National Transportation Safety Board

Enhancing Crew Monitoring and Cross-checking

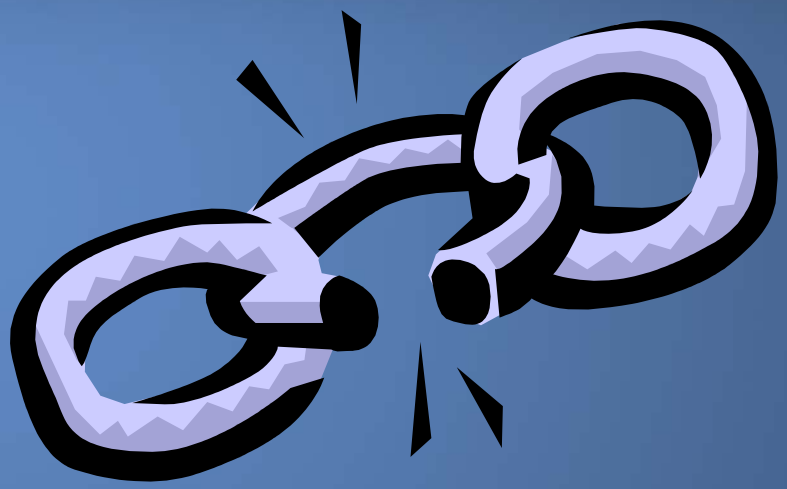
Robert L. Sumwalt, III

The last line of defense

- Each crewmember must carefully monitor the aircraft's flight path and systems, and actively cross-check the actions of each other.
- Effective monitoring and cross-checking can be the last line of defense
  - When this layer of defense is absent an error may go undetected, leading to adverse safety consequences

Good monitoring is important

- By better monitoring and cross-checking, a crewmember will be more likely to catch an error or unsafe act.
- This detection may break a chain of events leading to an accident scenario.



Structure of Today's Discussion

I. Why is monitoring important?

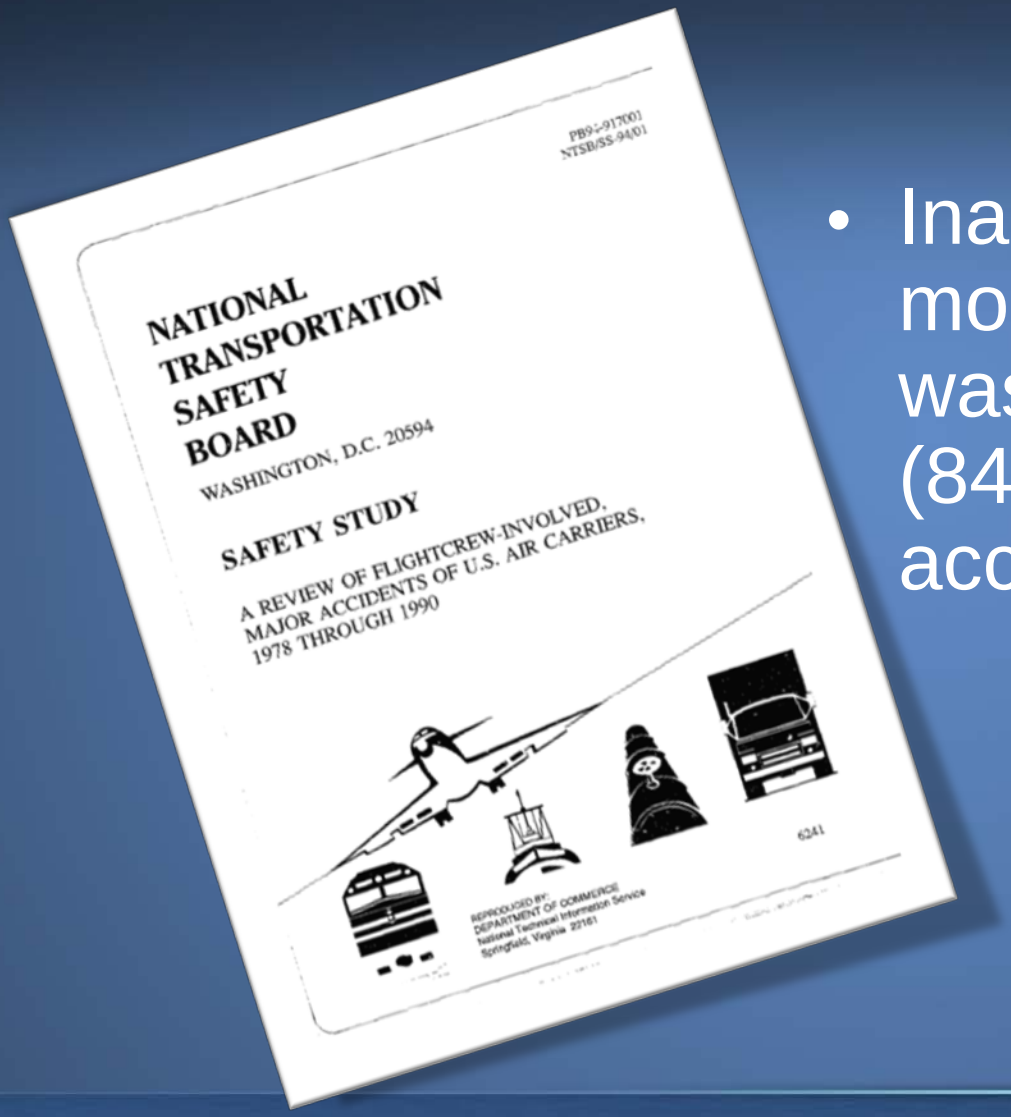
II. Accident case studies

III. Where and why monitoring errors occur

IV. What you can do to improve monitoring

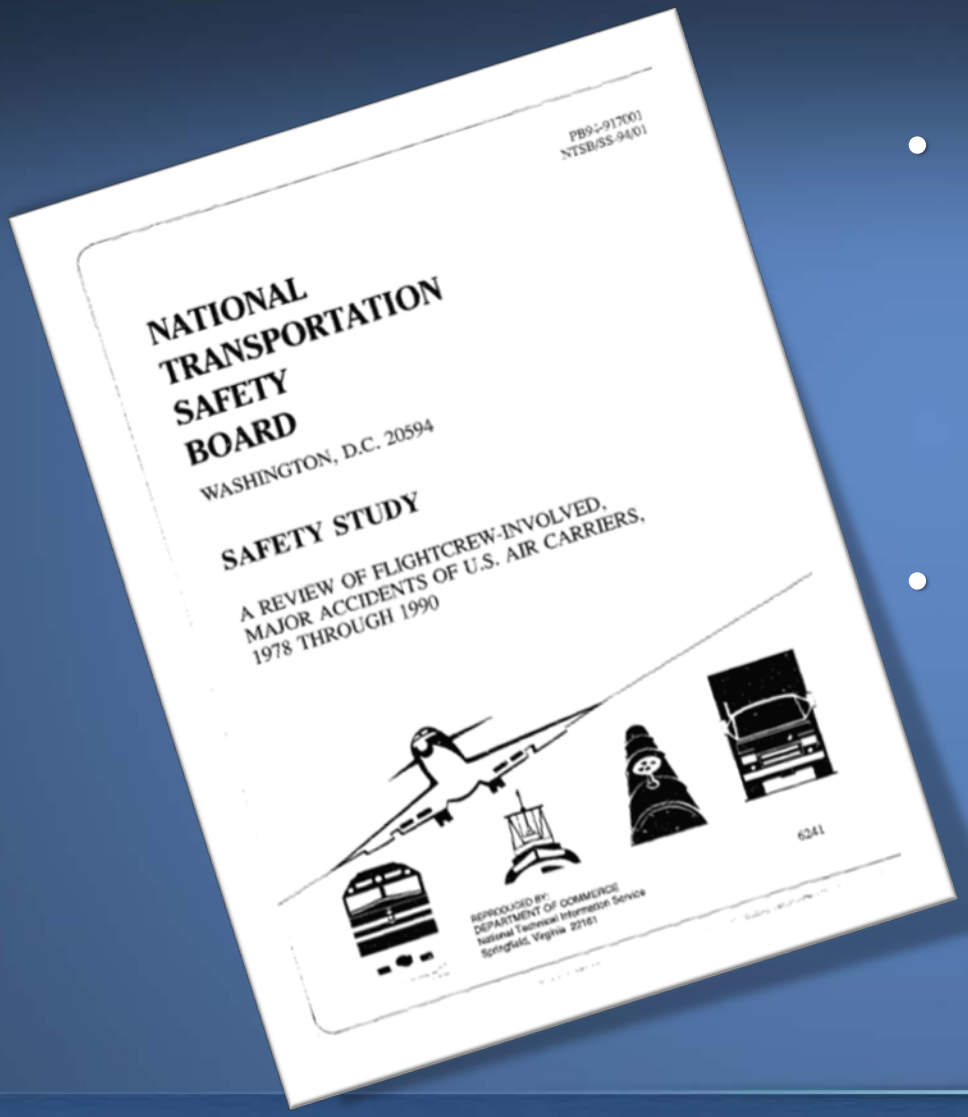
First discussion point:

WHY IS MONITORING IMPORTANT?



