



Atlas Centaur (AC-67) Lightning Strike Mishap 1987

**Leadership VITS Meeting
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**Previous Leadership VITS safety presentations can be found at:
http://www.hq.nasa.gov/office/codeq/safety/leadership_vits/index.htm**

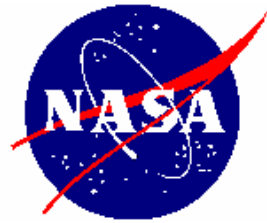


The Mishap

**On 26 March 1987,
NASA launched
Atlas/Centaur AC-67
from the Eastern Test
Range. The vehicle
triggered lightning 49
seconds after launch
resulting in GN&C
failure and structural
breakup.**

**Both launch vehicle
and Navy
communication
satellite were lost**





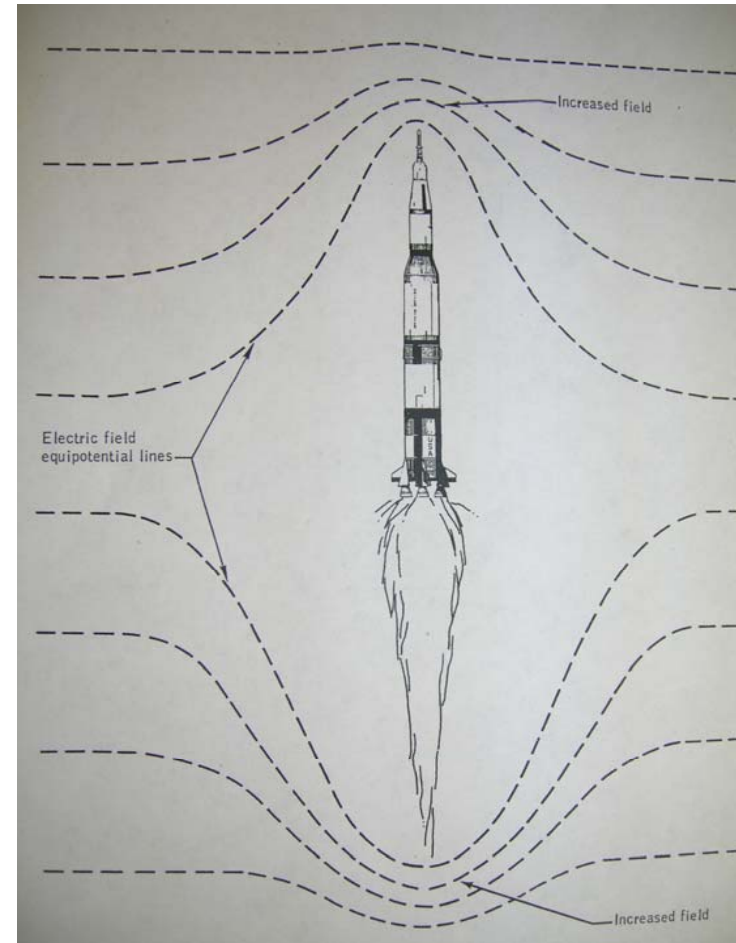
The Mishap – what?

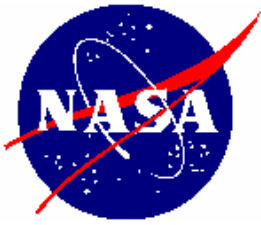
- Launching into conditions conducive to triggered lightning resulted in a lightning strike.
- The lightning strike resulted in a single random upset of a memory location in the Centaur Digital Computer Unit (DCU).
- This single random upset caused the DCU to send an erroneous hardover yaw command.
- The hardover engine yaw command to the Atlas booster engines overstressed the vehicle, resulting in structural breakup.

The Simplified Physics of Triggered Lightning

Lightning can be triggered when an aerospace vehicle with a conductive surface and an ionized exhaust plume distorts the electrical field equipotential lines, thus increasing the potential gradient at the top of the vehicle and below the exhaust plume.

