Operational Use of Flight Path Management Systems

Overview of the final report of the Performance-Based Operations Aviation Rulemaking Committee (PARC)/ Commercial Aviation Safety Team (CAST) Flight Deck Automation Working Group

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Report on:

The Interfaces Between Flightcrews
and
Modern Flight Deck Systems

June 18, 1996
Recommendations from 1996 Report

• Many implemented in Aircraft Certification
  – Regulatory material for design of autopilots, autothrust, alerting systems, electronic displays
  – New regulation on design-related pilot error

• Some implemented in Flight Standards
  – Automation policies
  – Approaches with 3D paths
  – Terrain awareness
  – Some training topics (e.g., mode awareness, upset recovery)
PARC/CAST Working Group Tasking

• Update the 1996 Human Factors Team Report
• Review operational use of, and training for, onboard systems for flight path management in “air carrier-like” operators
• Analyze operational experience since 1996 (where are we and what has changed?)
• Current and future operations
• Develop recommendations to address issues identified
Operational Use of Flight Path Management Systems


September 5, 2013
Automated Systems for Flight Path Management

Includes:
- Autopilot
- Autothrottle/autothrust
- Flight Management System
- Flight directors
- Associated pilot interfaces

Excludes:
- Autobrakes
- Autopressurization
- Etc.

“Automated Systems” will be used in the rest of this briefing
Membership

• Co-chaired by A4A, Air Line Pilots Association, FAA
• Manufacturers (Airbus, Boeing, Bombardier, Embraer, Honeywell)
• Operators (A4A, Regional Airline Association, Virgin, Korean, United)
• FAA Aircraft Certification, Flight Standards, and Air Traffic
• Researchers (Research Integrations)
• MITRE
Data Sources

• Structured interviews with operators, airframe manufacturers, avionics suppliers, training organizations
• Incidents: 734 Aviation Safety Reporting System (ASRS) reports
• Accidents and major incidents: 46 (26 accidents, 20 major incidents)
• Normal Operations (LOSA) aggregated data from 9155 flights 2001-2009
Findings

Findings are conclusions based on analysis of one or more data sources

NOTE: Findings are not specific to a particular manufacturer, operator, or other organization
Finding 1: Pilot Mitigation of Safety and Operational Risk

Pilots frequently mitigate safety and operational risks — and the aviation system is designed to rely on that mitigation:

• Adapting to changes in operational circumstances
• Managing operational threats
• Mitigating or managing errors
• Mitigating equipment limitations
• Managing equipment malfunctions
• Managing unexpected operational risk

*Note: Not comprehensive*
Finding 2: Manual Flight Operations

Significant instances of vulnerabilities were found in pilot knowledge and skills for manual flight operations. Areas of concern included:

- Prevention, detection and recovery from upset conditions, stalls or unusual attitudes;
- Appropriate manual handling after transition from automated control;
- Inadequate energy management;
- Inappropriate control inputs for the situation;
- Crew coordination;
- Definition, development, and retention of such skills.
Handling/Input Errors

- Manual Handling/Flight Controls
  - ASRS Incidents
  - Major Incidents
  - Accidents
  - LOSA

- Mode Selection
  - ASRS Incidents
  - Major Incidents
  - Accidents
  - LOSA

- Programming
  - ASRS Incidents
  - Major Incidents
  - Accidents
  - LOSA

- Systems/Radio/Instruments
  - ASRS Incidents
  - Major Incidents
  - Accidents
  - LOSA

- Ground Navigation
  - ASRS Incidents
  - Major Incidents
  - Accidents
  - LOSA
Manual handling/flight control errors

Hand flying vertical, lateral, or speed deviations; approach deviations by choice (e.g., flying below the GS); Missed runway/taxiway, failure to hold short, taxi above speed limit; incorrect flaps, speed brake, autobrake, thrust
Types of handling errors (accidents/major incidents)

• Incorrect manual handling after lack of recognition of autopilot or autothrottle disconnect
• Lack of monitoring/maintaining energy/speed
• Incorrect upset recovery
• Inappropriate control inputs
Finding 3: Managing Malfunctions

Pilots manage equipment malfunctions as a threat that occurs in normal operations. They successfully address many such situations, including malfunctions (or combinations of malfunctions) that have no associated procedures.

