Operations & Performance

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10 July 2019

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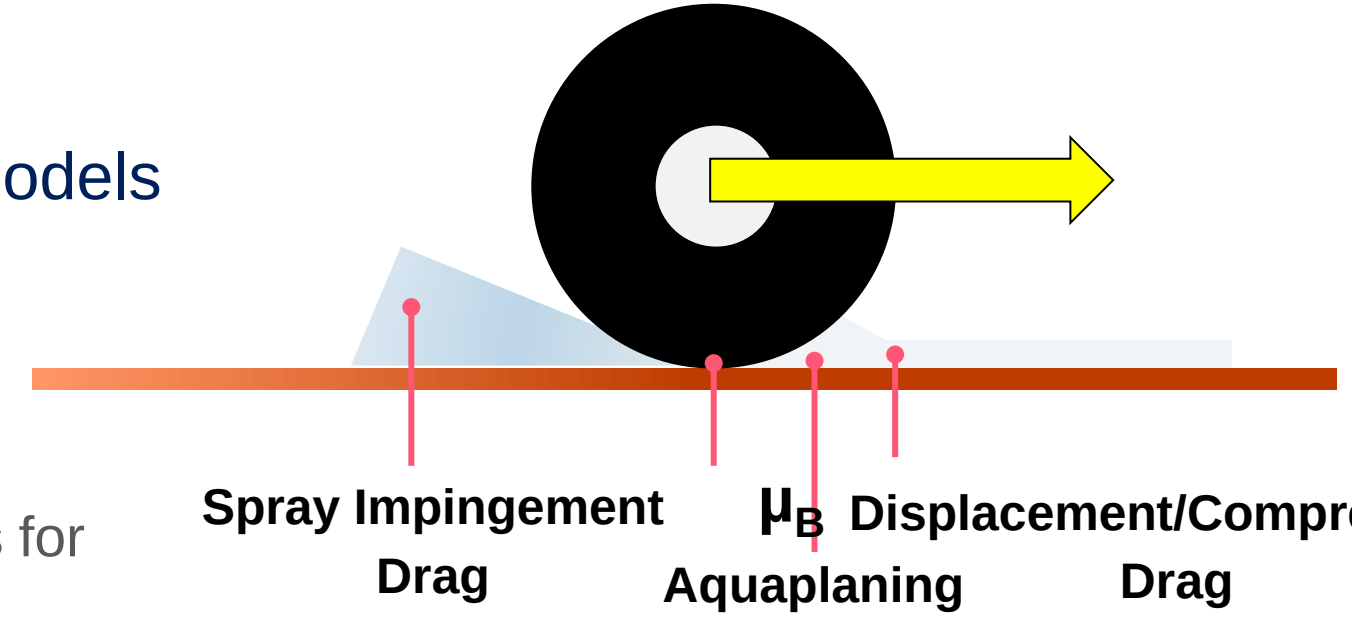
Effect of Runway Condition on Aircraft Performance

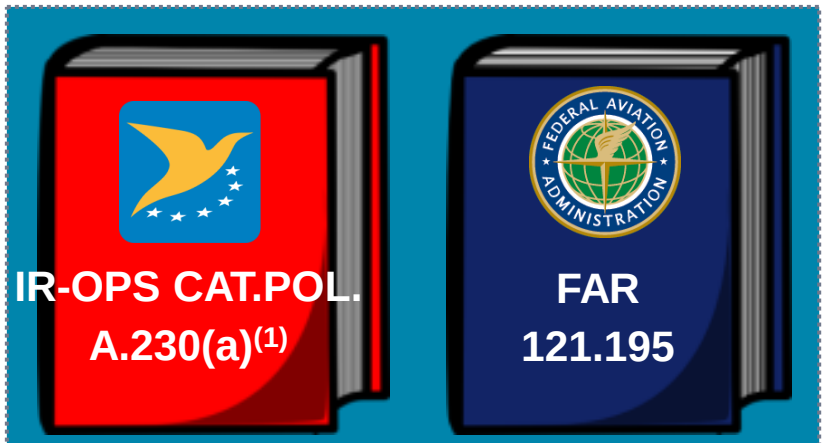
Effects in Performance Models



Braking Performance accounts for

Effect	Dry/Wet	Hard Contaminants	Fluid Contaminants
Effective wheel to ground friction	Yes	Yes	Yes
Displacement Drag	-	-	Yes
Compression Drag	-	-	Yes
Impingement Drag	-	-	Yes
Aquaplaning	-	-	Yes

Current Regulatory Dispatch Requirements



$RLD_{dry} = ALD / 0.6$

$RLD_{wet} = 1.15 \times RLD_{dry}$

$RLD_{conta} = \text{Max of} \begin{cases} 1.15 \times ALD_{conta} \\ RLD_{wet} \end{cases}$

RLD shorter than Landing Distance Available (LDA)

