40.017 UE/Lynch Sounding Rocket Mishap Investigation Board Briefing to SRWG

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Mishap Overview

- 40.017 UE/Lynch Sounding Rocket launched on March 6, 2005 from PFRR.
- Following nominal launch and burns of first two stages, the Black Brant Mk1 motor failed to ignite at the predicted T+33 secs, resulting in total loss of science.
- At T+86 secs, the Black Brant Mk1 motor separated from the Nihka. The Nihka ignited at a low altitude. Apogee was only 29.5 km.
- All motors & payload impacted on the PFRR. The Black Brant Mk1 exploded on impact.
- Designated Class A Mishap.

MIB Members

Board Members (voting)
Steve Nelson, Code 500, Chairman
David Kotsifakis, Code 598
Herb Morgan, Code 569
Thomas Moskios, Code 803
Robert Pfaff, Code 612.3
Phil Ward, Code 598
David Wilcox, Code 548

Advisors (nonvoting)
Laura Giza, Legal Advisor, Code 140
Keith Koehler, Public Affairs, Code 130
James T. Mahoney, Legal Advisor, Code 140
Emmett Ransone, Deputy, SRPO, Code 810
Odell Young, Import/Export Advisor, Code 239

Ex Officio Representative (nonvoting)
Terry Potterton, Code 803

Consultants/Support (nonvoting)
Bobby J. Flowers, FEI
Bob Giesler, Retired Air Force Propulsion Expert
Valerie Gsell, Engineer, NSROC
Regena Haugh, Code 800
William Hufferd, Chemical Propulsion Information Agency (CPIA)
Thomas Moore, CPIA
Kimberly Norrie, Bristol Aerospace, Ltd.

Key MIB Activities

- Flight telemetry indicated igniter fired, but did not ignite the motor (Ignition monitor, motor pressure, accelerometers).
- Interviewing of field operations personnel (NASA Campaign Mgr, NSROC Project Mgr, vehicle technicians) – indicated new igniter design.
- All-Sky Video – clearly showed a flash at ignition time, but no ignition.
- Meetings with Bristol representatives. Development and test data provided.
- Discussions with the Chemical Propulsion Information Agency (CPIA), a DoD Information Analysis Center operated by the Johns Hopkins University, and a retired AF consultant. CPIA provided analyses of igniter charge sizing.
- Discussions with SRPO and NSROC regarding risk management processes.
- Structural and material analyses performed on igniter basket.

Proximate Cause of Mishap

Proximate Cause: (event that occurred)

- Failure to ignite motor due to inadequate thermodynamic performance of igniter. (Charge size, geometry) OR
- Failure to ignite motor due to structural failure of igniter basket under ignition loads.

Root Causes

Root Cause: (One of multiple factors that contributed to or created the proximate cause. If eliminated or modified, would prevent the mishap.)

- RC.1) Igniter charge size computation method less than adequate (LTA) to reliably ignite the motor.
  - Recommendation 1: SRPO ensure charge size calculation method properly accounts for propellant, igniter chemistry, relevant motor parameters.

- RC.2) Igniter basket geometry resulted in LTA thermodynamic performance (vent area low).
  - Recommendation 2: SRPO ensure new basket design considers geometry affects on thermodynamics.

Root Causes
(Continued)

Root Causes:

- RC.3) Existence of/decision to use existing motor case steel inventory resulted in system design decision to reduce igniter charge to a LTA level.
  - Recommendation 3: SRPO ensure system design issues regarding motor casing strength is revisited.

- RC.4) Design, analysis, and development process for Nylon igniter basket was inadequate. (anisotropic material properties, strain-rate dependency, stress raisers).
  - Recommendation 4: SRPO ensure material properties and impact stresses are considered in analyses of redesigned igniter. Consider alternate materials.

Contributing Factors

Contributing Factors: (may have contributed, but if eliminated or modified, would not have prevented the mishap)

- CF.1) Design Reviews failed to identify the igniter design deficiencies.
  - Recommendation 5: Reviews (including DR reviews for new systems, or reviews supporting significant pre-procurement activities) should be non-advocate reviews chaired by NASA. Mission reviews should be assessed to determine whether circumstances warrant a non-advocate review.
  - Recommendation 6: Fault trees should be developed for new systems.
  - Recommendation 7: The NASA-chaired DR Board should provide a "qualitative assessment" of mission success risk to the SRPO (in addition to actions/recommendations).
  - Recommendation 8: SRPO and NSROC should ensure personnel with adequate expertise are involved in new vehicle system reviews. (Several external consultants supported MIB)

Contributing Factors (Continued)

- CF.2) Mission success risk not optimally managed by SRPO.
  - Recommendation 9: SRPO should determine the need for a test flight of unproven vehicles, motors, or other critical subsystems following a rigorous risk assessment. In consideration of the significant cost of a test flight, a flight opportunity should be afforded to an experimenter with the risk clearly communicated.
  - Recommendation 10: SRPO should only proceed with a mission (with informed concurrence of PI) when risk of undesirable outcomes is exceeded by expected benefits. (This is in addition to any consideration of human safety risk).

- CF.3) Igniter testing did not adequately verify igniter thermodynamic performance or basket strength design margins.
  - Recommendation 11: SRPO should ensure testing of new igniter verifies adequate thermodynamic performance.

Significant Observations

Significant Observations: (Identified, but did not contribute to mishap)

- SO.1) Humidity observations: Igniter may have been shipped without desiccant or humidity indicator; indicator with second igniter found saturated during inspection; Mylar tape applied to new igniter basket may not be adequate barrier.
  - Recommendation 12: SRPO ensure humidity barriers are adequate.
- SO.2) NSROC inspection procedures did not require verification (recorded) that controls were in place.
  - Recommendation 13: SRPO require modification of inspection procs.
- SO.3) Motor ignition transient pressure resulted in a less than desirable structural factor of safety of the motor case.
  - Recommendation 14: SRPO should require stress analysis of all motor structural elements.