Flight Path Management

David Morgan
Air New Zealand/IATA
https://m.youtube.com/watch?v=QVaQYhd_Qy0
Flight Plan

- Safety Data
- Regulatory matters
- Training content
- Instructor qualification
- FSTD requirements
- Evaluation
Safety data: big picture

Jet & Turboprop Aircraft

Accidents per Million Sectors


Industry, IATA, Non-IATA, IOSA, Non-IOSA
Global Accidents (2011-2014)
Global Fatal Accidents (2011-2014)
## Accident count (LOC-I)

<table>
<thead>
<tr>
<th>Year</th>
<th>Passenger</th>
<th>Cargo</th>
<th>Ferry</th>
<th>Jet</th>
<th>Turboprop</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>33%</td>
<td>67%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>2011-2015</td>
<td>68%</td>
<td>32%</td>
<td>0%</td>
<td>32%</td>
<td>68%</td>
</tr>
</tbody>
</table>

### Accident Count % from total

<table>
<thead>
<tr>
<th>Category</th>
<th>2015</th>
<th>‘11-‘15</th>
</tr>
</thead>
<tbody>
<tr>
<td>IATA Member</td>
<td>33%</td>
<td>16%</td>
</tr>
<tr>
<td>Full-Loss Equivalents</td>
<td>91%</td>
<td>81%</td>
</tr>
<tr>
<td>Fatal</td>
<td>100%</td>
<td>97%</td>
</tr>
<tr>
<td>Hull Losses</td>
<td>100%</td>
<td>97%</td>
</tr>
</tbody>
</table>

**3/27/2017**

UPRT Implementation
LOC-I Accidents by Region (2011-2015)
LOC-I Accidents by Phase (2011-2015)
Environmental & Airline Threats

- **Meterology**: 37%
- **Thunderstorms**: 13%
- ** Poor visibility / IMC**: 13%
- **Wind/Windshear/Gusty wind**: 11%
- ** Icing Conditions**: 13%
- **Lack of Visual Reference**: 11%
- **Air Traffic Services**: 3%
- **Wildlife/Birds/Foreign Object**: 3%
- **Nav Aids**: 8%
- **Ground-based nav aid malfunction or not available**: 8%
- **Aircraft Malfunction**: 37%
- **Gear/Tire**: 3%
- **Contained Engine Failure/Powerplant Malfunction**: 24%
- **Flight Control**: 3%
- **Primary Flight Controls**: 3%
- **Fire / Smoke (Cockpit/Cabin/Cargo)**: 5%
- **Other**: 8%
- **Operational Pressure**: 8%
- **Maintenance Events**: 5%
- **Manuals / Charts / Checklists**: 3%
- **Fatigue**: 3%

*Source: IATA GADM*
Flight Crew Errors

- Manual Handling / Flight Controls: 29%
- Automation: 5%
- Systems / Radios / Instruments: 5%
- SOP Adherence / SOP Cross-verification: 26%
- Intentional: 16%
- Unintentional: 11%
- Checklist: 3%
- Abnormal Checklist: 3%
- Callouts: 8%
- Pilot-to-Pilot Communication: 8%
- Failure to GOA after Destabilized Approach: 3%

Source: IATA GADM

UPRT Implementation
Flight Plan

- Safety Data
- **Regulatory matters**
- Training content
- Instructor qualification
- FSTD requirements
- Evaluation
References & regulatory framework

- 2008 Airplane Upset Recovery Training Aid (AURTA) Revision 2
- 2010 FAA SAFO 10012 (Recovery from stall does not mandate a predetermined value for altitude loss)
- 2012 FAA AC No: 120-109 Stall and Stick Pusher Training
- 2013 FAA SAFO 13002 (encourage manual flying)
- 2013 EASA SIB No.: 2013-02 Stall and Stick Pusher training
- 2013 TCAA AC 700-031
- 2013 FAA NOTICE N 8900.241
- 2013 ICATEE Research and Technology Report (FSTD)
- 2014 ICAO Annex 1 – Amdt.172 Annex 6 – Amdt.38 PANS-TRG – Amdt. 3 Doc 10011
- 2015 FAA AC No: 120-111
- 2015 EASA SIB No.: 2015-07 (low speed high altitude)
Regulatory, FAA example

FAR 121.423
(Extended Envelope Training)

- FAR 121.423 requires the following manually controlled maneuvers:
  - Slow Flight
  - Loss of reliable airspeed
  - Instrument departure and arrival
  - Recovery from bounced landing
  - Upset Recovery maneuvers

