



In flight Upset Accident Review: Lessons for Training

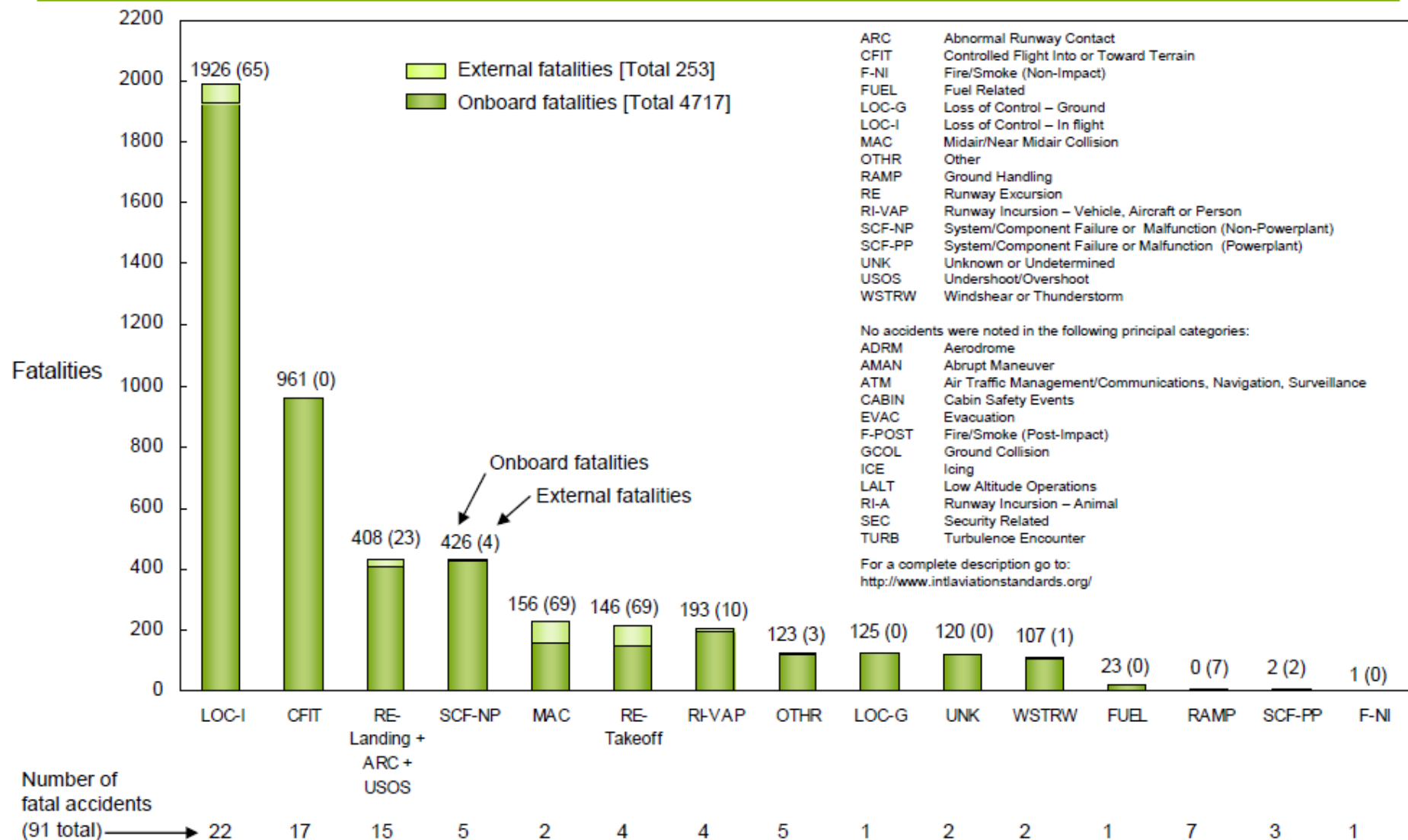
Dennis A. Crider

Chief Technical Advisor, Vehicle Simulation
National Transportation Safety Board

Fatalities by CAST/ICAO Common Taxonomy Team (CICTT)

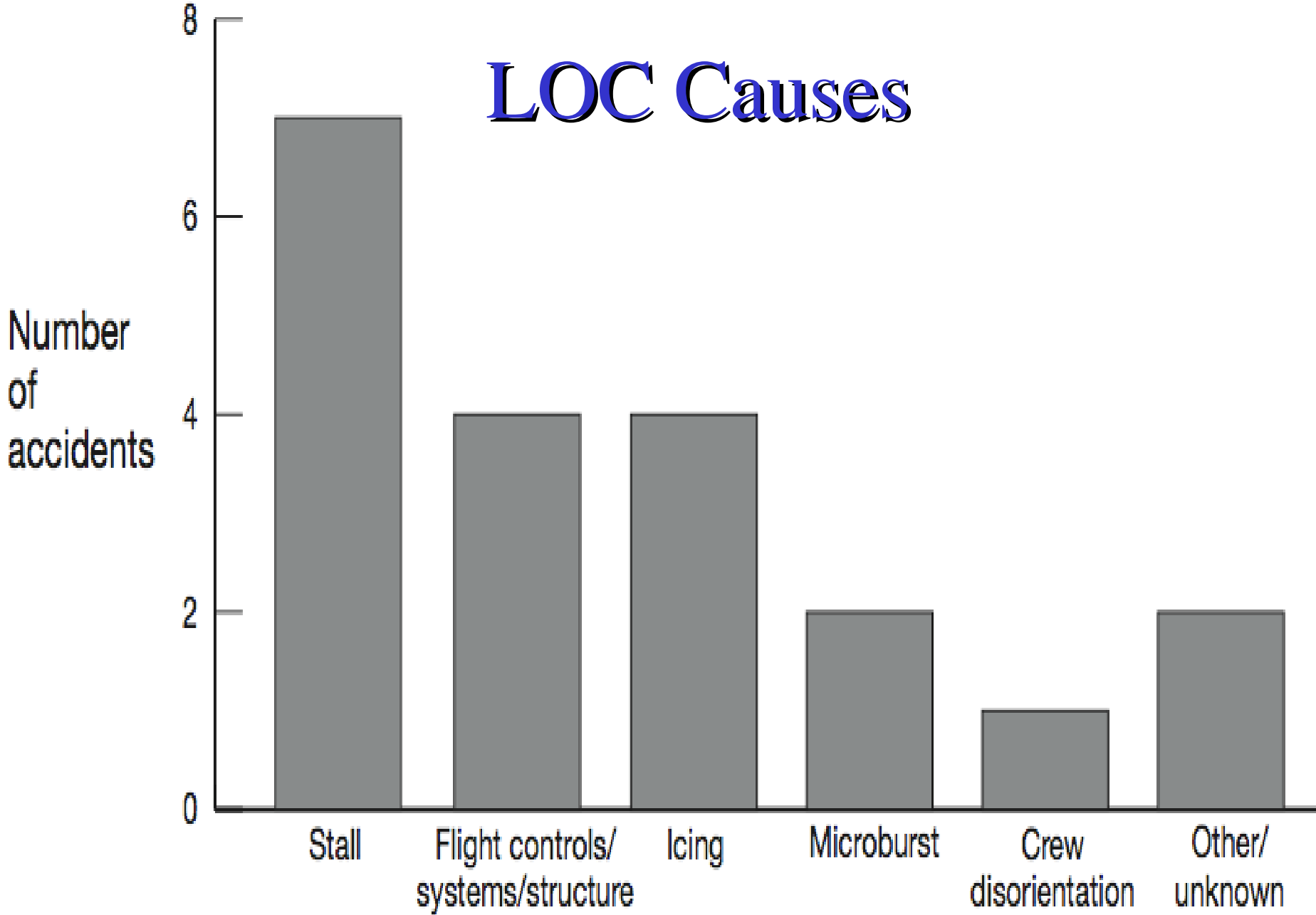
Aviation Occurrence Categories

Fatal Accidents – Worldwide Commercial Jet Fleet – 1999 Through 2008



Note: Principal categories as assigned by CAST.

