



AIRCRAFT BRAKING PERFORMANCE STANDARDS

CAPT. JOHN GADZINSKI



FOUR WINDS
Aerospace Safety



GiRaFfe 2019

AIRCRAFT BRAKING PERFORMANCE STANDARDS

CAPT. JOHN GADZINSKI



FOUR WINDS
Aerospace Safety

NEED FOR ENGINEERING BASED ASSESSMENT OF PREDICTED LANDING PERFORMANCE

$R_{nwyCC} = 3 = \text{Medium} - \text{Airport/Pilot}$

$\mu_{Brakes} = 0.199 - 0.16 - \text{Engineer}$

Were my assumptions correct?



BUT...CAN WE ALL SPEAK ENGINEER?

- WHAT ARE μ_{BRAKES} ?
- HOW DO I KNOW IF I HAVE A GOOD VALUE?
- HOW CAN I RELATE μ_{BRAKES} TO THE GLOBAL REPORTING FORMAT?
- IS MU FROM AIRCRAFT THE SAME AS MU FROM AIRPORTS?



- STARTED BY ORIGINAL MEMBERS OF THE “**TALPA ARC**” 2006-2009
- GLOBAL COMMUNITY OF ENGINEERS WHO ARE TASKED WITH ALL ASPECTS OF AIRCRAFT OPERATIONAL PERFORMANCE.
- ESTABLISHED A SPECIAL WORKGROUP IN 2017 FOR CREATING STANDARDS RELATED TO AIRCRAFT REPORTING SYSTEMS.



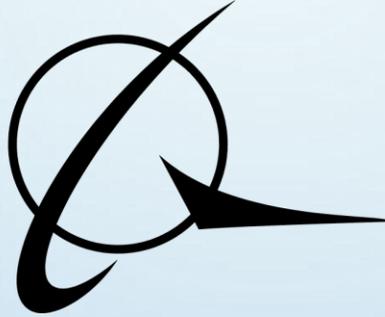
Lion Team working group formed “To develop standards (not algorithms) for aircraft friction recording and reporting technologies.”

AMERICAN SOCIETY FOR TESTING AND MATERIALS

- 140 + COUNTRIES
- 12,500 STANDARDS
- 30,000+ VOLUNTEERS AND MEMBERS
- COMMITTEE E17 – VEHICLE PAVEMENT SYSTEMS
- **2018 - E17.26 AIRCRAFT FRICTION**



E17.26/SAPOE TASK GROUP



E17.26 Member

E17.26 Member

E17.26 Member

FOUR WINDS
Aerospace Safety
E17.26 Member

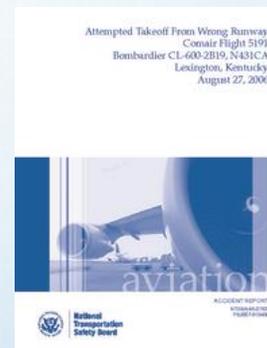




- Harmonization of new aircraft braking performance scale with investigations and research
- Harmonize engineering definitions with definitions of Pilot Reported Braking (AIREP/PIREP)
- Provide an objective guide for an engineering based Safety Assurance Process across national and international operators.

ENGINEERING SCALE FOR BRAKING PERFORMANCE

HIGHLIGHTS SEVERAL ISSUES



Runway Condition Code	Braking Description	Wheel Braking Coefficient
5	Good	Ground Speed Dependent per §25.109(c)
4	Medium to Good	0.20
3	Medium	0.16
2	Medium to Poor	50% of §25.109(c) Max $m_B=0.16$, min $m_B=0.05$
1	Poor	0.08

REASONS FOR AN AIRCRAFT BRAKING STANDARD #1

RISK IS A FUNCTION OF AIRCRAFT PERFORMANCE



Must allow crew to make decisions based on proper guidance, policies, and checklists.



$$\mu_{\text{Brakes}} = \frac{\text{Force of Braked Wheels Decelerating the Aircraft}}{\text{Normal Force on the braked wheels (W-L)}}$$



REASONS FOR AN AIRCRAFT BRAKING STANDARD #2

Performance versus Contamination

Braking	μ_{Brakes}
Good	per §25.109(c)
Good to Medium	0.20
Medium	0.16
Medium to Poor	50% of §25.109(c) Max $m_B=0.16$, min $m_B=0.05$
Poor	0.08



Runway Condition

- FROST
- WET (The runway surface is covered by any visible dampness or water up to and including 3 mm depth)

