MERS SplashSat

University of Victoria, User Presentation,
UNISEC First Global Meeting,
University of Tokyo,
November 24, 2013

Presentation Overview

- Need (Problem Statement)
- Idea Statement (Fulfilment of Need)
- Business Case
- Business Challenges
- Program Overview
- Payload Environment Requirements
- Prototype Mission

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Statement of Need

- Need for micro-gravity research platform to conduct materials and other research
- Existing options:
  - ISS
  - NanoRacks (also ISS)
  - Custom Built satellite (long development time, high cost)
- This restricts access thus slowing down research rate

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Idea Statement

- Recoverable Micro-satellite for materials and various research in microgravity
- Recoverability allows for precise evaluation of materials
- Initial mission is to develop and test the technology required for a recoverable Micro-satellite

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YEARS

Business Case

- NanoRacks is primary competition, but ISS has finite life (scheduled for 2028 decommission)
- The bar for costs to make business feasible per eq. U
  - NanoRack 1U experiment cost $60k, limited to 30 days
  - NanoRack 1U cube launch $73k
  - THIS DOES NOT INCLUDE RETURN TRIP - data only
- Experiment size, scope not limited to Cube standard with our satellite

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Business Challenges

- Large Satellite players are looking into this area – example: SpaceX Dragon Lab
- Reducing cost below that of waiting for space on the ISS
- Liability of failed return
- Ratio of materials and technology required for recoverability to weight available for experiment

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System Requirements: Power

- Power: Greater than 2W power/ 2W cooling per equivalent “U”
- ADCS power requirements must be met
- Power available for communication system

Payload Requirements: Environment

- Pressurized environment
- Should have multiple gas environment options available
- Active thermal environmental control with response to set point requests
- Temp ranges TBD

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System Requirements: Mission

- Duration: Must be able to provide greater than 30 day mission
- Completion: Must be able to re-enter to recover samples/ payload
- Sample recovery
- Minimize vibration of re-entry through damping (for crystal structure survival, other experiments)

System Requirements: Re-Entry/ ADCS

- ADCS: Must have non-gaseous ADCS (gas mass capacity needed for payload environment)
- ACDS potentially not needed for orbiting except to avoid high spin rates and activate controlled re-entry
- Re-Entry of either entire craft or a payload “capsule” a must for items such as

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Technical Demonstration Mission

- Initial Mission: The initial test flight of the craft will be performed with a telemetry gathering payload.
- Payload would test all systems of vehicle. Tests would include requesting atmosphere changes/ thermal changes/ data packet transmission
- Payload would record entire flight profile for use with future mission payload design

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Ability to Complete Design Phase

- University of Victoria:
  - Undergrad Student Capstone projects
  - Work Terms

- University of New South Whales
  - Graduate Student projects

Conclusion

- There is a need for a recoverable, experimental platform that is generic enough to support a wide variety of payloads
- The ability to have the experiment return is a new and useful addition to what is currently offered to researchers
- The prototype mission data of re-entry flight profile would be a valuable outcome for the scientific community

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Questions Following Developer Presentation

Thank You to UNISEC

UVic Client Presentation,
UNISEC First Global Meeting,
University of Tokyo,
November 24, 2013

SplashSAT – Developer's Perspective

Dr Sean Tuttle

Never Stand Still

School of Engineering and IT

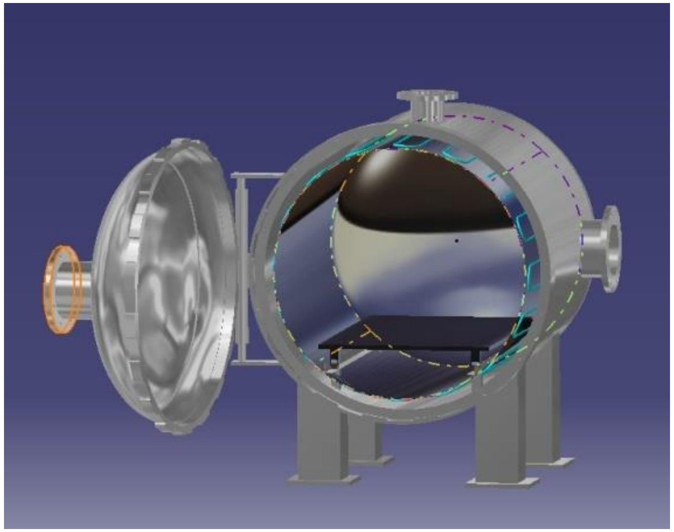
Introduction to the Technical Aspects of SplashSAT

