Runway Excursions at Landing
The n°1 Source of Insurance Claims for Aviation Industry
How Can We Reduce this Risk Through Innovative Avionics?

Presented by
Fabrice VILLAUMÉ, Business Development Director and Co-Inventor
Agenda

• Safety at landing: the n°1 air transportation safety issue

• Mitigation means: Technology, a part of the solution

• Runway Overrun Prevention System (ROPS)

• ROPS, an already available solution on Airbus fleet

• Airbus decision to address *globally* this top safety priority

• Conclusion and Perspective
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- **Safety at landing: the n°1 air transportation safety issue**
  - Mitigation means: Technology, a part of the solution
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- Conclusion and Perspective
Safety at Landing: the n°1 Air Transportation Safety Issue

AIRBUS-WILLIS Analysis on 1985-2010 Period : Incidents Statistics

<table>
<thead>
<tr>
<th>Flight Phase</th>
<th>Incident Count #</th>
<th>Passenger Fatalities</th>
<th>Crew Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>En Route (Cruise)</td>
<td>287</td>
<td>3,766</td>
<td>462</td>
</tr>
<tr>
<td>Ground - Taxi</td>
<td>301</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td>Landing - Approach</td>
<td>1,120</td>
<td>8,718</td>
<td>1,802</td>
</tr>
<tr>
<td>Landing - Go Around</td>
<td>107</td>
<td>1,324</td>
<td>209</td>
</tr>
<tr>
<td>Landing - Initial Descent</td>
<td>178</td>
<td>2,450</td>
<td>415</td>
</tr>
<tr>
<td><strong>Landing - Landing Roll</strong></td>
<td><strong>2,587</strong></td>
<td><strong>1,261</strong></td>
<td><strong>202</strong></td>
</tr>
<tr>
<td>Take Off - Climb to Cruise</td>
<td>298</td>
<td>5,250</td>
<td>722</td>
</tr>
<tr>
<td>Take Off - Initial Climb</td>
<td>541</td>
<td>3,936</td>
<td>854</td>
</tr>
<tr>
<td>Take Off Aborted</td>
<td>113</td>
<td>146</td>
<td>20</td>
</tr>
<tr>
<td>Take Off Run</td>
<td>407</td>
<td>725</td>
<td>106</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,939</strong></td>
<td><strong>27,600</strong></td>
<td><strong>4,810</strong></td>
</tr>
</tbody>
</table>

Data based on incidents arising from all western built fixed wing aircraft being used for domestic, international and passenger, cargo, ferry, business flights.

Landing roll, the most critical phase
Safety at Landing: the n°1 Air Transportation Safety Issue
AIRBUS-WILLIS Analysis on 1985-2010 Period: Incidents Statistics

Landing Roll Incidents #
Breakdown

Landing Roll Incidents #
Time History

Landing roll safety, a deteriorating situation
## Safety at Landing: the nº1 Air Transportation Safety Issue

**AIRBUS-WILLIS Analysis on 1985-2010 Period : Claims Data**

<table>
<thead>
<tr>
<th>Flight Phase</th>
<th>Incident Count #</th>
<th>Passenger Fatalities</th>
<th>Crew Fatalities</th>
<th>Hull Loss USD m</th>
<th>Liability USD m</th>
</tr>
</thead>
<tbody>
<tr>
<td>En Route (Cruise)</td>
<td>287</td>
<td>3,766</td>
<td>462</td>
<td>1,576</td>
<td>2,727</td>
</tr>
<tr>
<td>Ground (Taxi)</td>
<td>301</td>
<td>24</td>
<td>18</td>
<td>473.89</td>
<td>76.74</td>
</tr>
<tr>
<td>Landing - Approach</td>
<td>1,120</td>
<td>8,718</td>
<td>1,802</td>
<td>2,937.49</td>
<td>3,316.70</td>
</tr>
<tr>
<td>Landing - Go Around</td>
<td>107</td>
<td>1,324</td>
<td>209</td>
<td>511.22</td>
<td>498.68</td>
</tr>
<tr>
<td>Landing - Initial Descent</td>
<td>178</td>
<td>2,450</td>
<td>415</td>
<td>442.46</td>
<td>948.56</td>
</tr>
<tr>
<td><strong>Landing Roll - Excursions</strong></td>
<td><strong>1,020</strong></td>
<td><strong>970</strong></td>
<td><strong>112</strong></td>
<td><strong>5,429.54</strong></td>
<td><strong>1,133.26</strong></td>
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<tr>
<td>Landing – Landing Roll Others</td>
<td>1,567</td>
<td>291</td>
<td>90</td>
<td>1,139.66</td>
<td>186.05</td>
</tr>
<tr>
<td>Take Off - Climb to Cruise*</td>
<td>298</td>
<td>5,250</td>
<td>722</td>
<td>1,324.16</td>
<td>6,976.04</td>
</tr>
<tr>
<td>Take Off - Initial Climb</td>
<td>541</td>
<td>3,936</td>
<td>854</td>
<td>1,231.18</td>
<td>1,860.20</td>
</tr>
<tr>
<td>Take Off Aborted</td>
<td>113</td>
<td>146</td>
<td>20</td>
<td>352.43</td>
<td>61.55</td>
</tr>
<tr>
<td>Take Off Run</td>
<td>407</td>
<td>725</td>
<td>106</td>
<td>1,237.67</td>
<td>989.55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,939</strong></td>
<td><strong>27,600</strong></td>
<td><strong>4,810</strong></td>
<td><strong>16,655.69</strong></td>
<td><strong>18,774.32</strong></td>
</tr>
</tbody>
</table>