LOC Causes



Causes of loss-of-control accidents, 1986 to 1996

Spatial Disorientation Upsets

- **Air Transport International, Inc., Flight 805, DC-8-63, February 15, 1992**
 - Missed approach the captain apparently became spatially disoriented.
 - physiological factors
 - failed attitude director indicator.
 - Unusual attitude with bank angles up to 80 degrees and pitch angles up to 25 degrees.
 - The first officer assumed control
 - Began unusual attitude recovery
 - Ground impact before the recovery was completed.



Spatial Disorientation Upsets

- **Flash Air flight 604 Boeing 737-300 January 3, 2004**
 - Shortly after takeoff the aircraft developed a slow right roll as the aircraft flew over the Red Sea at night.
 - The captain began to correct the roll 17 seconds after the FO notified him of the roll off with a bank angle of 115 deg too late to avoid water impact.



Spatial Disorientation Upsets

- **Adams Air flight DHI 574, 737-400 January 1, 2007**
 - The aircraft developed a slow right roll at 35000 ft over the Java Sea.
 - The pilots lost control after being preoccupied with troubleshooting the inertial reference unit (IRU) and inadvertently disconnecting the autopilot.
 - The aural alert “bank angle” sounded as the bank angle exceeded 35 degrees.
 - The NTSC also concluded that, “After the autopilot disengaged and the aircraft exceeded 30 deg right bank the pilot appears to have become spatially disoriented.”



Spatial Disorientation Upset Patterns

- Distractions
- Autopilot sometimes inadvertently off
- Confusion and inappropriate response after aural or pilot monitoring warning of bank.
- Mitigations: TBD
 - Instrument monitoring
 - Experience flying instruments against vestibular cues
 - General upset/unusual attitude recovery training.



Atmospheric Disturbance Upsets (wakes)

- **Cessna 550, Dec 18, 1992, Billings Mt**
 - crashed
- **MD-88, March 1, 1993, Orlando FL**
 - recovered
- **B737 April 24, 1993, Denver CO**
 - recovered
- **Westwind, Dec 15, 1993, Santa Ana CA**
 - crashed



Atmospheric Disturbance Upsets (wakes)

- **American Airlines Flight 587, A300-605R**
 - The flying pilot responded with cyclic rudder commands to the second of sequential wake encounters producing loads that caused the vertical tail to separate.
 - Negative transfer of training (the simulator suppressed roll control during a simulated wake encounter) was sited as a factor in this accident.



Atmospheric Disturbance Upsets (wakes)

- **United Airlines flight 2036, B737-300**
 - The aircraft hit the wake of a MD11 at 24000 ft over California resulting in 1 serious and 13 minor injuries in addition to minor aircraft damage.



Atmospheric Disturbance Upsets

- **L'Express Airlines Flight 508 Beech C99**
 - The aircraft was upset by a thunderstorm on approach to Birmingham.
 - Conclusion 9: The difficulty that the L'Express flight crew experienced in controlling the airplane may have been exacerbated because they **had not received unusual attitude recognition and recovery training** from L'Express.



Atmospheric Disturbance Upset Patterns

- Atmosphere forces an unusual attitude
- Sometimes crews react poorly
- Mitigations: TBD
 - General upset/unusual attitude recovery training.



Structural/Mechanical Failures

- **Alaska Airlines Flight 261 MD-83**
 - A jackscrew failure caused the stabilizer to move past its airplane nose up stop.
- **Air Midwest flight 5481, Beech 1900D**
 - The combination of improper rigging of the pitch control system together with an aft c.g. caused an uncontrollable pitch up.
- **GOL flight 1907, B737-800**
 - The aircraft collided with an Embraer Legacy 600 business jet losing about 1/3 of the outboard wing.



Structural/ Mechanical Failures (cont.)

- **United Airlines 585, 737-200 and USAir 427 737-300**
 - A rudder hard-over caused the airplane to depart in roll. As the upset developed the crew pulled back in response to “ground rush”.
- **China Eastern Airlines Flight 583 MD-11**
 - After a inadvertent deployment of slats the autopilot disconnected and the pilot manually controlled the aircraft through several pitch oscillations losing 5000 ft.



Structural/ Mechanical Failures (pitot-static)

- **Birgenair 301; 757-200 February 6,1996**
 - The Captain's ASI was faulty due to a clogged pitot tube.
 - As the plane climbed captain's airspeed increased which caused the autopilot to pitch up and slow the aircraft.
 - The stick shaker activated and the aircraft experienced a stall upset.



Structural/ Mechanical Failures (pitot-static)

- **Aeroperú Flight 603, 757-23A October 2, 1996**
 - Erratic instruments and aural warnings
 - Shortly after takeoff at night
 - the crew began to return to the airport.
 - Masking tape was left on the static ports after cleaning.
 - Multiple stalls
 - Began a descent to the airport and eventually impacted the Pacific.



Structural/ Mechanical Failures (pitot-static)

- THY Flight 5904, 737-4Q8 April 7, 1999
 - The pitot tube had iced up causing errant airspeed readings.
 - The aircraft dived, climbed and dived again eventually impacting the ground.
- Air France flight 447 accident??



