# MERS

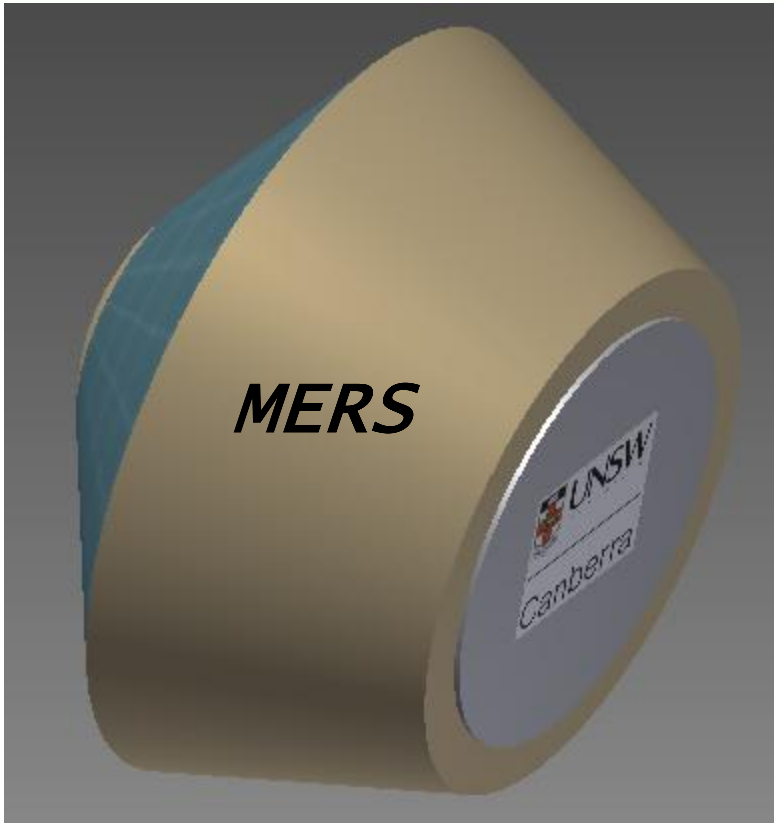
## The Microgravity Experiment Recoverable Satellite

Never Stand Still

School of Engineering and IT

**Presented by: Dr Sean Tuttle**

**Team Members:**
**Kieran Davis,**
**Scott Johnson,**
**Mitchell Woodward,**
**A/Prof Andrew Neely**



# The Mission Idea

*„maintain flexibility to enhance viability"*

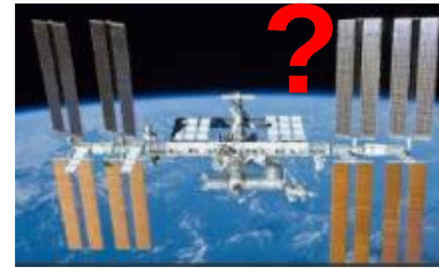



Image: Wikipedia

Aim:

➔ Provide **regular access** to **long-duration microgravity conditions** without the long waiting times of the ISS

**AND** the ability to **retrieve one`s experiment**

**Long-duration** means significantly longer than:

Drop towers

Parabolic flights

Sounding rocket flights

To enable:

R&D for new chemical & manufacturing processes

Biological R&D

Pharmaceutical R&D

Crystal growth & other industrial chemistry R&D

UNSW AUSTRALIA Canberra

# MERS Mission Concept: *balancing flexibility with simplicity*

**Mission is challenging & has clear cost-drivers. So:**

1. **Make MERS compatible with as many experiments, launch-opportunites and orbits as possible**
2. **Keep cost of the MERS vehicle down as far as possible**

