Materials Technologies for Robotics and Small Robotic Spacecraft

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April 2008

"Changing the Economics of Space"

Overview

- Brief overview of materials requirements for space missions
  - NOT the same as materials for rockets
- Large satellites v. small satellites
  - ‘Changing the economics of Space’
- Typical microspacecraft
  - Example: DMC
  - DMC structural materials, propulsion
- Precision optics on a small satellite
  - Lightweight optics
  - Solar arrays
- MoonLITE: A robotic mission to the Moon
- Rocket motors, or thrusters

- Current State of the Art and Market challenges

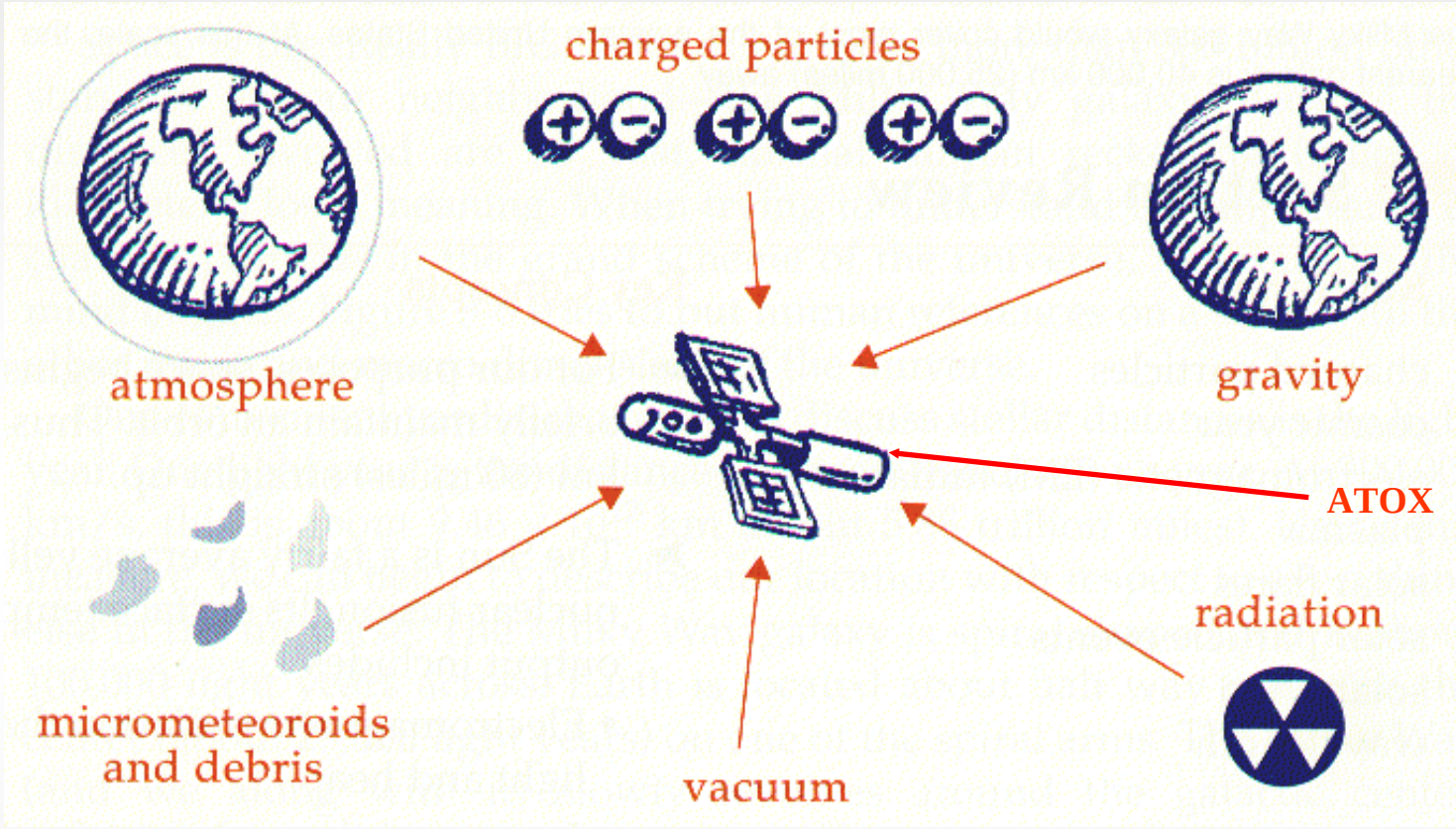
