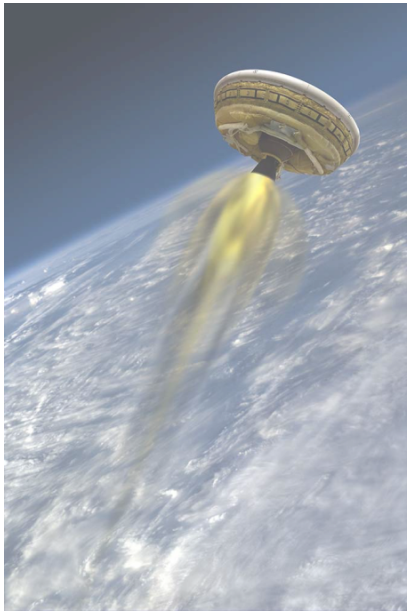
Jet Propulsion Laboratory
California Institute of Technology

LDSD



**Subject:** **V&V on a NASA Technology Demonstration Project: Low Density Supersonic Decelerator (LDSD)**

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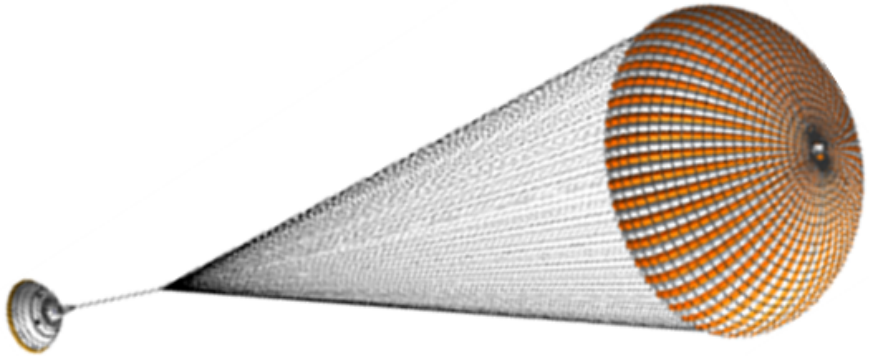
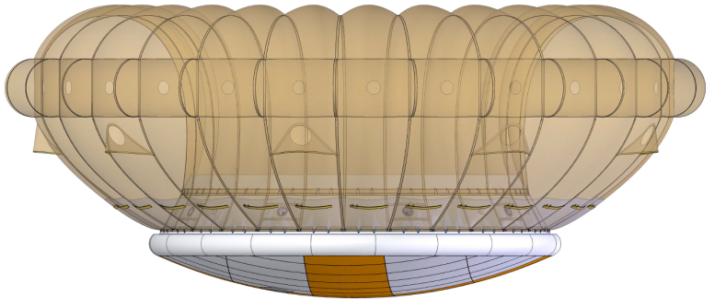
# Project Overview (1/3)



- Funded by NASA's Space Technology Mission Directorate (STMD) to develop, test and qualify new supersonic atmospheric decelerator technologies for future missions
- LDSD is developing three supersonic drag devices:
  1. SIAD-R: Supersonic Inflatable Aerodynamic Decelerator Robotic Class (6m diameter)
  2. SIAD-E: Supersonic Inflatable Aerodynamic Decelerator Exploration Class (8m diameter)
  3. 30.5m Nominal Diameter Supersonic Parachute





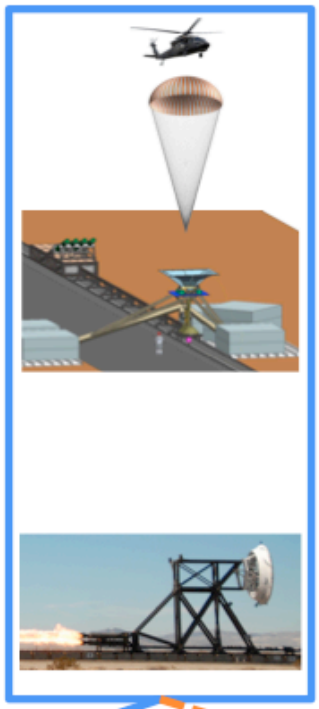
# Project Overview (2/3)



