Understanding Runway Excursions

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Runway Excursion Activity

Runway Excursions
• Off side events
• Overruns

Industry Activity
• Aviation Rulemaking Activity – FAA
• ECAS/Eurocontrol initiatives
• ICAO Friction Task Force
• Flight Safety Foundation
• Others?
Overruns Are Typically The Result of Multiple Factors

Most often overruns are not the result of a single factor

• Typically 2, 3 or more factors are involved
  – Approach and Flare
  – Speed
  – Stopping Devices
  – Runway conditions

• Often if 1 of the multiple factors were changed a successful stop would occur

Focus on landing
Study of 29 Excursions Since 2003

- Listing of contributing factors
- Demonstration that multiple factors typically are involved
Contributing Factors

Runway conditions
• Contaminated/slippery runways
• Wet runways
  – Runway deterioration effects

Performance knowledge
• Misconceptions on the conservatism available in the dispatch data
• Lack of knowledge on the basis of the data or what it covers
• Reverse thrust and autobrakes
Contributing Factors

Approach to touchdown
• Unstable approaches
• Long landing

High Speed landing
• Tailwind
• Carrying all of the speed additive or excessive speed to the runway
  – Above MCP speed

Reverse thrust technique
• Late application of reverse thrust
• Early shutdown of reverse thrust
• “Quick” shutdown of reverse thrust
Runway Condition – Wet Runway

Ability of the airplane to stop on a wet runway is a function of:

- Amount of wheel braking used/available
  - Manual or Auto brake
- How wet is wet?
  - Saturation
    - 3mm generally accepted threshold for dynamic hydroplaning
    - Heavy rain
- Runway condition - texture
  - Grooved / PFC or Wet smooth (non-grooved or PFC)
    - Rubber build up
    - Polishing
- Boeing FCOM
  - The performance level used to calculate the "good" data is consistent with wet runway testing done on early Boeing jets

3 mm
Wet Runway – Runway Texture

Runway texture (roughness)

“OPEN, HIGH”

“CLOSED, LOW”

Grooved
Runway Profile

Area of airplane braking
Periodically measure friction using vehicles designed to do this
Runway Deterioration

Polishing/Rubber Deposits

Example of Runway Friction Cross Section Profile

Notional

Left of C/L

Right of C/L

Measured Runway Friction

- 737 gear track
- 777 gear track

New/resurfaced runway

ICAO Design Level

ICAO Maintenance Level

ICAO Minimum Level

Traffic effects

Distance from Centerline - Meters

-25 -20 -15 -10 -5 0 5 10 15 20 25
Variability In Wet Runway Braking

All Factors (Rwy Texture, Tire Tread, Saturation, etc.)

Braking Action

Good

Medium

Poor

Ground Speed - KIAS

Dry

Wet rough macro texture

Wet smooth macro texture
For performance comparisons and effects we will use reasonably attainable assumptions and conditions for the baseline:

- Maximum Landing Weight
- Assume an **air distance of 1500 feet (450 m)** (touchdown within the touchdown zone)
- Threshold crossing speed – $V_{REF} + 5$
- Touchdown speed – $V_{Ref}$
- 500 ft pressure altitude, 30 C, no wind, no slope
- AB Max, QRH level of reverse thrust
- No factors, **wet** non-grooved runway assumption

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**Runway Condition / Runway Length**

- Runway avail – 7500 feet (2290 m)
- Runway avail – 8500 feet (2590 m)
- Runway avail – 8000 feet (2438 m)
- Runway avail – 7000 feet (2133 m)
- Runway avail – 6000 feet (1829 m)

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**Wet - Good**

**Medium**
Performance Knowledge

There have been issues with flight crew knowing and understanding the basis and assumptions for landing performance

- Assumptions used in computing data documented in Boeing documents
  - FCOM and FCTM
  - FOTB (2007)
  - Previous Symposium Presentations
  - Boeing Performance and Flight Operations Conference white papers

- Airline needs to determine if the assumptions are adequate for their operating environment and training
  - Increment or factor the data as appropriate
Performance Knowledge

• Understanding of interaction of reverse thrust and autobrake
  – Recurring issue

On a non-dry runway (braking action good, medium, poor)

