Human Factors in Glass Cockpit Aircraft
New Registrations of Study Aircraft per Year by Cockpit Configuration, 2002-2006

(FAA Civil Aircraft Registry Data)

Source: NTSB
Transition from B737-200 to A320

- Side stick instead of yoke
- No feedback on the side stick
- Dual side stick inputs – no visual
- FBW concept – Control laws
- Non-moving thrust levers
- FMS
- Autopilot interface
‘PHYSICAL’ AIRCRAFT

- ‘Good old fashioned’ traditional aircraft, that depends more on stick and rudder skills

- basic autopilot
- emphasis on handling
- ‘do-it-yourself’ pilots

Source: AOPA Air Safety Foundation
‘MENTAL’ AIRCRAFT

- Advanced automation systems
and CRT displays that offer a
range of information

- advanced autopilot
- emphasis on flight
  management
- ‘systems manager’ pilots

Source: AOPA Air Safety Foundation
Round dials

- Use information to create SA
- Decipher ground and flight information.
- Use of cognitive mental processes - space, time and altitude to determine aircraft position

Glass - TAA

- Single screen
- Cognitive process decreased
- Extract and use relevant information
Garmin 1000 PFD
NTSB Safety Study

Introduction of Glass Cockpit Avionics into Light Aircraft
Study Accident Severity by Aircraft Configuration, 2002-2008
(NTSB Aviation Accident Data, N=266)

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Glass cockpit</th>
</tr>
</thead>
<tbody>
<tr>
<td>NonFatal</td>
<td>84%</td>
<td>69%</td>
</tr>
<tr>
<td>Fatal</td>
<td>16%</td>
<td>31%</td>
</tr>
</tbody>
</table>

Purpose of Study Accident Flights by Aircraft Configuration, 2002-2008
(NTSB Aviation Accident Data, N=258)

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Glass cockpit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal/Business</td>
<td>52%</td>
<td>84%</td>
</tr>
<tr>
<td>Instructional</td>
<td>49%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Study Accident Phase of Flight by Aircraft Configuration, 2002-2008
(NTSB Aviation Accident Data, N=255)

<table>
<thead>
<tr>
<th>Accident Phase of Flight</th>
<th>Conventional</th>
<th>Glass cockpit</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTHER/UNKNOWN</td>
<td>12%</td>
<td>3%</td>
</tr>
<tr>
<td>TAKEOFF</td>
<td>12%</td>
<td>8%</td>
</tr>
<tr>
<td>CLIMB</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>CRUISE</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>DESCENT</td>
<td>15%</td>
<td>1%</td>
</tr>
<tr>
<td>MANEUVERING</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>APPROACH</td>
<td>5%</td>
<td>7%</td>
</tr>
<tr>
<td>GO-AROUND</td>
<td>1%</td>
<td>6%</td>
</tr>
<tr>
<td>LANDING</td>
<td>51%</td>
<td>44%</td>
</tr>
</tbody>
</table>
Experience of pilot
Knowledge of glass systems, function levels, and mode awareness
Human factors – systems manager + stick & rudder
Type of training - SBT
Automation

Current Technology Through CWS

Automation in glass cockpits

- Design philosophy
- Operating philosophy
- Golden rules for automation
- Standard Operating Procedures (SOP’s)

Source: Airbus
Automation in glass cockpits

*Design philosophy*

- How is the system designed?
- Why is the system designed this way?
- How does the pilot interface and communicate with the system?

Source: Airbus
Map Pages (MAP)
- Navigation Map
- Traffic Map
- Stormscope®
- Weather Data Link (service optional)
  - XM WX Satellite Weather
  - FIS-B Weather
  - GFDS Worldwide Weather
- Terrain Proximity/Terrain-SVS/TAWS-B

Figure 1-23 Map Pages

Waypoint Pages (WPT)
- Airport Information pages
  - Airport Information (INFO-1 Softkey)
  - Airport Directory (INFO-2 Softkey)
  - Departure Information (DP Softkey)
  - Arrival Information (STAR Softkey)
  - Approach Information (APR Softkey)
  - Weather Information (WX Softkey)
- Intersection Information
- NDB Information
- VOR Information
- User Waypoint Information

Figure 1-24 Waypoint Pages

Auxiliary Pages (AUX)
- Trip Planning
- Utility
- GPS Status
- System Setup
- SiriusXM Satellite pages
  - XM Information (INFO Softkey)
  - XM Radio (RADIO Softkey)
- System Status
- Video (Optional)

Figure 1-25 Auxiliary Pages

Flight Plan Pages (FPL)
- Active Flight Plan
  - Wide View, Narrow View (VIEW Softkey)
- Flight Plan Catalog
- Saved Flight Plan (NEW Softkey)

Figure 1-26 Flight Plan Pages
Automation in glass cockpits

Design philosophy

- How is the system designed?
- Why is the system designed this way?
- How does the pilot interface and communicate with the system?
- How does the system interface and communicate with the pilot?