Materials challenges in Space

Satellites

Rockets

Some common issues but quite a different set of problems…

The space environment



Lubrication *(graphite)*

Thermal cycles (±100°C)

Charging/discharging

(erosion - tethered satellite)

Radiation cascades (chips)

Impact damage (Cerise)

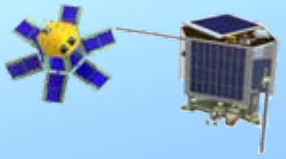
Orbit maintenance / drag

...and, of course, light weight (low mass)...

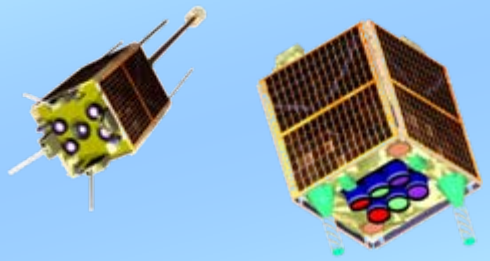
What is a ‘small satellite’ ?

A ‘small’ satellite has

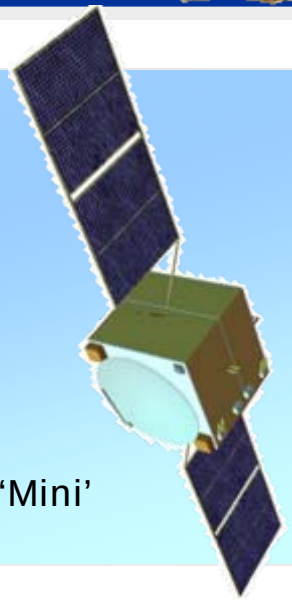
SSTL’s “*Spacecraft Platform*” families



‘Pico’ and
‘Nano’



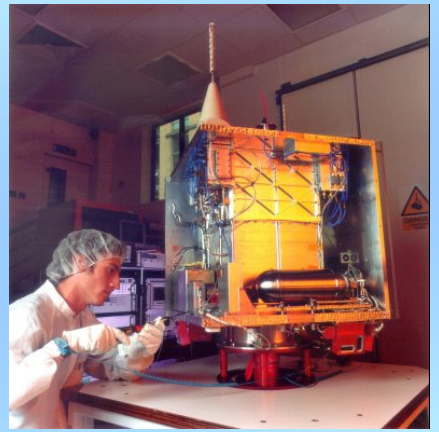
‘Micro’



‘Mini’