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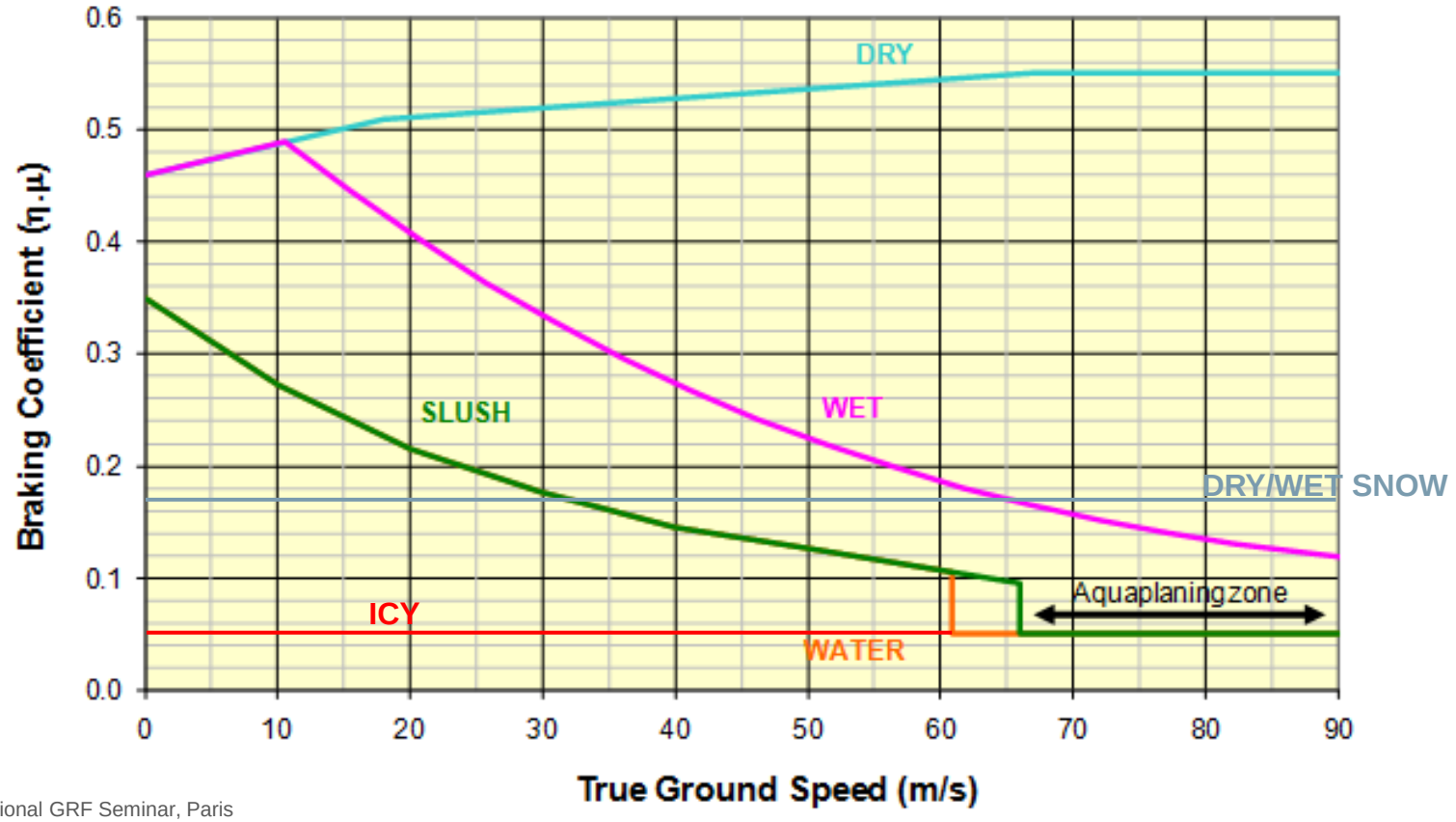
EASA Dispatch Requirements for contaminated runways

- Under EASA regulation CS25.1591 manufacturers may publish takeoff and landing performance for contaminated runways
- Associated AMC provides friction models for various contaminants



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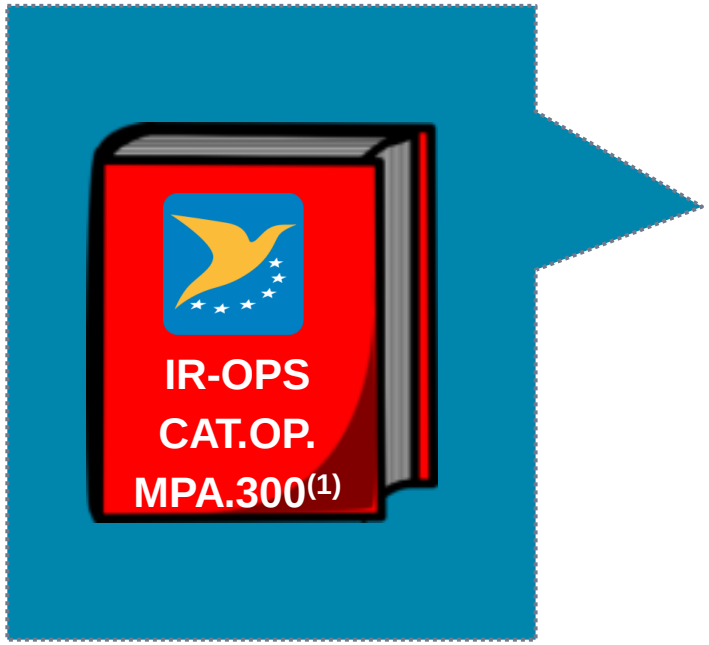
Current Regulatory In-Flight Requirements



The flight crew must check that a safe landing can be performed in the expected conditions

(1) Former EU-OPS 1.400

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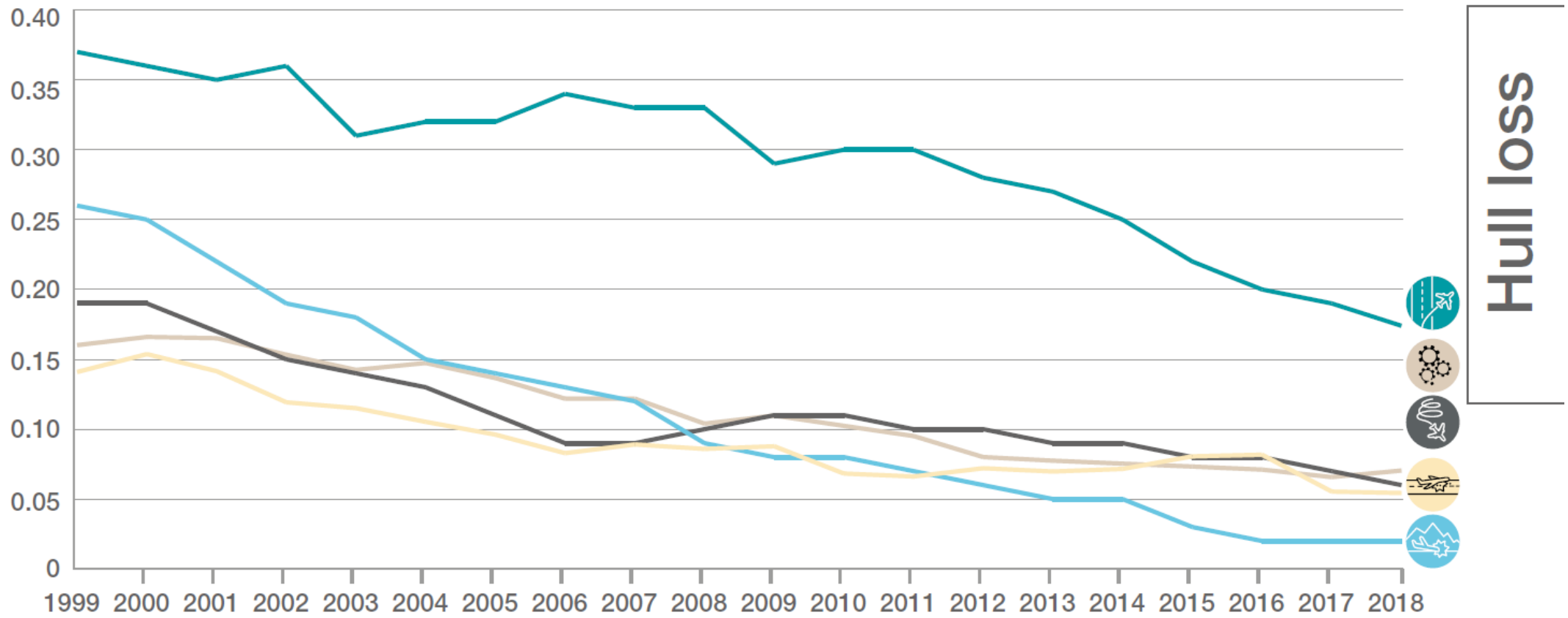
Accident Statistics