**Flexibility**

**Accommodate extremely different experiments ➔ more users**

**Be able to fly in a wide range of orbits ➔ more ride-share opportunities**

**Simplicity**

**Design for one kind of payload**

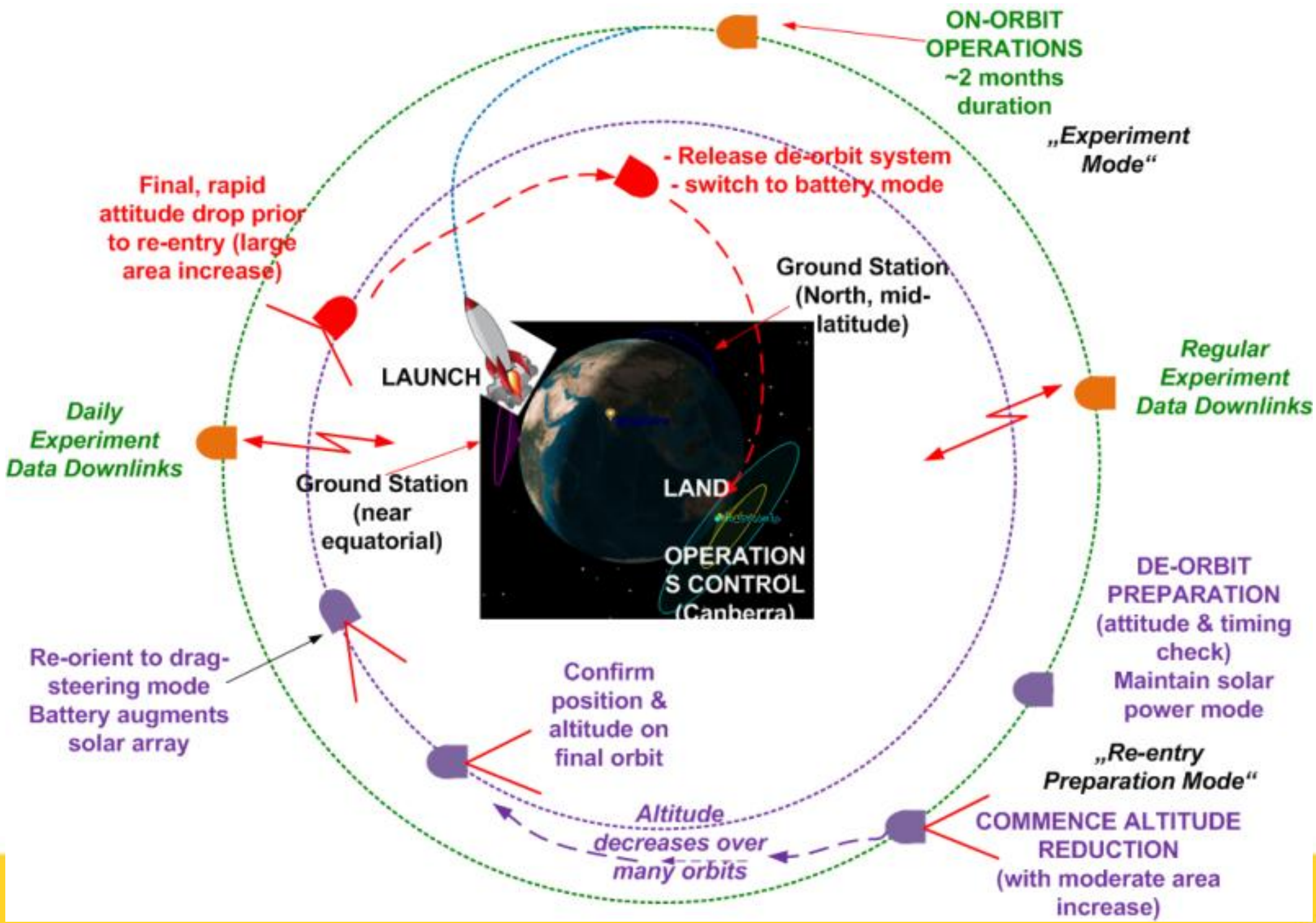
**Design power, TT&C & thermal subsystems for specific scenario(s)**

- **MERS Experiment Package concept**
- **Base subsystems on COTS cubesat components where possible**
- **Design for a range of orbits:**
  - **400-500 km altitude**
  - **47° - 98° inclination**

