GRF – Aeroplane Manufacturer View

Relevance to Aeroplane Performance

Lars Kornstaedt / Rapporteur Friction Task Force – Annex 6/8 Subgroup

26 March 2019

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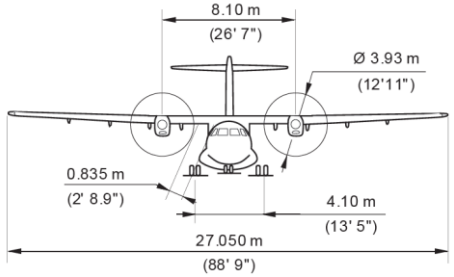
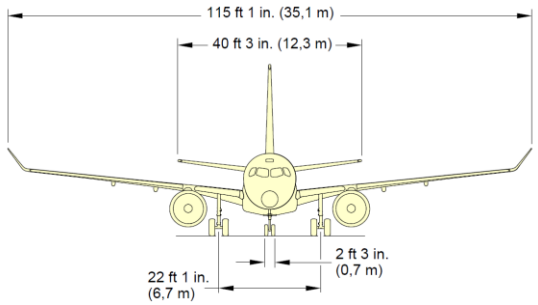
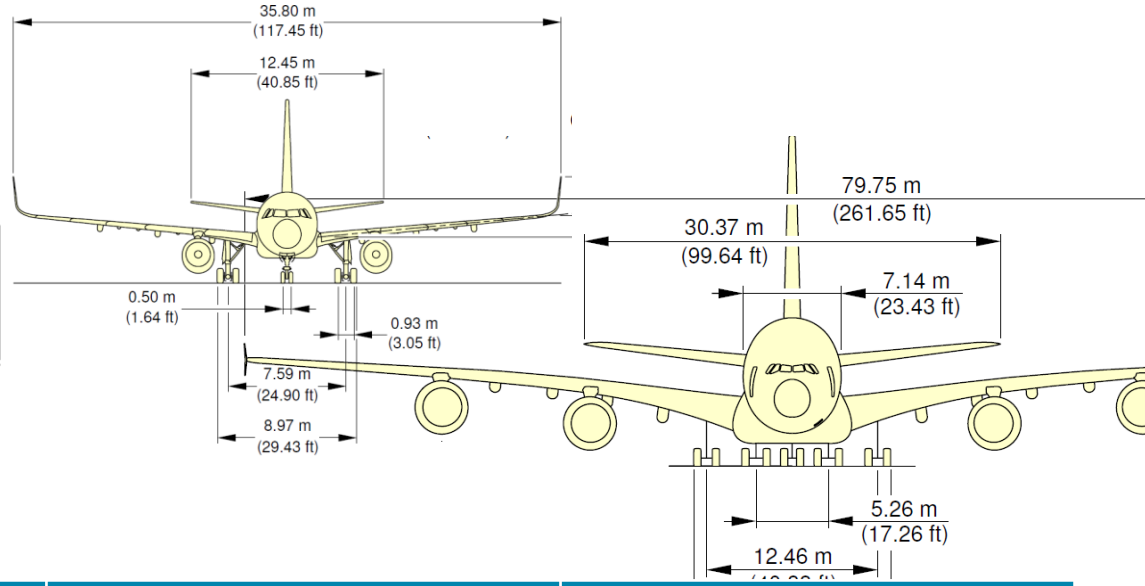
Aeroplanes are not all the same







Type	ATR72-600	A220-300	A321NX	A380-842
Track	4.1m	6.7m	7.6m	12.5m
MLW	22.8t	58.7t	79.2t	391t
VREF	113kt	137kt	138kt	138kt
RLD dry	920m	1510m	1590m	2040m

MLW – Maximum certified Landing Weight
VREF – Minimum Approach Speed
RLD DRY – Landing Field Length dry runway, sea level

How can the GRF apply to all of them?