**Phase 1: Initial Deployment**

***Phase 2: Inflation Dynamics***

**Phase 3: Peak Strength**



**Phase 4: Supersonic Performance**

**Phase 5: Subsonic Performance**

**Design Verification**

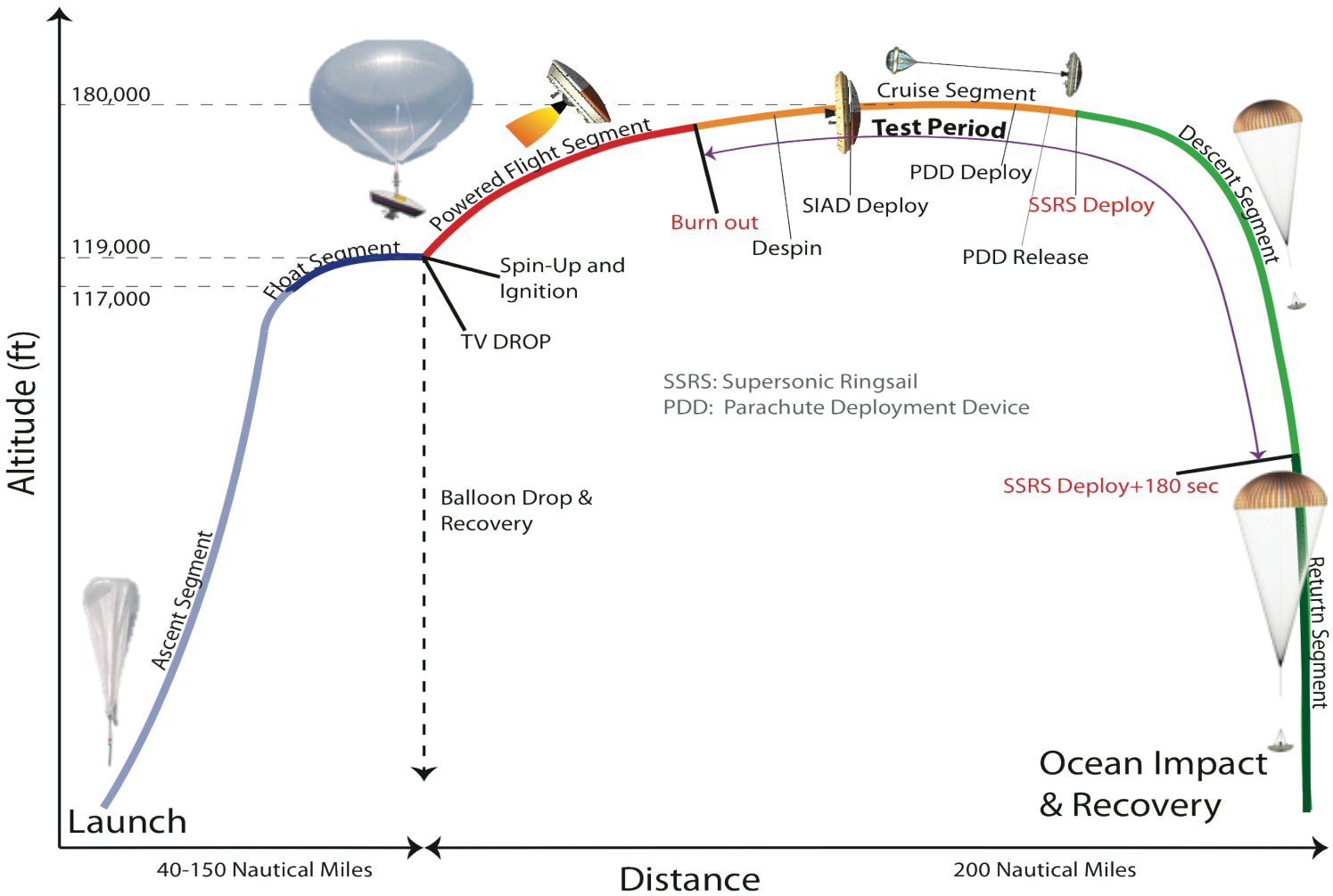
Full scale hardware testing to verify design functionality & integrity