UNSW AUSTRALIA Canberra

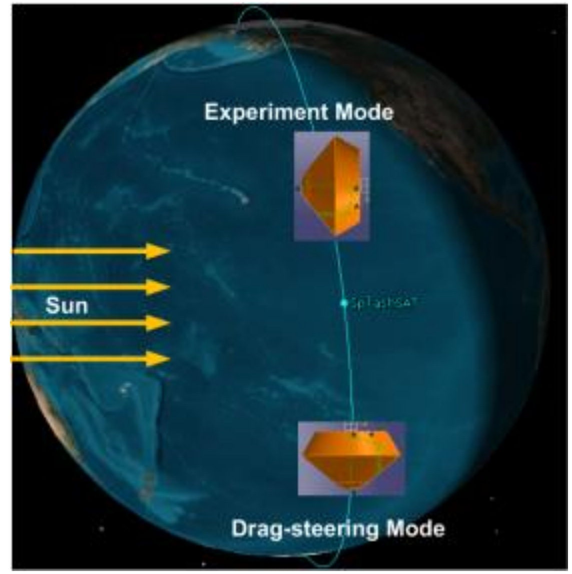
# Concept of Operations

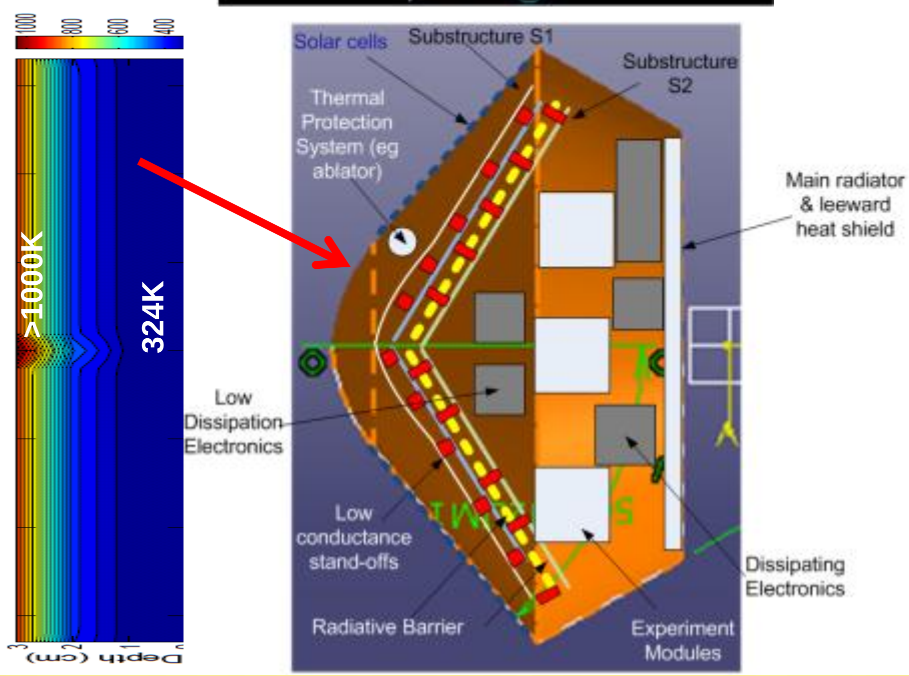
*„maintain flexibility to enhance viability"* - *balancing flexibility with simplicity*



# Space Segment Overview

1. Maximum power = 38W,
   includes 4 x 2W 1U payload modules,
   fixed, body-mounted solar array
2. TT&C: UHF D/L ➔ >10Mbits/day minimum,
   link margin = 6.6 dB
3. Thermal: 20° C on orbit;
   Maximum internal shield temperature during re-entry = 50° C,
   thermal protection system = ablative PICA-type material
4. Structure :
   double-frame, shock-damping
5. Total MERS Mass = 27.3 kg
6. AOCS: reaction wheels, magnetorquers, drag-steering using UHF antennas, sun sensors, horizon sensors