Mechanical Failure Upset Patterns

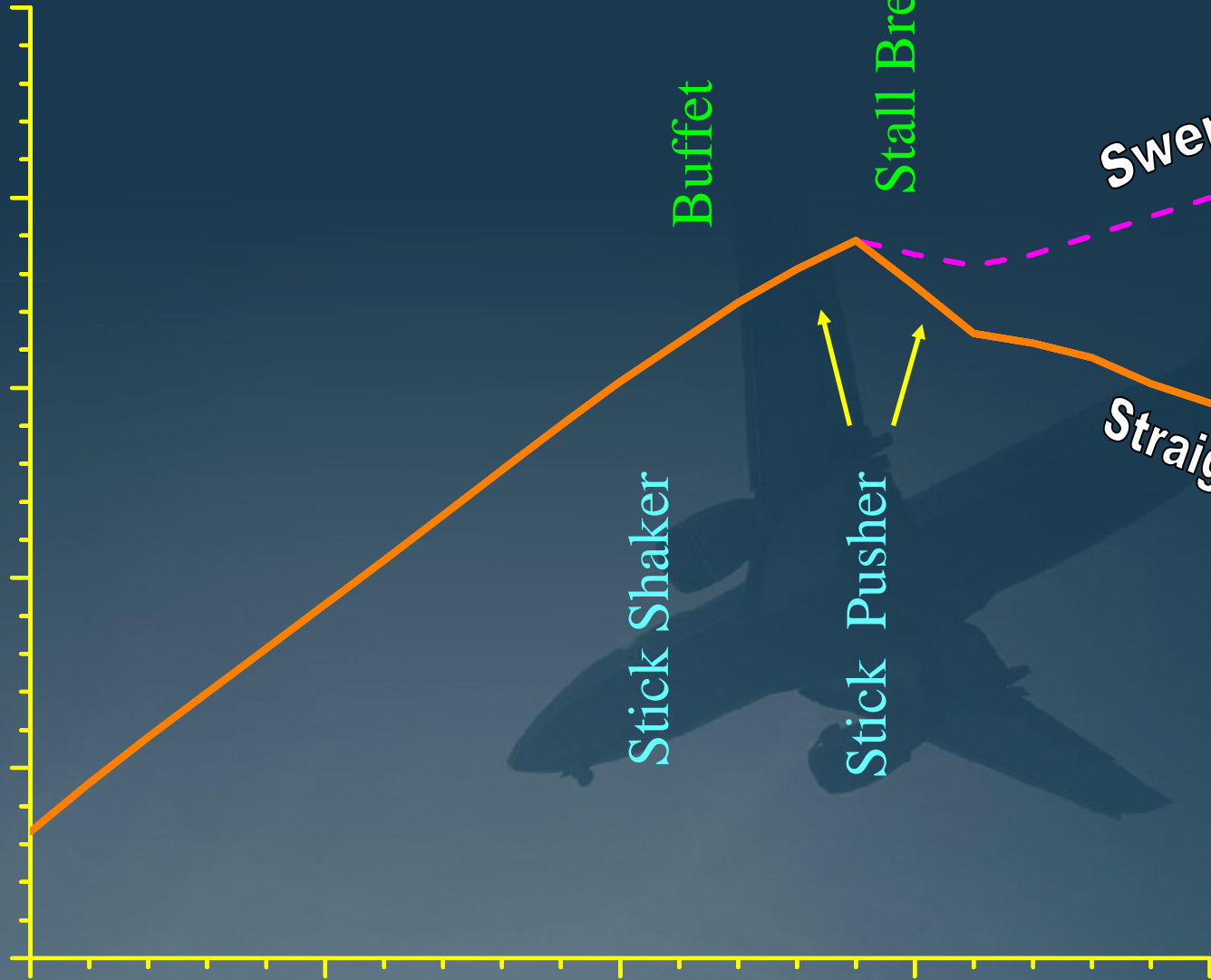
- Some Structural Mechanical failures not recoverable.
- General upset/unusual attitude recovery training can help others.
- Pitot/Static Failures common
 - Can we train recognition and alternate piloting strategies?



Stall Upsets



Lift Coefficient - C_L



Alpha (deg)

Stick Shaker

Stick Pusher

Buffet

Stall Break

Swept Wing

Straight Wing



Stall Upsets (no icing)

Accident	Shaker	Pusher	Break
Airborne Express DC-8-63 Dec 22, 1996	IO	IO	NR
China Airlines 676, A300-622, February 16, 1998	UK	UK	UK
Thai Airways Flight 261, Airbus A310-300, December 11, 1998	UK	UK	UK
Pinnacle Airlines Flight 3701 Bombardier CL-600-2B19, October 14, 2004	NR	NR	NR
United Express Flight 6291 Jetstream 4101, January 7, 1994	NR	NR	UK
Pulkova Flight 612, TU-154M, Aug 22, 2006	UK	UK	UK
West Caribbean airlines MD-82 near Machiques, Venezuela, August 16, 2005	NR	UK	NR
Continental Connection Flight 3407 Bombardier DHC-8-400, February 12, 2009	NR	NR	NR

IO = Inoperative

UK = Unknown

NR = Not responded to



Stall Upset Patterns

- Crews may not respond to:
 - Stick shaker
 - Stick pusher
 - Stall break (roll off and roll control)
 - Post stall flight characteristics
- Lack of stall recognition with nose low and banked.
- Mitigations: TBD



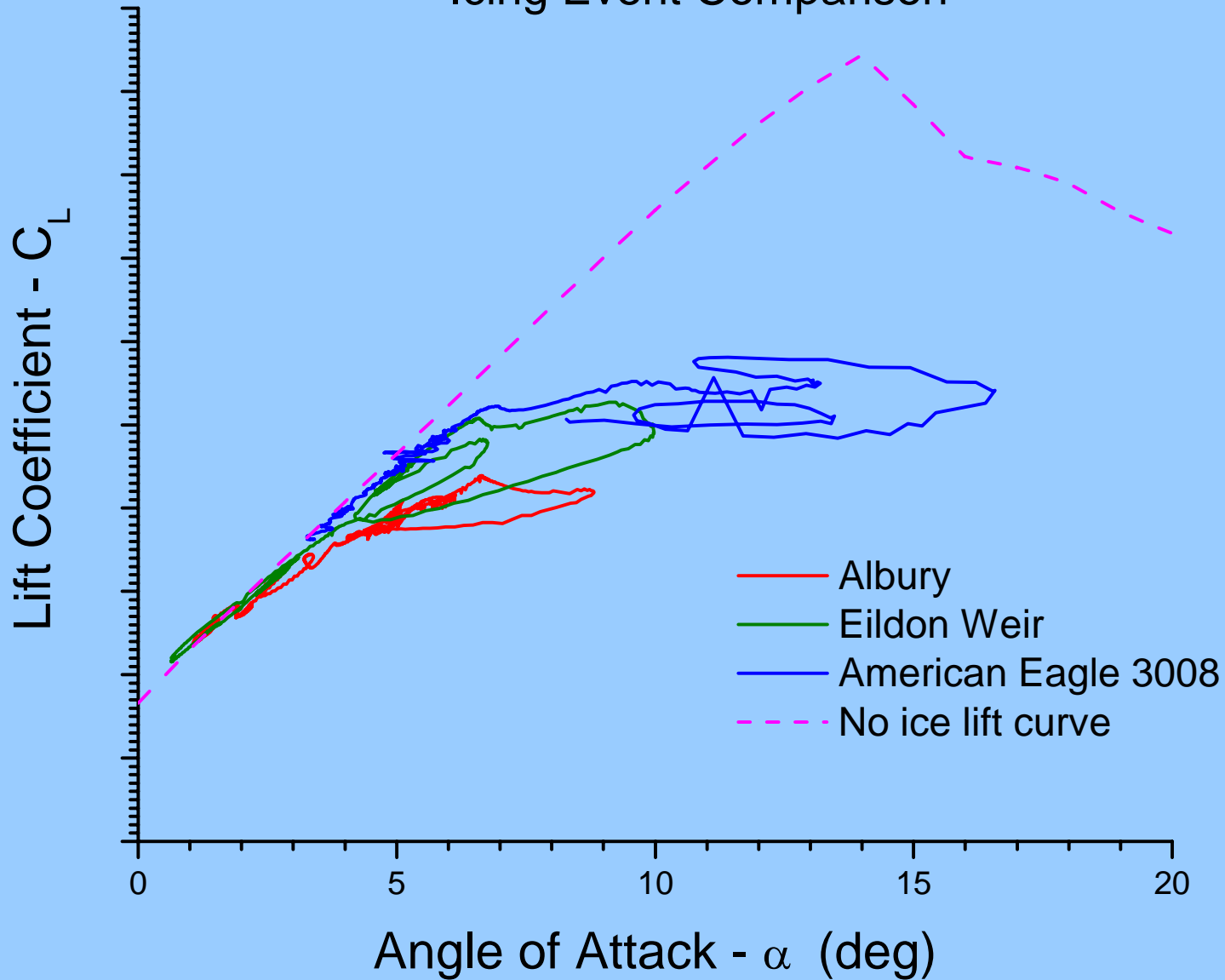
Icing Upsets

- Control
 - American Eagle Flight 4184 ATR 72-212, October 31, 1994
 - Loss of roll control, fatal accident upset
 - Air Canada Flight 457 & Air Canada Flight 1130; A321-211, December 7, 2002
 - Roll oscillations
 - Recovered with flap change.
- Stall



