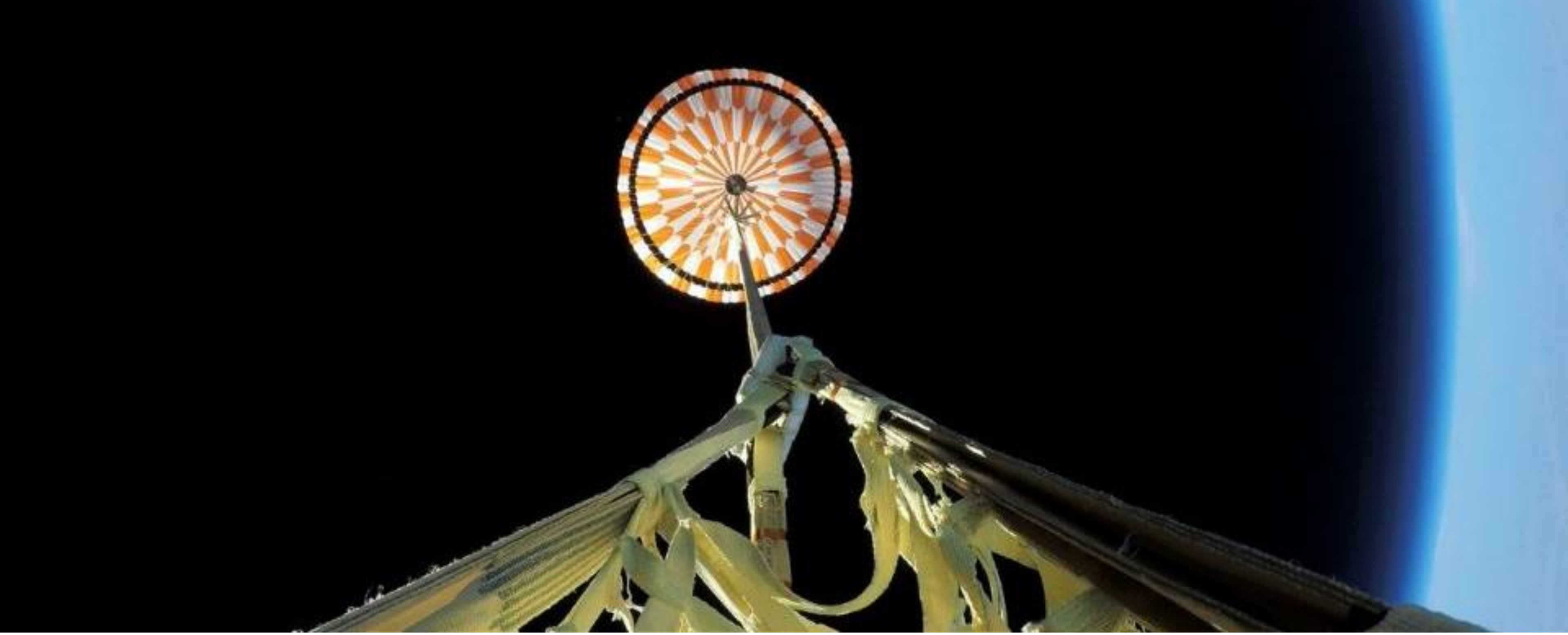

Overview of the First Two Flights of the ASPIRE Supersonic Parachute Test Program

15th International Planetary Probe Workshop

June 11-15, 2018 – Boulder, CO

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Jet Propulsion Laboratory, California Institute of Technology

