Apollo Main 15 Parachute Failure

Your severity # for Apollo failure
is too high given
the level of redundancy.

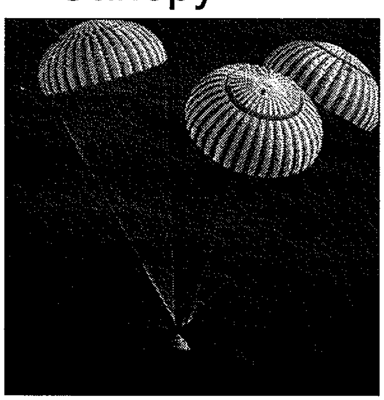
[redacted]

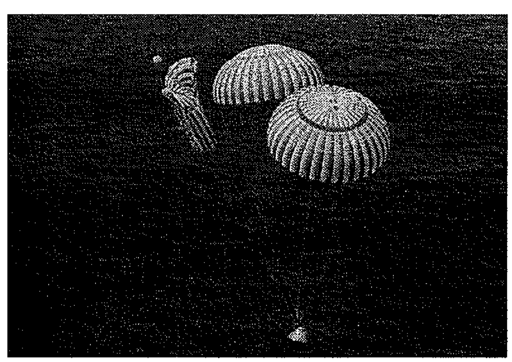
occ also high - ~~bo~~ w
→ see John's notes

Thorough but
Lack of original work
→ References for these historical failures?
that you pulled the info from

Item/Function

- Apollo Main Parachute System
  - Risers
  - Suspension Lines
  - Canopy



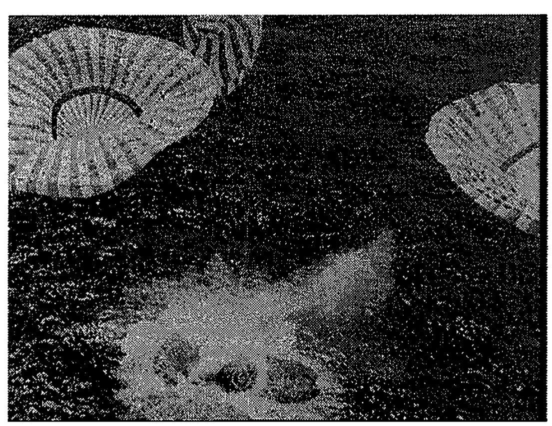


Potential Failure Mode

- Damage found on risers and suspension lines
  - Caused canopy to fail
- Normal dumping of fuel during descent
  - Caused being exceeding temperature limits for risers and suspension lines

Potential Effects of Failure

- Loss of 1 entire effective canopy
- Only 2 were required for safe operation
- Increased velocity on splashdown
- Less comfortable
- **Severity: 7**



Potential Causes

- Anomaly report found likely cause to be RCS fuel expulsion during descent
  - RCS system is used to stabilize entry, but not entire fuel reserve is utilized
  - Excess fuel is dumped before splashdown

Occurence

- Based on the number of failures on operational Mercury, Gemini, and Apollo missions: **Occurrence: 8**
- Total number of parachutes:

  Mercury (piloted launches): 6

  Gemini: 10

  Apollo (including Apollo-Soyuz): 15 x 3 = 45

  Number of failures: 1

  Occurrence ≈ 17 per thousand vehicles

Current Controls and Detection

- **Prevention:** Time delay for propellant expulsion
- **Detection:** Visual methods. Retrieval helicopters, mothership, and capsule crewmembers visually identified failure event, **Detection 10**

RPN and Recommended Actions

- **RPN Score: 560** Need to decrease Severity, then Occurrence, then Detection scores
- Increase amount of oxidizer in propellant
- Increase time delay before RCS thrusters turn off and fuel dumps
- Create orientation sensor to avoid dumping during parachute alignment with RCS thrusters
- Add thermal sensors on risers to take action if temperatures increase beyond limits prior to failure

Responsible Party and Actions to be taken

- Responsible Person:
  Failure Investigation Committee Chair: ***John Christian***
- Complete by: February 1972

1. Increase time delay from 42 to 61 seconds
2. Increase ratio of oxidizer to fuel
3. Conduct Additional Tests
4. Add thermocouples to risers

Severity 4
Occurrence 4
Detection 3
New RPN: 48

	Item/ Function	Potential Failure Mode	Potential Effects of Failure	Severity	Potential Causes/ Mechanisms of failure	Occurrence	Current Controls	Detecti
1	Apollo Main Parachute System	Damage to the riser, suspension line, and canopy, from exceeding temperature limits due to raw fuel expulsion during the tank depletion firing during descent.	Loss of entire canopy causing higher velocity impact. Potential damage to vehicle, injury to crew members dependent on number of canopies damaged.	7 (Given the Apollo Main parachute's redundancy, the severity of a single failure event does not cause safety requirements to be breached.)	Raw fuel expelled from RCS system as venting during descent.	8 (Based on the number of similar failures out of all the Mercury, Gemini, and Apollo missions)	Prevention: Time delay for propellant expulsion Detection: By visual methods; ground crew, Apollo crew saw the parachute burning	10 (Detecti can only perform after fail has occurred
2	Genesis Parachute System	The parachutes didn't deploy because no trigger from the G-Switches was given.	With no parachute deployment, Genesis had no decelerati on, resulting in a complete loss of the vehicle. The vehicle crashed at 200 mph and broke apart.	8 (Severe damage to vehicle, contaminatio n of science samples)	The G-Switches were installed backwards as specified in the Lockheed-Martin designs. This resulted in an opposite sign on the acceleration vector, which did not trigger the mortar fire.	10 (Out of 2 missions of similar design, there was 1 failure)	Prevention: Systems Engineering methods design reviews. Assumed function due to heritage. Detection: System testing. Inspection of workmanship. Sensor based detection system to account for lack of mortar firing and chute deployment. Visual methods from helicopter crews. (Crash was filmed)	6 (Detecti of misplace sensors could ha been achievec with current methods but they failed)

RPN	Recommended Actions	Responsibility and Target Completion Date	Action Taken	Sev	Occ	Det
60	-Increase time delay of rapid propellant dump. Increase amount of oxidizer in th RCS in order to mitigate the damage that would be done by the propellant. -Create a sensor that would detect the orientation of the main chutes in comparison to the vents and make sure that venting does not occur when a chute is in the path of the vent. -Add thermal sensors to risers, suspension lines, and canopy to provide early warning.	Responsible Person: Failure Investigation Committee Chair, John Christian Completion Date: February 1972	-Increased the time delay of the rapid propellant dump from 42 seconds to 61 seconds. -Increased the ratio of oxidizer to propellant. -Conduct Additional Tests. -Add thermocouples to risers to detect temperature increases that will shut down the RCS dumping.	4 (Damage caused by leaked fuel is mitigated by higher oxidizer mix. Damage caused will be within tolerance of riser strength)	4 (Damage should be avoided by adding delay time)	3 (Sensors will provide more immediate pre-failure warning)
80	-Overhaul project Systems Engineering methods to make certain that small issues are not overlooked. -Avoid assuming that heritage can be applied directly without any analysis. -Understand heritage components and their requirements. -Use redundant system for parachute deployment in case an error occurs in primary sensor.	Responsible Person: Failure Investigation Committee Chair, Dr. Wallace Fowler Completion Date: November 2004	-Systems Engineering methods revamped. -Future missions will conduct important centrifuge tests. -Corrected the orientation of the G-Switches. -Clarified requirements. -Add secondary method for parachute deployment.	6 (given added redundancy)	2 (Improved oversight should fix detected malfunctions)	2 (Improved oversight should detect failure mechanisms)