10 year moving average hull loss rate by accident category per million flights



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Situation of the Industry Today

Conta

Different terminology

Different contaminant types

Insufficient depth accuracy

Friction

No correlation with A/C performance

Not up to date

PIREP

Not objective

Ops Doc

Perfo.

Def.

Proc.

Reporting NOT Performance-Relevant

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ICAO Friction Task Force Jobcard

PART I

Category	**Safety**	Sustainability	Implementation	Reference: AP001
Title	Assessment and reporting of runway surface conditions			
Proposed by	Secretariat/WG-PDP			
Problem Statement	Runway surface conditions have contributed to many safety events and investigations have revealed shortfalls in the accuracy and timeliness of assessment and reporting methods currently provided for in ICAO provisions and guidance material			
Specific Details (including impact statements)	While techniques for the measurement of runway friction provide useful information for runway surface friction maintenance purposes, they are not suitable in all we… could be misleading to pilots. Reports used by pilots need to … ports that are directly related to the performance of t… essing conditions for reports. In addition, both airport oper… mp" and "slippery when wet", and how to use it effectively. … able or under development, and need to			

…need reports that are directly related to the performance of the aircraft.

Runway surface conditions have contributed to r… d shortfalls in the accuracy and timeliness of assessment and reporting methods currently pro…

Rationale for acceptance/rejection				
Action already in progress	Current work pro…		PANS-Aerodromes	
Interdependencies/References	AN-WP/8571 PD…			

Required Action				Timescales (for deliverable)
1	Develop provisions for the reporting of runway surface conditions	AP/PASG	Proposed amendments to Annex 14 Volume 1 and other related Annexes Proposed amendments to PANS-Aerodromes and PANS-ATM	Q2/2014 Q2/2015
2	Develop guidance material for the assessment of runway surface conditions, including friction level and where contamination exists	AP/PASG	Proposed amendments to PANS-Aerodromes Proposed amendments to Doc 9137	Q2/2015 Q1/2016
3	Develop guidance material for the measurement and maintenance of runway friction	AP/PASG	Proposed amendments to PANS-Aerodromes Proposed amendments to Doc 9137	Q2/2015 Q1/2016

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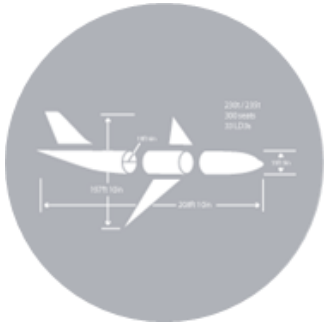
End to End System

Aerodromes



Manufacturers

Operators

Common Language

Contaminant Types

Runway Condition Codes

Direct Input to Performance Assessment

Performance Relevance

Depth Thresholds & Temperatures

Significant Changes

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Airworthiness – Annex 8

- Option for takeoff performance on contaminated runway
- Mandate split of landing performance information into
  - At Time of Takeoff data (dispatch)
  - At Time of Landing data (in-flight)
- New At Time of Landing Distances shall reflect real operating practices
- Both types of landing distances may be provided for contaminated runways

Operations - Annex 6

- For large and small airplanes
- Mandate AIREP when conditions worse than reported
- Mandate in-flight check with appropriate margin before starting approach

