



National Transportation Safety Board

The Critical Link between Human Factors and Safety

Robert Sumwalt

Presentation to ISE 370

Thursday, October 15, 2020



The Board



Michael Graham



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Human factors is a multidisciplinary science that examines the relationship between humans and the systems with which they interact, including...

Ergonomics
Engineering
Psychosocial interactions
Decision-making
Fatigue
TEM
Psychology
Physiology
Human-centered design
Information processing
Biomechanics
Medicine
Study of organizational issues
National cultural influences
Anthropometrics
Resilience engineering
Automation management
Communications
CRM

Aviation Human Performance Investigators



Evan Byrne, Ph.D.



Katherine Wilson, Ph.D.



Bill Bramble, Ph.D.



Sathya Silva, Ph.D.

NTSB Medical Officers



Mary Pat McKay, MD, MPH
Chief Medical Officer

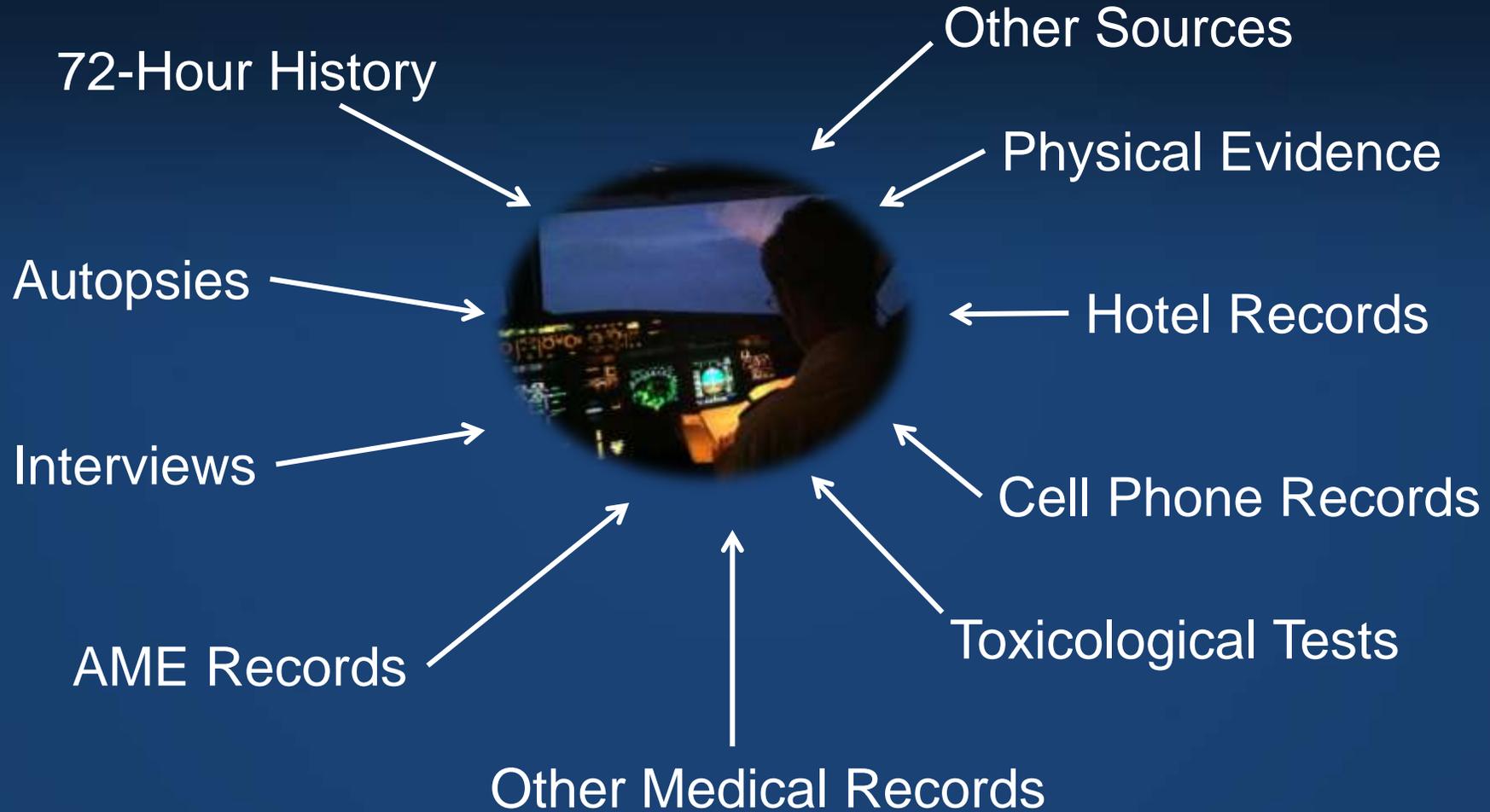


Michelle Watters, MD, PhD
Medical Officer



Turan Kayagil, MD
Medical Officer

Potential Sources of Information



NTSB Investigations Examine the Entire System



System Safety Order of Precedence*

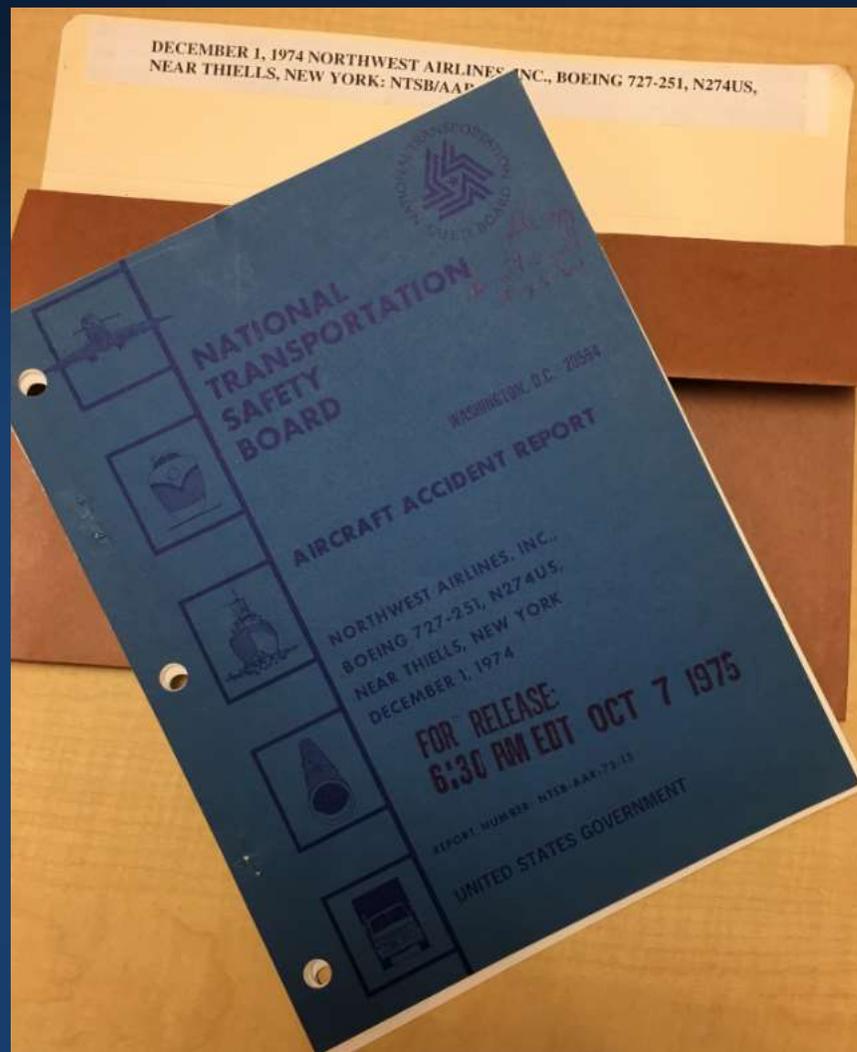
1. Eliminate the hazard through **Design/Engineering Features**
 - Hazard is corrected and eliminated
2. Incorporate **Guards/Safety Devices**
 - Guards put up to decrease exposure
3. Provide **Warning Devices**
 - Warn personnel if you can't eliminate or control the hazard
4. Develop **Procedures and Training**

*Also know as “Hierarchy of Controls.”

Source: MIL-STD-882E

ROBERT'S HF PREMISE # 1

If you design out the problem, you design out the problem. <duh>



ROBERT'S HF PREMISE # 2

If you design something with enough complexity, don't be surprised if someone can't use it when they really need it.

