



NTSB National Transportation Safety Board

Aircraft Performance

Airplane Performance Results

- Upper wing ice



Photo courtesy of NASA

Airplane Performance Calculations

- Acceleration and takeoff roll were normal
- Airplane had proper airspeed
- Airplane had proper pitch at liftoff
- Airplane stalled
- Loss of roll control

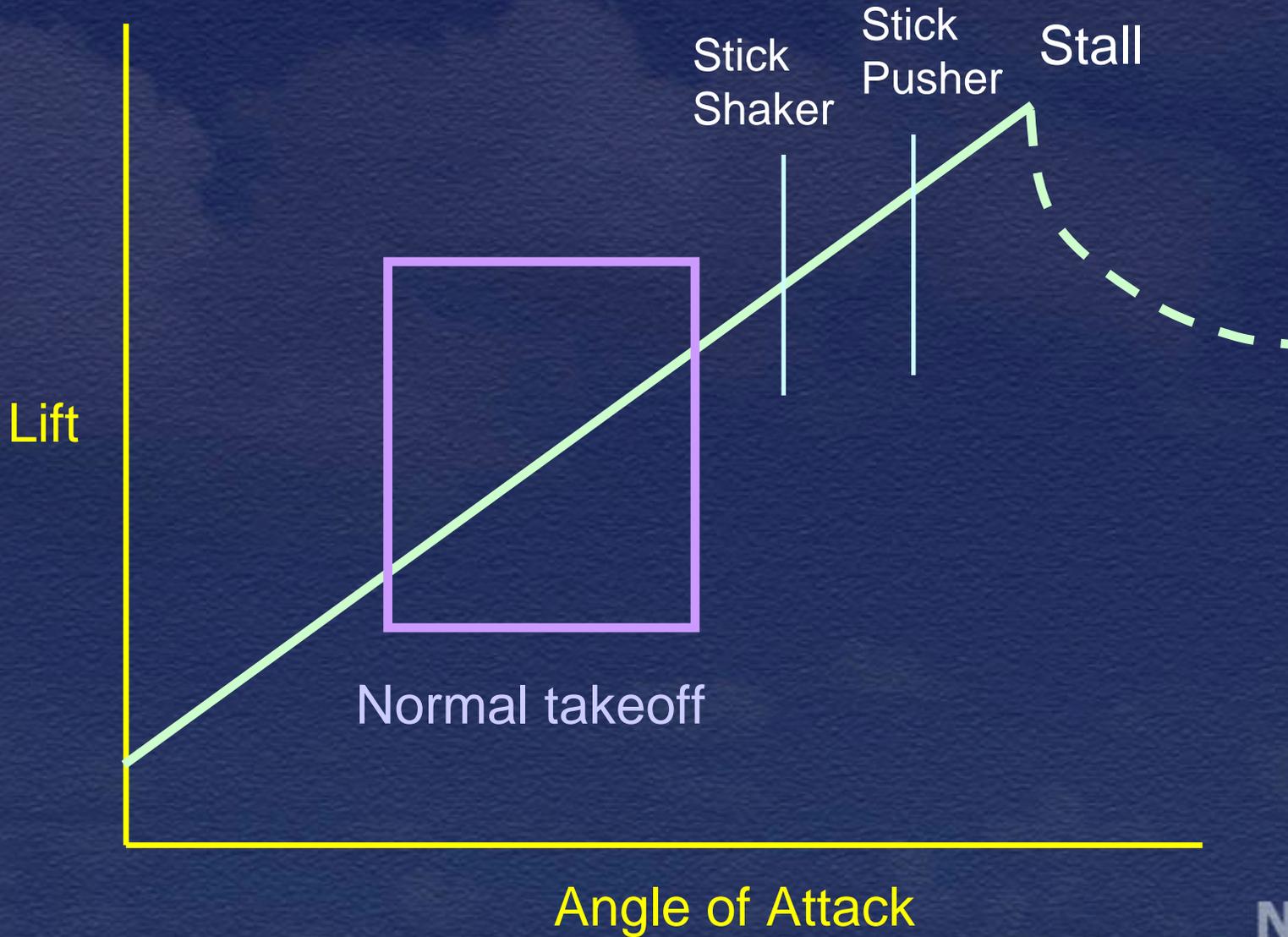
Airplane Performance Calculations

- Clean airplane should have climbed
- Accident airplane failed to climb
- Experienced several roll excursions
- Localized aerodynamic stall
- Indicative of surface contamination

