Aircraft Automation – Friend or Foe?
Safety Accidents – Causal Factors

Rick Howell
General Manager, Group Safety and Operational Risk, Cathay Pacific Airways

Rudy Quevedo
Director Safety, IATA
Overall Accident Update and automation as contributing factor

Rudy Quevedo
Director, Safety
Accident Category: Fatality Risk vs Frequency

Evolution in time

Number of Accidents vs Fatality Risk for 2005.
Since 2008, better automation management could have prevented **39** accidents from happening

**Accident with Automation management as countermeasure**

<table>
<thead>
<tr>
<th>Year</th>
<th>Selected Accidents</th>
<th>Fatal Accidents</th>
<th>IATA Accident Rate per 1 Million Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>4</td>
<td>3</td>
<td>0.16</td>
</tr>
<tr>
<td>2009</td>
<td>6</td>
<td>2</td>
<td>0.28</td>
</tr>
<tr>
<td>2010</td>
<td>3</td>
<td>1</td>
<td>0.18</td>
</tr>
<tr>
<td>2011</td>
<td>2</td>
<td>1</td>
<td>0.12</td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td>1</td>
<td>0.14</td>
</tr>
<tr>
<td>2013</td>
<td>3</td>
<td>1</td>
<td>0.03</td>
</tr>
<tr>
<td>2014</td>
<td>2</td>
<td>1</td>
<td>0.06</td>
</tr>
<tr>
<td>2015</td>
<td>1</td>
<td>0</td>
<td>0.08</td>
</tr>
<tr>
<td>2016</td>
<td>2</td>
<td>2</td>
<td>0.08</td>
</tr>
<tr>
<td>2017</td>
<td>2</td>
<td>2</td>
<td>0.07</td>
</tr>
<tr>
<td>2018</td>
<td>1</td>
<td>2</td>
<td>0.04</td>
</tr>
</tbody>
</table>

**Top contributing factors in these 39 accidents**

- **Undesired aircraft states**
  - 67% Vertical/lateral/speed deviation
  - 36% Flight control/Automation
  - 33% Long/floated/bounced/firm landing

- **Errors**
  - 85% SOP Adherence/ Cross-verification – Intentional
  - 77% Manual Handling/ Flight Controls
  - 54% Automation (settings/selections)

- **Threats**
  - 59% Meteorology
  - 38% Poor visibility/IMC
  - 26% Wind/Windshear/Gusty wind
  - 28% Nav aids
  - 21% Lack of visual reference

- **Latent conditions**
  - 67% Flight Operations
  - 59% Flight Ops: training systems
  - 46% Regulatory oversight
  - 31% Safety management

**End state distribution**

- Tailstrike
- Loss of Control In-flight
- Hard Landing
- Controlled Flight Into Terrain (CFIT)
- Runway / Taxiway Excursion
- In-flight Damage
- Undershoot

87% of these accidents involved jet aircraft
54% of these accidents happened during landing

39 accidents, 694 fatalities

54% of these accidents happened during landing
Since 2008, 25 accidents involved an Automation Setting error. Accident with Automation settings as error

End state distribution

25 accidents, 550 fatalities

Top contributing factors in these 25 accidents

Undesired aircraft states

- 60% Flight control/Automation
- 56% Vertical/lateral/speed deviation
- 40% Long/floated/bounced/firm landing

Countermeasures

- 84% Automation Management
- 84% Monitor/Cross-check
- 52% Overall crew performance

Threats

- 52% Meteorology
- 28% Wind/Wind shear/Gusty wind
- 28% Poor visibility/IMC
- 20% Nav aids

Latent conditions

- 64% Flight Operations
- 56% Flight Ops: training systems
- 44% Flight OPS: SOPs & Checking
- 36% Regulatory oversight
- 28% Safety management

92% of these accidents involved jet aircraft

56% of these accidents happened during landing
Since 2008, 22 accidents had *Flight control/automation* as undesired aircraft state

**Accident with Flight control/automation as undesired aircraft state**

- 22 accidents, 365 fatalities

**End state distribution**

- 91% of these accidents involved jet aircraft
- 64% of these accidents happened during landing

