Overview of the project implementation and key results

EASA Research project: Runway Micro Texture (RWYMT)
Final dissemination event - webinar
08 May 2025

Version 01-05-2025

Agenda

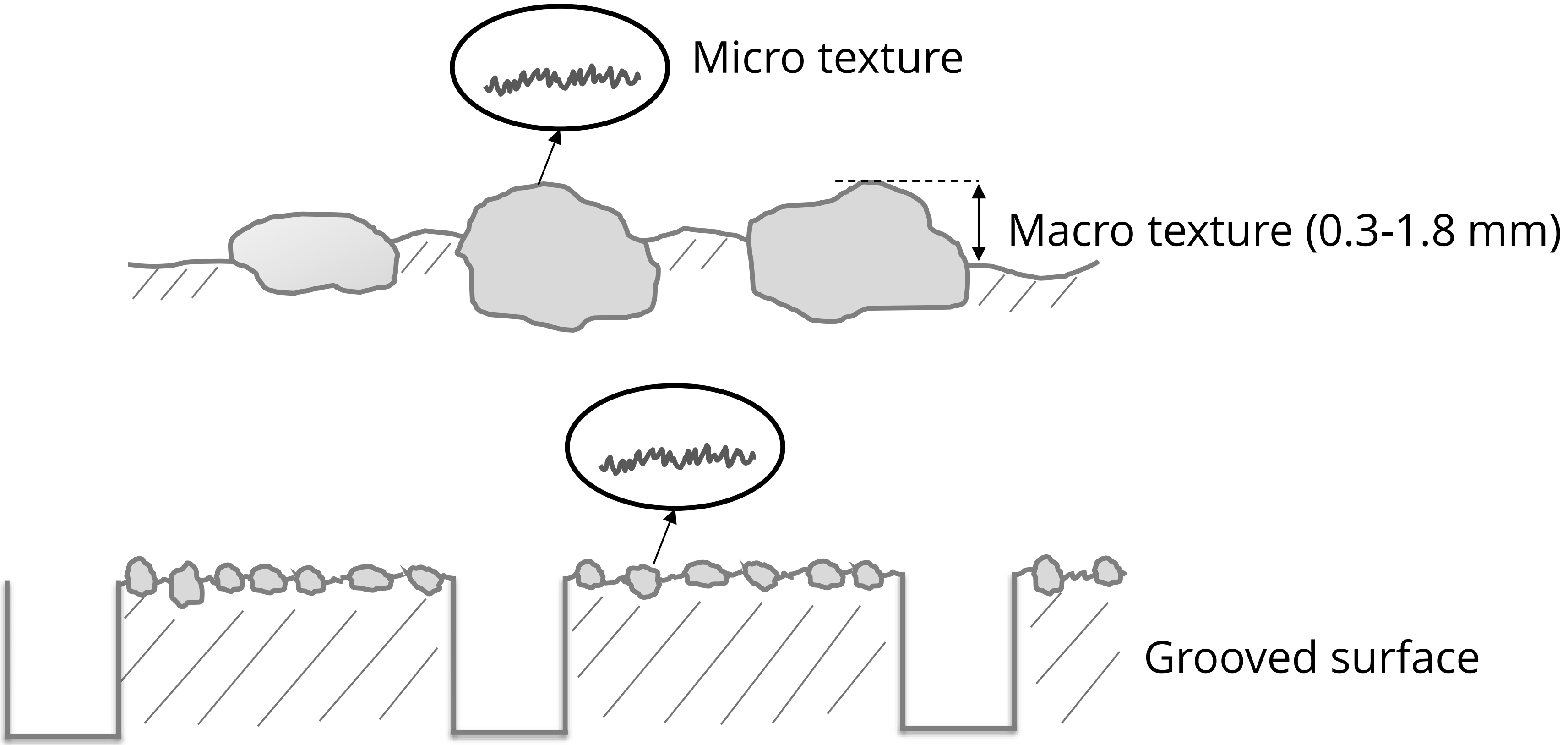
- Basics of wheel braking
- Slippery wet runways
- How to assess runway micro texture?
- Testing activities
- Micro texture characterisation
- Threshold for slippery wet runways
- Findings and next steps

