Materials for the Space Age

London – National Physics Laboratory 2008

New materials technologies for surviving the space environment?

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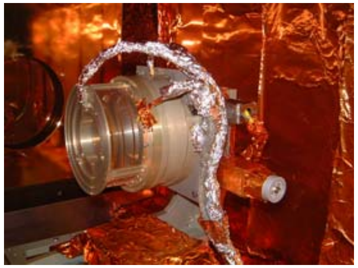
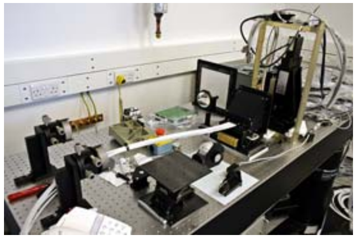
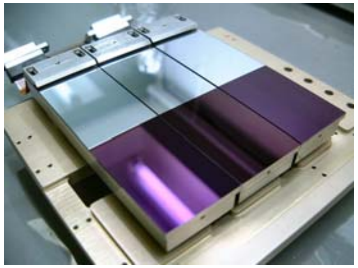
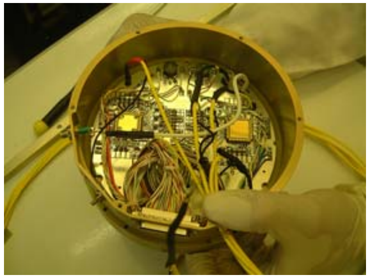
What is MSSL?

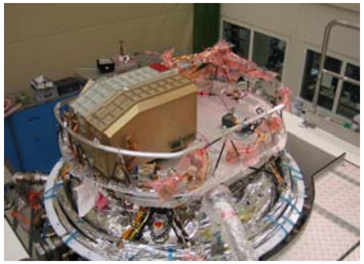






- Mullard Space Science Lab
- University Department
  - Part of University College London
  - Space and Climate Physics
  - Strong Engineering Involvement
    - Largest UK university based space research and engineering group
    - 40 years of space research and instrumentation projects
    - Involved in 273 missions to date
- MSSL: Working along side Scientists within one location
  - Focus on and deliver what they want

