



NTSB National Transportation Safety Board

An insiders look at aircraft accident investigation

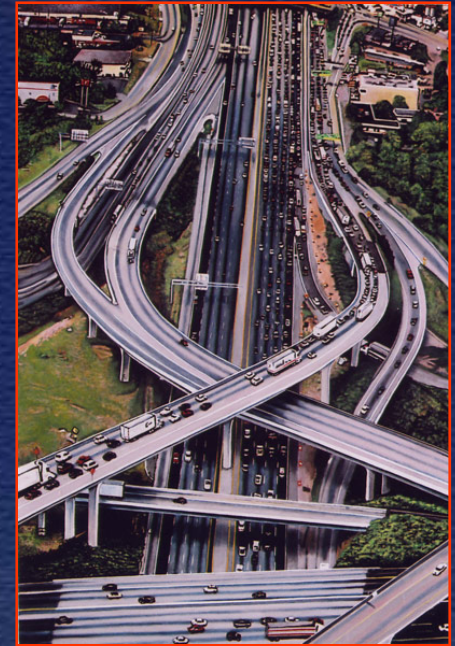
Robert L. Sumwalt

NTSB Board Member

March 2, 2010

NTSB's Mission

NTSB is an independent federal agency, charged by Congress to investigate transportation accidents, determine probable cause, and issue safety recommendations.



Since 1967 ...

- 142,000 accident investigations
 - 133,000 aviation accidents
- 13,000 + safety recommendations
 - 82 percent overall acceptance

Our independence is crucial to our mission.

Facilities

- Headquartered in Washington, DC
- NTSB Training Center
- 9 Regional Offices



 **NTSB** Training Center



The Board

- 5 Members, appointed by the President, with advice and consent of the Senate





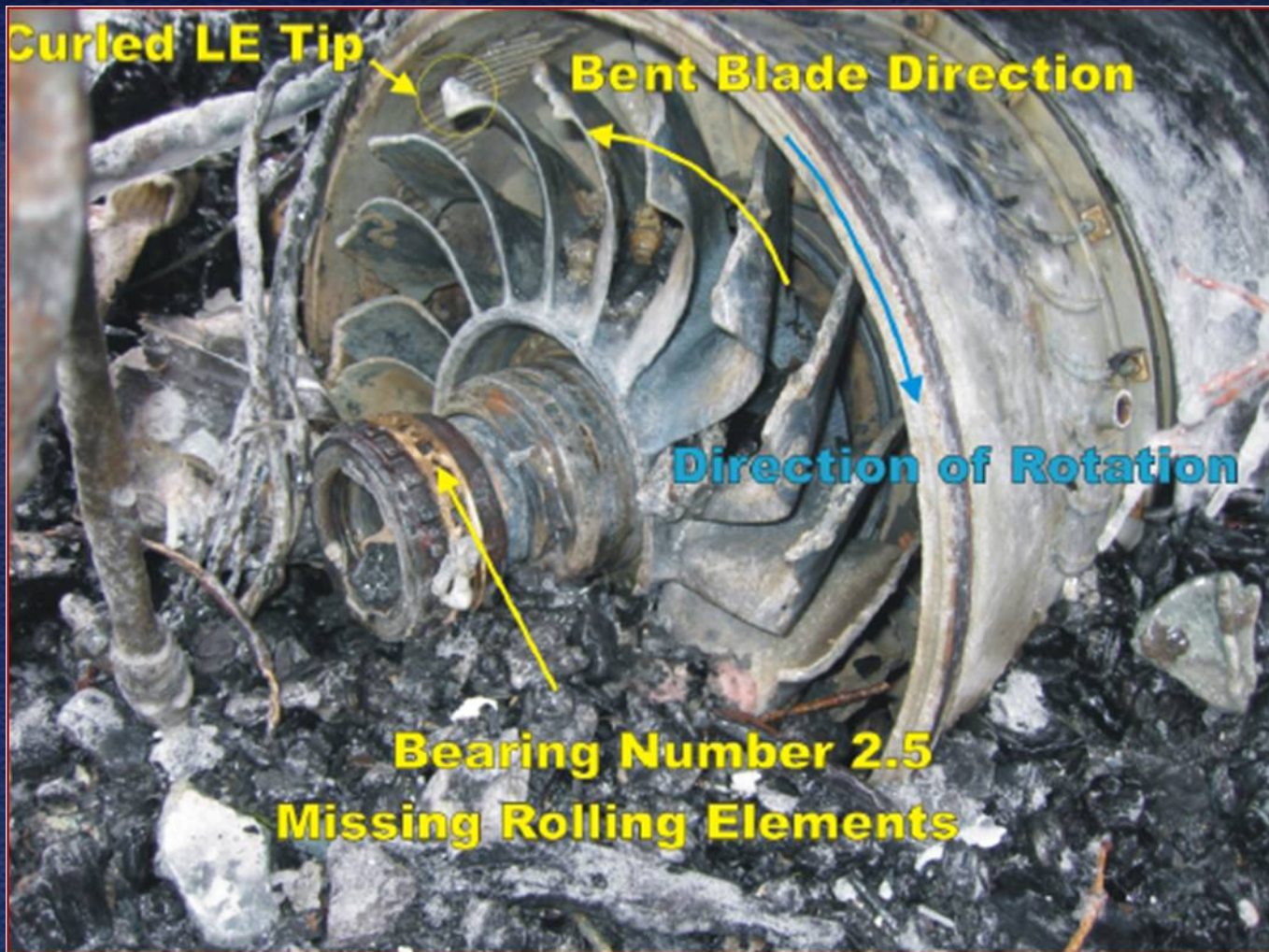


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Propellers









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USAir and Skywest Runway Collision

February 1, 1991

LAX/LAX

pt Elev 126'
49.8°/1.3 From LAX 113.6

D-ATIS Departure 135.65 Limited VOT 113.9	ACARS: D-ATIS PDC	LOS ANGELES Clearance 121.4	Ground North Complex 121.65	South Complex 121.75	(Between 1100 and 1400 LT, departure aircraft contact Metering 120.35 prior to contacting South Complex Ground Control)
North Complex 133.9	Tower South Complex 120.95	225°-044° 125.2	SOCAL Departure (R) 045°-224° 124.3	Helicopter 119.8	

JEPPESEN LOS ANGELES, CALIF
LOS ANGELES INTL
N33 56.6 W118 24.5
10-9 6 DEC 02

Advise Ground Control on frequency 121.65 whenever aircraft are not completely blocked on terminal gates adjacent to Taxiway D.

Tower may clear aircraft for take-off Rwy 24L from Taxiway E-8; 9572' (2918m) available from taxiway centerline.

