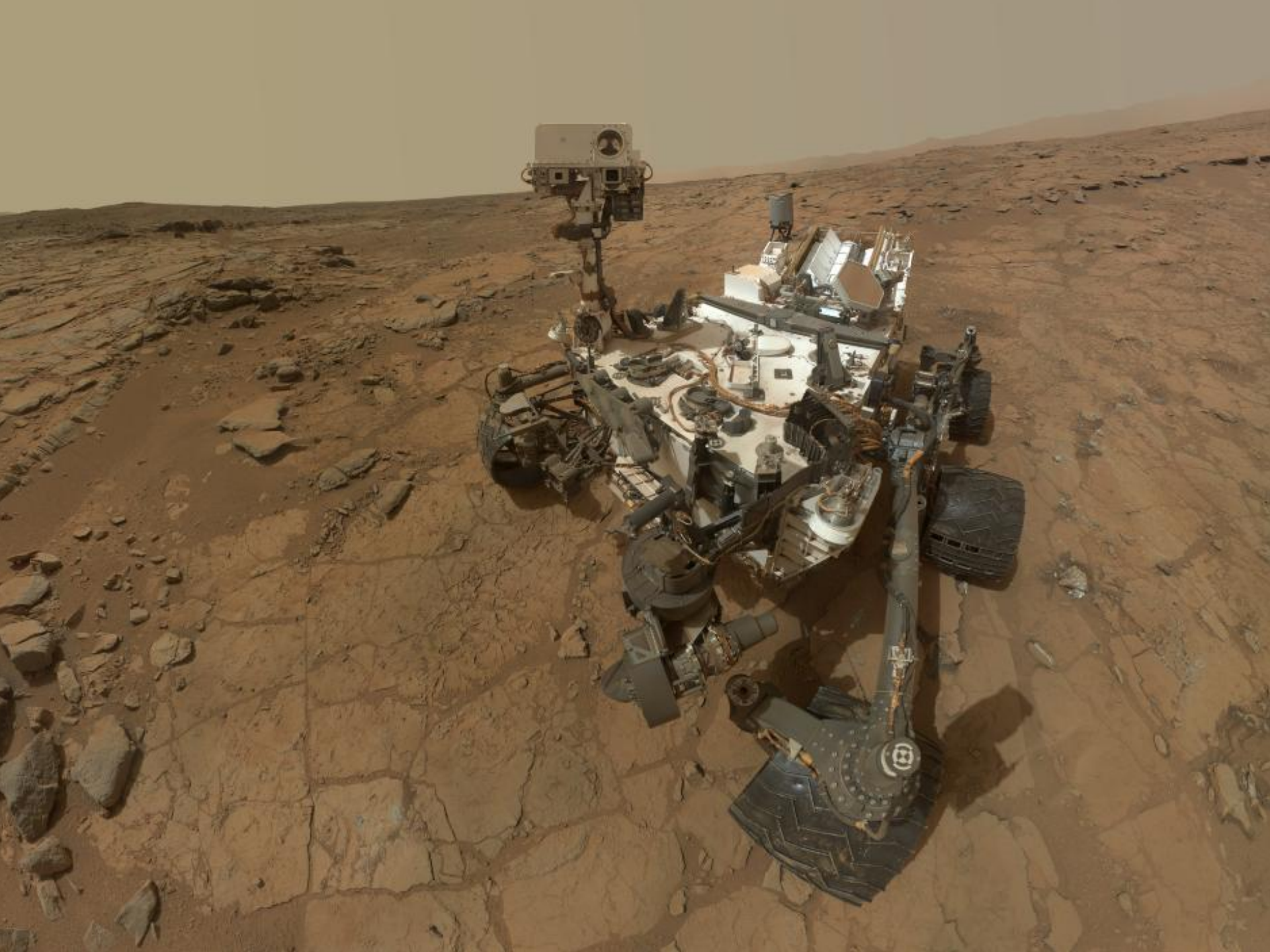




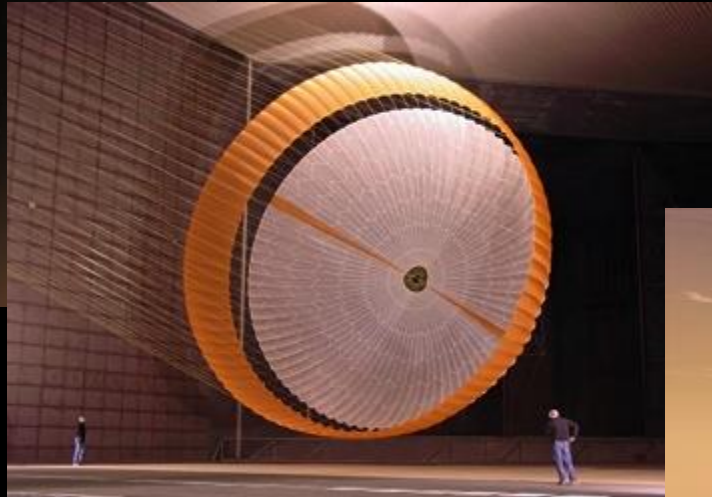
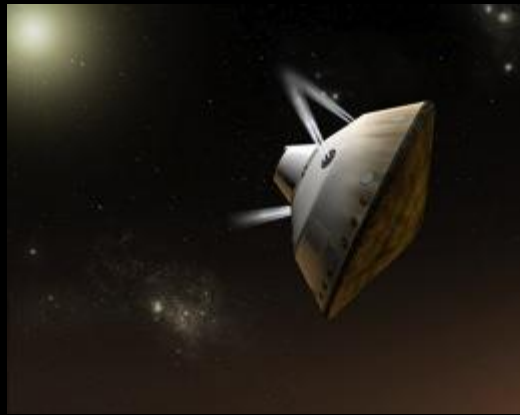
Low-Density Supersonic Decelerators