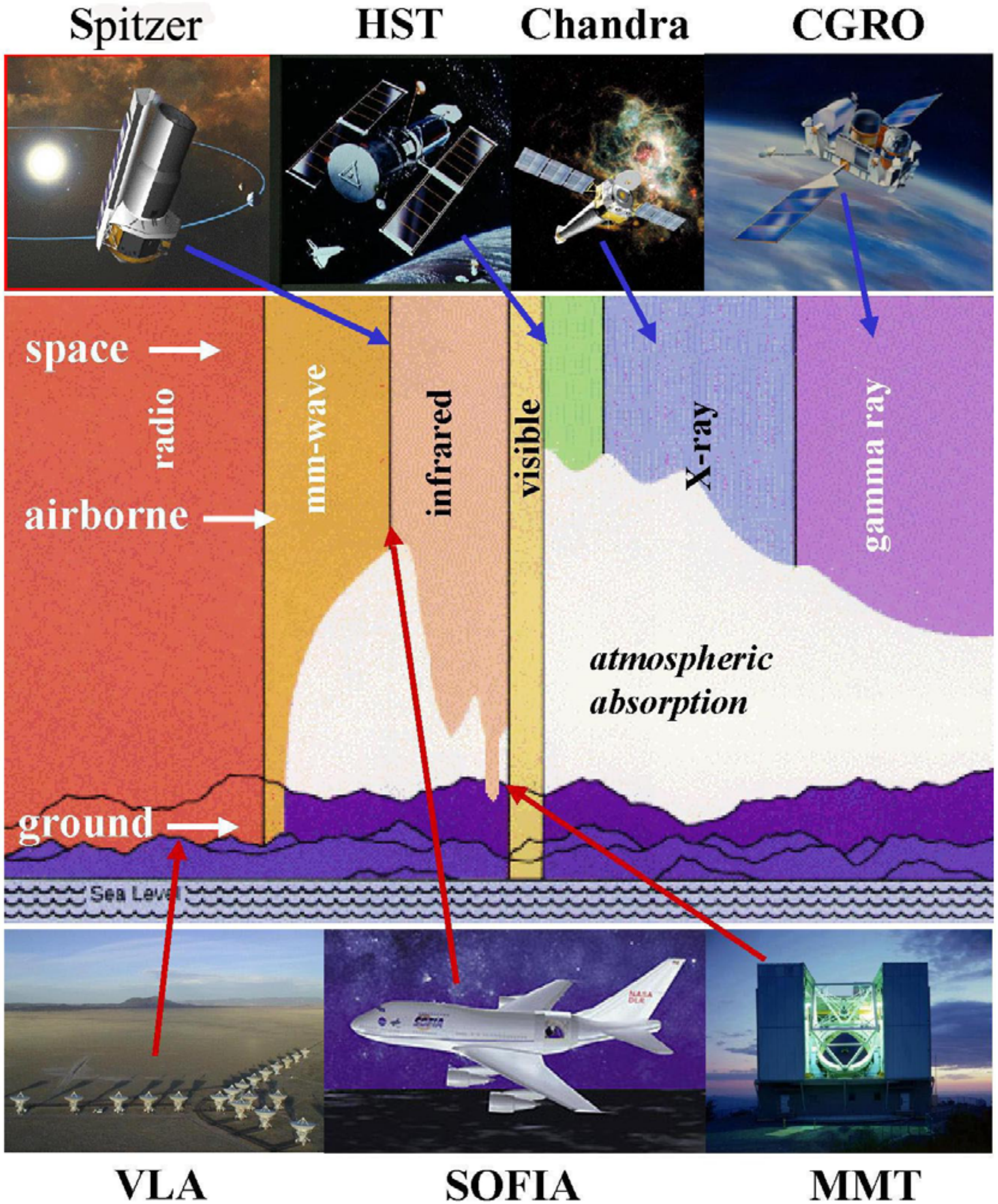




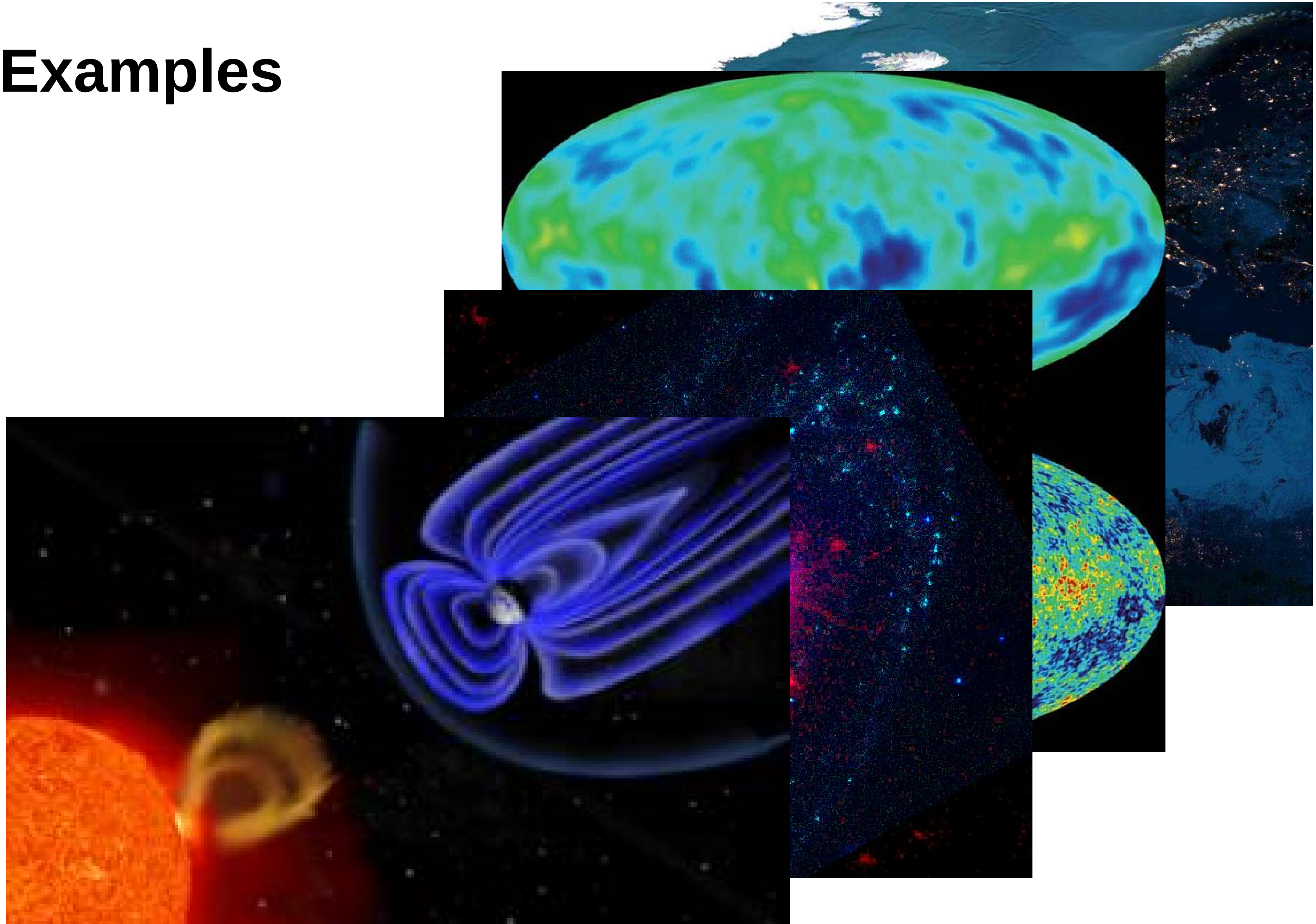
Why Space?

