AIRPORT TECHNOLOGY R&D

Aircraft Braking Friction Research

Presented to: REDAC Sub-Committee on Airports

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Date: March 3, 2020

Federal Aviation Administration

Aircraft Braking Friction

- **Airport Runway Conditions (i.e. Wetted and Contaminated) Can Cause Degraded Wheel Braking During Aircraft Landings.**
- **Degraded Aircraft Wheel Braking Has Contributed to Runway Overruns and Collisions (e.g. Southwest Airlines Flight 1248 Landing at MDW Under Snow Conditions).**
- **FAA Aircraft Braking Friction Research Initiated in Response to NTSB Issued Safety Recommendations.**

NTSB Safety Recommendations

- **NTSB, (2016), *Safety Recommendation* A-16-023:**
- **"Continue to work with industry to develop the technology to outfit transport-category airplanes with equipment and procedures to routinely calculate, record, and convey the airplane braking ability required and/or available to slow or stop the airplane during the landing roll."**
- **NTSB, (2016), Safety Recommendation A-16-24:**
- **"If the systems described in Safety Recommendation A-16-23 are shown to be technically and operationally feasible, work with operators and the system manufacturers to develop procedures that ensure that airplane-based braking ability results can be readily conveyed to, and easily interpreted by, arriving flight crews, airport operators, air traffic control personnel, and others with a safety need for this information."**
- **The NTSB encourages the FAA to perform flight tests on representative domestic and international runways that support turbine-powered airplane operations in order to validate the wet-ungrooved and wet-grooved wheel braking coefficient models in Section 25.109(c) (Code of Federal Regulations, Part 25 Airworthiness Standards: Transport Category Airplanes, Accelerate-Stop distance).**

REDAC Recommendations/FAA Actions

- **In 2016 REDAC Sub-Committee on Airports Requested Formation of a Technical Working Group to Review FAA Research on Aircraft Braking Friction and Make Recommendations Regarding Direction of Future Efforts.**
- **Airport Technology R&D Formed Technical Working Group in February 2017 to Evaluate FAA Aircraft Braking Friction Research.**
- **Technical Working Group Developed White Paper Recommending Elements of Future FAA Aircraft Braking Friction Research Including Obtaining of Test Aircraft and Runway to Conduct Controlled Condition Flight Testing.**
- **White Paper Document Supplied to REDAC Sub-Committees in 2018.**

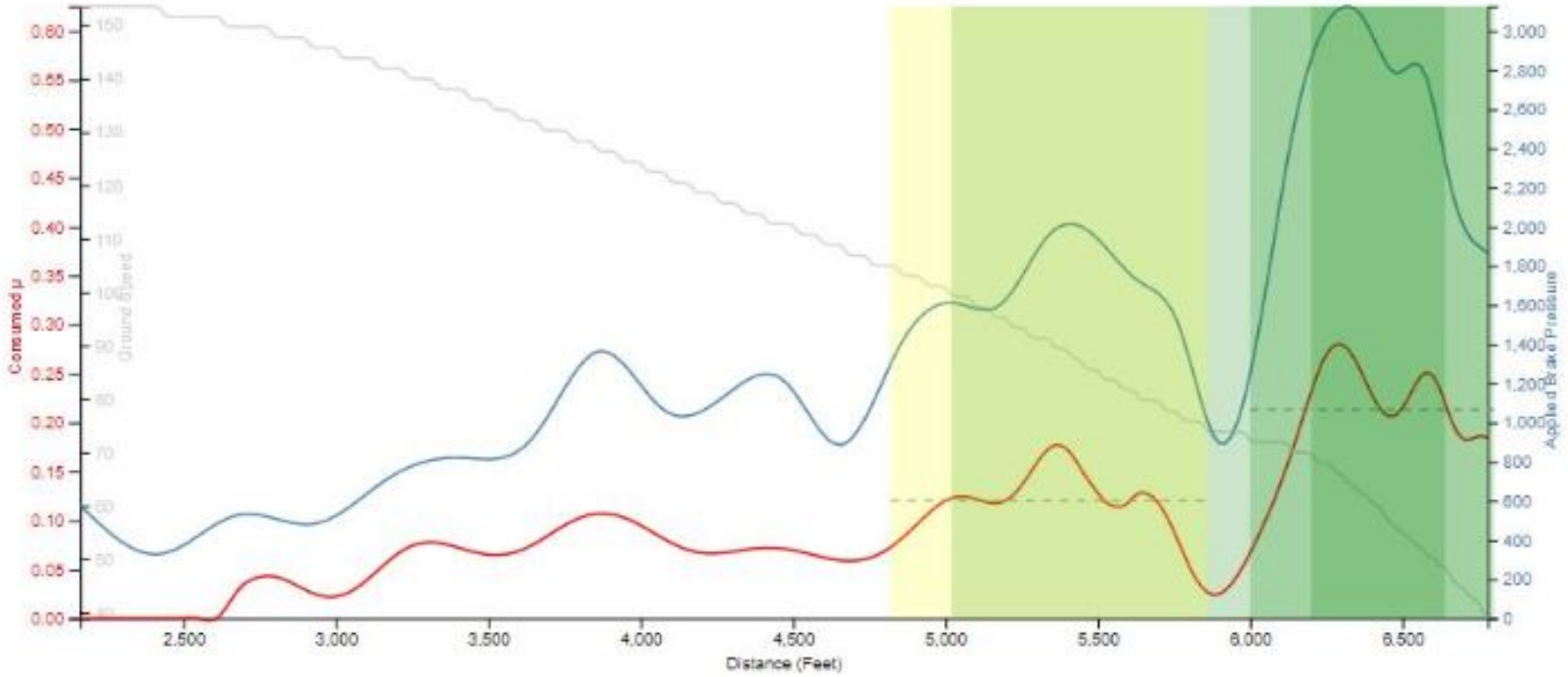
REDAC Recommendations/FAA Actions (Continued)