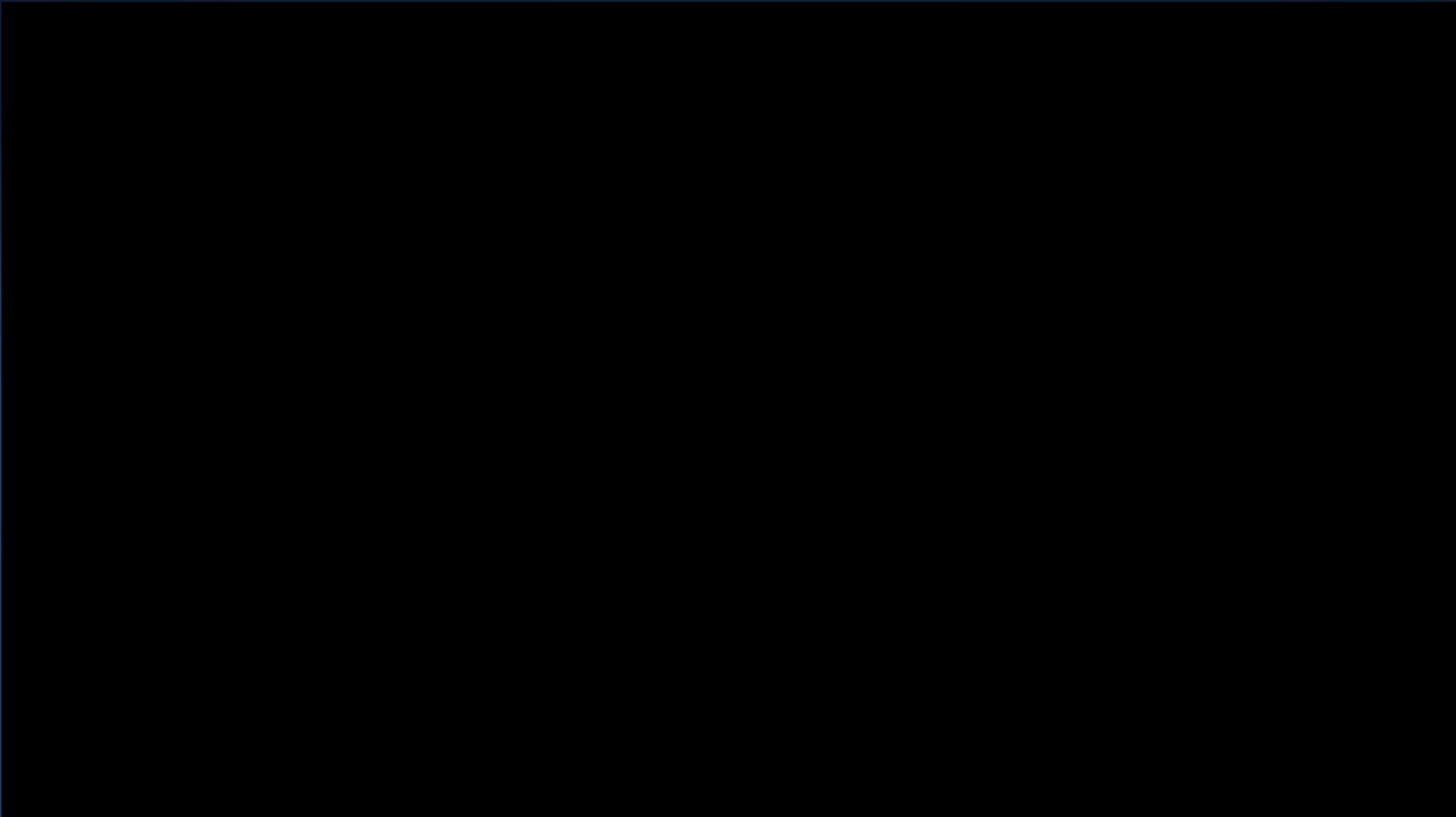
American 383, October 28, 2016



Rejected takeoff



Evacuation





ROBERT'S HF PREMISE # 3

If you don't account for human error, you, yourself, have made a very basic human error.



**National
Transportation
Safety Board**

Loss of Control at Takeoff

Frisco, Colorado
July 3, 2015
CEN15MA290

NTSB Finding

- “The design of Airbus Helicopters dual-hydraulic AS350-series helicopters did not account for the possibility of pilot error in configuring the tail rotor hydraulic circuit ...”