Basics of wheel braking

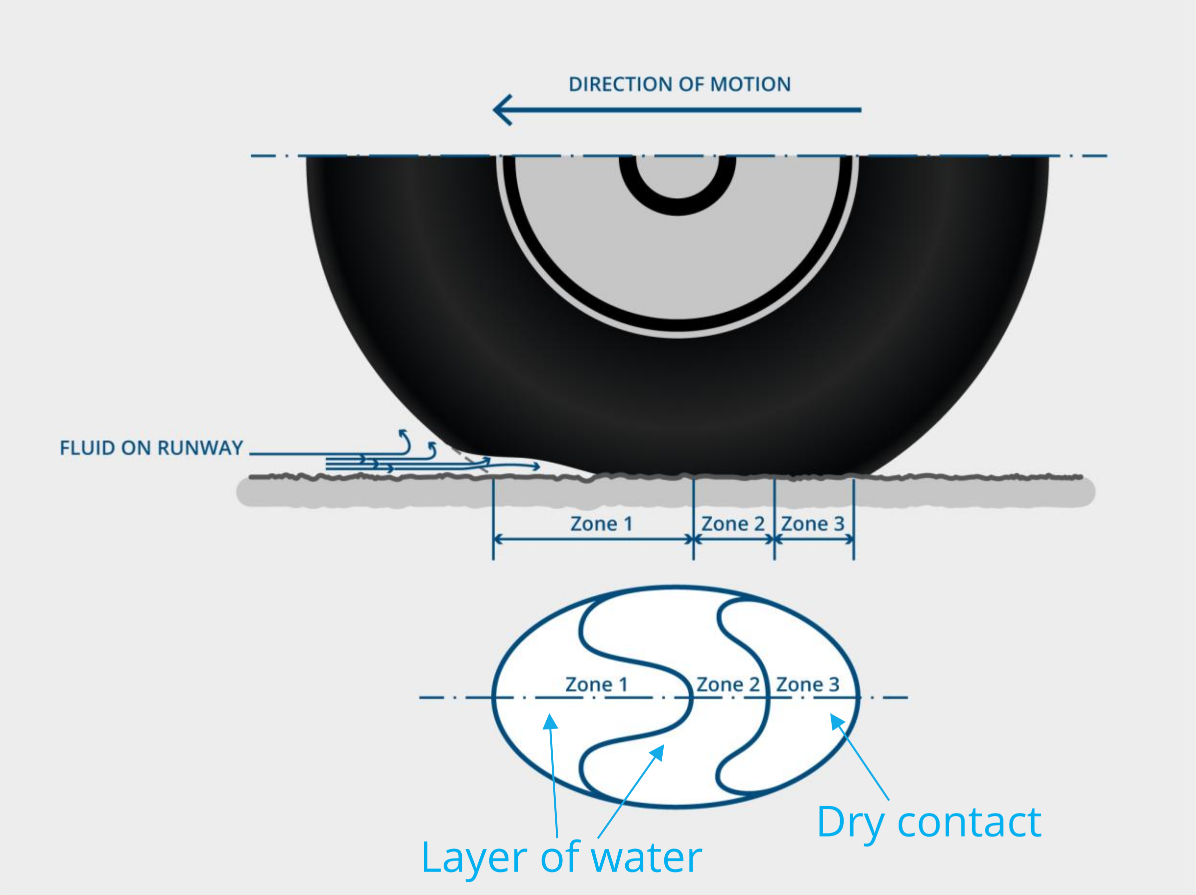
Wet runway wheel braking forces

- Runway texture (macro and micro)
- Speed
- Tyre pressure
- Antiskid
- Wetness
- Loading
- Surface temperature

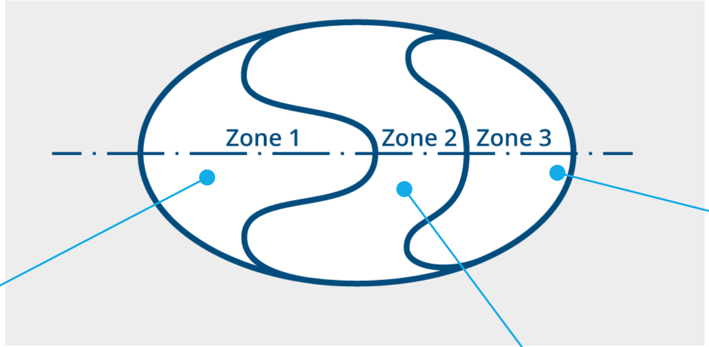
Micro texture versus macro texture



Tyre footprint on wet surface



What is happening in tyre-surface contact area?



- Dry contact area;
- Friction is generated here.

- Dynamic hydroplaning;
- Increases with lower macro texture and speed;

- Viscous hydroplaning;
- Increases with smoother micro texture;
- Present down to very low speeds.

Slippery wet runways

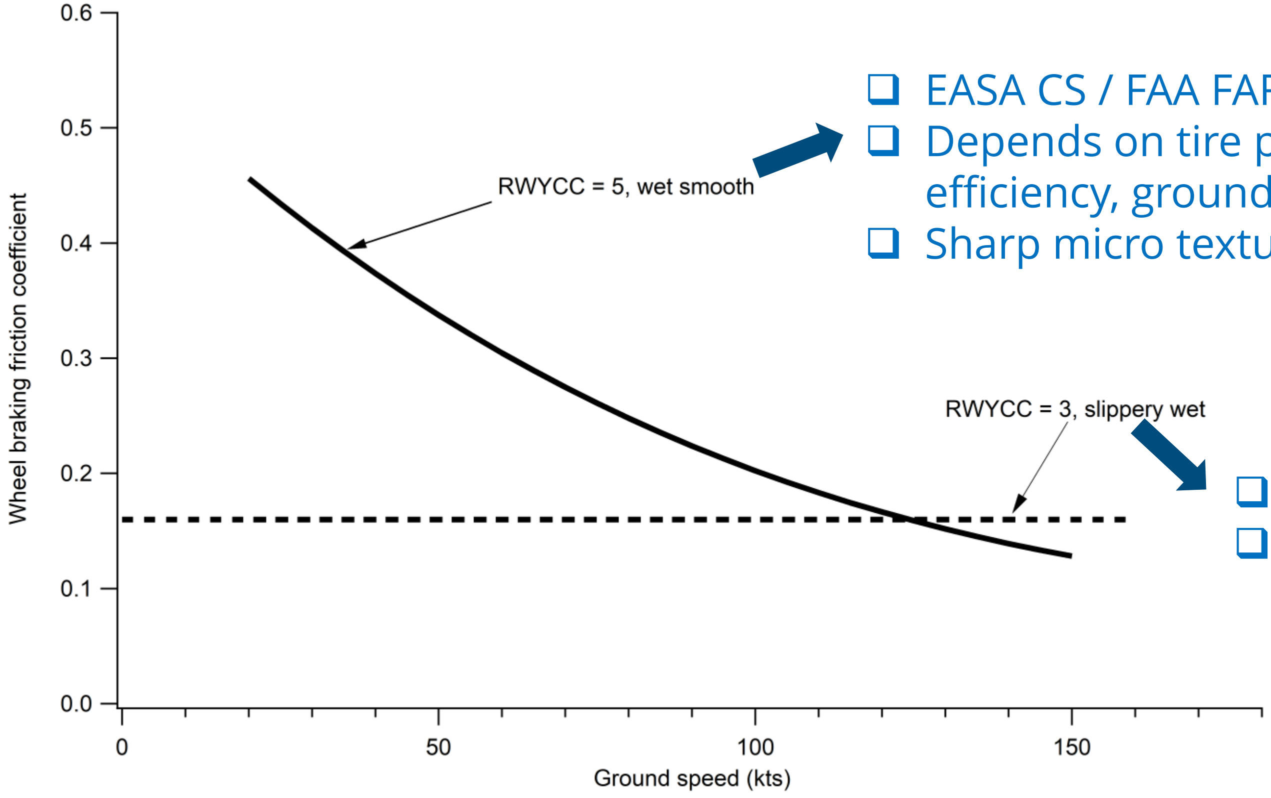
Slippery wet runway definition

EASA : *'Slippery wet runway' means a wet runway where the surface friction characteristics of a significant portion of the runway have been determined to be degraded.*