‘Pico’: PalmSat

‘Nano’: SNAP



‘Micro’: DMC

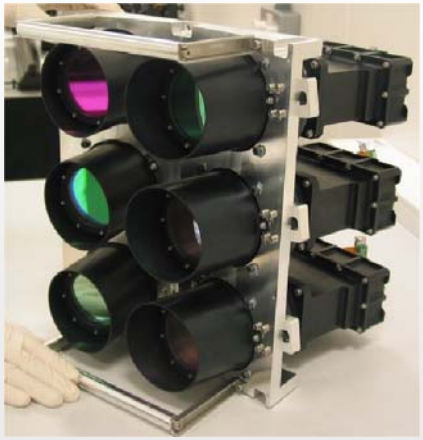
‘Mini’: GMP, GIOVE-A

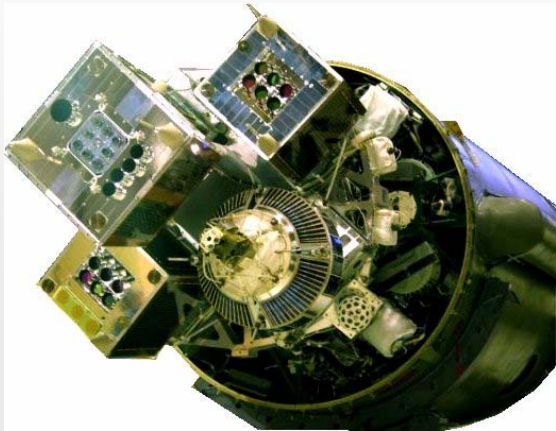
Materials

Small satellites (or low cost space missions) do not use advanced materials – nor can they afford to develop new materials

DMC

- Disaster Monitoring Constellation
- 100kg, ~80 × 80 × 80cm
- Uplink data at 9.6kbps, downlink at 8Mbps
- 1-2GByte data storage
- 50W available from solar panels / NiCd battery
- Small thruster for orbit manoeuvring
- Can carry a payload weighing 10-15kg
- Yours for only £5Million