- Inadequate crew monitoring or challenging was a factor in 31 of 37 (84 percent) reviewed accidents.

Monitoring errors are serious



- 76% of the monitoring/challenging errors involved failure to catch something that was causal to the accident
- 17% of the monitoring/challenging errors were failure to catch something that contributed to the accident's cause

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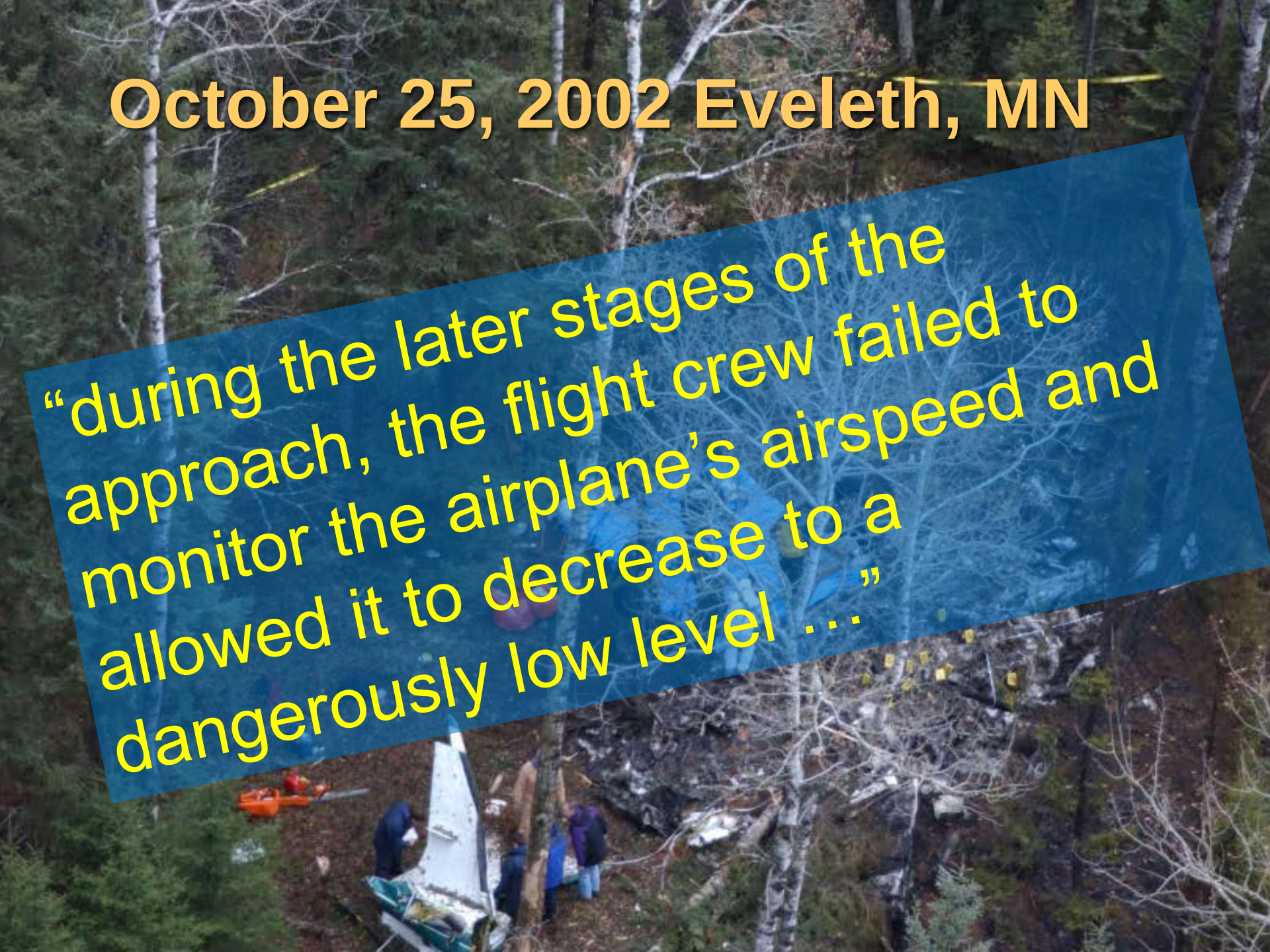
October 25, 2002 Eveleth, MN


October 25, 2002 Eveleth, MN
"during the later stages of the approach, the flight crew failed to monitor the airplane's airspeed and allowed it to decrease to a dangerously low level …"

Era, March 2004.
Gulf of Mexico

NTSB

Era, March 2004.
Gulf of Mexico

"The flight crew was not adequately monitoring the helicopter's altitude…"

Jetstream BAE-32, October 2004. Kirksville, MO

NTSB

Jetstream BAE-32, October 2004. Kirksville, MO

"The pilots failed to … effectively monitor the airplane's descent rate and height above terrain…"

G-III, November 2004. Houston, TX

NTSB

G-III, November 2004. Houston, TX

"The flight crew's failure to adequately monitor and cross check the flight instruments during the approach…"

Circuit City, CE 560, February 2005. Pueblo, CO

NTSB

Circuit City, CE 560, February 2005. Pueblo, CO

"Flight crew's failure to effectively monitor and maintain airspeed…"

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Comair, August 2006. Lexington, KY

Comair, August 2006. Lexington, KY

"their failure to cross-check and verify that the airplane was on the correct runway before takeoff…

Colgan Air, 2009

NTSB

Colgan Air, 2009

"The flight crew's failure to monitor airspeed…"

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Empire Airlines, January 2009. Lubbock, TX