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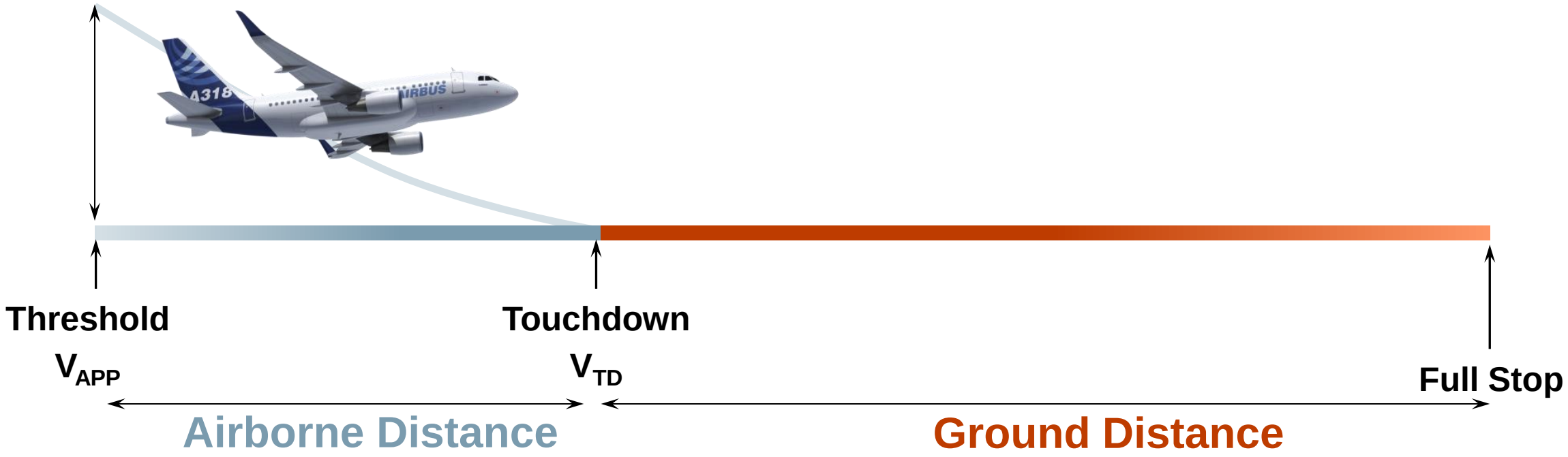
Annex 8 – New Landing Distances at Time of Arrival

Published Landing Distances include

- An allowance for the distance between threshold and touchdown
- A calculated distance for the ground roll



Ground Roll

Touchdown

V_{TD}

Decelerating Force

Full Stop

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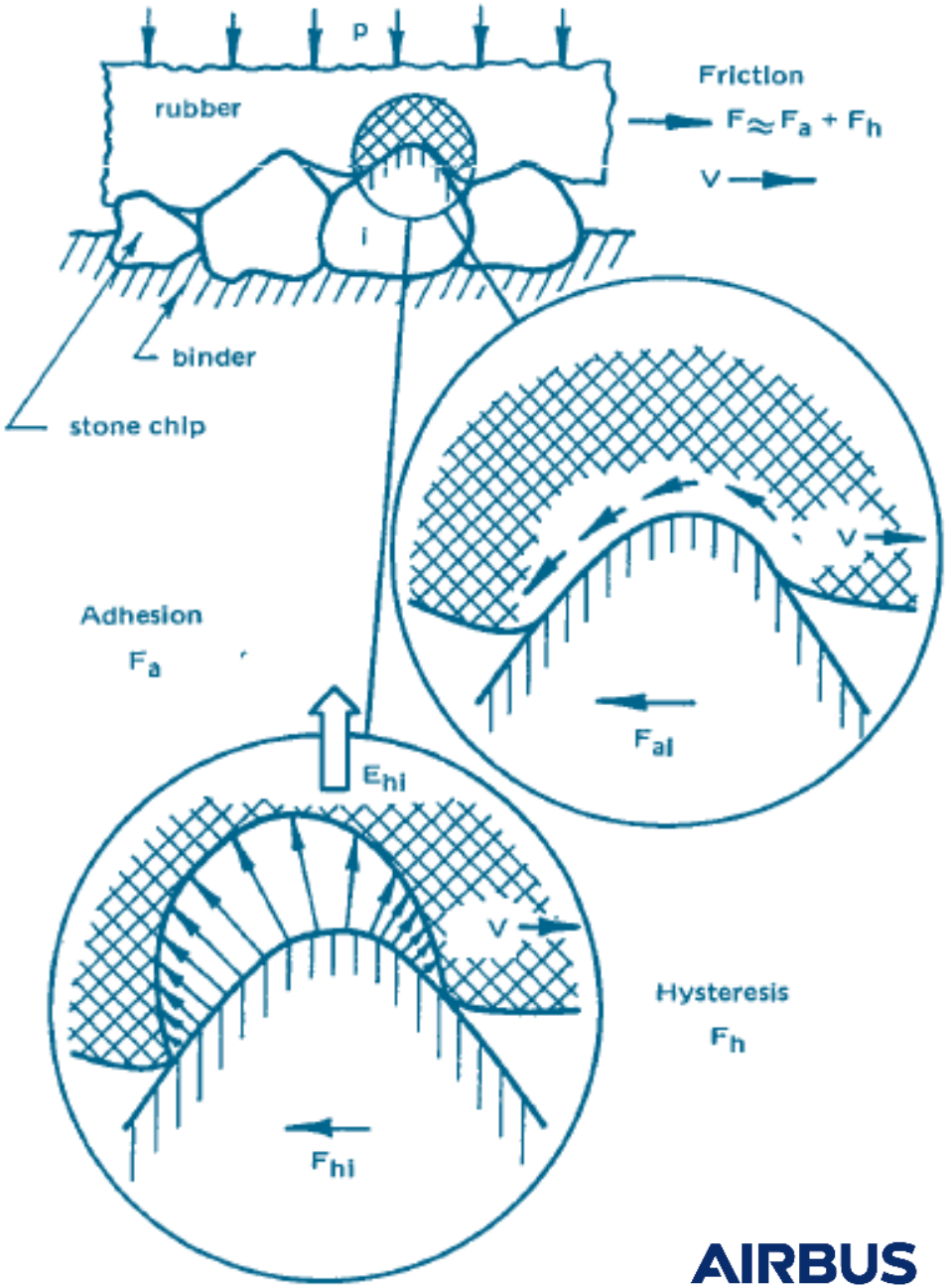
Friction

