NTSB National Transportation Safety Board

Circuit City Cessna 560
Pueblo, CO
February 16, 2005

Dr. Daniel Bower
Aircraft Performance

Overview

- Types of icing environments- SLD
- Accident aircraft performance
- Cessna 560 modified stall warning system
- De-ice boot activation
- Automatic mode for de-ice boots
- Previous icing recommendations

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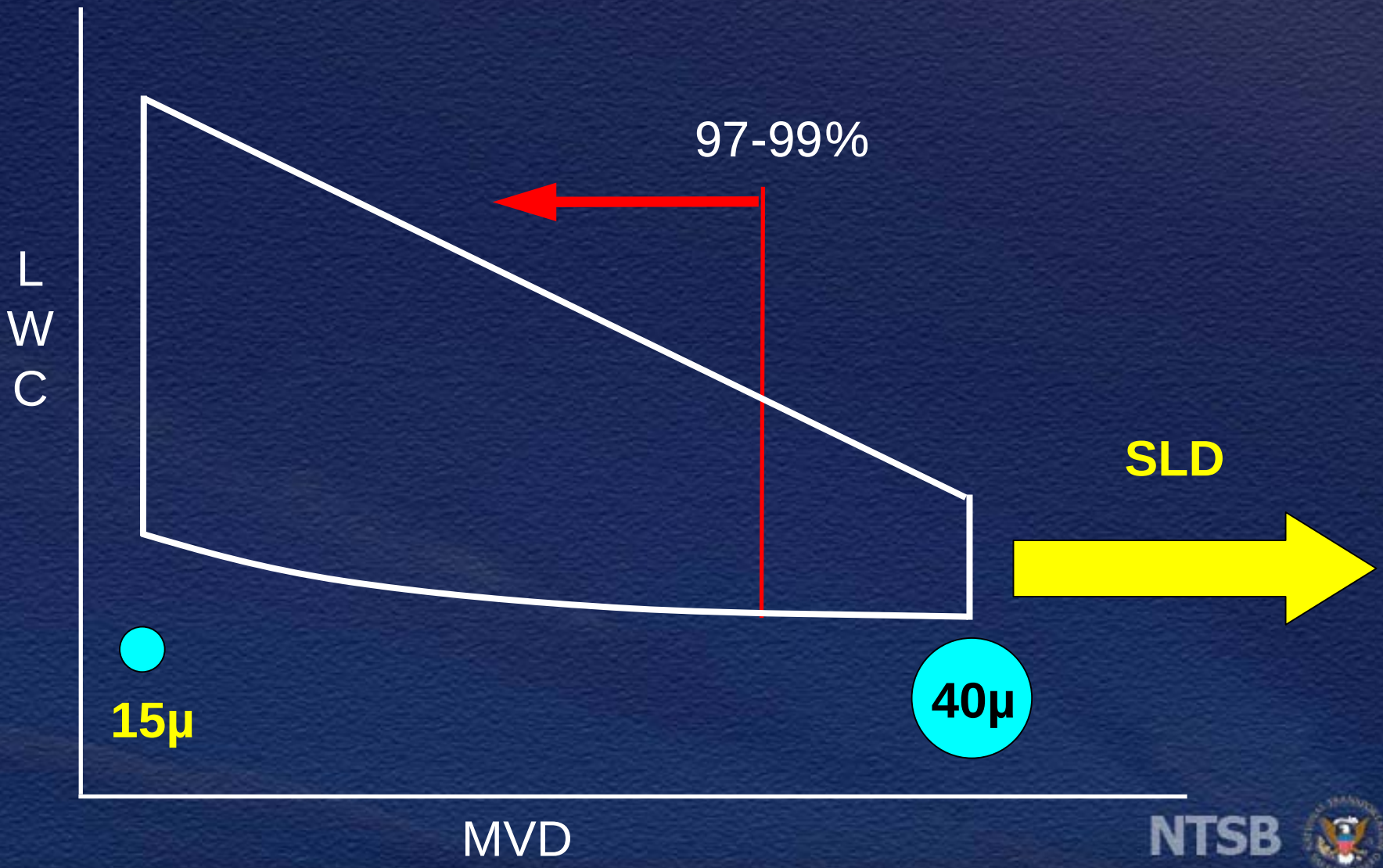
Part 25 Appendix C
Continuous Maximum