- FAR 121.423 also requires experience of full stall and stick pusher recovery procedures
  - Instructor-guided
  - Upgraded simulator modeling required

- Extended Envelope Training is required during:
  - Initial
  - Transition
  - Upgrade
  - Differences
  - Requalification
  - Recurrent
Flight Plan

- Safety Data
- Regulatory matters
- **Training content**
- Instructor qualification
- FSTD requirements
- Evaluation
ICAO Doc 10011  UPRT Manual

A. Aerodynamics
B. Causes and contributing factors of upsets
C. Safety review of accidents and incidents relating to upsets
D. G-awareness
E. Energy management
F. Flight path management (manual handling skills included)
G. Recognition (importance of monitoring)
H. Upset prevention and recovery techniques
I. System malfunction (fbw)
J. Specialized training elements
K. Human Factors (importance of TEM)
## Initial training

**ref IATA guide**

<table>
<thead>
<tr>
<th>The ideal complete UPRT program</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic Preparation</strong></td>
</tr>
<tr>
<td>Exposure to flight within the full range of the FAA25/CS25 certification g-envelope, all attitude exposure, essential human factor training.</td>
</tr>
<tr>
<td>• Adapting to all attitudes</td>
</tr>
<tr>
<td>• Adapting to g-exposure (-1g to 2,5g)</td>
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<tr>
<td>• Overcoming surprise and startle</td>
</tr>
<tr>
<td>• Developing counter-intuitive recovery skills</td>
</tr>
<tr>
<td>• Developing AOA awareness</td>
</tr>
<tr>
<td>• Recovery from aerodynamic stall</td>
</tr>
<tr>
<td>• Recovery from all attitude aeroplane upsets</td>
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</table>

<table>
<thead>
<tr>
<th><strong>On-aeroplane UPRT</strong></th>
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<tbody>
<tr>
<td>MPL, CPL</td>
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<table>
<thead>
<tr>
<th><strong>Academic Preparation</strong></th>
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<tbody>
<tr>
<td>Non-type-specific UPRT in FSTDs</td>
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<tr>
<td>MPL, CPL</td>
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<table>
<thead>
<tr>
<th><strong>Non-type-specific UPRT in FSTDs</strong></th>
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<td>MPL, CPL</td>
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</table>

**Non type-specific upset prevention and recovery training, consolidation of OEM recommendations**
Conversion & Recurrent training *ref IATA guide*

- **Academic Preparation**
- Type-specific upset prevention and recovery training including SOPs, OEM recommendations and operator training methodologies

- Type-specific UPRT in FSTDs
  - Operator training (type rating, conversion, recurrent, command upgrade) and MPL
## Human Factors - Importance of TEM

<table>
<thead>
<tr>
<th>Subjects and training elements</th>
<th>Academic training</th>
<th>On-aeroplane training — CPL(A)/MPL</th>
<th>Non-type-specific FSTD training — (CPL(A)/MPL)</th>
<th>Type-specific FSTD training</th>
<th>AURTA, Revision 2, references</th>
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<tr>
<td></td>
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<tr>
<td>ii) inattention, fixation, distraction</td>
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<td>iii) perceptual illusions (visual or physiological) and spatial disorientation</td>
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<tr>
<td>iv) instrument interpretation</td>
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<tr>
<td>2) startle and stress response</td>
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<tr>
<td>i) physiological, psychological, and cognitive effects</td>
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<tr>
<td>ii) management strategies</td>
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<tr>
<td>3) threat and error management (TEM)</td>
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<tr>
<td>i) TEM framework</td>
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<td>ii) active monitoring, checking</td>
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<td>iii) fatigue management</td>
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<td>iv) workload management</td>
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<tr>
<td>v) crew resource management (CRM)</td>
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</tbody>
</table>
Human Factors importance of TEM

Threat and Error Management (TEM)

- Anticipate or Recognize / Mitigate
- Detect / Correct
- Recognize / Recover

Crew Factors

Threat (T)

Error (E)

Undesired Aircraft State (U)

Policies / Procedures
Monitor / Cross-Check
CRM Skills
Checklists
Deviation Callouts
Aircraft Hardware
Airmanship
Luck

Incident Accident
Recognition: importance of monitoring

- **Predictive Monitoring**
  - anticipate expected threats and mitigate consequences

- **Reactive Monitoring**
  - identify unexpected threats and mitigate consequences
  - detect and correct errors
  - recognize and recover undesired aircraft states

- **Threats**
  - (expected)

- **Threats**
  - (unexpected/pop-up or latent)