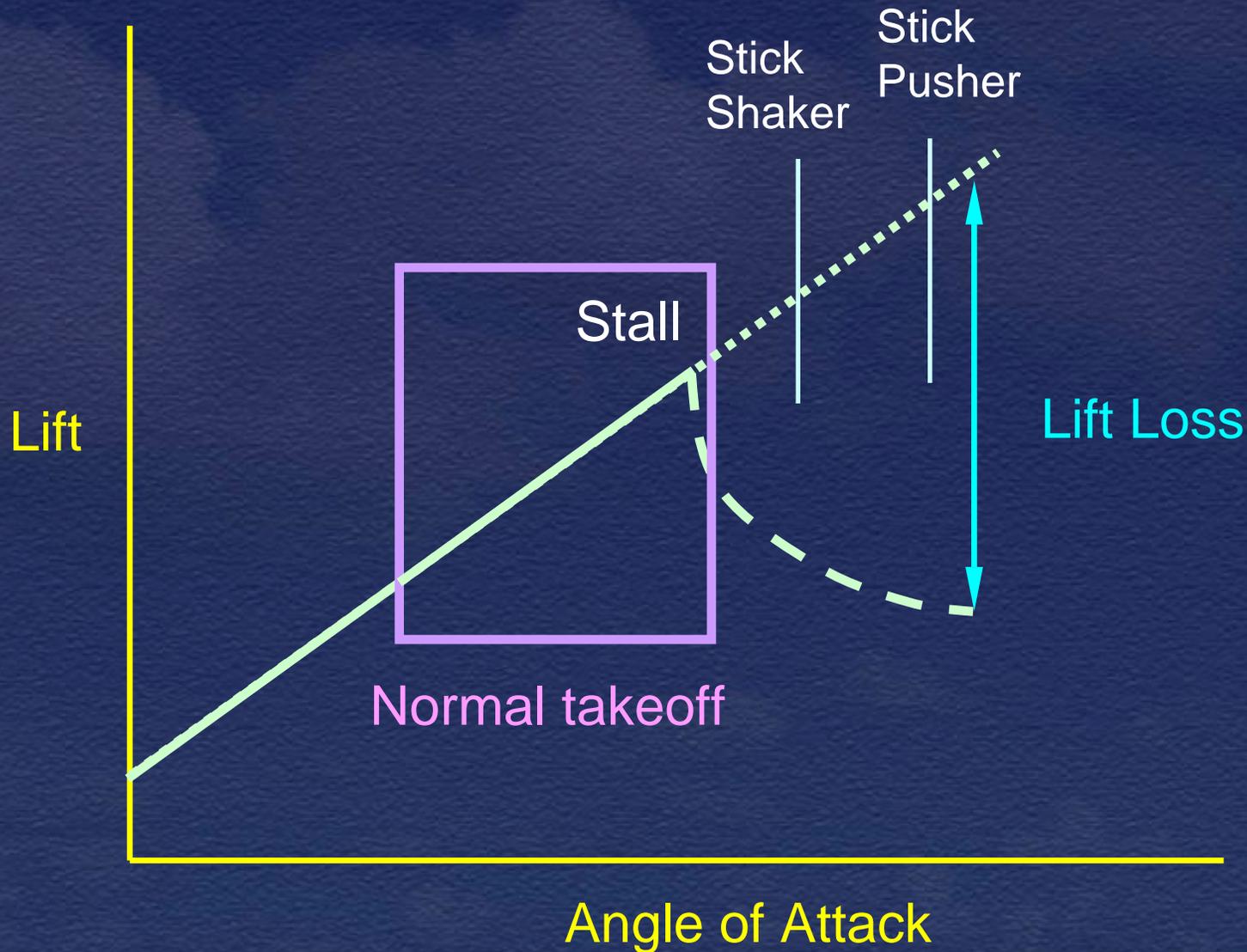
Effects of Surface Contamination

- Reduces maximum lift generated by wing
- Reductions of lift up to 30% are possible