➔ Only deployables: UHF antennas,de-orbit device

➔ No parachute = current baseline

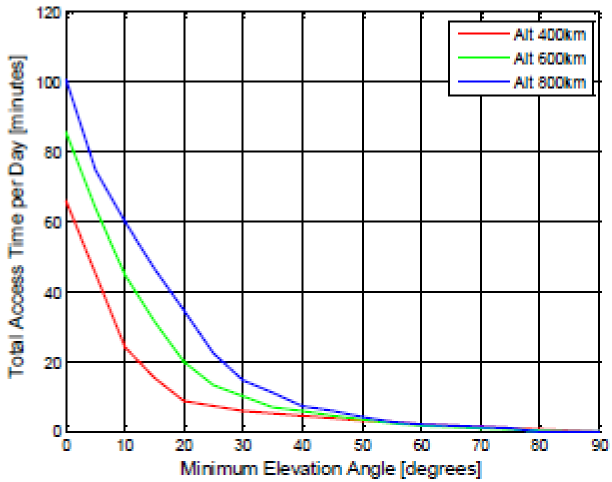
➔ ***Means high reliability***

# Key Performance Parameters

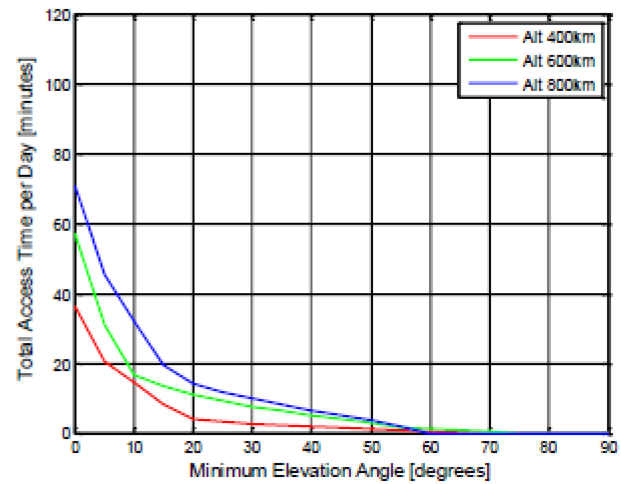
- Level of microgravity
  - Orbit selection & MERS size effectively guarantee μg levels, but quality can be increased by flight orientation, payload location
- On-orbit temperature stability
  - The passive thermal control adopted will achieve degree-range stability; finer control can be added by active heater control, if needed
- Attitude stability
  - This is critical to know and achieve prior to starting re-entry
- Re-entry thermo-mechanical environment
  - Temperature rise must not influence experimental results
  - Deceleration during re-entry and shock at landing must not break the results of the experiments
- Payload Data
  - It must be possible to retrieve all experimental data before starting re-entry
  - It must be possible to retrieve each experiment's data before starting the next