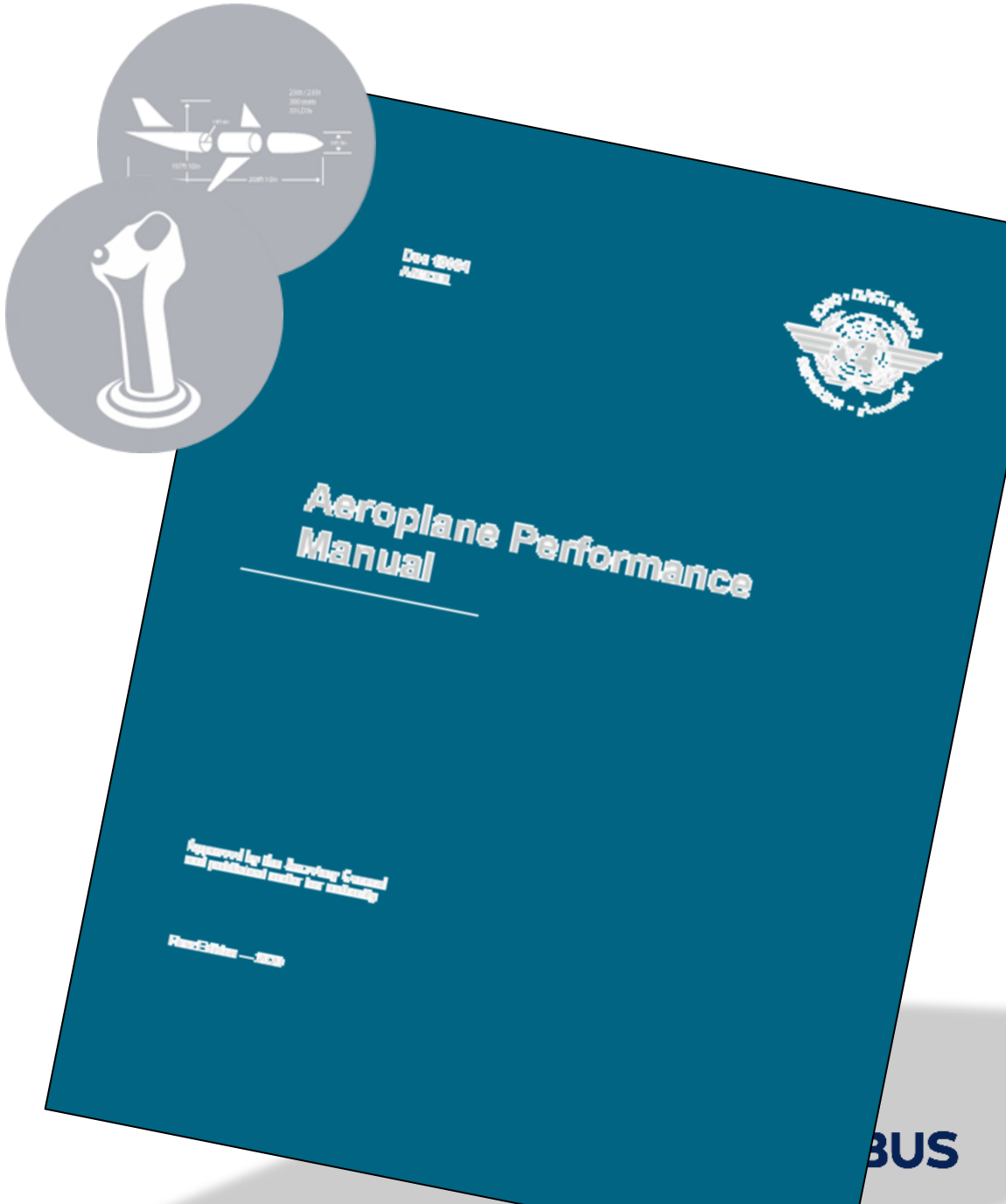
Aeroplane Performance Manual

- Introduction to Operations on Contaminated Runways
- 4 Flight-Phase oriented Chapters
  - Take-off
  - En-Route
  - Landing
  - Missed Approach

- **Clear Focus on GRF**

- Other information considered as non-controversial
- Based on existing national guidance and practices

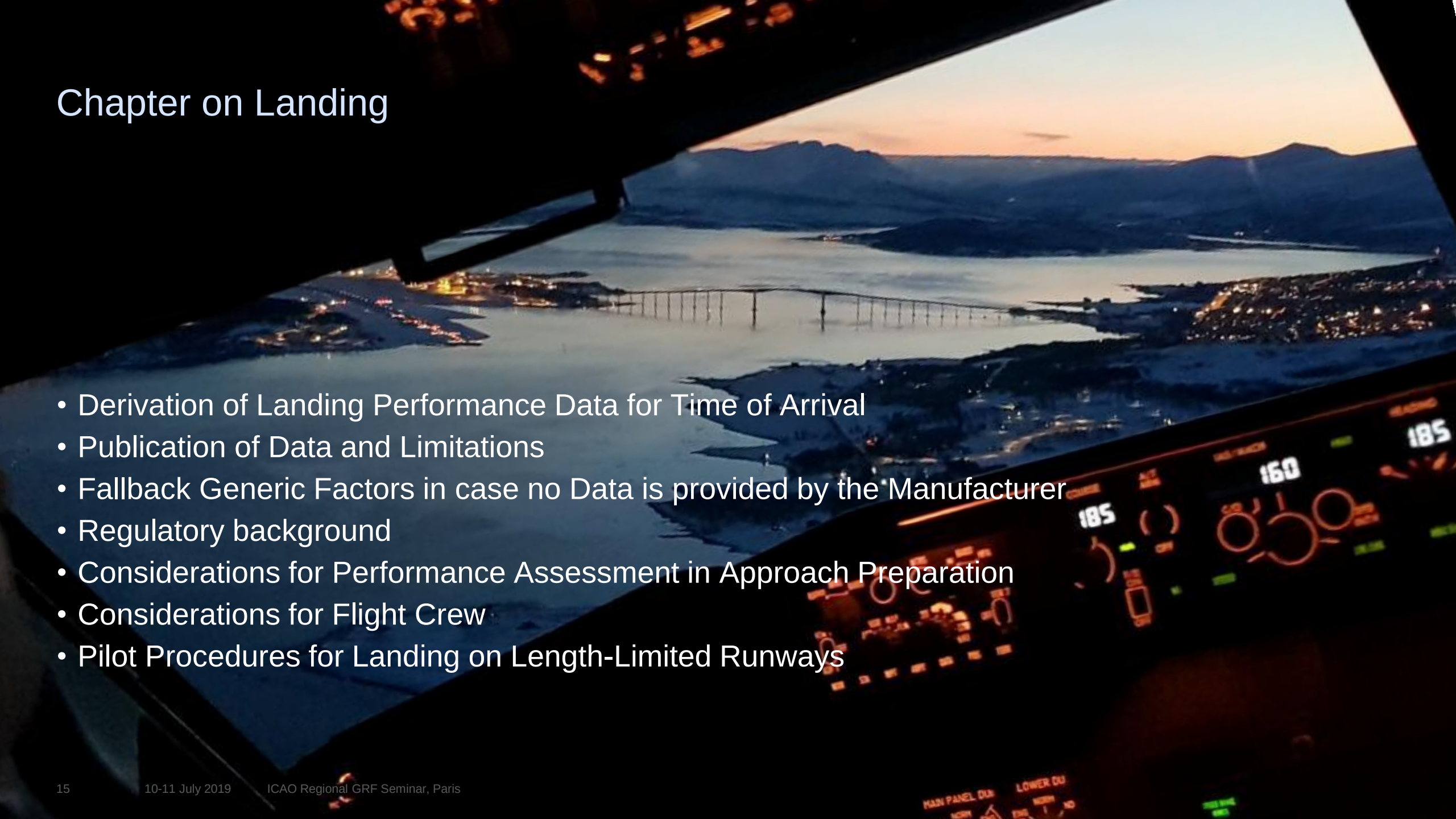
- Still under Review by Ops Section



Chapter on Operations On Contaminated Runways

- Description of the RCR for Operators and Pilots
- Introduction to the Assessment Process applied by the Aerodrome
- Description and use of the RCAM and RWYCC
- Considerations for making AIREPs of Braking Action
- Training Syllabus