**Top contributing factors in these 22 accidents**

**Errors**
- 91% SOP Adherence/ SOP cross-verification
- 77% Manual handling/ flight control
- 68% Automation

**Countermeasures**
- 82% Monitor/Cross-check
- 64% Automation Management
- 41% Overall crew performance

**Threats**
- 41% Meteorology
- 23% Wind/Wind shear/Gusty wind
- 14% Poor visibility/IMC
- 18% Airport facilities

**Latent conditions**
- 86% Flight Operations
- 68% Flight Ops: training systems
- 68% Flight OPS: SOPs & Checking
- 36% Regulatory oversight
- 36% Safety management
Thank you

Rudy Quevedo
quevedor@iata.org

For information on this or any other GADM analysis products, please e-mail us at:
gadm@iata.org
Flight operational envelope ‘v’ capability areas

Normal Operational Envelope

Margin

Aircraft Limit of Operations

Information Processing

Technical Knowledge

Normal Operational Envelope

Raw flying ability

Contextual Experience

Procedural Knowledge

capability in practice

Normal Operational Envelope
Laparoscopic ‘v’ Conventional Surgery & Use of Automation ‘v’ Manual Flying
Automation ‘v’ Manual…….

- Used 98% of the time (HKG-JFK ± 16hrs) manual flying approx. 4 mins – better job than human
- Automation is becoming more and more complex
- Requires different skill set
- Trying to balance limited trg budget (both time & money) with likely use of that trg - always a trade-off
- Reduced training footprints
- Manual handling skills diminishing, therefore reversion can be difficult
- EBT = good, but still a dilemma. How to use available training time effectively

Laparoscopic ‘v’ Conventional…. 

- Used more and more frequently where possible (90% of scenarios) – better for many reasons
- Laparoscopic is becoming more and more complex
- Requires different skill set
- Trying to balance limited trg budget (both time & money) with likely use of that trg - always a trade-off
- Reduced training footprints
- Conventional surgical skills diminishing, therefore reversion to conventional is difficult
- What to train for? Separate team?
Aircraft Automation – Friend or Foe?
Today’s Automated Flight Deck
Captain Malcolm Ridley
Lead Safety Test Pilot,
Airbus
Aircraft Automation – Friend or Foe?

Today’s Automated Flight Deck

Malcolm Ridley
2 April 2019
Fatal accident rate evolution 1958-2018
Fatal accidents per million flight cycles, 10 year moving average

The safety win

- First generation
- Second generation
- Third generation
- Fourth generation

Moving average in 2018

3rd Gen 0.17
4th Gen 0.05
The Golden Rules...

1. Fly, navigate and communicate:
   In this order and with appropriate tasksharing

2. Use the appropriate level of automation at all times

3. Understand the FMA at all times

4. Take action if things do not go as expected
Aircraft Automation – Friend or Foe?
The Pilots Voice
Captain Patrick Magissson,
Executive Vice President
Technical and Safety Standards,
IFALPA
AUTOMATION
FRIEND OR FOE ?

Or is it the other way around ?
“40 years ago, we made the mistake to believe that automation and procedures would solve all the problems...”
Jean Pinet
Where is the Life we have lost in Living?

Where is the Wisdom we have lost in Knowledge?

Where is the Knowledge we have lost in Information?

TS Eliot
FROM LIFE TO INFORMATION

What’s left of some ideas?

- Scientific Management principles vs 10-6 safety target?
- Top-down vs Bottom-up balance?
LIVING IN A WORLD OF TOOLS

- How many tools do you have at home?
- How many of them did you craft yourself?
- How many of them did you harm yourself with?
- How many of them are you able to repair yourself?
- How many of them do you know how they were crafted?
CRAFTSMANSHIP IN THE MODERN WORLD

It’s a matter of what you expect to achieve...
“Sometimes when the mind and the hands are not there together, I don’t even try to craft. All I would achieve is something only worth opening cans, not knives!”
藤井敬一
CRAFTSMANSHIP IN THE MODERN WORLD

It’s a matter of what you expect to achieve...
Don’t mix up the quality of the process, with the quality of the product!
Another automation accident...