(NASA Analysis of Apollo 12 Lightning Incident; Feb 1970)



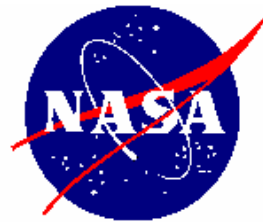


The Mid Level Cloud Rule (March '87)

Post Apollo 12 research and analysis resulted in triggered lightning launch commit criteria that applied to both manned and unmanned launch vehicles. By the time of AC-67, the following was the official version for ELVs:

The flight path of the vehicle should not be through mid level clouds 6,000 feet or greater in depth, when the freezing level is in the clouds.

Note: In the console launch commit criteria, this rule had no title or rationale or notes aligning it to triggered lightning hazard. Today's version of the rule is in a section titled "Lightning"



Findings of the AC 67 Mishap Investigation Board

- *...there was no convincing evidence that one of the criteria used to avoid potential electrical hazards [the mid level cloud rule] was met. (note: no waiver was processed)*
- *Before the AC-67 launch, there were a significant number of indications that generally the weather was unfavorable and that specifically there was a lightning hazard. Yet the real import of these indications escaped the launch management team because of imprecise communications, lack of awareness, or both.*
- *Although the Weather Officer did give a go-for-weather as late as lift-off minus three minutes, there was a belief among some members of the launch weather team that their function was only to provide data to the Launch Director for his analysis and that the Launch Director must decide if the weather criteria had been met.*



Major Recommendations of the AC 67 Mishap Board

- *Require clear and convincing evidence that launch constraints are not violated*
- *All Managers must exercise constant awareness, judgment, and leadership. Managers must be constantly alert to variations to planned launch activities. They must provide a questioning, challenging attitude toward the validity of inputs being made.*
- *Establish electric field mill LCC for ELVs.*
- *Publish clear, concise directive of duties and responsibilities of launch weather team*
- *Converge Shuttle and ELV weather criteria*

Additional Finding and Recommendation in AA's Endorsement



(R. Truly, June '87)

Finding

In prelaunch discussions on Channel 20 (Launch Director and Project Coordination Loop), both launch and weather team personnel appeared to believe that the constraint...was an icing rather than an electrical concern. This particular constraint was discounted after hearing that two aircraft in the area had flown through the clouds and reported no visible icing.

Recommendation

Precisely written launch rules and associated rationale should be available for launch team training and on-console use.



Lessons for NASA

- Effective communications are essential to safe operations.
- Relevant lessons learned should be easy to find...e.g. rationale statements in our requirements and rules documents
- Know, understand, and follow the rules that are set,
but,
- If the mission calls for a waiver or exception discussion, make sure all involved understand the rationale for the rule, otherwise human nature is such that the team might invent a rationale
- Ensure that everyone on the team understands his/her role and authority,
and,
- If it doesn't sound right, speak up!

Ref: HQ OSMA, O. Greulich



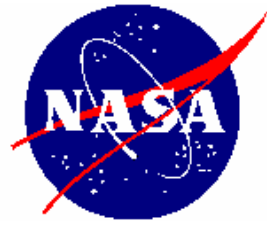
AC-67 Mishap

BACKUP



The Simplified Physics of Triggered Lightning

- Weather conditions most conducive to triggered lightning:
 - mid level clouds that are greater than 4500 ft thick, with the 0 degree centigrade line inside the clouds or
 - thunderstorm related anvil, or
 - thunderstorm related debris cloud
- Lightning may not occur under the same conditions in the absence of the vehicle/plume.



History of Triggered Lightning Launch Commit Criteria (LCC) before AC 67

- Apollo 1-12: “Vehicle will not be launched when flight path will carry it through cumulonimbus (thunderstorm) cloud formation.” (no rules specific to triggered lightning phenomenon).
- Apollo 12 was struck twice by lightning on November 14, 1969, resulting review of applicable atmospheric science and adoption of five LCCs related to lightning, including one for triggered lightning.
- In the Apollo-Soyuz era, circa 1975, a relaxation of the post-Apollo 12 LCC was permitted based on electrical field measurements around the launch site.
- By 1986 the LCC for Shuttle were based on clouds, precipitation, thunderstorms, known lightning, and a measured ground level electric field measurement along with a value not to be exceeded. Field mills not yet used for ELVs.