Pushing the Envelope of Flight Test Safety

Technical, Physical and System Issues Behind AC-130J Flight Test Mishap

May 2018
Summary

- **Date:** April 21, 2015
- **Company:** U.S. Air Force
- **Details:** An AC-130J, assigned to the 413th Flight Test Squadron at Eglin Air Force Base in Florida, departed controlled flight over water about 41 nautical miles south of the Air Force base. Under the AXZD0023 Job Order Number (23 JON), the mishap copilot was able to recover the plane and land it safely.
- **Results:** While the crew and personnel were uninjured, the aircraft exceeded the design limit load and was severely damaged. Cost of damages totaled $115,600,000, including the total loss of the aircraft.

Key Conclusions

- The AIB report revealed the following underlying issues: technical difficulty of the flight, instrumentation/warning system issues, inadequate procedural guidance and communication problems.
- The mishap pilot experienced spatial disorientation and confusion during the flight.
Background

• **AC-130J**
  – Highly modified MC-130J aircraft
  – Advanced features make it the most modern gunship in the Air Force inventory

• **Air Force Test Chain of Command**
  – Air Force Test Center oversees developmental test and evaluation using two test wings: the 95th Test Wing and the 96th Test Wing
  – 96th Test Wing supports multiple units, including the 413th Flight Test Squadron, which plans, executes and manages test and evaluation of special operations (among other activities)

• **17 JON Flight Test, a Precursor to the Mishap**
  – Departure from controlled flight during stall testing
  – Some test team members questioned if the new and slightly different aerodynamic shape of the AC-130J had degraded its handling qualities over the C-130J

• **Lack of Predictive Flight Data**
  – Although the test team members knew they were skirting the edge of known flight test knowledge, they were denied access to that information
  – Air Force had not purchased developmental engineering and test data rights from Lockheed Martin — specifically a 2013 report that contained predictive data
  – Test team installed new special instrumentation, which allowed it to view rudder forces but without predictive data
Background

• **23 JON Mission Planning**
  - Extensive planning included a well-documented test and safety process
  - Test program unaccountably took the aircraft “to the edges of the aircraft envelope in sideslip 183 times” before the mishap event occurred
  - Mishap pilot was expected to maneuver the aircraft in a buildup fashion to reach the SIDESLIP Special Alert (first alert) and the RUDDER Special Alert (second alert)

• **Waiver**
  - Air Force Materiel Command/A3 signed a waiver to give “approval to intentionally maneuver the AC-130J into a sideslip resulting in a LEFT/RIGHT RUDDER alert during regression testing,” even though this would exceed the flight manual limit for the aircraft
  - Participating aircrews were directed to review the High Sideslip Recovery Procedures (C-130J-1) and Fin Stall Recovery (C-130H-1) before flight when intentional rudder alert test points were to be flown
  - High Sideslip Recovery Procedures stated: “If either RUDDER Special Alert occurs, immediately apply the indicated rudder to center the sideslip display on the HUD [heads up display]”
  - Waiver was signed in February 2014 as part of the 17 JON flight test program and before the safety planning and first departure of the 23 JON flight test program

• **Approvals/Authority**
  - 96th Operations Group Commander reviewed and approved technical and safety considerations during the Test Approval Brief (Aug. 6, 2014)
  - While the Safety Annex was updated with Amendment 1 on Sept. 18, 2014, it “did not make any changes regarding the High Sideslip Recovery or the Fin Stall warning even though the first departure was a departure in sideslip”
  - 413th Flight Test Squadron technical director removed himself from reviewing test cards (Feb. 12, 2015)
  - Technical director rescinded his signature authority on all test planning and execution documents associated with AC-130J development test (March 5, 2015)
What Happened

The following events occurred on April 21, 2015:

**10:46 a.m.** — After takeoff, the mishap pilot completed a series of flying qualities test points at 15,000 feet.

**12:10 p.m.** — The crew began performing SHSSs with flaps at 100 percent, gear down and 140 knots. The mishap pilot reached SHSSs to the right but did not stabilize at the RUDDER alert. He applied as much as 278 pounds of rudder pedal force, indicating that his foot was at the end of the rudder pedal travel. The test point to the right was terminated. He proceeded to conduct SHSSs to the left at 12:16 p.m.

