Aircraft/Runway Friction Performance
A practical application on winter surfaces

Presented by

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Transport Canada

EASA Runway Friction and Aircraft Braking Workshop
- The Way Forward - Paris, March 2010

Transport Canada Transports Canada

Canada

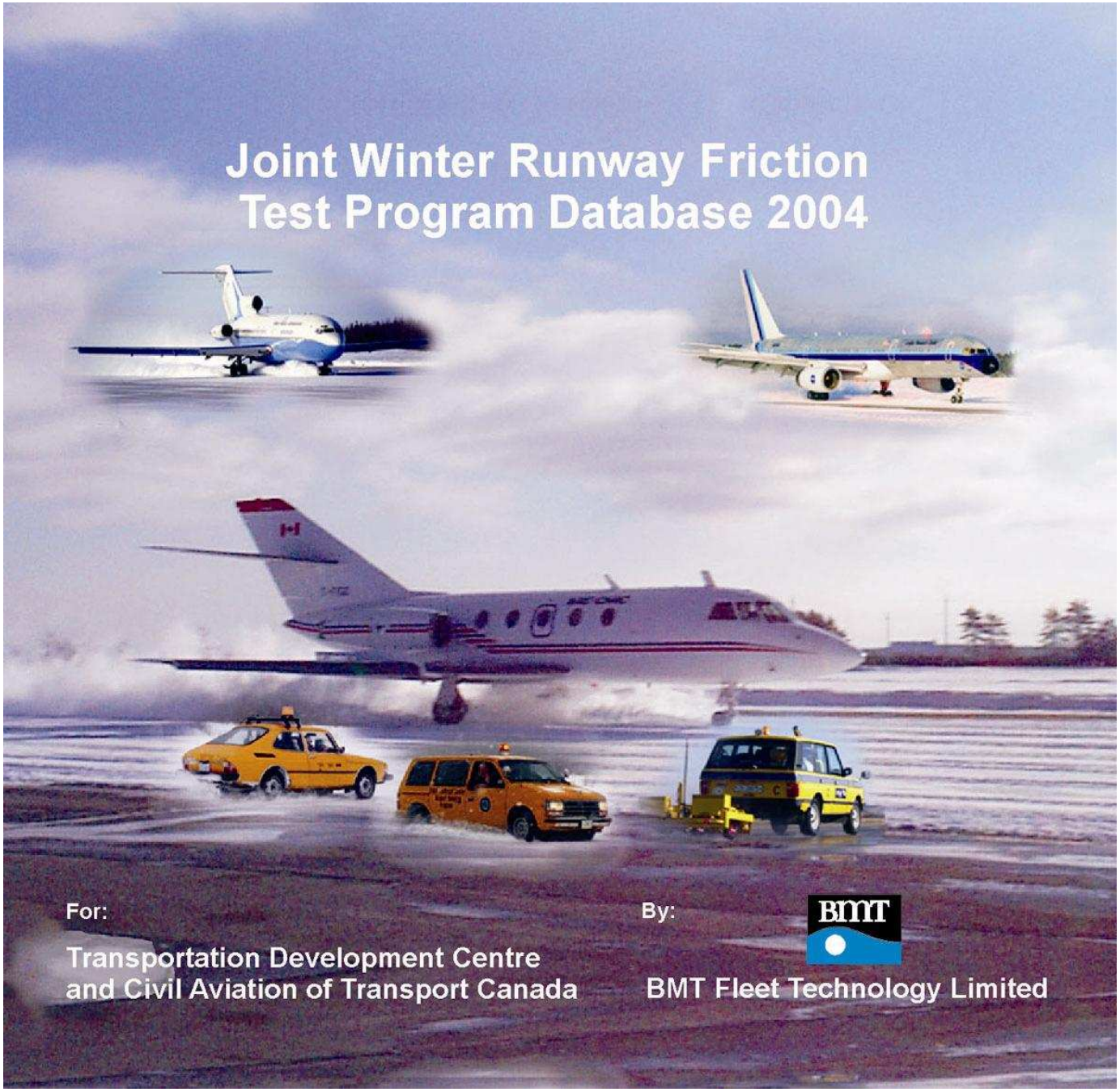
Outline

- JWRFMP Background
- Achievements
- Canadian Application
- Current Developments within Transport Canada

Program Objectives

- To determine the relationship between measured friction and aircraft braking performance on contaminated surfaces.
- To correlate ground friction measuring devices when operating on a contaminated surface.
- To establish an international methodology whereby a common indication of runway conditions can be implemented worldwide.