**Flight Dynamics**

Supersonic and subsonic flight testing to verify flight dynamics and aerodynamic performance in relevant conditions

# Project Overview (3/3)

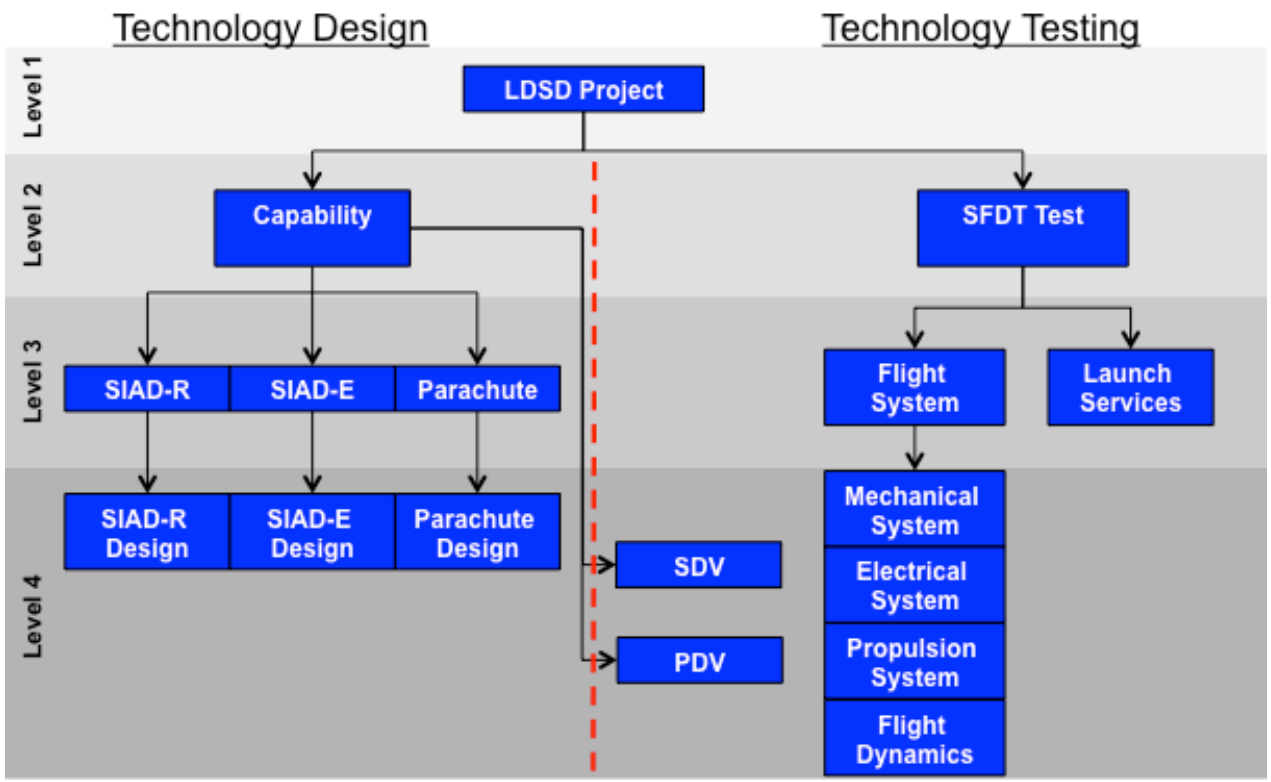




# Requirements



- Unique requirement structure reflects project objectives
- Two aspects: 1)Technology Design and 2)Technology Testing
- Requirements and V&V evidence captured in DOORs
  - ~ 700 requirements