**12:16 p.m.** — While completing SHSSs to the left, the mishap pilot stabilized the SIDESLIP Special Alert (first alert) for nearly 10 seconds, applying 125 pounds of force to the rudder pedal.

**12:18 p.m.** — The mishap test conductor started to clear the mishap pilot to proceed to the second special alert.

- **Within 2 seconds** of increasing force, the mishap pilot reached 180 pounds of rudder pedal force. Less than 1 second later, the RUDDER Special Alert came on immediately after the mishap test conductor said “continue nose left, second alert” at 14.5 degrees AoS and 204 pounds of force.
- **About 1.5 seconds later** — The rudder peaked at 229 pounds of force, which was already greater than 17 degrees AoS.
- **About 4 seconds after** the RUDDER Special Alert went off, the mishap pilot modulated the rudder back down to 160 pounds of force. At this point, the AoS was already greater than 21 degrees (criteria for test termination) and getting worse. The mishap pilot started to completely release all rudder pedal force right before the mishap test conductor called “recover.” The rudder was locked in a fully deflected condition with no pilot rudder pedal force being applied.

What Went Wrong:
- Technical Difficulty
- Instrumentation and Warning System Issues
- Spatial Disorientation
- Confusion
- Inadequate Procedural Guidance
- Communication Problems
What Happened

- The copilot issued the following directive callouts: “Nose down,” “Power out,” and “Let go, let go.”
- The aircraft eventually inverted and recorded over 56 degrees of sideslip. (Instrumentation may be unreliable due to the extreme conditions.)
- The aircraft violently dropped its nose, rolled and inverted.
- The mishap pilot never applied the corrective rudder. According to the AIB report, “the rudder pedal position did not approach neutral or an ‘unlocked’ state until 12:18:55L.” The mishap pilot was distracted when an object from the cockpit hit him in the head.

Recovery events (undetermined time) —

- The copilot began the recovery from the dive. He pulled the aircraft out of the dive, retracted the flaps and recovered with less than 10,000 feet of altitude.
- The aircraft was overstressed and reached 3.194 Gs. The flaps were oversped by more than 100 knots.
- The smoke alarm in the cargo compartment was triggered by powder from a fire extinguisher that broke apart by the violent movement of the aircraft.
Proximate Cause

• Mishap pilot’s incorrect response to flight test conditions:
  – Excessive rudder input during the test point
  – Inadequate rudder input to initiate a timely recovery from a high sideslip angle due to overcontrolled/undercontrolled aircraft and wrong choice of action during an operation

Underlying Issues

• Technical difficulty of the task
• Instrumentation and warning system issues
• Spatial disorientation and confusion
• Inadequate procedural guidance or publications
• Communication problems
Applying Lessons Learned to Current and Future NASA Missions

• NASA is now involved in planning, research and test operations.
• In conjunction with International Space Station crew and cargo launches and recoveries, the following NASA projects are proceeding on a weekly basis:
  – X-plane projects at NASA Armstrong Flight Research Center
  – Space Launch System/Orion systems tests and qualification assessments at multiple NASA centers
  – Government insight into commercial launch service providers (instead of more direct oversight)

• Flight-related projects and their associated test operations involve high-risk exposure to thermal, pressure and sonic environments, making the planning for worst-case situations vital.
• Proper planning for test flights will help safeguard crews and vehicles during test operations.

What Went Wrong:
5/18/2018
Precautions for test planning include the following:

– When working with companies holding proprietary test data, the effort to understand and even purchase data rights may be critical to successful testing and troubleshooting.

– When members of the test team express reservations regarding the necessity of taking identified risks, do not just retreat from the test, but try to analyze the potential benefit(s) versus the potential cost. This will help separate needless risks from needful risks.

– Organizational leaders should create an environment where every member of the test team not only feels empowered to express concerns but also sees that a technical concern is technically addressed.

– Waivers and deviations are not recognized by the laws of nature.
Questions for Discussion

• How do you determine the acceptable amount of risk to take during a test?
• How important is obtaining predictive data prior to the testing phase?
• Within your project, are there multiple levels of review and approval required prior to moving forward with test procedures?
• If instrumentation and warning systems seem lacking, is there a process in place to report and modify these systems?