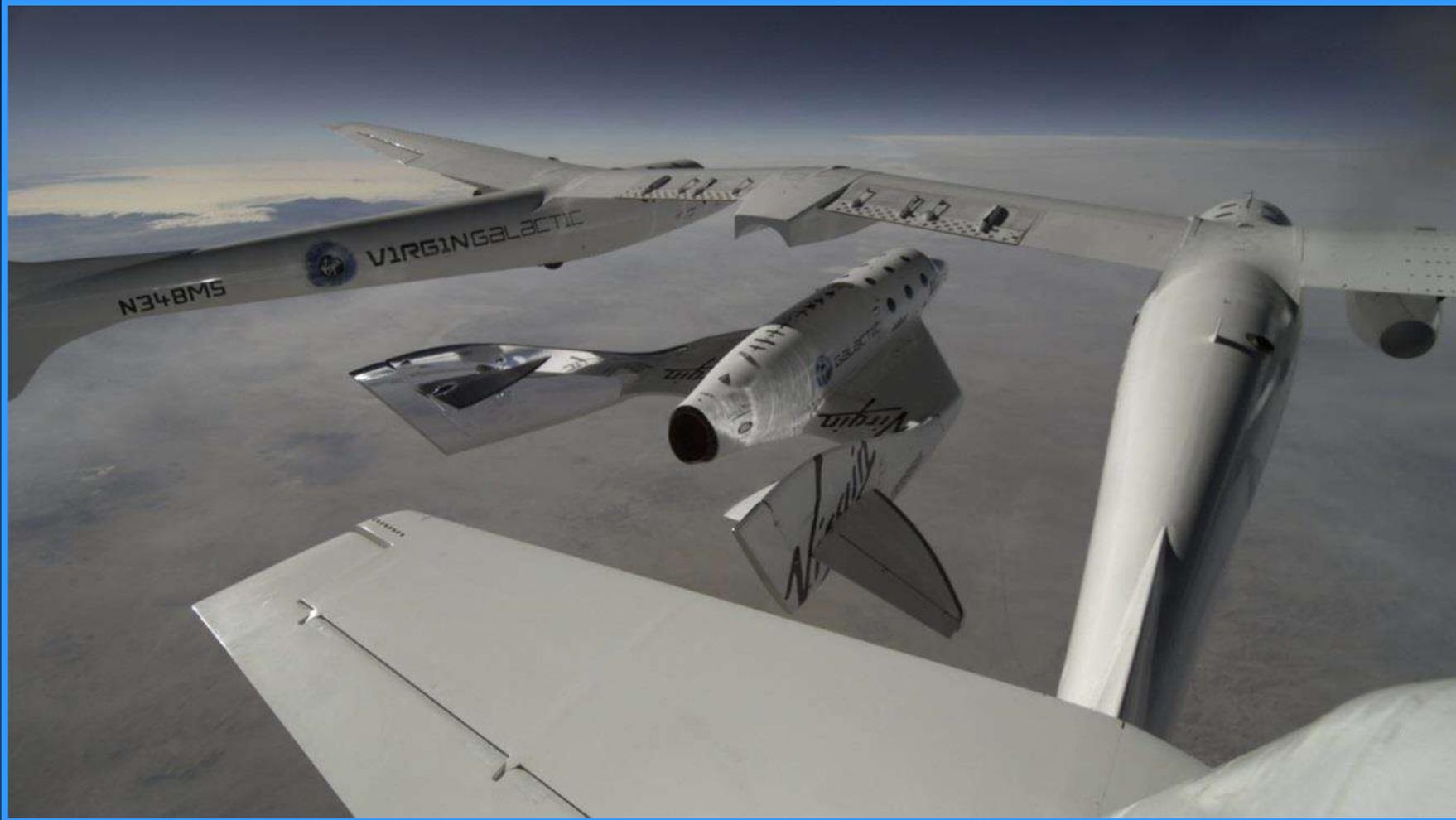
In-Flight Breakup During Test Flight

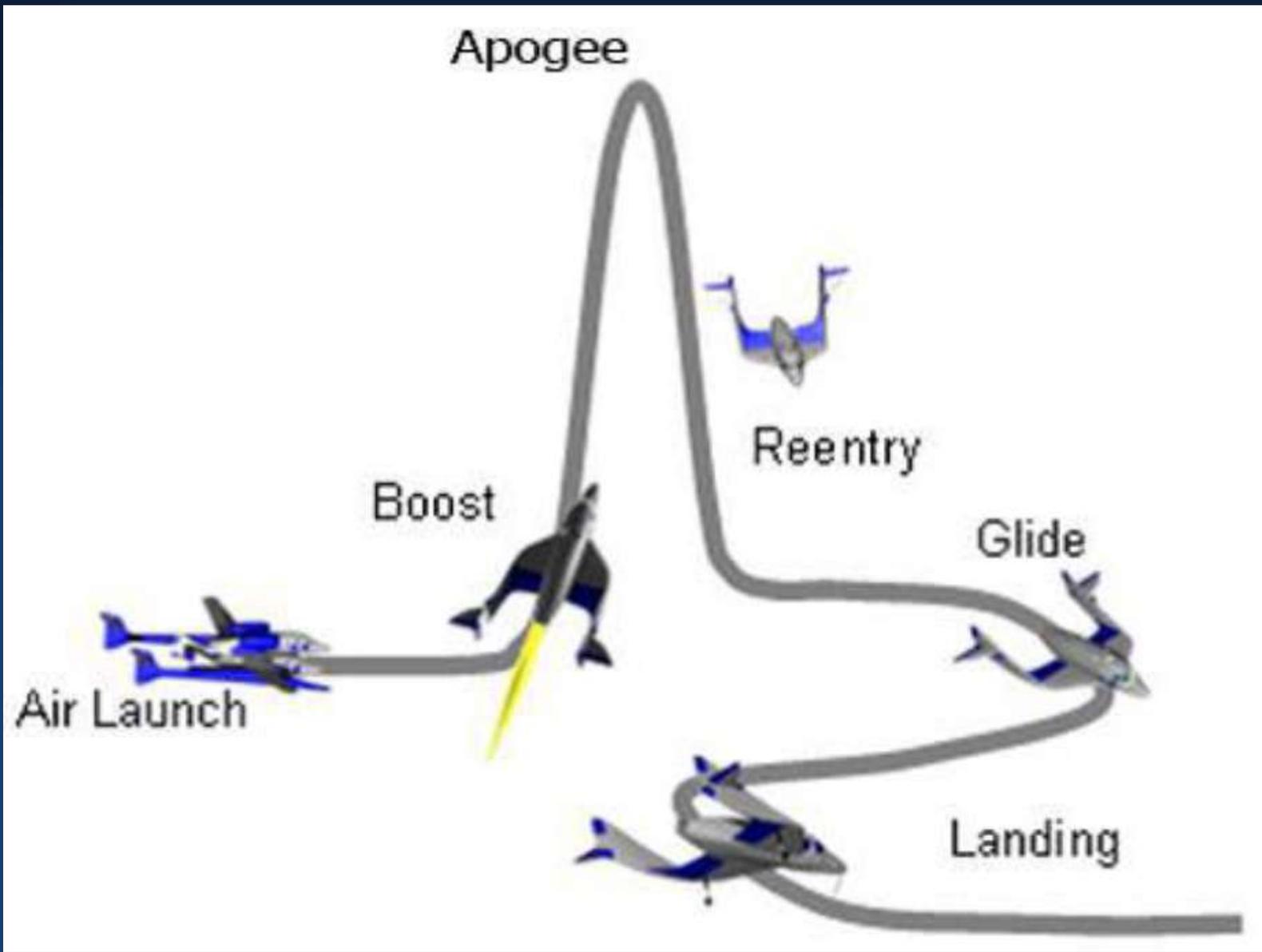
October 31, 2014

SpaceShipTwo

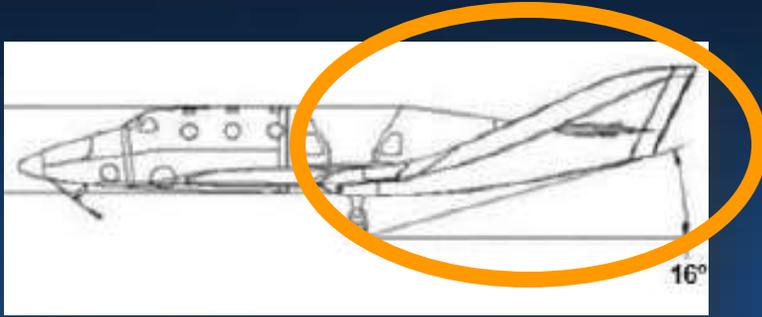