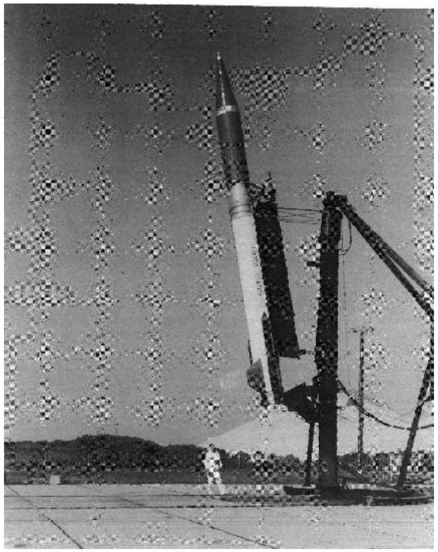
ASPIRE

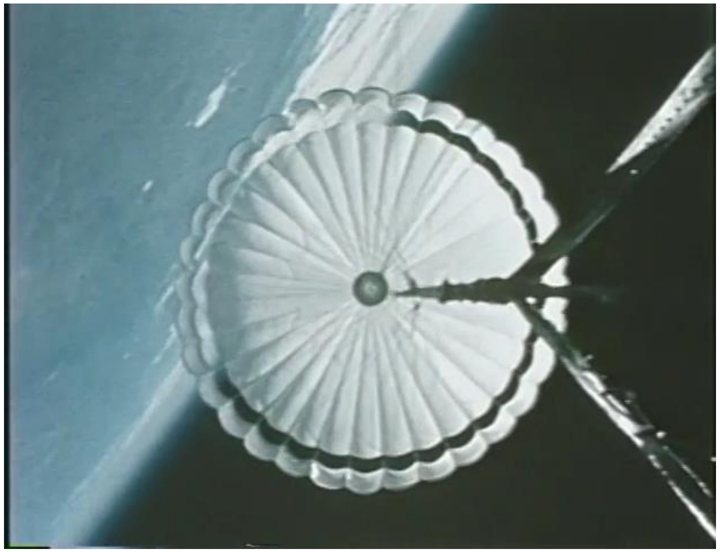
Jet Propulsion Laboratory
California Institute of Technology

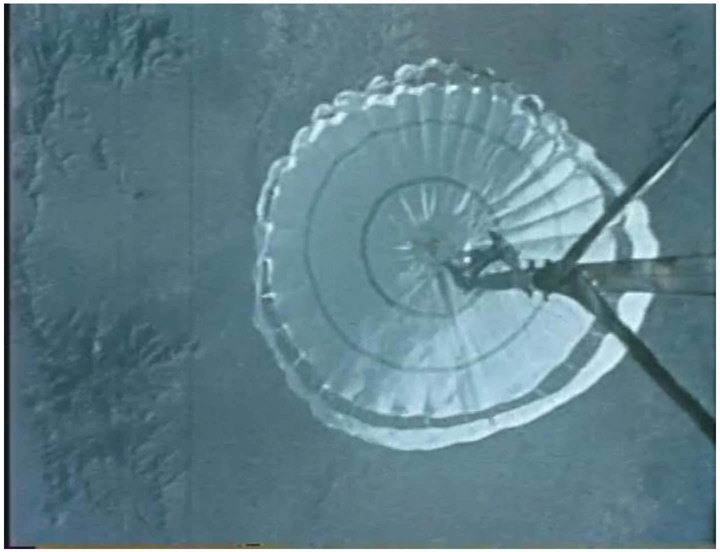
Supersonic Parachute Testing Heritage

ASPIRE

- Disk Gap Band (DGB) Parachute developed in 60’s & 70’s for the Viking program
- DGB development included the Planetary Entry Parachute Program (PEPP) which used sounding rockets and high-altitude balloon launched vehicles to test supersonic parachutes in Atmospheric conditions analogous to Mars:







- DGB has been used successfully on 5 Mars Missions (leveraged Viking development)
- The Low-Density Supersonic Decelerators (LDSD) Project saw failures of two supersonic Ringsail parachutes
- LDSD experience showed that stresses seen in subsonic testing may not bound the stresses seen in supersonic testing, at least for some parachutes
- **ASPIRE project was started as a risk reduction activity for the Mars 2020 mission**

The ASPIRE Project

ASPIRE

ASPIRE = **A**dvanced **S**upersonic **P**arachute **I**nvestigation and **R**esearch **E**xperiments

- **Objective**: Expose two candidate M2020 parachute designs to a supersonic inflation environment and acquire sufficient data to characterize the flight environment, loads, performance of the parachute.