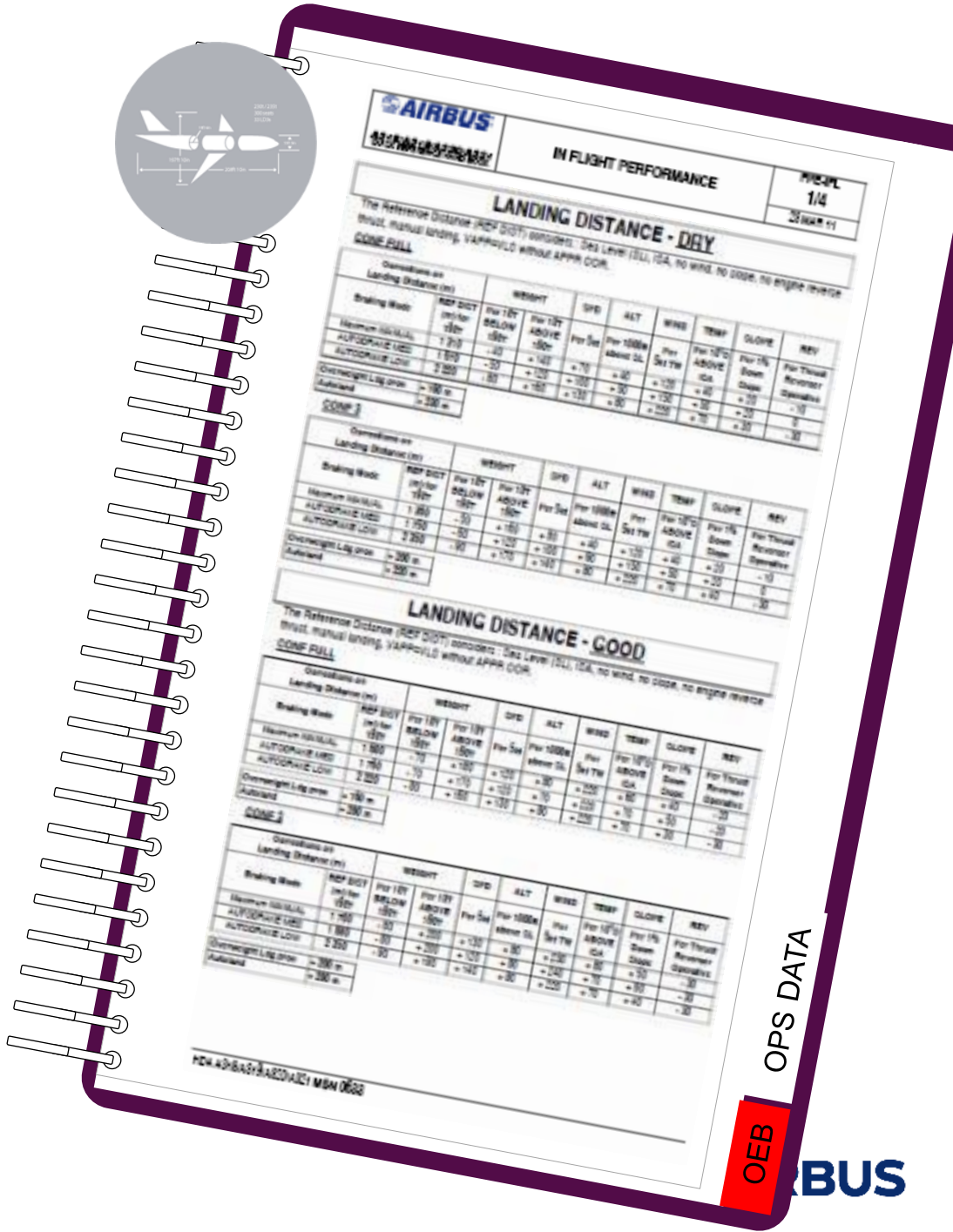
Chapter on Landing



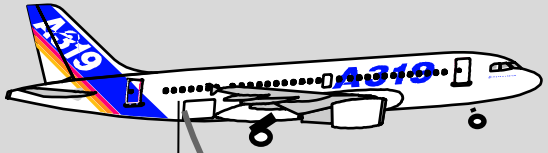
- Derivation of Landing Performance Data for Time of Arrival
- Publication of Data and Limitations
- Fallback Generic Factors in case no Data is provided by the Manufacturer
- Regulatory background
- Considerations for Performance Assessment in Approach Preparation
- Considerations for Flight Crew
- Pilot Procedures for Landing on Length-Limited Runways

Guidance for Manufacturers

- Publish Operational Landing Distances
  - "Minimum" Compliance with principles
    - Cover all 6 friction levels
    - Introduce Accountability for
      - Temperature effect
      - Runway slope effect
      - Approach speed increment effect



