Causes for Pilot Mistakes

- Aircraft Controllability - Cockpit Design - Flight Displays - Basic Pilot Training

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Subject outline:

– Review of Aircraft Accidents
– Typical Handling Skills Accidents
– Cause Factors
– Coffin Corner
– Stall
– Deep Stall
– Spin
– Developments in Flight Displays
– Developments in Pilot Education
– Summary
Accident Statistics
Major Accidents by Decade
Worldwide Commercial Jets
1960 to 2009

<table>
<thead>
<tr>
<th>Decade</th>
<th>Major Accidents per Million Departures</th>
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</thead>
<tbody>
<tr>
<td>60's</td>
<td>6.21</td>
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<tr>
<td>70's</td>
<td>2.42</td>
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<tr>
<td>80's</td>
<td>1.59</td>
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<tr>
<td>90's</td>
<td>1.18</td>
</tr>
<tr>
<td>2000's</td>
<td>0.57</td>
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</tbody>
</table>
CFIT
All Commercial Turbojets

CFIT Accidents per Year

Year

5 Year Running Average

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Loss of Control Major Accidents
Commercial Jets
1999 through 2010

Number of Accidents

Source: Ascend, Boeing
Some typical LOC accidents and Cause Factors
Stall during high altitude cruise:

- West Caribbean MD-82. Venezuela 2005 – high altitude stall (coffin corner) – climbed rapidly from 31,000 ft to 33,000 ft to avoid TS – altitude could not be sustained – on autopilot which gradually lifted the nose to hold altitude until AP disengaged and A/C entered a stall.

- Contributing cause factors: Let A/S drop to stall speed - improper stall recovery - A/C held with aft stick in deep stall with engine climb power until crashing – limited knowledge.

- Air France A330. South Atlantic 2009 - high altitude stall after loss of IAS (coffin corner) – A/C held with aft stick in a deep stall with engine climb power until it crashed in the sea.

- Contributing cause factors: Lost A/S – not controlling attitude – allowed the A/C to stall – improper stall recovery – A/C held in deep stall and climb power – limited knowledge.
Stall during Approach:

- Colgan Air DHC-8-Q400. Buffalo USA 2009 – stall during approach – went through stick shaker and pusher. Contributing cause factors: Improper stall recovery - overrode the pusher (by pulling) and entered a fatal spin to the right – limited knowledge.

- Turkish Airlines B737-800. Amsterdam 2009 – stall during final approach on autopilot with one rad alt malfunction – stick shaker at 460 feet. Contributing cause factors: Improper stall recovery – too late recovery actions – limited knowledge.

- Contributing cause factors: Practiced approach to stall with stick pusher deactivated - lack of knowledge.


- Contributing cause factors: Unable to maintain manual control - lack of knowledge.

http://www.aibn.no/Luftfart/Rapporter/2012-01-eng
Accident Investigations:
Most LOC accidents are labeled «Pilot/Human Error»

Professor Sidney Dekker offers two views on HE, 2006:
The Old View: «Human error is a cause of trouble» (bad Apple Theory)
The New View: «Human error is a symptom of trouble deeper inside a system»

Professor James Reason, 1997:
«The Organizational model views human error more as a consequence than as a cause. Errors are the symptoms that reveal the presence of latent conditions in the system at large»

Dr. Simon Bennett, 2012:
“Malfunctions are to be expected in aircraft, by virtue of their interactive complexity, tight coupling and risk-and-error-prone operating environment. In the risk-laden world of aviation the pilot is the last line of defense”.

In modern accident investigation theory Human Error is not considered a cause of accident, but a symptom of systemic weakness.
LOC accidents have several underlying cause factors – Organizational Accidents
Coffin Corner
True Air Speed = $V_{\text{AS}}$

$$a = k \sqrt{T}$$

Mach = $V/a$

Altitude (feet)

Velocity (mph)

$V_{\text{min}}$

$V_{\text{max}}$

$V_{\text{cruise}}$

True Air Speed = $V$
Max g Turn - Graph of Load Factor

Max altitude

Stall

Top speed

Alt [kft]

Mach

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Stall
Stalls can occur when performing a variety maneuvers.

The wing does not know about airplane attitude or airspeed.

The deciding factor is the critical/stall angle of attack.

The wing stops flying when the stall angle of attack is exceeded.

Result = Stall (and possible LOC)

Required = Angle of Attack Indicator

Deep Stall
Stall recovery:

**JAR 25 CS:** «As soon as the aeroplane is stalled, recover by normal recovery technique.»

**What is normal recovery technique?**

**UK CAA:** “Simultaneous pitch down and full power”

**FAA:** “Unstall, smoothly increase power to increase airspeed and minimize loss of altitude”

**NTPS:** “Unstall, let airspeed increase to at least 1.2Vs before increasing power, recover” (or, “unstall, delay power for 2 sec and increase power in 2 sec, recover”).