Joint Winter Runway Friction Test Program Database 2004



For:

Transportation Development Centre
and Civil Aviation of Transport Canada

By:

BMT Fleet Technology Limited









Achievements

- Aircraft braking coefficients were determined on contaminated runways for several aircraft types with similar anti-skid systems
- Braking coefficients correlated better with deceleration devices than with other types of friction measuring equipment
- Each of the major classes of aircraft tested (transport, business jet, turboprop) showed a similar relationship between braking coefficient and CRFI
- Aircraft braking distance ratios were similar to the results of earlier NASA tests
- In Canada, tables of Recommended landing distance were developed as a function of the CRF

Canadian Runway Friction Index Application

Decelerometer: spot measurements taken every 1000 ft on both sides of the runway.

- Measuring
- Reporting
- Application
- Limitations

CRFI Measurements

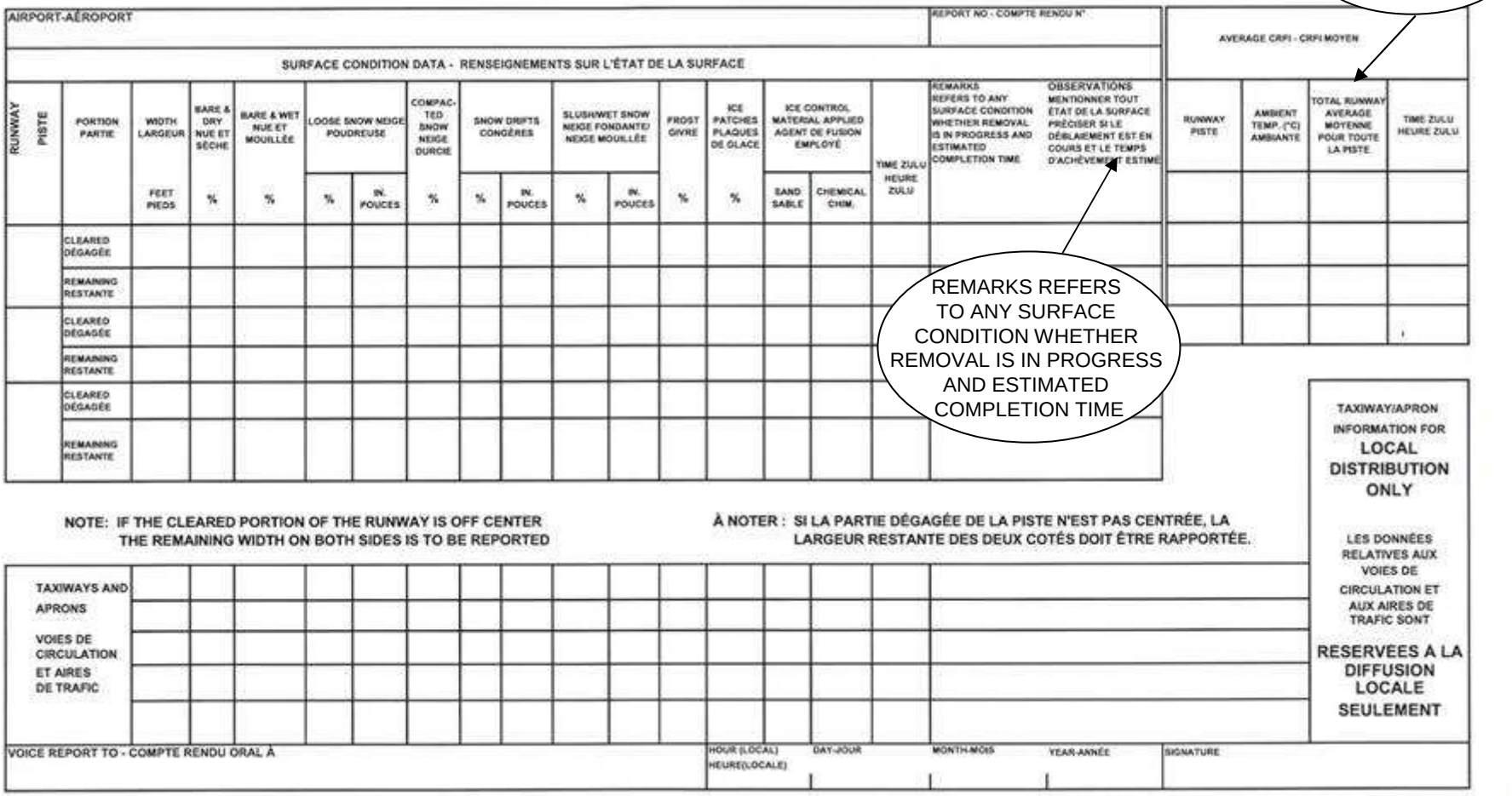
- Winter surfaces
  - Ice, frost, ice covered with thin water film, ice covered by slush, sand, aggregate material, de/anti-icing chemicals, compacted snow, loose snow not exceeding 1 inch.

