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Braking Availability Tester (BAT)

Professor Susan Tighe, Ph.D, P.Eng
Canada Research Chair and Director Centre for Pavement and Transportation Technology, Civil Engineering

Professor HJ Kwon, Ph.D, P.Eng
Assistant Professor, Mechanical and Mechatronics Engineering

Professor Soo Jeon, Ph.D, P.Eng
Assistant Professor, Mechanical and Mechatronics Engineering

In partnership with Team Eagle Ltd., Ontario Centres of Excellence, Waterloo International Airport, West Jet, Arnie Beck

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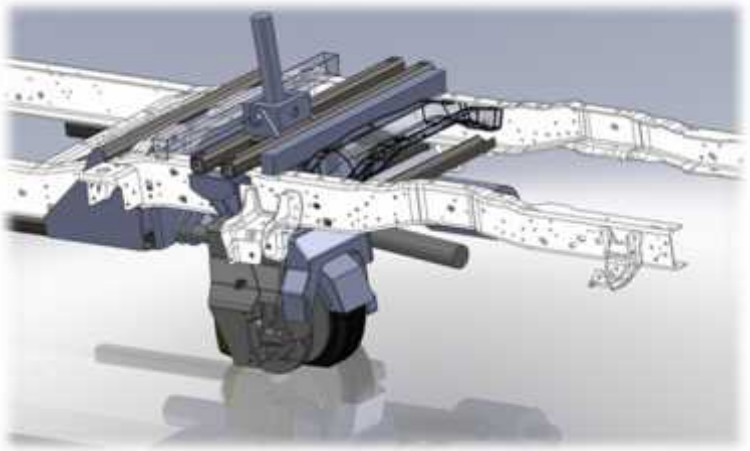
Presentation Overview

- Background
- Objective
- Partners
- Testing Methodology
- Upcoming Trials
- Next Steps



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What observable and measurable runway conditions can we provide our aviators so they can safely and accurately predict wheel braking aborted take off and landing stopping distances?

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Background: Challenges

How do we collect the right data?
Use real-time data to reflect the situation?

Is there an opportunity to improve state-of-the-art by providing information?

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Why this 'BAT' project?

- Midway – Southwest Flight 1248 – December 8, 2005
- **'Friction' .4 , 'Braking' .085**

- 'Braking' was about 20% of 'Friction'
- Would it be possible to test for 'Braking', instead of 'Friction'

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Braking vs. Friction

- Systems challenged to emulate how the anti-skid braking systems on airplanes react when braking aggressively in deformable contaminants

- If Brake > slip to a maximum slip value > auto-release brake > wait for wheel spin up to a level less than maximum slip > reapply braking > slip to a maximum ...>>>>

- Repeat, cycle, modulate, cycle ….until braking is either no longer required, or desired braking can be achieved without exceeding maximum slip values of anti-skid braking system algorithms

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The Braking Availability Testing (BAT) Technology

The BAT technology is completely different in concept and design:

1. It uses an actual aircraft tire instead of a 'friction' testing tire, inflated to much higher 'aircraft' tire pressures

2. During operation, ballast from the BAT chassis is transferred to BAT aircraft tire to produce a scaled tire patch with equivalent tire/ground contact pressure to a reference aircraft

3. The braking of this emulative tire patch is driven by the aircraft anti skid braking algorithm of a reference aircraft

4. The braking forces are then measured in the BAT using embedded sensors and then are extrapolated into the actual braking forces that an aircraft will see if maximum braking is applied by the reference aircraft landing, or, even more importantly, during an aborted take off.

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Objective

The goal of the BAT technology is to provide our aviators with a meaningful indicator of the ***MINIMUM*** **maximum** braking that they can expect to be available if they apply maximum braking on their aircraft.

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Objective

- Too many variables between reference aircraft to expect extreme precision, but we are striving for ***absolute*** accuracy – Example – Our pilots would be advised ".3 braking (or NOTAM acceptable jargon) is available."

- An aircraft might 'see' .34 or .37 actual braking, but never less than .3 – **zero** outliers.

