Jet Transport Airplane Performance - Briefing For Business Aviation Pilots & Operators

Presented to: NBAA 2013 Convention
By: Transport Airplane Performance Planning Working Group
Date: 22 October 2013
TAPP WG – Who are we?

- Chartered through the FAA Aeronautical Charting Forum
- FAA & Industry Representation
  - NBAA
  - Society of Aircraft Performance and Operations Engineers (SAPOE)
  - Airlines & Aircraft Manufacturers
  - FAA (Operations, Procedures, Aircraft Certification)
- Objective:
  - Improve understanding of transport airplane performance concepts & requirements.
  - Address industry/FAA misconceptions.
  - Integrate airplane performance & NextGen.
  - Improve overall system safety.
  - Level the playing field.
Subjects

- Part 25 Airplane Landing Performance Certification
- Wet & Contaminated Runway Planning for Landing
- Runway Excursions
- Roundtable Discussion
Part 25
Airplane Landing Performance

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Building Blocks of Landing Distance

• Part 25 Certification
• Operating Rules
• Safety Margins
• Landing Procedure
Landing Distance Data In the AFM

- Actual Landing Distance.
- Factored Landing Distance
Part 25 – Landing Distance

Ground Distance Assumptions:
- Normal Wheel Brakes (Anti-Skid, If Equipped)
- Spoilers (or Lift Dumps)
- No Thrust Reverser Credit

1.30 \( V_{SO} \) or \( V_{REF} \)

50 Feet

Air Distance  Transition  Ground Distance

Part 25 Landing Distance
Part 25 – Landing Distance

• The actual (unfactored) landing distances in the manufacturer-supplied AFM reflect performance in a flight test environment that is not necessarily representative of normal flight operations.

• It does not include any safety margin and represents the best performance the airplane is capable of for the conditions.
<table>
<thead>
<tr>
<th>AFM Actual Landing Distance (Baseline Distance)</th>
<th>Operational Factors Affecting Landing Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>• $V_{REF}$ at 50’</td>
<td>• Speed &gt; $V_{REF}$ at 50’ (+)</td>
</tr>
<tr>
<td>• Cross threshold at 50’</td>
<td>• High (+) or Low (-)**</td>
</tr>
<tr>
<td>• Approach angle between 2.5° &amp; 3.5°</td>
<td>• Published glide path (+) or (-)</td>
</tr>
<tr>
<td>• Dry runway</td>
<td>• Non-dry runway (+)</td>
</tr>
<tr>
<td>• Zero slope</td>
<td>• Up-slope (-), or down-slope (+)</td>
</tr>
<tr>
<td>• Touchdown 1,000’ from threshold</td>
<td>• Normal sink rate (+) or (-)</td>
</tr>
<tr>
<td>• Touchdown sink rate 2-6 fps (maximum 8 fps)</td>
<td>• Extended flare, touchdown beyond 1,000’ (+)</td>
</tr>
<tr>
<td>• Standard Temp (TAS)</td>
<td>• Non-standard temperature (+) or (-)</td>
</tr>
<tr>
<td>• Maximum manual braking</td>
<td>• Less than maximum braking or auto brakes (+)</td>
</tr>
<tr>
<td>• No credit for thrust reversers</td>
<td>• Thrust reversers (-)</td>
</tr>
</tbody>
</table>
Hazards of Low or Shallow Approach

Numerous hazards exist if the pilot attempts to touchdown prior to the target touchdown point (1000’):

1. Obstacle clearance in the visual segment compromised.

2. Risk of premature MLG touchdown prior to the runway threshold

A Shallow Approach or Crossing Threshold Low May Result In Obstacle Contact or Touchdown Prior to Runway

AND IS NEVER ADVISED!
# Effects of Operational Factors

Ref: AC 91-79 – Table 2

<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible Effect on Landing Distance</th>
</tr>
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<tbody>
<tr>
<td>Non-stabilized Approach</td>
<td>Unpredictable</td>
</tr>
<tr>
<td>Excess Airspeed</td>
<td></td>
</tr>
<tr>
<td>Dry Runway</td>
<td>Additional 300 feet per 10 knots</td>
</tr>
<tr>
<td>Wet Runway</td>
<td>Additional 500 feet per 10 knots</td>
</tr>
<tr>
<td>Extended Flare (Floating)</td>
<td>Additional 2500 feet per 10 knots</td>
</tr>
<tr>
<td>Normal Airspeed</td>
<td></td>
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<td>Negative Runway Slope</td>
<td>Additional 10 percent of landing distance per 1 percent downhill slope</td>
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<tr>
<td>Delayed Touchdown</td>
<td>Additional 230 feet per second (fps)</td>
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<tr>
<td>Excessive TCH</td>
<td>Additional 200 feet per 10 feet above TCH</td>
</tr>
<tr>
<td>Delayed Braking</td>
<td>Additional 220 fps</td>
</tr>
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</table>
Operating Rules

- Landing distances determined during certification tests are aimed at demonstrating the shortest landing distances for a given airplane weight with a test pilot at the controls.