Runway Condition Assessment Matrix

RUNWAY CONDITION CODE	RUNWAY SURFACE CONDITION DESCRIPTION	REPORTED BRAKING ACTION
6	Dry	Dry
5	Wet (Smooth, Grooved or PFC) or Frost 3 mm (0.12 inches) or less of: Water, Slush, Dry Snow or Wet Snow	Good
4	Compacted Snow at or below -15°C OAT	Good to Medium
3	Wet (Slippery), Dry Snow or Wet Snow (any depth) over Compacted Snow Greater than 3 mm (0.12 inches) of : Dry Snow or Wet Snow Compacted Snow at OAT warmer than -15°C	Medium
2	Greater than 3 mm (0.12 inches) of: Water or Slush	Medium to Poor
1	Ice	Poor
0	Wet Ice, Water on top of Compacted Snow, Dry Snow or Wet Snow over Ice	Nil

RCAM Assumed braking friction in performance calculations – example



- ❑ EASA CS / FAA FAR 25.109(c) and (d)
- ❑ Depends on tire pressure, anti-skid efficiency, ground speed
- ❑ Sharp micro textured surfaces

- ❑ Constant
- ❑ Depends only on anti-skid type

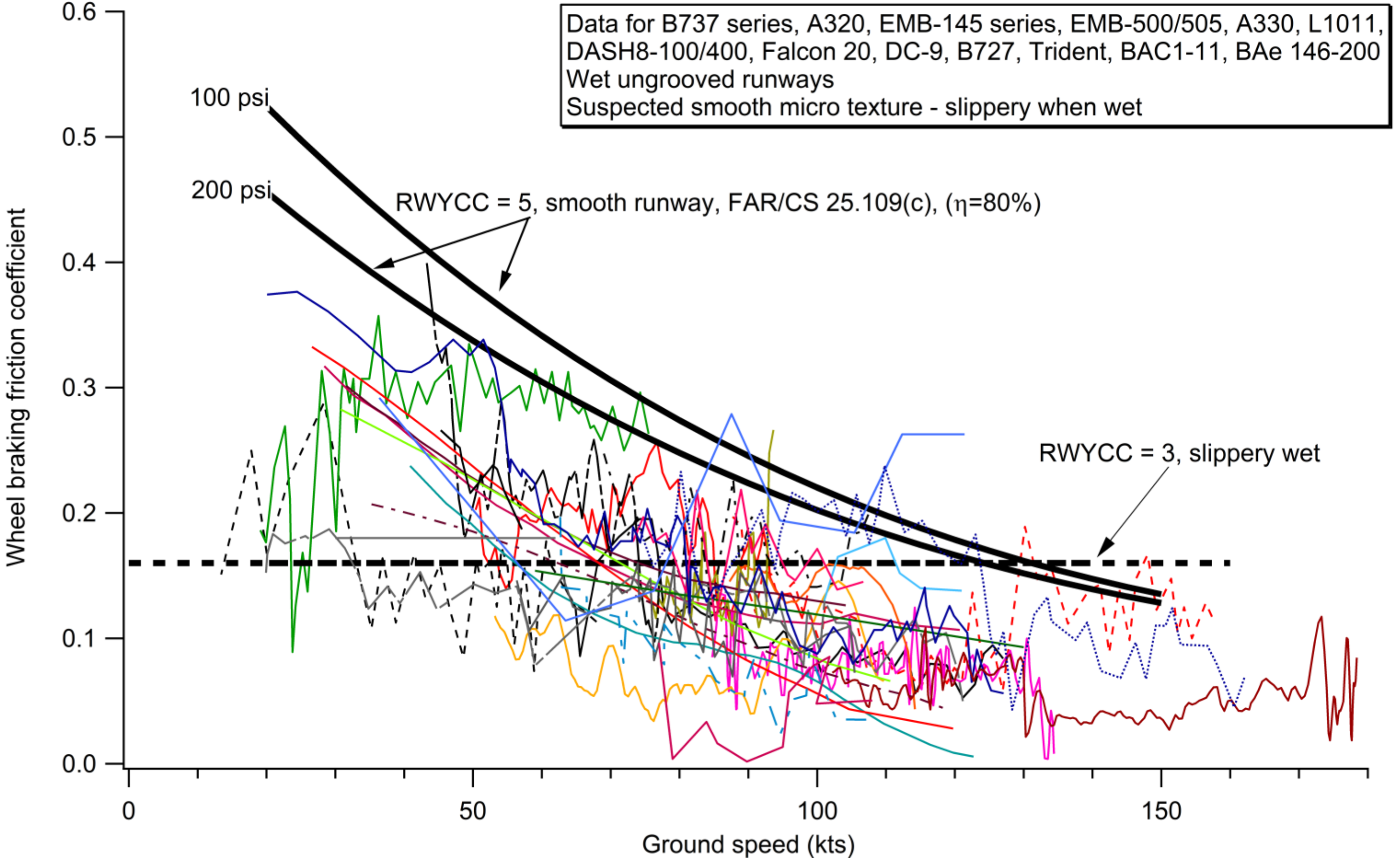
Slippery wet runway braking performance

- TALPA ARC proposed to relate *slippery wet* to braking performance **medium**;