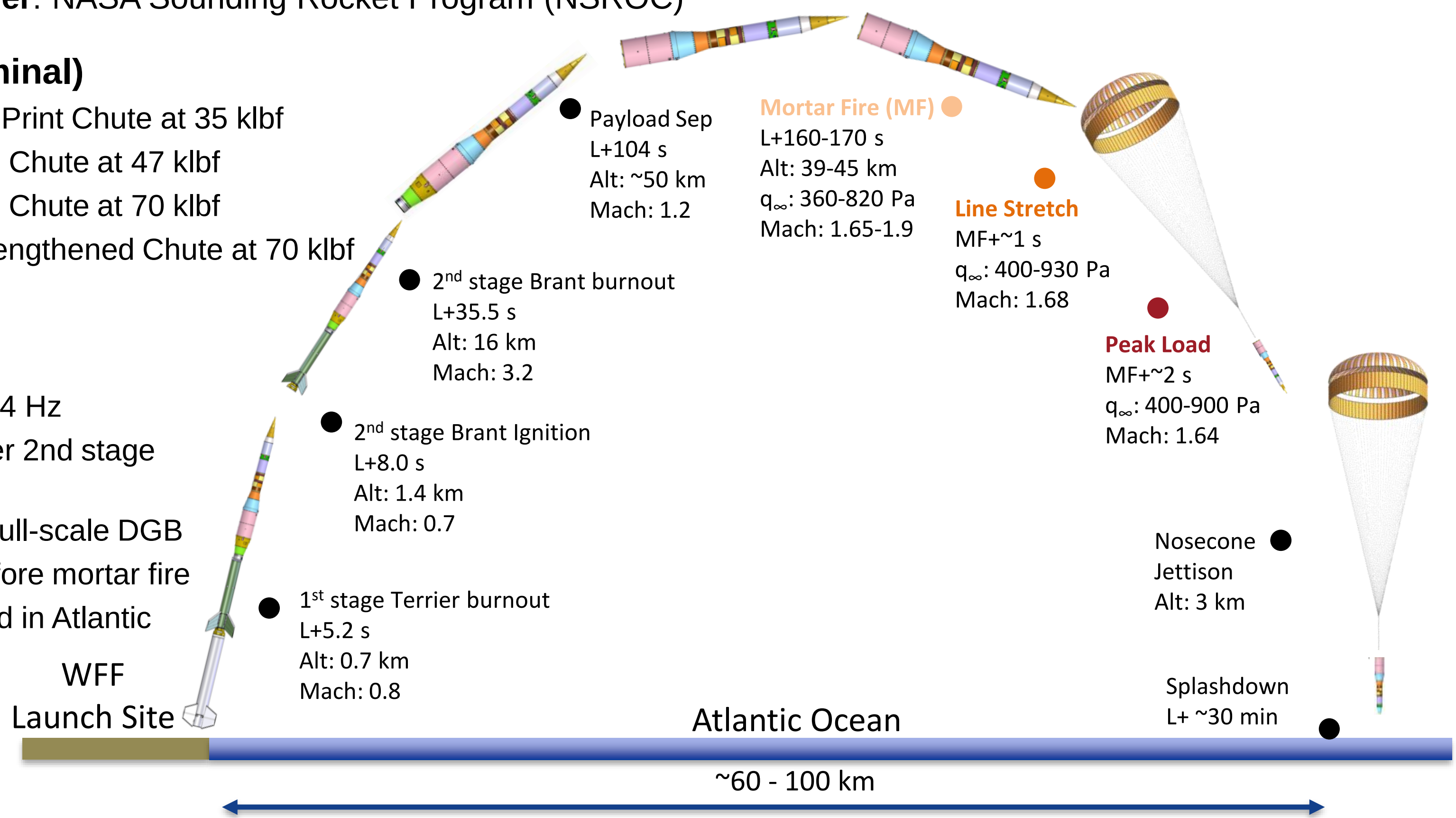
- **Launch Site**: Wallops Flight Facility at Wallops Island, VA
- **Launch Vehicle**: Terrier Black Brant IX Sounding Rocket
- **Launch Provider**: NASA Sounding Rocket Program (NSROC)

Three Flights (nominal)