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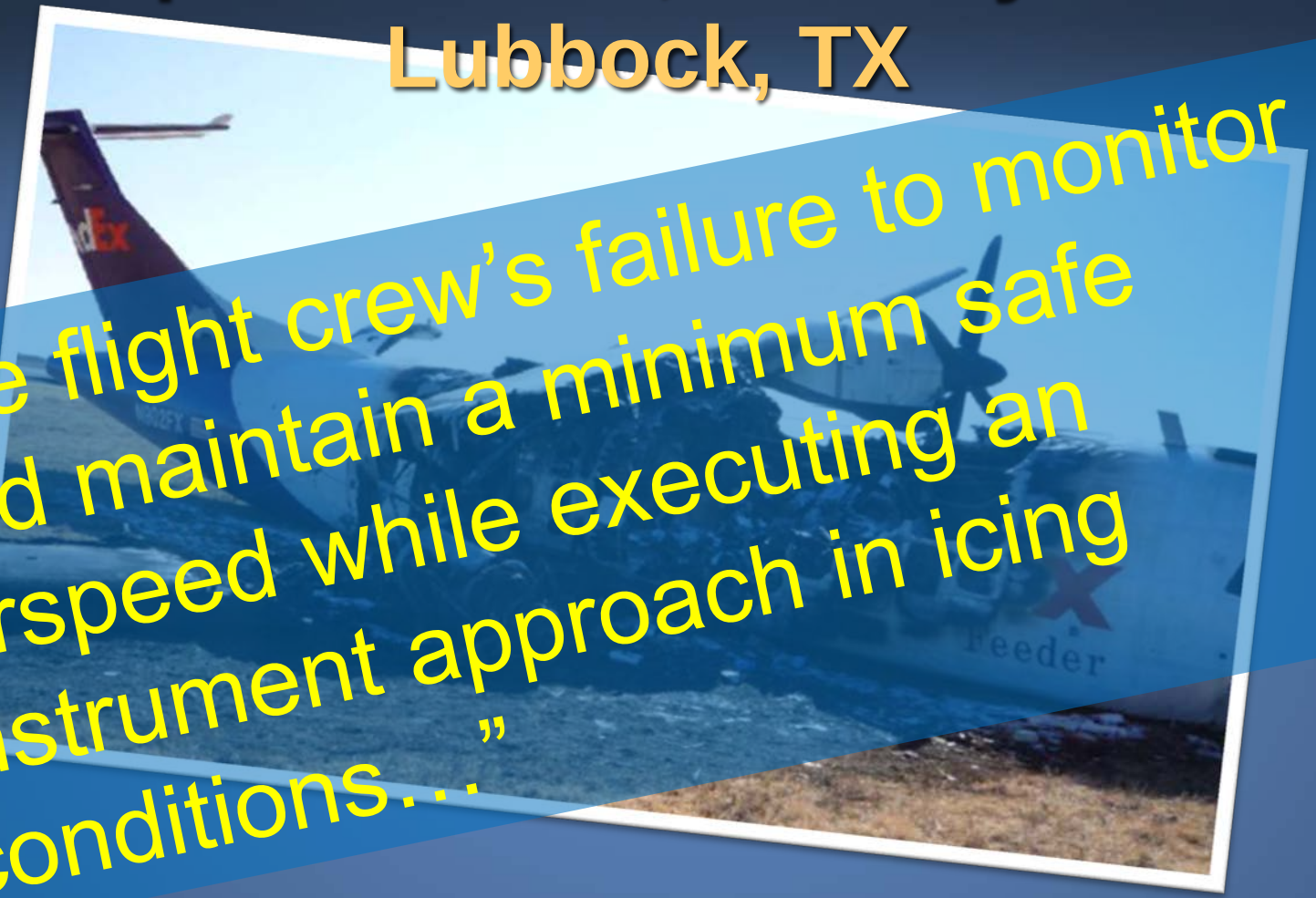
Empire Airlines, January 2009. Lubbock, TX



"the flight crew's failure to monitor and maintain a minimum safe airspeed while executing an instrument approach in icing conditions…"

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Turkish Air. Amsterdam. February 2009

- Dutch Safety Board

Turkish Air. Amsterdam. February 2009

"The airspeed reached stall speed due to a failure of monitoring the airspeed and pitch attitude…"

- Dutch Safety Board

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Asiana 214. July 2013

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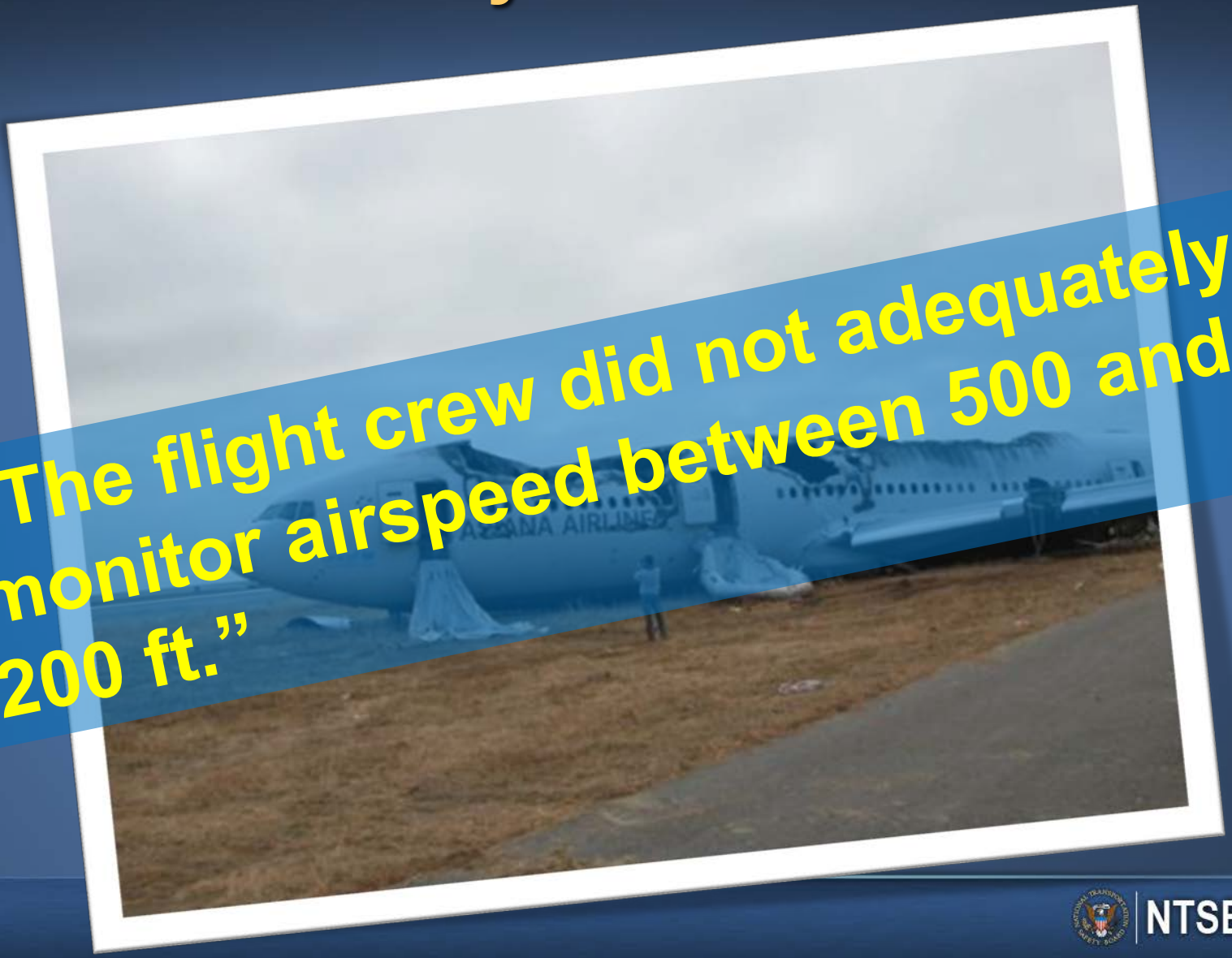
Asiana 214. July 2013



“The flight crew did not adequately monitor airspeed between 500 and 200 ft.”