Insufficient depth of system knowledge or understanding of aircraft state, or over-reliance on procedures or checklists may decrease pilots’ ability to respond to failure situations for which they do not have procedures, or situations for which the procedures do not completely apply.
Malfunctions
(summary from accidents/major incidents)

- Air data computer failures
- Air Data Inertial Reference Unit/Inertial Reference Unit/Secondary Standby Air Data Attitude Reference Unit failures
- Computer/software failures
- Electrical failures
- Uncommanded autopilot disconnects or pitchup (reason not known)
Failure-Related Issues

- Failure assessment is difficult
- Failure recovery is difficult
- Failure modes are unanticipated by designers

Graph showing the distribution of failure-related issues across ASRS Incidents, Major Incidents, and Accidents.
Finding 4: Automated Systems

Automated systems have been successfully used for many years, and have contributed significantly to improvements in safety, operational efficiency, and precise flight path management. However, the following aspects of pilot use of, and interaction with, automated systems were found to have some vulnerability areas:

- Pilots sometimes rely too much on automated systems and may be reluctant to intervene;
- Autoflight mode confusion errors continue to occur;
- The use of information automation is increasing, including implementations that may result in errors and confusion; and
- FMS programming and usage errors continue to occur.
Pilots are overconfident in automation
Different Types of Automation

• Control automation – control-related tasks
  E.g., Autopilot, flight director guidance, autothrust

• Information automation – calculation, integration, presentation of information
  E.g., moving map display, Heads-up display, alerting systems

• Management automation – management tasks
  E.g., certain flight management systems functions
Southwest accident at Chicago Midway
Onboard Performance Computer

- OPC assumptions:
  - Reverse thrust use assumed
  - Tailwind component limit (5 kt)

- Had the actual 8 kt tailwind component been used, the stopping value would have been
  - 260 feet
Finding 5: Pilot-to-Pilot Communication

Pilot-to-pilot communication and coordination have improved and been more formalized; however, communication and coordination vulnerabilities still contribute to accidents and incidents.
Pilot-to-Pilot Communication Errors

Bar chart showing the distribution of Pilot-to-Pilot Communication Errors categorized by ASRS Incidents, Major Incidents, Accidents, and LOSA.
Finding 6: Coordination Between Pilots and Air Traffic Services

Communication and coordination between pilots and air traffic services has vulnerabilities that can affect flight path management. Amended clearances from air traffic generally are issued with good intentions but can lead to misunderstandings, increased flightcrew workload, and potential pilot errors when using flight path management systems.
Flightcrew-to-ATS Communication Errors

- **ASRS Incidents**
  - LOSA
  - Major incidents
  - Accidents

Bar chart showing the distribution of different types of incidents in communication errors.
Finding 7: Standard Operating Procedures

Compliance with published procedures has been increasingly emphasized, with safety and operational benefits. However, pilots do not always follow standard operating procedures, for a variety of reasons, including:

• Procedures do not match operational situations well,
• Workload may not permit completion of the procedures,
• Procedures may be too prescriptive or detailed,
• No adverse consequences occur by not following the SOP.
Operator-Related Threats

- Policy/Procedures
- Operator Operational Pressure
- Manuals/Charts
- Aircraft Malfunctions/MEL items
- Other Operator threat
- Dispatch/Paperwork
- Ground Maintenance
- Ground/Ramp
- Cabin Events

Legend:
- ASRS Incidents
- Major Incidents
- Accidents
- LOSA
Tradeoff in Proceduralization

High Experience

Low Experience

“Recipe” focus

Problem solving/decision making focus

Recipe focus
Finding 8: Data entry and cross verification errors

Data entry errors, together with cross check errors, may introduce significant safety risk
Cross-Verification Errors

0% 10% 20% 30% 40% 50% 60%

ASRS Incidents
Major Incidents
Accidents
LOSA

Cross-verification Errors:

- **ASRS Incidents**
- **Major Incidents**
- **Accidents**
- **LOSA**
Finding 9: Operator policies for flight path management