- CRFI not taken
  - Loose snow exceeding 1 inch.
  - Wet surfaces or a slush layer with no other contaminant.

Reporting

- Aircraft Movement Surface Condition Report
  - Information obtained by airport operators and used in NOTAMs and Automatic Terminal Information Systems.
- NOTAM Report
  - Issued when runway is contaminated by:
    - slush or wet snow or compacted snow or ice or frost or loose snow exceeding 0.25 inch in depth.
    - Also issued if runway is not fully cleared or partially cleared.
    - CRFI of 0.4 or less is present.
- Pilot Information Reports

Aircraft Movement Surface Condition Report CRFI



AIRPORT-AÉROPORT

REPORT NO - COMPTE RENDU N°

SURFACE CONDITION DATA - RENSEIGNEMENTS SUR L'ÉTAT DE LA SURFACE

RUNWAY PISTE	PORTION PARTIE	WIDTH LARGEUR FEET PIEDS	BARE & DRY NUE ET SÈCHE %	BARE & WET NUE ET MOUILLÉE %	LOOSE SNOW NEIGE POUDREUSE %	LOOSE SNOW NEIGE POUDREUSE IN. POUCES	COMPACTED SNOW NEIGE DURCIE %	SNOW DRIFTS CONGÈRES %	SNOW DRIFTS CONGÈRES IN. POUCES	SLUSH/WET SNOW NEIGE FONDANTE/ NEIGE MOUILLÉE %	SLUSH/WET SNOW NEIGE FONDANTE/ NEIGE MOUILLÉE IN. POUCES	FROST GIVRE %	ICE PATCHES PLAQUES DE GLACE %	ICE CONTROL MATERIAL APPLIED AGENT DE FUSION EMPLOYÉ SAND SABLE	ICE CONTROL MATERIAL APPLIED AGENT DE FUSION EMPLOYÉ CHEMICAL CHIM.	TIME ZULU HEURE ZULU	REMARKS REFERS TO ANY SURFACE CONDITION WHETHER REMOVAL IS IN PROGRESS AND ESTIMATED COMPLETION TIME	OBSERVATIONS MENTIONNER TOUT ÉTAT DE LA SURFACE PRÉCISER SI LE DÉBLAIEMENT EST EN COURS ET LE TEMPS D'ACHÈVEMENT ESTIMÉ
	CLEARED DÉGAGÉE																	
	REMAINING RESTANTE																	
	CLEARED DÉGAGÉE																	
	REMAINING RESTANTE																	
	CLEARED DÉGAGÉE																	
	REMAINING RESTANTE																	

AVERAGE CRFI - CRFI MOYEN

RUNWAY PISTE	AMBIENT TEMP. (°C) AMBIANTE	TOTAL RUNWAY AVERAGE MOYENNE POUR TOUTE LA PISTE	TIME ZULU HEURE ZULU

TOTAL RUNWAY AVERAGE

REMARKS REFERS TO ANY SURFACE CONDITION WHETHER REMOVAL IS IN PROGRESS AND ESTIMATED COMPLETION TIME

NOTE: IF THE CLEARED PORTION OF THE RUNWAY IS OFF CENTER THE REMAINING WIDTH ON BOTH SIDES IS TO BE REPORTED

À NOTER : SI LA PARTIE DÉGAGÉE DE LA PISTE N'EST PAS CENTRÉE, LA LARGEUR RESTANTE DES DEUX COTÉS DOIT ÊTRE RAPPORTÉE.