NO MARGIN



ACTUAL LDG DIST

DRY
WET
WATER
SLUSH
SNOW
ICE

V_{REF} V_{TD} STOP

Demo/Regul

ISA

15% MARGIN

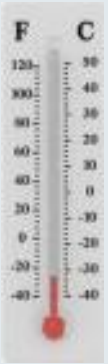
IN-FLIGHT LDG DIST

DRY
GOOD
GOOD TO MEDIUM
MEDIUM
MEDIUM TO POOR
POOR

V_{APP} V_{TD} STOP

%

Operational



OAT

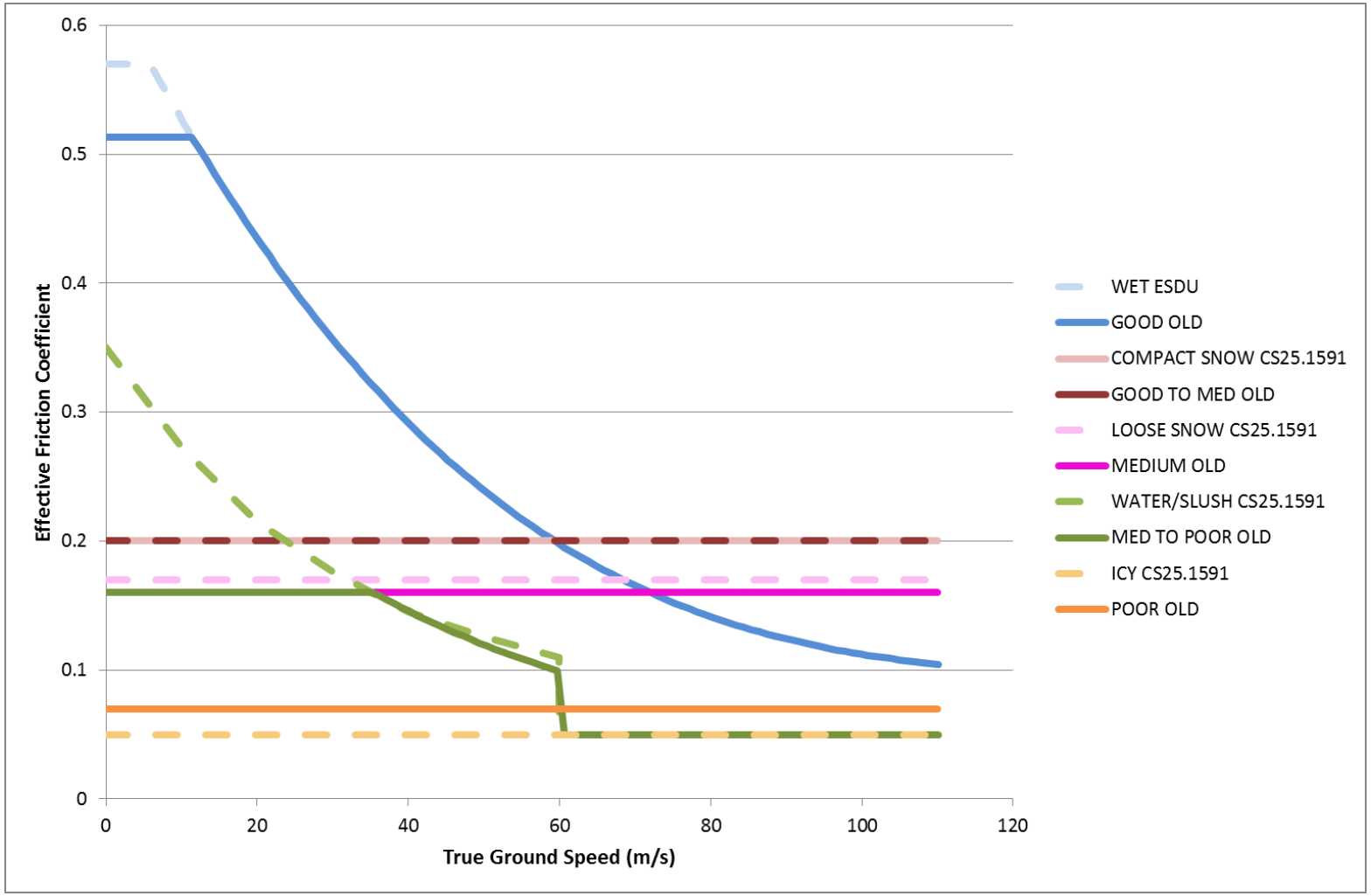
ICAO Doc 10064 Aeroplane Performance Manual

- Provides the effective wheel to ground coefficient for each RWYCC
- Not specific to an individual aeroplane
- Adaptable to the anti-skid system type
- Ensures harmonized Landing Distances at Time for Arrival between all types

RWYCC	Runway Surface Condition Description	Pilot-Reported Braking Action	Wheel Braking Coefficient
6	DRY	—	90 per cent of certified value used to comply with Annex 8 Part IIB 2.2.7 e)[1].
5	FROST WET (The runway surface is covered by any visible dampness or water up to and including 3mm deep.) SLUSH (up to and including 3mm depth) DRY SNOW(up to and including 3mm depth) WET SNOW(up to and including 3mm depth)	Good	Per method defined in Note 2 below.
4	COMPACTED SNOW (Outside air temperature minus 15 degrees Celsius or below)	Good to Medium	0.20[3]
3	WET ("Slippery Wet" runway) DRY SNOW (more than 3mm depth) WET SNOW (more than 3mm depth) DRY SNOW ON TOP OF COMPACTED SNOW (Any depth) WET SNOW ON TOP OF COMPACTED SNOW (Any depth) COMPACTED SNOW (Outside air temperature above minus 15 degrees Celsius)	Medium	0.16[3]
2	STANDING WATER (more than 3mm depth) SLUSH (more than 3mm depth)	Medium to Poor	(1) For speeds below 85 per cent of the aquaplaning speed[3]: 50 per cent of the wheel braking coefficient determined for RWYCC=5, but no greater than 0.16; and (2) For speeds at 85 per cent of the aquaplaning speed[4] and above: 0.05[3].
1	ICE	Poor	0.07[3]

ICAO Doc 10064 Aeroplane Performance Manual

- Provides the effective wheel to ground coefficient for each RWYCC
- Not specific to an individual aeroplane
- Adaptable to the anti-skid system type
- Ensures harmonized Landing Distances at Time for Arrival between all types
- Based on existing EASA guidance on contaminated runway friction from historic flight tests