- Astronomy at “other wav
- Remote Sensing
- In Situ

- Communication
- Navigation
- Military



Examples



New Materials – Do *we* want them?

- No
  - Introduction of new materials is time consuming and expensive
  - It ruins the chance of winning any proposal
    - TRL of your application will be (too) low
- New materials will only be applied if it is really necessary
  - They require “road mapping”
  - They require time and money

ESA - Technology Readiness Level

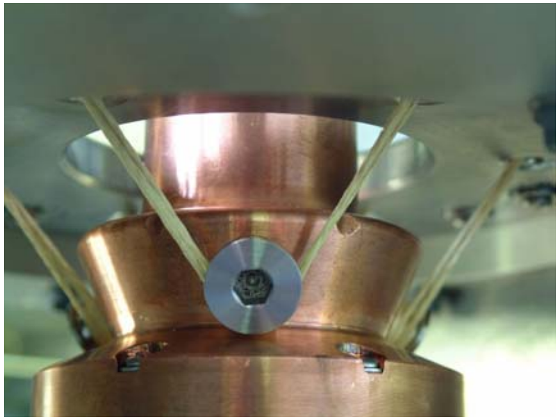
1. Basic principles observed and reported
2. Technology concept and/or application formulated
3. Analytical & experimental critical function and/or characteristic proof-of-concept
4. Component and/or breadboard validation in laboratory environment
5. Component and/or breadboard validation in relevant environment
6. System/subsystem model or prototype demonstration in a relevant environment (ground or space)
7. System prototype demonstration in a space environment
8. Actual system completed and "Flight qualified" through test and demonstration (ground or space)
9. Actual system "Flight proven" through successful mission operations

New Materials at MSSL?

- We don’t develop new materials
- We do however
  - Work together with suppliers to earmark new materials or new applications and help to qualify
  - Mostly coatings/plating/paint/adhesives
    - Peel testing
    - Thermal cycling (down to cyrogenic temperatures)
    - Vibration testing if applicable
    - Outgassing