Increasingly, operators use a documented automation policy. Lessons learned in the application of these policies reveal that improvements could be made to better focus attention on the flight path management related tasks and more effectively use automated systems.
Finding 10: Task/workload management

Flight deck task/workload management continues to be an important concern that affects flight path management

• Distraction often goes hand-in-hand with workload
• High workload and time pressure continue to be common vulnerabilities
• Technology such as, TAWS, altitude alerting, stall warnings, etc, are effective as a backup “safety net”
• These “safety nets” are being used as the primary means to address the risks, rather than a backup
New Tasks and Errors

New tasks and errors exist

ASRS Incidents
Major Incidents
Accidents

0% 10% 20% 30% 40% 50%
Finding 11: Pilot knowledge and skills for flight path management

Flightcrew members sometimes lack sufficient or in-depth skills and knowledge to most efficiently and effectively accomplish the desired flight path management related tasks

- Emphasis on pilot training for managing autoflight modes has improved
- Knowledge and skills needed by pilots is growing but minimum regulatory training has not expanded accordingly
Threats Related to Insufficient Pilot Knowledge

- Accidents
- Major Incidents
- ASRS Incidents
Areas of Insufficient Pilot Knowledge (from accident/major incident data)

• Understanding of flight director, autopilot, autothrottle/autothrust, and flight management system/computer:
  – Knowledge of systems and limitations
  – Operating procedures
  – Need for confirmation and crosscheck
  – Mode transitions and behavior

• Unusual attitude recognition and recovery, including high altitude

• Speed and energy management
Finding 12: Current Training Time, Methods, and Content

Current training methods, training devices, the time allotted for training, and content may not provide the flight crews with the knowledge, skills and judgment to successfully manage flight path management systems.
Finding 13: Instructor Training and Line Experience

Current instructor knowledge, training and line experience may not provide the required instructor experience and skills to effectively provide flight crews training to successfully manage flight path management systems for future operations.
Finding 18: Complex and Unfamiliar Instrument Flight Procedures

Complex or unfamiliar airspace flight procedures can be confusing to flightcrews and lead to errors involving flight path management systems. In addition, airspace design and associated airspace procedures are not always compatible with aircraft capabilities.
PROOF COPY. NOT FOR NAVIGATION.

This SID requires take-off minimums. (For standard minimums, refer to airport chart): 
Rwy 14, 32, 34/L/R, 55: Not authorized - ATC. 
Rwy 16L: Standard (or lower than standard, if authorized) with minimum climb of 381' per NM to 8000'. ATC climb of 410' per NM to 13000'. 
Rwy 16R: Standard (or lower than standard, if authorized) with minimum climb of 413' per NM to 8000'. ATC climb of 410' per NM to 13000'. 
Rwy 17: Standard (or lower than standard, if authorized) with minimum climb of 367' per NM to 8000'. ATC climb of 410' per NM to 13000'. 

Grid speed-KT: 70 100 160 200 250 300 
367' per NM: 459 619 718 1229 1629 1936 
381' per NM: 476 635 553 1270 1588 1906 
410' per NM: 513 683 1025 1387 1708 2050 
413' per NM: 516 688 1033 1377 1723 2065 

OBSTACLES 
Rwy 16: Multiple light poles beginning 988' from DSR, 890' RIGHT of centerline, up to 34' AGL/4254' MSL. 
Rwy 17: Vehicle on road 434' from DSR, 516' RIGHT of centerline, 17' AGL/4537' MSL. 

Initial Climb: 
Rwy 16: Climb heading 161° to 4727', then RIGHT turn direct PPIG, then via depicted route to LEETZ. 
MAINTAIN FL230 or lower filed altitude. 

Routing: 
Via transition, EXPECT filed altitude 10 minutes after departure.
Finding 19: Knowledge and Skills of Air Traffic Personnel

Air traffic service personnel often do not have sufficient knowledge of how clearances affect flight deck operations and lack knowledge of aircraft capabilities.

As a result, the airspace and air traffic procedures are sometimes not compatible with the aircraft operating in the systems.
Other Findings

• Equipment design
• Lessons learned from data and event analysis and investigation
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