



Ground Effect

Gulfstream G650 Test Flight Crash

Senior Management ViTS Meeting

April 4, 2016

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What Happened and Why

April 2, 2011, 9:34 a.m. MDT, Roswell International Air Center, Roswell, NM — An experimental Gulfstream G650 was preparing to takeoff on a planned one-engine-inoperative (idle), heavy take-off weight test flight. Scheduling had been aggressive in order for Gulfstream to obtain Federal Aviation Administration (FAA) type certification for the G650 by the third fiscal quarter of 2011.

- The G650 was not meeting a design requirement (achieve minimum safe takeoff speed with one engine inoperative using 6,000 feet of runway \pm 8%).
- The right wing had stalled on takeoff tests one and five months prior to the mishap. The team opted to develop a takeoff technique for the pilot to use to meet the requirement without investigating stall causes.
- April 2, 2011, 9:34 a.m.: On takeoff, mishap pilot abruptly raised the G650 nose 11.2 degrees (past the target pitch angle of 9 degrees) using the developed technique.
- The right wing stalled; the aircraft rolled right, striking the ground and catching fire. All four crewmembers survived the initial impact, but died in the post-crash fire.
- National Transportation Safety Board post-crash findings: The Gulfstream program
 - Used a flawed assumption for maximum lift coefficient in ground effect, calculating a minimum safe takeoff speed too low to be achievable;
 - Overestimated aircraft stall angle of attack, setting the aircraft stall warning system too high to warn the crew of stall;
 - Failed to fully investigate two precursor stall events during testing;
 - Focused on adapting pilot technique to achieve desired takeoff performance rather than investigate the underlying cause for performance failure;
 - Failed to establish adequate flight test operating procedures, adjust test schedule to account for program delays, and develop an effective flight test safety management program.

What Happened and Why (Cont'd):

- Contributing to the accident was Gulfstream's failure to effectively manage the G650 flight test program by pursuing an aggressive program schedule without:
 - Ensuring that the roles and responsibilities of team members had been appropriately defined and implemented;
 - Ensuring that engineering processes had received sufficient technical planning and oversight;
 - Ensuring that potential hazards had been fully identified;
 - Ensuring that appropriate risk controls had been implemented and were functioning as intended.

Relevance to NASA and Lessons Learned

- Even highly experienced crews can have a flight test accident.
- Trying “too hard” to achieve a test point or a milestone should raise a red flag. When should we stop trying?
- All stakeholders should understand the system under test.
- Listen to the hardware and think about why you’re having trouble.
- Think about changes in paradigms with changes in designs.
 - The hardware may look alike, but transference of learning may be inaccurate
- Know the limitations of your assumptions and engineering data. How many have to be wrong before your margin is gone?
- Schedule pressure is a reality. Don’t get caught up in the “train to success.”
- Seek the experts if the answers don’t make sense.

Relevance to NASA & Lessons Learned (Cont'd):

- Stay hungry. Years of safety vigilance guarantees nothing today.
- Investigate anomalous test events as far as evidence allows.
 - Beware of developing workaround techniques instead of understanding the environment and design.
- Rigorously and carefully evaluate the effects of removing or changing a safety barrier or control from the design.
 - Flight control limits to G650 takeoff pitch attitude were removed.



Closing Comments

- Have you ever been in an accident or incident lessons learned presentation and at the conclusion resolved to yourself that “you’ve got the issue covered” or “your organization wouldn’t let that happen?”
- It is easy to focus on the specific mechanics of an event...however it’s much more difficult to understand the realities that lead to a particular point in time.
- It is even more difficult to identify our own similarities or vulnerability... especially in the heat of the moment.
- In our business—good isn’t perfect—and perfect is the only guarantee it won’t happen to us.