An Update

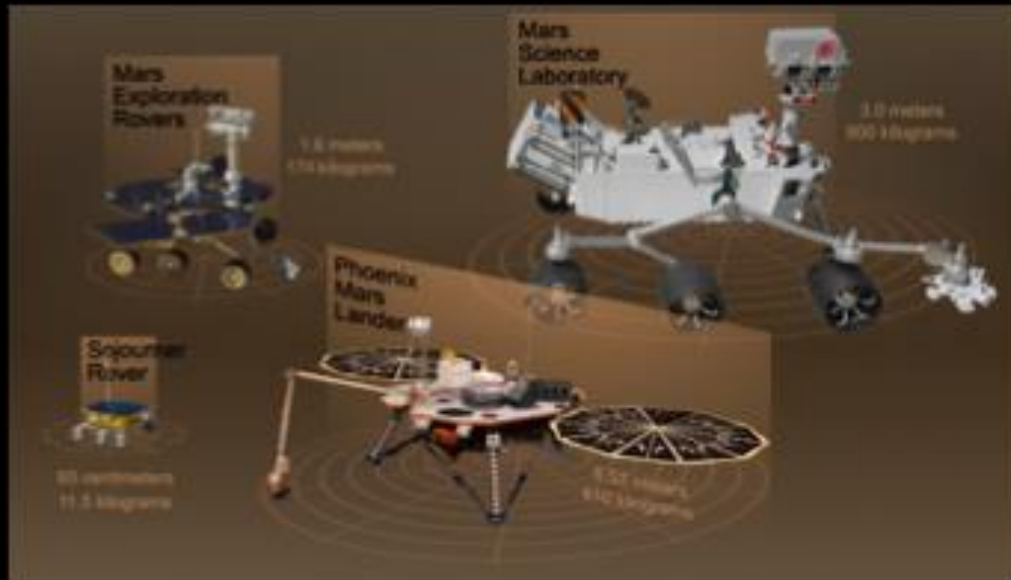
Dr. Mark Adler
Dr. Ian Clark



Mars Entry, Descent, and Landing Technology State of the Art



Square-Cube Law



$$F_{drag} = \frac{1}{2} \rho v^2 C_D A$$

$$A \sim L^2$$