TAXIWAYS AND APRONS / VOIES DE CIRCULATION ET AIRES DE TRAFIC																	

TAXIWAY/APRON INFORMATION FOR LOCAL DISTRIBUTION ONLY

LES DONNÉES RELATIVES AUX VOIES DE CIRCULATION ET AUX AIRES DE TRAFIC SONT RESERVEES A LA DIFFUSION LOCALE SEULEMENT

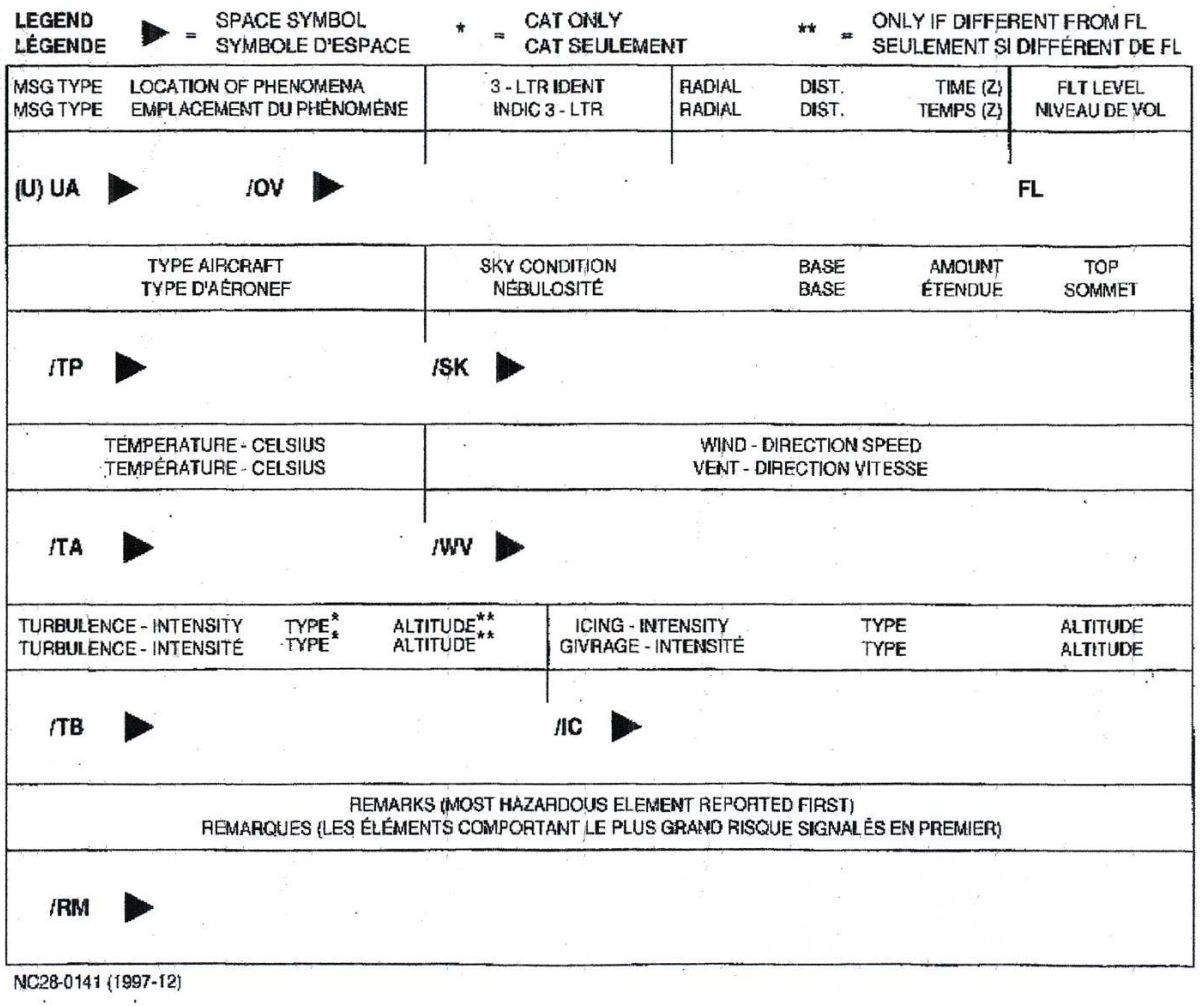
VOICE REPORT TO - COMPTE RENDU ORAL À

HOUR (LOCAL) HEURE(LOCALE) | DAY-JOUR | MONTH-MOIS | YEAR-ANNÉE | SIGNATURE

Transport Canada Transports Canada

Canada

PIREP Form



LEGEND / LÉGENDE ▶ = SPACE SYMBOL / SYMBOLE D'ESPACE * = CAT ONLY / CAT SEULEMENT ** = ONLY IF DIFFERENT FROM FL / SEULEMENT SI DIFFÉRENT DE FL