- **Errors**
  - (spontaneous or threat induced)

- **Undesired Aircraft State**
### Monitoring & Competencies

**Countermeasures are:**

<table>
<thead>
<tr>
<th>Core Competencies</th>
<th>Countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Application of Procedures</td>
</tr>
<tr>
<td>2</td>
<td>Communication</td>
</tr>
<tr>
<td>3</td>
<td>Flight Path Management, manual control</td>
</tr>
<tr>
<td>4</td>
<td>Flight Path Management, automation</td>
</tr>
<tr>
<td>5</td>
<td>Leadership and Teamwork</td>
</tr>
<tr>
<td>6</td>
<td>Problem Solving and Decision Making</td>
</tr>
<tr>
<td>7</td>
<td>Situation Awareness</td>
</tr>
<tr>
<td>8</td>
<td>Workload Management</td>
</tr>
</tbody>
</table>

*Note: IATA considers the Core-Competencies of ICAO DOC 9995 (EBT) to be a valid example-set of countermeasure*

**Threats** (expected)

**Threats** (unexpected/pop-up or latent)

**Errors** (spontaneous or threat induced)

**Undesired Aircraft State**
## Aerodynamics

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<tr>
<th>Subjects and training elements</th>
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<th>AURTA, Revision 2, references</th>
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</thead>
<tbody>
<tr>
<td>A. Aerodynamics</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1) general aerodynamic characteristics</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
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</tr>
<tr>
<td>2) advanced aerodynamics</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
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</tr>
<tr>
<td>3) aeroplane certification and limitations</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>4) aerodynamics (high and low altitudes)</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>5) aeroplane performance (high and low altitudes)</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>6) angle of attack (AOA) and stall awareness</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<td></td>
</tr>
</tbody>
</table>
Academics & Practical Application
Academics & Practical Application

How is AoA defined?

- AoA - the difference between aircraft pitch and flight-path angle
IATA recommends manual flying skills training

- Continuous use of auto flight systems lead to degradation of the pilot’s manual handling skills and ability to recover the aircraft from an upset.

- Manual handling errors have been increasing. Operators and authorities have recognized that operators need to enhance the manual flying skills of flight crews.

- This includes new guidance by regulators, OEMs, and the review of operator policies to promote manual flying and manual throttle/thrust operation where appropriate in line operations, and the respective adaptation of recurrent training programs in FSTDs.
Scenario-Based Training and Upset Prevention

- Training scenarios should be designed in a way that crews can develop the core competencies to recognize and manage threats, errors and undesired aircraft states successfully and to achieve a safe outcome.

- The ultimate training objective of scenario-based training is to avoid or arrest a divergence from the intended flight path as early as possible and secure the intended flight path.

- Scenarios leading to upsets, despite correct intervention by the crew, are not recommended.
Maneuver-Based Training and Upset Recovery

- The instructor, not the crew, takes responsibility for the creation of the upset condition. Training starts after the upset condition has been established.

- Reasons/causes for upset conditions may be taken from case studies but should not be the responsibility of the crew under training.

- The ultimate training objective is to effectively apply recovery actions and to return the aircraft to a stabilized flight path.
“OEM recommendation”

6 Recovering from Upsets

6.2 Nose-High Recovery 1/3

### Nose HIGH Recovery

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>MONITOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Autopilot disconnect</td>
<td>airspeed and attitude throughout the recovery and announce any continued divergence</td>
</tr>
<tr>
<td>2</td>
<td>Autothrust/Autothrottle OFF</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>APPLY as much nose-down control input as required to obtain a nose-down pitch rate</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>THRUST adjust (if required)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>ROLL adjust (if required)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>When airspeed is sufficiently increasing RECOVER to level flight</td>
<td></td>
</tr>
</tbody>
</table>
# Example of training syllabi

<table>
<thead>
<tr>
<th>Module</th>
<th>Content</th>
<th>Terminal training objectives</th>
</tr>
</thead>
</table>
| 1      | Advanced Manual Flying Skills | - Handling characteristics - airplane response to specific primary and secondary flight control inputs  
          |                                         | - Gain confidence for appropriate application of manual flight control inputs required during upset prevention and recovery conditions  
          |                                         | - Energy awareness                                                                         |
| 2      | AOA awareness            | - Vn diagram in practical application, loading and unloading  
          |                                         | - Stall is independent from attitude and speed  
          |                                         | - Stall recovery is based on AOA-reduction only - must be separated from the application of thrust  
          |                                         | - High Altitude ops                                                                       |
| 3      | Recoveries               | - Apply the OEM-recommendations  
          |                                         | - Separate “push/unload” from “roll”, control thrust at the correct time during recovery  
          |                                         | - Apply the airplane specific STALL-RECOVERY SOP correctly  
          |                                         | - Increase resilience by managing surprise and startle, and develop counterintuitive actions  |
Flight Plan