# Ground Segment & Orbital Aspects

**47° Inclination**




**98° Inclination**



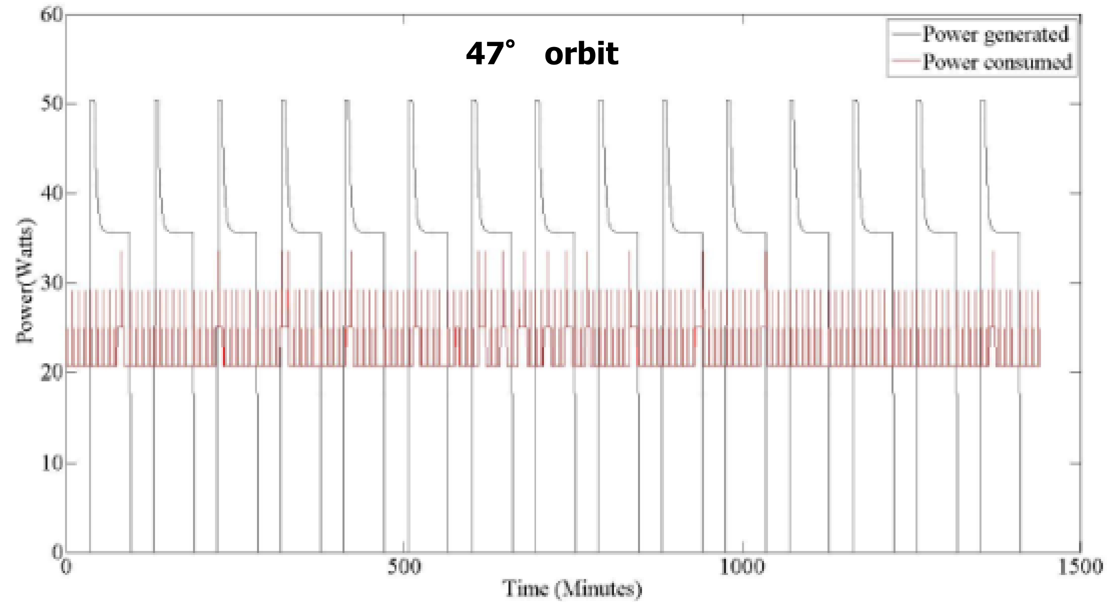

**System can be made to work using a UHF downlink and 1 ground station**

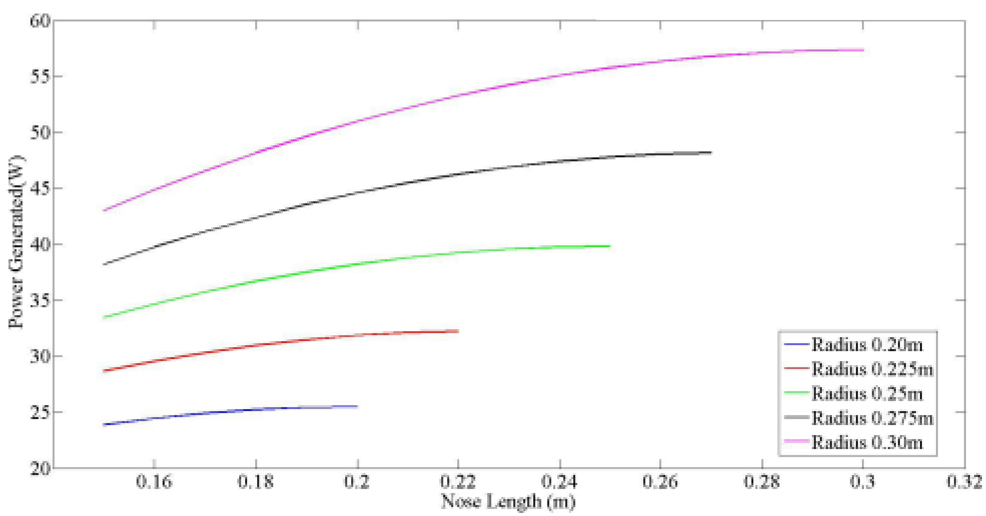
**A network of ground stations is a desirable goal**

# Power Aspects

- 47° orbit is our worst case for power generation, but still works, as can be seen to the left
- 98° orbit is comfortable for power generation