* Includes WTC

**Source : ASCEND Database**

Excursions, the nº1 source of claims (mainly hull losses)
Safety at Landing: the n°1 Air Transportation Safety Issue
AIRBUS- WILLIS Analysis on 1985-2010 Period : Claims Data

USD(m) Cumulative Hull Loss Value
Adjusted at 2% inflation rate per Annum

Flight Safety Foundation
ALAR toolkit introduction

USD 6,8b

This is only a portion of total costs...
• Claims above USD 10m
• w/o airline operational losses
• w/o airport operational losses
• Etc.

Source: ASCEND Database

Landing excursions claims: 33% of hull losses in the last 25 years
Safety at Landing: the n°1 Air Transportation Safety Issue
AIRBUS-WILLIS Analysis: 2020 Claims Forecast

USD(m) Cumulative Hull Loss Value
Adjusted at 2% inflation rate per Annum

USD 6,8b
USD 9,2b

This is only a portion of total costs...
- Claims above USD 10m
- w/o airline operational losses
- w/o airport operational losses
- Etc.

Source: ASCEND Database

Aviation industry now needs a game changer...
**Safety at Landing: the n°1 Air Transportation Safety Issue**

**Existing Situation**

<table>
<thead>
<tr>
<th>Main contributing factors to runway overrun at landing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No regulation defining realistic operational landing distances</td>
</tr>
<tr>
<td>• Unstable Approaches at 1000ft / 500ft</td>
</tr>
<tr>
<td>• Destabilization of the Approach at low or very low altitude</td>
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<tr>
<td>• Long flare</td>
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<td>• Long derotation</td>
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<td>• Late selection of Reversers (MAX)</td>
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<td>• Runway condition / friction lower than reported</td>
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<td>• Reversers Max to Reverser Idle at usual procedure speed</td>
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<tr>
<td>• Too weak basic auto-brake setting</td>
</tr>
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<td>• Late or insufficient pedal braking (no auto-brake or after disconnection / override)</td>
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<tr>
<td>• Failures affecting landing distance</td>
</tr>
</tbody>
</table>

*A vast majority of overruns at landing is avoidable*
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• Safety at landing: the n°1 air transportation safety issue

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• Runway Overrun Prevention System (ROPS)

• ROPS, an already available solution on Airbus fleet

• Airbus decision to address globally this top safety priority

• Conclusion and Perspective
Safety at Landing: the n°1 Air Transportation Safety Issue
A Mapping of Mitigation Means of Runway Overrun Risk

Only a combined prevention approach should be effective
As it was for CFIT and Mid-Air collisions
Safety at Landing: the n°1 Air Transportation Safety Issue
A Mapping of Mitigation Means of Runway Overrun Risk

Like E-GPWS & TCAS, on-board technology will be key to mitigate Runway Excursion Risk
But clear different design intents exist
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Runway Overrun Prevention System
A Sound Expertise

F. Villaumé Ph. D Thesis

1st Prototype
Apr. 2004

A380
Oct. 2009

A320 Family
Q2 2012

A330/A340
Q4 2012

A350XWB
Q3 2013

Standardization for all existing Airbus models in production

Deployment for all existing Airbus models in production

Exploration on Airbus flagship

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Runway Overrun Prevention System
EASA Consideration for ROPS Certification

• In heavy workload / stress most often associated to accidents at landing, the crew is focused on the primary objective and unable to intellectually consider the alternative to Go-Around