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Boeing:

“Emphasis during recovery should be to immediately reduce angle of attack and return the aircraft to a safe flying condition”.

“Reducing angle of attack as the first and most important response in the recovery”.

Airbus:

“Apply nose down pitch control to reduce AOA”.

“Tests show that while applying full thrust at stall warning while maintaining altitude can contribute to reaching full stall conditions”.

“Civilian pilots and even turboprop military pilots are not familiar with high Mach buffet”.

“Stall recovery training is possible in FFS.”

BOTH EMPHEZISING REDUCING AOA – NEITHER IS INSTALLING
Detrimental development over time:

After JAR FCL introduced the concept of «Approach to stall recovery» we have seen a gradual tendency to (mal)practise stall recovery from Stall Warning by applying (climb) power and focusing on «minimum altitude loss»

This may result in increased AOA and unintentional full stall and LOC

as opposed to traditional «Stall Recovery» at the Stall/G-break/pitch down/pusher
Some aircraft are equipped with artificial stall warning (shaker) and artificial stall break/nose drop (pusher).

In US NAVY AOA has been in use since the early jet days. Ex A-4 A-7 etc

In USAF AOA was introduced in some «difficult» A/C types during 1950-ies, ex F-104.

Later A/C has AOA, ex F-16.

During stall training with «pusher» A/C, activation of «pusher» is the artificial «stall» which must trigger recovery action.

More accurate flying by AOA. We may control A/C by using AOA. Indicated Airspeed (actually EAS) is just an aerodynamic reference associated with airloads.
Deep stall
Deep stall

Controllable

Uncontrollable
Spin

1. Apply full opposite rudder briskly.

2. Hesitate momentarily, then move the stick forward briskly beyond the neutral position.

3. Hold the controls in these positions against the spin until the spinning stops. Then neutralize the rudder and elevator. Recover from the resulting dive and assume level flight.
Criteria for entering Spin

1. $\alpha > \alpha_{\text{stall}}$ (angle of attack is higher than stall angle of attack)

2. $C_n > 0$ (yaw input – uncoordinated flight)
Criteria for stabilized Spin

1. $\alpha > \alpha_{\text{stall}}$ (angle of attack is higher than stall angle of attack)

2. $C_m < 0$ (stabilizing pithing moment)

3. $C_{m\alpha} < 0$ (negative pitching curve)
Developments in Flight Displays
Basic T
Basic T
Pilot information cueing channels

Diagram:

- Auditory
- Peripheral Visual
- Central Visual
- Tactile

Diagram shows the flow of information from external cues to the PILOT.
The series pilot model
Developments in Pilot Education
Pitch instruments interpreted in a climb.

Pitch instruments interpreted in a descent.

Bank instruments interpreted in a right turn.

Bank instruments interpreted in a left turn.
INSTRUMENT CATEGORIES

Instruments can be divided into three general categories.

THE NAVIGATION INSTRUMENTS

THE CONTROL INSTRUMENTS

Figure 7-2.
Instrument Categories:
Control-Performance-Navigation
1. Maintain indications constant
2. Observe — to detect any deviation
3. Deviation detected — 4. Adjust
4. Monitor — to insure indications changed as desired
5. Adjust attitude, power, or both

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A direct control response to the PERFORMANCE INSTRUMENTS without proper reference to the CONTROL INSTRUMENTS may result in useless chasing of instrument indications.

CONTROL INSTRUMENTS

Predetermine definite indications to be held or established on the CONTROL INSTRUMENTS.
Developments in Pilot Education

Stall and Aerobatic Training
STAY – WITHIN THE ENVELOPE

Limiting Load Factor

Stall Region

LOAD FACTOR

POSITIVE

NEGATIVE

Stall Region

Limiting Load Factor

+6G

-3G

IAS

V_{ne}
Deepstall
Stall training in Safir (and other aerobatic A/C):

- Clean stall recovery
- Landing config stall recovery
- Final turn stall recovery
- Deep stall control and recovery
Summary

• Flight safety is increased to a very high level, but may still be improved.

• The improvements are mainly a result from improved flight displays and technology (Navigation Displays).

• The technology on the other hand, has reduced pilots ability to manually control the aircraft in unusual attitudes (Flight Displays/Controls).

• The basic pilot education seems to have declined over time (Academics/Full Stall Recovery Training).

• Further improvements in flight safety requires improvements in basic pilot education and training.
Thank you for your attention

Questions?