Presentation Outline

- Introduction
- Key mission requirements *(from the developer's point of view)*
- Initial Project Plan & Teaming
- Key Technical Challenges
- Conclusions on Technical Feasibility

Introduction to UNSW Canberra

The University of New South Wales, Canberra



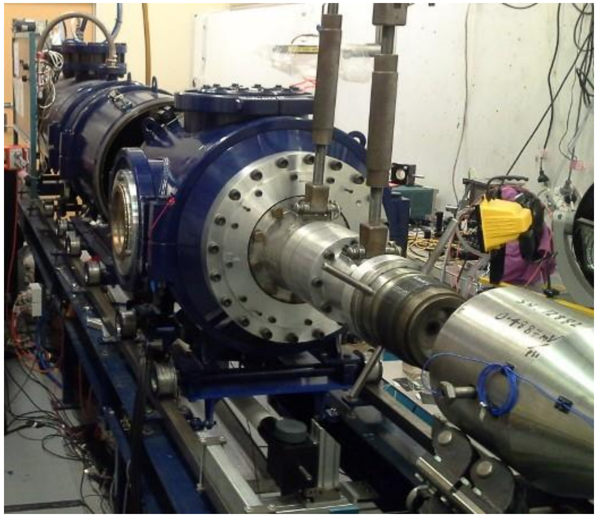
Thermal Vacuum Chamber

UNSW Canberra Team:

Dr Sean Tuttle

A/Prof Andrew Neely

Dr Sean O'Byrne



Hypersonic Shock Tunnel

High Altitude Ballon Launches

Key Mission Requirements

1. Recovery of the satellite and / or payload
2. Payload to comprise 50% of total mass
3. No expulsive AOCS actuators (i.e. Thrusters)
4. Experiment volume to be 255 litres.
5. Thermal & mechanical environments allowed for the experiments