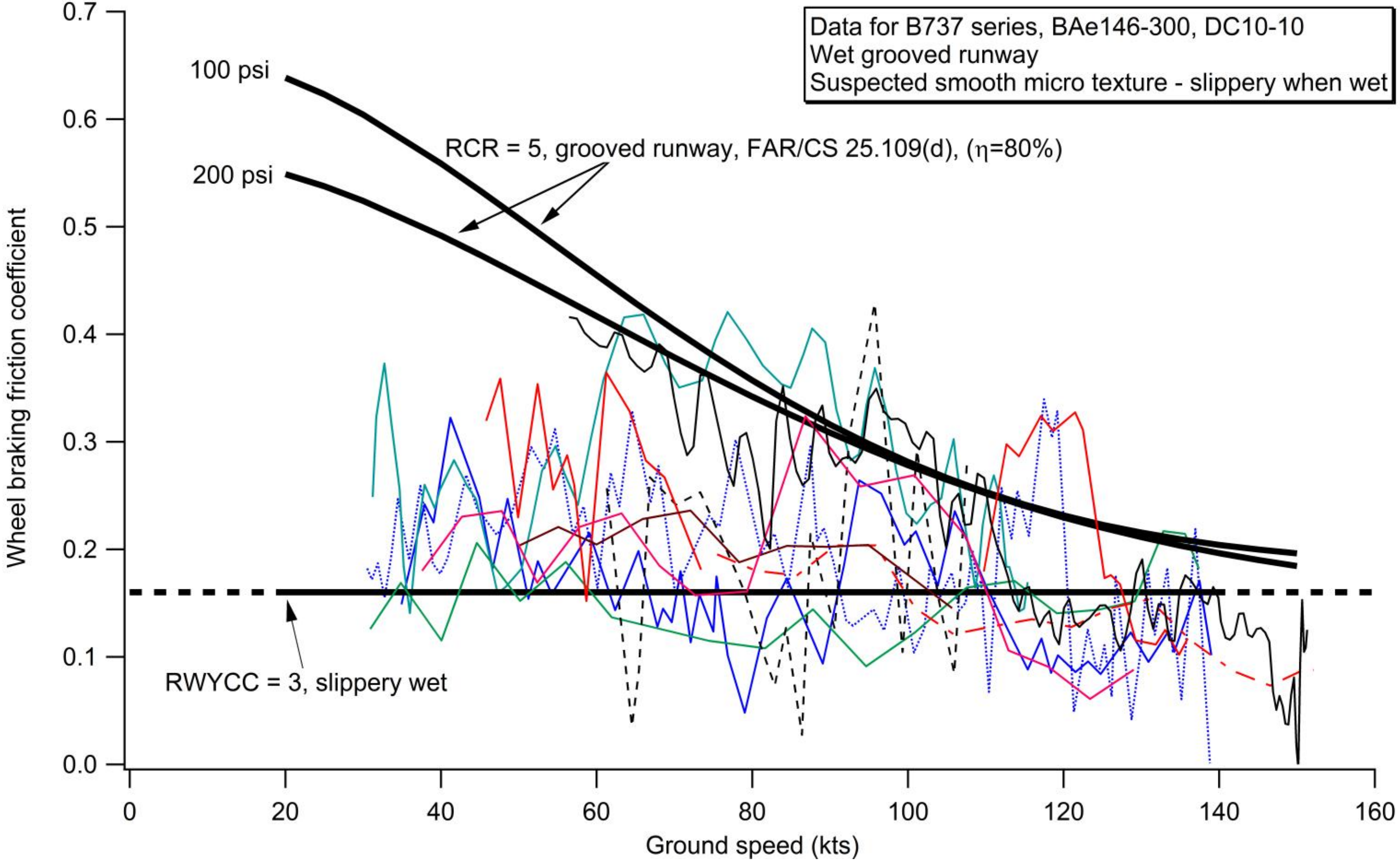
- Wheel braking friction coefficient μ_{EFF} **chosen** for this level is:

  - **0.16 (**fully modulating anti-skid system);
  - **0.10 (**quasi modulating anti-skid system).

Braking on slippery wet ungrooved runways



Braking on slippery wet grooved runways



Braking friction levels on slippery wet runways

- μ_{EFF} can be up to 80% **lower** than assumed for RWCC 5;
- Sometimes lower μ_{EFF} than for snow/ice covered runways;
- Differences in μ_{EFF} mainly caused by variations in texture along a given runway:
  - Micro texture is dominant (smoother than assumed in 25.109)
  - Viscous hydroplaning