Clean Wing



Effect of Surface Contamination



Bombardier Challenger

Birmingham, England – January 4, 2002



- Airplane rolled left despite full right aileron and rudder input
- AAIB finding:
Roll was due to stall caused by frost contamination

Ground Icing



Ground Icing

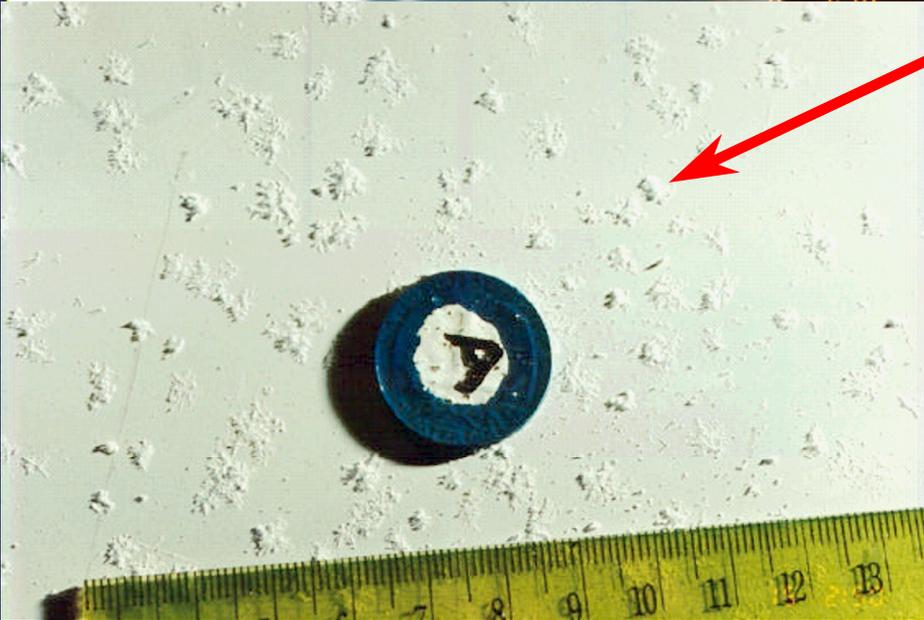


Photo courtesy of NASA