Saab 340

Icing Event Comparison



Stall Upsets (icing)

Accident/Incident	Shaker	Pusher	Break
Saab 340A, VH-LPI, Eildon Weir, Victoria, Nov 11, 1998	ES	ES	NR
Saab 340A, VH-KEQ, Albury, New South Wales Australia, June 18, 2004	ES	ES	PR
Saab 340B, VH-OLM, Bathurst, New South Wales Australia, June 28 2002	ES	ES	NR
American Eagle 3008, Saab 340B+, January 2, 2006	ES	ES	NR
Air Canada Flight 646, Canadair CL-600-2B219, December 16, 1997	--	--	--
Cessna Citation 560, Pueblo, Colorado, February 16, 2005	UK	UK	UK
Comair Flight 3272, Embraer EMB-120RT, January 9, 1997	ES	--	NR
Skywest 3855, Bombardier CL-600-2B19, January 17, 2004	--	--	--
ComAir 5054, EMB-120, March 19, 2001	NR	NR	NR

IO = Inoperative

NR = Not responded to

UK = Unknown

ES = Early stall

PR = Proper response



Icing Stall Upset Patterns

- Stick shaker and pusher:
 - May occur after stall if at all.
- Crews may not respond to:
 - Stall break (roll off and roll control)
 - Post stall flight characteristics
- Lack of stall recognition with nose low and banked.
- Mitigations: TBD



Thank You



National Transportation Safety Board



Stall Training Recommendation

Require 14 Code of Federal Regulations Part 121, 135, and 91K operators and 14 Code of Federal Regulations Part 142 training centers to develop and conduct training that incorporates stalls that are fully developed; are unexpected; involve autopilot disengagement; and include airplane-specific features, such as a reference speeds switch. (A-10-XX)



Stick Pusher Recommendation

Require all 14 Code of Federal Regulations Part 121, 135, and 91K operators of stick pusher-equipped aircraft to provide their pilots with pusher familiarization simulator training. (A-10-XX) (Supersedes Safety Recommendation A-07-4)



Simulator Stall Fidelity Recommendation

Define and codify minimum simulator model fidelity requirements to support an expanded set of stall recovery training requirements, including recovery from stalls that are fully developed. These simulator fidelity requirements should address areas such as required angle-of-attack and sideslip angle ranges, motion cueing, proof-of-match with post-stall flight test data, and warnings to indicate when the simulator flight envelope has been exceeded. (A-10-XX)



Reserves



National Transportation Safety Board



Stall Upsets (no icing)

- **Airborne Express DC-8-63 December 22, 1996**
 - As part of a functional evaluation flight-following modifications and a “C” check, the crew was conducting a stall speed test a 13,600 feet when the aircraft stalled without the stick shaker. The crew increased power but maintained aft column throughout the departure. The aircraft did not recover from the stall but experienced a series of roll oscillations at a nose-low attitude for most of the descent until ground impact. The crew had trained in a simulator that produced a stall upset without roll excursions and in a nose-high attitude counter to the nose-low roll oscillations that the crew actually experienced.



Stall Upsets (no icing)

- **China Airlines 676, A300-622, February 16, 1998**
 - The aircraft stalled and crashed during a go-around near Tapei.
- **Thai Airways Flight 261, Airbus A310-300, December 11, 1998**
 - The aircraft stalled and crashed during a go-around on 3rd landing attempt at Surat Tanai.



Stall Upsets (no icing)

– Pinnacle Airlines Flight 3701 Bombardier CL-600-2B19, October 14, 2004

- The aircraft was on a repositioning flight when the crew decided to climb to the performance limits and set the autopilot for a climb rate. As the aircraft climbed to 41,000 feet, the aircraft slowed and stalled causing both engines to flame out. The aircraft rolled to 80 degrees left with the nose 25 degrees nose-low while the crew maintained up elevator ignoring the shaker and fighting the pusher. The crew stalled a second time after recovering from the first stall when they tried to re-establish normal flight attitude too quickly. The crew had never had a simulator exercise to demonstrate the stick pusher.



Stall Upsets (no icing)

- United Express Flight 6291 Jetstream 4101, January 7, 1994
 - The crew allowed the airspeed to decay and the aircraft stalled on approach to Columbus Ohio.
- West Caribbean airlines MD-82 near Machiques, Venezuela, August 16, 2005
 - The final report is not available. The Board of Civil Aviation Accident Investigation has, however, released information that the stabilizer trim moved in increments to full nose up as the aircraft passed through 20,000 feet during the upset descent. Though column position from the flight data recorder (FDR) was not useable, the cockpit voice recorder (CVR) recorded the sound of the stick shaker for 2 minutes and 46 seconds prior to impact.

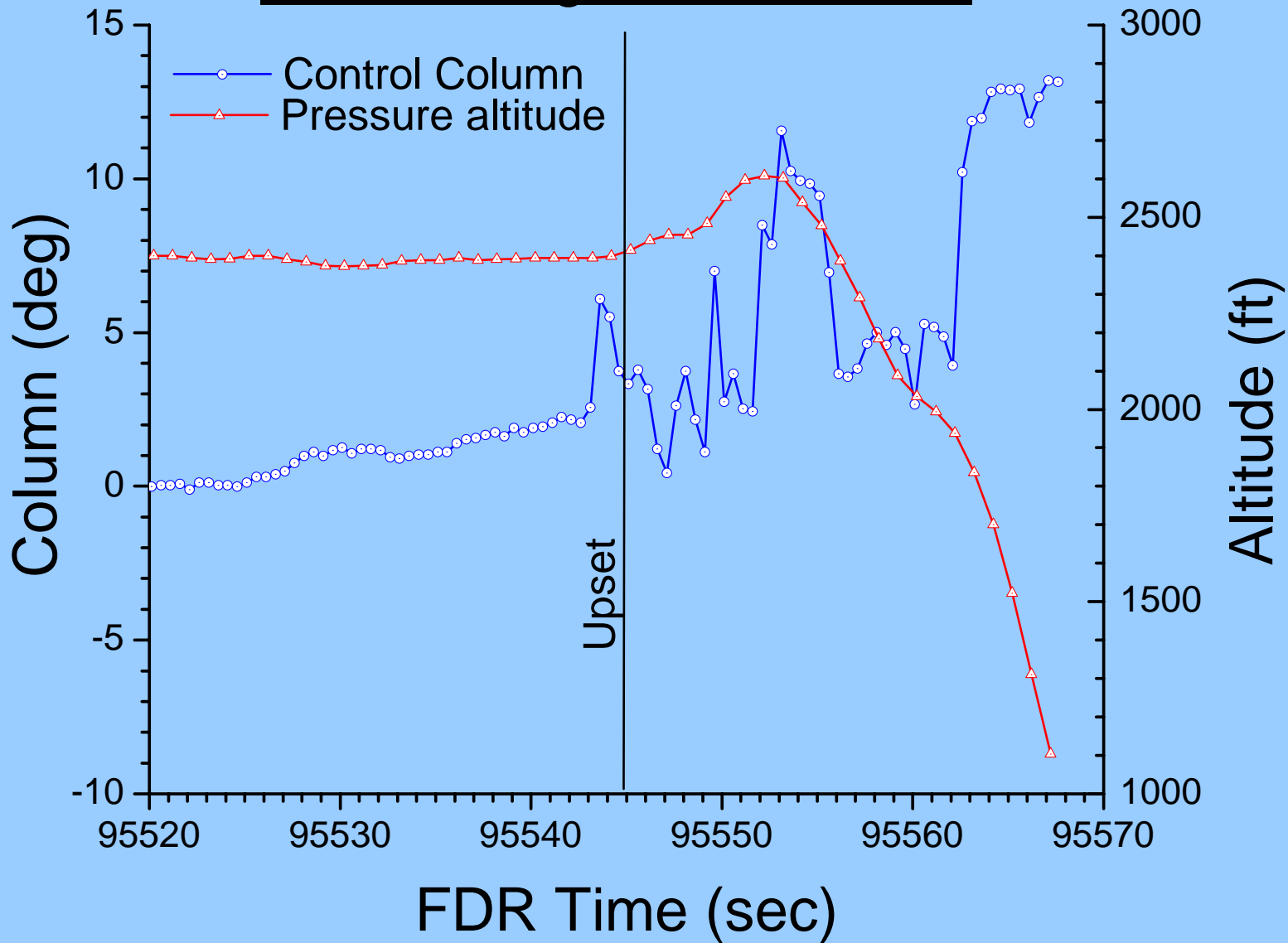


Stall Upsets (no icing)

