HOW ARE HOF INTEGRATED IN AUTOMATION IN AVIATION?

Jean Pariès  Scientific Director
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1914: first autopilot

1937: Carl Joseph Crane, first automated landing

18/12/2019: Airbus, first autonomous take-off & taxi

9 janvier 1969 : first low visibility landing (Caravelle III Air Inter)
The extension of the automated domain

- Flight control: attitude (pitch, roll, yaw) then flight path (heading, speed, vertical speed, FP angle)
- Navigation: track, position, altitude,
- Flight plan: way points, 3D trajectory, 4D trajectory
- Flight management: flight plan, fuel management, ATM communication, pressurization & A/C,
- A/C monitoring: systems
Positive Features of Automation

• Enhanced performance:
  • Two-member flight-crews.
  • Navigation & guidance accuracy, flight time, fuel efficiency, overall flight operation and maintenance performance and cost/benefit ratio.
  • Fly-by-wire increases flight efficiency and makes manual flying easier.

• Increased reliability:
  • Technical reliability, redundancy of the processing chains
  • Computing power, lots of sensors and parameters, flexibility of reconfigurations

• Dramatic evolution of instrument panels:
  • Giant advances in flight, navigation, and systems displays
  • Accurate and reliable representation of the outside and inside world
## Expected benefits vs. Real effects

<table>
<thead>
<tr>
<th>Expected benefits</th>
<th>Real effects</th>
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<tr>
<td>Components roles substitutions within the same system</td>
<td>The system is changed, roles of people change. Activities are transformed. Monitoring rather than acting</td>
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<td>Decreased workload</td>
<td>Low workload decreased (routine situations) and high workload increased (abnormal situations)</td>
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<td>Simplified cognitive tasks</td>
<td>Creates new kinds of cognitive tasks, often at the wrong time. With programming, consequences of errors shift into the future.</td>
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<td>Focuses user’s attention on the right issues</td>
<td>Makes it harder for users to remain “in the loop” and aware of the situation. Reliability induces complacency. Decrease in non-verbal communication Increase in standardized verbal communication</td>
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<td>Less knowledge and skills required</td>
<td>New knowledge and skills demands.</td>
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<td>Same kind of skills acquisition and maintenance trough experience</td>
<td>Ironies of automation: basic skills are lost, but even more needed when things get really wrong</td>
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<tr>
<td>Better accuracy, reliability, efficiency, safety</td>
<td>… but “automation surprises”</td>
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</tbody>
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Adapted from Dekker & Woods, 1999
The history of aviation accidents related to automation clearly shows that automation rises serious HOF safety issues, including:

- Management of automation failures
- Loss of situation awareness
- Automation surprises
- Ironies of automation
China Airlines Flight from Taipei to LA on 19 February 1985, (Boeing 747SP)

- Turbulences occurred while the AP was engaged in a « speed » mode. #4 engine failed
- The plane lost speed. The captain disengaged the speed mode, this switched the AP to pitch mode. He then rotated the pitch control wheel to begin a descent as he intended to restart the engine
- AP still engaged in a lateral mode tried to compensate for the asymmetrical thrust
- When the captain finally disengaged the AP, the plane was out of trim and he lost control at once

Pitch max: -68°
G max: +5.1
IAS min: 54 kt
1/6/2009 AF 447 Rio de Janeiro-Paris

- AP+ATHR disengaged
- Loss of airspeed info
- Alternate 2 flight control law
- +20"
- 36’000ft
- +1’:30’’
- 35000 ft
- -10’000 ft/mn
- Stall warning
- Stall
- Pitch down (and up) inputs
- Pitch up (and down) inputs
- +4’:24’’
- crash
- 35’000ft
- 02:10:04
- 38’000ft
- 02:10:04
- 35’000ft
- 36’000ft
- 38’000ft
- 35’000ft
- 02:10:04
Accident rates and aircraft generations

10 year moving average fatal accident rate (per million flights) per aircraft generation

Source Airbus
Addressing HF

• Design:
  • Automation philosophy
  • User centered design
  • Airworthiness specifications
  • Complexity assessment

• Procedures
  • Automation usage policy
  • Automation levels
  • Automation modes
  • Crew coordination, tasks and roles definition
  • Terminology and language
Addressing HF

- Training
  - High fidelity simulation
  - Unexpected situations
  - Career management, aircraft family
  - CRM, Team work
  - Crew pairing

- Monitoring
  - Feed-back from operational experience
    - QARs
  - Feed-back from training
  - Real life observation (LOSA)
More than 400 large U.S. military drones have crashed in major accidents around the world since 2001, (Washington Post investigation).

- A limited ability to detect and avoid trouble.
- Pilot error
- Persistent mechanical defects
- Unreliable communications links.
In the next 20 minutes Mr. Jean Pariès will reply live to your questions.

- You may wish to write your question in the Teams Live chat, or
- Receive a detailed reply after this conference: use the link provided on the event webpage.
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