- Safety Data
- Regulatory matters
- Training content
- **Instructor qualification**
- FSTD requirements
- Evaluation
Personnel Providing FSTD Upset Prevention & Recovery Training

Standardization and training should ensure that personnel are able to demonstrate the correct upset recovery techniques for the specific aeroplane type and;

1) understand the importance of applying type-specific Original Equipment Manufacturers (OEMs) procedures for recovery maneuvers;

2) are able to distinguish between the applicable SOPs and the OEMs recommendations (if available);

3) understand the capabilities and limitations of the FSTD used for UPRT;

4) are aware of the potential of negative transfer of training that may exist when training outside the capabilities of the FSTD;
Personnel Providing FSTD Upset Prevention & Recovery Training

6) understand and are able to use the IOS of the FSTD in the context of effective UPRT delivery;

7) understand and are able to use the FSTD instructor tools available for providing accurate feedback on flight crew performance;

8) understand the importance of adhering to the FSTD UPRT scenarios that have been validated by the training program developer; and

9) understand the missing critical human factor aspects due to the limitations of the FSTD and convey this to the flight crew receiving the training.
Instructors qualification process

- Core group
  - design course & teach senior instructors

- senior instructors
  - Teach instructors

- Instructors
  - teach pilots

- Pilots
Instructor initial training

- Academics ½ day up to 1 day
- Practical FFS instruction 4H00
- exercises example:
  - Uncommand FLAPS retraction during climb
  - High pitch attitude protection and Steep Turns at FL 100
  - Steep Turns at high altitude
  - STALL RECOVERY (at high altitude)
  - Demo low speed protections
  - STALL RECOVERY (at low altitude)
Flight Plan

- Safety Data
- Regulatory matters
- Training content
- Instructor qualification
- **FSTD requirements**
- Evaluation
FSTD Limitations

- G-loads below 1g
- G-loads above 1g
- FSTD motion limitations

FSTD motion limitations

Motion systems of modern full flight simulators are only capable of delivering less than 10% of the real g-loads.
When training upset recovery the simulation environment, they cannot deliver the real sensations.

These human factors play a key role in UPRT. To compensate for the shortcomings of FSTD motion this CBT and your instructor will emphasize on human factors, especially during counterintuitive actions.
Flight Plan

- Safety Data
- Training content
- Instructor qualification
- Training delivery
- FSTD requirements

**Evaluation**
Evaluation of training efficiency

- Exercises assessment
- Pilot proficiency assessment
- Pilots’ feedback
- Tutors’ Observations
- Line Check/observation
- FDM (FOQA) improvements
Pilot Proficiency: Core competencies

- Aircraft Flight Path Management, manual control
- Aircraft Flight Path Management, automation
- Application of Procedures
- Communication
- Situation Awareness
- Workload Management
- Leadership and Teamwork
- Problem Solving and Decision Making
Line ops checks / observations

- Area of special emphasis, example:
- Flight level choice

- Radar tilt selection
- Weather avoidance (icing, …)
Flight data monitoring

Speed below design maneuvering speed
Take away

- Issue is real and persistent
- Pan-industry collaborative approach required
- System constraints will take time to resolve
- Human factor is key
- Training at all levels key to success

Train to Proficiency to make crew Resilient
Loss of Control In-flight (LOC-I)

Loss of Control In-flight (LOC-I) remains one of the most significant contributors to fatal accidents worldwide. LOC-I refers to accidents in which the flight crew was unable to maintain control of the aircraft in flight, resulting in an unrecoverable deviation from the intended flight path.

LOC-I can result from a range of interferences including engine failures, icing, or stalls. It is one of the most complex accident categories, involving numerous contributing factors that act individually or, more often, in combination.

Reducing this accident category, through understanding of causes and possible intervention strategies, is an industry priority.
Available studies & reports

- SAFETY REPORT 2015 Issued April 2016
- Loss of Control In-Flight Accident Analysis Report
- Environmental Factors Affecting Loss of Control In-Flight: Best Practice for Threat Recognition & Management
- Loss of Control In-flight (LOC-I) Prevention: Beyond the Control of Pilots
Flight Path Management

David Morgan

Air New Zealand/IATA