- Friction Coefficient μ expresses the proportion of the vertical load that can be transformed into braking force
- Friction
  - Not a characteristic of a surface
  - Characterizes behavior of a couple of surfaces
  - Occurs at molecular scale
- Influenced by runway surface characteristics
  - Macrotexture
  - Microtexture



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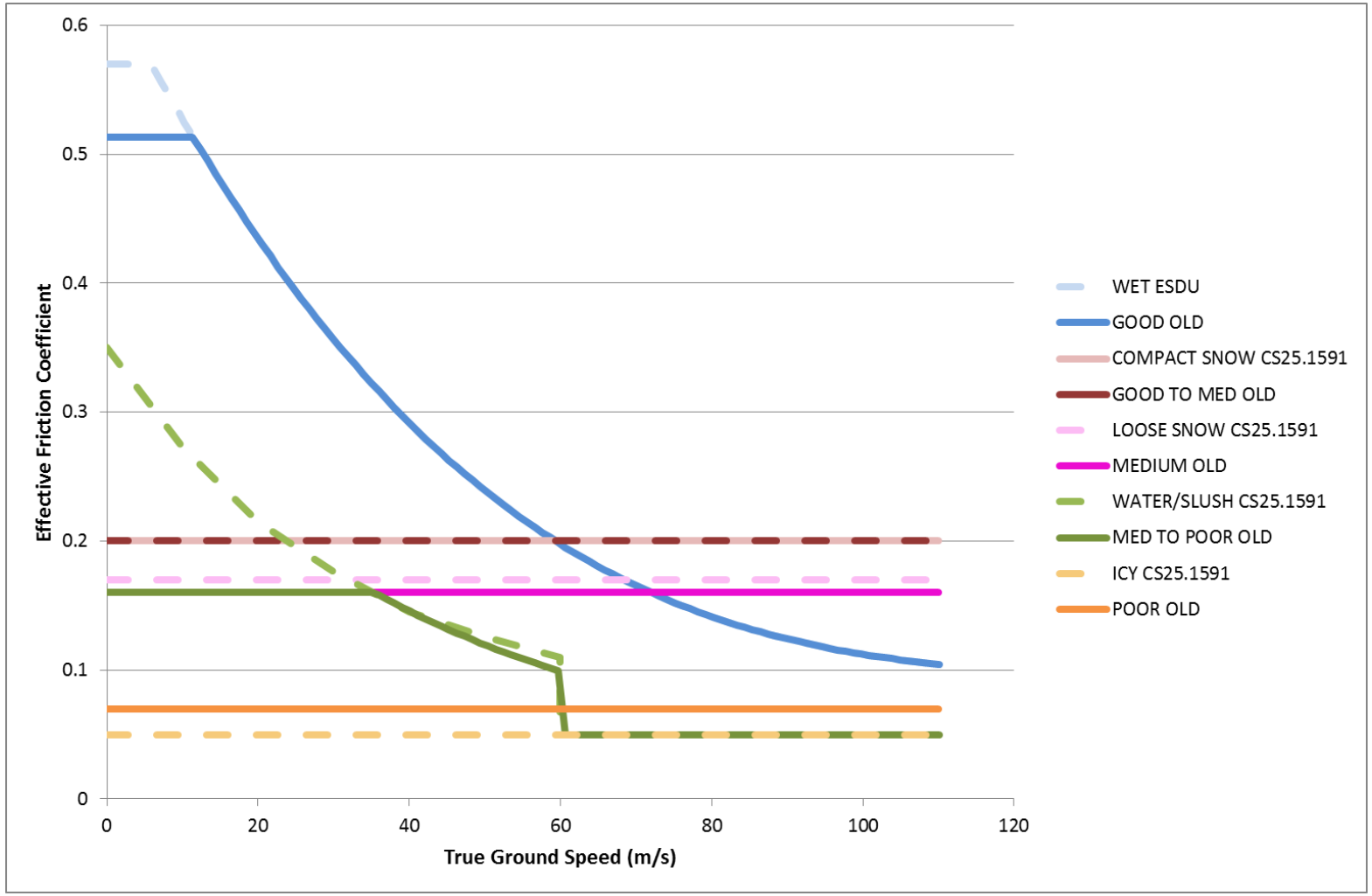
ICAO Doc 10064 Aeroplane Performance Manual

