

Technical Report: LADEE Mission Analysis

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The Lunar and Dust Environment Explorer mission was created to study the lunar atmosphere and conditions of the moon involving the surface and dust (Page 1, Paragraph 1). However, a catastrophe that involved sine burst testing, short and high-intensity pulses to measure the strength and durability of a structure, within this mission would eventually lead to task forces to analyze this error and publish case studies. Involving the events that occurred with this LADEE incident, it is crucial to develop a strong risk management plan to prevent such mishaps, involving key elements. It is also important to understand responsibilities by clearly defining roles to make sure every member knows what they are doing. Every pre-flight test also carries potential risks to equipment and personnel. Therefore, this report will highlight the lessons learned from the LADEE incident and incorporate better measures by analyzing the failure in risk management, lack of clear roles, and different risks that come with pre-flight testing.

On May 3, 2012, the incident that occurred involved a vibration test in which an anomalous sine burst test due to mismanagement led to great damage to the spacecraft (Page 2, Paragraph 3). The root cause of this incident was due to very high pre-existing frictional force that came from bearings that were misaligned and seized. This caused the control system to use a very high, unnecessary amount of voltage and work unnaturally (Page 3, Paragraph 3). Risk management is very significant for space missions because it makes sure that any potential risks or hazards are located and addressed before any testing can start. In terms of elements for a risk management plan, a strong one should have some form of identifying hazards and assessing them, a plan of action to address given risks, and periodic reviews of the plan during implementation. An important thing to note about the LADEE incident is how the team failed to integrate risk tracking into their process as they lacked formal contractor surveillance and

cross-referencing risks in the NASA database (Page 3, Paragraph 5). Through the mentioned components of proper risk management, this failure could have been stopped by conducting harsher inspections and ensuring test equipment functionality before testing.

Another important issue that was present in the LADEE event was there being no clear, established guidelines for team responsibilities, lacking clarity. Through the NASA mishap investigation, it was revealed that before the test, there were no personal responsibilities that individuals could understand to accomplish the parts they were supposed to be involved with (Page 3, Paragraph 5). Furthermore, as a direct example, it is recorded that the NASA test director and the contractor test engineer did not fully understand the requirements of the control system. This would go on to cause a poor calibration phase that contributed to the slippable failure (Page 2, Paragraph 5). In order to avoid this, there could have been various measures taken like training sessions for all the involved individuals for the sine burst testing component and holding a personnel meeting to directly address each individual's role before testing. Educating those involved on general test protocols and maybe even having personnel look at past case studies of successful, dynamic testing could have helped lessen and prevent this issue. To highlight this need for education, the contractor responsible for the vibration testing had little experience with sine burst testing, given only a few hours of training on the control software before the test (Page 3, Paragraph 4). Additionally, the test director made a late decision to override the control system's default -12dB start pulse value, which further worsened the issue (Page 2, Paragraph 5). These instances clearly show a lack of planning and coordination that could have been prevented with measures like training, meetings, surveillance, and education.

When conducting pre-flight tests, the personnel must be aware of many risks including, from most to least in terms of likelihood, equipment damage from mechanical failure as very

likely, calibration errors through excessive force which is possible, possible injury to personnel which is also possible, and errors in data interpretation that is unlikely. In the LADEE Mishap, equipment failure occurred when the slidable's misaligned and seized bearings caused excessive stress and damaged the propulsion structure of the aircraft (Page 3, Paragraph 3). This has a high chance of occurring, especially with new personnel in place or when testing new technology. Calibration errors happened when the test began without its low-power pulses and this led to a very high force being applied, which is possible in the early stages of testing for any system (Page 2, Paragraph 5). The case study also mentioned the slidable doing sudden and violent movements, which posed a threat of injuring nearby personnel as it made a loud bang and did not return back to its normal position, correlating strongly with equipment damage (Page 2, Paragraph 5). Lastly, while unlikely, data errors could occur as seen within this situation since the strain gauges and accelerometers were monitored severely and could have poorly measured the aircraft's condition (Page 2, Paragraph 3).

The LADEE mishap involving its vibration test incident is a strong example of the importance of managing risks, assigning clear roles, and being aware of testing risks in pre-flight testing. The failure to properly inspect materials, track and plan against risks, and set responsibilities clearly for each individual could have been avoided. It was without proper, established roles and training that important personnel made destructive errors in testing. Also, the need for such safety measures is present with possibilities of mechanical failure, calibration errors, potential injury, and data misrepresentation in testing before flight. Ultimately, through measures of greater surveillance, education, training, and risk assessment similar failures can be avoided in spacecraft testing.

References

National Aeronautics and Space Administration (2015). All Shook Up: The LADEE Spacecraft Vibration Mishap. *System Failure Case Study*, 8(3), 1-4. NASA Safety Center.