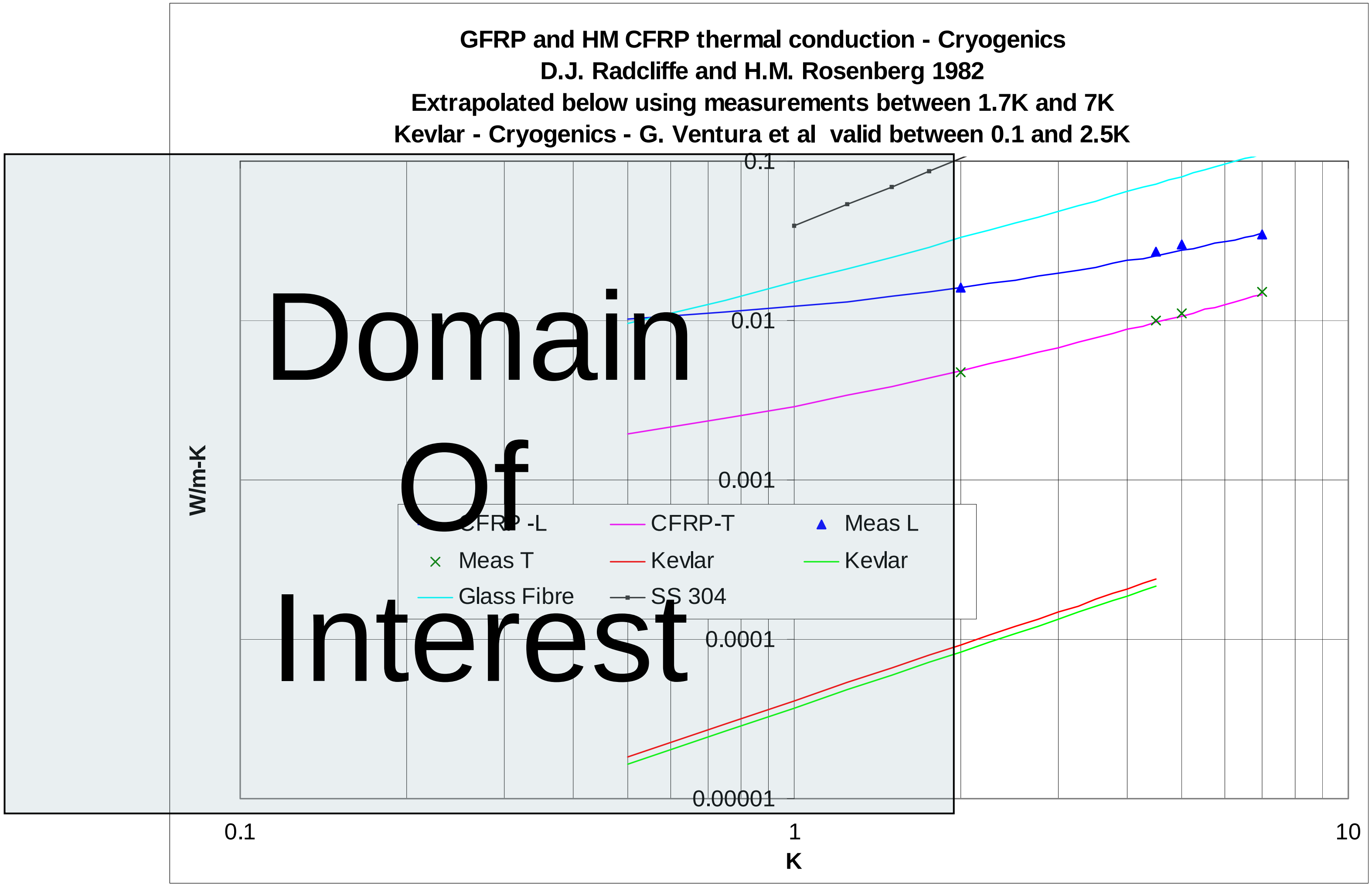
Some of the areas where we (might) look for new material applications

- XEUS and SPICA
- FPA design
  - Support detector box
    - Gradient 4.5 to 1.7 K
    - Mass 2 to 4 kg
    - Parasitic via support <1 mW (ROM)
  - Detector Support (TES/KID and such)
    - Gradient 0.05 to 1.7 K
    - Mass 0.5 kg
    - Parasitic via support <1 micro-W (ROM)



- We need thermal conductance properties below 1K

Thermal Conductance Around and Below 1K



Penetrators

Track record

No survivable high velocity impacting probe has been successfully landed on any extraterrestrial body