• Runway Excursion Prevention design intent implied the request to demonstrate the relevance of ROPS alerts and protections
  ‣ No Airborne Alert: Continuing landing is safe, no unprotected area
  ‣ Airborne Alert: Without unjustified conservatism and increase of Go-Around rate
  ‣ On-Ground Alert: Apply (and maintain) all deceleration means

• This was ruled by a new EASA certification basis in 2009 covering aircraft performance, Man-Machine Interface, Systems and need for validated runway database
Runway Overrun Prevention System

Design Objectives

• To significantly reduce runway overrun risk at landing, 8 goals were necessary to achieve
  1. Compute **continuously, in real time** aircraft realistic landing distance and remaining landing/stopping distance
  2. Compare it **in real time** with **legal** Landing Distance Available (LDA)
  3. Trigger, **only when necessary**, alerts with simple operating procedures
  4. Guarantee both reliability and not excessive margins
  5. Be approved through a dedicated **EASA** rule
  6. Ensure consistency with future **FAA** TALPA rule
  7. Use **validated** runway data (Terrain or Airport Mapping DataBases)
  8. Avoid any additional tuning by airline (**no liability transfer**)

• This **does not** invalidate the need to fly stable approach...
  ... this is a supplement to the necessary Stable Approach concept
Runway Overrun Prevention System

Description

EASA CRI Philosophy

“In the whole approved flight domain,
If no ROW alert before decision point
Then, thanks to ROP, no runway excursion
While no significant increase of go-around rate”
## Runway Overrun Prevention System

### Description

<table>
<thead>
<tr>
<th>ROW (WET)</th>
<th>PFD (and HUD)</th>
<th>Audio (Below 200 ft)</th>
<th>Crew Actions (Below 500 ft)</th>
<th>AMM ND line symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF WET: RWY TOO SHORT (amber)</td>
<td>None</td>
<td>Go-Around if runway is wet / damp or more slippery</td>
<td>WET (amber) DRY (magenta)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ROW (DRY)</th>
<th>RWY TOO SHORT (red)</th>
<th>&quot;RWY TOO SHORT !&quot;</th>
<th>Go-Around</th>
<th>WET (red) DRY (red)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>ROP</th>
<th>MAX BRAKING MAX REVERSE (red)</th>
<th>&quot;BRAKE... MAX BRAKING MAX BRAKING&quot;</th>
<th>MAX braking (Auto/Pilot)</th>
<th>Red STOP bar Red path</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;MAX REVERSE&quot; &quot;KEEP MAX REVERSE&quot;</td>
<td></td>
<td>MAX REV (Pilots)</td>
<td></td>
</tr>
</tbody>
</table>
Main contributing factors to runway overrun at landing

- No regulation defining realistic operational landing distances
- Unstable Approaches at 1000ft / 500ft
- Destabilization of the Approach at low or very low altitude
- Long flare
- Long derotation
- Late selection of Reversers (Max)
- Runway condition / friction lower than reported: DRY, DAMP, WET
- Reversers Max to Reverser Idle at usual procedure speed
- Too weak basic auto-brake setting
- Late or insufficient pedal braking (no auto-brake or after disconnection/override)
- Failures affecting landing distance
- Runway condition/friction lower than reported: SLIPPERY, CONTAM.
Runway Overrun Prevention System

Illustration on a Real Accident Scenario
Runway Overrun Prevention System

Illustration on a Real Accident Scenario

Aircraft with excess energy (i.e. excess ground speed or excessive height above normal glide slope, or long flare)

DRY/WET line translated

Nominal 3° glideslope

Dry and Wet line translated

Runway Threshold  Touchdown  Flooded Runway  Runway End
Runway Overrun Prevention System

Illustration on a Real Accident Scenario

As runway condition was reported WET (and PIREP POOR of preceding aircraft), Crew decision to Go-Around
Runway Overrun Prevention System

Illustration on a Real Accident Scenario

Immediate Crew Decision to Go-Around
Runway Overrun Prevention System

Illustration on a Real Accident Scenario

Application of max pedal braking  
(done during event)

Selection of Max Rev. down to stop  
(10 sec delayed during event)
Runway Overrun Prevention System
Implementation Challenges of such a New Technology

- In safety enhancement design, failure is not an option
  - Conservative iterative approach of such new system
  - In-depth analysis of (E)GPWS design and deployment history

- A must to achieve - Ensure pilot appropriation
  - Reliable system with multi-dimension aspects to take into account
  - Simple operating procedures well integrated in existing “environment”
  - Training simplicity
  - Help the pilot in its decision making process and surely not replace him