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Partners

- Team Eagle Ltd.
- Provincial research grant from Ontario Centres of Excellence (OCE) for 3 years
- Waterloo International Airport
- WestJet
- Aircraft ASBS Expert, Arnie Beck

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Methodology of Evaluation

Truck Prototype & Proof of BAT Design

- Build out of the truck was successful, may need more power and capacity for ballast - YTBD
- Integration of ‘scaled’ components has been challenging, many of our aircraft braking system components are designed to perform in very well defined envelopes that we cannot manipulate without comprehensive investigation

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Methodology of Evaluation

Truck Prototype & Proof of BAT Design

- BAT vehicle was delivered to University of Waterloo Test Center early 2011
- Proof of design was initiated – many small issues and challenges became evident – a few blown tires from inappropriate use of a very powerful braking system ☺
- Algorithm development a lot more complex than anticipated (over 350 kb *without* aircraft landing gear harmonics)

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Methodology of Evaluation

Truck Prototype & Proof of BAT Design

- Prototype is necessarily much more complex to measure and understand the many 'background' forces in play (example – weight transfer)

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Methodology of Evaluation

- Proof of design/concept testing should be completed early this winter at Waterloo International Airport.
- Other aviation stakeholders are stepping forward to compliment/broaden Waterloo IA experience
- Expected testing at additional airports and with additional airlines and aircraft types.
- Reviewing opportunity for a CRADA (Cooperative Research and Development Agreement) with the FAA Test Center in Atlantic City, and an invitation to participate in ICAO's FTF (Friction Task Force)

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Methodology of Evaluation

Our team at the University have structured a comprehensive civil engineering based testing, evaluation and possible confirmation/validation program that will be initiated immediately following proof of design and concept mid 2011/12 winter.

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Methodology of Evaluation

- Running BAT Testing Concurrent with:
  - Waterloo International Airport Transport Canada Runway Condition Reporting (including CRFI)
  - WestJet Airlines partnering with us and will be supplying us with flight deidentified FDR data from which UofW (under a confidentiality NDA) can extrapolate actual, current time, wheel braking data from WestJet aircraft landings that take place during our testing

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Methodology of Evaluation

WinterOps™ Pro digital runway condition reporting software will be integrated into the BAT Technology this winter.

WinterOps™ Pro will provide the ability of the operator of the BATMobile ☺ to create and wirelessly distribute real time RCRs to our Team in the testing phase, and then to all authorized aviation stakeholders via NOTAMs, SNOTAMS, SNOWWIZ and equivalents if/when testing is successfully completed and the system is authorized for use.

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Methodology of Evaluation

- Intend to include drag sensing and friction testing functionality to the next iteration of the BAT
- Eventually consider adding drag forces to reduce anticipated ‘wheel braking and drag’ aircraft stopping distances.
- Include friction testing as it is very helpful in safely reducing the cost of conservative airfield maintenance practices.
- BAT may provide savings in WinterOps in snow and rain through improved operations .

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Outstanding Challenges – For BAT

- Update performance requirements of certain hardware elements.
- Source components as close to requirements as possible.
- New iterations of algorithm and extrapolation software to integrate with and accommodate new componentry.

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Outstanding Challenges – For Everyone

Quantifying and qualifying our 'observables' and 'measurables'.

Can we address the challenge that is inherent in the historical observation that even a 1/8 depth of snow may generate a 'friction' value range of less than .2 to more than .7?

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Outstanding Challenges – For Everyone

Quantifying and qualifying our 'observables' and 'measurables'.

Can we address the challenge that data downloaded and extrapolated from FDRs only provides us with meaningful data for the (hopefully) very small portion of the runway where maximum wheel braking was applied?

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Outstanding Challenges – For Everyone

Quantifying and qualifying our 'observables' and 'measurables'.

Can we address the challenge that is inherent in the fact that the only comprehensive, objective and definitive PIREP is that of a pilot that has just applied maximum braking the entire length of a runway?

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Closing Comments

- Public-Private-Academic Partnership to improve state-of-the art practice
- In additional to all partners, two full graduate students (one MME and one CEE) working on BAT
- BAT will provide better in-situ data
- Excellent opportunity to improve the current methods of evaluation
- Interested in partnering with aviation industry / government / research communities
- BAT Technology Executive Summary available

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Questions/Comments

Susan L. Tighe, PhD, PEng
Principal Investigator
Professor and Canada Research Chair
Civil and Environmental Engineering
University of Waterloo
sltighe@uwaterloo.ca or 519-888-4567 x 33152