- Are established with full awareness that operational rules in part 121, part 135, and part 91K establish minimum operational field lengths for landing.
Part 121, 135, 91K Landing Field Length Requirement

• Sections §§ 121.195, 135.385, and 91.1037 prohibit the takeoff of a transport category airplane unless its weight on arrival, allowing for normal consumption of fuel and oil in flight, will allow a full stop landing at the intended destination airport within 60 percent of the Effective Runway Length.

• Three Considerations:
  – Aircraft is landed on the most favorable runway in still air, and
  – Aircraft is landed on the most suitable runway considering probable wind, landing aids and terrain.
  – If the runway is forecast to be wet or slippery at time arrival, the required field length is increased 15%.
Part 121, 135, 91K Landing Field Length Requirement

• Sections §§ 121.197, 135.387 prohibit the takeoff of a transport category airplane unless its weight on arrival, allowing for normal consumption of fuel and oil in flight, will allow a full stop landing at the alternate airport within 60 percent of the Effective Runway Length.

• Section § 91.1037 prohibit the takeoff of a transport category airplane unless its weight on arrival, allowing for normal consumption of fuel and oil in flight, will allow a full stop landing at the alternate airport within 80 percent of the Effective Runway Length.
Part 121, 135, 91K Dry Runway Landing Field Length Requirement

Part 121/135/91K Dry Runway Landing Field Length Requirement

Actual Landing Distance
(60% or 80%)

(40% or 20%)

Landing Distance Available (LDA)*

*Equivalent to “Effective Runway Length”
Part 121, 135, 91K Wet or Slippery Runway Landing Field Length Requirement

Part 121/135/91K Wet or Slippery Runway Landing Field Length Requirement

Actual [Dry Runway] Landing Distance

(60% or 80%)  (40% or 20%)  (15%)

Landing Distance Available (LDA)*

*Equivalent to “Effective Runway Length”
Part 121, 135, 91K Landing Field Length Requirement

- Some Part 91K and eligible on-demand Part 135 operators may substitute 80% in place of 60% if the operation is conducted in accordance with an approved Destination Airport Analysis contained in their program operations manual.

- Contact your Certificate Management Office (CMO) regarding how to apply for the applicable OpSpec/MSpec.
Part 121, 135, 91K Landing Field Length Requirement

• The intent of the regulations is to ensure that a flight operation does not begin that cannot reasonably be concluded upon reaching the destination or alternate airport, as applicable.

• Factored landing distance data provided in the AFM used for the assessment.

• Pre-departure planning requirement is a limitation on maximum allowable takeoff weight.
Compliance with the operating rules may not be enough to prevent a landing overrun
What Would You Do - Scenario

- Chicago Executive Airport (KPKW)
- Runway 16
  - ILS approach
  - Landing Distance Available – 5,001’
What Would You Do - Scenario

- **Chicago Executive Airport (KPKW) Weather:**
  - ETA TAF (Using ORD):
    
    KORD 22008KT 2SM -SHRA SCT015 BKN025 OVC030 PROB40
    xx20/xx24 1SM SN OVC010
- **Part 121, 135, 91K (60%) Landing Weight Limit:**
  - Wet runway
  - 29,532 lbs.
- **Planned Landing Weight:**
  - 29,000 lbs.
  - Actual Landing Distance = 2,578’
  - Wet Runway Factored Landing Distance = 4,950’
  - Landing Distance Available = 5,001’
What Would You Do - Scenario

• Chicago Executive Airport (KPWK) Weather:
  – Arrival Weather:
    KPWK xx2154Z 27009G18KT 1SM SN BR BKN009 BKN014
    OVC022 00/M01 A2984 RMK AO2
  – Field Condition NOTAM and ATIS Broadcast:
    • !PWK PWK RWY 16/34 FICON 1/4IN WET SN OBSERVED AT
      xxxxxxxxx2130.
Field Condition (FICON) NOTAM

- **Effective October 1, 2013**

- Aid in identifying a contaminated runway.

- Intended to correlate to transport airplane contaminated runway data.

- * = Reporting depth measurement required with contaminant type.

- Permits use of FICON report with contaminated runway takeoff and landing distance data.