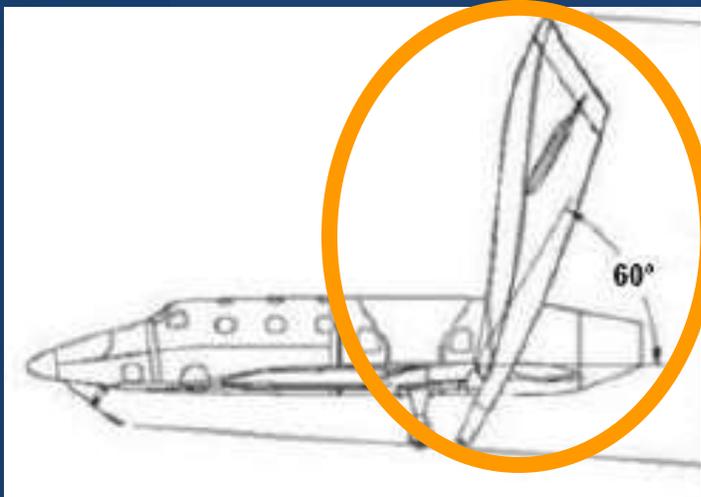




SpaceShipTwo Feather System



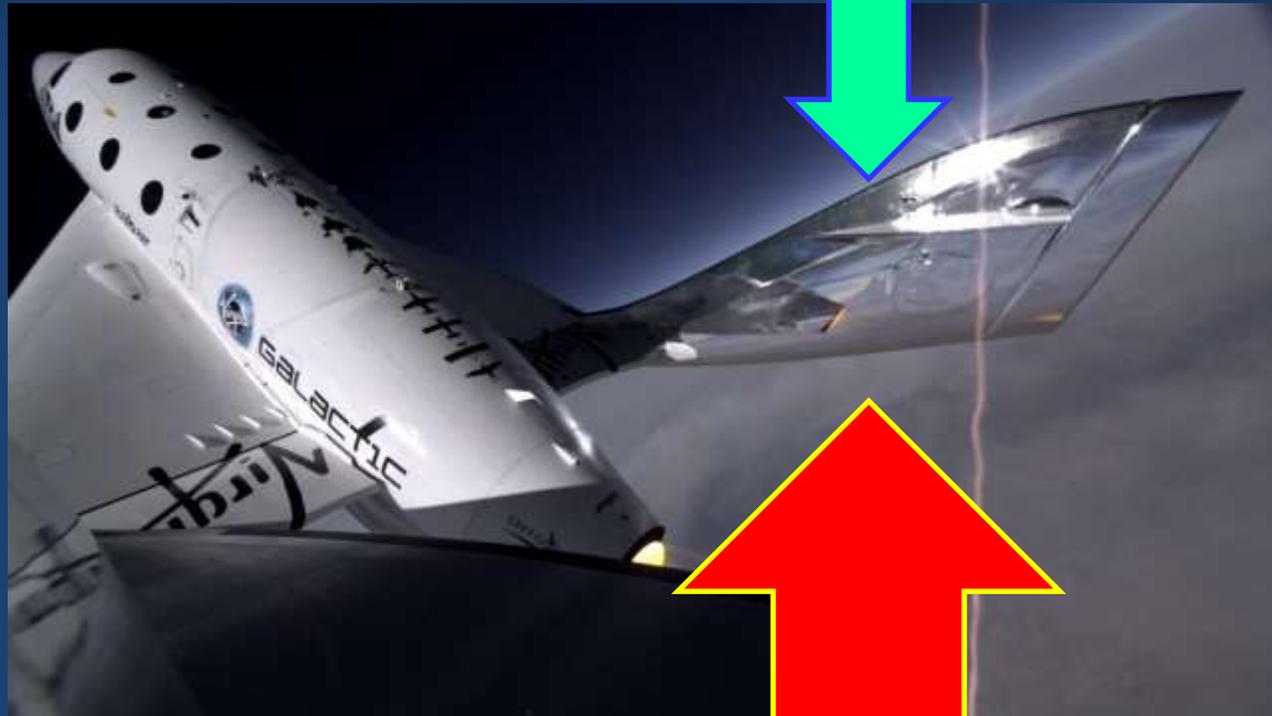
Feather retracted



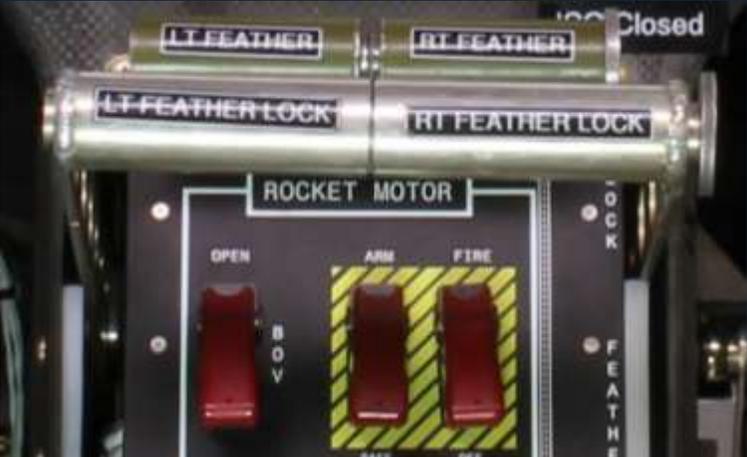
Feather extended

PROBLEM: During the transonic region, the upward aerodynamic forces acting on the feather exceeded the ability of the feather actuators to keep the feather retracted.

SOLUTION:
Provide mechanical locks to keep feather retracted during this region.