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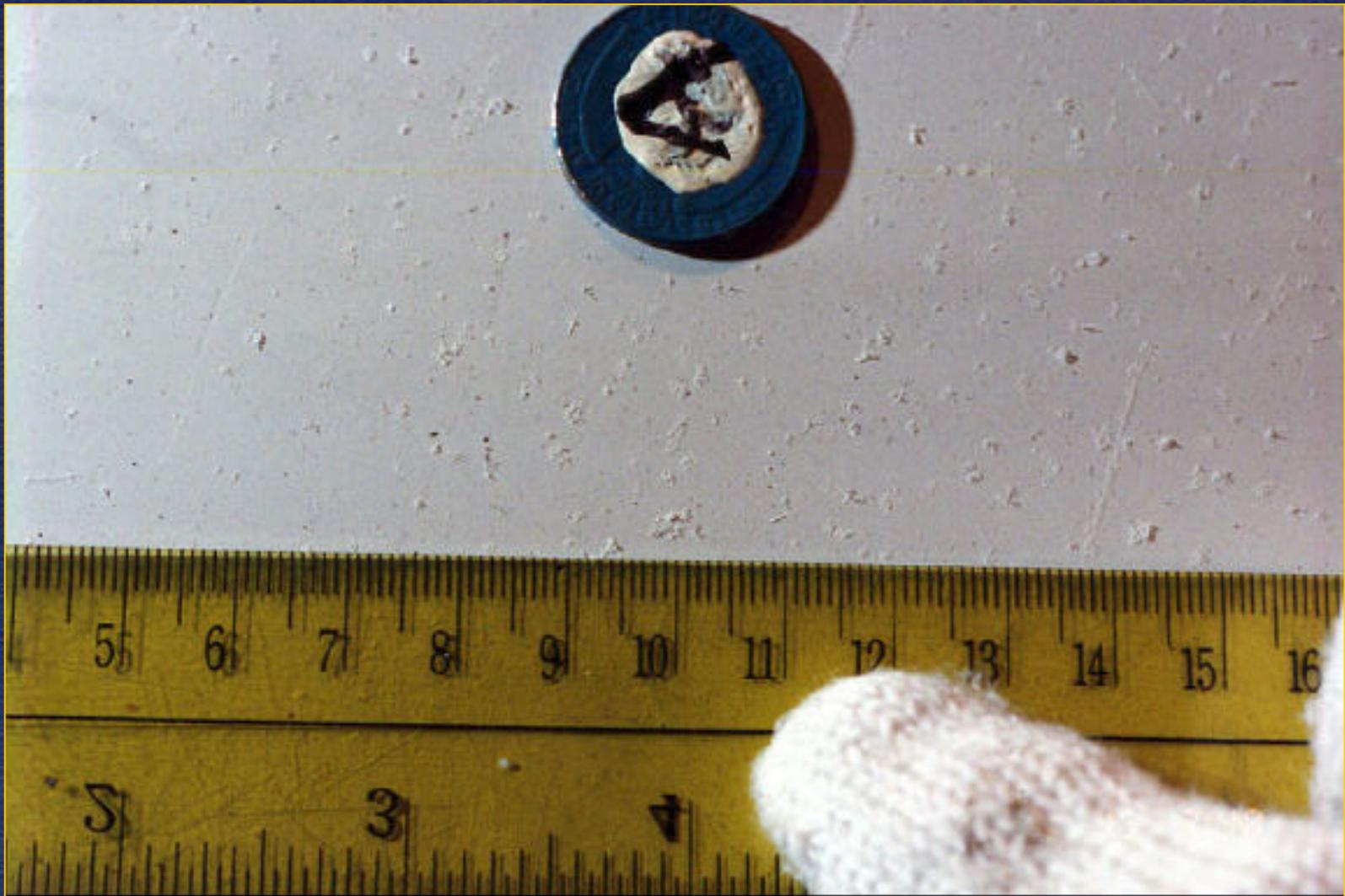
Ground Icing



Small, almost imperceptible accumulations

Photos from Chaput, M., Hanna M., Ruggi E., and Mayhew, J. *Aircraft Full-Scale Test Program for the 1998/99 Winter*,
APS Aviation, Inc., Montreal, October 1999,
Transportation Development Centre TP 13485E