Turbulence may be deflected upward from blast fence 180' (55m) east of Rwy 25R.

Taxiways C-1, and (C-7, C-8, C-9 North of C) and Taxiway D between D-8 and D-7 South of E will not accommodate B747 aircraft.

B747 aircraft westbound on Taxiway C prohibited from southbound turn onto Taxiway P with B747 aircraft on Gate 101.

All B747 eastbound on Taxiway C are prohibited from transiting to Taxiway B via Taxiway C-9.

Simultaneous aircraft operations prohibited on Taxiways WG and G between Rwy 07L/25R and 07R/25L.

Simultaneous aircraft operations prohibited on Taxiways T and ST between Rwy 07L/25R and 07R/25L.

All B747 aircraft tow onto gates.

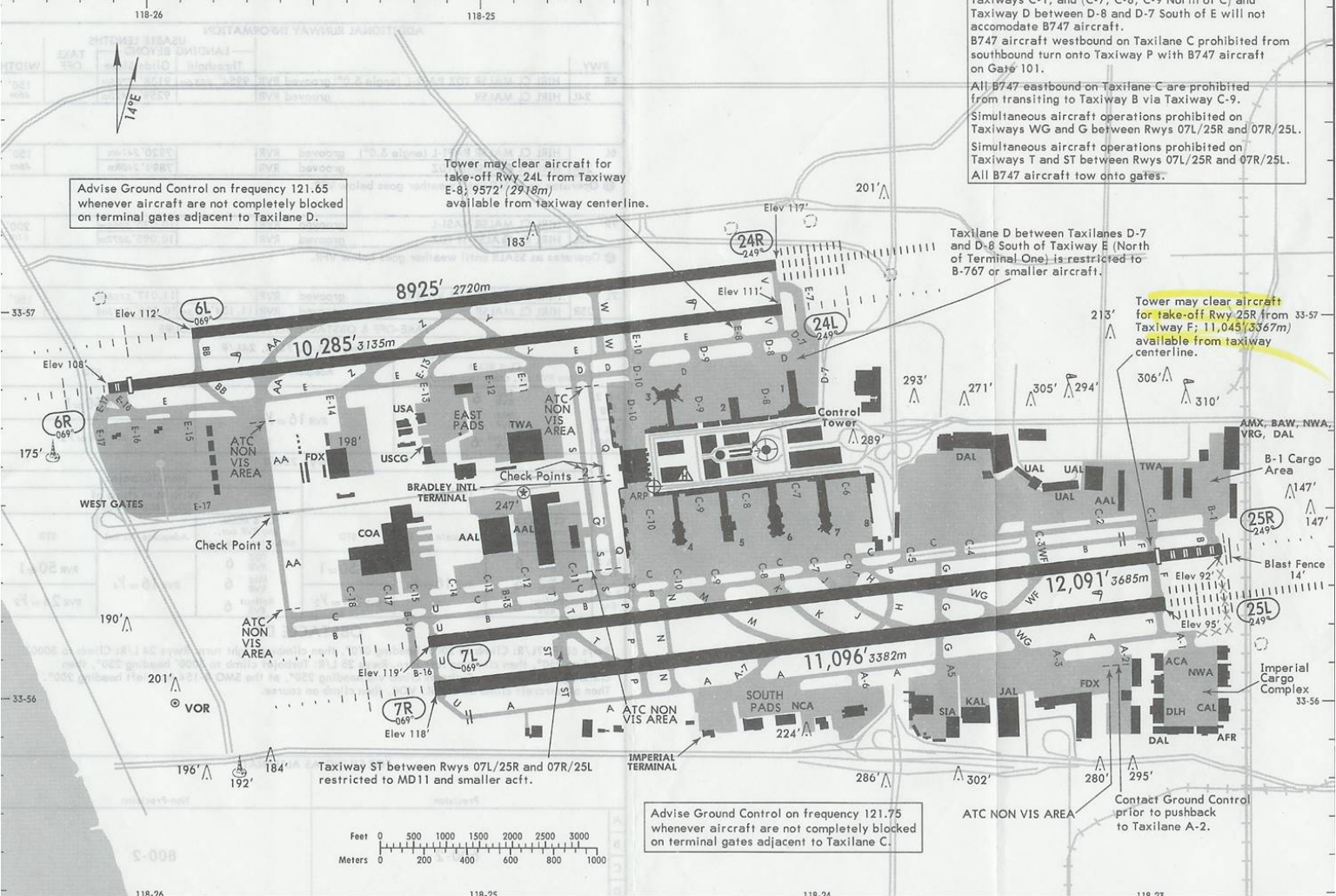
Taxiway D between Taxiways D-7 and D-8 South of Taxiway E (North of Terminal One) is restricted to B-767 or smaller aircraft.

Tower may clear aircraft for take-off Rwy 25R from Taxiway F; 11,045 (3367m) available from taxiway centerline.

Advise Ground Control on frequency 121.75 whenever aircraft are not completely blocked on terminal gates adjacent to Taxiway C.

Contact Ground Control prior to pushback to Taxiway A-2.

Taxiway ST between Rwy 07L/25R and 07R/25L restricted to MD11 and smaller act.