- 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
5
4
3
2
1

AIR CANADA — A318/A319/A320/A321 QUICK REFERENCE HANDBOOK — IN FLIGHT PERFORMANCE — PER-B 1/2 — 22 MAR 17

AIR CANADA — A318/A319/A320/A321 QUICK REFERENCE HANDBOOK — IN FLIGHT PERFORMANCE — PER-B 2/2 — 22 MAR 17

6 - DRY

reverse thrust, manual landing[1], VAPP=VLS without APPR COR.

6 - DRY

Corrections on Landing Distance (ft)			WGT[2]	SPD	ALT	WIND	TEMP	SLOPE	REV	OVW
Maximum MANUAL	FULL	3 320	+ 120	+ 220	+ 110	+ 340	+ 100	+ 60	0	+ 2 240
	3	3 570	+ 150	+ 220	+ 120	+ 370	+ 110	+ 60	0	+ 2 920
AUTOBRAKE MED	FULL	4 120	+ 90	+ 290	+ 140	+ 410	+ 130	+ 30	0	+ 730
	3	4 470	+ 100	+ 300	+ 150	+ 430	+ 130	+ 30	0	+ 770
AUTOBRAKE LOW	FULL	5 790	+ 140	+ 440	+ 210	+ 630	+ 190	+ 90		
	3	6 350	+ 150	+ 470	+ 230	+ 650	+ 220			

5 - GOOD

4 - GOOD TO MEDIUM

Corrections on Landing Distance (ft)			WGT[2]	SPD	ALT	WIND	TEMP	SLOP
Braking Mode	LDG CONF	REF DIST (ft) for 63T	Per 1T above 63T	Per 5kt	Per 1000ft above SL	Per 5kt TW	Per 10°C above ISA	Per 1 Dow Slop
Maximum MANUAL	FULL	4 240	+ 140	+ 350	+ 200	+ 630	+ 180	+ 15
	3	4 730	+ 160	+ 380	+ 240	+ 700	+ 210	+ 17
AUTOBRAKE LOW	FULL							
	3	6 350	+ 150	+ 470	+ 230	+ 650	+ 220	+ 10

(1) Automatic Landing correction: if CONF FULL, add 920ft. If CONF 3, add 720ft.
(2) Weight correction: if CONF FULL, subtract 40ft per 1T below 63T. If CONF 3, subtract 60ft per 1T b

4 - GOOD TO MEDIUM

Corrections on Landing Distance (ft)			WGT[2]	SPD	ALT	WIND	TEMP	SLOP
					Per			

3 - MEDIUM

3 - MEDIUM

Corrections on Landing Distance (ft)			WGT[2]	SPD	ALT	WIND	TEMP	SLOPE	REV	OVW
Maximum MANUAL	3	5 540	+ 130	+ 330	+ 210	+ 630	+ 190	+ 26		
AUTOBRAKE MED	FULL	5 090	+ 110	+ 320	+ 190	+ 600	+ 170	+ 24		

(1) Automatic Landing correction: if CONF FULL, add 940ft. If CONF 3, add 750ft.
(2) Weight correction: if CONF FULL, subtract 50ft per 1T below 63T. If CONF 3, subtract 70ft per 1T below 63T.

Braking Mode	LDG CONF	REF DIST (ft) for 63T	Per 1T above 63T	Per 5kt	Per 1000ft above SL	Per 5kt TW	Per 10°C above ISA	Per 1% Down Slope	Per Thrust Reverser Operative	If OVW PROC applied
Maximum MANUAL	FULL	5 600	+ 130	+ 330	+ 210	+ 700	+ 190	+ 320	- 70	+ 1 800
	3	6 200	+ 140	+ 360	+ 240	+ 740	+ 220	+ 370	- 100	+ 2 400
MED	FULL	5 650	+ 120	+ 350	+ 220	+ 710	+ 190	+ 330	- 110	+ 730
	3	6 290	+ 140	+ 370	+ 240	+ 740	+ 220	+ 380	- 160	+ 750
AUTOBRAKE LOW	FULL	6 100	+ 140	+ 430	+ 230	+ 730	+ 210	+ 290	- 20	+ 800
	3	6 730	+ 150	+ 460	+ 250	+ 760	+ 230	+ 340	- 80	+ 850

2 - MEDIUM TO POOR

1 - POOR

(1) Automatic Landing correction: if CONF FULL, add 910ft. If CONF 3, add 710ft.
(2) Weight correction: if CONF FULL, subtract 50ft per 1T below 63T. If CONF 3, subtract 60ft per 1T below 63T.