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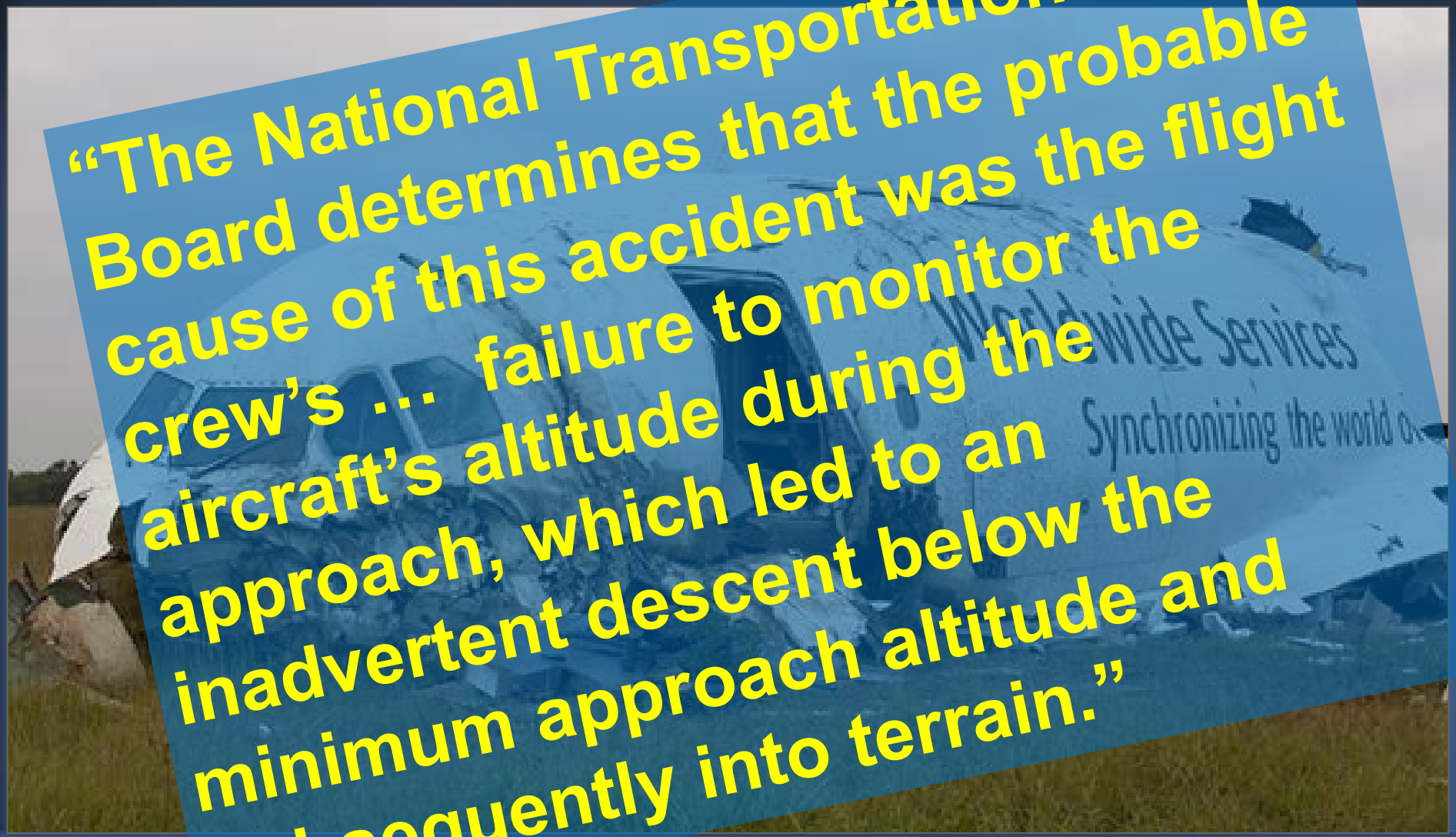
UPS 1354. August 2013

UPS 1354. August 2013



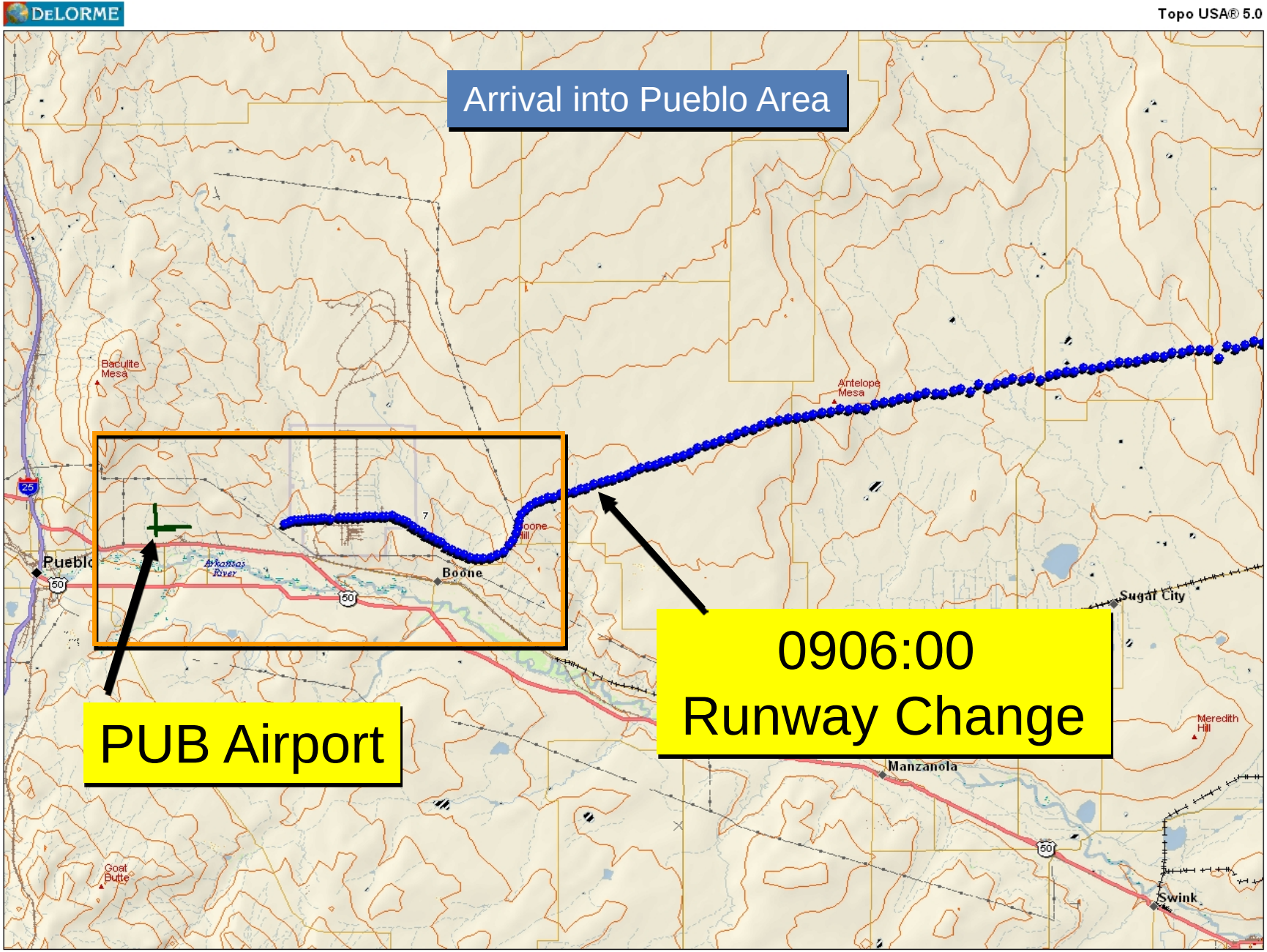
"The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's … failure to monitor the aircraft's altitude during the approach, which led to an inadvertent descent below the minimum approach altitude and subsequently into terrain."