<table>
<thead>
<tr>
<th>Contaminant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (⅛ inch and greater)</td>
</tr>
<tr>
<td>Frost</td>
</tr>
<tr>
<td>Slush*</td>
</tr>
<tr>
<td>Ice</td>
</tr>
<tr>
<td>Wet ice</td>
</tr>
<tr>
<td>Water* over ice</td>
</tr>
<tr>
<td>Wet snow*</td>
</tr>
<tr>
<td>Wet snow* over ice</td>
</tr>
<tr>
<td>Dry snow*</td>
</tr>
<tr>
<td>Dry snow* over ice</td>
</tr>
<tr>
<td>Compacted snow</td>
</tr>
<tr>
<td>Water* over compacted snow</td>
</tr>
<tr>
<td>Wet snow* over compacted snow</td>
</tr>
<tr>
<td>Dry snow* over compacted snow</td>
</tr>
<tr>
<td>Ash*</td>
</tr>
<tr>
<td>Mud*</td>
</tr>
<tr>
<td>Rubber</td>
</tr>
<tr>
<td>Oil</td>
</tr>
<tr>
<td>Sand</td>
</tr>
</tbody>
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Field Condition (FICON) NOTAM

- Contaminant depth reported.
  - Fractions up to 1”
  - Inches up to 35”, then by feet.

- A runway is not considered “contaminated if:
  - If contaminant is described as “THIN”, meaning depth is less than 1/8”, or
  - If contaminant is described as “PATCHY”, meaning coverage is 25% or less.

Use value “1/8IN” to report 1/8 inch
Use value “1/4IN” to report > 1/8 inch to and including 1/4 inch
Use value “1/2IN” to report > 1/4 inch to and including 1/2 inch
Use value “3/4IN” to report > 1/2 inch to and including 3/4 inch
Use value “1IN” to report > 3/4 inch to and including 1 inch
What Actions Should The Flightcrew Take In Response To The FICON NOTAM?

!PWK PWK RWY 16/34 FICON 1/4IN WET SN OBSERVED AT xxxxxxxxxx2130
PREDEPARTURE Landing Distance Planning

PREDEPARTURE Landing Distance Assessment 91.103

Time of Arrival Landing Distance Assessment 91.103
Landing Distance Assessment


• AC 91-79, Runway Overrun Prevention (2007) expands on the guidance provided in SAFO 06012 & provides guidance to part 91 operators of turbine-powered airplanes.

• Both documents recommend landing distance assessment using real-time field conditions.

• Different calculation from normal pre-departure calculation based on your operating rules.
Landing Distance Assessment

• **Who** – Recommendation to all operators (Parts 121, 135, 91K and 91) of turbine-powered, transport category airplanes.

• **What** – Calculate the actual landing distance based on best available data (e.g. AFM supplementary contaminated runway landing distance data). To this actual landing distance for runway & weather conditions, add an additional 15% safety margin to account for variations in achieved performance. The result is the recommended minimum runway length for landing. If contaminated runway data is not available, use SAFO 06012 Table 2 factors and apply them to the “Factored Landing Distance” to determine the minimum runway required.

• **When** – Preferably, considered during in pre-flight planning. However, completed not later than committing to a landing at the destination airport or alternate airport.

• **Why** – Conditions may change from assumptions made during pre-departure planning. Pre-departure operating rule margins are insufficient for other than dry or “wet” runways.
May be used with transport airplanes without supplemental contaminated runway landing distance data.

<table>
<thead>
<tr>
<th>Runway Condition</th>
<th>Reported Braking Action</th>
<th>Factor to apply to (factored) dry runway landing distance*</th>
</tr>
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<tbody>
<tr>
<td>Wet Runway, Dry Snow</td>
<td>Good</td>
<td>0.9</td>
</tr>
<tr>
<td>Packed or Compacted Snow</td>
<td>Fair/Medium</td>
<td>1.2</td>
</tr>
<tr>
<td>Wet snow, shish, standing water, ice</td>
<td>Poor</td>
<td>1.6</td>
</tr>
<tr>
<td>Wet ice</td>
<td>Nil</td>
<td>Landing is prohibited</td>
</tr>
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</table>

- Actual Landing Distance = 2,578’
- 60% Dry Factored Landing Distance = 4297’
- Minimum Runway Length Required for Wet Snow (4297’ x 1.6) = 6875’
- Includes the 15% safety margin recommended in SAFO 06012
Landing Distance Assessment – Using Supplemental Contaminated Runway Data

KPWK xx2154Z 27009G18KT 1SM SN BR BKN009 BKN014 OVC022 00/M01 A2984 RMK AO2

!PWK PWK RWY 16/34 FICON 1/4IN WET SN OBSERVED AT xxxxxxxx2130

- Actual Landing Distance = 4,288’
- Additional 15% Safety Margin = 4,931’
- Landing Distance Available – 5,001’

Can You Stop?
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</tr>
<tr>
<td><strong>U—Understand</strong></td>
</tr>
<tr>
<td><strong>S—Stabilize</strong></td>
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<td><strong>P—Professional</strong></td>
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Can You Land Like A Professional?