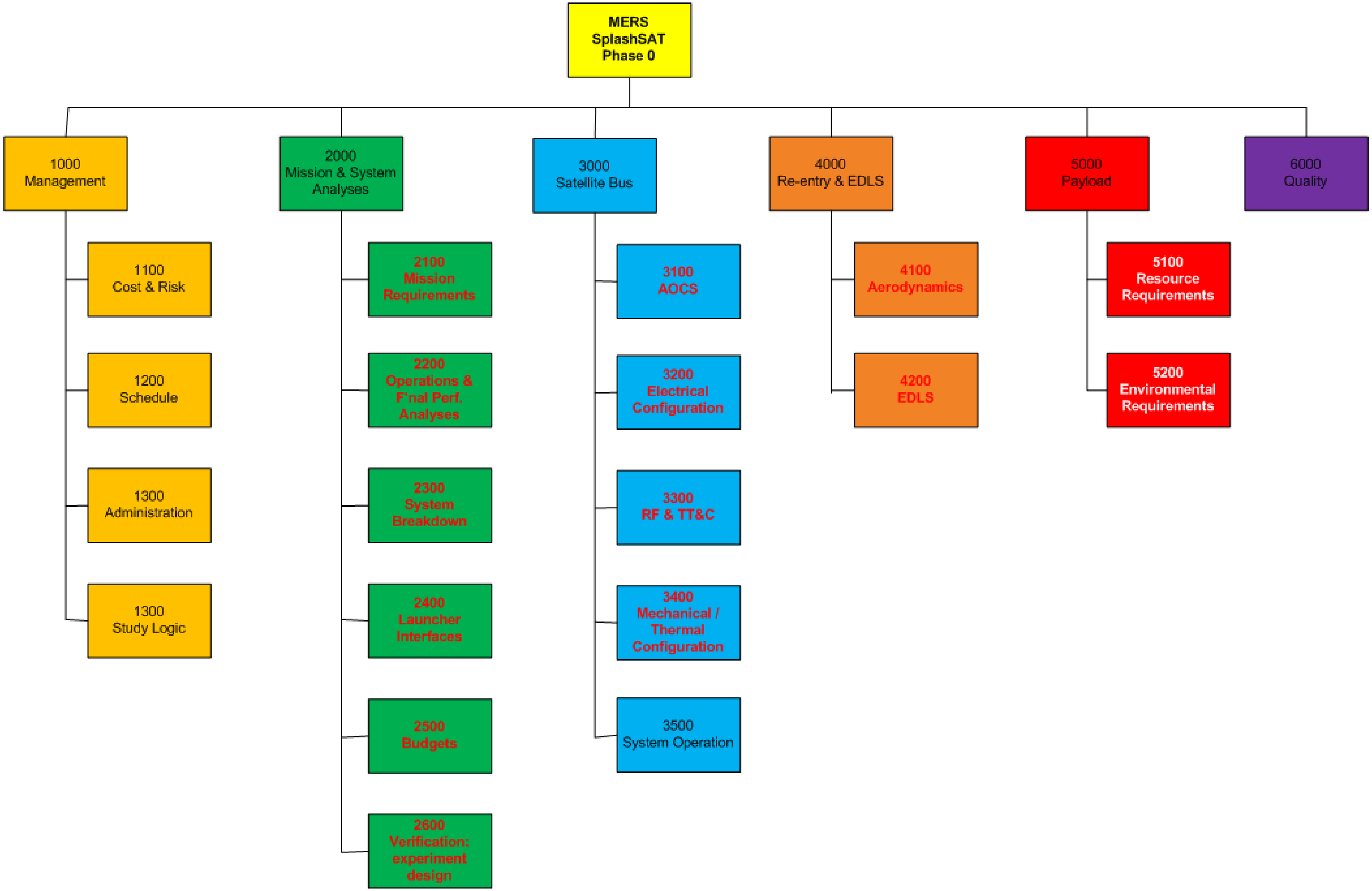
- Number 1 is clearly the most driving of all the requirements. Almost everything else flows on from it – for example:
  - *Recover* ***all or part of the satellite?*** *– drives configuration and internal complexity*
  - *It impacts the* ***mass*** *(via the TPS)*
  - *It impacts the* ***configuration*** *(via required aerodynamic shape and location of C-of-G for stability during EDL)*
  - *Likely need for a controlled re-entry (eg so we know where to find it) implies a certain minimum level of sophistication in the* ***AOCS*** *(therefore, it implies an AOCS)*
  - *Location after landing means some* ***power*** *is needed for the EDL phase; external shape impacts power, too*
  - *The* ***thermal*** *design is clearly dominated by the re-entry phase*
  - *The configurational constraints impact the maximum* ***volume*** *available for the experiment compartment(s)*
  - *Complicates the* ***programmatics***