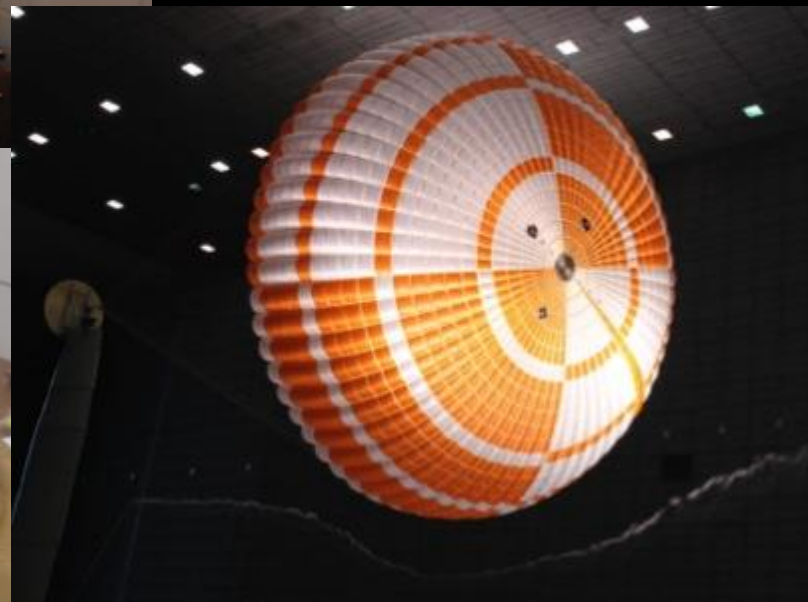
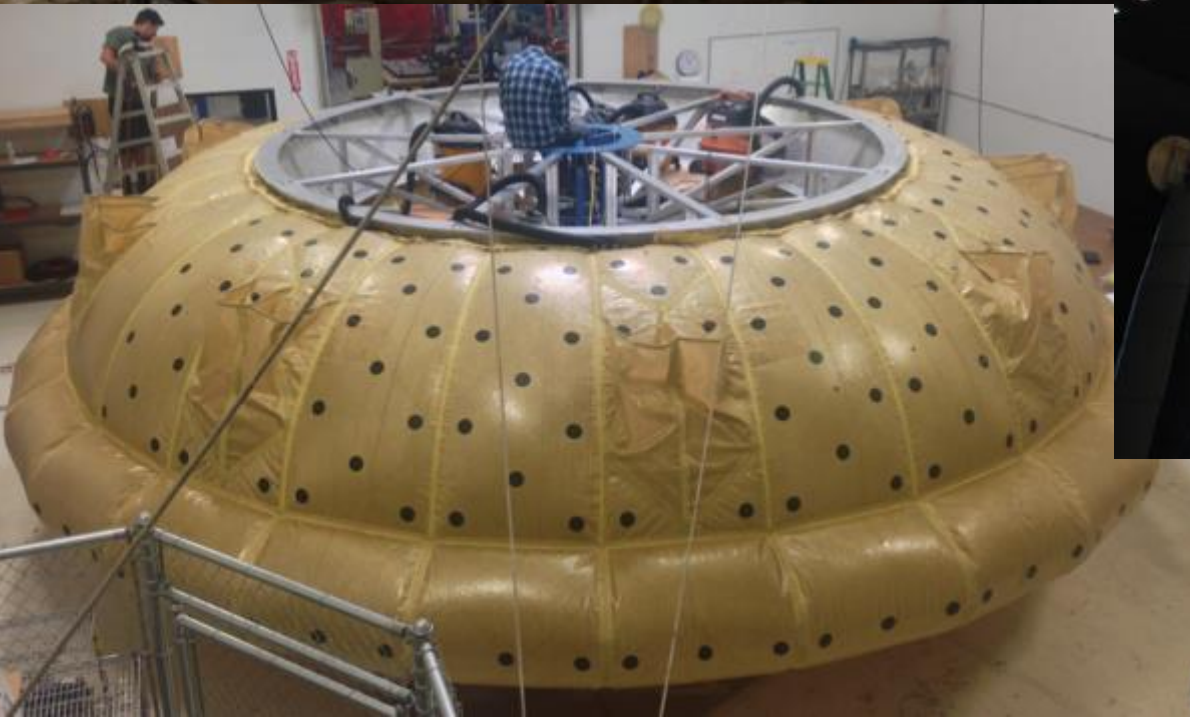
$$F = ma$$

$$m \sim L^3$$

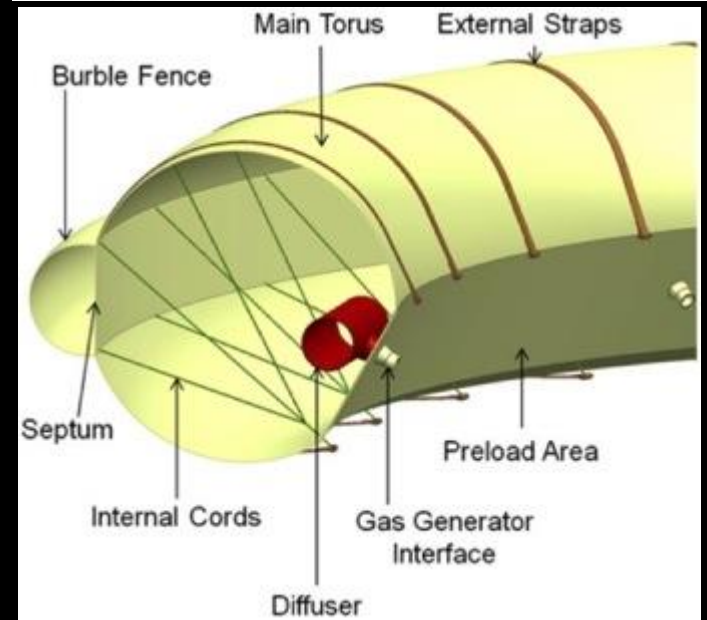
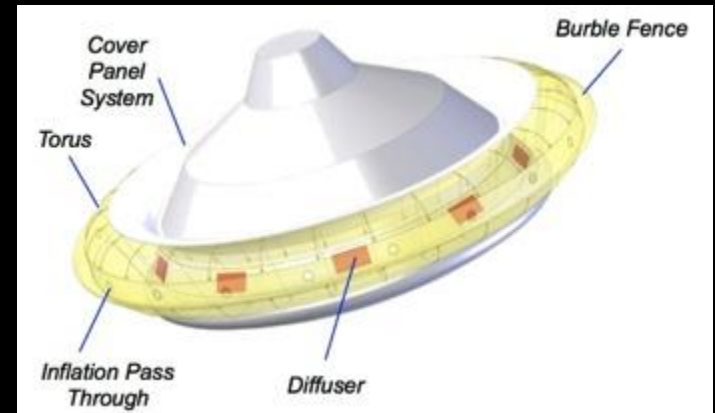
$$a_{drag} = \frac{1}{2} \rho v^2 \frac{C_D A}{m}$$