Up to and including 3 mm depth:

- SLUSH
- DRY SNOW
- WET SNOW

-15°C and lower outside air temperature:

- COMPACTED SNOW

- WET ("slippery wet" runway)
 - DRY SNOW or WET SNOW (any depth) ON TOP OF COMPACTED SNOW
- More than 3 mm depth:

- DRY SNOW
- WET SNOW

Higher than -15°C outside air temperature¹:

- COMPACTED SNOW

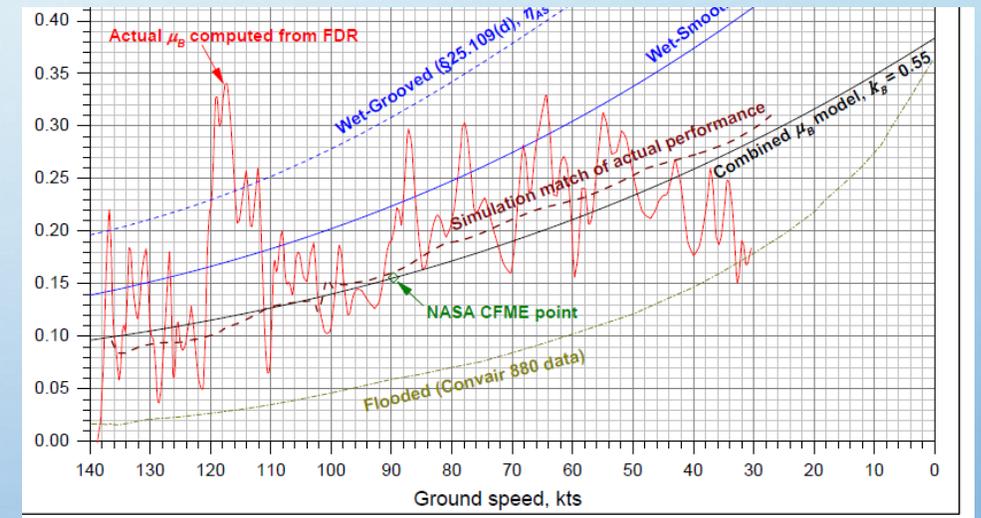
More than 3 mm depth of water or slush:

- STANDING WATER
- SLUSH

- ICE 2

REASONS FOR AN AIRCRAFT BRAKING STANDARD #3

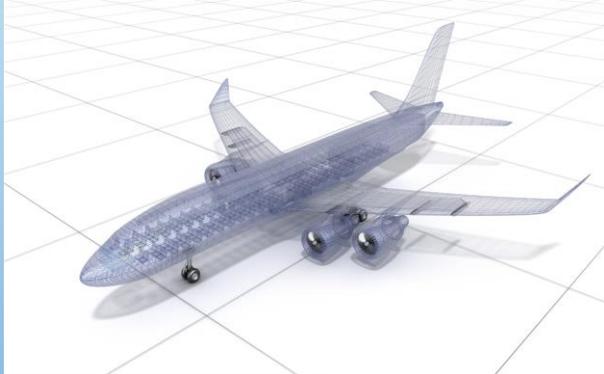
PILOTS BRAKING ACTION REPORTS – CAN WE COMPLETELY DEPEND ON THEM?



ASTM E3188-19

STANDARD TERMINOLOGY FOR AIRCRAFT BRAKING PERFORMANCE

YES, YOU CAN SPEAK ENGINEER!!