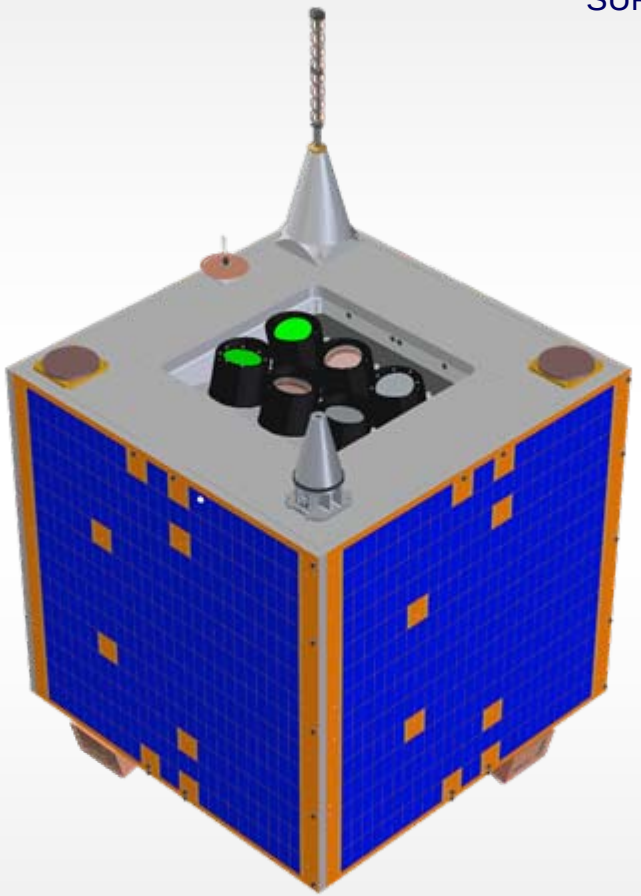


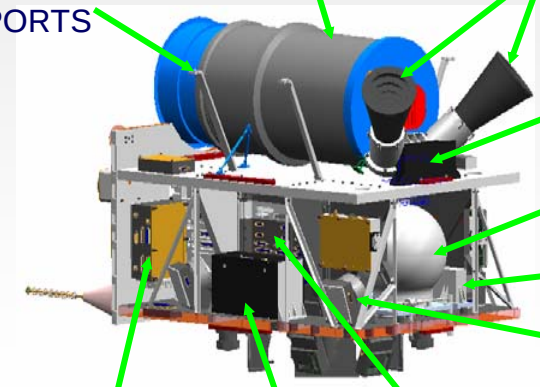


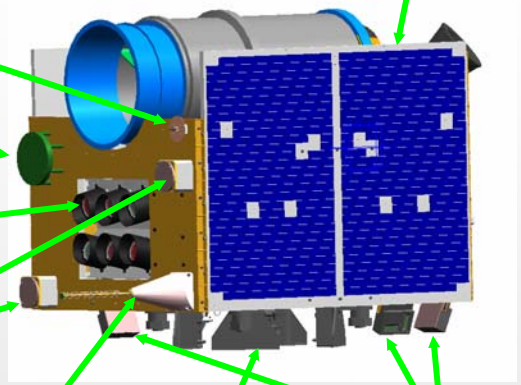
SURREY
SATELLITE TECHNOLOGY LTD

DMC results

Inside a DMC

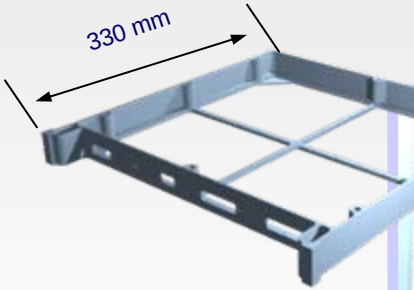


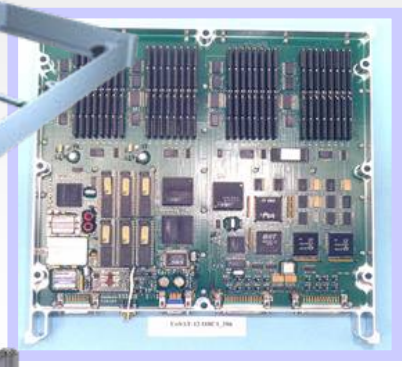

SOLAR ARRAY SUPPORTS
PAN CAMERA
STAR TRACKERS
PAN INTERFACE ELECTRONICS
PROPULSION TANK
PROPULSION CONTROLLER
REACTION WHEELS
S-BAND HIGH RATE TRANSMITTER
BATTERY
CENTRAL ELECTRONICS STACK

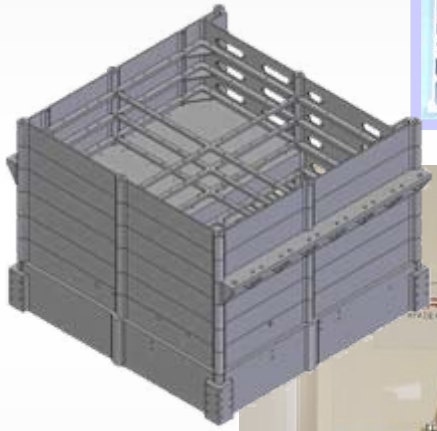

+X SOLAR PANEL
S-BAND TELEMETRY ANTENNA
X-BAND DATA DOWNLINK ANTENNA
MS CAMERA
S-BAND COMMAND ANTENNAS
S-BAND DATA DOWNLINK ANTENNA
4 POINT LAUNCHER INTERFACE
2 AXIS SUN SENSORS