$$a_{drag} \sim \frac{A}{m} \sim \frac{1}{L}$$

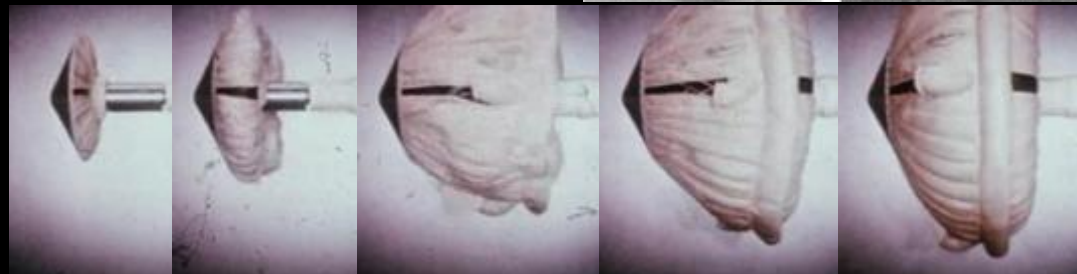
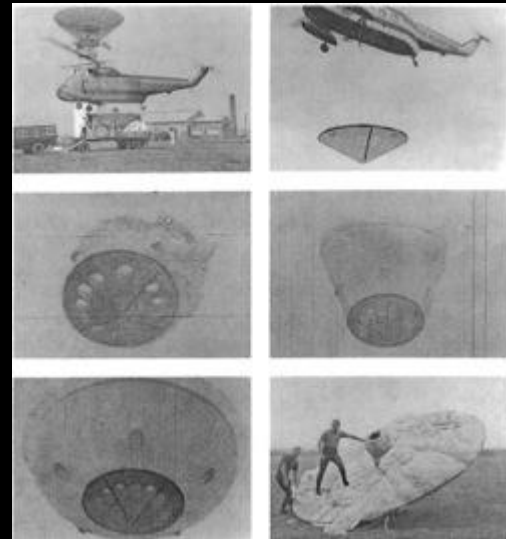
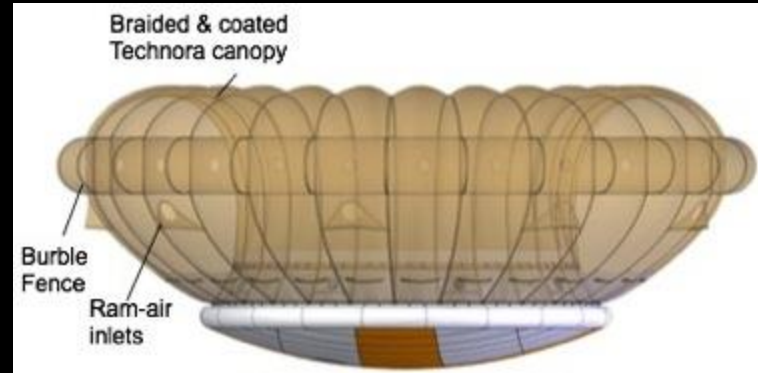
LDSD: Low-Density Supersonic Decelerator