Feather Lock Handle



Feather Locked

Lock



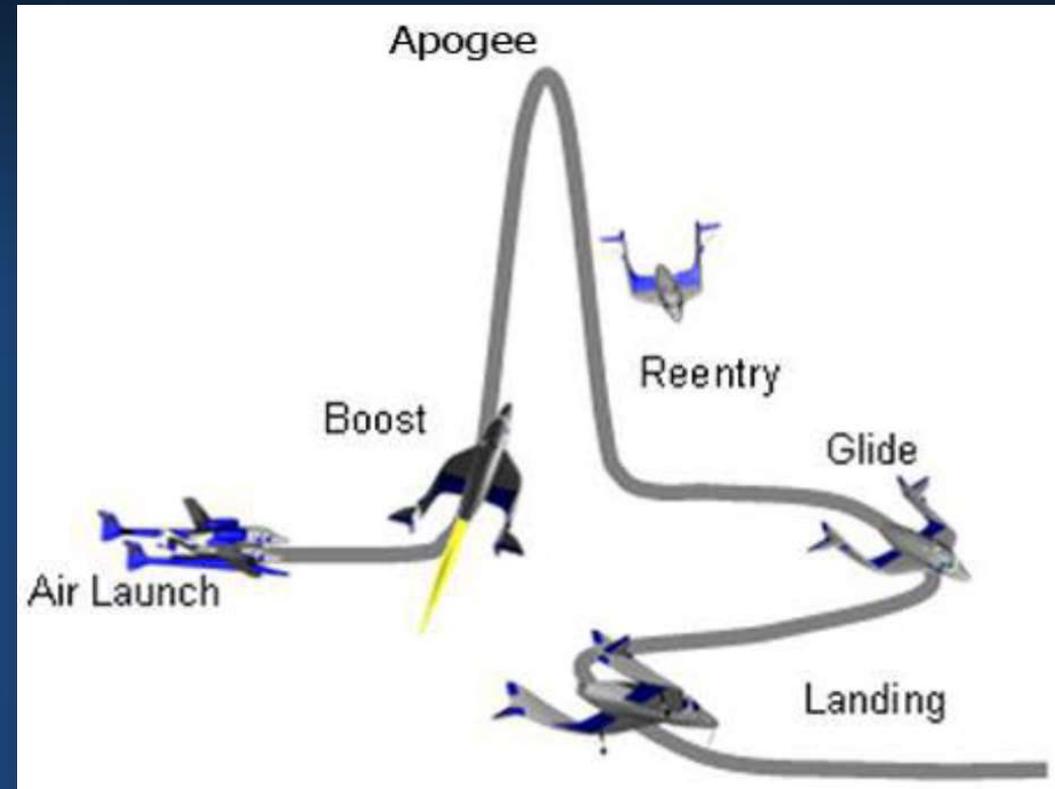
Unlock



Feather Unlocked

PROBLEM: If feather could not be unlocked, it would pose a very high risk (probably catastrophic) reentry.

SOLUTION: Unlock feather at 1.4 Mach.

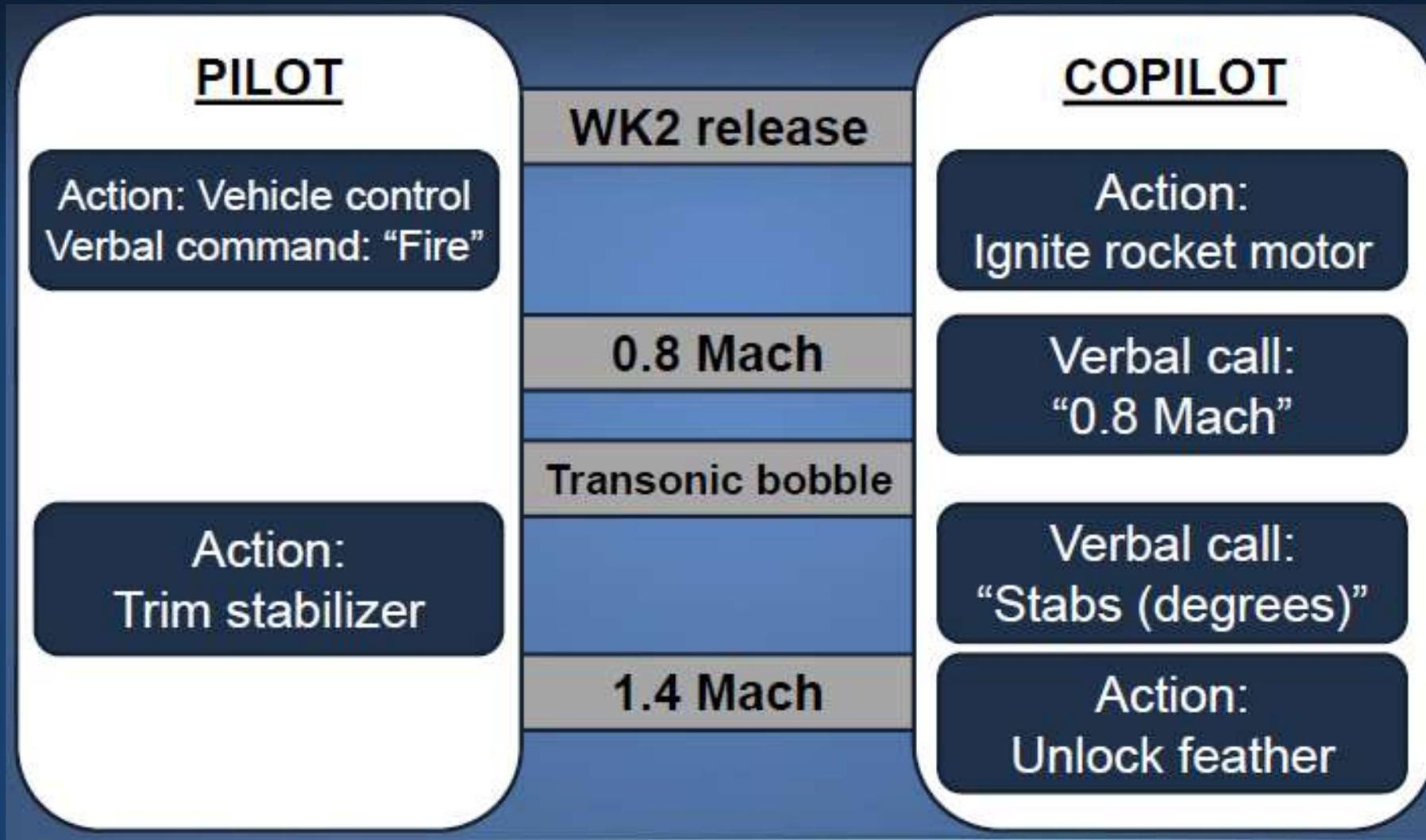


If not unlocked at 1.5 Mach, cockpit alert.
If not unlocked at 1.8 Mach, mission abort.