Ground Icing

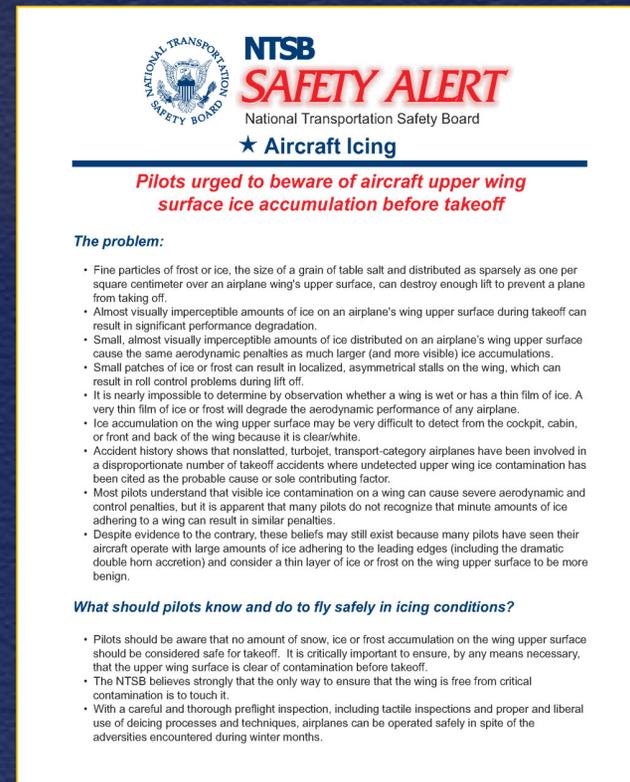


NTSB



NTSB Alert to Pilots: Upper Wing Surface Ice Accumulation

- Issued December 29, 2004
- Reiterated findings from research and ground-icing investigations
- Fine particles of frost or ice the size of a grain of table salt and distributed as sparsely as one per square centimeter can destroy enough lift to prevent an airplane from taking off



The graphic is a white rectangular box with a yellow border. At the top left is the NTSB logo, a circular seal with an eagle and the text 'NATIONAL TRANSPORTATION SAFETY BOARD'. To its right, the text 'NTSB SAFETY ALERT' is written in bold, with 'SAFETY ALERT' in red. Below that, 'National Transportation Safety Board' is written in a smaller font. A blue horizontal line separates this header from the main content. Below the line, the title '★ Aircraft Icing' is written in blue. Underneath, the main message 'Pilots urged to beware of aircraft upper wing surface ice accumulation before takeoff' is written in red. The body of the alert contains two sections: 'The problem:' followed by a bulleted list of technical details, and 'What should pilots know and do to fly safely in icing conditions?' followed by another bulleted list of recommendations.

NTSB SAFETY ALERT
National Transportation Safety Board

★ Aircraft Icing

Pilots urged to beware of aircraft upper wing surface ice accumulation before takeoff

The problem:

- Fine particles of frost or ice, the size of a grain of table salt and distributed as sparsely as one per square centimeter over an airplane wing's upper surface, can destroy enough lift to prevent a plane from taking off.
- Almost visually imperceptible amounts of ice on an airplane's wing upper surface during takeoff can result in significant performance degradation.
- Small, almost visually imperceptible amounts of ice distributed on an airplane's wing upper surface cause the same aerodynamic penalties as much larger (and more visible) ice accumulations.
- Small patches of ice or frost can result in localized, asymmetrical stalls on the wing, which can result in roll control problems during lift off.
- It is nearly impossible to determine by observation whether a wing is wet or has a thin film of ice. A very thin film of ice or frost will degrade the aerodynamic performance of any airplane.
- Ice accumulation on the wing upper surface may be very difficult to detect from the cockpit, cabin, or front and back of the wing because it is clear/white.
- Accident history shows that nonslatted, turbojet, transport-category airplanes have been involved in a disproportionate number of takeoff accidents where undetected upper wing ice contamination has been cited as the probable cause or sole contributing factor.
- Most pilots understand that visible ice contamination on a wing can cause severe aerodynamic and control penalties, but it is apparent that many pilots do not recognize that minute amounts of ice adhering to a wing can result in similar penalties.
- Despite evidence to the contrary, these beliefs may still exist because many pilots have seen their aircraft operate with large amounts of ice adhering to the leading edges (including the dramatic double horn accretion) and consider a thin layer of ice or frost on the wing upper surface to be more benign.

What should pilots know and do to fly safely in icing conditions?

- Pilots should be aware that no amount of snow, ice or frost accumulation on the wing upper surface should be considered safe for takeoff. It is critically important to ensure, by any means necessary, that the upper wing surface is clear of contamination before takeoff.
- The NTSB believes strongly that the only way to ensure that the wing is free from critical contamination is to touch it.
- With a careful and thorough preflight inspection, including tactile inspections and proper and liberal use of deicing processes and techniques, airplanes can be operated safely in spite of the adversities encountered during winter months.

Airplane Performance

- Aerodynamically clean airplane should have lifted off
- Airplane motion indicates contamination present on wings
- Past investigations have demonstrated small amounts of contamination can be deadly



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