RWY COND

Cancel

Select runway condition from list

- 6-Dry
- 5-Good
- 4-Good to medium
- 3-Medium
- 2-Medium to poor
- 1-Poor

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RCAM Elements

RWYCC

Depth

OAT

Contaminants

Coverage

"Other" Observations

AIREPs

~~Measured Friction~~

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	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is	MEDIUM

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Reportable Contaminants

COMPACTED SNOW
DRY SNOW
DRY SNOW ON TOP OF COMPACTED SNOW
DRY SNOW ON TOP OF ICE
FROST
ICE
SLUSH
STANDING WATER
WATER ON TOP OF COMPACTED SNOW
WET
WET ICE

Layered associated with top contaminant or Less Than Poor

WET SNOW
WET SNOW ON TOP OF COMPACTED SNOW
WET SNOW ON TOP OF ICE
CHEMICALLY TREATED
LOOSE SAND

Situational Awareness

MUD
DUST
SAND
VOLCANIC ASH
OIL
RUBBER

Not in the RCAM

- RCAM covers only conditions with deterministic performance effect
- Other conditions (sanding/chemicals) addressed by down-/upgrade mechanism
  – Driven by Mu / Other observations / AIREPs

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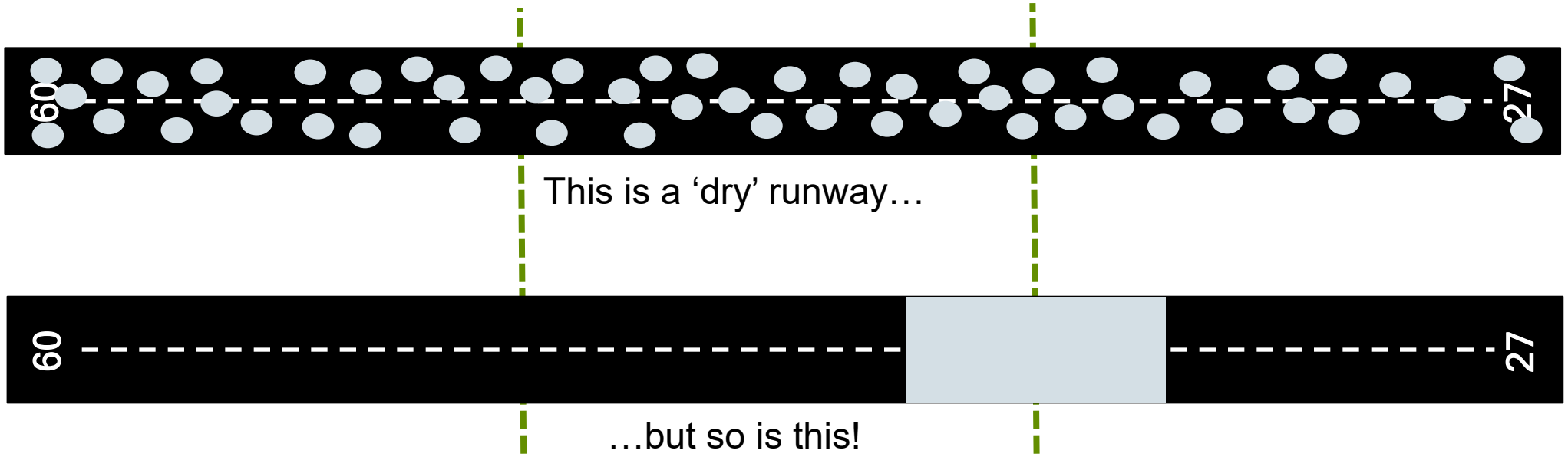
Depth

- Any fluid contaminant up to 3mm = WET
  - Well constructed and maintained pavement allows tire to drain fluid from footprint and maintain contact with runway – NO dynamic AQUAPLANING
- Any fluid contaminant above 3mm = CONTAMINATED
  - AQUAPLANING occurs above aquaplaning speed

- Dry Snow and Wet Snow are not fluids
  - Same 3mm depth threshold
  - Below 3mm loose contaminant is compressed into macrotexture allowing contact of tire and runway surface
  - Caution - Some evidence shows that conditions may become slippery even below 3mm

Coverage

- Coverage reported for each third
- Coverage reported as 25% above 10% observed coverage
- Contaminated in terms of performance above 25% coverage



- It has been demonstrated that, if performance calculated for dry condition, regulatory/recommended margins cover concentration of contaminant in worst location