MSG TYPE / MSG TYPE	LOCATION OF PHENOMENA / EMPLACEMENT DU PHÉNOMÈNE	3 - LTR IDENT / INDIC 3 - LTR	RADIAL / RADIAL	DIST. / DIST.	TIME (Z) / TEMPS (Z)	FLT LEVEL / NIVEAU DE VOL
(U) UA ▶	/OV ▶					FL

TYPE AIRCRAFT / TYPE D'AÉRONEF	SKY CONDITION / NÉBULOSITÉ	BASE / BASE	AMOUNT / ÉTENDUE	TOP / SOMMET
/TP ▶	/SK ▶			

TEMPERATURE - CELSIUS / TEMPÉRATURE - CELSIUS	WIND - DIRECTION SPEED / VENT - DIRECTION VITESSE
/TA ▶	/WV ▶

TURBULENCE - INTENSITY / TURBULENCE - INTENSITÉ	TYPE* / TYPE*	ALTITUDE** / ALTITUDE**	ICING - INTENSITY / GIVRAGE - INTENSITÉ	TYPE / TYPE	ALTITUDE / ALTITUDE
/TB ▶			/IC ▶		

REMARKS (MOST HAZARDOUS ELEMENT REPORTED FIRST)
REMARQUES (LES ÉLÉMENTS COMPORTANT LE PLUS GRAND RISQUE SIGNALÉS EN PREMIER)

/RM ▶

NC28-0141 (1997-12)

CRFI Application

- CRFI tables are intended to be used at the pilot's discretion.
- Overriding manufacturer data is an individual operators choice.
- CRFI at the very least can be used in tactical decision-making when landing on contaminated runways.

CRFI Recommended Landing Distance (Discing/Reverse Thrust)

Reported Canadian Runway Friction Index (CRFI)														
Landing Distance (feet) Bare and Dry Unfactored	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.27	0.25	0.22	0.20	0.18	Landing Field Length (feet) Bare and Dry	Landing Field Length (feet) Bare and Dry
	Recommended Landing Distances (Discing/Reverse Thrust)												60% Factor	70% Factor
1,200	2,000	2,040	2,080	2,120	2,170	2,220	2,280	2,340	2,380	2,440	2,490	2,540	2,000	1,714
1,400	2,340	2,390	2,440	2,500	2,580	2,660	2,750	2,820	2,870	2,950	3,010	3,080	2,333	2,000
1,600	2,670	2,730	2,800	2,880	2,970	3,070	3,190	3,280	3,360	3,460	3,540	3,630	2,667	2,286
1,800	3,010	3,080	3,160	3,250	3,350	3,480	3,630	3,730	3,810	3,930	4,030	4,130	3,000	2,571
2,000	3,340	3,420	3,520	3,620	3,740	3,880	4,050	4,170	4,260	4,400	4,510	4,630	3,333	2,857
2,200	3,570	3,660	3,760	3,880	4,020	4,170	4,360	4,490	4,590	4,750	4,870	5,000	3,667	3,143
2,400	3,900	4,000	4,110	4,230	4,380	4,550	4,750	4,880	4,980	5,150	5,270	5,410	4,000	3,429
	4,200	4,300	4,420	4,560		4,890	5,100		5,350	5,520	5,650	5,790	4,333	3,714
	4,460	4,570	4,700	4,840		5,190	5,410		5,670	5,850	5,980	6,130	4,667	4,000
	4,740	4,860	5,000	5,160		5,550	5,790		6,070	6,270	6,420	6,580	5,000	4,286
	5,080	5,220	5,370	5,550		5,970	6,240		6,560	6,770	6,940	7,110	5,333	4,571
3,400	5,350	5,500	5,660	5,850	6,060	6,310	6,590	6,790	6,930	7,170	7,340	7,530	5,667	4,857
3,600	5,620	5,780	5,960	6,160	6,390	6,650	6,960	7,170	7,320	7,570	7,750	7,950	6,000	5,143
3,800	5,890	6,060	6,250	6,460	6,700	6,980	7,310	7,540	7,700	7,970	8,160	8,380	6,333	5,429
4,000	6,070	6,250	6,440	6,660	6,910	7,210	7,540	7,780	7,950	8,220	8,430	8,650	6,667	5,714

0.40

0.28

3030

5400

5970

CRFI Recommended Landing Distance (No Discing/No Reverse Thrust)