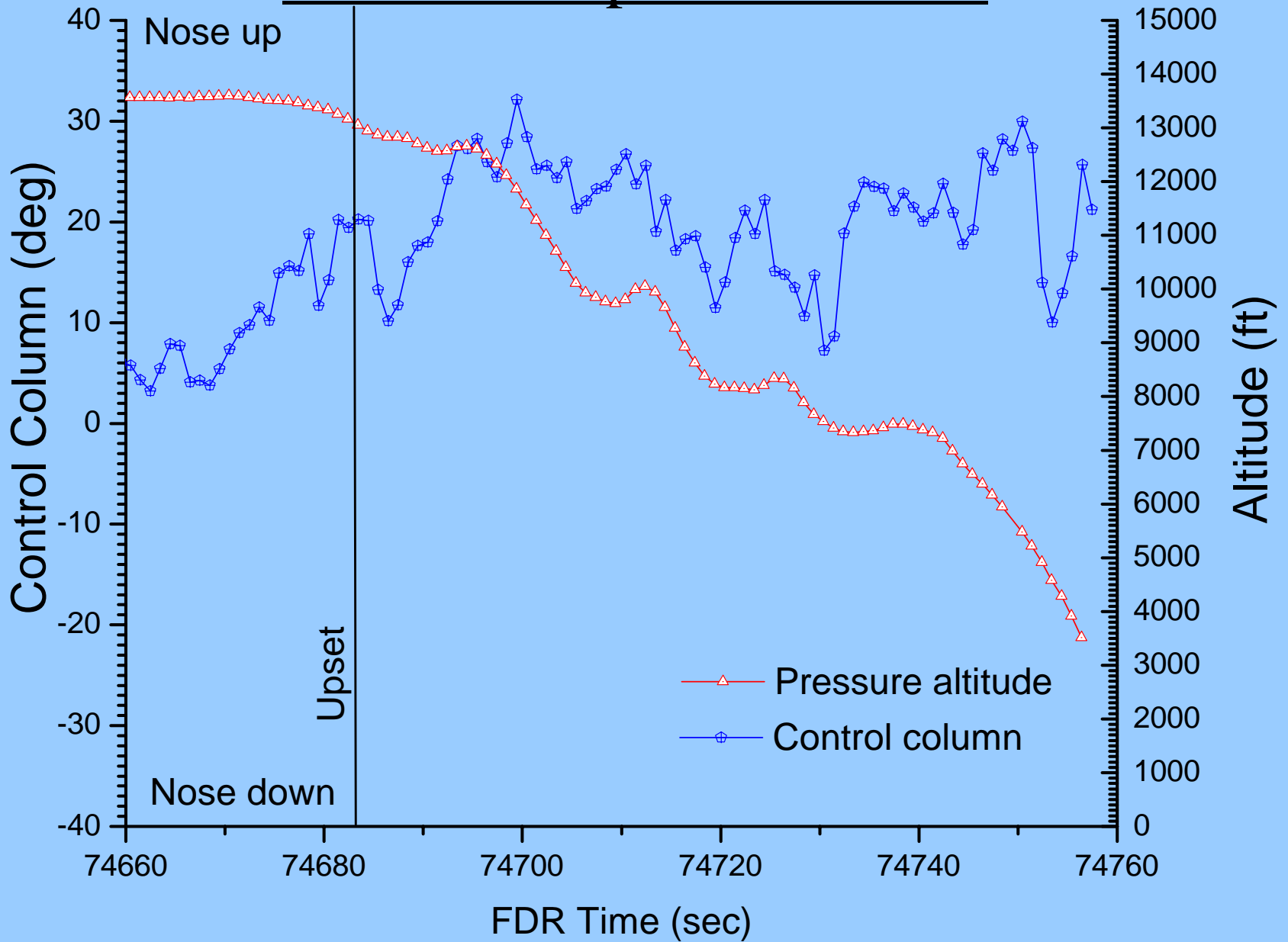
- **Continental Connection Flight 3407
Bombardier DHC-8-400, February 12, 2009**
 - While on approach to Buffalo the aircraft slowed after a power reduction to the point stick shaker activated
 - at a reduced angle of attack due to being set for icing conditions.
 - The pilot pulled back in response to the stick shaker and stalled.
 - The pilot fought the stick shaker and failed to recognize the rolling with ineffective roll controls as an indication of stall.
 - Controls remained aft till ground impact.