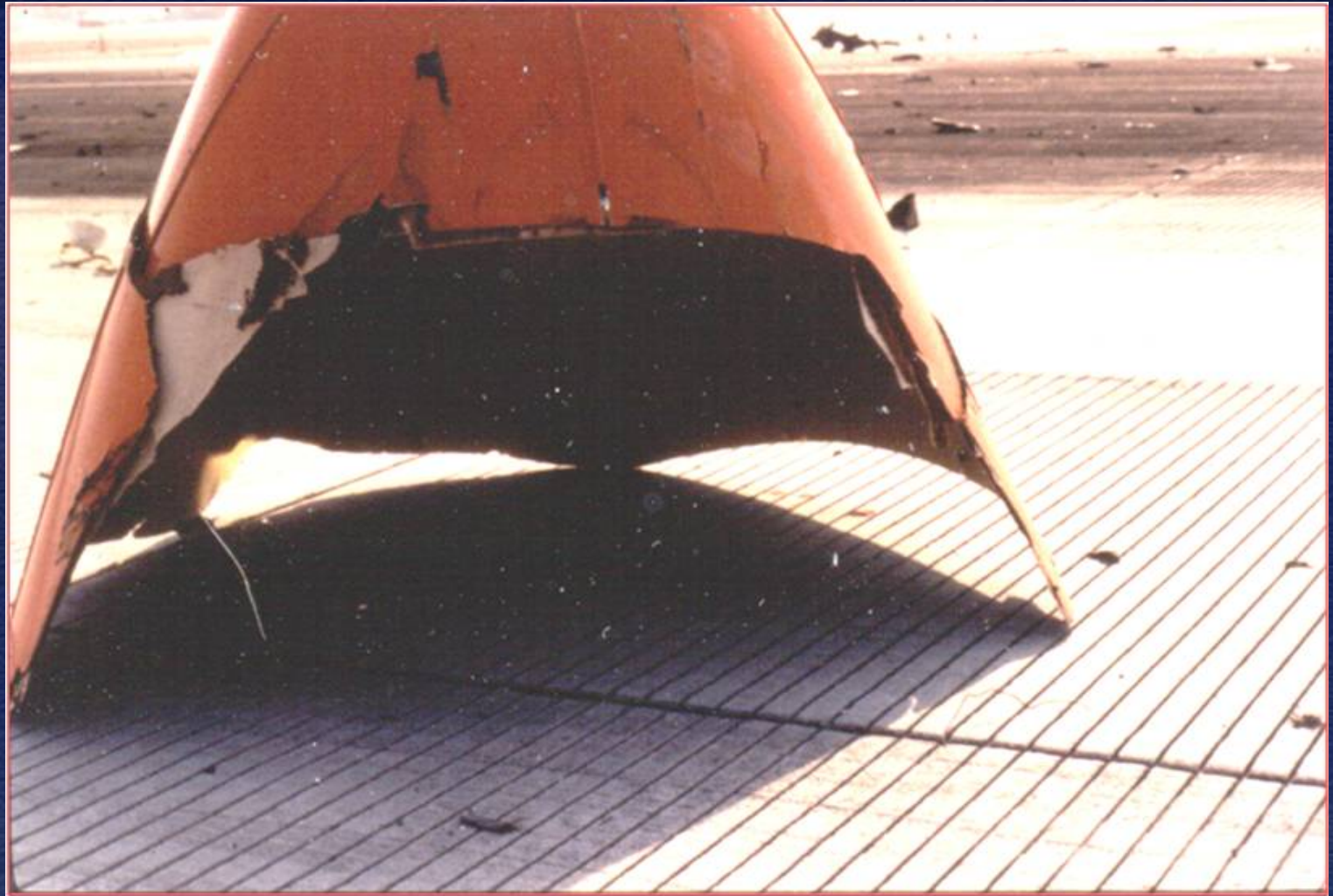






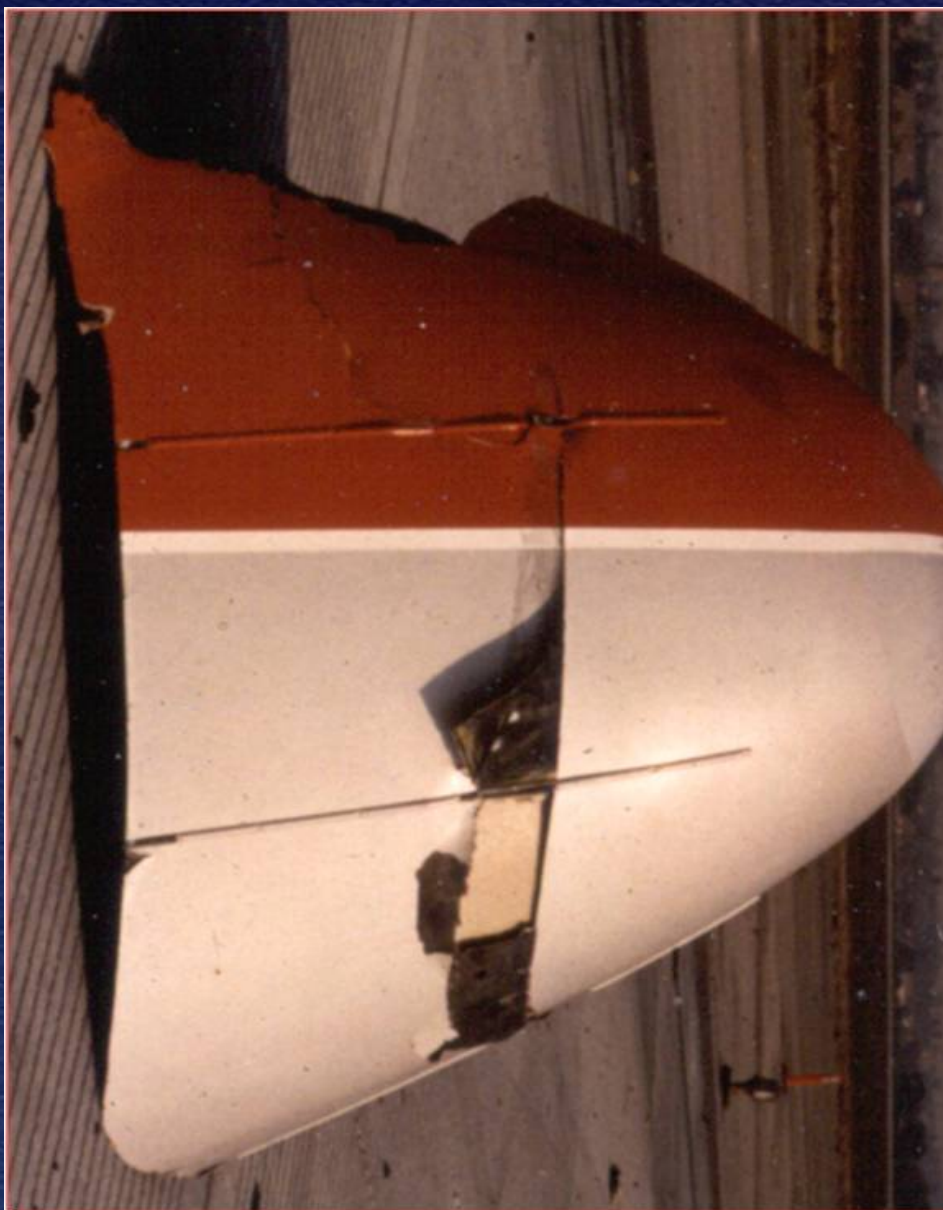
SEVERAL QUESTIONS

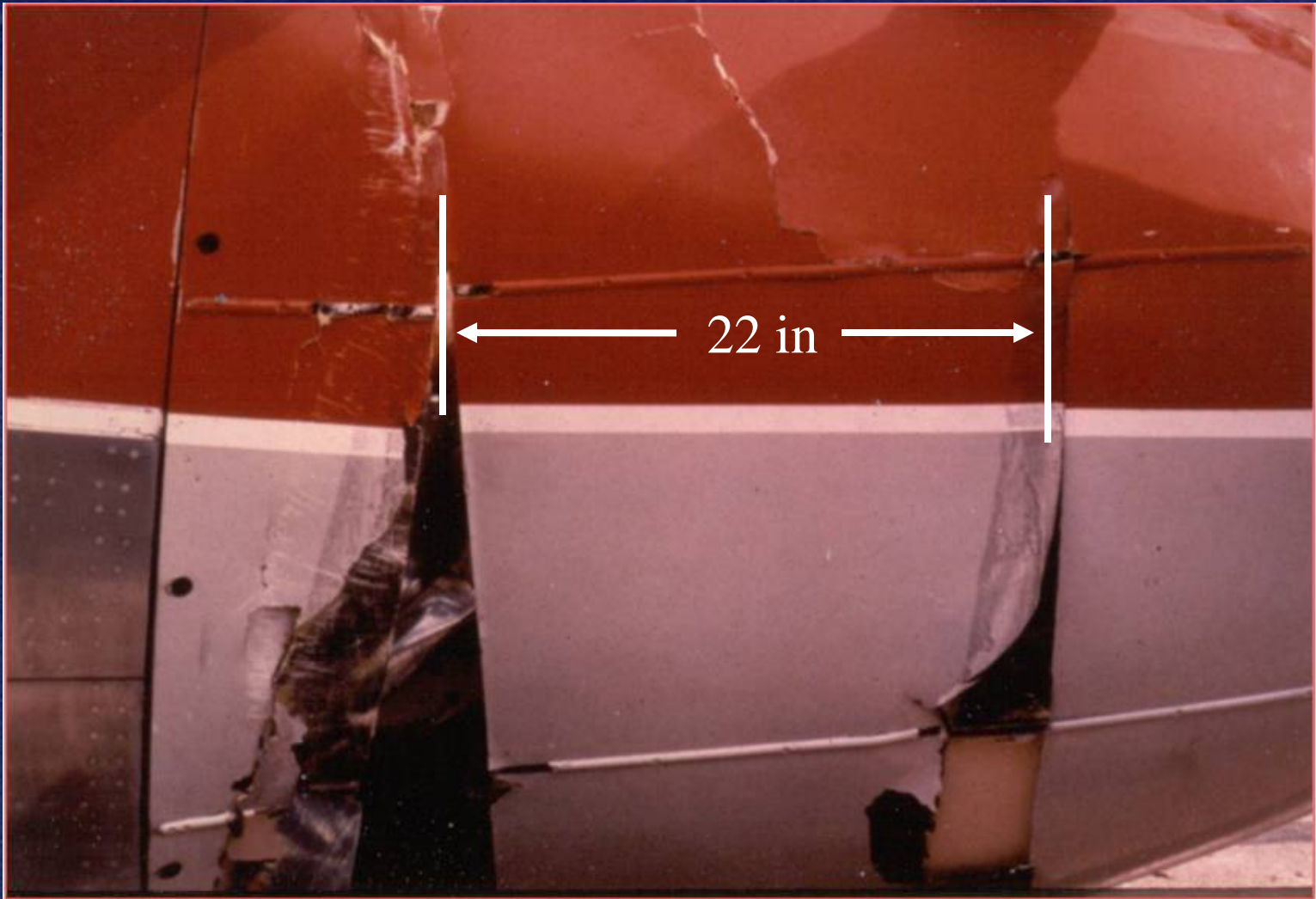
- HAD THE 737 DEROTATED?
- WAS THE Metroliner ROLLING?



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SPEED = DISTANCE / TIME

DISTANCE = _____ in / 12 = _____ ft

PROP SPEED = _____ rpm / 60 = _____ rps

BLADES/SEC = # OF BLADES X PROPSPEED

= _____ BLADES X _____ rps = _____ bps

TIME = 1 / bps = 1 / _____ bps = _____ sec/blade

SPEED = DISTANCE / TIME = _____ ft / _____ sec