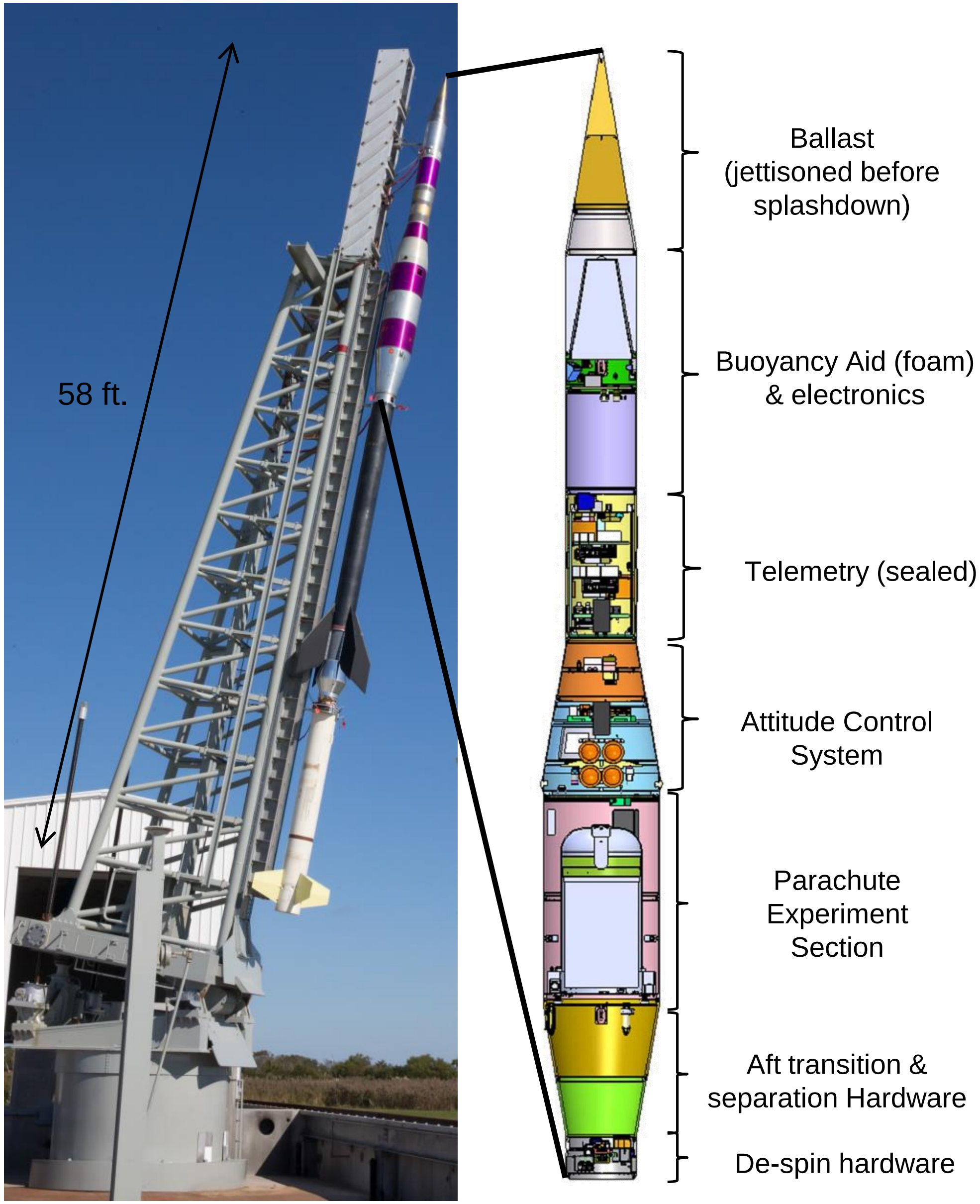
Flight 1: MSL Build-to-Print Chute at 35 klbf
Flight 2: Strengthened Chute at 47 klbf
Flight 3: Strengthened Chute at 70 klbf
Flight 4: (optional) Strengthened Chute at 70 klbf

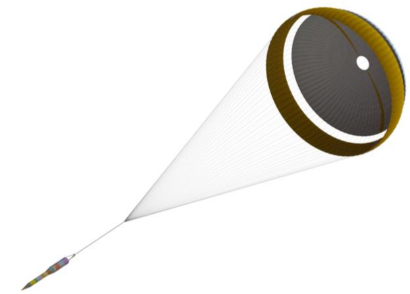
Test Architecture

- Rail-launched
- Spin-stabilized at 4 Hz
- Yo-yo de-spin after 2nd stage burnout
- Mortar-deployed full-scale DGB
- Cold gas ACS before mortar fire
- Payload recovered in Atlantic Ocean



Payload Configuration & Instrumentation





Onboard Instrumentation	Rate	Resolution
GLN-MAC IMU	400 Hz	-
GPS	20 Hz	-
C-band transponder (radar tracking)	50 Hz	-
Parachute Triple-Bridle Load Pins	1 kHz	1100 lbf
High Speed Cameras (x3)	1000 fps	3840x2400
Situational Video (x3)	120 fps*	1920x1080*