The investigation found

- High emphasis on making sure feather was unlocked at 1.4 Mach.
 - Cockpit visual and aural alerting
 - Training and procedures
 - Mission abort if not unlocked by 1.8 Mach
- Not great concern placed on low speed unlocking.
 - Relied on pilots to do it right

Specified Flight Crew Procedures



What actually occurred

- Copilot made 0.8 Mach callout
- At 0.82 Mach, called out “unlocking” and moved feather handle to unlocked position
- Video and telemetry stopped





Ground-based camera



WhiteKnightTwo camera



SpaceShipTwo camera

DCA15MA019
SCALED COMPOSITES
SPACESHIPTWO
N339SS
POWERED FLIGHT #4



- A single-point mechanical failure with catastrophic consequences would be unacceptable.
- However, Scaled Composites failed to consider that a single human error could be catastrophic.

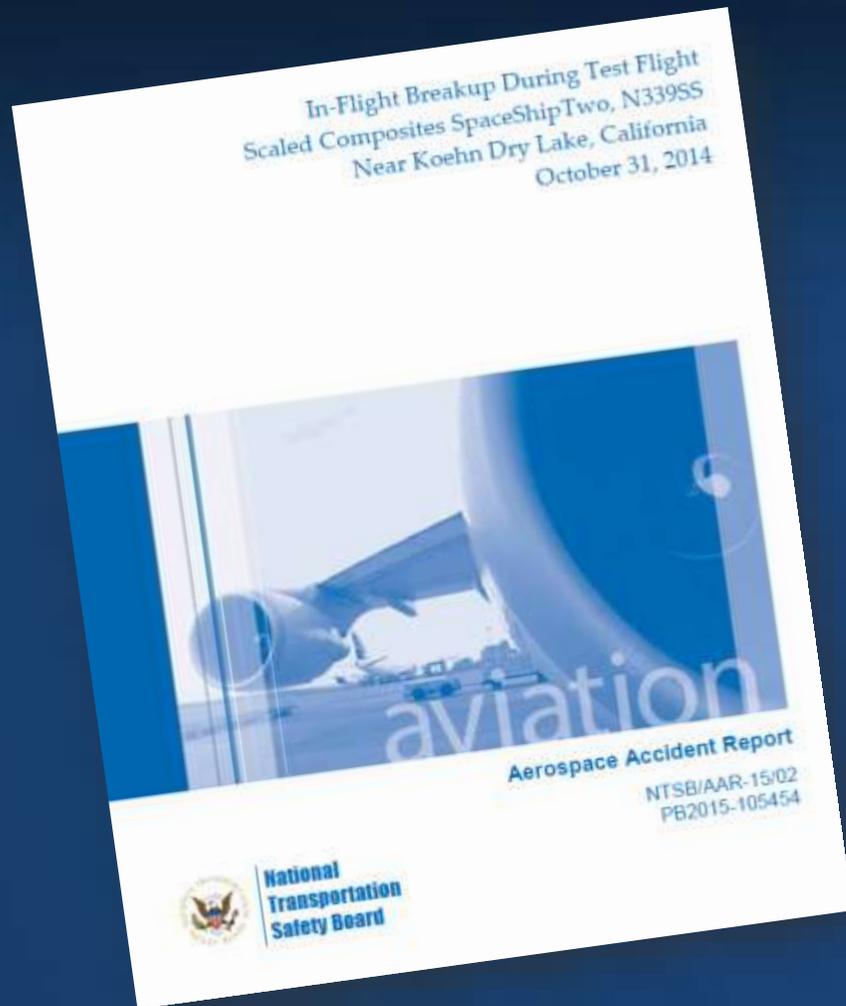
NTSB Finding

“By not considering human error as a potential cause of uncommanded feather extension on the SpaceShipTwo vehicle, Scaled Composites missed opportunities to identify the design and/or operational requirements that could have mitigated the consequences of human error during a high workload phase of flight.”

Probable Cause of the Accident

- “Scaled Composites’ failure to consider and protect against the possibility that a single human error could result in a catastrophic hazard to the SpaceShipTwo vehicle.
- This failure set the stage for the copilot’s premature unlocking of the feather system as a result of time pressure and vibration and loads that he had not recently experienced, which led to uncommanded feather extension and the subsequent aerodynamic overload and in-flight breakup of the vehicle.”

NTSB Recommendation



Develop and issue human factors guidance for use during the design and operation of crewed vehicles.