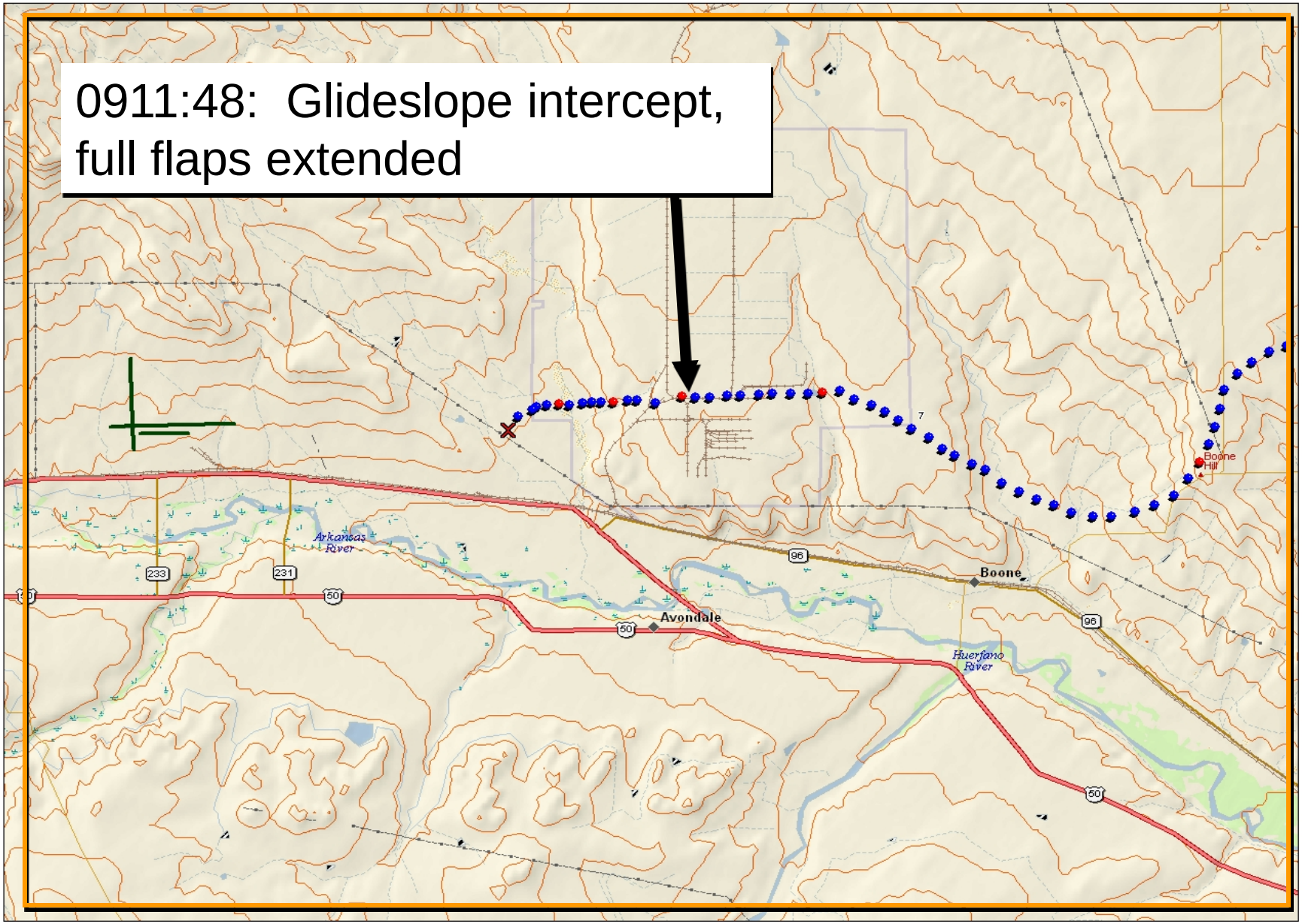
Second discussion point:

ACCIDENT CASE STUDIES

Accident Summary

- February 16, 2005
- Pueblo, CO
- Cessna Citation 560
  - Owned by Circuit City, Operated by Martinair
- Eight fatalities
- Part 91 flight


DeLORME
Topo USA® 5.0
Arrival into Pueblo Area
Baculite Mesa
Antelope Mesa
Pueblo
Boone
Arkansas River
Sugar City
Meredith Hill
Manzanola
Goat Butte
Swink
0906:00
Runway Change
PUB Airport
Data use subject to license.
© 2004 DeLorme. Topo USA® 5.0.
www.delorme.com
MN (0.0° W)
0 2 4 6 8 10 mi
Data Zoom 9-0


DeLORME
Topo USA® 5.0
0911:48: Glideslope intercept, full flaps extended
Arkansas River
Boone
Avondale
Huerfano River
Boone Hill
233
231
50
96
Data use subject to license.
© 2004 DeLorme. Topo USA® 5.0.
www.delorme.com
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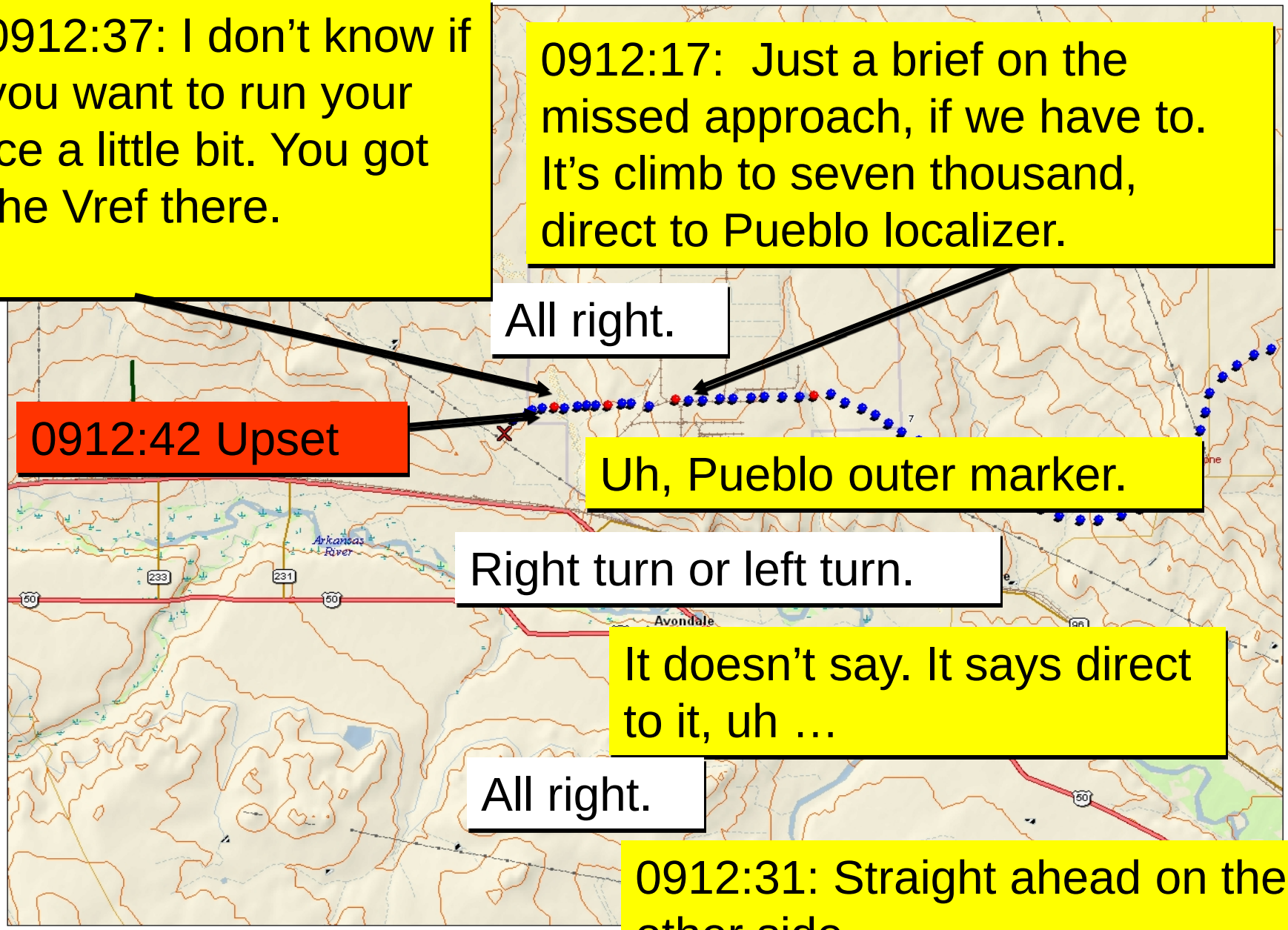
DeLORME
Topo USA® 5.0
0912:37: I don't know if you want to run your ice a little bit. You got the Vref there.
0912:17: Just a brief on the missed approach, if we have to. It's climb to seven thousand, direct to Pueblo localizer.
All right.
0912:42 Upset
Uh, Pueblo outer marker.
Right turn or left turn.
Arkansas River
233
231
50
Avondale
It doesn't say. It says direct to it, uh …
All right.
0912:31: Straight ahead on the other side.
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NTSB Finding

- "All operators would benefit from an increased focus on providing monitoring skills in their training programs…"

NTSB Recommendation A-07-13 to FAA:

Require pilot training programs be modified to contain modules that teach and emphasize monitoring skills and workload management and include opportunities to practice and demonstrate proficiency in these areas.