Reported Canadian Runway Friction Index (CRFI)														
Landing Distance (feet) Bare and Dry Unfactored	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.27	0.25	0.22	0.20	0.18	Landing Field Length (feet) Bare and Dry	Landing Field Length (feet) Bare and Dry
	Recommended Landing Distances (No Discing/No Reverse Thrust)												60% Factor	70% Factor
1 800	3 120	3 200	3 300	3 410	3 540	3 700	3 900	4 040	4 150	4 330	4 470	4 620	3 000	2 571
2 000	3 480	3 580	3 690	3 830	3 980	4 170	4 410	4 570	4 700	4 910	5 070	5 250	3 333	2 857
2 200	3 720	3 830	3 960	4 110	4 280	4 500	4 750	4 940	5 080	5 310	5 490	5 700	3 667	3 143
2 400	4 100	4 230	4 370	4 540	4 740	4 980	5 260	5 470	5 620	5 880	6 080	6 300	4 000	3 429
2 600	4 450	4 590	4 750	4 940	[illegible]	5 420	5 740	5 960	6 130	6 410	6 630	6 870	4 333	3 714
2 800	4 760	4 910	5 090	5 290	[illegible]	5 810	6 150	[illegible]	6 570	6 880	7 110	7 360	4 667	4 000
3 000	5 070	5 240	5 430	5 650	[illegible]	6 220	6 590	[illegible]	7 060	7 390	7 640	7 920	5 000	4 286
3 200	5 450	5 630	5 840	6 090	[illegible]	6 720	7 130	[illegible]	7 640	8 010	8 290	8 600	5 333	4 571
3 400	5 740	5 940	6 170	6 430	6 740	7 110	7 550	[illegible]	8 100	8 500	8 800	9 130	5 667	4 857
3 600	6 050	6 260	6 500	6 780	7 120	7 510	7 990	8 330	8 580	9 000	9 320	9 680	6 000	5 143
3 800	6 340	6 570	6 830	7 130	7 480	7 900	8 410	8 770	9 040	9 490	9 840	10 220	6 333	5 429
4 000	6 550	6 780	7 050	7 370	7 730	8 170	8 700	9 080	9 360	9 830	10 180	10 580	6 667	5 714

