Automated in-situ Turbulence reports from Airbus aircraft

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6 to 10 November 2017, Météo-France, Toulouse
Atmospheric Turbulence is leading to situations somewhat uncomfortable...
An intensive investigation has been performed by METRON company on Airbus request.

### INJURIES
According to the US Department of Transportation, costs associated to one injured person range from $11,000 (minor) to $333,000 (serious):
- Medical expenses
- Potential Legal Costs
- Lost employee time

For US Part 121 Flights (airliners) in the 2000s:
- 700 injured flight attendants per year
- 125 injured passengers per year

\[ \text{33M$ / year} \]

In addition, in-flight injuries can lead to IFTB:
- 100k$ / event

### ROUTE - FL CHANGE
- Deviation from optimal F-PLN inducing extra fuel & delays
- Schedule disruption due to limited reporting

For US Part 121 Flights (airliners) in the 2000s:
- 57.4M$ / year

\[ \Rightarrow \text{large additional cost for operators} \]

### Ongoing Costs
- Cabin Refurbishing / Loads Inspection / Structural Repairs
- Beyond Parts & Labor:
  - Lost revenue
  - Pax re-accommodation
  - Schedule disruption

### Worldwide cost of turbulence = 2 billion $ per year

### Airbus A319/A320/A321 Cost Comparison

<table>
<thead>
<tr>
<th>A/C</th>
<th>1 Hour delay</th>
<th>Cancellation + 1 Day AoG</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA</td>
<td>3800 US$</td>
<td>22850 US$</td>
</tr>
<tr>
<td>LR</td>
<td>13500 US$</td>
<td>78140 US$</td>
</tr>
<tr>
<td>DD</td>
<td>31900 US$</td>
<td>187600 US$</td>
</tr>
</tbody>
</table>
Cost of Turbulence for Air Carriers – … and in future

Situation will be strongly worsened in the coming years due to both:

- Air Traffic growth, which will be more than doubled in 20 years

- Climatic Changes, which will rise frequency and severity of turbulence

Cost impact could go as high as 250% in 20 years

$+170\%$ of chance to be hit by a turbulence for A/C going from Europe to North America by next decades (*)

Turbulence potentially up to 40% stronger

* Research by Dr Williams (university of Reading)
Observed EDR – The mitigation

Need of more, live and accurate information

Solution: Real-time Turbulence Automatic Reporting

Turbulence knowledge uncertainty

Already installed on board of 40 A/C over Europe.

Live massive information leading to:

- Safer flights with less injuries
- Airline Operations optimisation (delays, fuel consumption, diversions avoidance ...)
- Improvement of forecast
- Enhance climate change understanding
A/C as a weather sensor

Met offices & Weather providers

Services/Applications providers

Operational Control Center

A/C Airlines solutions

Improved weather forecasts

Airports solutions

Flight planning tool

Flight tracking tool

Ground modules

A/C Airlines solutions

Weather information or alerts

Flight crew

Dispatcher
Observed EDR applications (1/4)

- On-ground Segment
Observed EDR applications (2/4)

- On-ground/on Board Segments

Alerting msg
Observed EDR applications (3/4)

- Statistical information
Observed EDR applications (4/4)

- Statistical information

Maximum EDR Mean
All reports
2017-01-23 16H
2017-10-09 09H
More to come!

- Windshear, Icing conditions
- Humidity
- UV
- Connected Weather Radar
- Pollution sensors, others...
Thank you
Backup Slides
Metric Selection & Computation

- **Turbulence Assessment.** Several options (as identified by WMO/AMDA, 2003)
  - Aircraft Vertical Acceleration \( (N_z) \) \{ A/C response characterization (A/C dependant) \}
  - Derived Equivalent Vertical Gust \( (DEVG) \) \{ Atmosphere characterization (no A/C dependant) \}
  - Eddy Dissipation Rate \( (EDR) \): **ICAO guideline**

- **EDR computation.** Several algorithms (developed by NCAR, DLR ...)
  - DLR algorithm benefits: → no use of A/C response
  - → use of all wind components

**Geodetic Wind**
\[
\begin{align*}
V^\text{cs}_w &= V^\text{cs}_k - V^\text{cs}_a \\
\text{Wind Speed} &\quad \text{Ground Speed} &\quad \text{Air Speed}
\end{align*}
\]

**Turbulence Metric**
- Fluctuations of each geodetic wind component along A/C flight path
- Time average (moving window)

EDR - Eddy Dissipation Rate

- Turbulence reports downlink frequency:
  - Every 10’ for Routine reports
  - Every 1’ for Special reports

Routine Reports
(non-significant turbulence)

Special Reports
(significant turbulence)