SPEED = _____ fps = _____ knots

SPEED = DISTANCE / TIME

DISTANCE = 22 in / 12 = 1.833ft

PROP SPEED = 1543rpm / 60 = 25.7rps

BLADES/SEC = # OF BLADES X PROPSPEED

= 4 BLADES X 25.7 rps = 102.9 bps

TIME = 1 / bps = 1 / 102.9 bps = .00972 sec/blade

SPEED = DISTANCE / TIME = 1.833ft / .00972sec

SPEED = 189 fps = 112 knots



THE FDR SHOWS 118 KNOTS.
WE CALCULATED 112 KNOTS.

WHY DO WE HAVE A DIFFERENCE?

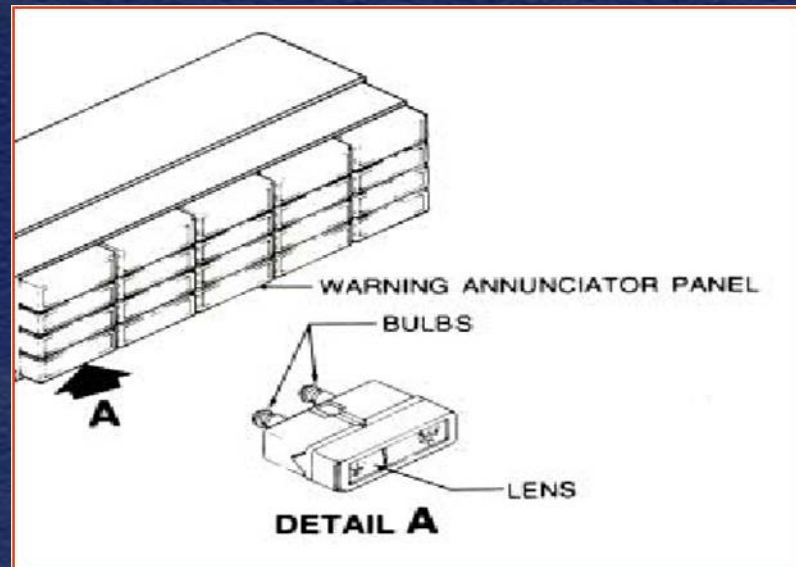
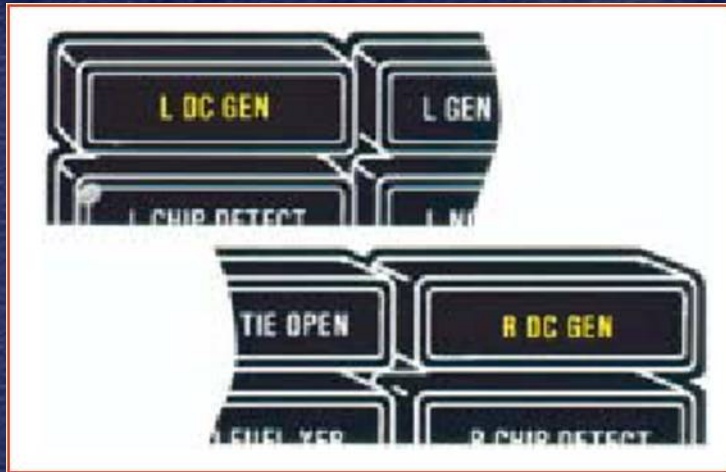
118 knot AIRSPEED
Minus
6 knot wind
Equals
112 knots GROUND SPEED