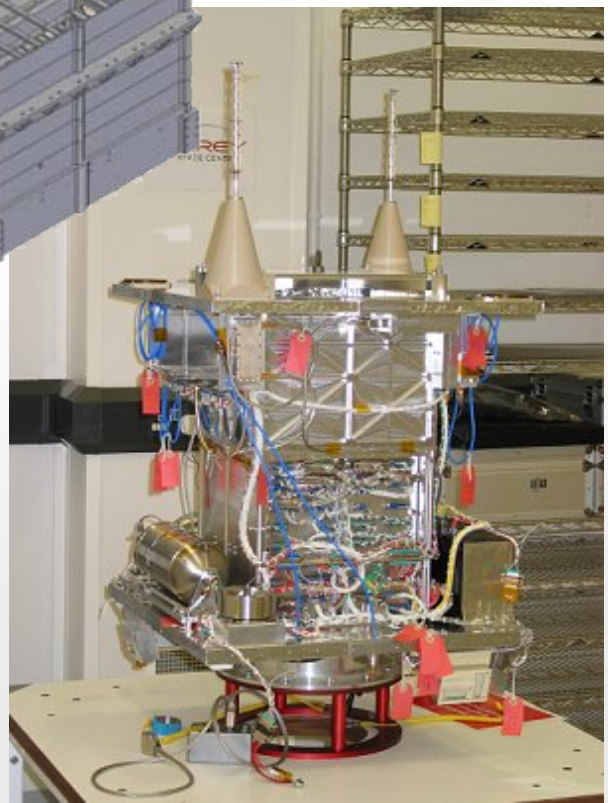
DMC structure and materials

- Machined Al alloy trays and boxes
  - 6082-T6
  - *7075-T7351*
- Titanium bolts / tie rods
  - Ti-6Al-4V
- Al honeycomb panels, Al faceskins
  - 0.6mm 2014-T6 clad with 1050
  - 5052 Core
- Carbon fibre faceskins for larger solar cells