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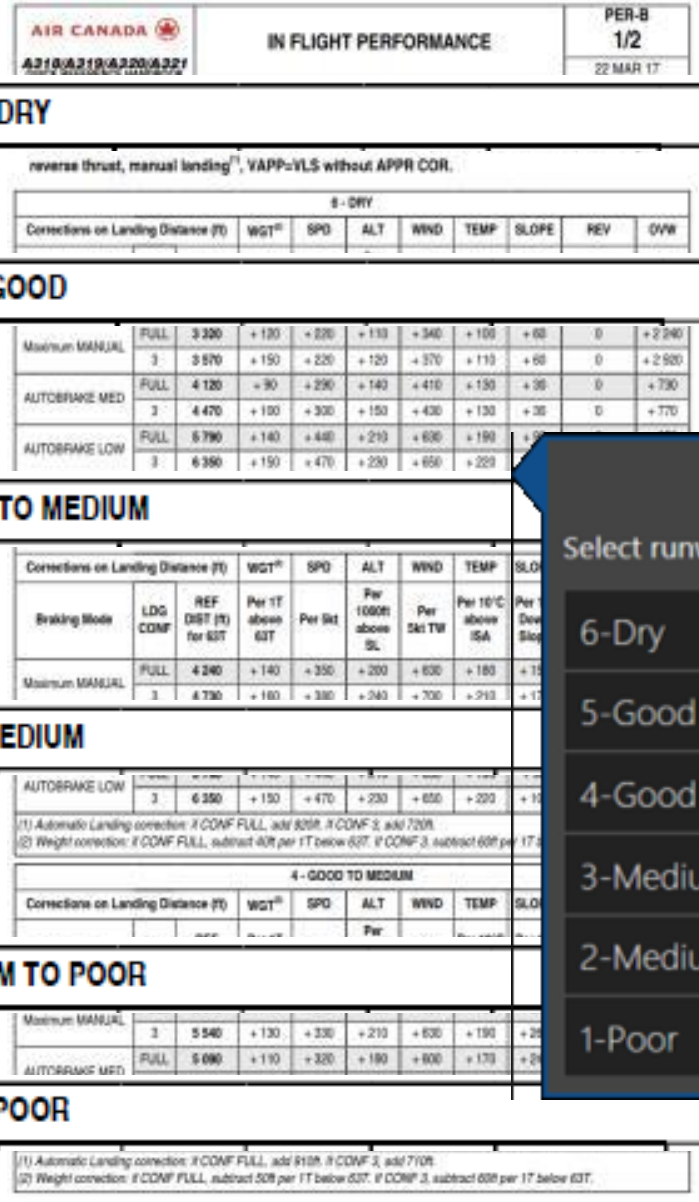
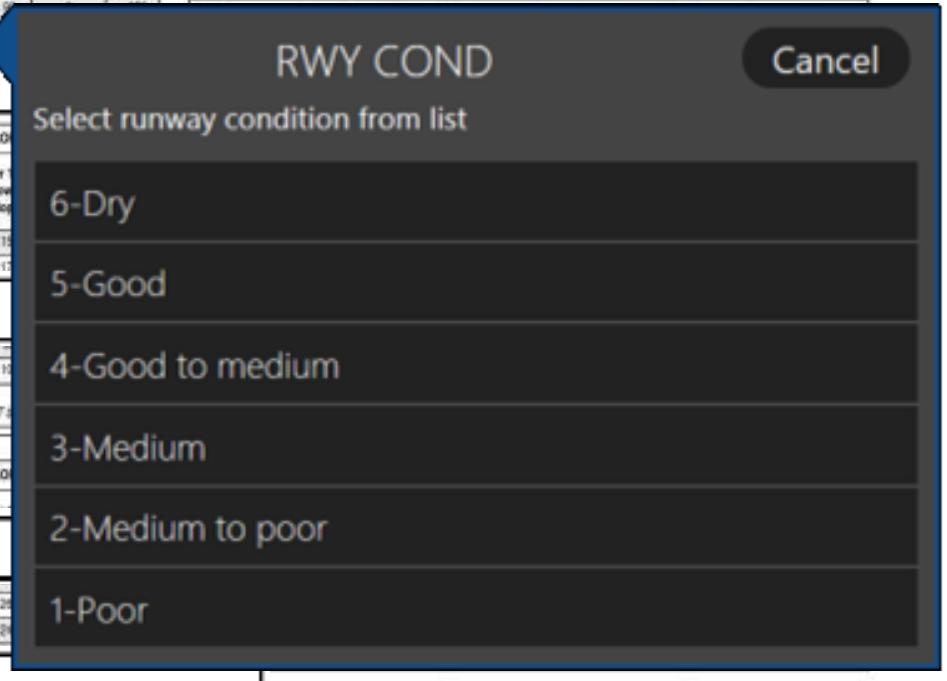
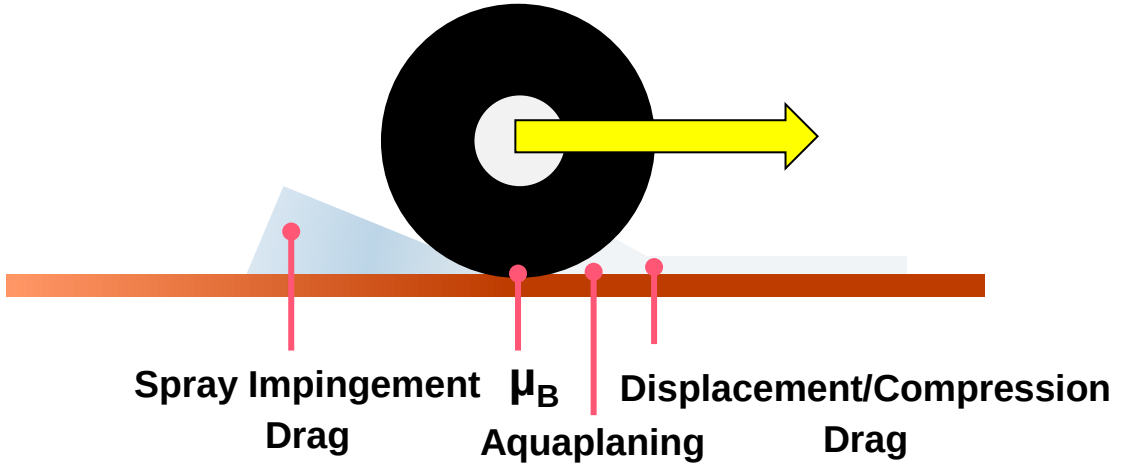
Runway Condition Code – Direct Input to Landing Distance Computation

Runway condition code	
6	6 - DRY
5	5 - GOOD
4	4 - GOOD TO MEDIUM
3	3 - MEDIUM
2	2 - MEDIUM TO POOR
1	1 - POOR





Chapter on the Situation for Takeoff



- RWYCC provides information on friction only
- At takeoff fluid contaminants generate drag
  - Displacement
  - Compression
  - Impingement
- Takeoff can be limited by
  - Distance needed to accelerate to lift-off speed
  - Distance needed to accelerate to decision speed V1 and come to full stop on available runway
- Contaminant drag must be accounted for in takeoff computations

Takeoff computation must be done for prevailing contaminant!