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Well defined and enforced SOPs are one key method to ensuring safe and repeatable landing operations. SOPs should include:

- Stabilized approaches to include executing a go-around if approach parameters are exceeded
- Landing distance reassessment at the time of arrival methodology (SAFO 06012 & AC 91-79)
- Factors under the pilot’s control:
  - Consideration of landing weight.
  - Selection of landing flaps.
  - Threshold crossing height & approach angle.
  - Threshold crossing airspeed.
  - Touchdown point & landing flare technique.
  - Use of brakes and other deceleration devices
Don’t Let this be You
Please keep in mind…

75% of Business Jet Runway Excursions Occur on a DRY Runway > 5,000 feet!
Runway Excursion Characteristics

• **Unstable Approach** (too low / too slow OR too high / too fast)
• **Go-Around Decision**
• **Late Rejected Takeoff Decision or Rejecting Takeoff after \( V_1 \) Speed**
• **Runway Condition** (wet/contaminated, slope)
• **Mechanical Issues** (Stuck brake pedal)
• **Runway Selection** (tailwind/crosswind, too short)
• **Inaccurate Takeoff & Landing Performance and Weight and Balance Calculations**

* Note: There are many factors that can contribute to an RE. This is not intended to be an exhaustive list of characteristics.
Runway Excursions - Type

Counts (n=548)

Takeoff

Landing

Most common

Most injuries/fatalities

80%

20%
Why focus on Runway Excursions?

1. **The majority of the runway safety accidents and fatalities occur in the runway excursion area.**
2. **Costly**
   - Aircraft and airport property damage, airport delays
   - Estimated at $900 million annually (*NLR-ATSI*)
3. Over 120 reported U.S. General Aviation REs in first six months of 2013
4. Excursions at airports in densely populated areas brings huge risks to airport neighbors
5. **By discussing and understanding RE characteristics, the hazards can be mitigated**
Runway Excursion:
The most common type of runway accident

If you can’t keep it on the runway there is a high probability of aircraft damage, injury or fatality.
Landing Excursions – Top 10 Factors
All Aircraft

- Delayed Touchdown: Additional 230 feet per second (fps)
- Delayed Braking: Additional 220 fps

- Dry Runway: Additional 300 feet per 10 knots
- Wet Runway: Additional 500 feet per 10 knots
Consequences?
Round-Table Discussion
Today’s Realities

• There are significant complexities today about Part 25 aircraft performance, operating rules, and the other factors influencing performance calculations that were not present 50 years ago
Additional References

- Advisory Circular (AC) 91-79, Runway Overrun Prevention
- AC 120-71, Standard Procedures for Flight Deck Crewmembers
- AC 121.195-1, Operational Landing Distances for Wet Runways; Transport Category Airplanes
- SAFO 06012, Landing Performance Assessment at Time of Arrival
Additional Resources

• Skybrary
  http://www.skybrary.aero/index.php/Runway_Excursion

• CANSO – RE Mobile Website
  http://www.cansosafety.com/

• IATA’s Runway Excursion Risk Reduction Toolkit
  http://www.iata.org/publications/Pages/runway-toolkit.aspx
Summary of TAPP Work to Date

The Transport Airplane Performance Planning Group videos are the definitive technical work available in the US today on the major subjects covered. Those include:

- Departure Planning (Aspen)
- Understanding Declared Distances
- Wet Runway Takeoff Performance
- Effect of Slope on Takeoff Performance
- Divergent Departure Procedures
- Landing Distance Assessments
Where to find the videos

• NBAA Website:


• Aircraft Performance Group Website:

http://www.flyapg.com/
Closing Remarks

- Operators must understand the data presented in their AFM vs. normal operating performance
- Utilizing AFM landing data and pertinent operating rules only ensures compliance
- FAA urgently recommends landing distance assessment using real-time field conditions
- Properly developed SOPs and adherence to the stabilized approach will reduce the possibility of landing overruns
Acknowledgments

• Bombardier
• Jeppesen
• APG (Aircraft Performance Group)
• ASAP (Automated Systems in Aircraft Performance)
• Boeing Commercial Group
• Delta Air Lines Performance Engineering
• National Business Aviation Association
Additional Slides
Part 25 – Landing Distance Changes With AC 25-7C

Ground Distance Assumptions:
- Normal Wheel Brakes (Anti-Skid, If Equipped)
- Spoilers (or Lift Dumps)
- No Thrust Reverser Credit

Part 25 Landing Distance (Change AC 25-7C)