Initial Project Plan & Teaming

CURRENT STATUS

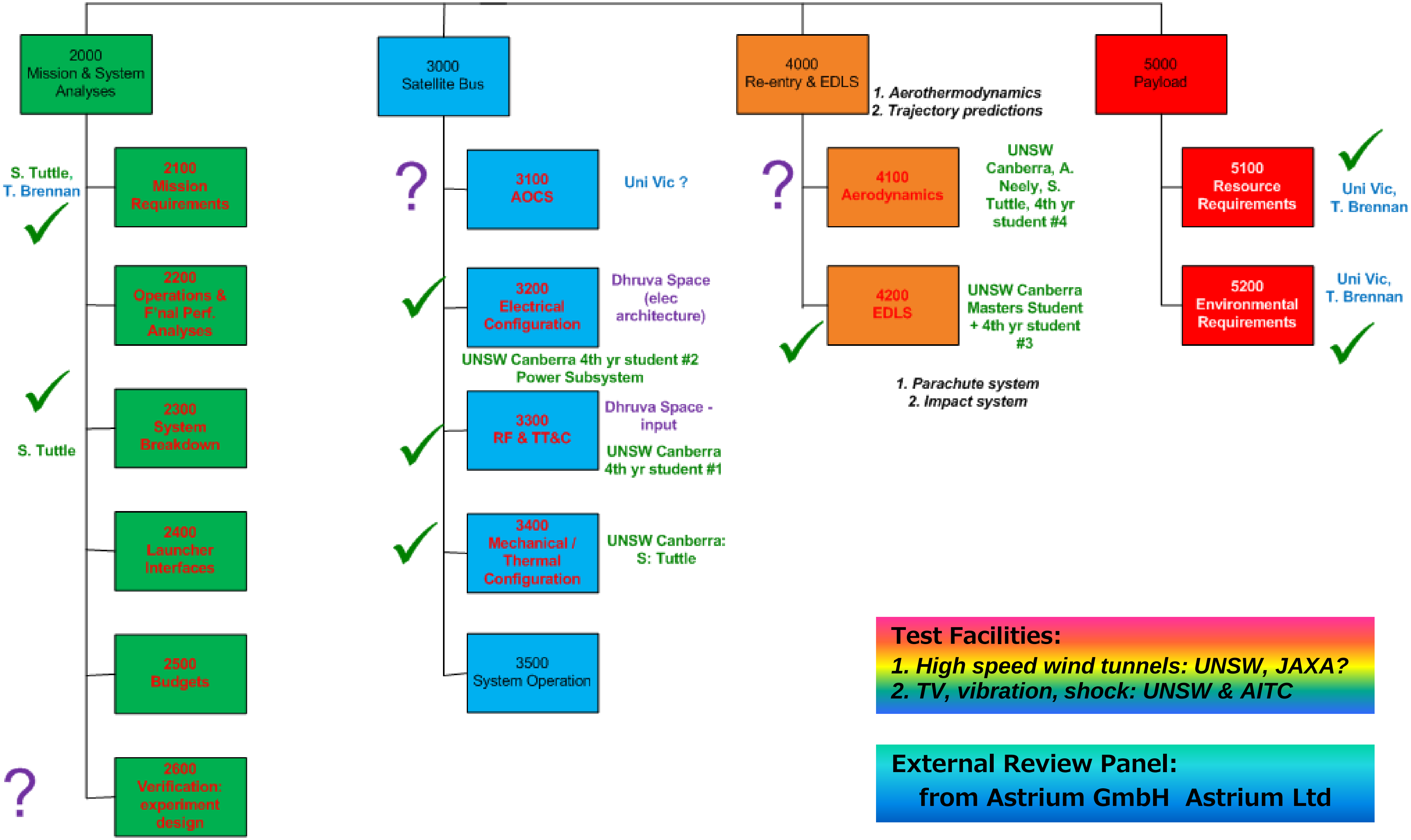
1. The Work Breakdown Structure - WBS
2. Initial thoughts on teaming – the SplashSAT Consortium
3. Generation of a Mission & Systems Requirement – a document from which we can all work.

Project Structure - WBS



- **MERS SplashSAT Phase 0**
  - 1000 Management
    - 1100 Cost & Risk
    - 1200 Schedule
    - 1300 Administration
    - 1300 Study Logic
  - 2000 Mission & System Analyses
    - **2100 Mission Requirements**
    - **2200 Operations & F'nal Perf. Analyses**
    - **2300 System Breakdown**
    - **2400 Launcher Interfaces**
    - **2500 Budgets**
    - **2600 Verification: experiment design**
  - 3000 Satellite Bus
    - **3100 AOCS**
    - **3200 Electrical Configuration**
    - **3300 RF & TT&C**
    - **3400 Mechanical / Thermal Configuration**
    - 3500 System Operation
  - 4000 Re-entry & EDLS
    - **4100 Aerodynamics**
    - **4200 EDLS**
  - 5000 Payload
    - **5100 Resource Requirements**
    - **5200 Environmental Requirements**
  - 6000 Quality

Progress on the Project Set-up & Teaming



2000
Mission & System Analyses

2100
Mission Requirements

S. Tuttle,
T. Brennan
✓

2200
Operations & F'nal Perf. Analyses

2300
System Breakdown

✓
S. Tuttle

2400
Launcher Interfaces

2500
Budgets

2600
Verification: experiment design

?