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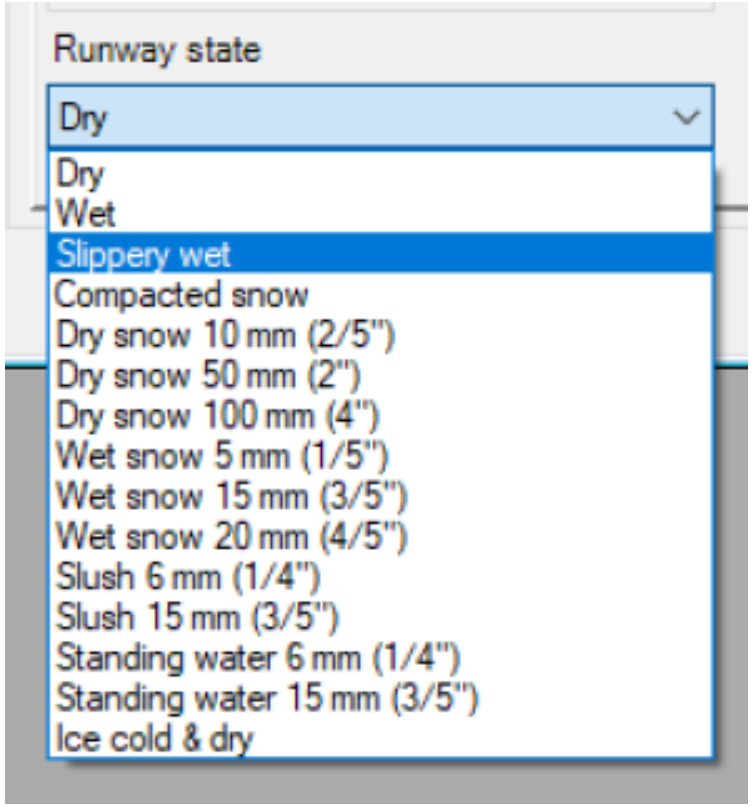
Takeoff

Computation with Contaminant Type and Depth

- Takeoff performance presented for contaminant type and depth



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Takeoff

Computation with Contaminant Type and Depth

- Typical manufacturer data certified to CS25 pre-Amdt 2 does not cover many contaminants in the RCAM
- Missing:
  - Frost
  - Dry Snow
  - Wet Snow
  - Compacted Snow at OAT above -15ºC
  - Slippery When Wet
  - Ice Cold & Dry

- APM offers advice on how to compute for missing contaminants conservatively

Runway condition assessment matrix (RCAM)			
Assessment criteria		Downgrade assessment criteria	
Runway condition code	Runway surface description	Aeroplane deceleration or directional control observation	Pilot report of runway braking action
6	• DRY	---	---
5	• FROST • WET (The runway surface is covered by any visible dampness or water less than 3 mm deep) ***Less than 3 mm depth:*** • SLUSH • DRY SNOW • WET SNOW	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	GOOD
4	***-15ºC and Lower outside air temperature:*** • COMPACTED SNOW	Braking deceleration OR directional control is between Good and Medium.	GOOD TO MEDIUM
3	• WET ("Slippery wet" runway) • DRY SNOW or WET SNOW (Any depth) ON TOP OF COMPACTED SNOW ***3 mm and more depth:*** • DRY SNOW • WET SNOW ***Higher than -15ºC outside air temperature[1]:*** • COMPACTED SNOW	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	MEDIUM
2	***3 mm and more depth of water or slush:*** • STANDING WATER • SLUSH	Braking deceleration OR directional control is between Medium and Poor.	MEDIUM TO POOR
1	• ICE [2]	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	POOR
0	• WET ICE [2] • WATER ON TOP OF COMPACTED SNOW [2] • DRY SNOW or WET SNOW ON TOP OF ICE [2]	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	LESS THAN POOR

Takeoff

Computation with Downgraded RWYCC

METAR

PAMC 13$^{09:53\ Z}$ AUTO 000°00^{KT} 10SM CLR M09/M12
A2972 *RMK AO2 SLP073 T10891117 TSNO=*

FICON

!MCG 03/104 MCG RWY 05 FICON 2/2/2 100 PCT
COMPACTED SN OBS AT 1803121907. 1803121907-
1803131907

APM recommends “to delay take-off. However, […], it may be sufficient to determine performance in nominal conditions and to adopt appropriate operational procedures such as considering reduced crosswind limits, using the full length of available runway and avoiding rolling take-off.”

Runway condition assessment matrix (RCAM)			
Assessment criteria		Downgrade assessment criteria	
Runway condition code	Runway surface description	Aeroplane deceleration or directional control observation	Pilot report of runway braking action
6	• DRY	---	---
5	• FROST • WET (The runway surface is covered by any visible dampness or water less than 3 mm deep) ***Less than 3 mm depth:*** • SLUSH • DRY SNOW • WET SNOW	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	GOOD
4	***-15°C and Lower outside air temperature:*** • COMPACTED SNOW	Braking deceleration OR directional control is between Good and Medium.	GOOD TO MEDIUM
3	• WET (“Slippery wet” runway) • DRY SNOW or WET SNOW (Any depth) ON TOP OF COMPACTED SNOW ***3 mm and more depth:*** • DRY SNOW • WET SNOW ***Higher than -15°C outside air temperature[1]:*** • COMPACTED SNOW	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	MEDIUM
2	***3 mm and more depth of water or slush:*** • STANDING WATER • SLUSH	Braking deceleration OR directional control is between Medium and Poor.	MEDIUM TO POOR
1	• ICE [2]	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	POOR
0	• WET ICE [2] • WATER ON TOP OF COMPACTED SNOW [2] • DRY SNOW or WET SNOW ON TOP OF ICE [2]	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	LESS THAN POOR

A) ENNK
B) 11 JAN 2013 04:43
C) 01 F) 379/379/379 G) XX/XX/XX H) 3/4/4
N) C/CLSD ALL REMAINING TWYS/379
R) APRON B/CLSD ALL REMAINING APRONS/379
T) CONTAMINATION/100/100/100/PERCENT. SAND APPLIED.

UUEE 050230Z 17004MPS 0900 R25R/P1500U +SHSN VV004
M01/M01 Q1017 **75590230 25590230**

Landing Performance Level

Direct input into At Time of Arrival Assessment

ENCN 09111400 09L **3/3/2** 25/50/50 05/05/02 DRY SNOW/WET SNOW/WET SNOW 30.
DRIFTING SNOW. RWY 09L CHEMICALLY TREATED. TWY B POOR

Thank you

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