• Reverse thrust is required to obtain the QRH or OPT computed autobrake stopping distances (AB setting greater than 2 or 1)

• The published stopping distance will increase if:
  – Reverse selection is delayed
  – Less than assumed level of reverse thrust is used
    – Detent 2 (737) or Max (other 7 series models)
    – Reducing reverse at higher speeds than recommended
Approach to Touchdown

Unstable approach

• Know the criteria
  – FCTM
  – ALAR tool kit (Flight Safety Foundation)

• Flight crew mindset

• It is okay to go-around
Proper Speed Additives / Flair and Speed Bleed Off

Airspeed Control

If the autothrottle is disengaged, or is planned to be disengaged prior to landing, maintain VREF plus the wind additive until beginning the flare. The steady headwind correction is bled off during the flare, however the gust correction is maintained to touchdown. Plan to touchdown at VREF plus the gust correction. With proper airspeed control and thrust management, touchdown should occur at no less than VREF - 5 knots.

With calm winds and tailwind

- $V_{Ref} + 5$ at threshold
- $V_{Ref}$ at touchdown
High Speed Landings

Stopping distance will be directly related to ground speed
- Approach speed above MCP speed
- Speed increase during the flare
- Tailwind
  - Runway choice
  - Unreported tailwind

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Runway Avail</th>
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</thead>
<tbody>
<tr>
<td>AFM Wet</td>
<td>Runway avail – 8500 feet (2590 m)</td>
</tr>
<tr>
<td>Base conditions</td>
<td>Runway avail – 7500 feet (2290 m)</td>
</tr>
<tr>
<td>10 knot TW</td>
<td></td>
</tr>
<tr>
<td>MCP+10</td>
<td></td>
</tr>
<tr>
<td>10 kt TW, MCP+10</td>
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</table>

Wet - Good

Medium
Air Distance

Touchdown zone often described as 1st third of runway up to 3000 ft
  - Boeing FCTM 1000-2000 ft

Touchdown point becomes more important with
  - Higher speeds
  - Worse runway conditions
  - Shorter runways

Touchdown an additional 1000 ft down the runway (2500 ft air dist.)
Reverse Thrust usage

QRH performance assumes reverse thrust usage

• Prompt use of reverse thrust required to achieve normal performance numbers
  – Delayed Reverse
  – Early reduction of reverse to forward idle
Example of good use of reverse thrust
Example of early reduction in reverse thrust
Reverse Spinup Time

- Reverse idle to maximum reverse immediately after landing – 3.5s
- Reverse idle to maximum reverse after spindown to ground idle – 10+s
- On the ground selecting forward idle allows thrust to spin down to ground idle
  - Result - in a long spinup time to achieve effective reverse
Reverse thrust issues

Many excursion incidents have a contribution of reduced reverse thrust either by:

- Early stowage of reverser and unsuccessful re-application
- Delayed selection and therefore spin-up of reverse thrust
- The more slippery the runway the greater the contribution of reverse thrust to stop

![Graph showing runway availability and distance increase with 10 second delay in selecting reverse.]

Runway avail – 8500 feet (2290 m)
Runway avail – 7500 feet (2290 m)
Distance increase with 10 second delay in selecting reverse
Delayed Reverse Thrust Application and Unarmed Speed Brakes

Deceleration Capability – 120 kts

<table>
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<tr>
<th>Good runway</th>
<th>Drag, speed brakes up with reverse</th>
<th>Drag, speed brakes down, no reverse</th>
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<tr>
<td>Medium runway</td>
<td>Drag, speed brakes up with reverse</td>
<td>Drag, speed brakes down, no reverse</td>
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Runway avail – 7500 feet (2290 m)
Runway avail – 8500 feet (2590 m)

Distance increase with 10 second delay in selecting reverse and speedbrake
Boeing Performance Data in QRH is Consistent With Recommended Flying Techniques in the FCTM

Assumed time for device activation:

- Brake application
- Spoiler deployment
- Reverse thrust usage
Summary

- Overruns are typically the result of multiple issues
  - Some not under flight crew control
  - Some under flight crew control

- Pilot flying
  - Fly the airplane following standard procedures

- Pilot monitoring
  - Has shared responsibility

- It is okay to go-around