AIRCRAFT BRAKING COEFFICIENT

AIRCRAFT BRAKING SIMULATION EQUIPMENT

AIRPORT FRICTION MEASUREMENTS

ANTI-SKID EFFICIENCY

AUTOBRAKES

AVERAGE BRAKING COEFFICIENT

BRAKING ACTION

AIRCRAFT BRAKING ACTION REPORT

PILOT BRAKING ACTION REPORT

FRICTION LIMITED BRAKING

FRICTION LIMITED (AIRCRAFT/WHEEL) BRAKING COEFFICIENT

MAXIMUM AIRCRAFT WHEEL BRAKING PERFORMANCE

MAXIMUM TIRE TO GROUND BRAKING COEFFICIENT

MU SLIP CURVE

SCAP

SLIP-RATIO

TIME VARYING BRAKING COEFFICIENT

TIRE TO GROUND FRICTION COEFFICIENT

TORQUE LIMITED BRAKING

WHEEL BRAKING COEFFICIENT

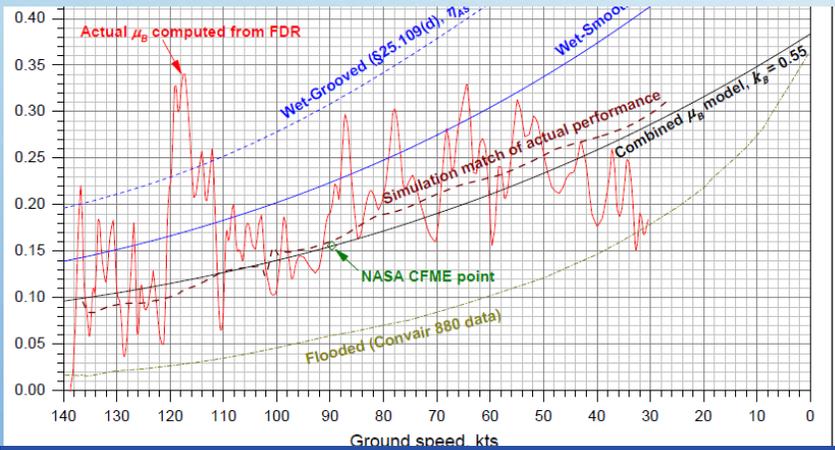


Ensure good data from aircraft



What the Standard Will Address

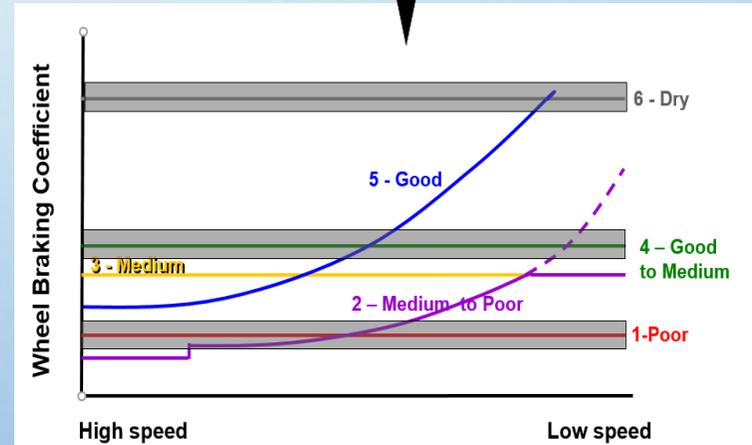
Friction Limited Aircraft Braking Measurements and Reporting



Ensure accurate data analysis

Aircraft Braking Action Report

“Good” “Medium” Etc.



Map result to standardized scale (TALPA/APM)



STANDARD PRACTICES FOR FRICTION LIMITED AIRCRAFT BRAKING MEASUREMENTS AND REPORTING

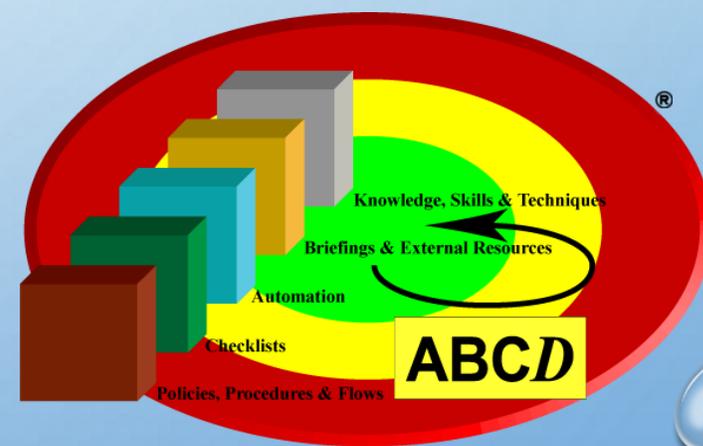
Must not limit participation
to only Aircraft
Manufacturers



Must provide actionable
information for decision making



Not intended as operational
policy but must support the
creation of policies,
procedures, checklists,
automation, and briefings



STANDARD PRACTICES FOR FRICTION LIMITED AIRCRAFT BRAKING MEASUREMENTS AND REPORTING

Standard

$$F = m \times a$$

Requirements, lists, acceptance methods. Intentionally broad in some areas due to aircraft variances.

Appendix

Guidance material, examples, best practices, and recommendations.



QUESTIONS?

WWW.FOURWINDSSAFETY.COM

JOHN@FOURWINDSSAFETY.COM

WWW.ASTM.ORG

WWW.SAPOE.ORG