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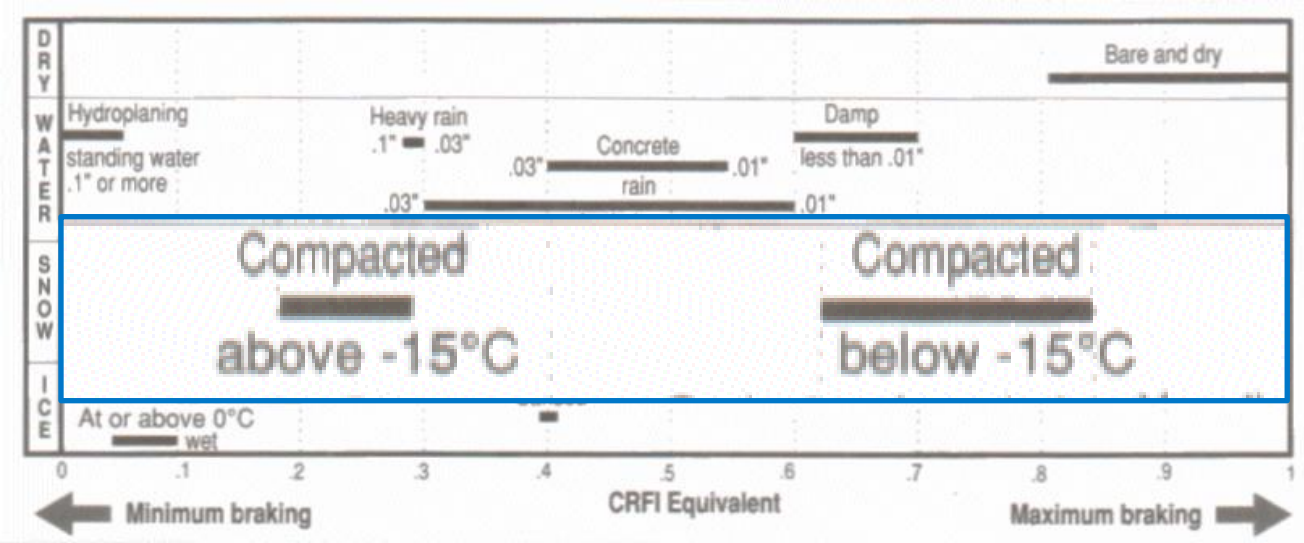
Temperature

Contaminant	Better Braking Action	Worse Braking Action
Compacted Snow	Below -15°C	Above -15°C

- -15°C based on original JWRFMP data
- Probably very conservative



- Braking Action is more closely correlated with surface temperature than with OAT

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Measured Friction

- ICAO provides no friction scale due to poor correlation with aircraft braking action
- CFME used is based on a method approved by the State

Measured coefficient	*Estimated braking action*	*Code*
0.40 and above	Good	5
0.39 to 0.36	Medium to good	4
0.35 to 0.30	Medium	3
0.29 to 0.26	Medium to poor	2
0.25 and below	Poor	1