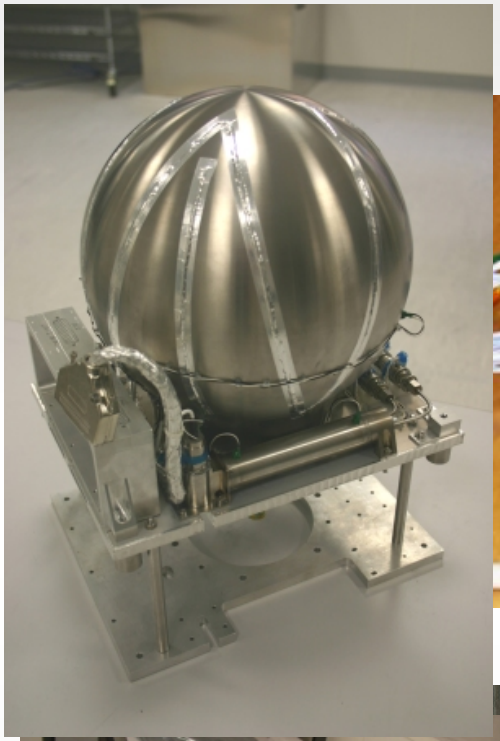


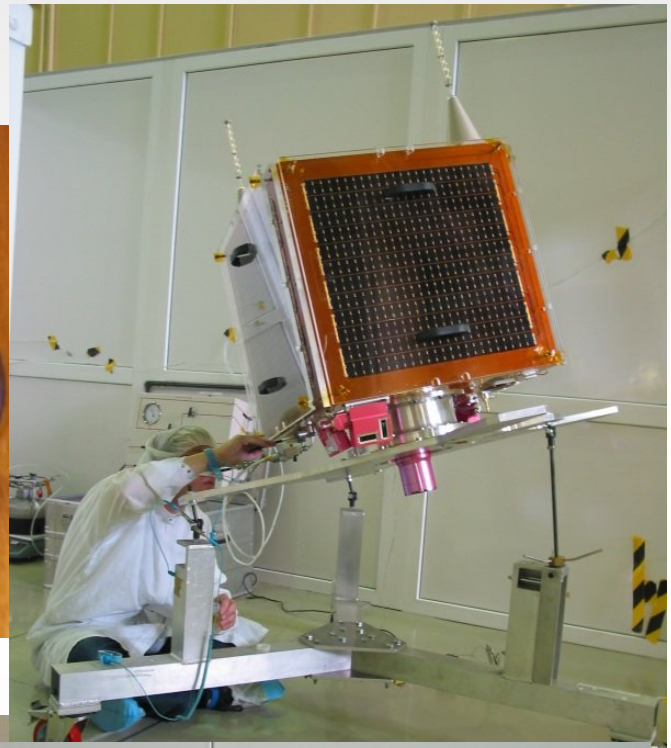


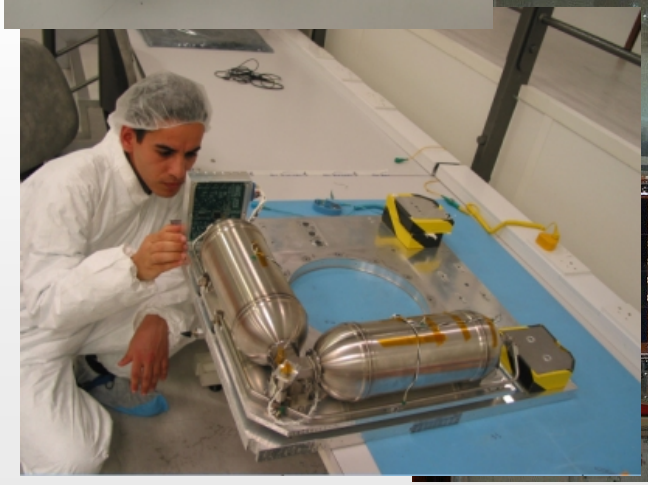




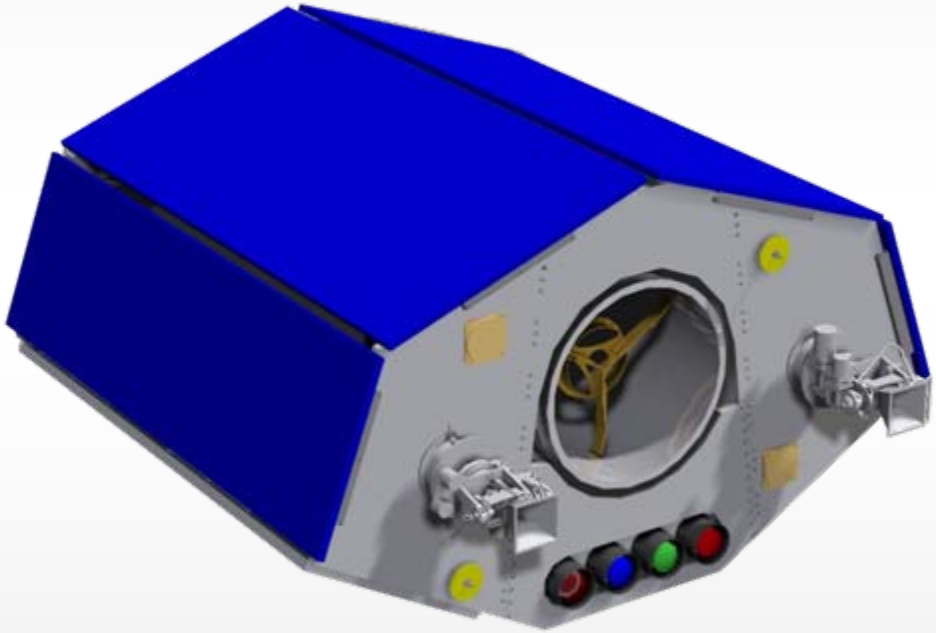
DMC propulsion – propellant tanks