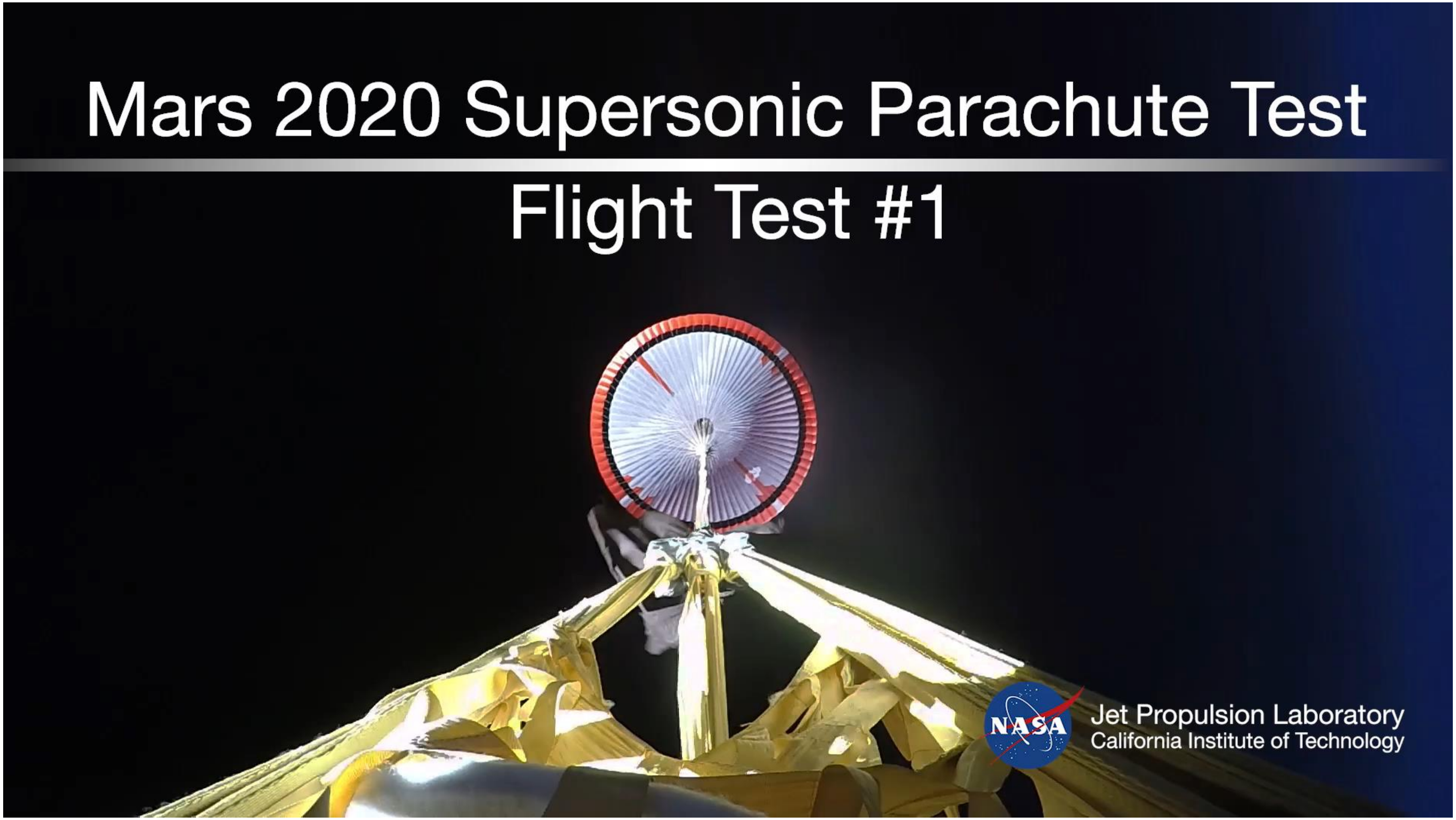
*One Situational Video Camera set to 4K resolution and 30 fps

Meteorological instrumentation:

- 6x meteorological balloons carrying Radiosondes: temperature, density, winds to 37 km
- GEOS Analysis: temperature, density, winds above 37 km