3000
Satellite Bus

3100
AOCS

?
Uni Vic ?

3200
Electrical Configuration

✓
Dhruva Space (elec architecture)

UNSW Canberra 4th yr student #2
Power Subsystem

3300
RF & TT&C

✓
Dhruva Space - input

UNSW Canberra 4th yr student #1

3400
Mechanical / Thermal Configuration

✓
UNSW Canberra:
S: Tuttle

3500
System Operation

4000
Re-entry & EDLS

1. Aerothermodynamics
2. Trajectory predictions

4100
Aerodynamics

?
UNSW Canberra, A. Neely, S. Tuttle, 4th yr student #4

4200
EDLS

✓
UNSW Canberra Masters Student + 4th yr student #3

1. Parachute system
2. Impact system

5000
Payload

5100
Resource Requirements

✓
Uni Vic,
T. Brennan

5200
Environmental Requirements

Uni Vic,
T. Brennan
✓

Test Facilities:

1. High speed wind tunnels: UNSW, JAXA?
2. TV, vibration, shock: UNSW & AITC

External Review Panel:

from Astrium GmbH Astrium Ltd

Technical Challenges – the „Top 5“

The TOP 5 Technical Challenges:

1. Re-entry heating
2. Stability during re-entry
3. Finding the right configuration (impacts the LV volume/compatibility, the expt volume, the dynamic behaviour, the aerothermodynamic heating, the solar power collection capability…)
4. De-orbiting. Starting it, controlling it.
5. Mass or Power? POWER, probably

Non-Technical Challenges:

- Finding & funding a launch
- Ground stations
- Funding in general
- Legal: regulatory & safety aspects of re-entry and recovery; selection of landing site(s)

Technical Challenges – how will we deal with them?

1. Re-entry heating
   - Use a simple, well proven shape (sphere-cone)
   - TPS technology – two options: (1) use latest developments or (2) use a well-established one
   - Make it one of the first design and trade-off and analysis tasks.
   - Use CFD initially. Try to test early and on ground (eg in UNSW, shock tunnel, JAXA arc tunnel?)
2. Stabilty during re-entry
   - Choose a controlled de-orbit to provide best start of re-entry
   - Use an inherantly stable shape and use UNSW Canberra in-house expertise to analyse
   - For simplicity, have to assume no attitude control during re-entry
3. Finding the right configuration
   - Agree on and freeze mechanical envelope EARLY. WHY?, Because it

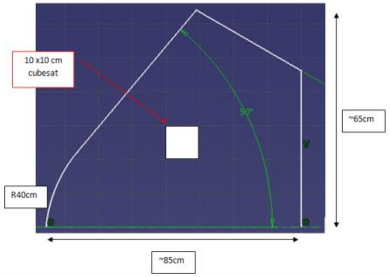
a) impacts our launcher compatibility (use of excess or complex volume as a minor secondary passenger would be very constraining)

b) It directly impacts the experiment volume we can offer to potential customers,

c) In turn, it affects the dynamic behaviour (via location of the C-of-G)