- 4 years of discussions,
- 3 months approval process,
- 2 days publication delay,
- 1 media accident!

www.ifalpa.org
AUTOMATION FOR LIFE

And not the other way around...

- Information
- Knowledge
- Wisdom
- Life
- Meaningful
- In the Loop
- Under Control
- Safe
THANK YOU

Questions for HAL 9000?

- Safe
- Under Control
- In the Loop
- Meaningful
Aircraft Automation – Friend or Foe?
Human Factors at Play

Dr. Kathy Abbott
Chief Scientific and Technical Advisor for Flight Deck Human Factors, FAA
Artificial Intelligence, Automation, and Autonomy in Aviation

Kathy H. Abbott, PhD, FRAeS
Chief Scientific and Technical Advisor
Flight Deck Human Factors
Federal Aviation Administration
2 April 2018
Resurgence in Artificial Intelligence (AI): Enablers

• Increased computing capability
• Big data
• Reduced cost of storing data
• Improvements in sensors
What is AI? There is no single accepted definition. Examples:

- Machine Learning
- Deep Learning
- Artificial Neural Networks
- Machines that reason/behave like humans
- Computational techniques for solving certain kinds of problems
- Magic ??
What can and can’t AI do?

• Weak versus strong AI

• Weak AI has limitations...

**Why Watson and Siri Are Not Real AI**

Douglas Hofstadter is a cognitive scientist at Indiana University and the Pulitzer Prize-winning author of *Gödel, Escher, Bach: An Eternal Golden Braid*. While the face of the artificial intelligence field today is IBM's Watson or Apple's Siri, Hofstadter says these have nothing to do with thinking machines.

Also see:
Statistics

• Self-driving cars: 1 critical disengage per 40,000 miles (2017)

• Human Drivers: 1 injury accident per 1,000,000 miles

• Time from software hand-back to human control ~ 1min

Courtesy Alonso Vera, NASA Ames
Forward collision warning systems for automobiles fail dramatically to detect motorcycles,

Providing inadequate results in 41 percent of tested cases, against only 3.6 percent for passenger cars.

Car as Guardian: Assisted Driving

• Lane keeping (Tight or loose?)
• Blind-spot monitoring
• Adaptive cruise control (speed & spacing)
• Automated Emergency Braking
• Forward Collision Warning

Car as Chauffeur: Self-Driving

• Autosteering (Tesla); DrivePilot (MB)

Courtesy Alonso Vera, NASA Ames
Autonomy Issues

• Trust issues (none or too much)
• Understandability Issues
• Training issues

The Autonomy Paradox

(Blackhurst, Gresham & Stone, 2011)

• Why ‘unmanned systems’ don’t shrink manpower needs
• Autonomy doesn’t get rid of humans, it changes their roles

As machine intelligence advances, the need for better human interfaces increases
Automated Systems Technology

Requires testing of complex software

- Current modern large transports can have
  - Highly complex and integrated systems
  - 10’s of millions of lines of code

“It’s relatively easy to stage a demonstration that looks impressive but to get to the point where a system is ready for public use is vastly more complicated and challenging”

Steve Shladover, UC Berkeley.
Challenges

• Variable expectations of safety
• Cybersecurity
• Infrastructure
• Over-expectation
• Need to learn lessons from past experience
• Liability/responsibility/authority – who?
Who is Responsible? Who is Liable?

Shift of responsibility/liability??

Pilot responsibility/liability

Product liability
Lessons – Automated Systems

- Automated systems have contributed significantly to safety, effectiveness and efficiency
- Appropriate integration of humans and automated systems is necessary for success
- Our view of automated systems has matured
Automated Systems

<table>
<thead>
<tr>
<th>Old View</th>
<th>New View</th>
</tr>
</thead>
</table>

130
## Automated Systems

<table>
<thead>
<tr>
<th>Old View</th>
<th>New View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Automated systems</td>
</tr>
</tbody>
</table>
## Automated Systems