ASPIRE Flight 1 Footage

ASPIRE

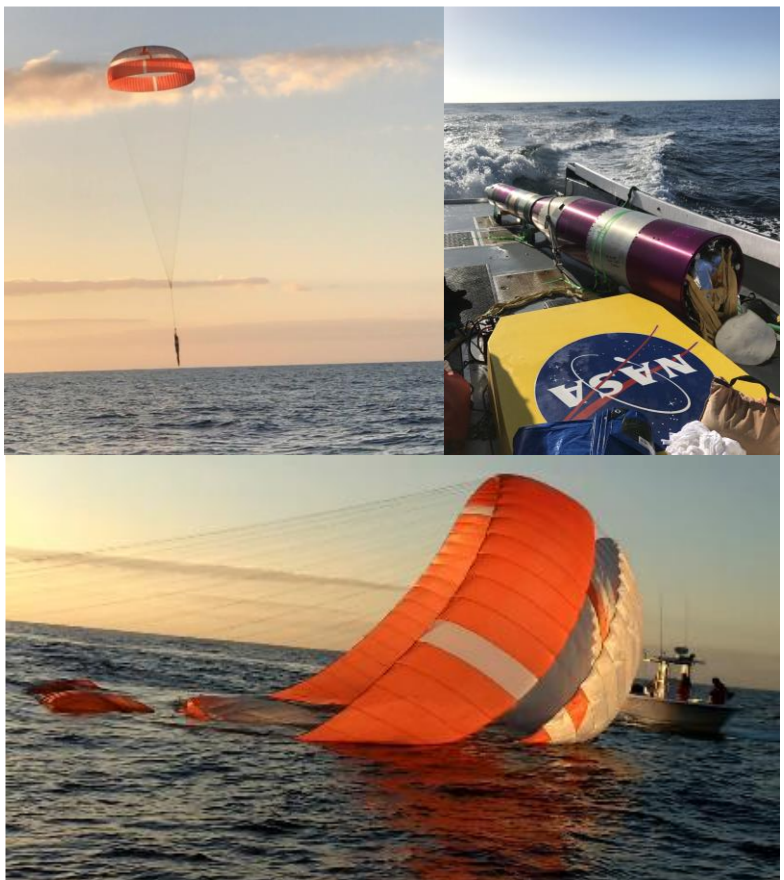


ASPIRE Flight 2 Footage

Payload Recovery

ASPIRE

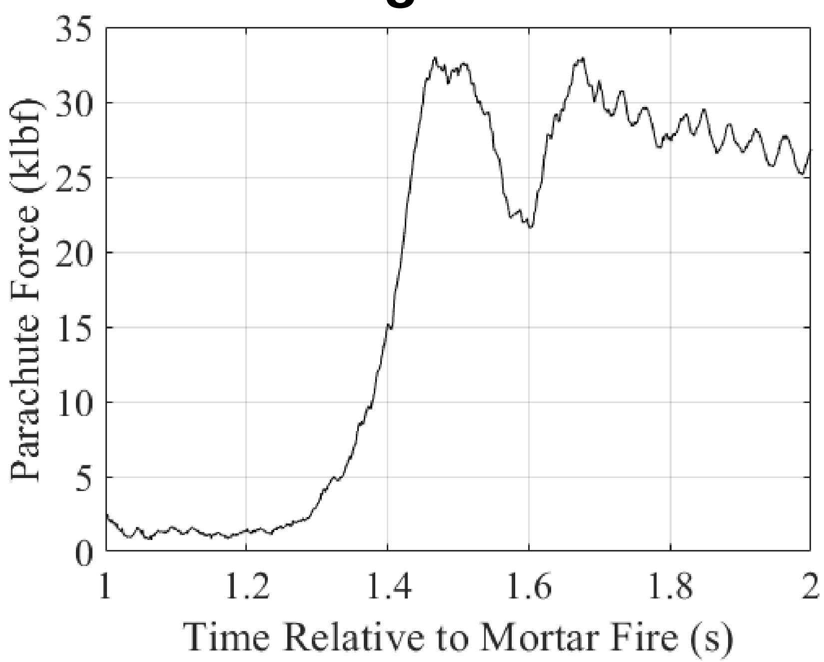
- Payload is recovered from the Atlantic Ocean in order to extract onboard data that is not telemetered during flight
- Payload recovery was successful for both ASPIRE flights with no recovery-induced damage to the parachute or instrumentation