d) It impacts the aerothermodynamic heating loads

e) On orbit, it impacts the solar power collection capability



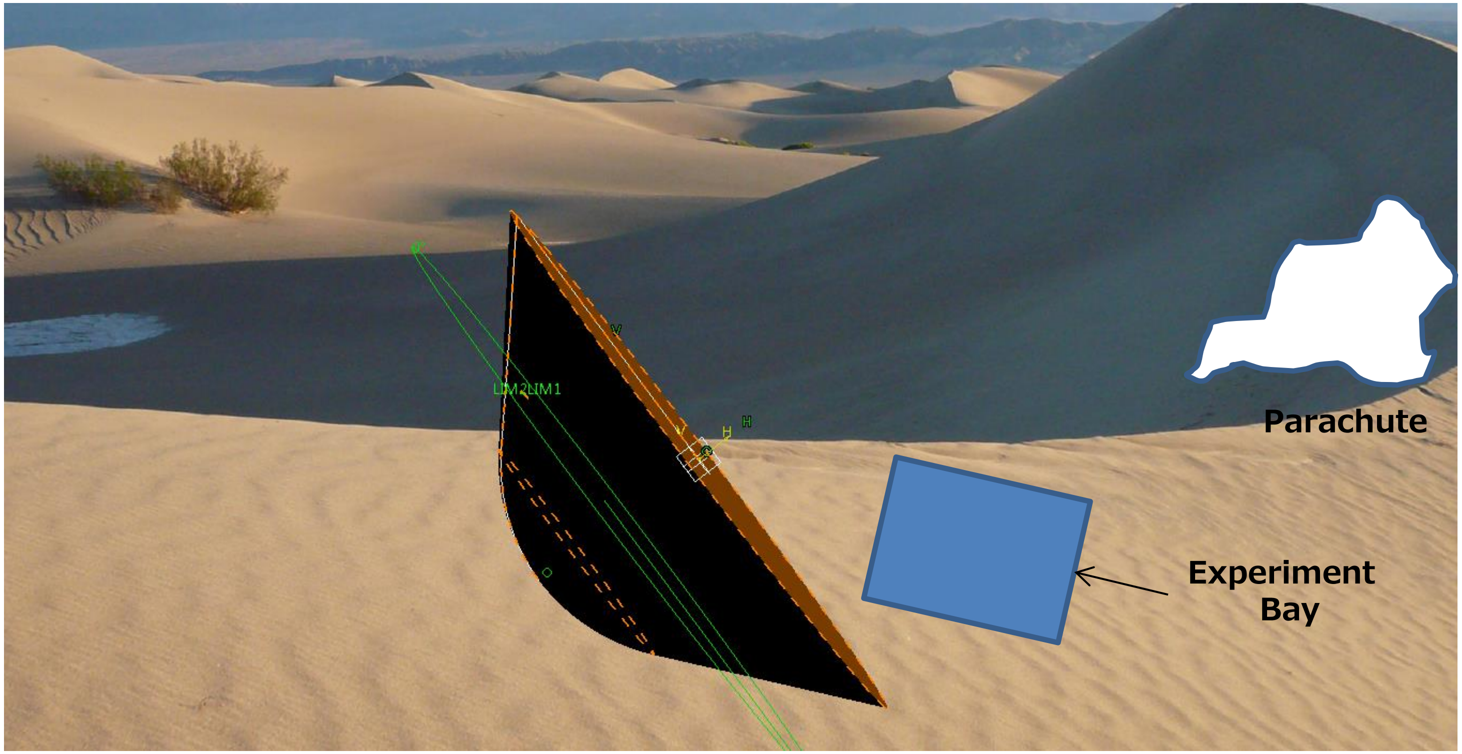
Technical Challenges – how will we deal with them?

4. De-orbiting. Starting it, controlling it.
   - Adopt a controlled re-entry strategy i.e. Not natural orbit decay
   - Talk to those who have – eg lessons learned from JAXA (HYFLEX, Hayabusa), ESA (ARD), DLR (SHEFEX, Mirka), UQ scramjet people (sub-orbital flights), BREM-SAT
   - Examine technologies, such as tethers for cubesat de-orbit, deployable flexible drag devices; avoid anything complex – want simple and reliable
   - Directly impacts design of EDLS
   - Directly impacts regulatory effort, landing site selection & reliability of experiment recovery
5. Power (on-board ,electrical)
   - Make it an early design task
   - Involve innovators and explore new technology where appropriate

OTHER METHODS:

- ***Keep team relatively small during the first 12 months study phase with realistic goals***
- ***Make use of an external technical review panel: members of Astrium Germany and Astrium UK have agreed to help***

A Glimpse of the Future?



Parachute

Experiment Bay