0.4

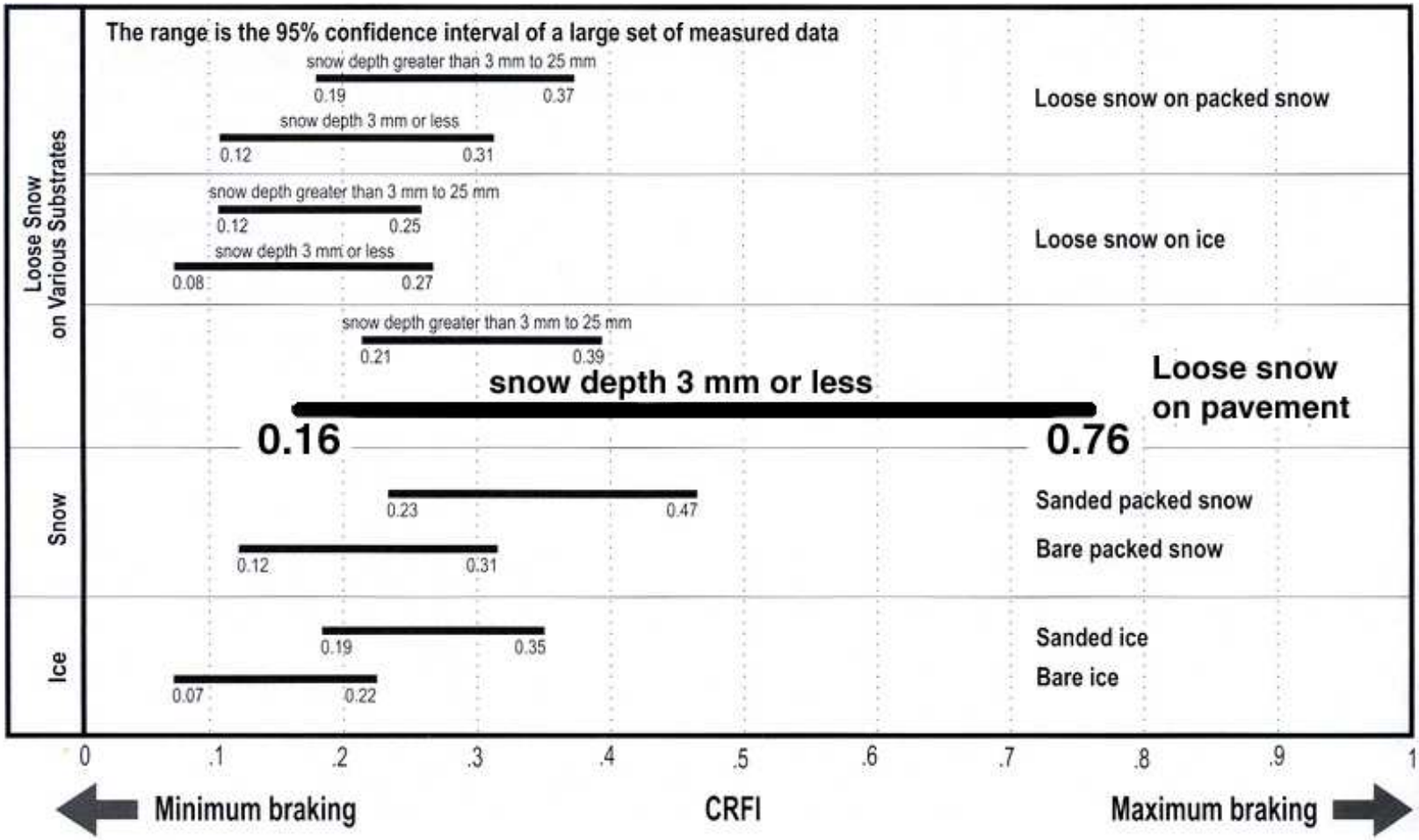
0.28

3030

5980

6850

Expected Range of CRFIs by Surface Type



Limitations

Cons

- The CRFI measurement may be influenced by operator technique (training reduces this potential).
- Longer runway occupancy times.
- Vehicle type may affect measurements.
- ABS systems on or off.

Pros

- Cheap and simple system to use.
- CRFI/ERD correlates well with aircraft braking performance.

Effect of Vehicle Type on Decelerometer Friction Coefficients: Summary Results

Parameter Varied	Bare Ice (friction of about 0.1)	Sanded Packed Snow (friction of about 0.35)
Vehicles (SUV, ½ ton, ¾ ton, 1 ton & minivan)	Max. friction variation was about 0.02	Max. friction variation was about 0.05
Decel type	Higher friction with Tapley and Bowmonk by 0.05 and 0.025 than ERD	Higher friction with Tapley and Bowmonk by 0.05 and 0.025 than ERD
ABS on or off	Max. friction variation was about 0.02	Max. friction variation was about 0.05
Weight Distribution (50:50 vs. As-Is)	Friction was about 0.02 lower for the 50:50	Friction was about 0.02 lower for the 50:50

Significance of Friction Variations

- Effect of Decelerometer Type
  Landing distance variation of about 152 m (Tapley) and 76 m (Bowmonk).
- Effect of Vehicle Type
  Maximum landing distance variation of about 152-183 m.
- Effect of ABS On or Off
  Maximum landing distance variation of about 152 m.
- Effect of Weight Distribution
  Maximum landing distance variation of about 61 m.