Power generation capability versus MERS nose radius shown below



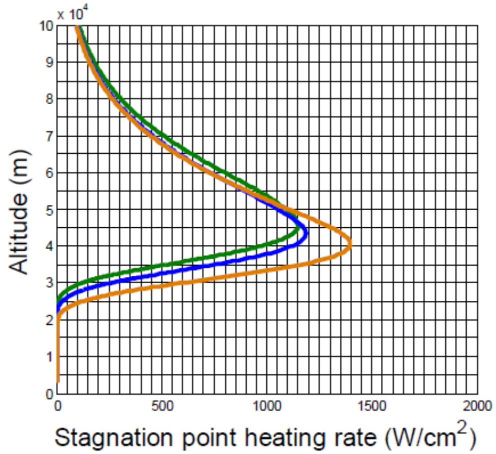



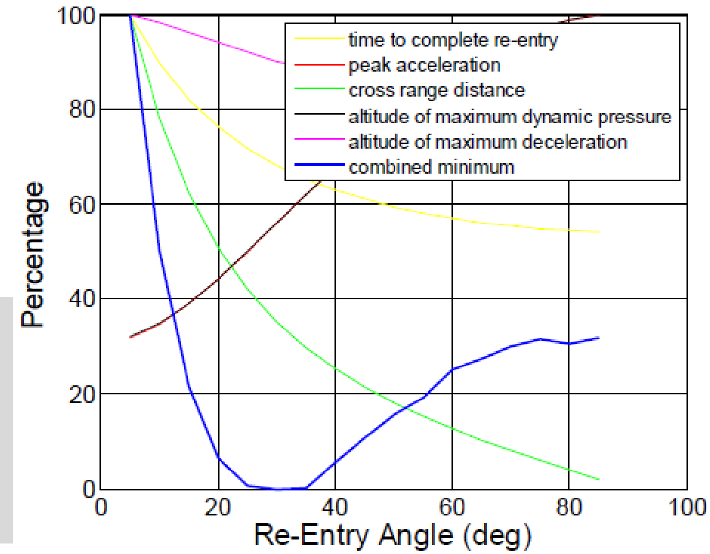

**Regular peaks = reaction wheel usage**

**Sporadic peaks = data downlinking**

# Re-entry Aspects

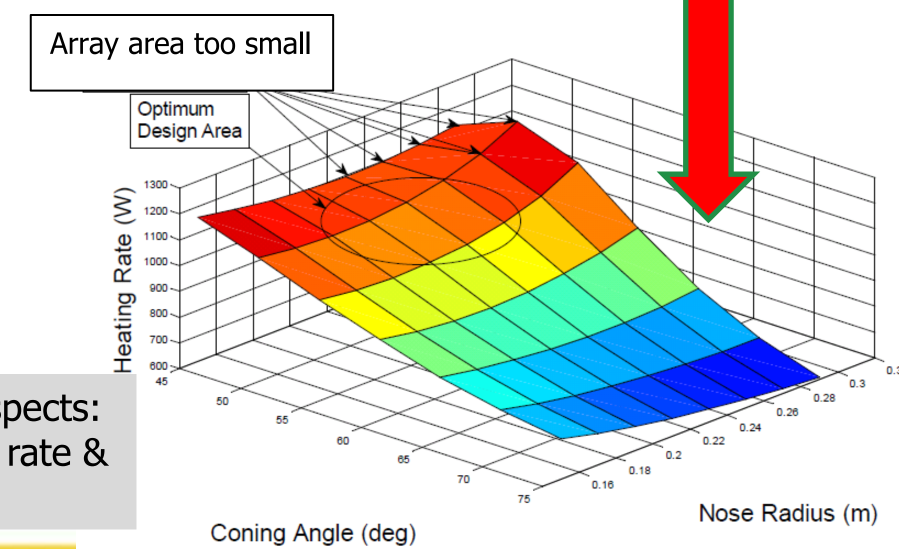
**Peak heating at different re-entry angles**




Find entry angle which is best for all parameters ➔ 30°

Re-entry trajectory (angle) strongly influences key parameters such as heating rate & deceleration




Then look at MERS geometry aspects: here, acounting for heating rate & solar array area

UNSW AUSTRALIA Canberra

# Key Design Aspects - Status

- **Thermal Protection System**
  - ➔ technology development underway with JAXA
  - ➔ UNSW Canberra undergraduate thesis in 2015 to further the trajectory analysis, landing prediction & refine the heat shield characteristics
- **Internal Structure**
  - ➔ UNSW Canberra undergraduate thesis in 2015
- **Leeward Radiator Heat Shield**
  - ➔ concept refinement in 2015
- **Solar cells integrated into heat shield**
  - ➔ concept refinement in 2015 & possible testing in 2015/2016
- **AOCS & Drag steering**
  - ➔ concepts and design to be evolved in 2015-2016

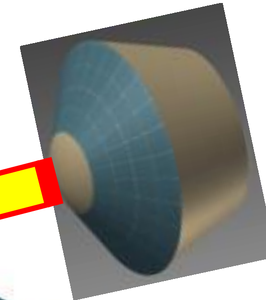
***These technical challenges should be seen as an opportunity:***