- Used basically for downgrade
- Upgrade only with significant margins

Differences with Aircraft

Tire Size
Tire Load
Tire Press
Speed
Slip Ratio
Drag

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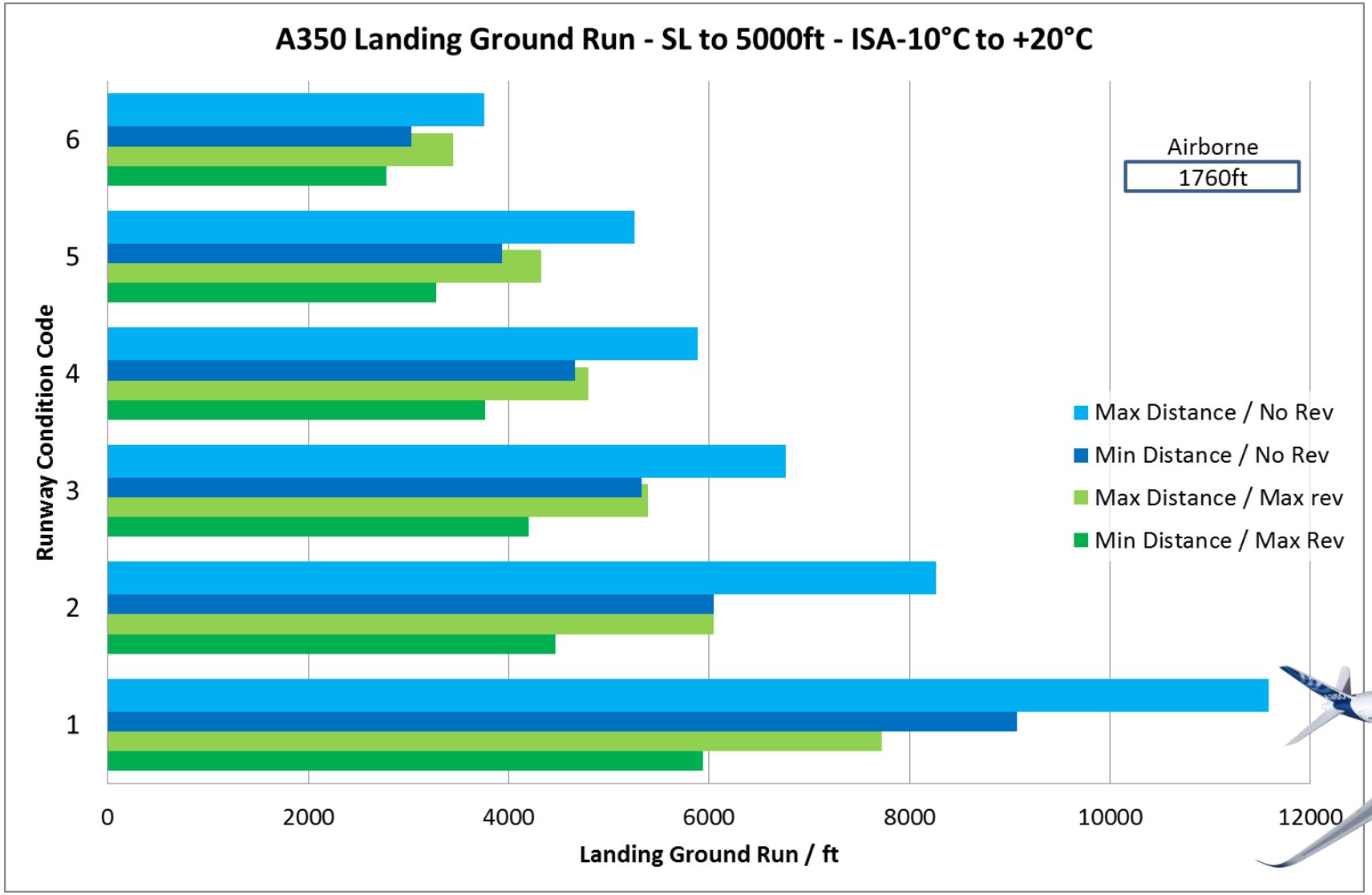
Cir329 – Overall Landing Ground Run



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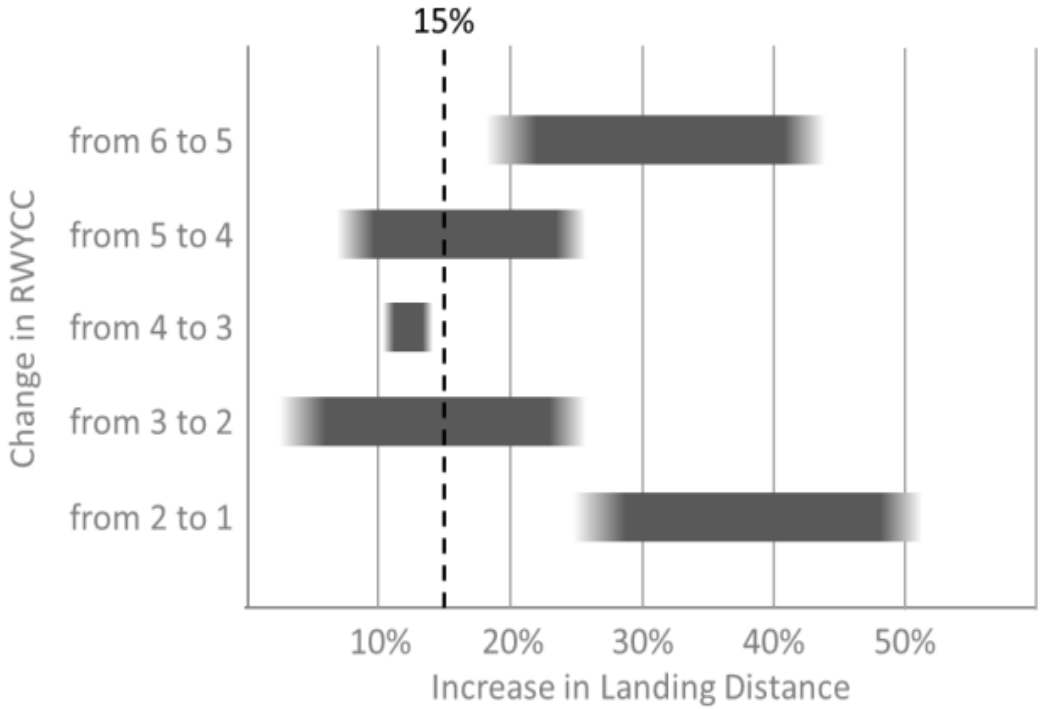
Doc10064 – Robustness to Misreported RWYCC

- Pilots are encouraged to apply 15% distance margin to distance assessment at time of arrival
- Computation not systematically robust to optimistic classification by 1 RWYCC