Source: Airbus
Figure 5-12 Navigation Map - Information Window - Airspace
Automation in glass cockpits

Design philosophy

- How is the system designed?
- Why is the system designed this way?
- How does the pilot interface and communicate with the system?
- How does the system interface and communicate with the pilot?
- How does the pilot operate the system in normal and abnormal situations?

Source: Airbus
Figure 1-13  G1000 System Failure Annunciations
Automation in glass cockpits

Design philosophy

- How is the system designed?
- Why is the system designed this way?
- How does the pilot interface and communicate with the system?
- How does the system interface and communicate with the pilot?
- How does the pilot operate the system in normal and abnormal situations?
- What are the mode transition and reversion sequences?

Source: Airbus
Figure 7-12 Vertical Path Tracking Mode

GPS is Selected Navigation Source
Terminal Phase of Flight
Command Bars Indicate Descent to Maintain Required Vertical Speed
Vertical Deviation Indicator
VNV Target Altitude
Required Vertical Speed Indication

Figure 7-11 Vertical Path Capture

Altitude Hold Mode Active
Vertical Path Tracking Armed, (Flashing Indicates Acknowledgment Required)

GPS | AP | ALT
--------
2990 ft

Selected Altitude Below VNV Target
Vertical Deviation Indicator
Required Vertical Speed Bug

GPS is Selected Navigation Source
Terminal Phase of Flight

HUMID iof
DIS 5.0NM
BRG 290°
ALTV
Automation in glass cockpits

Operating philosophy - Pilot System Interface

- What do I want the aircraft to fly now?
- What do I want the aircraft to fly next?
- Which mode did I engage and which target did I set for the aircraft to fly now?
- Is the aircraft following the intended vertical and lateral flight path and targets?
- Which mode did I arm and which target did I preset for the aircraft to fly next?

Source: Airbus
Automation in glass cockpits

Operating philosophy - Pilot System Interface

- Mode selection-keys, target-setting knobs and display windows?
- Auto pilot mode engagement status on PFD or auto-pilot panel
- PFD and MFD displays and scales (i.e., for cross-checking guidance targets)

Source: Airbus
AFCS CONTROLS

AFCS STATUS BOX

GARMIN
Honeywell
Bendix King
KAP 140
Automation in glass cockpits

Operating philosophy – mode confusion

Causes

- complexity of the mode of operation
- paths to achieve mode of operation
- disuse of the mode

Resolution – Mode awareness

- How to use – knowledge and skill
- When to use – most appropriate mode
- Why to use – understanding of goals of each mode

Source: Airbus
Golden rule 1

Use appropriate level of automation at all times

- Task to be performed – short term or long term
- Flight phase
- Time available

Source: Airbus
Workload vs flight phase
Golden rule 2

Understand available guidance at all times

- Autopilot selection knobs/buttons – set targets, arm, engage modes
- PFD / MFD – confirm correct acceptance of selections
- Check & announce mode – autopilot status bar
- Observe & announce result – PFD / MFD
- Supervise – “Flying with your eyes”
Automation in glass cockpits

Golden rule 3

*Take actions if things do not go as expected*

- Check autopilot engagement status – hand fly

Source: Airbus
AUTOMATION PHILOSOPHY

Use of Automation

The following guidelines will assist flight crew in determining and using the appropriate level of automation:

- Programming actions and changes to automation status should be verbal and acknowledged.
- Flight crew should consider that all automated systems are dumb, dutiful and inflexible. Pilots must continually evaluate the automation and what it is doing. Be prepared to make changes.
Automation in glass cockpits

Standard Operating Procedures - Massey

AUTOMATION PHILOSOPHY

Use of Automation

Pilots should ensure that all crew members are aware of the current status as well as any changes made in the use of automated systems.

Flight crew should plan ahead, using the low-workload periods of flight effectively and avoid programming during departures and arrivals.

Flight crew should disengage the automatics or change the level of automation in use when programming demands create work overload.
When programming the FMS extreme care shall be taken to ensure the correct information is entered into the system. The following process shall be used at all times:

- Load
- Verify
- Execute
- Monitor (change if necessary)
Use of the Autopilot

Use of the Autopilot shall be as follows:

Up to First Solo - Not used in this phase.

Instrument Flying Basic / VFR Navigation Basic - HDG and ALT modes only

VFR Navigation Advanced / Instrument Rating Basic – HDG, ALT, VS, FLC, NAV modes

Instrument Rating Advanced - APR VNV

Multi Engine Instrument Rating - All modes as appropriate
Two Fallacies About Human Error

MYTH: Experts who make errors performing a familiar task reveal lack of skill, vigilance, or conscientiousness.

FACT: Skill, vigilance, and conscientiousness are necessary but not sufficient to prevent error.

MYTH: If experts can normally perform a task without difficulty, they should always be able to perform that task correctly.

FACT: Experts periodically make errors as consequence of subtle variations in task demands, information available, and cognitive processing.

Source: NASA Human Integration Systems division
Questions?

Comments?