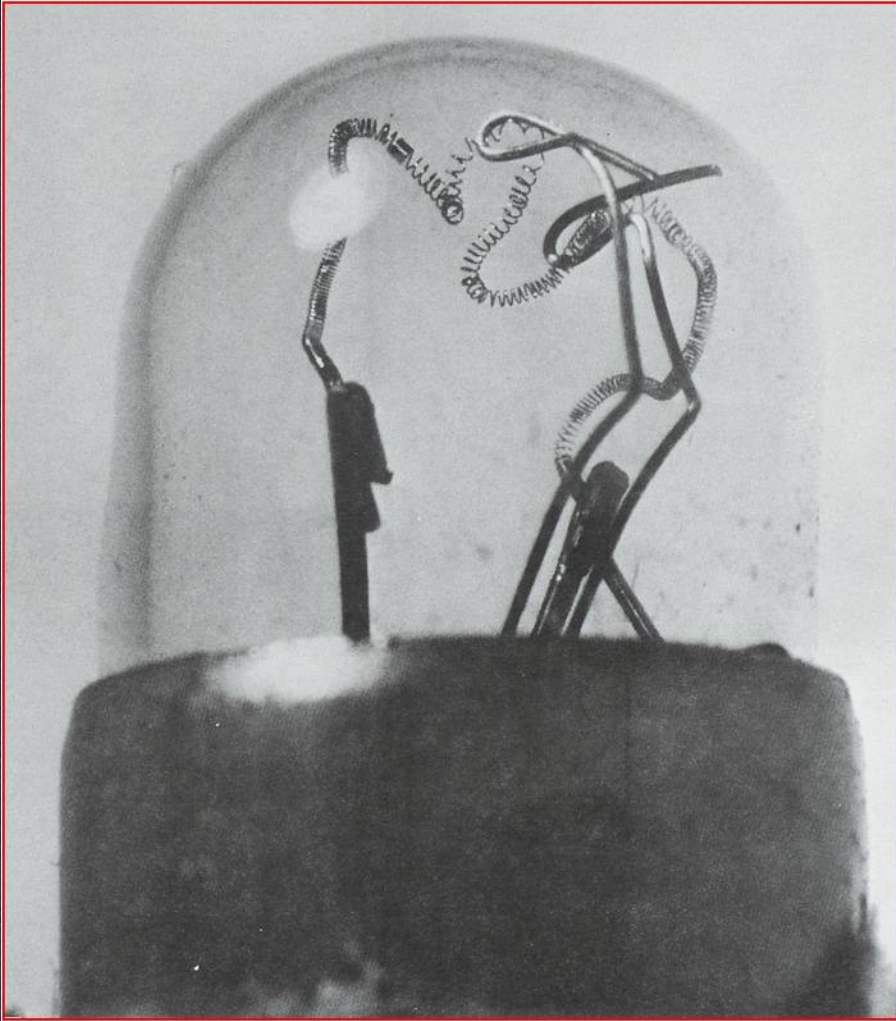


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Light Bulb Analysis

Light Bulb Filaments





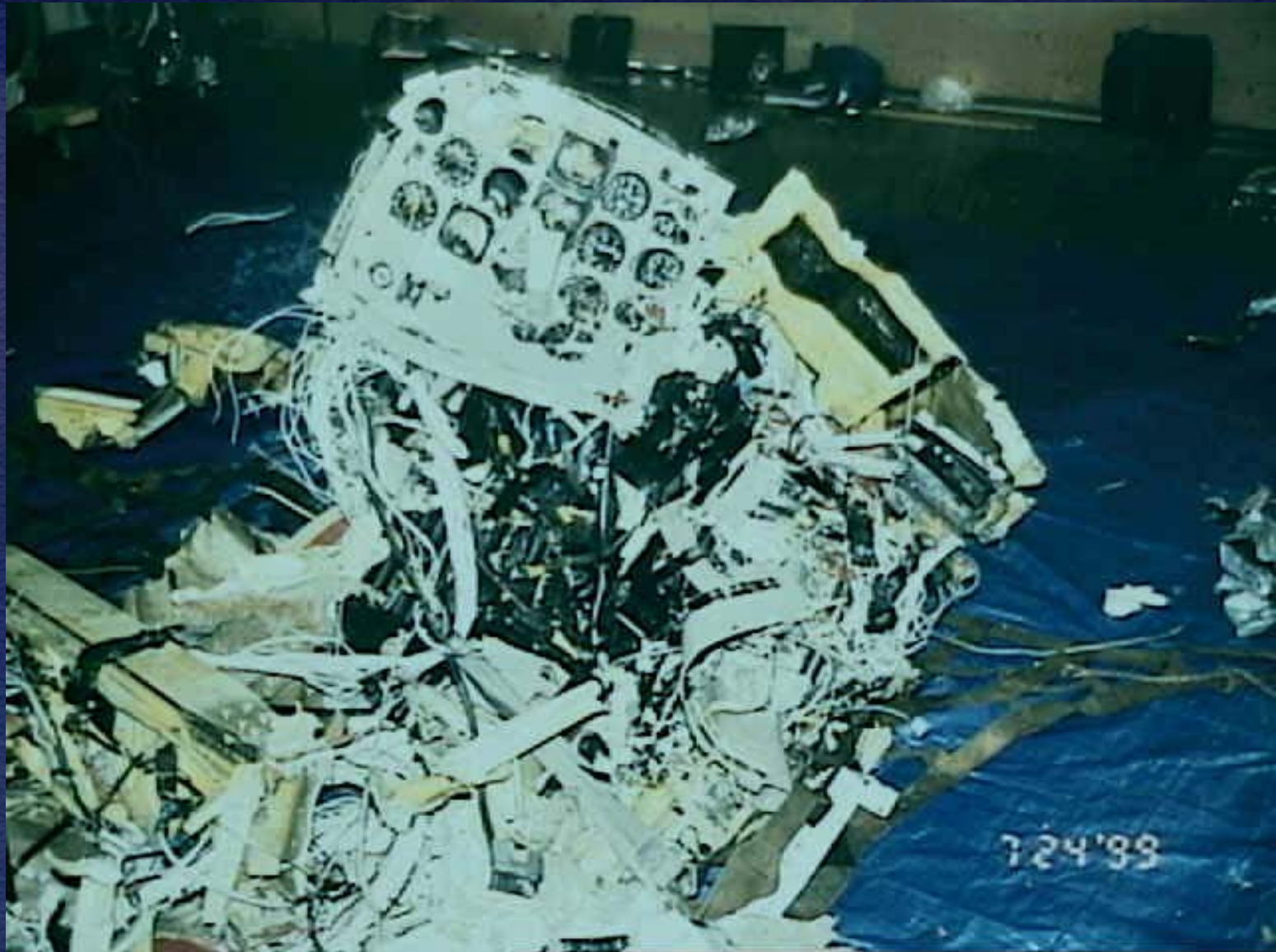
- Was this light illuminated or extinguished at impact?