Colgan Air flight 3407

HOT-2: gear's down.

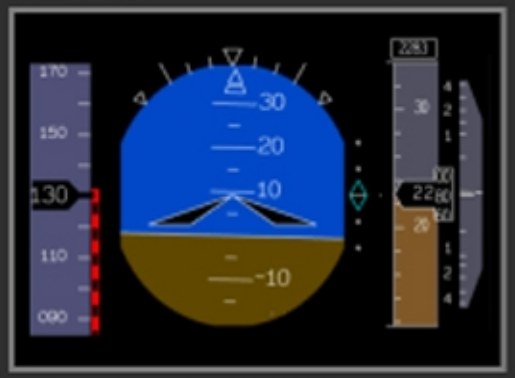
HOT-1: flaps fifteen before landing checklist.

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** °

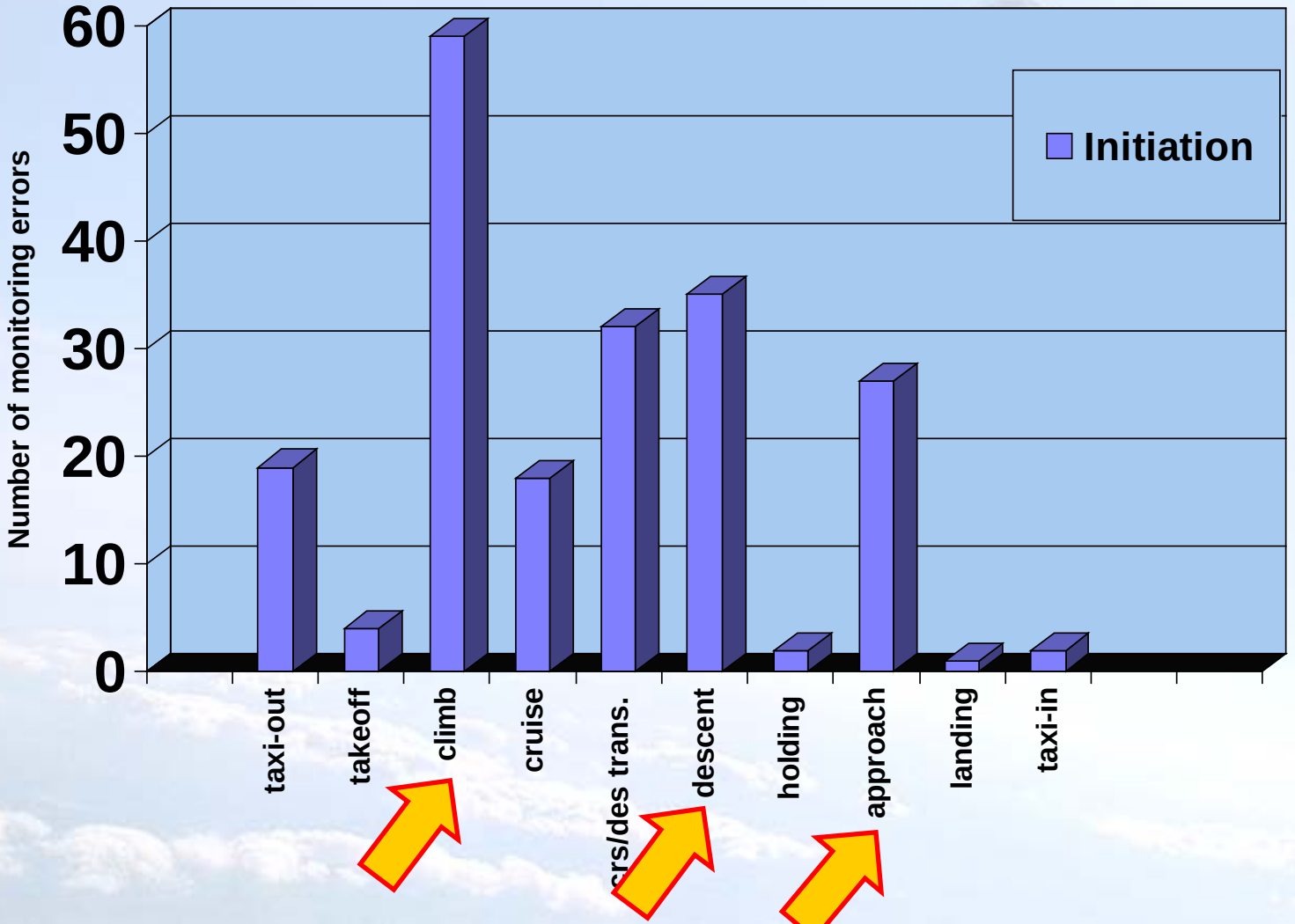
Pedal L R

Auto Pilot **OFF** Gear **DOWN**

Third discussion point:

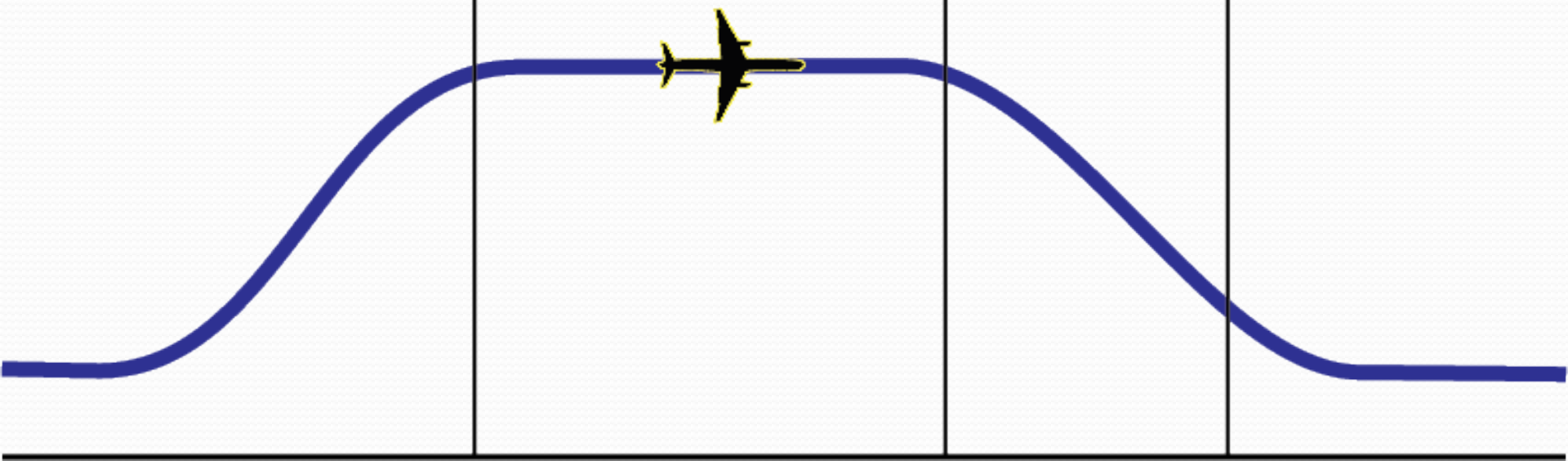
WHERE AND WHY MONITORING ERRORS OCCUR

ASRS Monitoring Study: Flight Phase where Monitoring Errors Occurred



Flight phase where Flight Path Deviation occurred

	Climb	Level	Descent	Approach
ASRS	26%	8%	46%	20%
Accidents	16%	12%	4%	68%



Crew activities when flight path deviation occurred

ASRS Reports

- Programming FMS, radio communications, traffic search, dealing with aircraft malfunction, normal checklists, chart reading/approach briefing.

Accidents

- 6 of the 25 accidents involved dealing with aircraft abnormality or malfunction.

Contributing factors

- Distractions
- Automation reliance
- Fatigue
- High workload
- Complacency
- Runway/arrival change
- Rushing/time pressure

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Who or what first detected the flight path deviation?