***They force us to develop new things***

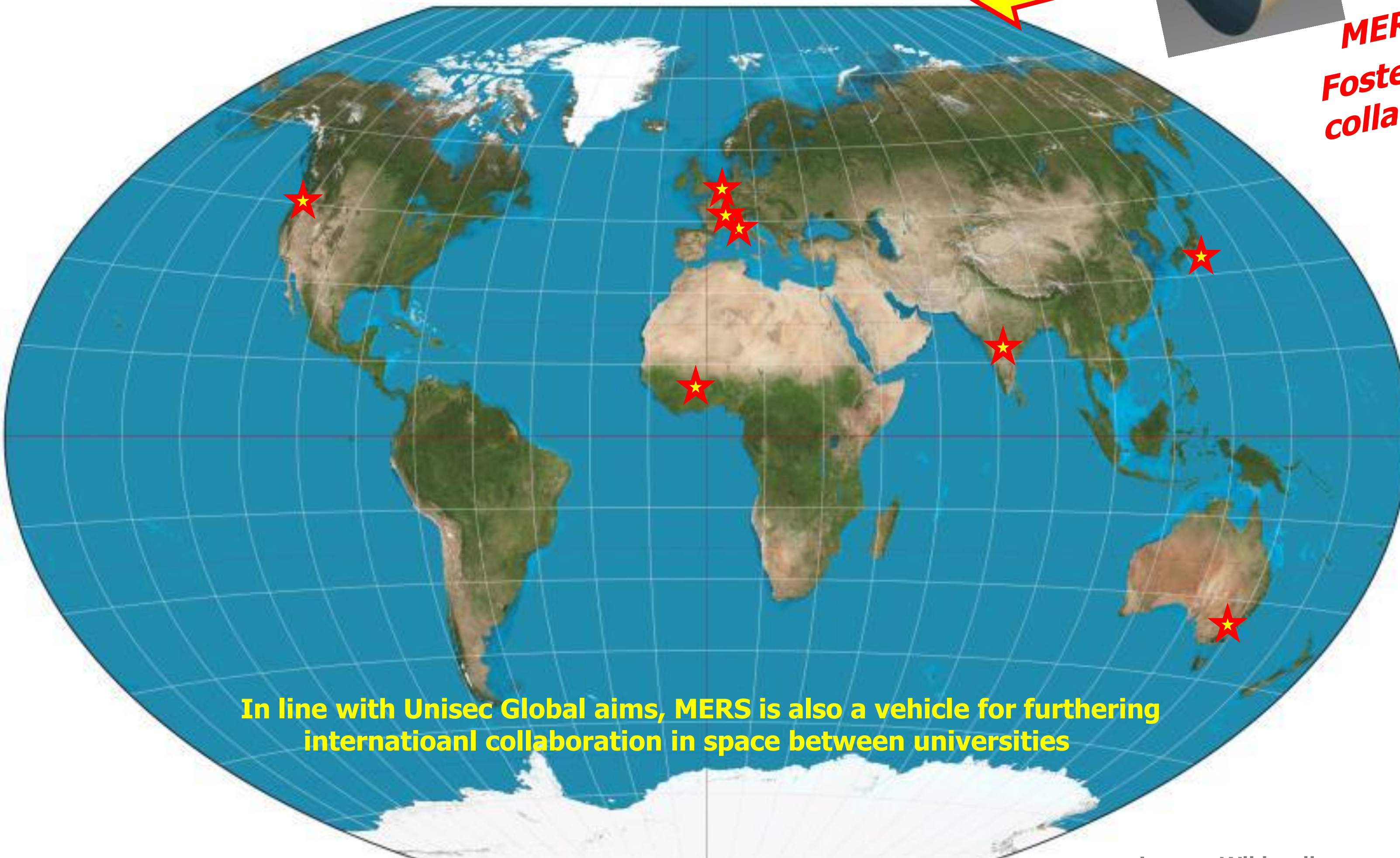
***Some of these clearly have application beyond MERS***

***It is a novel mission!***

# International Collaboration



MERS
Fostering collaboration!



In line with Unisec Global aims, MERS is also a vehicle for furthering internatioanl collaboration in space between universities

Image: Wikipedia

# Business Aspects

**BUSINESS ASPECTS**

- At present, MERS will be challenging to make commercially viable ➔ now, in presence of the ISS
- But, when the ISS is no longer there, the picture will be quite different
- So MERS needs to be considered in this light:
  - A longer term vision(eg operational ~2020), BUT requires planning and preparation NOW
  - This timeframe will allow the necessary development to occur
- Economy of scale: the current size (~ϕ50cm, 27kg) may not be best commercially ➔
  But we have plenty of scope to to explore this further, even within the frame of the MIC3 50kg limit
- MERS experiment module concept is compatible with existing μg offerings in the market place which fly on the ISS
- Will consider giving the experiment marketing & acquisition to an existing commercial enterprise

UNSW AUSTRALIA Canberra

# Programmatic Aspects

**PLANNING & PROGRAMMATICS**

- Grant obtained for initial TPS developmental tests:
  - To be conducted jointly by UNSW Canberra, JAXA with supply of TPS material from KIT (TBC)
  - Letter of support from JAXA for initial TPS developmental tests
- Embedded software has been offered by PnP Software, Switzerland
- UNSW Canberra has commissioned a ground station feasibility study by a consultant
- UNSW Canberra is well underway with the build-up of test facilities which will be used to support the technology developments
- AITC at Mt Stromlo has the necessary infrastructure for clean assembly and testing of flight hardware.
- 2015 will be an important year for MERS:
  - Refinement of the thermal design
  - Initial heat shield testing
  - Detailed evolution of the internal structure & configuration, with some testing
  - Evolution of the attitude control concept for MERS

# Conclusions on MERS

**We have demonstrated that…**

**It works**

**It enables µg R&D**

**It costs**

**Clearly, it is challenging…..**

**but so was Rosetta!**