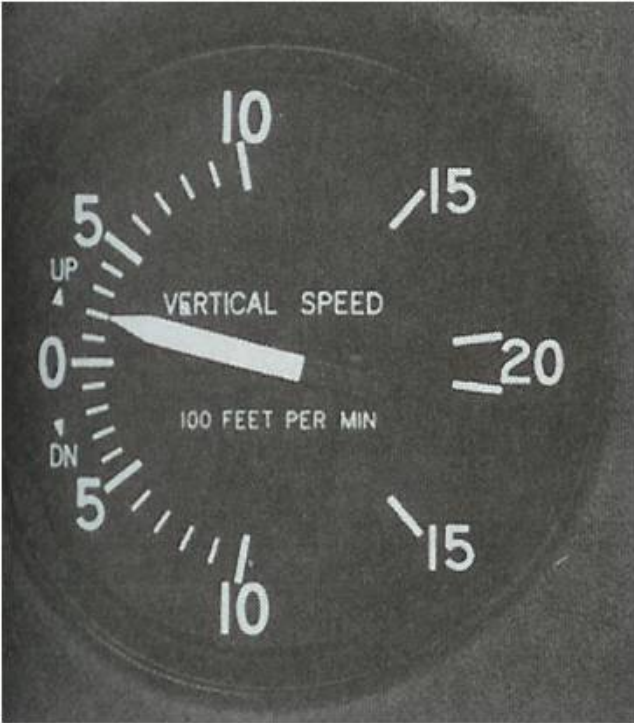
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Cockpit Instruments

Cockpit – Instruments (JFK Jr)



Cockpit Instruments (JFK Jr)



Airspeed Indicator Witness Marks









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**The anatomy of an
accident:
Colgan Air flight 3407**

Background

- February 12, 2009
- 10:17 pm Eastern Standard Time
- Colgan Air, Inc.
 - Operated as Continental Connection
- Bombardier DHC-8-400
- On approach to Buffalo, New York
- 50 fatalities
 - 2 pilots
 - 2 flight attendants
 - 45 passengers
 - 1 resident killed

History of flight

- Crew engaged in almost continuous conversation throughout flight
 - Conversation mostly extraneous to flight operations
- Conversation preempted timely performance of flight-related duties
 - Approach briefing, descent checklist, approach checklist



History of flight

- Approximately 3 miles from outer marker:
 - power was reduced to slow for approach
 - gear extended
 - props to max RPM
- Airspeed decreased 50 kts in 21 seconds

Stall, Upset, Loss of Control

- Stick shaker (stall warning) activated at 131 knots
- Autopilot disconnected
- Captain reacted with “startle and confusion”
- Captain pulled nose to 19 degrees nose up pitch
- Stall, extreme roll
- Stick pusher activated 3 times
 - countered by captain’s actions of pulling
- Loss of control



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Local Time (hh:mm:ss)	FDR SRN (seconds)	Source	Event
22:14:39.8	95434.9	CAM	[sound similar to engine power increase]
22:15:06.3	95461.4	HOT-1	flaps five.
22:15:08.1	95463.2	HOT-2	what?
22:15:08.8	95463.9	HOT-1	flaps five please.
22:15:11.2	95466.3	CAM	[sound similar to flap handle movement]
22:15:13.5	95468.6	APP	Colgan thirty four zero seven three miles from KLUMP turn left heading two six zero maintain two thousand three hundred until established localizer. cleared ILS approach runway two three.
22:15:22.2	95477.3	RDO-2	left two sixty two thousand three hundred 'til established and cleared ILS two three approach Colgan thirty four zero seven.
22:15:31.7	95486.8	HOT-1	alright approach is armed.
22:15:32.8	95487.9	HOT-2	roger.
22:15:59.5	95514.6	CAM	[sound similar to decrease in engine power]
22:16:04.1	95519.2	HOT-1	gear down...loc's alive.
22:16:06.2	95521.3	CAM	[sound similar to landing gear handle movement]
22:16:06.4	95521.5	APP	Colgan thirty four zero seven contact tower one two zero point five. have a good night.
22:16:07.4	95522.5	CAM	[sound similar to landing gear deployment]
22:16:11.5	95526.6	RDO-2	over to tower you do the same thirty four zero seven.
22:16:21.2	95536.3	HOT-2	gear's down.
22:16:23.5	95538.6	HOT-1	flaps fifteen before landing checklist.
22:16:26.0	95541.1	CAM	[sound similar to flap handle movement]
22:16:26.6	95541.7	HOT-2	uhhh.
22:16:27.4	95542.5	CAM	[sound similar to stick shaker continues for 6 7

22:16:26.0	95541.1	CAM	[sound similar to flap handle movement]
22:16:26.6	95541.7	HOT-2	uhhh.
22:16:27.4	95542.5	CAM	[sound similar to stick shaker continues for 6.7 seconds]
22:16:27.7	95542.8	HOT	[sound similar to autopilot disconnect horn repeats until end of recording]
22:16:31.1	95546.2	CAM	[sound similar to increase in engine power]
22:16:35.4	95550.5	CAM	[sound similar to stick shaker continues until end of recording]
22:16:37.1	95552.2	HOT-2	I put the flaps up.
22:16:42.2	95557.3	HOT-1	[sound of grunt]
22:16:45.8	95560.9	HOT-2	should the gear up?
22:16:46.8	95561.9	HOT-1	gear up.
22:16:50.1	95565.2	CAM	[increase in ambient noise]
22:16:51.9	95567.0	CAM	[sound of thump]
22:16:53.9	95569.0		End of Transcript; End of Recording

HOT-2: gear's down.

HOT-1: flaps fifteen before landing checklist.

HOT-2: uhhh.