<table>
<thead>
<tr>
<th>Old View</th>
<th>New View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Automated systems</td>
</tr>
<tr>
<td>Give the human operator what s/he does best, give the automation what it does best</td>
<td>Human-system integration to enable the human operator</td>
</tr>
</tbody>
</table>
# Automated Systems

<table>
<thead>
<tr>
<th>Old View</th>
<th>New View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Automated systems</td>
</tr>
<tr>
<td>Give the human operator what s/he does best, give the automation what it does best</td>
<td>Human-system integration to enable the human operator</td>
</tr>
<tr>
<td>Automation causes degradation of basic skills</td>
<td>Lack of practice causes degradation of basic skills</td>
</tr>
</tbody>
</table>
# Automated Systems

<table>
<thead>
<tr>
<th>Old View</th>
<th>New View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Automated systems</td>
</tr>
<tr>
<td>Give the human operator what s/he does best, give the automation what it does best</td>
<td>Human-system integration to enable the human operator</td>
</tr>
<tr>
<td>Automation causes degradation of basic skills</td>
<td>Lack of practice causes degradation of basic skills</td>
</tr>
<tr>
<td>Automation should be another “crewmember”</td>
<td>Automated systems are tools to help the responsible human</td>
</tr>
</tbody>
</table>
## Automated Systems

<table>
<thead>
<tr>
<th>Old View</th>
<th>New View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Automated systems</td>
</tr>
<tr>
<td>Give the human operator what s/he does best, give the automation what it does best</td>
<td>Human-system integration to enable the human operator</td>
</tr>
<tr>
<td>Automation causes degradation of basic skills</td>
<td>Lack of practice causes degradation of basic skills</td>
</tr>
<tr>
<td>Automation should be another “crewmember”</td>
<td>Automated systems are tools to help the responsible human</td>
</tr>
<tr>
<td>More automation reduces training</td>
<td>More automation can increase training</td>
</tr>
</tbody>
</table>
## Automated Systems

<table>
<thead>
<tr>
<th>Old View</th>
<th>New View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>Automated systems</td>
</tr>
<tr>
<td>Give the human operator what s/he does best, give the automation what it does best</td>
<td>Human-system integration to enable the human operator</td>
</tr>
<tr>
<td>Automation causes degradation of basic skills</td>
<td>Lack of practice causes degradation of basic skills</td>
</tr>
<tr>
<td>Automation should be another “crewmember”</td>
<td>Automated systems are tools to help the responsible human</td>
</tr>
<tr>
<td>More automation reduces training</td>
<td>More automation can increase training</td>
</tr>
<tr>
<td>More automation reduces risk</td>
<td>More automation introduces different risks</td>
</tr>
</tbody>
</table>
Lesson: Pilots and controllers mitigate risk on a regular and ongoing basis.
Some current related activities

• **Air Carrier Training Aviation Rulemaking Committee – Flight Path Management Working Group**
  
  [https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs200/afs280/act_arc/](https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs200/afs280/act_arc/)

• **Extended Envelope Training**
  

• **Research activities (examples):**
  
  – Emerging pilot workforce
  – Training effectiveness
  – Pilot contributions to safety
  – Airspace and systems complexity
Concluding Thoughts

• We can expect amazing improvements
• Use of automated systems/autonomy is intended to reduce cost and staffing and improve safety – but when does it?
• Moving from demonstration to real world is challenging
• One size does not fit all
• Human operators bring more safety than is often acknowledged
• If the pilot isn’t responsible, who is?
• Should we be rethinking our approaches to safety, operations, and training?
Thank You!
kathy.abbott@faa.gov
Aircraft Automation – Friend or Foe?
The Way Forward

Moderator:
- Captain John Monks, Director Safety and Security, British Airways

Panelists:
- Dr. Kathy Abbott, Chief Scientific and Technical Advisor for Flight Deck Human Factors, FAA
- Rick Howell, General Manager, Group Safety and Operational Risk, Cathay Pacific Airways
- Captain Patrick Magisson, Executive Vice President Technical and Safety Standards, IFALPA
- Captain Malcolm Ridley, Lead Safety Test Pilot, Airbus
- Rudy Quevedo, Director Safety, IATA