- Leading to 12 years of R&D effort

A complex and long development – A real know-how
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• **ROPS, an already available solution on Airbus fleet**

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• Conclusion and Perspective
ROPS, an already available solution on Airbus fleet

• A380
  ‣ Approved by EASA on October 15th, 2009
  ‣ Selected on 63% of ordered / in-service A380s
  ‣ Fitted by software update

• A350 XWB
  ‣ Basic at Entry Into Service

• A320 et A330/A340 families
  ‣ First flight tests on December 2010
  ‣ First certification mid-2012
  ‣ Option easy to install (retrofit in 1 night)

Airbus types in production are now addressed
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Why AIRBUS has decided to Address *Globally* this Top Safety Priority?

- Runway excursions are
  - Highly visible
  - Costly... in lives and treasure
  - Unacceptable
  - Not linked to aircraft type and generation

- Safer runway operations are a key enabler in ensuring sustainable growth and long-term public acceptance of air transportation

- ROPS was/is warmly welcomed by the main aviation stakeholders as being an effective solution

- Achieve safety enhancement breakthrough cannot be considered as a “traditional” competitive advantage

- ROPS is now a “state-of-the-art” solution
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ABC Conference - Boston, MA - September 19th-20th, 2011
Conclusion and Perspective

- **Reduction of runway overruns**
  - A top priority for all aviation segments

- **ROPS on-board technology**
  - A game changer... Like EGPWS and TCAS

- **Complex and long development**
  - A real know-how

- **Airbus types in production now addressed**
  - A credible basis to go further
Conclusion and Perspective

NTSB Safety Recommendations to FAA (March 29, 2011)
“Actively pursue with aircraft and avionics manufacturers the development of technology to reduce or prevent runway excursions and, once it becomes available, require that the technology be installed. (A-11-28)”

ROPS is that requested technology...
...and it is now accessible for all aircraft manufacturers!
Conclusion and Perspective

• EASA-approved design intent to prevent overrun at landing
  ‣ Initial step: DRY/WET only without failure affecting landing performance
  ‣ But already on the complete flight domain up to landing at MTOW
  ‣ And whatever the crew-selected level of braking automation

• Already coherent with future rules (FAA TALPA) and future Airbus in-flight documentation
  ‣ Minimum training
  ‣ Clear SOP
  ‣ No impact on Go-Around rate except when justified!

• Homogeneous design and HMI on complete Airbus fleet at least
  ‣ No hide of vital call out, i.e. “RETARD”
  ‣ No additional risk linked to unavoidable pilot complacency to absence of alert

• Easy to install in one night stop

• Delivered ready to fly
  ‣ No complex tuning and SOP to be designed and justified by airline
AIRBUS Decision to Address **Globally** this Top Safety Priority

**Flighglobal**

Aircraft

**Aircraft**

You are in Home > Aircraft's Name Article

DATE: 02/06/11

SOURCE: Flight International

**Airbus offers runway overrun protection system to competitors**

By David Learmount

**Airbus has decided not to keep its patented runway overrun prevention system (ROPS) as a "product differentiator", but will release it to competing aircraft builders.**

The manufacturer says its decision has been spurred by the fact that runway excursions is by far the air transport industry's most common serious accident category. The occurrence rate is also increasing faster than the world fleet is expanding.

Airbus's executive vice-president and future programmes Christian Scherer said that it has received "a very positive reaction" from Bombardier, Embraer, Dassault - and from the aviation insurance industry - to the proposal to make ROPS commercially available to other manufacturers.

Scherer said that the idea was also well received at last month's International Civil Aviation Organization's Global Runway Safety Symposium, and that the International Federation of Airline Pilots Associations backs the manufacturer's move.

At present ROPS, which consists of a software upgrade to existing aircraft systems, will be fitted on all A380s that come off the line. It is installed on more than 60% of the in-service A380 fleet. It will be in all A350s, and from next year, it will be available on the other newbuild Airbus types or for retrofit.

ROPS is integrated with the aircraft's flight management and navigation systems, and provides the pilots with a real-time constantly updated picture in the navigation display of where the aircraft will stop on the runway in wet or dry conditions.

If the approach profile varies, no does the stopping point. If it will not be possible to stop on the runway, the system provides the crew with a written and spoken "runway too short" warning.

**Related Articles**

AIRBUS: Airbus to extend runway overrun protection to corporate jets (20/10/11)

**FARNBOROUGH: Smart safety antennas in the AS6211 (12/07/11)**

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