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Effect of SLD on ice accretion

Wing leading edge cross section

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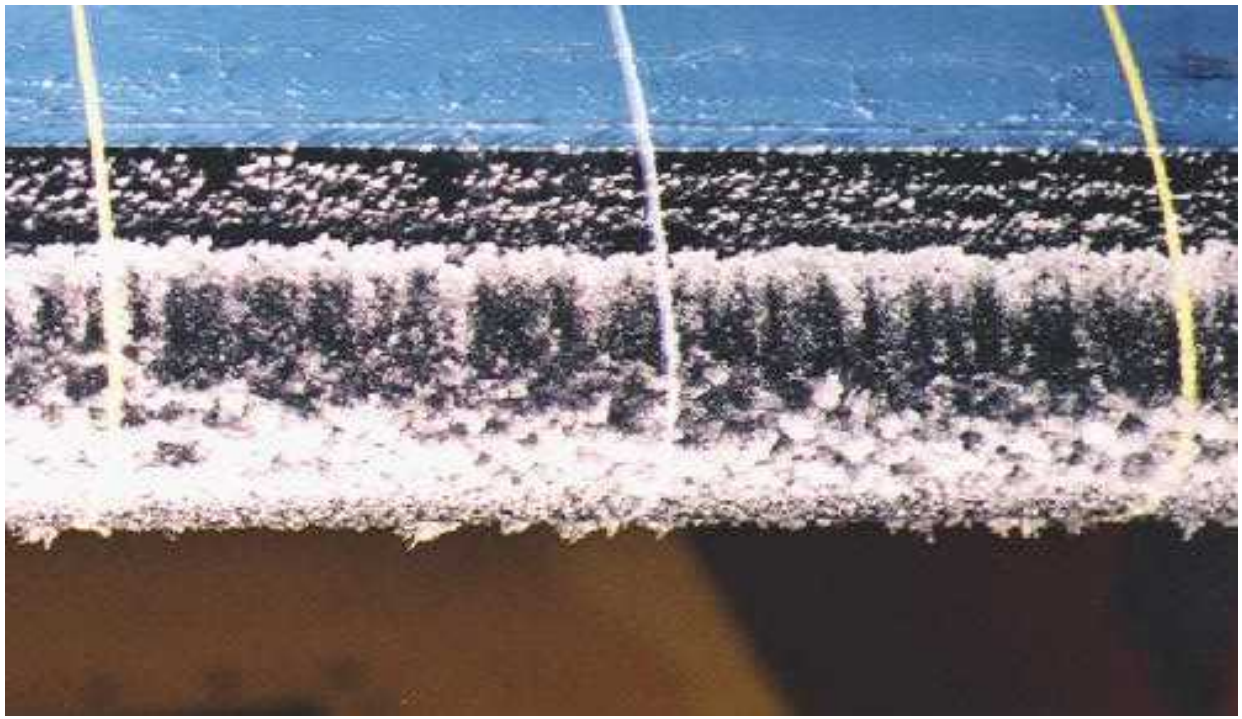
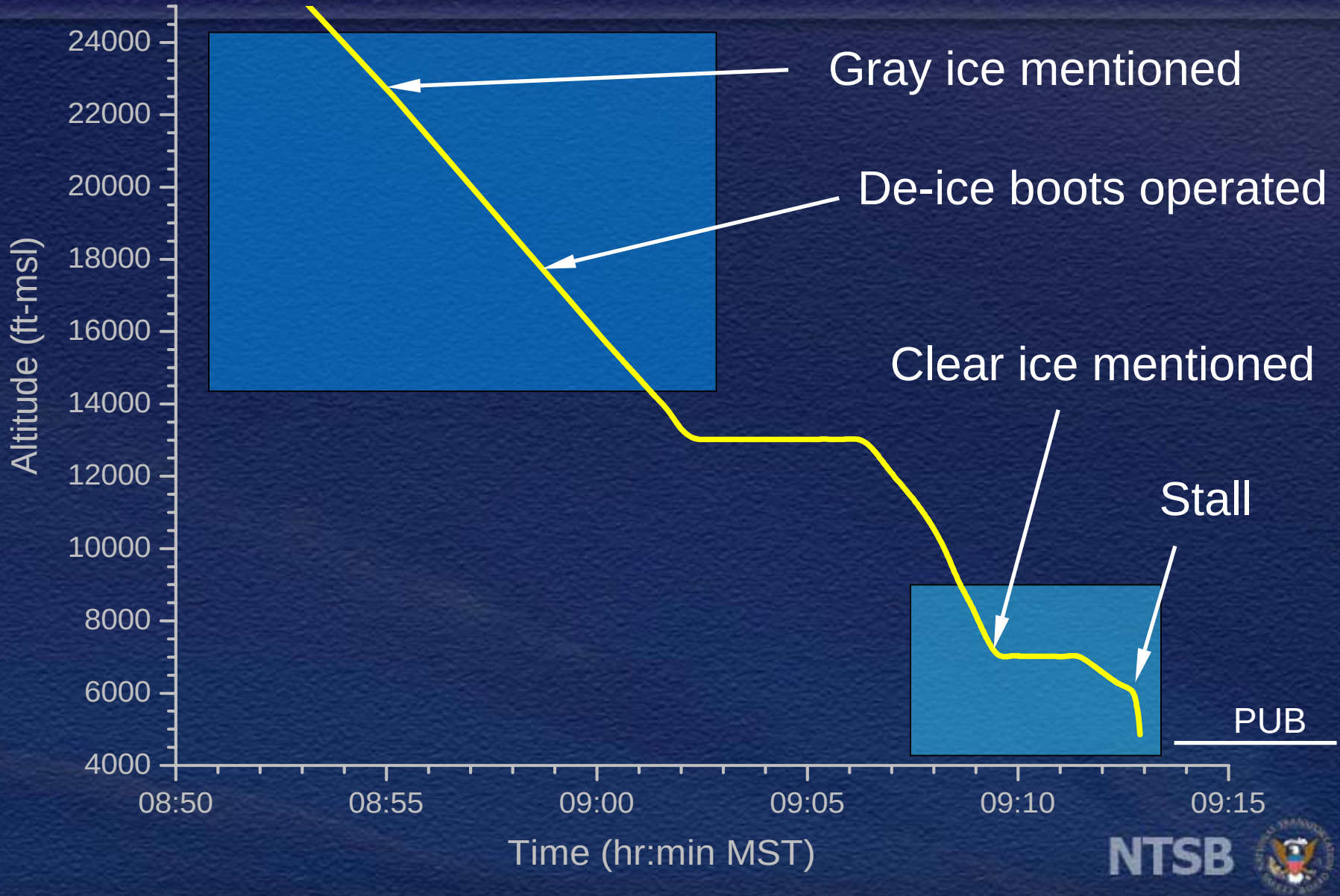
Resultant Ice Shapes