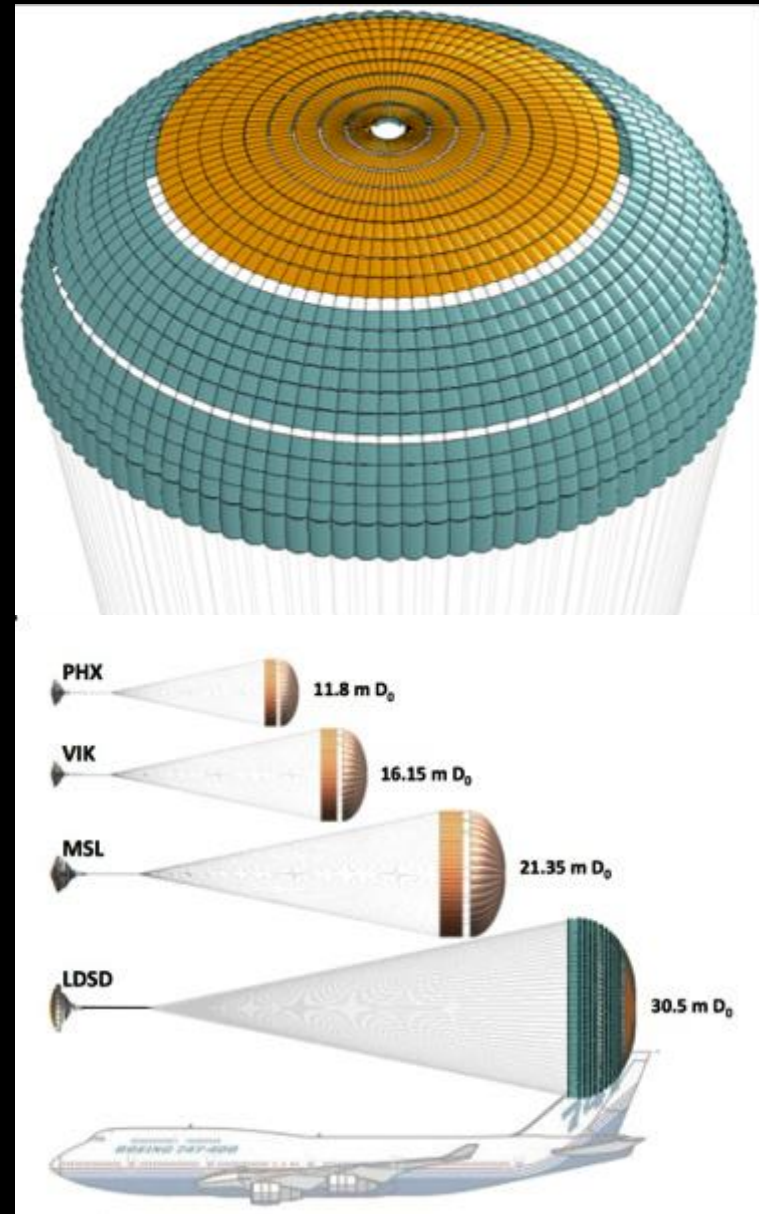
6m Attached Torus Overview



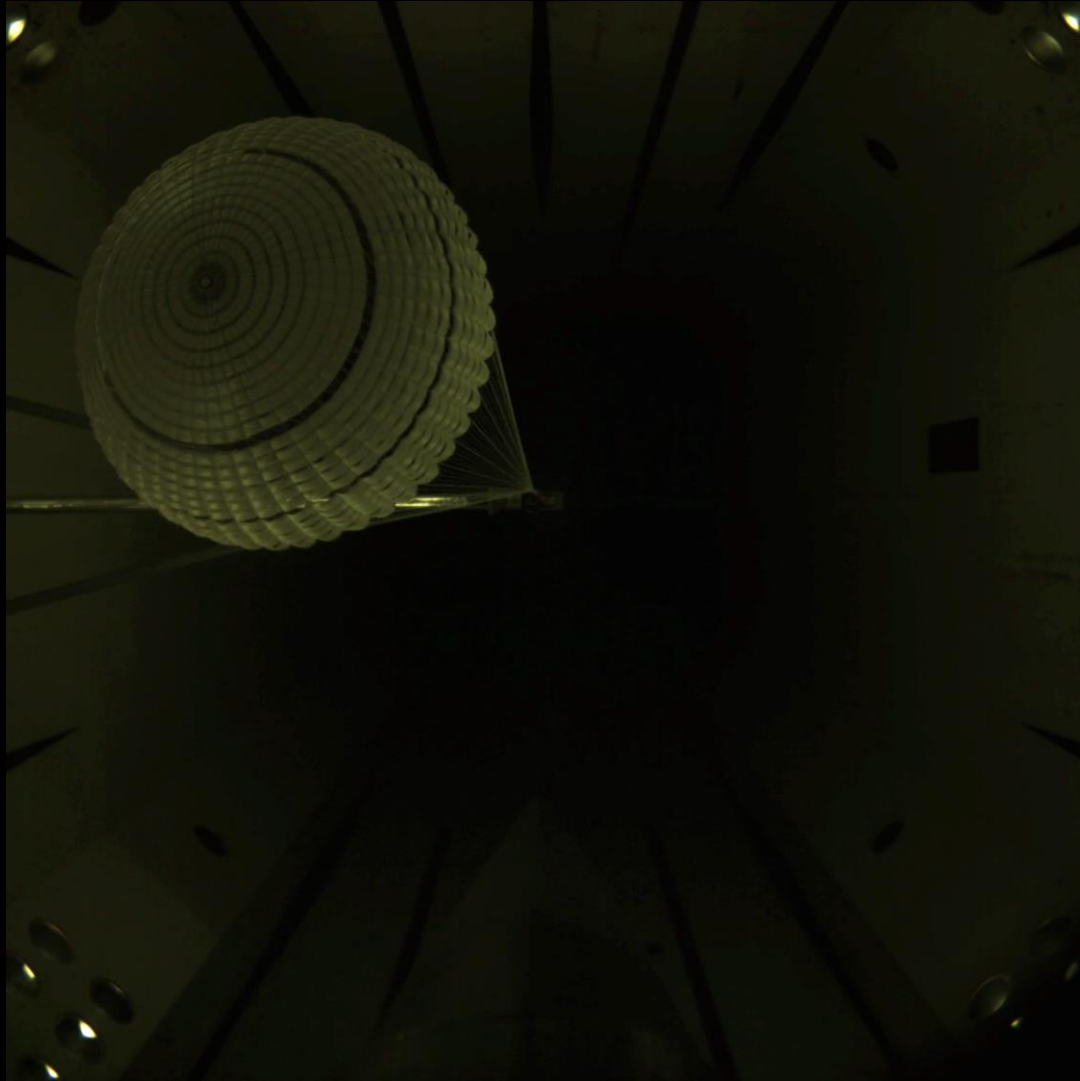
8m Attached Isotenoid



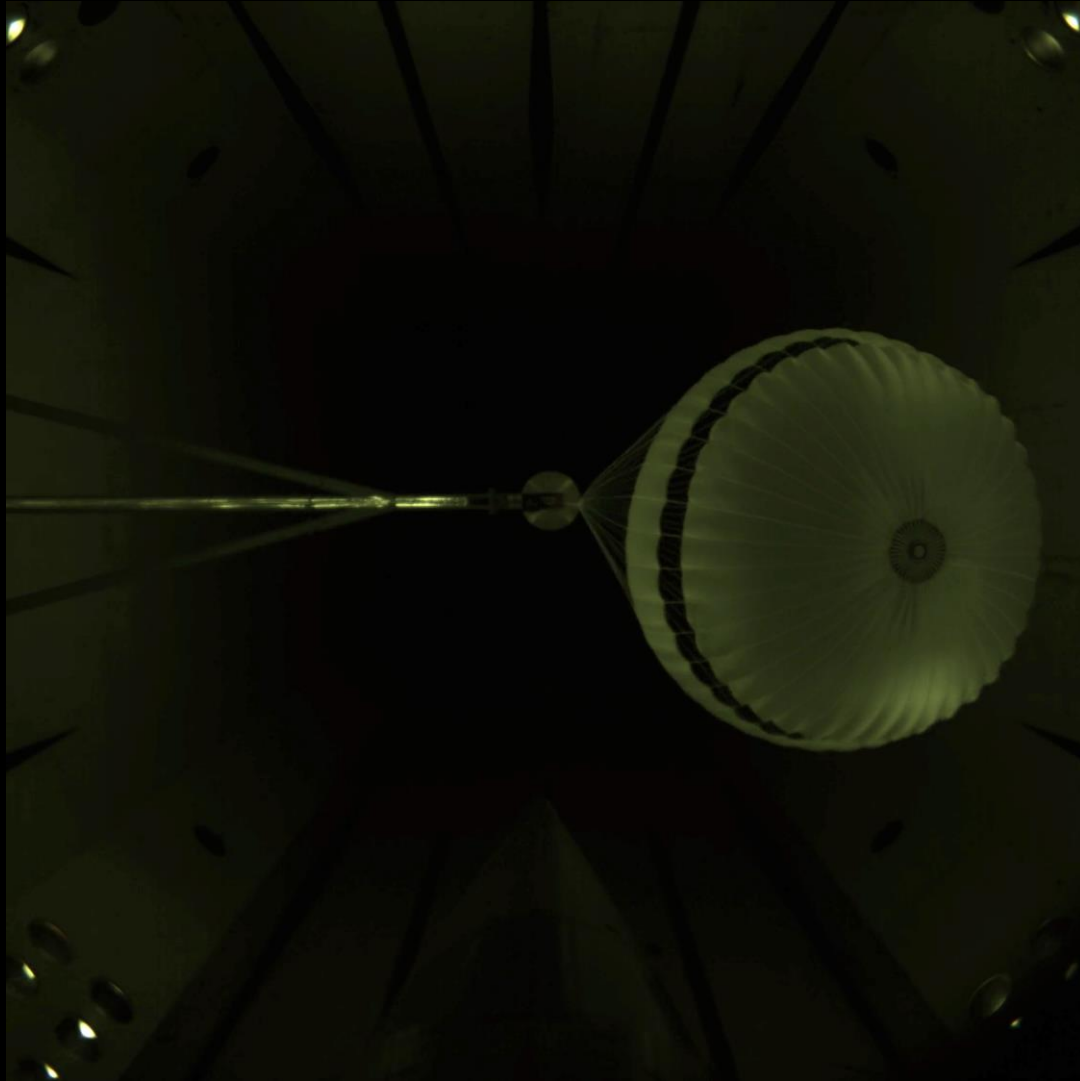
30.5m Supersonic Parachute



Transonic Dynamics Tunnel, October 27, 2014



Transonic Dynamics Tunnel, October 30, 2014



Rocket Sled PDV2 SSRS, February 18, 2015

Peak Load ~120k lbf



Rocket Sled SDVE2 SIAD-E, April 17, 2015



SFDT2 Balloon Launch, June 8, 2015



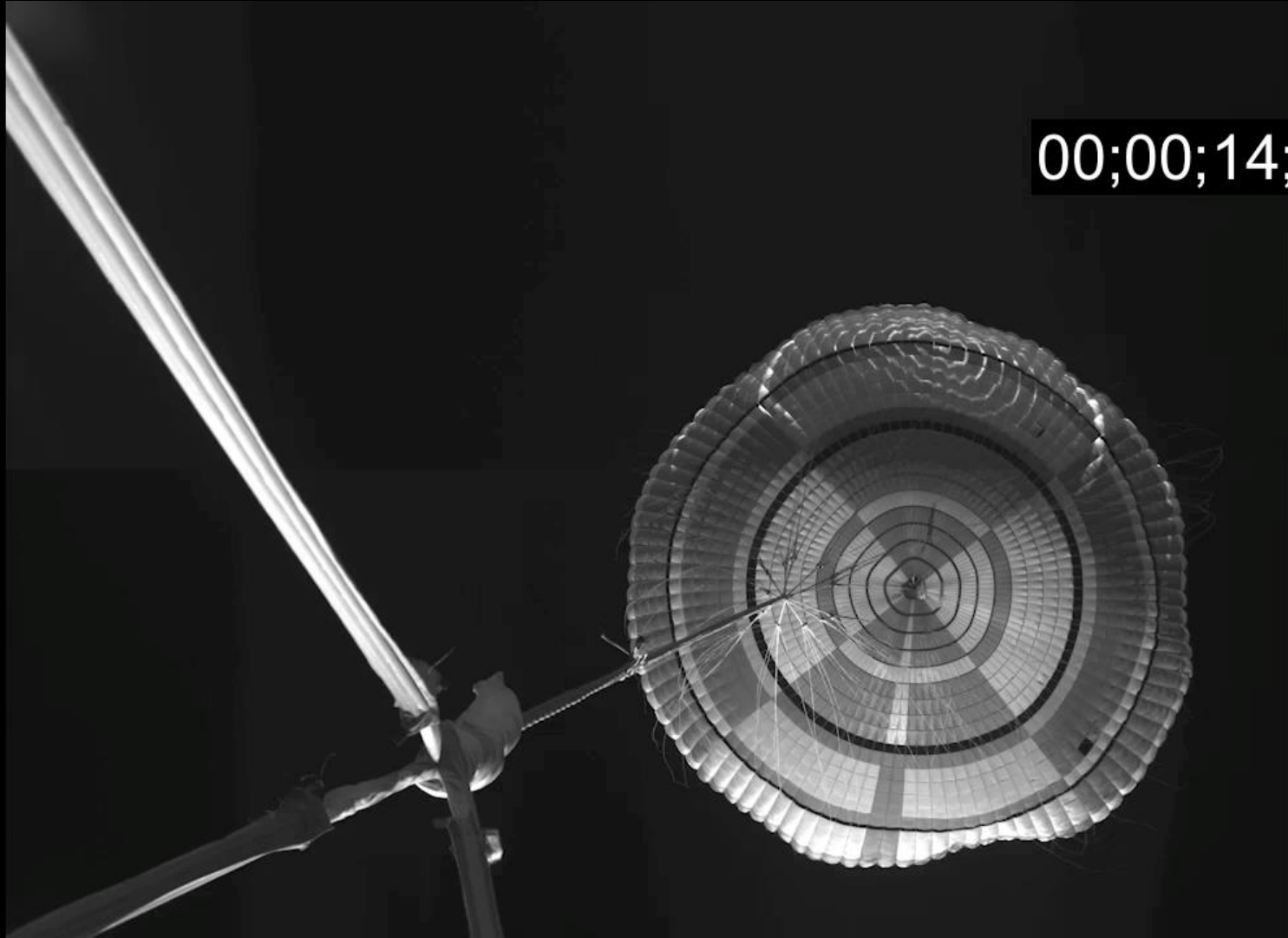
00;00;18;27

SFDT2 High Altitude Supersonic Flight



00;00;15;29

SFDT2 High Resolution Deployments