Current assessment of slippery wet runways

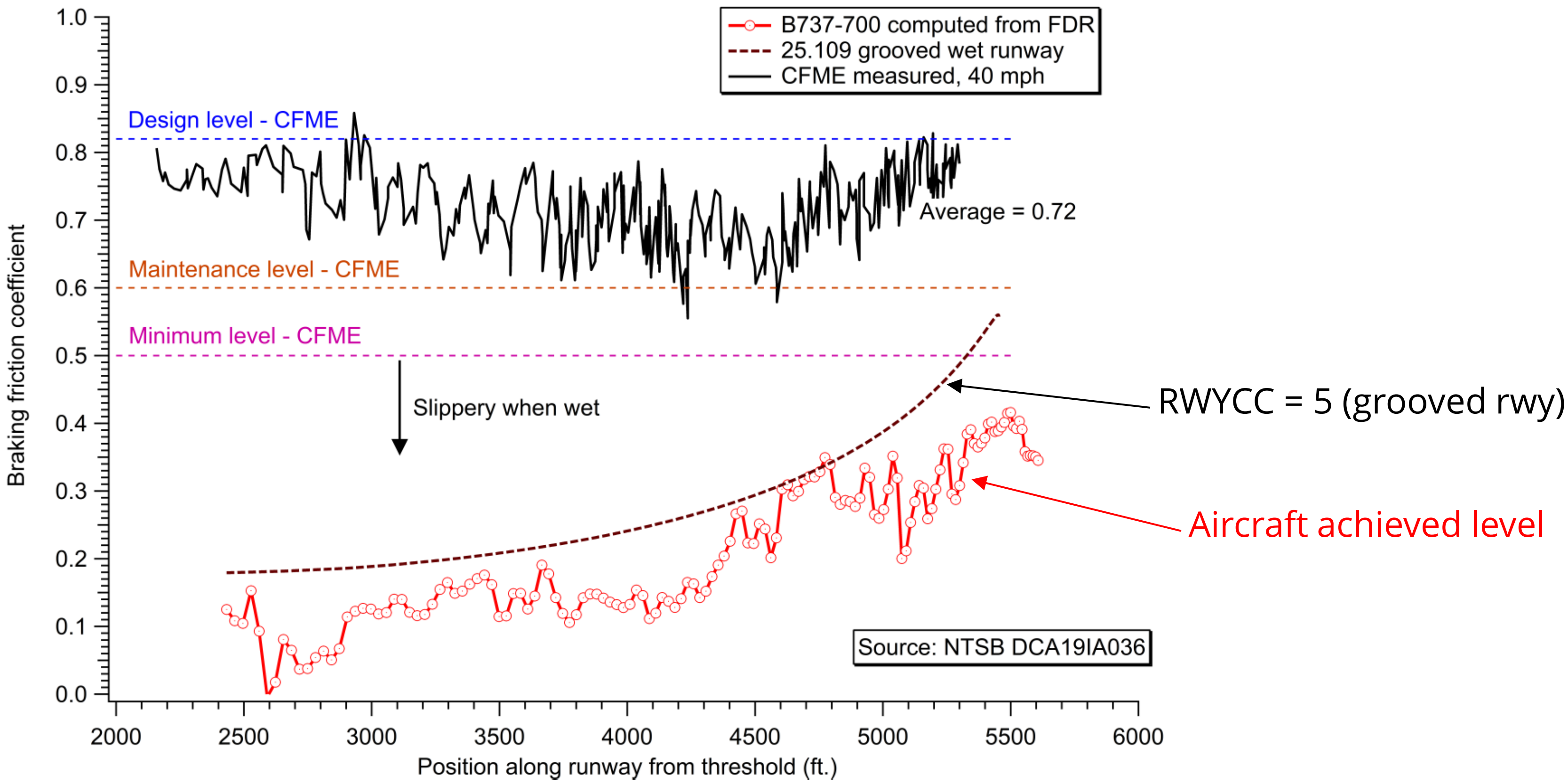
- CFME compared to Minimum Friction Level MFL
  - *CFME can give optimistic results*
  - *MFL arbitrarily chosen based on experience and highly scattered data*

- Observation by aerodrome maintenance personnel
  - *Subjective*

- Pilot reports
  - *Subjective (e.g. thrust reversers will mask true braking performance)*

- Realtime onboard analysis of braking performance
  - *Promising but requires wet runway with friction limited braking*
  - *Equipped aircraft needed that land on your aerodrome*

Example CFME results in a B737 overrun



What causes slippery wet runways?

- Smooth micro textured runway surfaces are believed to be responsible for most slippery wet runways:

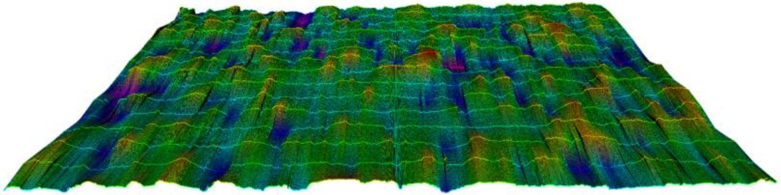
  - Due to normal wear of runway surface;
  - None visible rubber build-up after touchdown zone (reduces micro texture);
  - Use of fog seal/rejuvenators to repair runway surface (can reduce micro texture).

How to assess runway micro texture?

High Resolution surface laser scanner

Source: NLR

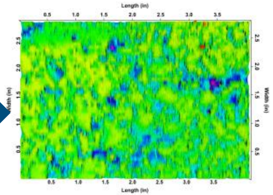
Scan ‘area’



Basic approach EASA project

Runways

Surface scans



Algorithms

Micro texture parameter

Threshold for slippery wet runway

EASA project tasks

- Literature survey;
- Testing:
  - Flight tests on wet runways
  - Surface tests
- Development of algorithms to deduce micro texture parameters from surface laser scans;
- Development of slippery wet runway threshold;
- Guidance material.

Testing activities

Testing activities

- Flight tests on wet runways:
  - Collect wheel braking friction data on different runways surveys;

- Surface tests:
  - Use laser scanner on a variety of surfaces;
  - Tests using **British Pendulum Tester (BPT)** on same surfaces.

↳ BPT indicative for micro texture characteristics

Flight test aircraft


Baks


PH-LAB

Test runs at Twente airport – Falcon 2000

Surface tests

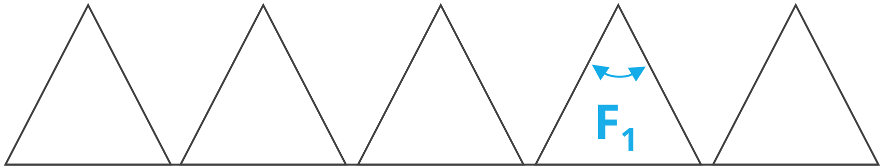
- Measurements using BPT and high resolution surface laser scanner;
  - All locations used for flight testing;
  - Additional surfaces including taxiways, road surfaces, rubber deposited surfaces, fog sprayed surfaces and very smooth surfaces
- BPT provides additional test data used for correlation and validation.