Front Edge of Wing

Rough Ice

Altitude Time History



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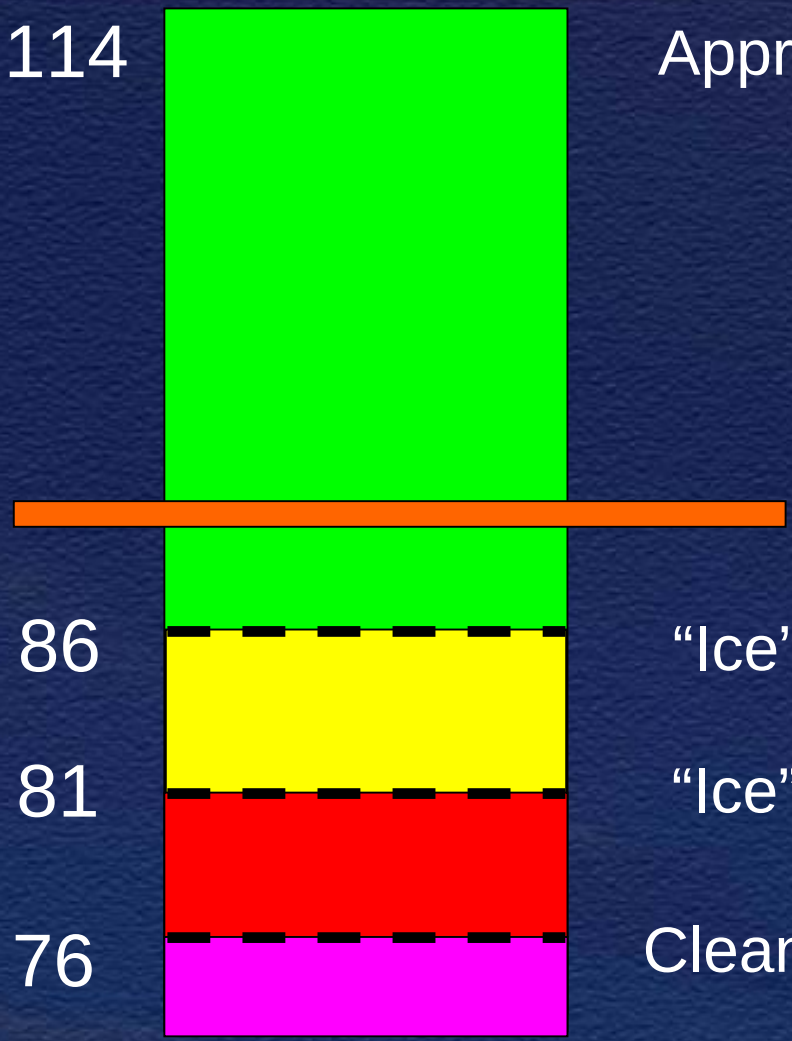
Accident Airplane Relevant Speeds



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Accident Sequence

- Airplane slowed below Vapproach
- De-ice boots not operated in second icing layer
- Presence of an estimated 1/6 of an inch or less of ice accreted in SLD conditions caused the airplane to stall prior to stick shaker
- Airplane entered a rapid left roll
- Airplane did not recover in the 1,500 feet agl available

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Stall Warning modifications

- 1996 - In response to 3 accidents in icing conditions FAA performed flight testing with artificial 1/2-inch ice shapes.
  - Ice Shape generated using one App C condition
  - Larger droplets not considered
- Resulted in modifications to stall warning system to increase stick shaker speed in icing conditions

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De-ice Boot Operation

- 1998 – NTSB issued Rec. A-98-91 to activate deice boots upon entering icing conditions
- FAA issued NPRM for several airplanes including the 560.
- Cessna used results from 1996 flight tests with 1/2-inch ice shape to request withdrawal of NPRM
- FAA withdrew NPRM

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De-ice Boot Operation

- Current company and manufacturer guidance states boots should be operated when ice is 1/4- to 1/2-inch thick, and AFM states
  - "early activation of the boots may result in ice bridging on the wing"
- Deice Boot Bridging – Ice in the shape of an inflated deice boot forms as the boot is cycled, which cannot be removed by subsequent cycles

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De-Ice Boot Bridging - Recent research

- 1997 Deice Boot Bridging Workshop
- FAA AC 25.1419 (2004)
- Recent research by FAA

No evidence that modern turbine powered airplanes are at risk for bridging

Total number of accidents investigated by the Board related to bridging = **0**

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Automatic boot cycle

- Bridging is no longer a valid reason to allow a buildup between boot cycles
- Research by FAA indicates residual ice is not as detrimental as intercycle ice
- Manually operated boots can lead to excessive intercycle ice buildup in high workload situations

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Revised Icing Certification

- Upgrade aircraft icing certification criteria to include SLD **(A-96-54)**
- Research into effects of in-flight icing, including intercycle and residual ice **(A-98-92)**
- All de-ice boot aircraft certified for icing should be subject to revised icing criteria

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Summary

- **Airplane slowed below approach speed**
- **Deice boots were not operated during approach**
- **Airplane encountered supercooled large droplets**
  - Caused a thin, rough ice accretion with large aerodynamic penalties
- **Stall warning was inadequate**
  - Ice accretions used to determine the stall warning margin were not representative of the most detrimental

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Summary

- **Deice Boots bridging is not a concern**
  - Warrants activation of deice boots upon entering icing conditions
  - Warrants development of system for automatically cycling of deice boots
- **Icing certification standards**
  - Need to be updated based on accident history and recent research, and applied to all deice boot equipped aircraft

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