National Transportation Safety Board *Board Meeting*

22:16:27

130

knots

2280

feet

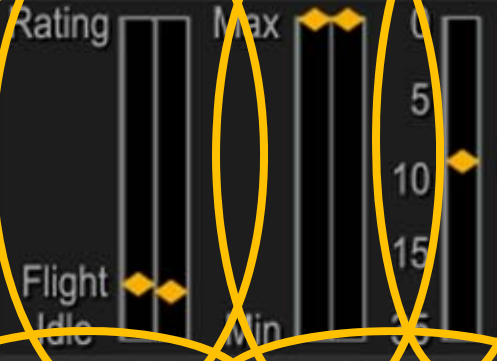
Shaker **ON**

Pusher **OFF**

Power

Condition

Flap



Heading

247°

Pedal



Auto Pilot **OFF**

Gear **DOWN**



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Office of Research and Engineering

Flightpath

Loss of Control on Approach

Colgan Air, Inc., Operating as
Continental Connection Flight 3407
Bombardier DHC-8-400, N200WQ

Clarence Center, New York

February 12, 2009

DCA09MA027

Board Meeting





NTSB Findings

- Flight crew and airplane properly certificated
- No evidence of any preimpact structural, engine, or systems failures
- Aircraft had minimal aircraft performance degradation from ice accumulation
 - this did not affect the flight crew's ability to fly and control the airplane.

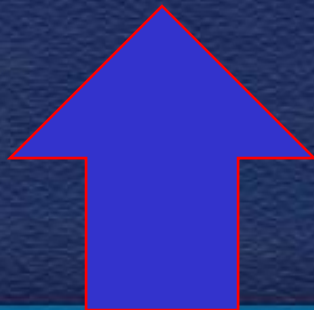
Major Areas of Focus



Airspeed
Selection

Cockpit
Discipline

Crew Reaction
to Stall Warning
and Stall



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Primary Flight Display



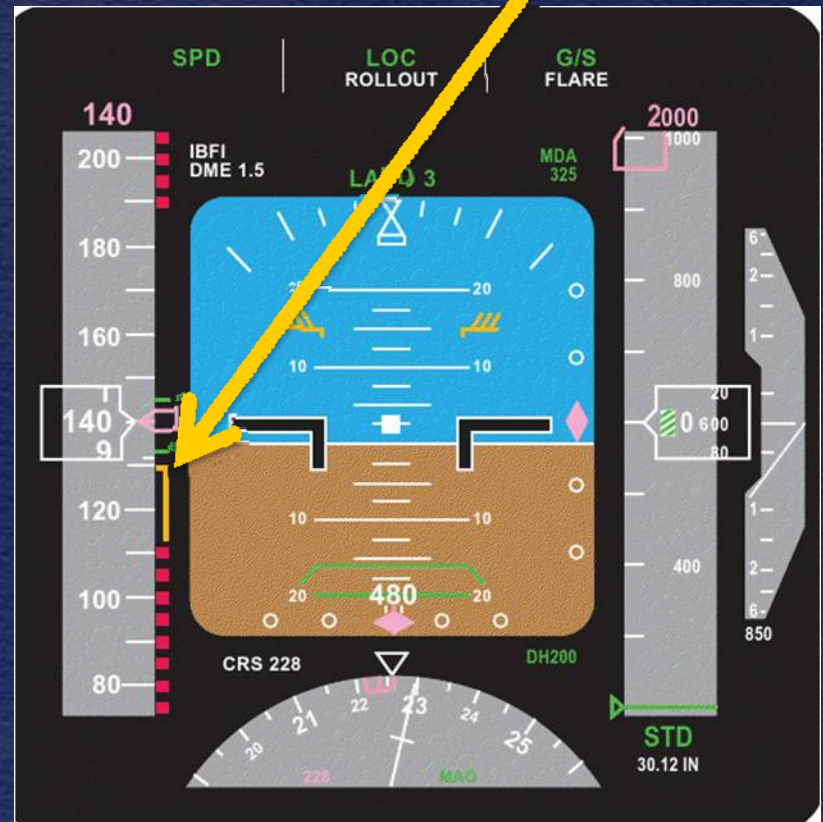
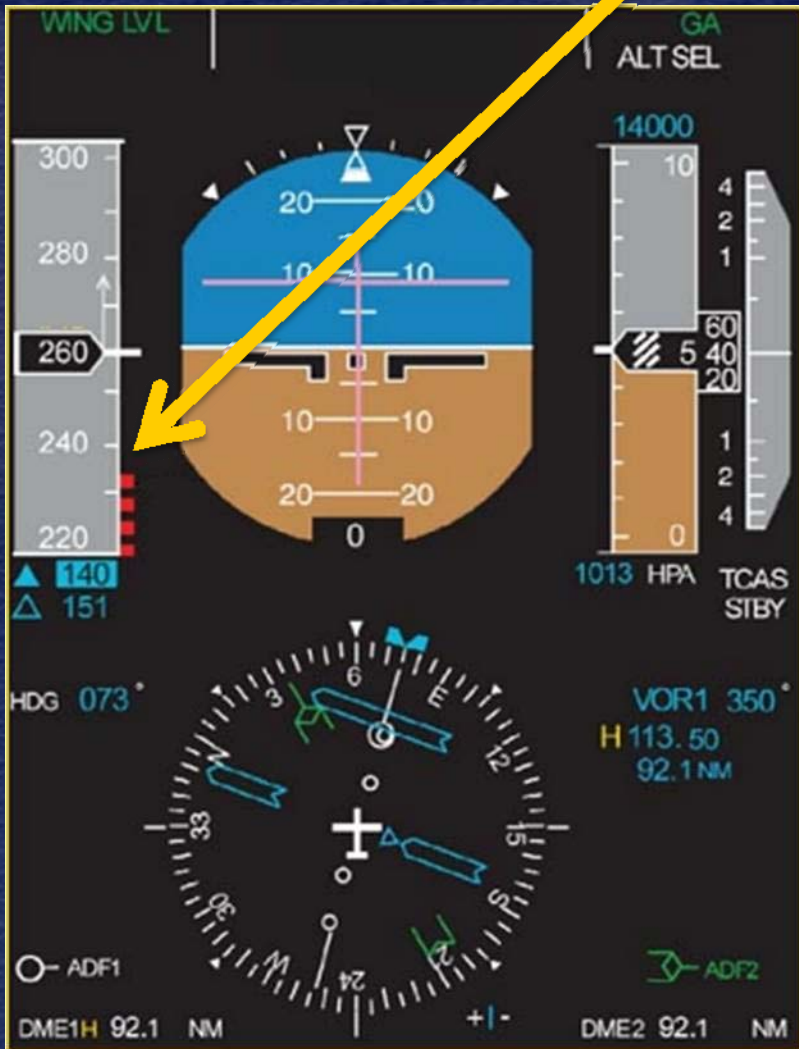
Ice Protection Panel

Mismatch of Landing Ref Speeds

- Flight operated in light-to-moderate icing en route and on approach
- Captain set reference speeds switch to increase (icing conditions)
- First officer obtained landing speeds for non-icing conditions
 - Mismatch with position of ref speeds switch resulted in landing speed that was 13 knots lower than stick shaker activation speed
 - 118 vs. 131 knots

No Cautionary Range

Cautionary Range



Q400

Exemplar Display

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NTSB Findings

- The Q400 airspeed indicator lacked low-speed awareness features, such as an amber band above the low-speed cue ...that would have facilitated the flight crew's detection of the developing low-speed situation.
- An aural warning in advance of the stick shaker would have provided a redundant cue of the visual indication of the rising low-speed cue and might have elicited a timely response from the pilots before the onset of the stick shaker.