~~DS2 (Mars) NASA 1999~~

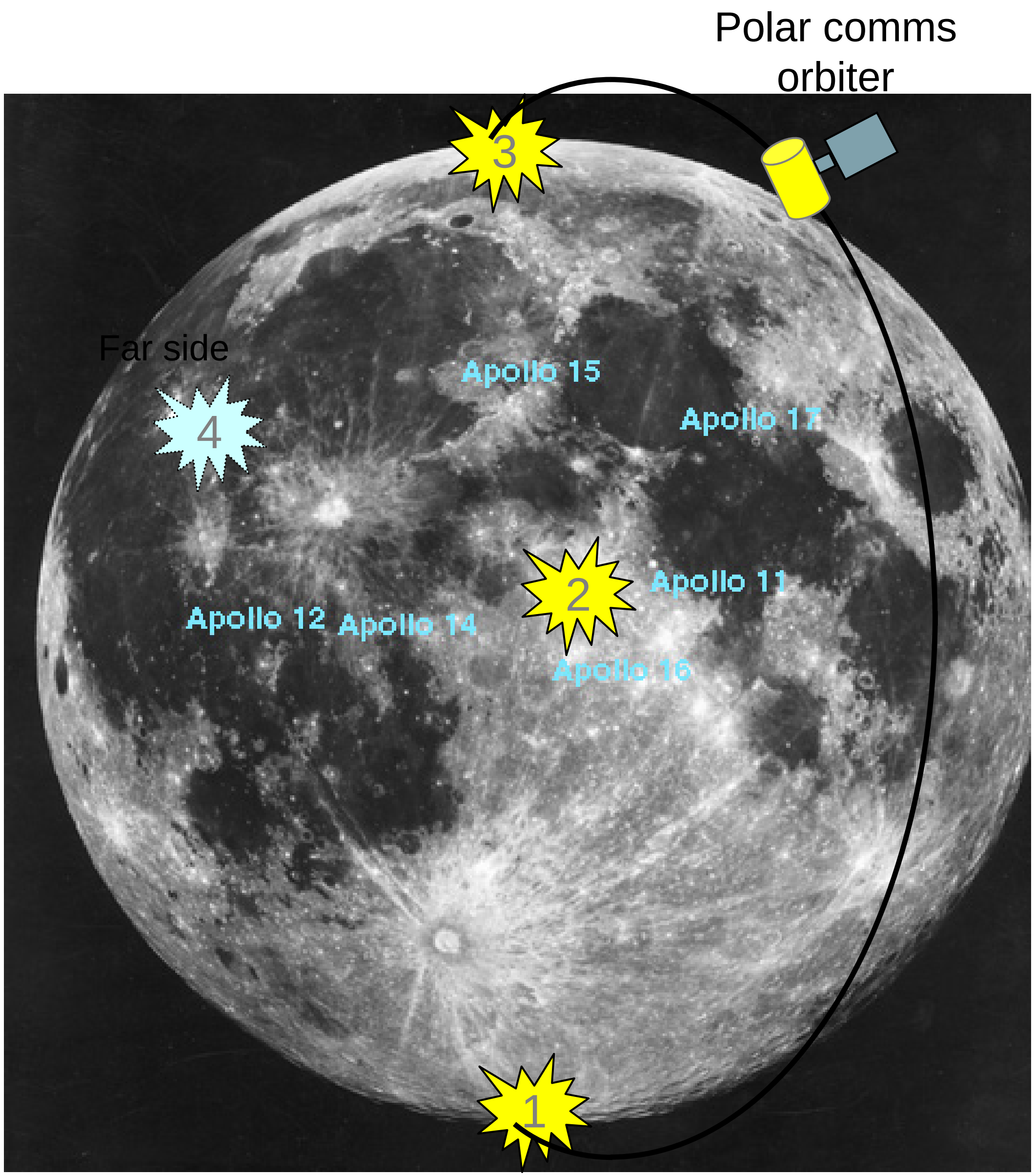
~~Mars96~~ (Russia) failed to leave Earth orbit

Japanese Lunar-A cancelled
(now planned to fly on Russian Lunar Glob)