ASPIRE Flight 1 & 2 Results

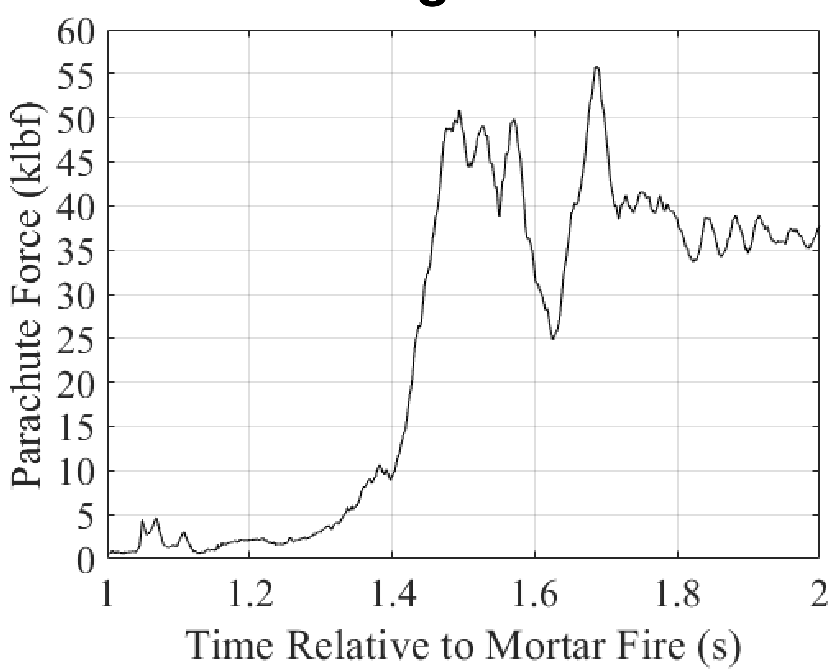
- ASPIRE Flight 1 & 2 were a success
- Both Parachutes survived their flight loads and showed no significant damage from inflation
- See C. O’Farrell *et al* “Reconstructed disk-gap-band parachute performance during the first two ASPIRE supersonic flight tests” (presentation)