- **In 2018 REDAC Sub-Committee on Aircraft Safety (SAS) Requested that the FAA Develop a Plan to explore Data Reduction Methods and Provide the REDAC with an Updated Research Approach including the Overall Roadmap and Strategic Plan.**
- **Technical Working Group Met June 6-7, 2019 at MIT in Cambridge, MA to Develop Parameters for Incorporating Data Reduction Methods Into the White Paper.**
- **Modified White Paper Completed in July, 2019.**
- **Modified White Paper Recommends FAA Research Objectives Include Big Data Analytics/Machine Learning and Controlled Condition Flight Testing with Leased Instrumented Aircraft.**

Big Data Analytics/Machine Learning

- **Big Data Analytics will Involve Comparison of Aircraft Performance Data with Data Collected External to the Aircraft.**
- **Machine Learning Model Developed to Extract Relationships Between Contributing Variables and Resultant Degraded Aircraft Braking Performance.**
- **FAA Has Contracted with Aviation Safety Technologies (AST) to Obtain Data From Aircraft Landings Generated over a Two Year Period (2017 and 2018). AST will provide Technical Support in Big Data Analysis.**
- **AST Data Represents Several Million Aircraft Landings Including Thousands of Friction Limited Landings.**
- **Processed Data, Weather Data, and Runway Data to be Supplied.**
- **FAA to Pursue Obtaining Additional Large Quantities of Data from Other Sources.**

AST Aircraft Braking Plot
Consumed Mu/Applied Brake Pressure/Ground Speed vs. Distance Traveled



- **Plot Identifies Friction Limited Braking Condition at Approximately 5,000 ft. and 5,500 ft. (Mu = 0.10)**

Big Data Analytics/Machine Learning

- **Data Collected External to Aircraft to include Pilot Braking and Field Condition Reports (FICON NOTAMS) and Airport Surface Detection Equipment (ASDE-X).**
- **Big Data Analytics and Machine Learning Effort to be Performed by the FAA and MIT. MIT Work to be Funded Under the FAA Joint University Program (JUP).**
- **Machine Learning Working Group for Runway Friction Being Formed to Support MIT and the FAA with Analysis.**
- **Machine Learning Working Group for Runway Friction to Include Representation from the FAA, Academia, Industry Representatives with Big Data Analytics Background, and Others that are Developing Runway Braking Friction Assessment Technologies.**

Machine Learning Working Group for Runway Friction

- **Objectives/Goals of the Machine Learning Working Group are as follows:**
  - **Identify Various Data Sources and Facilitate Sharing Such Data.**
  - **Support the FAA and MIT in Big Data Analysis in Understanding the Data and its Organization.**
  - **Make Recommendations on Appropriate Use of Machine Learning Methods.**
  - **Support the Interpretation of Results, Findings, and Conclusions, and Make Recommendations for the Direction of Future Efforts.**

Machine Learning Working Group for Runway Friction

- **Initial Meeting of Machine Learning Working Group to be Held in April, 2020 at either MIT or the FAA Technical Center.**
- **Meeting Objectives will be to allow Members to Brief Group on their Experience in Big Data Analytics Related to Aircraft Braking Performance and Develop a Road Map for Future Group Work.**

Controlled Condition Flight Testing

- **Instrumented Aircraft (to be Leased by FAA) Used to Conduct Brake Testing on Wetted and Contaminated Runways to Assess Degraded Braking.**
- **Flight Testing will be Complimentary to Big Data Analytics/Machine Learning Study in that it Helps Validate Statistical Models.**
- **Flight Testing can Isolate the Contribution of Particular Factors Related to Degraded Braking such as Pavement Micro- and Macro-Texture.**

QUESTIONS?