Almost Perfect: X-31 Mishap

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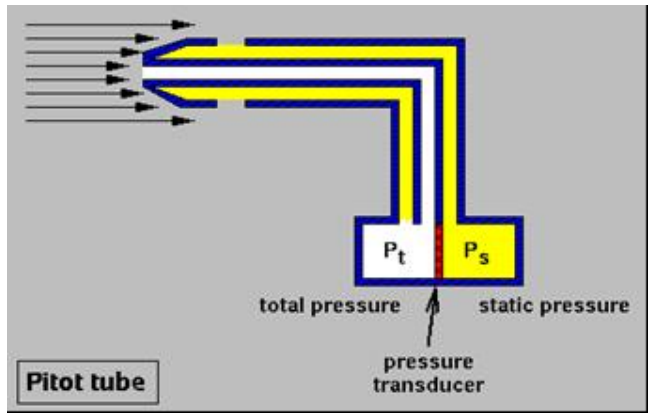
The Accident

- On January 19, 1995, during a routine flight test, the X-31's flight control computers (FCC) began registering errors in flight data about 20 minutes after take-off.
- Unbeknownst to the pilot and control room, ice was accumulating and blocking air flow around the 'Pitot tube,' (a device used for measuring air speed).
- Later in the flight, the pilot noticed further errors in airspeed indication, prompting him to notify the control room and turn on the Pitot heat.
- The control room notified the pilot that the Pitot heat might not be hooked up.
- After receiving this message, the aircraft began to oscillate out of control and then violently pitched upward.
- The pilot ejected before the aircraft departed into a spin and impacted the ground.

Airspeed Indication

- Air speed for the X-31 (and most conventional aircraft) is calculated based on inputs from a device called a Pitot tube.
- Pitot tubes are susceptible to accumulation of ice which causes them to malfunction.
- Accurate airspeed measurements were especially critical to the X-31's FCCs which were responsible for vectoring thrust to keep the aircraft stable and on course.
- In the original X-31 design, the Pitot tube was mounted on a "Rosemount probe" which had a heater to prevent Pitot tube icing.
- To improve performance, the Rosemount probe was replaced with a Keil probe which did not have a heater.



National Aeronautics and Space Administration

Proximate Causes in Event Chain

- Pitot tube icing caused incorrect total air pressure data to be sent to the FCCs by the Pitot-static system.

Causal Web – Underlying Issues

- Misinterpretation of the risk of iced Pitot probe in hazard analysis
  - The risk was identified in the hazard analysis, but because of the low likelihood of occurrence, not all failure modes were addressed.
- Failed configuration management
  - When the Kiel probe was installed, it was not equipped with Pitot heat as the Rosemount probe had been. Yet, only a limited number of flight personnel were aware of this change.
- Inadequate operational controls
  - Pitot icing risk was not included in pre-flight brief to pilot because the hazard analysis didn't label it a "critical hazard."
  - Reversionary flight mode was not put into effect because the flight team had not tested/trained with it properly.
  - Lack of communication between the X-31 and chase plane because of faulty "hot mike" technology.

Lessons Learned for NASA

- Conduct rigorous hazard analyses and carefully interpret the results.
- Consider both the likelihood and consequence of risk – even a very unlikely event could jeopardize mission success and crew safety.
- Aggressively test critical hardware/software systems in nominal and off-nominal operational regimes to flush out latent design defects and test assumptions.
- Ensure effective communication and rigorous configuration management, even with operationally mature programs and projects.