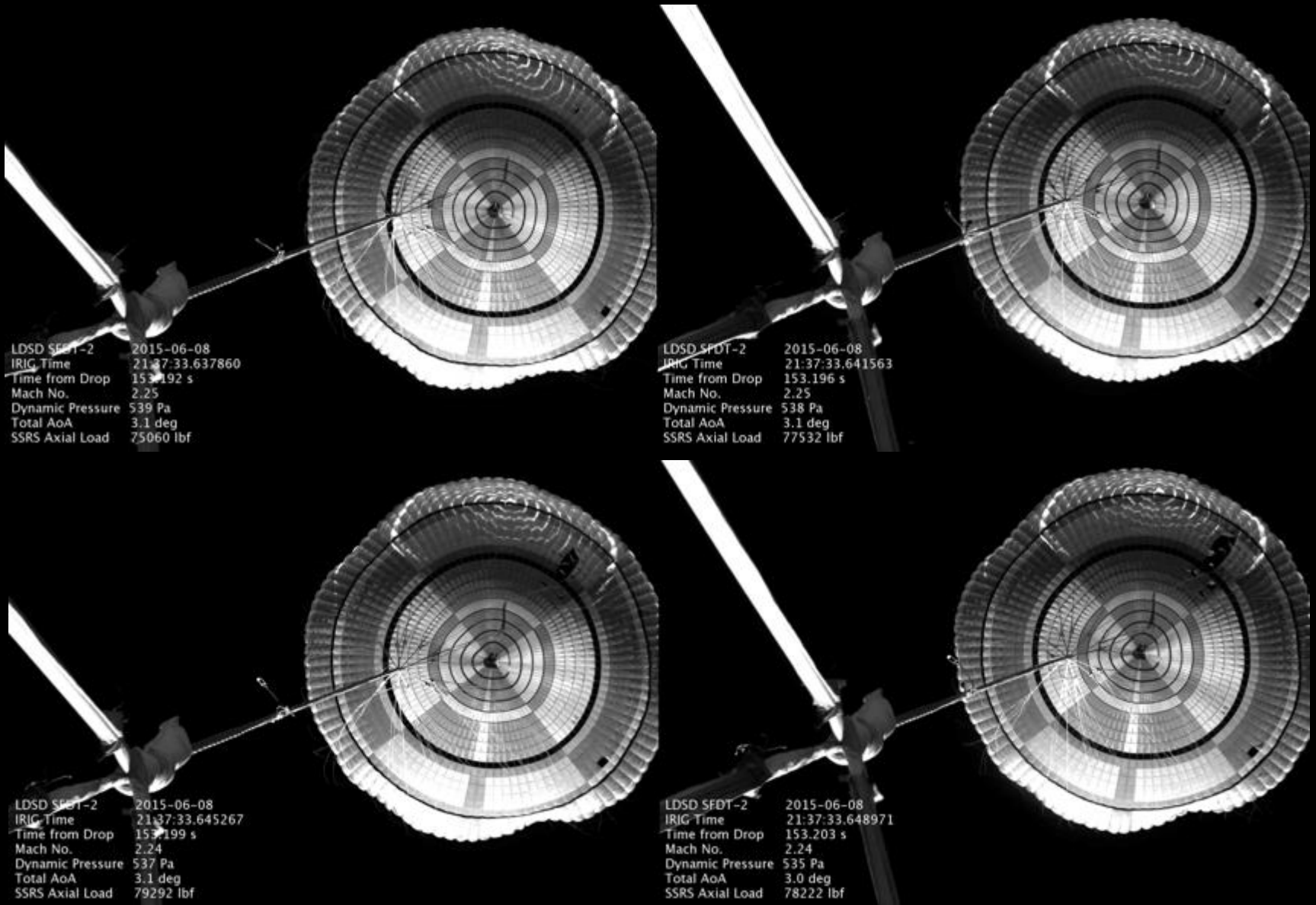


00;00;14;14

SFDT2 Recovery



SFDT2 Damage Progression



SFDT-2 Investigation Status

- SFDT-1 yielded best set of data on a supersonic parachute, ever
- SFDT -2 was even better
- Parachute advanced through inflation process much further than in SFDT-1 and ultimately failed at full inflation
 - SFDT-1 remedy was successfully demonstrated
- Three families of hypotheses being actively worked for SFDT-2 parachute
 - Material and fluid inertial forces significantly larger than expected
 - Pressure forces significantly larger than expected and asymmetric
 - Material/Seam and Joint strength not as expected under loading environment
- *We are in the midst of a paradigm shift in our understanding of supersonic parachutes*

Key LDSD Accomplishments in the Past Year

Technologies

- Successfully conducted 2nd Supersonic Flight Dynamics Test
- Successfully matured two separate supersonic decelerators to TRL-6
 - SIAD-R and ballute both largest ever of their kind and both exceeded performance expectations
- Successfully conducted structural and inflation test of 8m SIAD-E
 - SIAD-E progressing towards TRL-5
- Successfully conducted three separate structural tests of a 30.5 m parachute
 - Each test yielded valuable insight into design and construction details of large parachutes
- Continued to rewrite the textbook on supersonic parachutes
 - Lessons learned have been shared with industry and numerous flight projects utilizing soft good decelerators

Documentation

- Presented over two dozen papers at aerospace technical conferences
 - Including five full sessions at the AIAA Aerodynamic Decelerator Systems Conference
- Completed 400+ page SFDT-1 Post-Test Report
- Completed draft of SIAD-R Technology Archive Report
 - Continuing to progress on other Technology Archive Report