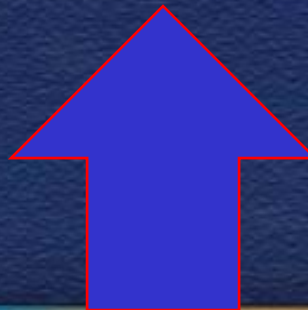
Major Areas of Focus



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Crew Activities

- Captain should have seen rising low-speed cue during instrument scan, as well as high pitch attitude
 - No evidence explained why these were missed
- First officer should have detected captain's error
 - Duties directed her attention away from primary flight display
- Missed cues reflects breakdown in monitoring and workload management

Leadership Training

- Captain did not establish appropriate tone or show strong command authority
 - Operators not required to provide upgrading captains with leadership training
- Recommendation issued in this area

NTSB Finding

- The captain's failure to effectively manage the flight
 - enabled conversation that delayed checklist completion and conflicted with sterile cockpit procedures, and
 - created an environment that impeded timely error detection.

NTSB Report

“Because of their conversation, the flight crewmembers squandered time and their attention, which were limited resources that should have been used for attending to operational tasks, monitoring, maintaining situational awareness, managing possible threats, and preventing potential errors.”

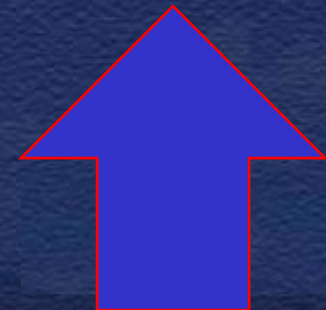
Major Areas of Focus



Airspeed
Selection

Cockpit
Discipline

Crew Reaction
to Stall Warning
and Stall



Response to Stick Shaker

- Captain's actions inconsistent with trained recovery procedures
- Captain's aft control column inputs led to stall
- Power advanced but not to rating detent
- Neither pilot made callouts or commands associated with stall recovery

Crew's Reaction

- Stick pusher activated three times
- After each activation, captain continued to pull back on control column
 - Exacerbated airplane's stalled condition
 - Prevented potential recovery

Actions During Stall Event

- Captain's actions did not indicate well-learned habit pattern
- Improper inputs consistent with startle and confusion
- History of training failures may have played role

Actions During Stall Event

- First officer's uncommanded raising of flaps and suggestion to raise gear not consistent with recovery procedures
- Reasons for first officer's actions could not be determined

Airline “approach to stall” training

- Air carrier pilots trained on “approach to stall,” requiring recovery with minimal altitude loss
- Altitude loss standards not appropriate for fully developed stall
 - Positive nose-down control force necessary once actual wing aerodynamic stall occurs

Stall Training

- Conformed to industry standard practices
- Not conducted with element of surprise
- Did not involve autopilot disconnect
- Did not address actions needed to recover from fully developed stalls

NTSB Findings

- The current air carrier approach-to-stall training did not fully prepare the flight crew for an unexpected stall and did not address the actions that are needed to recover from a fully developed stall.
- Realistic, fully developed stall models should be incorporated into flight simulators.
- Pilots should have stick pusher demonstrated to them during training.

Other Issues Examined



- Role of Fatigue
- Tailplane Icing/Stall
- Pilot Selection

Role of Fatigue

- Captain
 - Reduced sleep opportunities
 - Stayed overnight in crew room
 - Accessed company computer at 0310
 - Accident occurred at normal bedtime
- First officer
 - Overnight transcontinental commute
 - Slept on airplanes and in crew room

NTSB Finding

- The pilots' performance was likely impaired because of fatigue, but the extent of their impairment and the degree to which it contributed to the performance deficiencies that occurred during the flight cannot be conclusively determined.

Tailplane Icing

- NASA In-Flight Icing video explains that tailplane stall recovery is to:
 - Pull back on control wheel
 - Retract flaps to previous setting
 - Decrease power (aircraft dependent)
- Even though there is no evidence the Q400 was susceptible to tailplane stall, Colgan showed this video in ground school.

Tailplane Icing

- NASA video also stated that pilots need to properly diagnose icing problems because the difference between a wing and a tailplane stall were subtle but the recovery techniques were different.
- Captain reacted within approximately one second
- NTSB Finding: It is unlikely that the captain was deliberately attempting to perform a tailplane stall recovery.

Captain's Training History



Captain's record of failed FAA checkrides

Date of Checkride	Certificate Attempted
October 1991	Instrument Rating
May 2002	Commercial SEL
March 2004	Commercial MEL
October 2007	ATP and Saab 340 type rating

Additional training difficulties

Date	Difficulty Encountered	Checking Event
October 2005	graded “train to proficiency”	initial Saab 340 flight check
October 2006	unsatisfactory	recurrent Saab 340 flight check
October 2007	unsatisfactory	Saab 340 upgrade proficiency check

- Captain had not established good foundation of attitude instrument flying skills early in career
- Weaknesses in basic aircraft control and instrument flying continued
- Colgan did not proactively address these issues

- Successful transition to Q400 in Dec. 2008
 - Flying Q400 for 2 months at time of accident
- Simulator instructor: captain was rough on flight controls and over-controlled roll axis
 - Consistent with previous aircraft control problems

Pilot Records Improvement Act

- PRIA requires airlines to check for verification of:
 - current airman certification and medical certification
 - any FAA certificate actions and violations
 - drug and alcohol test results
 - records pertaining to the individual's performance, including discipline, as a pilot
 - check of National Driver Registry (DUI convictions, suspensions, or revocations)
- Does not require records of FAA notice of disapprovals (checkride busts), or records from non-air carrier employers



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Probable Cause

- 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:

- 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
- 4) Colgan Air's inadequate procedures for airspeed selection and management during approaches in icing conditions.

25 recommendations to FAA

- Strategies to prevent flight crew monitoring failures
- Pilot professionalism
- Fatigue
- Remedial training
- Pilot records
- Stall training
- Airspeed selection procedures
- FAA oversight



“From tragedy we draw knowledge to improve the safety of us all.”

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