Deviation first detected by:	Number of ASRS Reports
ATC	49
Cockpit alerting system	22
Jumpseat rider	1
Crewmember	32

72

- Someone or something other than the operating crew first detected the flight path deviation in 72 of 104 reports.
- $\chi 2 = 15.39$, $df = 1$, $p < 0.001$.

LOSA Findings

- 20% of flights had substandard monitoring/cross-checking in at least one flight phase.
  - These flights had 2-3 times more errors and undesired aircraft states (compared to flights with outstanding monitoring)

Underlying factors associated with poor monitoring

Effective monitoring is not easy and intuitive.

- It requires skill and discipline

Underlying factors associated with poor monitoring

There is somewhat of a monitoring paradox that works against effective monitoring.

- Serious errors do not occur frequently which can lead to boredom and complacency

"A low-probability, high-criticality error is exactly the one that must be caught and corrected."

Underlying factors associated with poor monitoring

Although traditional CRM courses have generally improved the ability of crewmembers to challenge others when a situation appears unsafe or unwise…

- many of these courses provide little or no explicit guidance on how to improve monitoring.

Barriers to Effective Monitoring

- Boredom
- Complacency
- Fatigue
- Time Pressure
- Mental workload
- Lack of vigilance
- Looking without seeing
  - Inattention blindness
  - Change blindness
- Poor workload management/ task allocation

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Change Blindness

- “People are surprisingly poor at detecting even gross changes in a visual stimulus if they occur in objects that are not the focus of attention.”

  - S. Palmer, 1999, *Vision Science*.

MACH
ALT CRZ
NAV
AP1
1FD2
A/THR
300
280
260
240
220
.80
10
10
10
10
375
370
20
00
80
365
STD
4
5
6
7
8

MACH
ALT CRZ
NAV
1FD2
A/THR
300
280
260
240
220
.80
375
370
20
00
80
365
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20
20

Inattentional Blindness

Bad News / Good News

Bad News

- Humans are not naturally good at monitoring highly reliable / highly automated systems over periods of time.

Good News

- Monitoring performance can be improved significantly by using the following procedures.

FLIGHT SAFETY FOUNDATION
A Practical Guide for Improving
Flight Path Monitoring
FINAL REPORT OF THE ACTIVE PILOT MONITORING WORKING GROUP
NOVEMBER, 2014

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Fourth discussion point:

WHAT YOU CAN DO TO IMPROVE MONITORING

Improving monitoring

- SOPs to support effective monitoring
  - FAA Advisory Circular AC 120-71A
- Training
- Practice

Actively Monitor

- Pilots must “actively monitor” the aircraft.
- This means you must mentally fly the aircraft, even when the autopilot or other pilot is flying.
  - Monitor the flight instruments just as you would when hand flying.

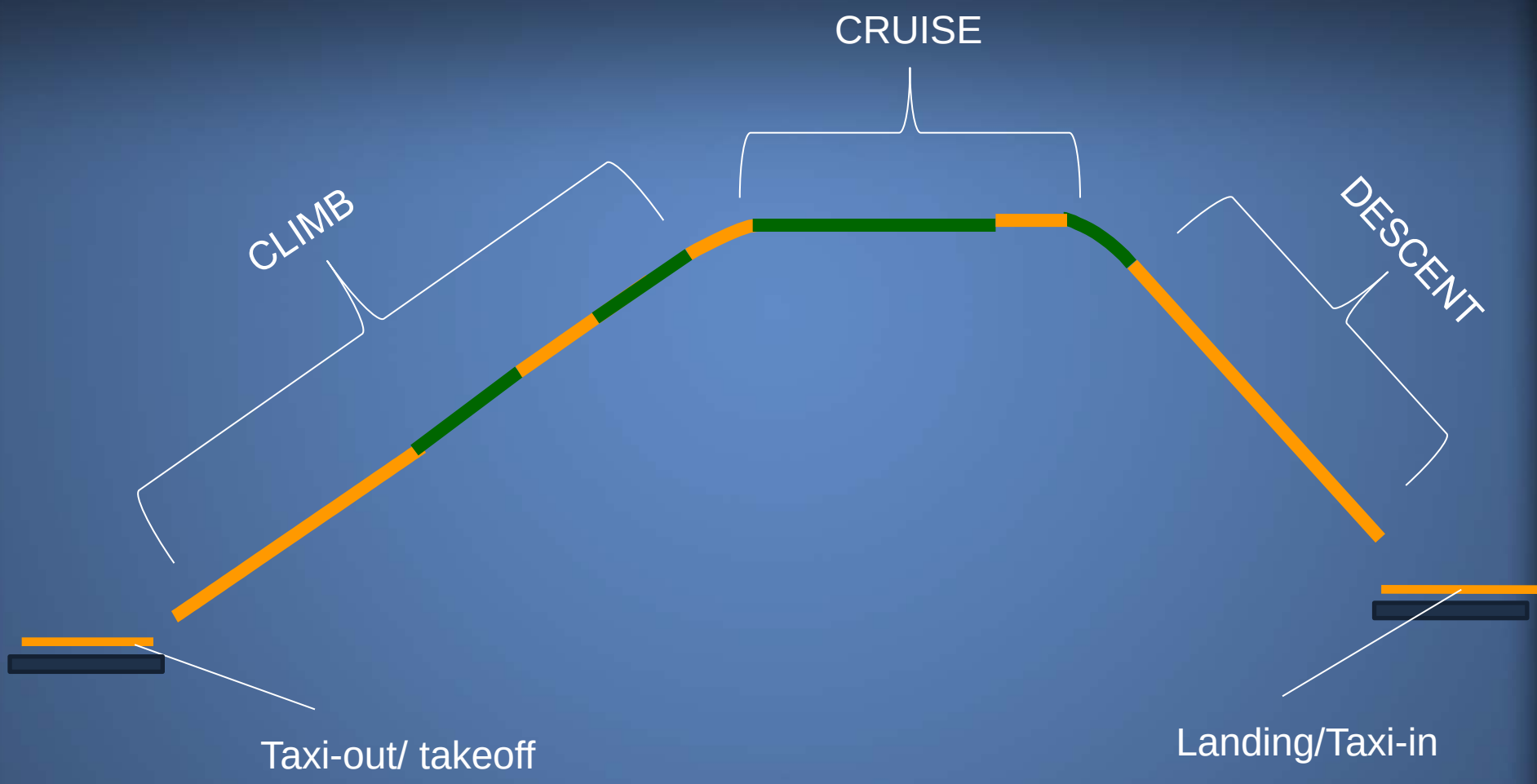
Strategically Planning Workload

- In approximately one-third of the cases studied by researchers, pilots “failed to monitor errors, often because they had planned their own workload poorly and were doing something else at a critical time.”
  - Jentsch, Martin, Bowers (1997)
- Doing the right thing at the wrong time.
- Doing the wrong things at the wrong times.