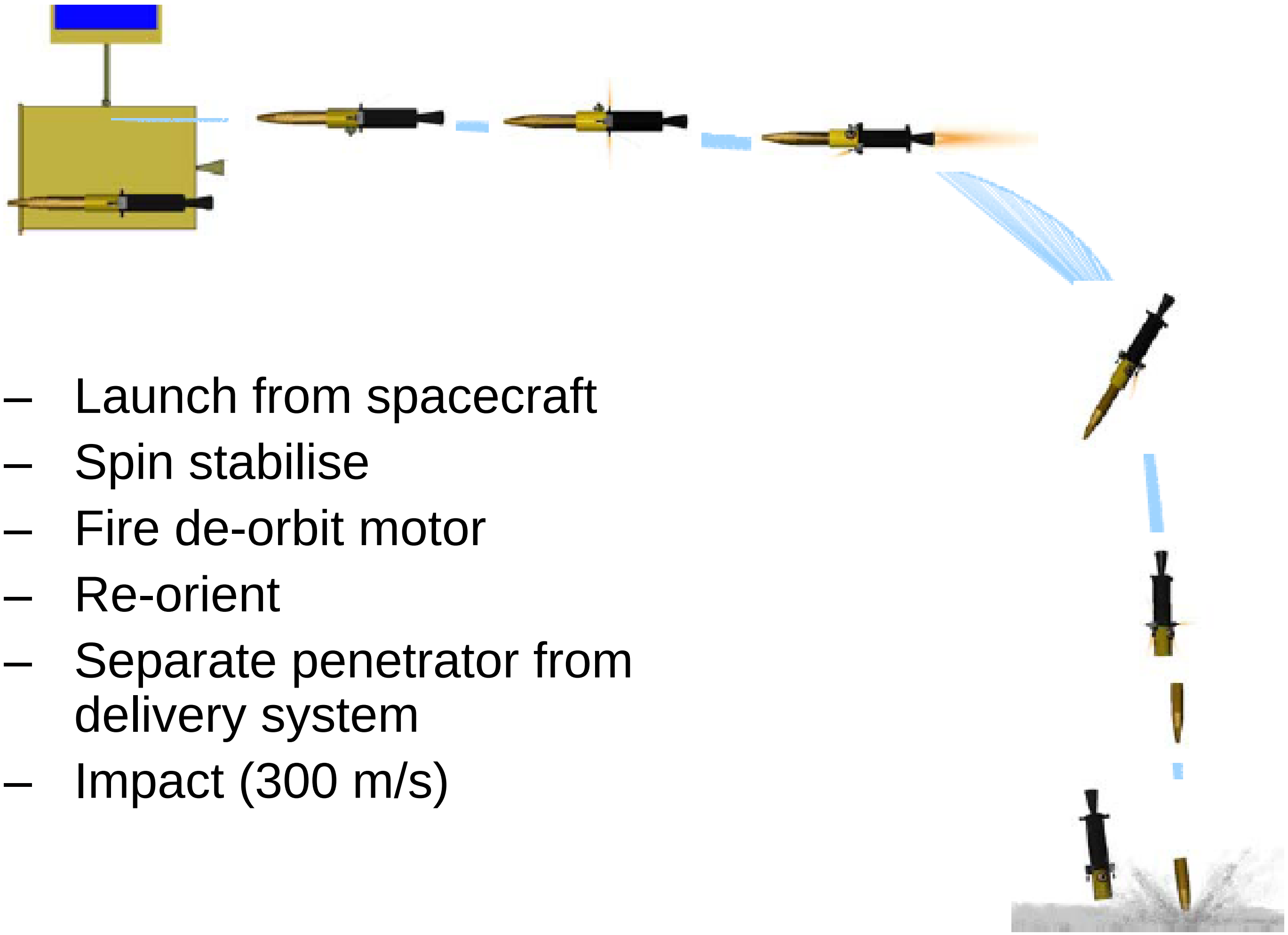
Many paper studies and ground trials

MoonLITE

- **Delivery and Comms Spacecraft (Orbiter).** Deliver penetrators to ejection orbit. provide pre-ejection health status, and relay communications.
- **Orbiter Payload**: 4 Descent Probes (each containing 10-15 kg penetrator + 20-25 kg de-orbit and attitude control).
- **Landing sites:** Globally spaced Far side, Polar region(s), One near an Apollo landing site for calibration.
- **Duration**: >1 year for seismic network. Other science does not require so long (perhaps a few Lunar cycles for heat flow and volatiles much less).
- **Penetrator Design:** Single Body for simplicity and risk avoidance. Battery powered with comprehensive power saving techniques.