British Pendulum tester & laser scanner

Micro texture characterisation

Micro texture representation – ESDU model

Assume protrusions in micro texture are triangular with vertex upward

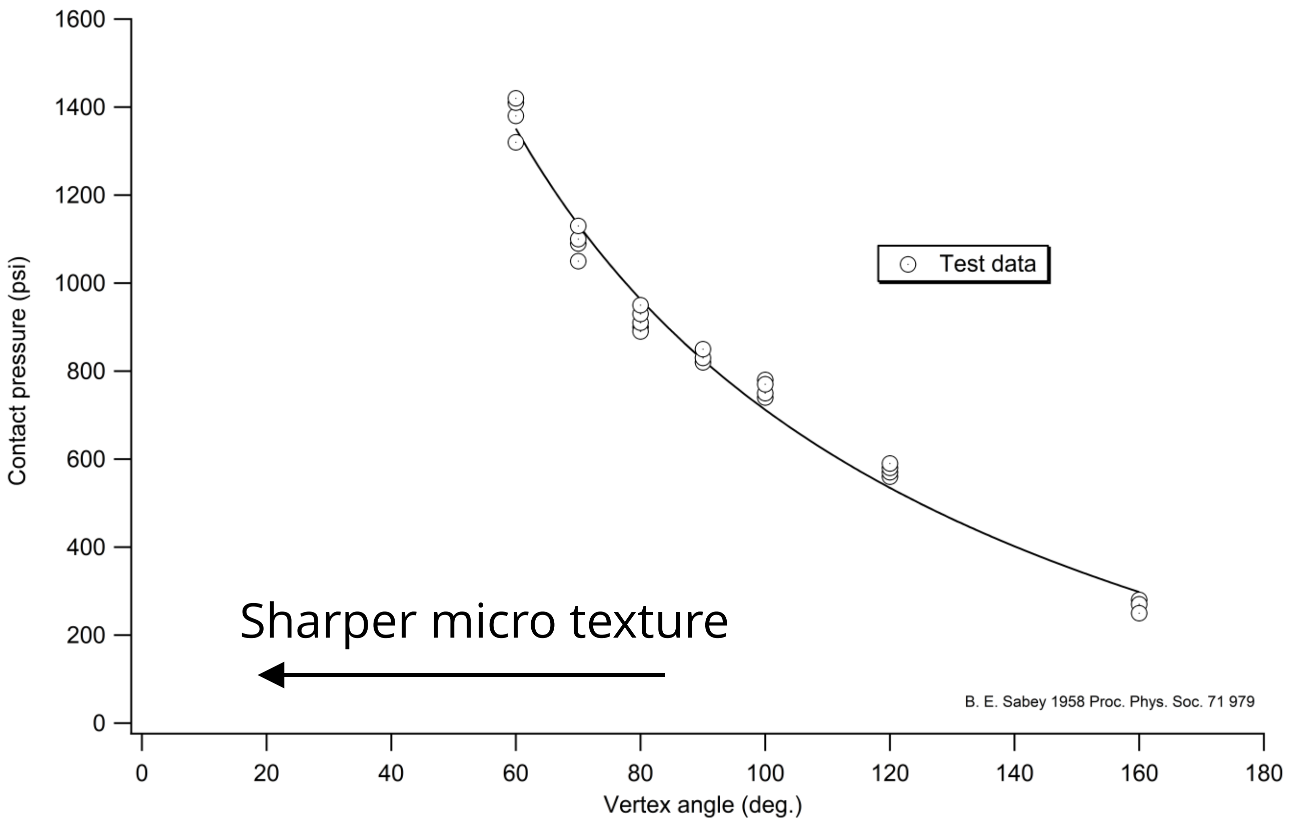


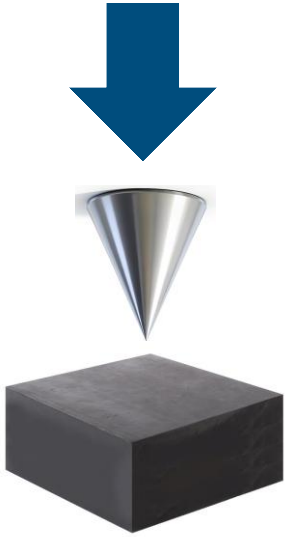
Assume a micro texture parameter related in some way to angle of vertex F_1

- On a nearly complete **sharp** surface $F_1 = 0$
- On a perfectly **smooth** surface $F_1 = \pi$

F_1 = **Balkwill parameter** (micro texture sharpness)

Example: Pressures beneath metal cones pressed into rubber





ESDU models for micro texture sharpness

- Vertex angle (F_1) determines contact pressure between surface and tyre;
- High contact pressures needed to reduce viscous hydroplaning;
- ESDU (*Ken Balkwill*) developed models for deducing F_1 from BPT and aircraft wheel braking friction test data;
- Models are semi-empirical.

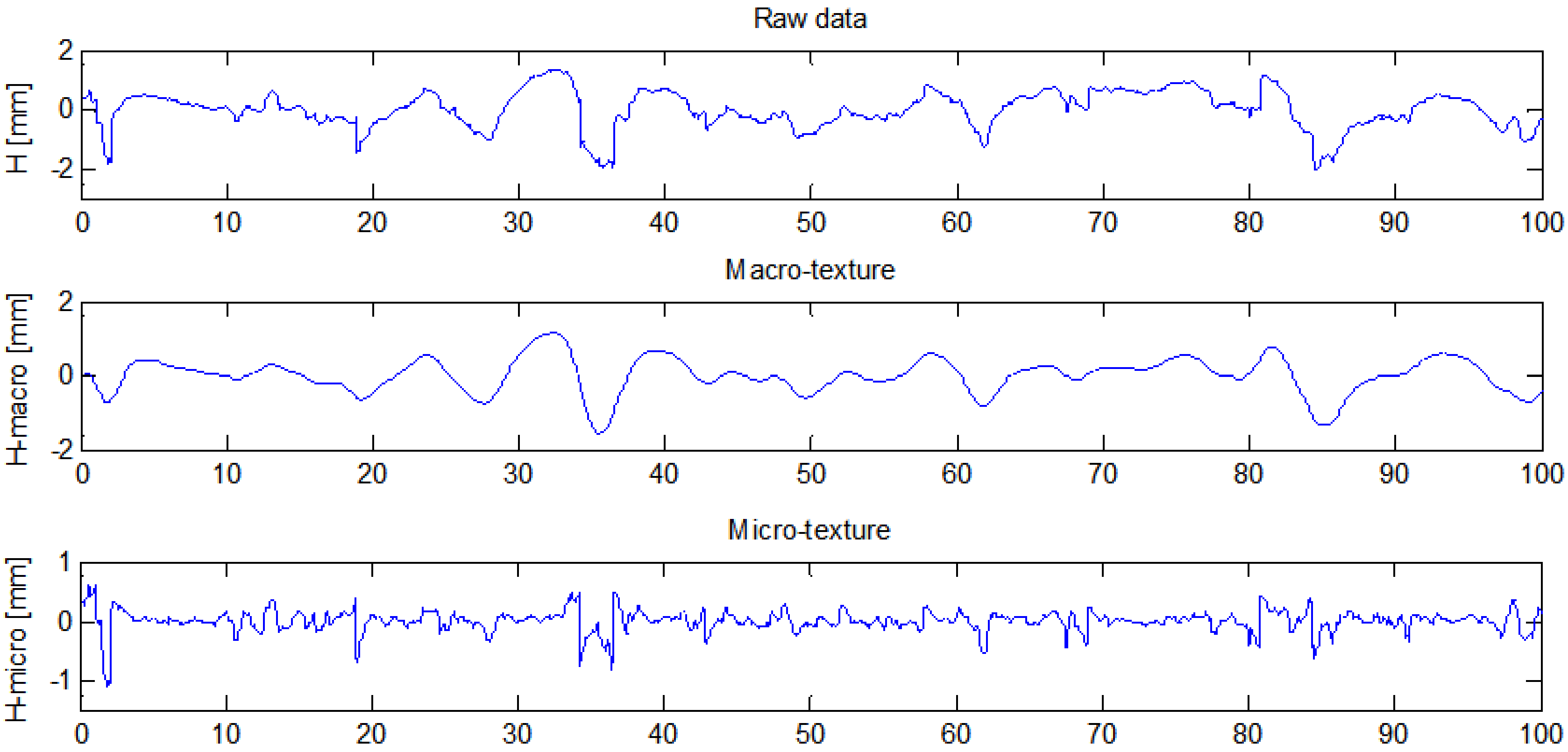
Sources: ESDU Data Item 10015 & 23002 and TM 201.