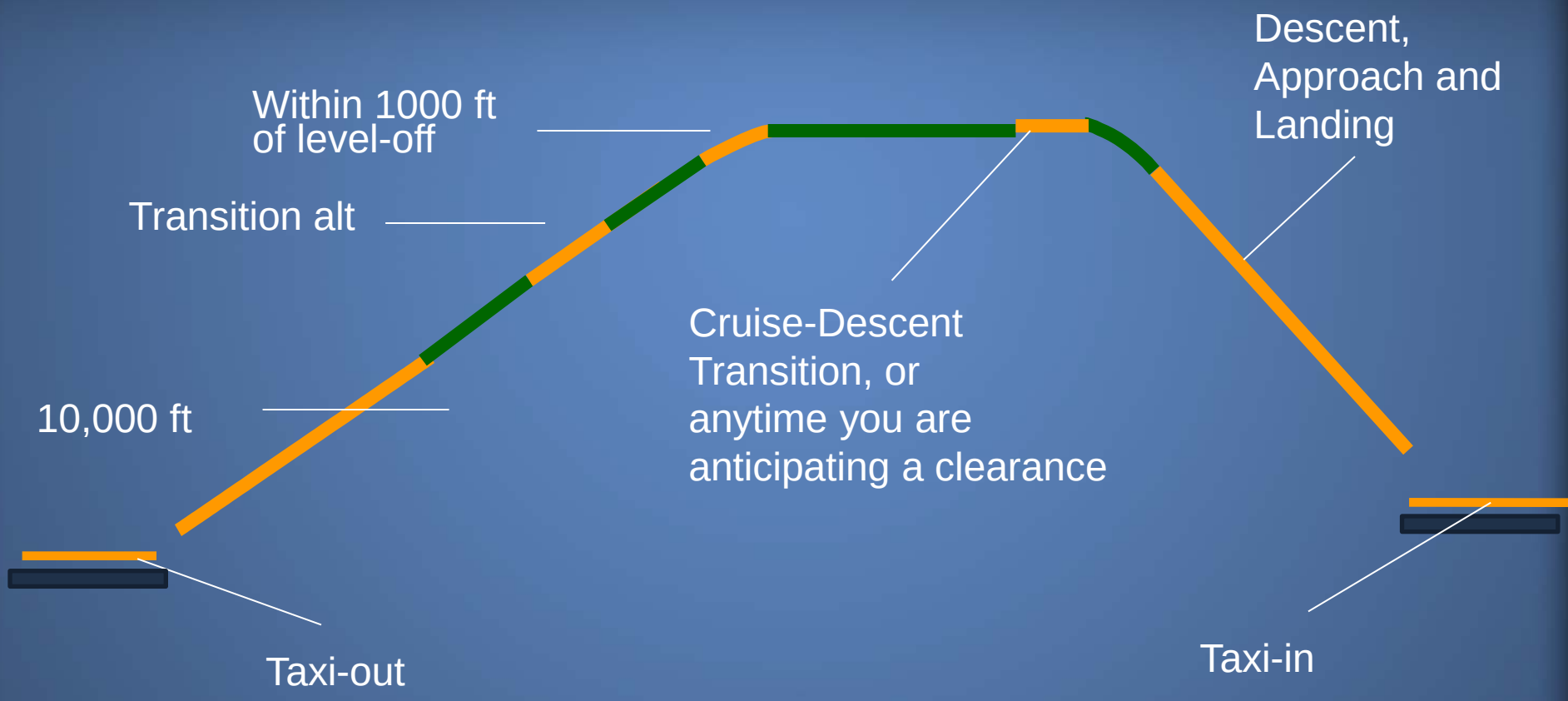
Strategically Planning Tasks

- Pilots should recognize those flight phases where poor monitoring can be most problematic.
- Strategically plan workload / tasks to maximize monitoring during those Areas of Vulnerability (AOV)
  - Examples of non-monitoring tasks that should be conducted during lower AOV include stowing charts, programming the FMS, getting ATIS, accomplishing approach briefing, PA announcements, non-essential conversation, etc.

Areas of Vulnerability



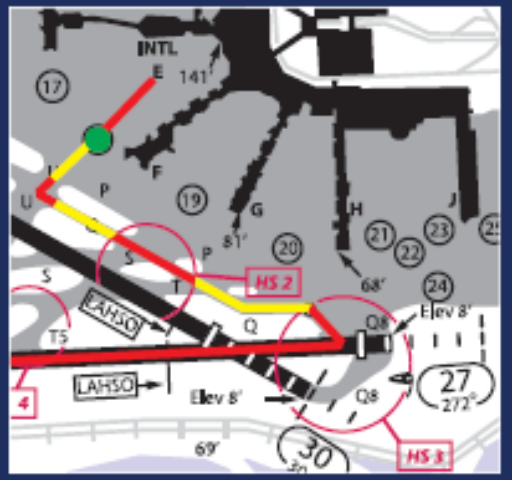
Areas of Vulnerability



Actively Monitor and Assess

American Airlines

- Actively and Methodically Monitor for threats and errors
- Actively Assess if what you are doing, or about to do, is sensible
- Reassess whenever a threat or error is discovered; intervene when necessary



THREAT	IN FLIGHT	ON GROUND	ALLOWABLE TASKS
HIGH	- All Lateral, vertical and speed changes - Climb/Descent within 1,000' of mandatory speed/altitude constraints - Flight close to the ground	- Approaching/crossing/ entering/exiting a runway, hot spot or tight space	- Both pilots manage/monitor aircraft path (high scan rate) - Essential and time critical tasks (not related to flight path) performed by PM
MEDIUM	- Climb/Descent and flight below 10,000'	- All other ground movement	- PF (and PM task permitting) manage/monitor aircraft path - Essential time critical tasks - Essential non-time critical tasks when necessary
LOW	- Straight and level at or above 10,000'	- Parking brake or chocks set	- In flight at least one pilot manage/monitor aircraft path - Essential time critical tasks - Essential non-time critical tasks - Non-essential tasks

Pilot

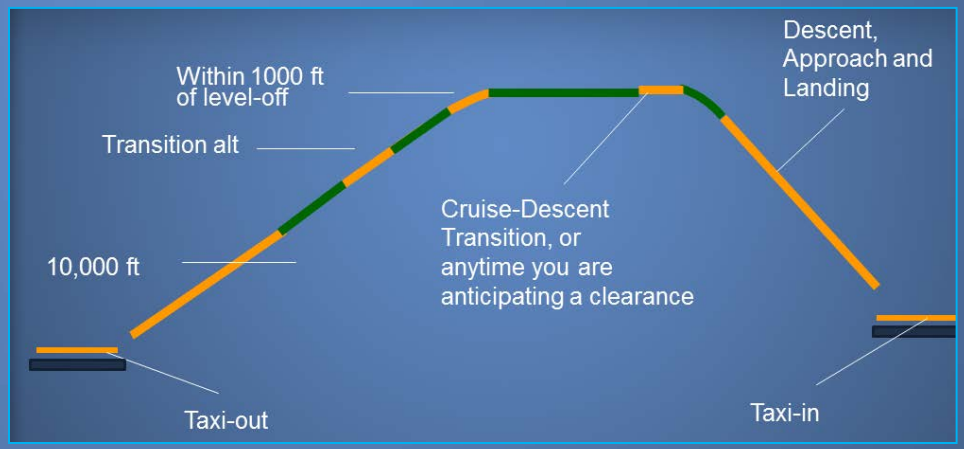
Enhancing Monitoring: Taxi

- When approaching an active runway, **both pilots** will suspend non-monitoring tasks to ensure the hold short instructions are complied with.

- Non-monitoring tasks:
  - FMS programming
  - Calling FBO
  - Checklists
  - etc.

Enhancing Monitoring: In-Flight

- Perform non-essential duties/activities during lowest workload periods (e.g., cruise altitude or level flight)



- During the last 1000 feet of altitude change, both pilots will focus on making sure the aircraft levels at the assigned altitude

Approach Briefing: Before TOD

- By briefing prior to TOD, greater attention can be devoted to monitoring during descent.
- LOSA Data: Crews who briefed after TOD averaged making 1.6 times more errors in descent/ approach/ landing phase.

Enhancing Monitoring: Automation

- During high workload, FMS inputs will be made by PM, upon the request of PF.

  High workload examples

  - below 10,000 feet
  - within 1000 feet of level off or Transition Altitude.

Findings and recommendations

- Data show that pilots are, in some cases, treating automation as “setting it and forgetting it.”
  - » Pilots should “mentally fly” the aircraft when automation (or the other pilot) is flying.
  - » This can be accomplished calling anticipated FMA changes before they occur, instead of waiting for them to occur.

How is your monitoring?

- One way of assessing your current monitoring ability is to ask: “How often do I miss making the 1,000’ to level-off altitude callout?”

  - When this callout is missed, you probably aren’t actively monitoring the aircraft.

Paradigm shift

- It must become accepted that monitoring is a “core skill,” just as it is currently accepted that a good pilot must posses good “stick and rudder” and effective communicational skills.

Summary

- Inadequate flight crew monitoring has been cited by a number of sources as a problem for aviation safety.

- While it is true that humans are not naturally good monitors, crew monitoring performance can be significantly improved.

“If I had been watching the instruments, I could have prevented the accident."

- First Officer in fatal CFIT accident

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