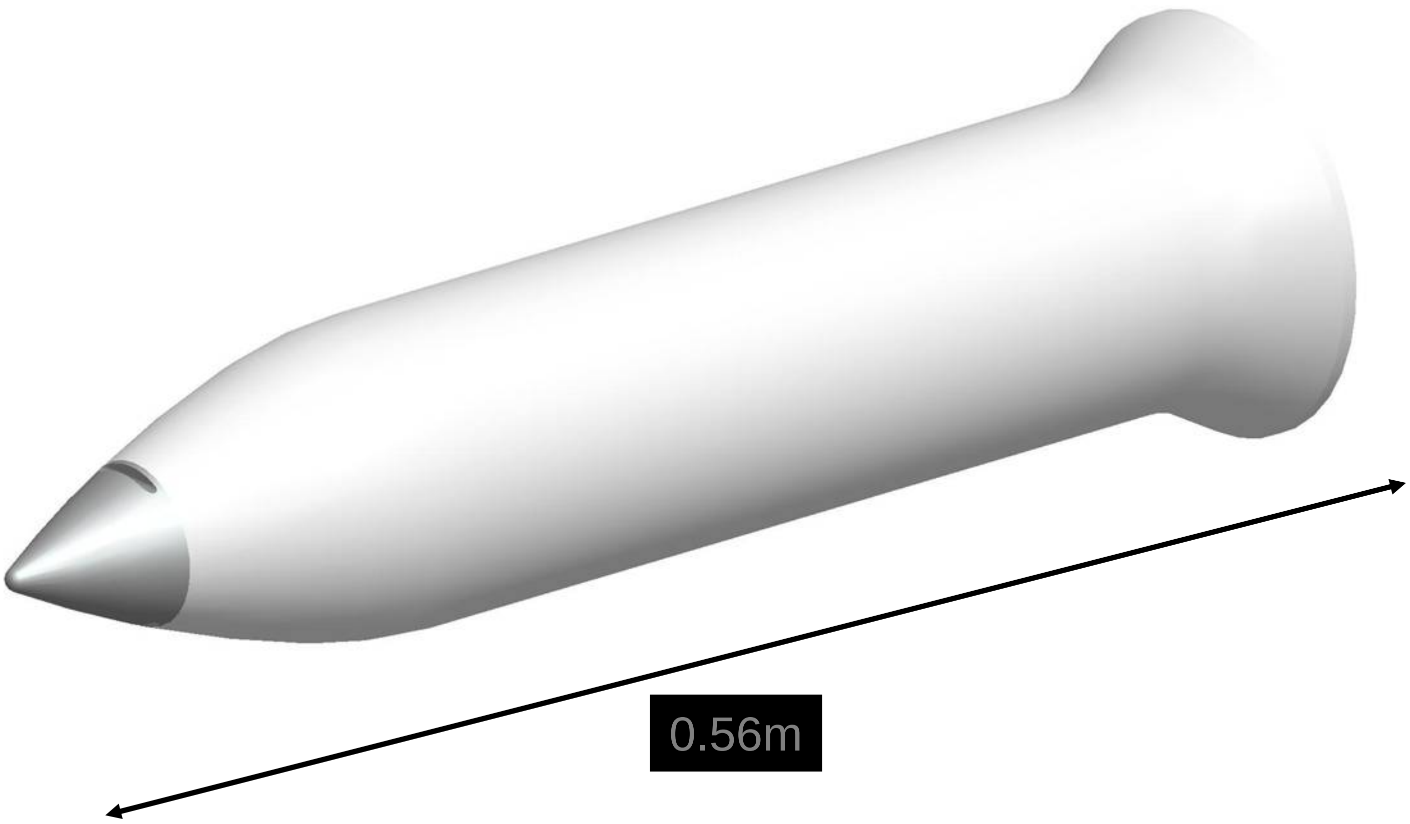


Penetrators Delivery System

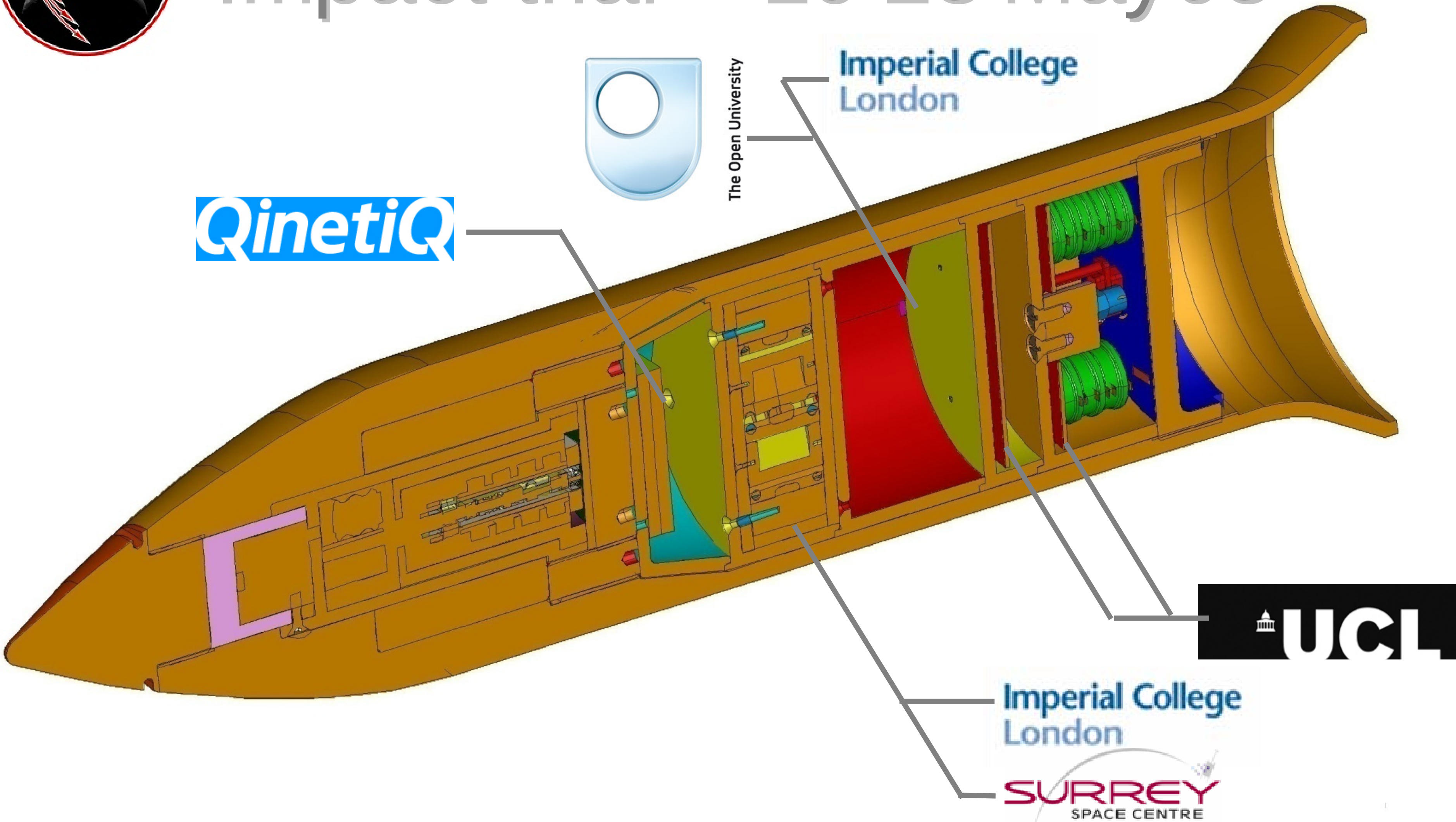


- Launch from spacecraft
- Spin stabilise
- Fire de-orbit motor
- Re-orient
- Separate penetrator from delivery system
- Impact (300 m/s)

Test Track – MoD examples


0.56m

Impact trial – 19-23 May08



What Do We Need?

- High impact (20,000 to 40,000 g) resistive:
  - Batteries
    - Maximised mAh
    - Vacuum compatible would be nice
    - Operating for 2 years
    - Preferably working at -100 Celsius
  - Thermal insulation along the penetrator shell
    - Enable us to measure moon regolith thermal gradient along the penetrator (without disturbing it)
    - Currently we are thinking to use CFRP
  - Alternatively push thermometers into the regolith over a long distance (memory metals?)

Thank you