Flight 1



Parachute peak load: 32.4 +/- 1.1 klbf

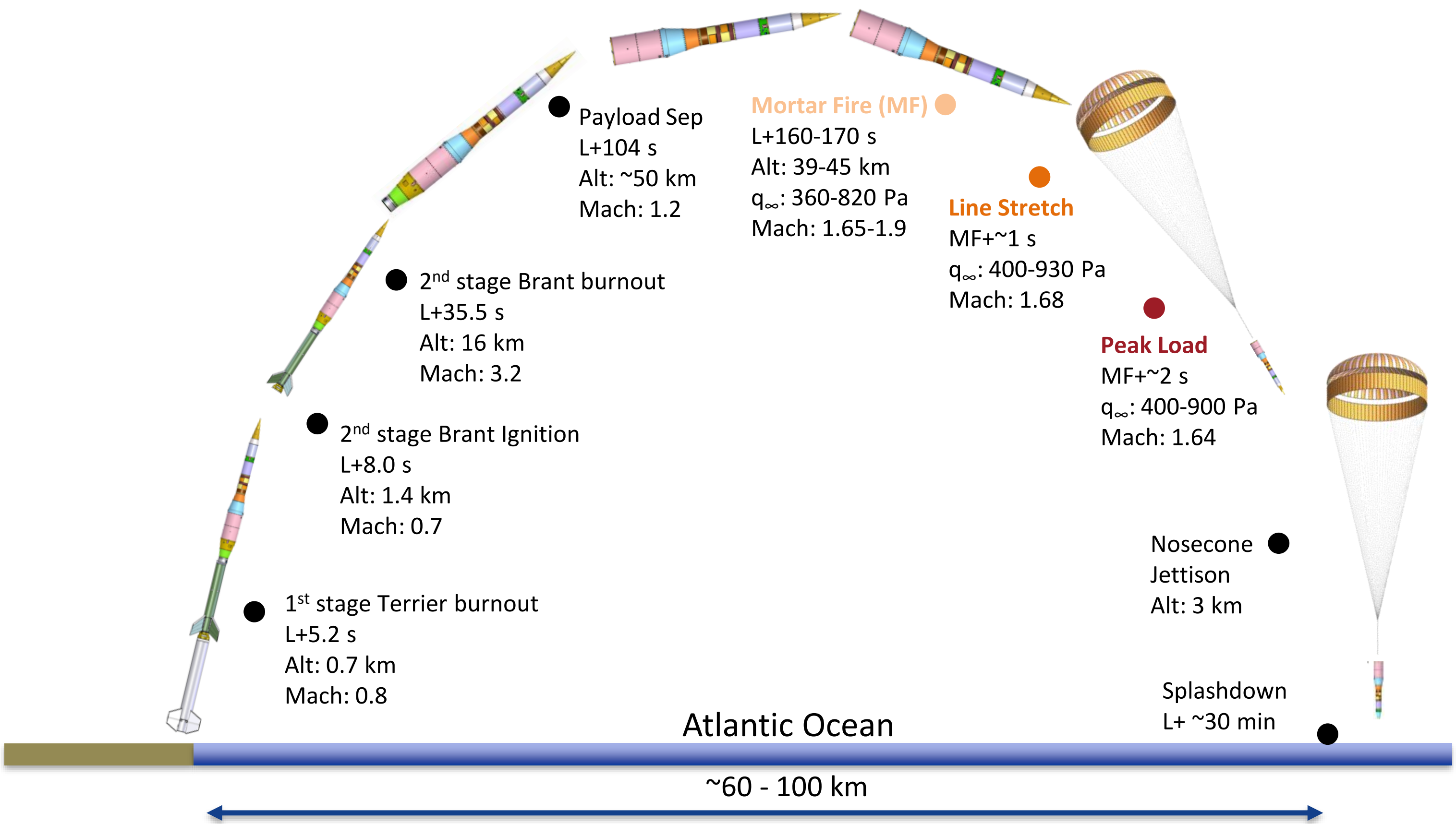
Flight 2



Parachute peak load: 55.8 +/- 1.1 klbf

What's next? Overview of ASPIRE Flight 3

- 21.5 meter Airborne Strengthened DGB parachute
- Target Parachute peak Load of 70,000 lbf
- Launch planned for July/August 2018



Acknowledgements

The success of these two flights is due to the greater ASPIRE Team

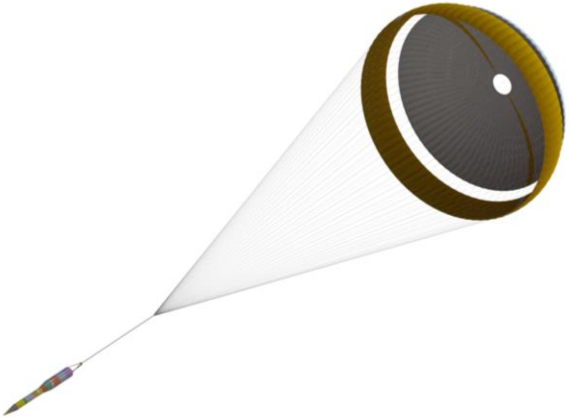
Project Manager: Tom Randolph
Project Manager Emeritus: Mark Adler
Principal Investigator: Ian Clark
Parachute CogE: Chris Tanner
Flight Performance (JPL): Mark Ivanov
Flight Performance (LaRC): Eric Queen
Aerosciences: Suman Muppidi
Sounding Rocket Lead: Brian Hall
NSROC Mission Manager: Jay Scott
WFF Range Lead: John Valliant
Recovery Lead: John McCann

And many others from the Jet Propulsion Laboratory, NASA Langley Research Center, NASA Ames Research Center, NASA Wallops Flight Facility, and the Thomas Reed Boat Recovery Crew

Backup

Overview of ASPIRE Flight 1 and Flight 2

Parameter	Flight 1	Flight 2
Launch Date	October 4th, 2017	March 31st, 2018
Launch Time	6:45 am local time	12:19 pm local time
Parachute	21.3 meter Pioneer MSL Build-to-Print DGB chute	21.5 meter Airborne Strengthened DGB chute
Parachute Pack Mass	61 kg (134 lbm)	82 kg (181 lbm)
Mass underneath the Parachute	1,121 kg (2,471 lbm)	1,121 kg (2,471 lbm)
Target Peak Parachute Load	35,000 lbf (~156 kN)	47,000 lbf (~209 kN)
Flight Peak Parachute Load	32,400 lbf (~144 kN)	55,800 lbf (~248 kN)
Mach at Full Inflation	1.77	1.97



ASPIRE Flight 1 & 2 Trajectory

ASPIRE