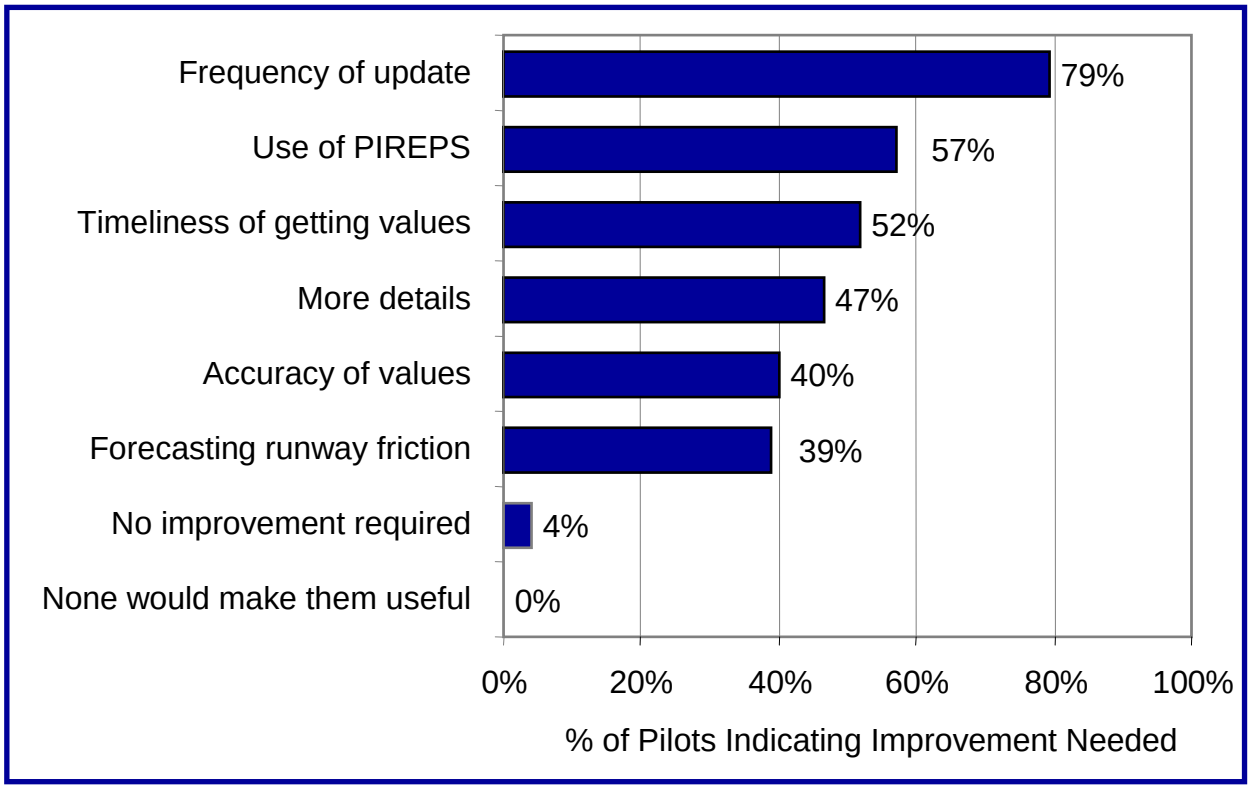
Aspects of Runway Friction Information Needing Improvement

Survey of Airline Pilots

- Distributed to 2,450 airline pilots with support from ALPA and ACPA.
- 393 responses received – 11% response rate.
- Covered a good cross-section of aircraft types (turboprop to widebody jets) and pilot experience.
- 95% of pilots are aware of guidance material for slippery runways.
- 85% of pilots have guidance material for determining landing distance and crosswind limits and find the material very useful.

Survey of Airline Pilots

Aspects of runway friction information needing improvement



Canadian Runway Friction Index

- James Brake Index was renamed CRFI
- CRFI tables were developed based on real test data using several aircraft types with similar anti-skid systems
- Airports throughout Canada equipped with mechanical or electronic decelerometers
- CRFI landing distance tables are not aircraft specific but generic type tables.
- Tables are based on corrections to individual aircraft flight manual dry runway data.

Current Development and the Way Forward For TC

Friction Specifications

Wintertime Friction Measurements

Decelerometers

- Goal: Performance-Based Procedures
- Intended Applications
  - New Device or Model Entering the Market
  - QA Checks at an Airport, eg, by inspector or airport staff

Friction Spec's cont'd

Summertime Friction Measurement

Goal: Define Performance Specifications for CFMEs

Intended Application:

Define Criteria: That a Device Must Meet to be Acceptable

Goal: Produce Specifications for Runway Friction that:

- ✓ Allow Airports to Use Various CFMEs
- ✓ Maintain Consistency With TC Present Standards

Way Forward Summary

- Build on past efforts
- Recommendations should be practical in an operational environment
- The way forward should address the enforcement issue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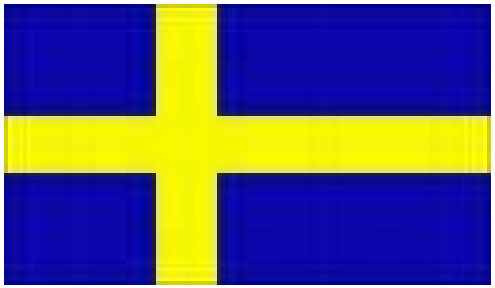
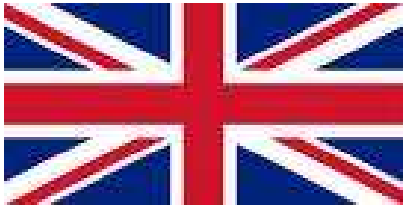
THANK YOU


IATA



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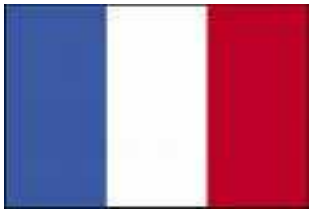


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