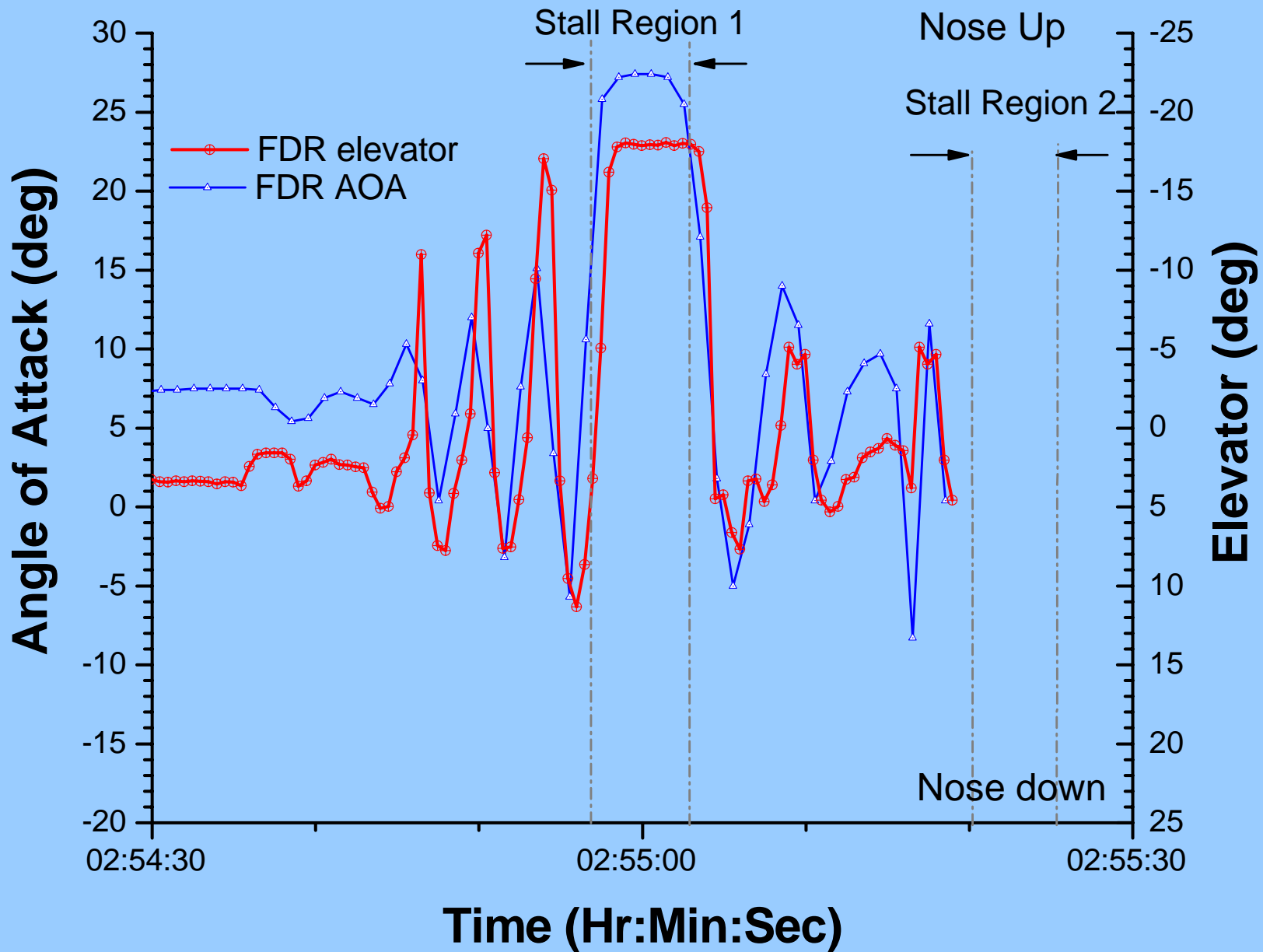
Buffalo Colgan DHC-8-400



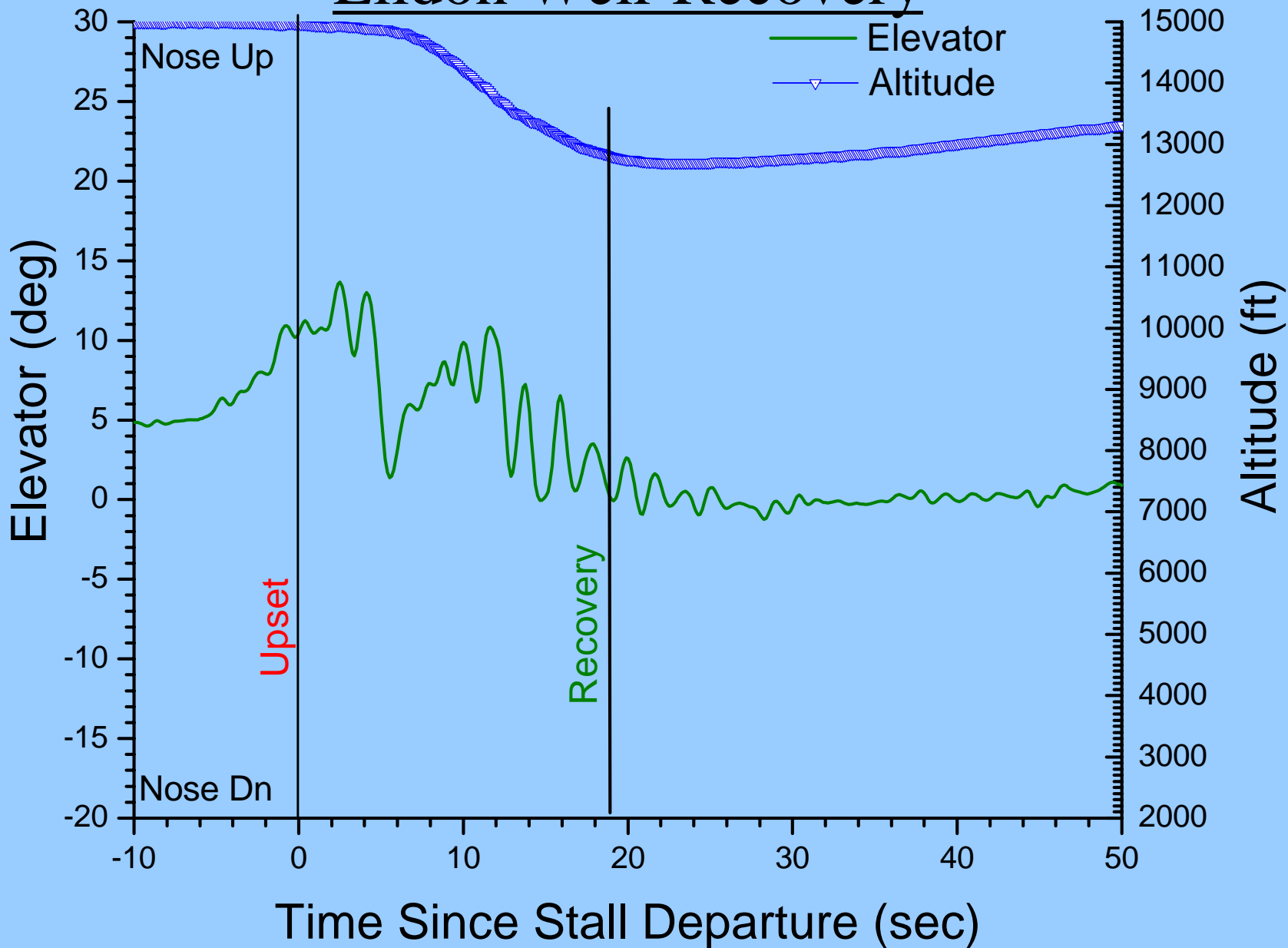
Airborne Express DC-8-63



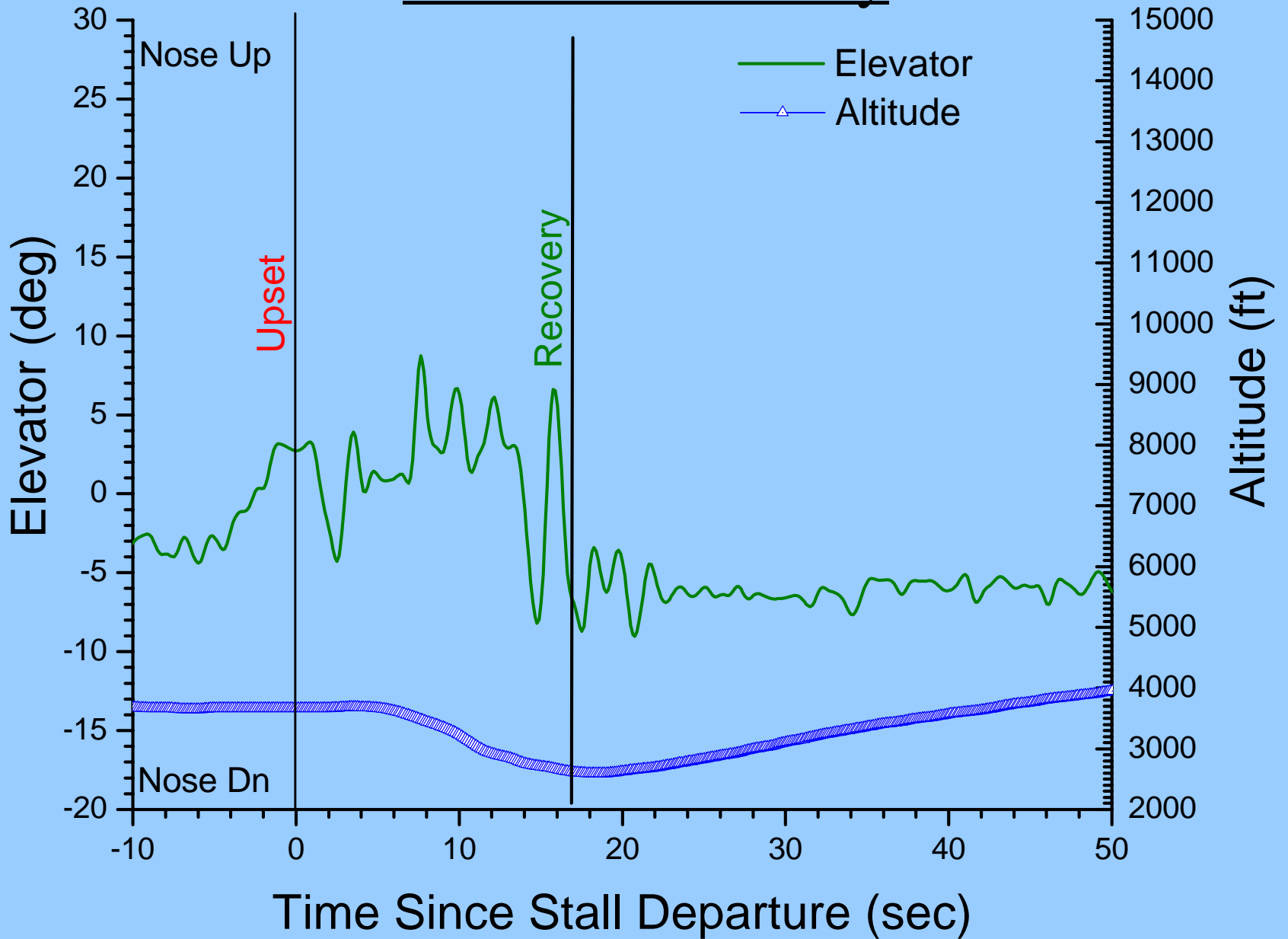
Pinnacle Airlines Flight 3701



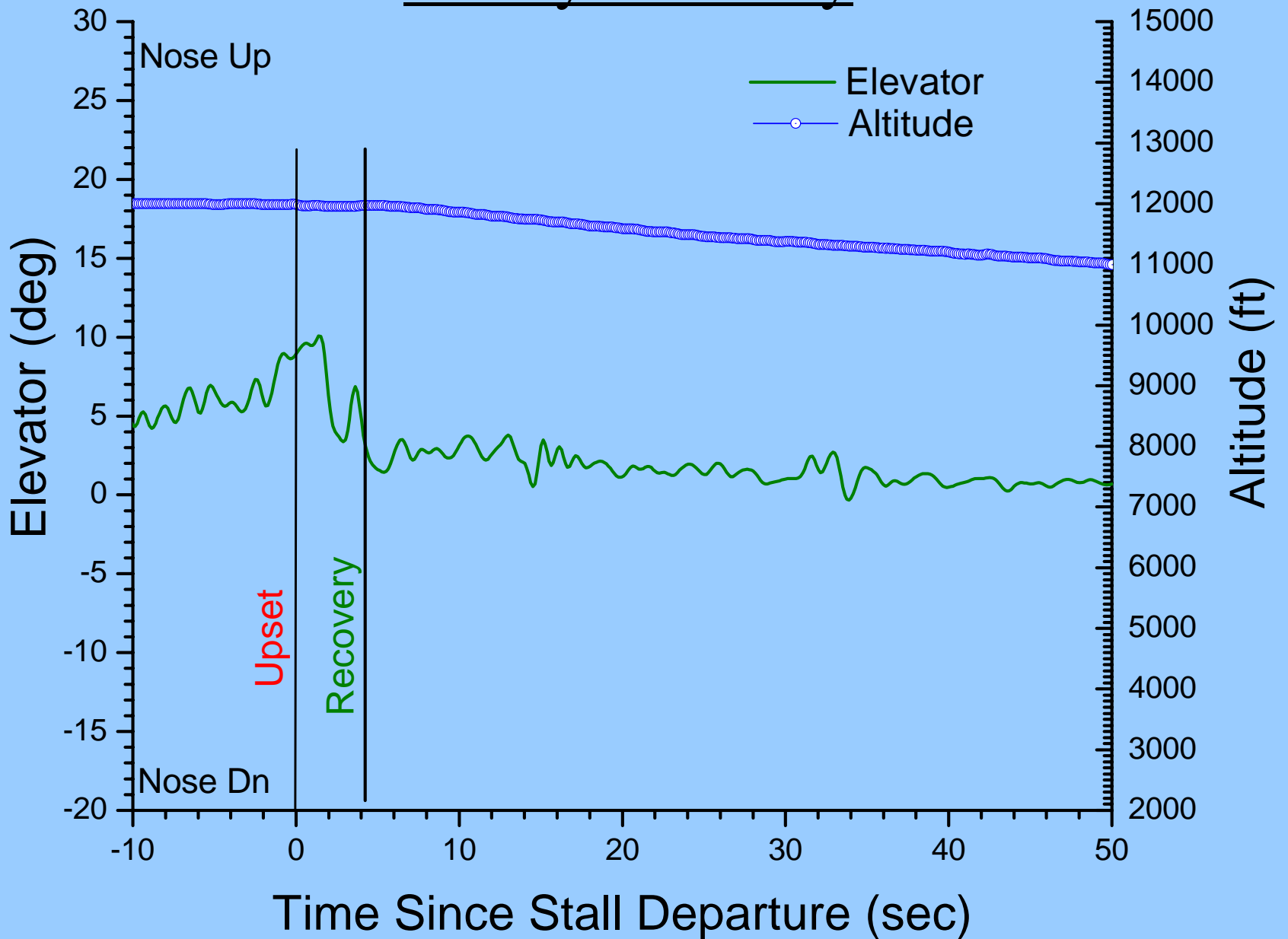
Eildon Weir Recovery



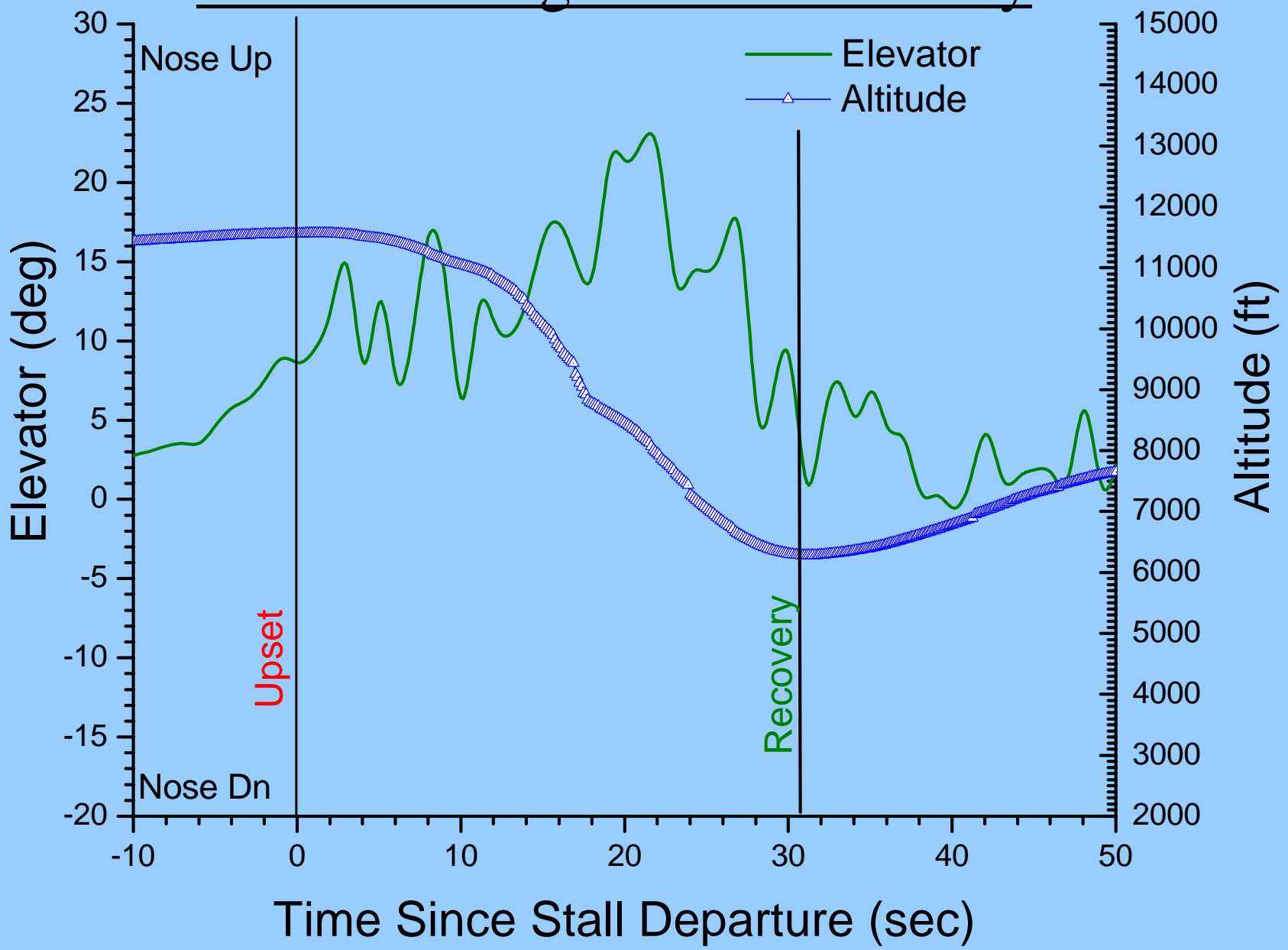
Bathurst Recovery



Albury Recovery



American Eagle 3008 Recovery



Continental Connection 3407

- February 12, 2009
- Clarence Center, New York
- Bombardier DHC-8-400
- Safety Board Adopted Report Feb 2, 2010



Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the captain's inappropriate response to the activation of the stick shaker, which led to an aerodynamic stall from which the airplane did not recover.

Contributing to the accident were (1) the flight crew's failure to monitor airspeed in relation to the rising position of the low-speed cue, (2) the flight crew's failure to adhere to sterile cockpit procedures, (3) the captain's failure to effectively manage the flight, and (4) Colgan Air's inadequate procedures for airspeed selection and management during approaches in icing conditions.

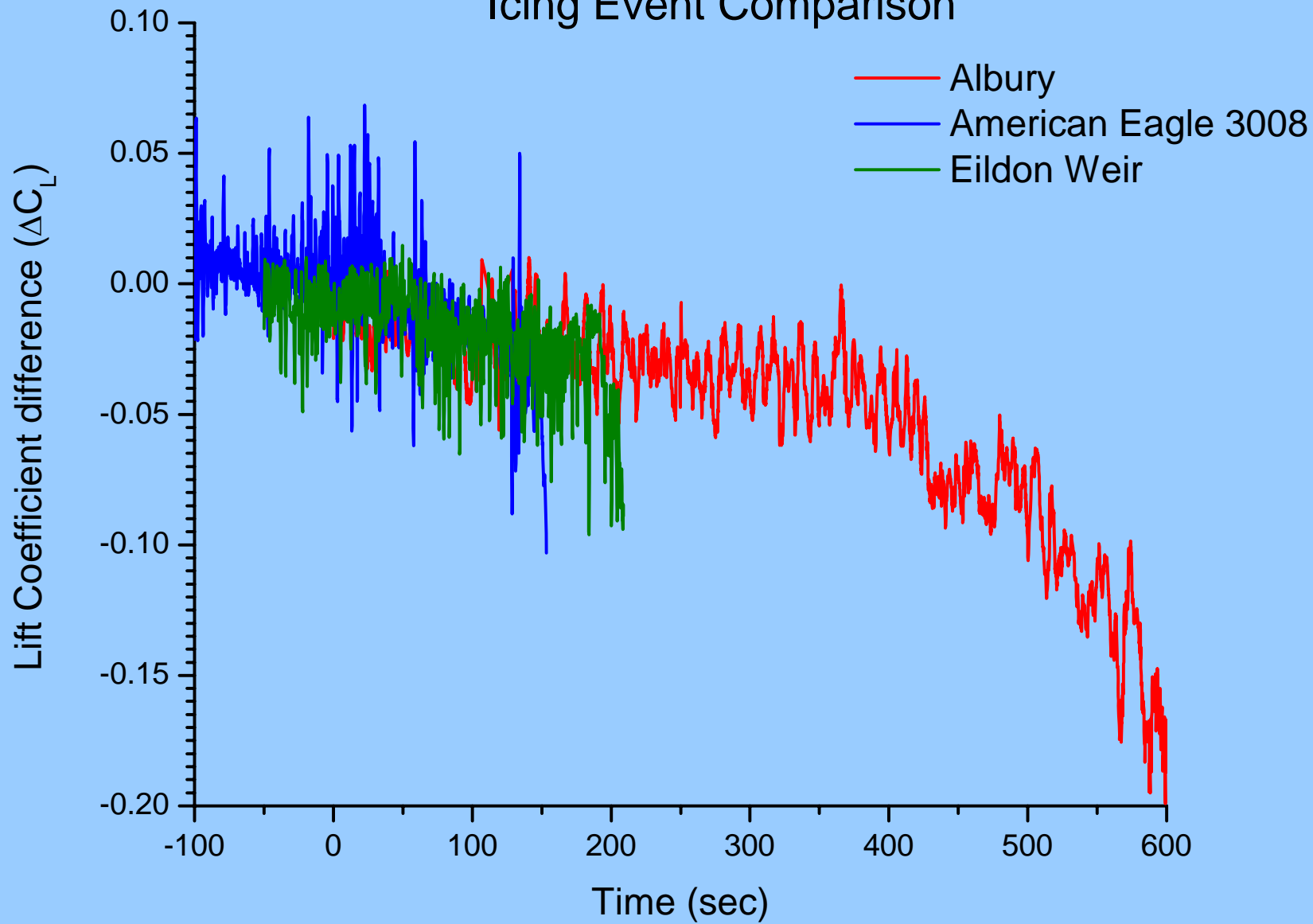


Upsets from Stalls due to Icing

- Saab 340: Eildon Weir, Australia,
 - November 1998
 - 2300-foot altitude loss
- Saab 340: Albury, Australia,
 - June 2004
 - 40-foot altitude loss
- Saab 340: San Luis Obispo, CA, USA
 - January 2006
 - 5000-foot altitude loss



Saab 340 Icing Event Comparison



Upset types

- Spatial disorientation
- Atmospheric Disturbances
 - Wake vortices, wind shear etc.
- Stall Upsets
 - Uncontaminated
 - With icing contamination
- Mechanical Failures