Deducing micro texture parameter from laser scans

- Different parameters can be derived from surface scans that characterise micro texture;

- Identify parameter that gives best correlation with F_1 deduced from flight tests and BPT.

High Resolution surface laser scan line



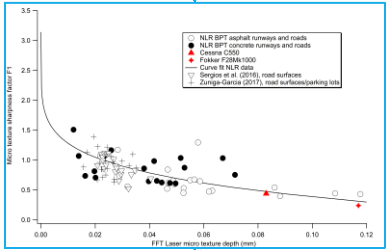
Correlation analysis

Test aircraft & BPT

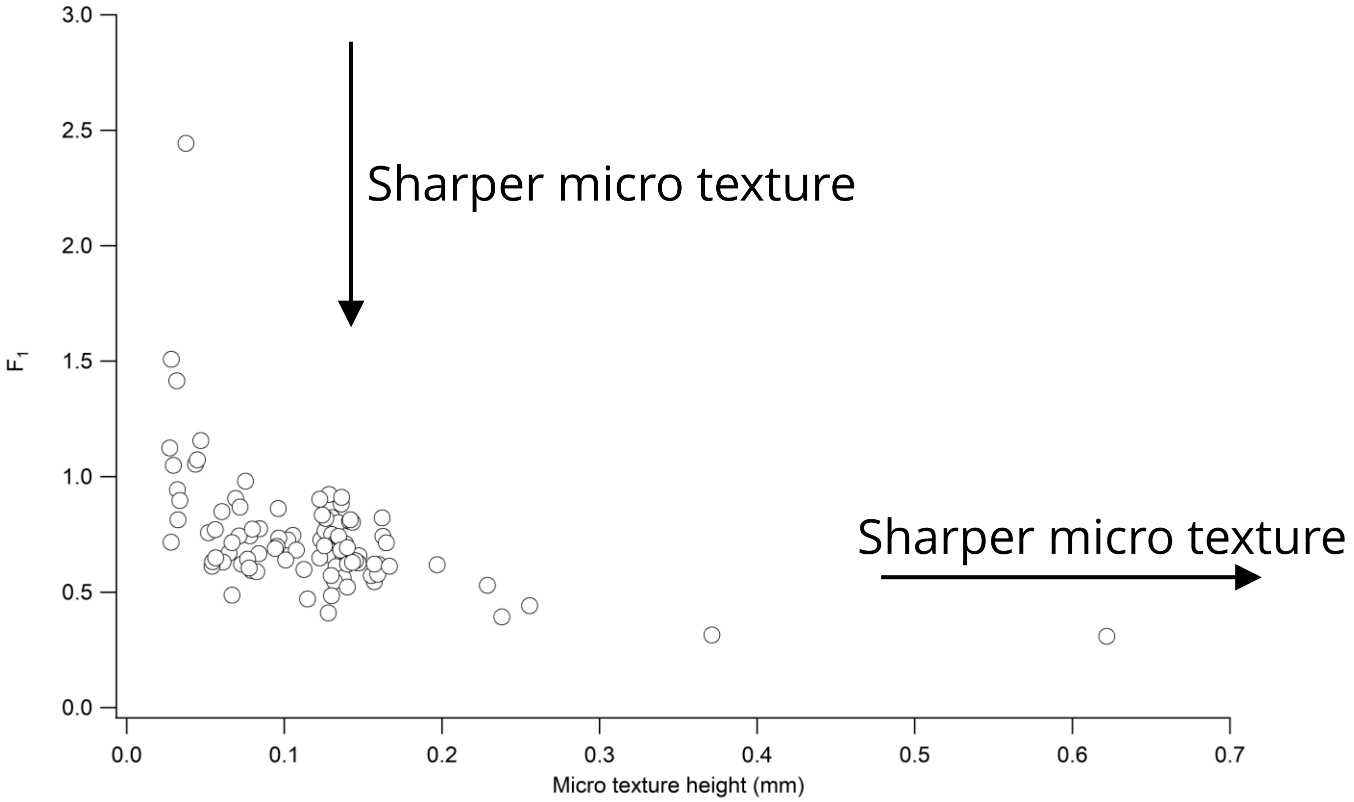
micro texture sharpness parameter F_1

Surface laser scanner

micro texture characteristic



Example of relation F_1 and selected micro texture parameter

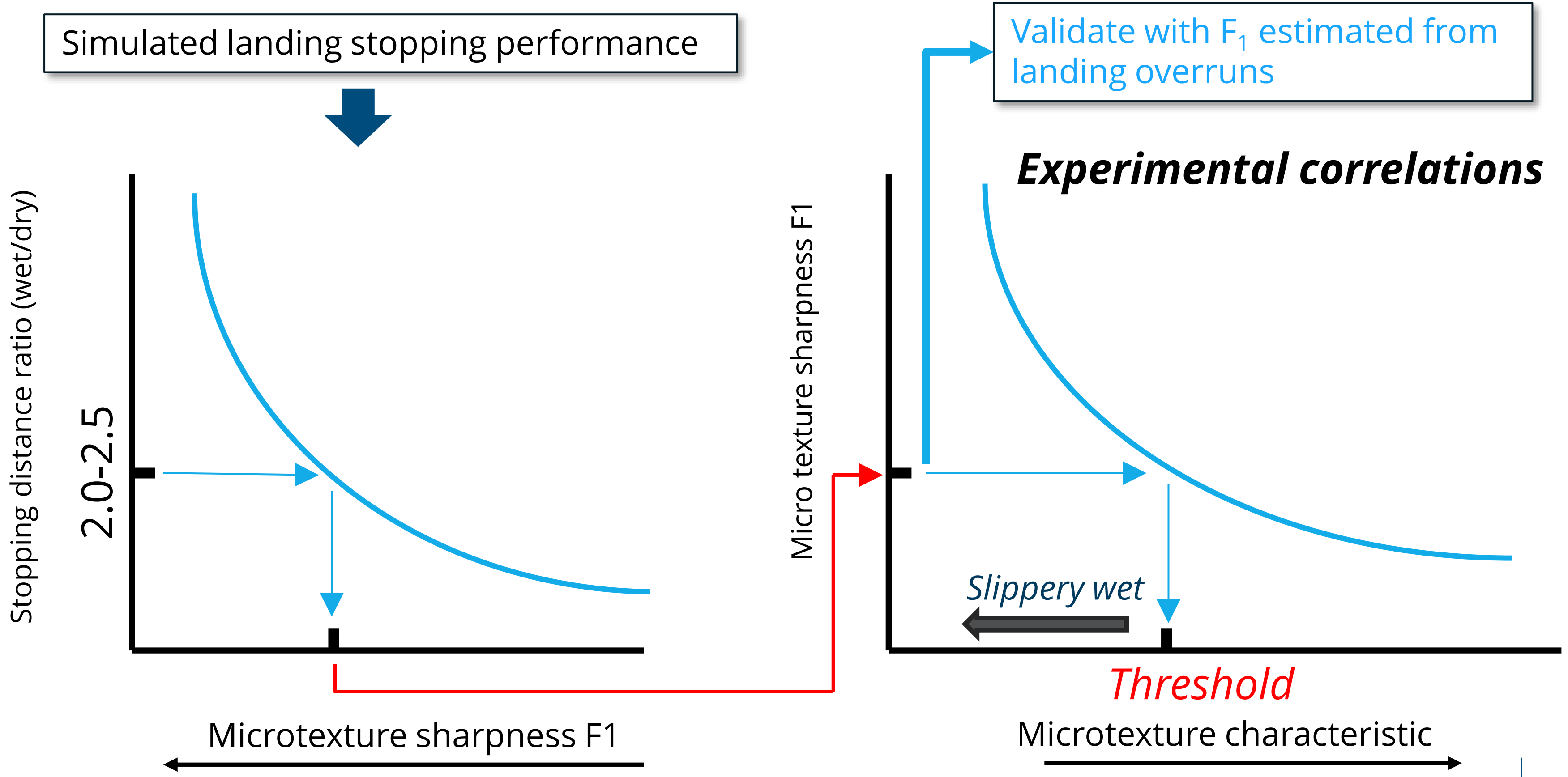


Threshold for slippery wet runways

Threshold for slippery wet runways

- '*Slippery wet*' runway is defined by ICAO study group (1991):
  - a wet runway on which ***twice*** dry braked stopping distance is approximately needed to stop an aeroplane;
  - Should correspond to MFL;
  - Based on FAA/NASA/USAF Runway Research program.
- US study proposed stopping distance ratio of **2.0-2.5** as threshold;
- Currently for performance calculations constant μ_{eff} of 0.16 is used for 'slippery wet' (RWYCC=3):
  - FCOMs MEDIUM versus DRY give avg. SDR of **2.3**

Threshold for slippery wet runways



Threshold F_1

- Proposed F_1 threshold based on combination of:
  - Simulations of landing stopping performance by varying F_1, macro texture and water depth (*μ-speed relations based on ESDU models*);
  - F_1 deduced from wet runway overrun accidents by matching ESDU model results.
- Further validation is recommended by analysis of 'slippery wet' runways as identified by for instance onboard measurements (*like RunwaySense on Airbus aircraft*).

Findings and next steps

Findings

- New method for objective assessment of runway micro texture is developed;
- Method can assist in assessing braking friction characteristics of runways in a more consistent manner which is much less subjective;
- Method can help in determining slippery wet runways.

Next steps

- Choices need to be made which micro texture parameter derived from surface scans should be used;
- Proposed threshold should be evaluated in order to establish a common accepted criterium for slippery wet surface related to micro texture or macro texture (in case the macro texture is very smooth);
- Consider other devices to assess micro texture (e.g. optical);
- Approach needs further validation before full operational use by aerodrome operators and AIBs.

Open Issues

- Operational water depth measurements remains challenging;
- Consideration of surface temperature in wet runway friction;
- Macro texture depth effects (need for minimum values);
- Integrate overall review, link runway, operation, airworthiness & airlines → safety;
- Review & revise runway condition code underlying assumptions?


EASA
European Union Aviation Safety Agency
Research Project Runway Micro Texture - Final Dissemination Event
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