, including recognition of flight characteristic changes; procedures for maintaining appropriate airspeeds, including the use of icing airspeed reference indices; and procedures for responding to decaying airspeed, stall protection system activation, and stalls that can occur without stall protection system activation
Response From Congress, FAA

  • Congress mandated FAA to determine, for Part 121, improved training regarding response to icing, among other weather conditions

– Per P.L. 111-216, FAA requiring improved training re the effects of icing for Part 121, effective 2019
High-Altitude Stalls

– Stall recognition and recovery are very different at cruise altitude than at low altitudes
  • Example: Rio to Paris (2009)

– Simulator stall training is usually done at lower altitudes, not often at cruise altitude

– NTSB Recommendation A-07-3 – Require training re recognition of and recovery from high-altitude stalls

– FAA Response: Simulators will simulate fully developed stalls, as noted above; still considering extent of training requirement
Future Challenge: Increasing Automation

- Automation can eliminate human error by eliminating the human from the loop – while increasing productivity, efficiency, reliability, throughput, and safety

**BUT**

- “In their efforts to compensate for the unreliability of human performance, the designers of automated control systems have unwittingly created opportunities for new error types that can be even more serious than those they were seeking to avoid.” Prof. James Reason
The Human Operator

- Human pilot is at both ends of the spectrum
  - Most vulnerable and unreliable part of the system
  - Most flexible and adaptable part of the system

- Training challenge
  - How to maximize the flexibility and adaptability while minimizing the vulnerability and unreliability
Training for Automation

- Automation may not work as intended because
  - Human factors were not adequately considered in designing automation
    - Example: Cali, Colombia (1995)
  - Automation encountered unanticipated circumstances
    - Example: Rio to Paris (2009)
  - Automation failed
    - Example: Washington Metro Fort Totten crash (2009)

- Need to enhance training for those scenarios
Proposal

- Mine ASIAS data for reports of automation issues
  - Those issues would probably not otherwise be generally known in the absence of a mishap or reportable event
- Incorporate those scenarios into simulator training
Conclusion

• Flight simulator training has significantly improved safety

• Simulator capability and fidelity are improving significantly

• There is room for more improvement
Thank You!

Questions?
Last slide with NTSB 50th Anniversary Commemorative Emblem - Making Transportation Safer Yesterday, Today, Tomorrow.