- Particular attention required for transition
  - Dry to Wet (6 to 5)
  - Wet to Standing water (5 to 2)
  - To Poor or Less Than Poor (1 or 0)



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Takeoff Performance

- A350 Takeoff from Montreal Pierre-Elliott Trudeau 06R Intersection A4
  - Elevation 101ft
  - Runway Length 2700m (ASDA 2400m)
  - Temperature 25°C
  - Takeoff Weight 230t

A350941 - EASA	Trent XWB-84 Engine	MONTREAL - P.E TRUDEAU YUL - CYUL	06R A4	37.0.0 20-Mar-19 AJ941B02 V32
Wind 0 KT QNH 1013.25 HPA Air cond. On Anti-icing Off Crosswind UP TO 25KT All reversers inoperative Dry check		Elevation 101 FT TORA 2399 M Isa temp 15 C TODA 2699 M Rwyslope 0.21% ASDA 2399 M Line up dist. TOD/ASD: 0 M / 0 M	2 obstacles	CONF 2 TOGA
		STD. At 1700 turn LEFT to YUL HP. D116.3 YUL HP: Inbound 150 , LEFT turn.		

OAT C	DRY		WET	
15	249.7 143/44/52	3/4	205.0 133/36/45	3/3
20	248.4 142/44/51	3/4	191.5 134/36/46	3/3
25	247.1 141/43/51	3/4	178.2 134/36/46	3/3
30	245.6 140/43/51	3/4	164.9 134/36/46	3/3

Maximum Takeoff Weight:

Dry 247.1t Wet 178.2t

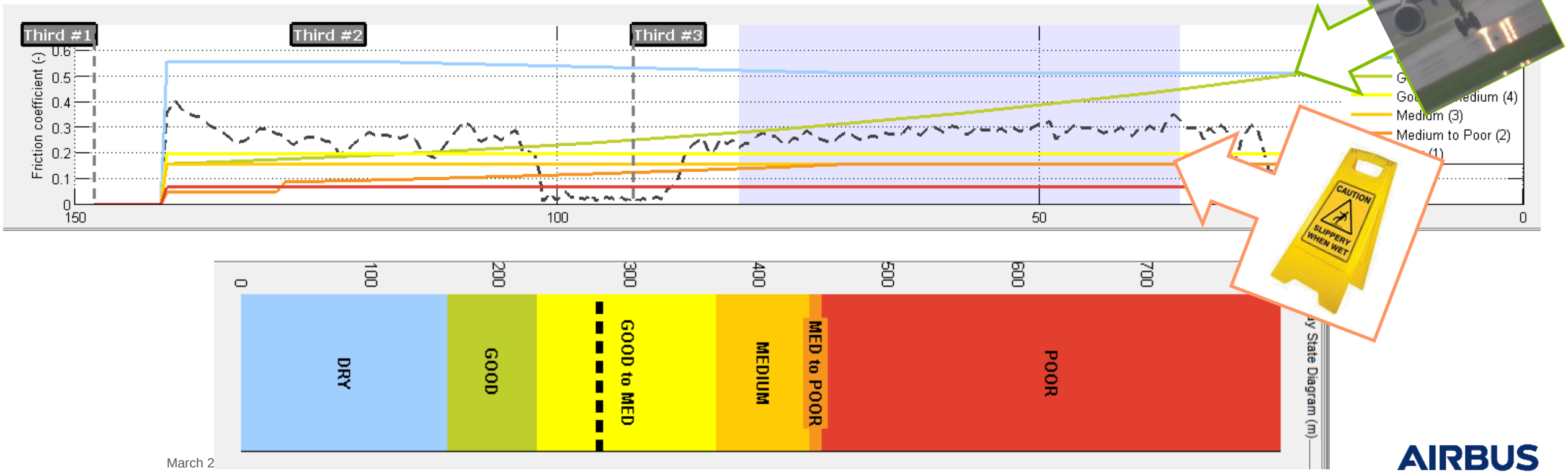
What if dry is assumed when it is wet?

Accelerate-Stop Distance (V1 dry):

Dry 1975m Wet 2575m

Transition Damp to Wet to Slippery Wet

- Why is “Damp” now “Wet”? An example…
  - Airbus A320 & A350 Flight Tests on runway at commercial airport in France
  - Light to Medium Rain, Runway reported Damp
  - Runway surface fulfills new construction criteria according to CFME
  - Aircraft data identifies substandard surface



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Takeaways

Performance Relevant Condition Reporting

Runway Condition Codes directly linked to Landing Performance available to Pilots

Thresholds

Representative of effect on aeroplane performance (depth, coverage,…)

Difference between Dry and Wet matters even on long runways

Wet includes Damp

Aircraft data is final arbiter on real runway condition

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Thank you!

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What we observe is not nature herself,
but nature exposed to our method of questioning.

Werner Heisenberg, theoretical physicist

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Thank you

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