# V&V Challenges



| Challenge | Solutions |
| --- | --- |
| • V&V Schedule Constraint | • Requirement Classification |
| • V&V Tracking & Reporting | • Simple Logistics Reporting |
| • V&V Closure Process | • Streamlined Closure Process |
| • How to V&V after each test? | • Defined Re-flight V&V Criteria |

# V&V Approach and Practices (1/2)

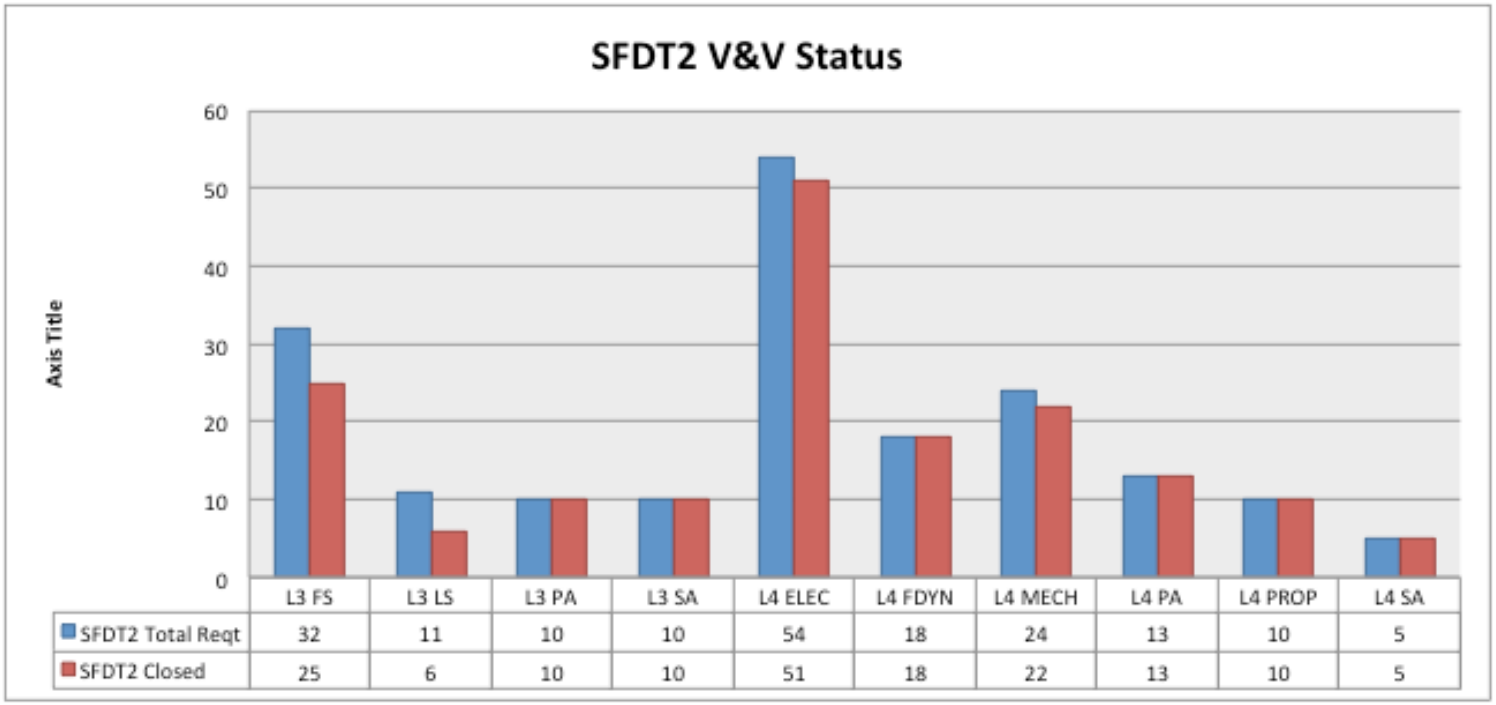


## 1. Requirement Classification

- Safety Critical
- Flight Worthiness
- Scientific Integrity

## 2. V&V Tracking

- No burndown plots
- Simple dxl scripts to collect V&V logistics: closure status

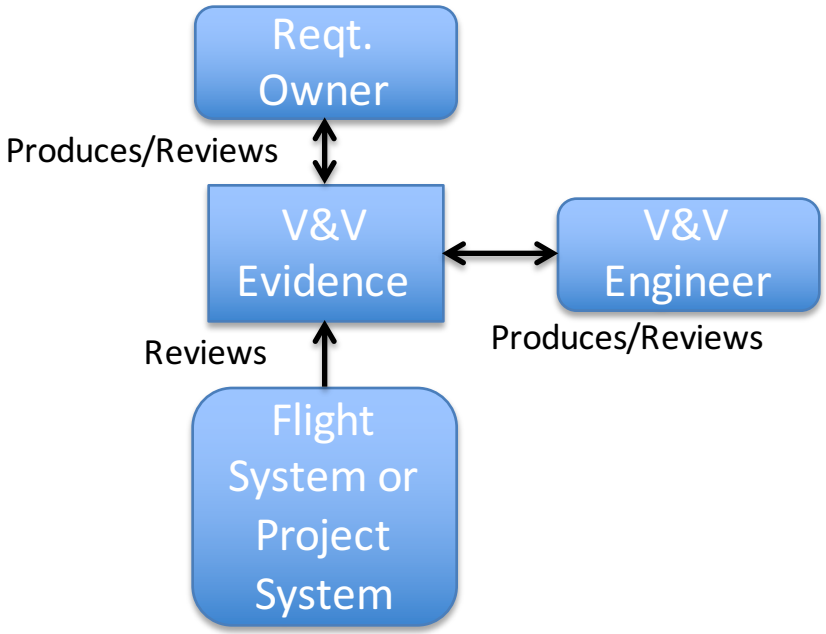



| | L3 FS | L3 LS | L3 PA | L3 SA | L4 ELEC | L4 FDYN | L4 MECH | L4 PA | L4 PROP | L4 SA |
|---|---|---|---|---|---|---|---|---|---|---|
| SFDT2 Total Reqt | 32 | 11 | 10 | 10 | 54 | 18 | 24 | 13 | 10 | 5 |
| SFDT2 Closed | 25 | 6 | 10 | 10 | 51 | 18 | 22 | 13 | 10 | 5 |

# V&V Approach and Practices (2/2)



## 3. Requirement V&V Closure Process




## 4. Re-Flight V&V Planning

- Requirements selected for re-verification
  - Design Changes
  - Workmanship
  - Failed Requirements
  - Extra Credit
- Requirements NOT selected for re-verification
  - One-off Analysis
  - One-off Tests
  - System Level Protoflight Tests

# Lessons Learned



- Start V&V planning early and maintain V&V oversight through development
- By classifying the requirements into categories, the verification rigor can be tuned for each category allowing more prioritization on how and when requirements are verified
- Establish a criteria on which requirements needed to be re-verified early and revisit these requirements often and between each test
- Aside from requirement verification, other verification activities such as parameter and phasing verification are important to ensure the success of SFDT
- Same equipment used for ground testing were also use for operations; this greatly improved confidence in operating the test vehicle at launch
- Simple V&V logistics were sufficient for V&V management on a technology demonstration project

# Conclusion



- Fast paced project that required an efficient and flexible V&V planning and execution
  - Requirement Classification
  - Flexible V&V Logistics Reporting
  - Simple V&V Review Processes
- Unique V&V challenge: how to determine which requirements were to be re-verified for each tests

# Questions?

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