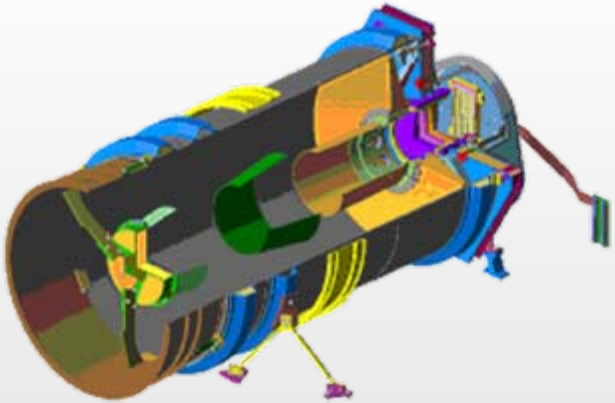






Precision optics for larger small satellites

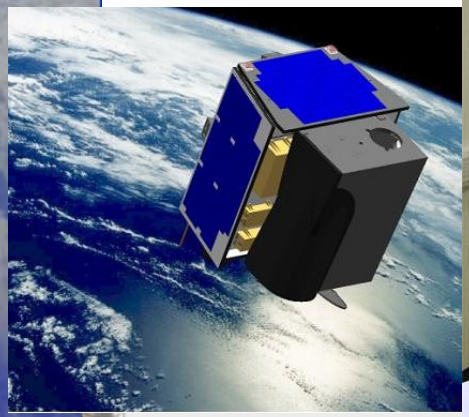




Precision lightweight optics

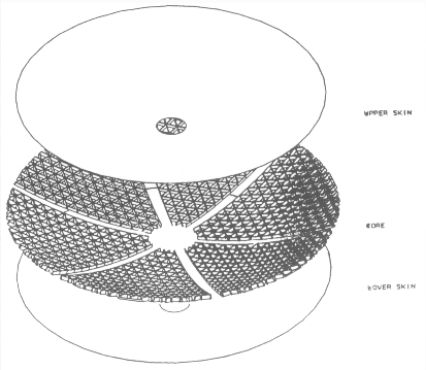
TOPSAT:

- Tactical Optical Satellite

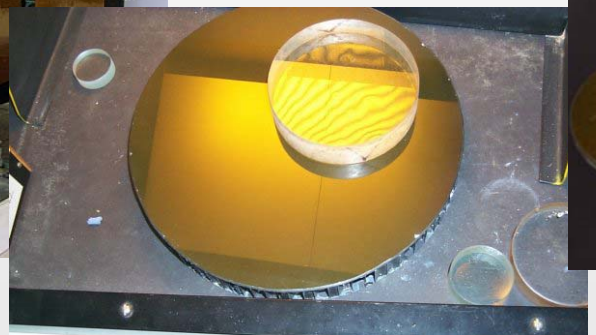


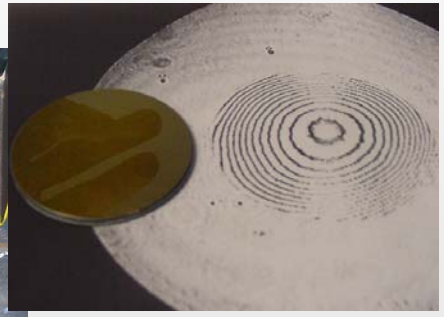
Light Weight optics programme for BNSC

- TOPSAT primary mirror 220mm diameter, machined glass, 180kg / m^2

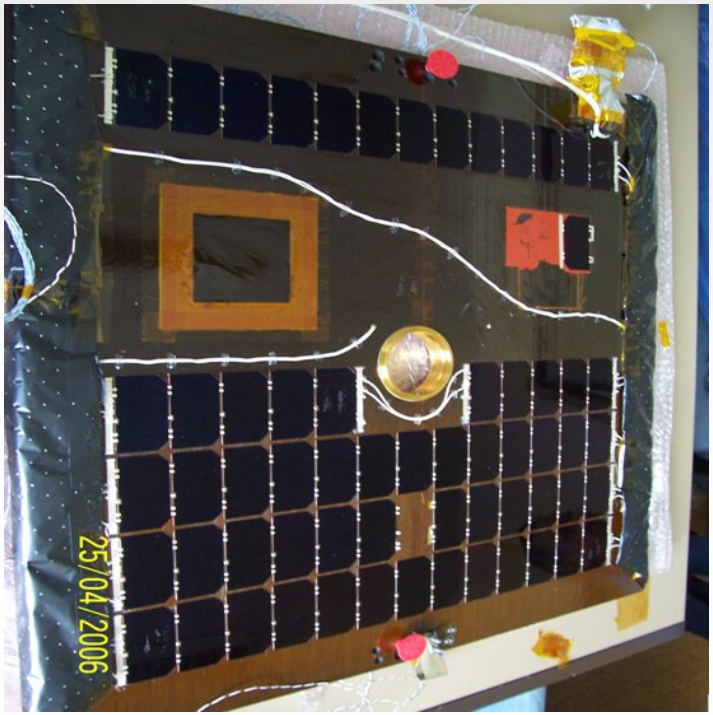


$(E/\rho^3)^{1/2}$





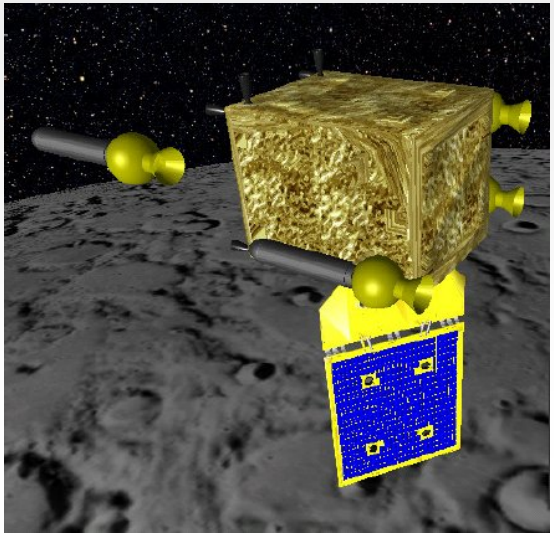
Solar arrays



Surrey Rigid Array, supporting 80 x 120mm GaAs cells

- M55J UD / Cytec Cycom 950-1 resin quasi isotropic panels
- Al honeycomb core
- **Stiffness and low moisture uptake are key parameters**

MoonLITE: to the Moon on a budget



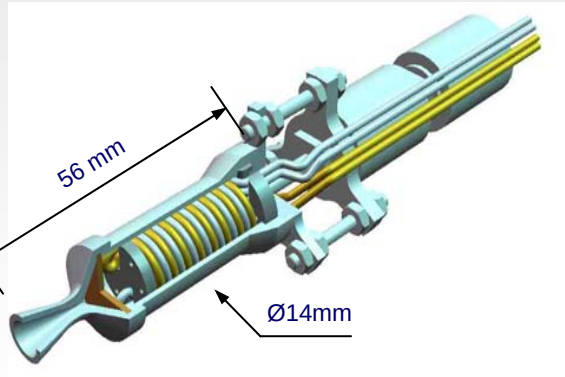
Tsiolkovsky's Rocket Equation

$$\Delta V = V_e \ln\left[M_{start} / M_{burnout} \right]$$

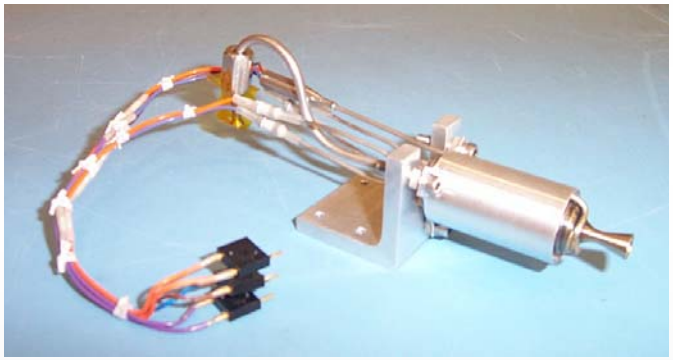
High performance ***rocket engine***

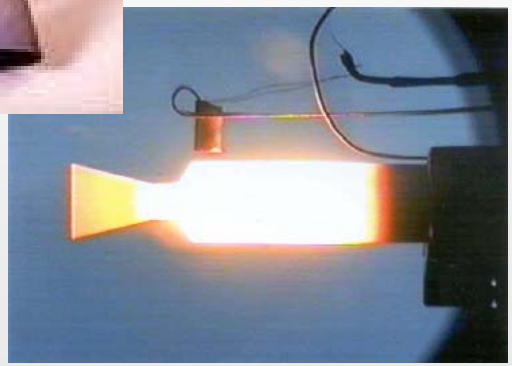
Lightweight ***rocket vehicle structure***

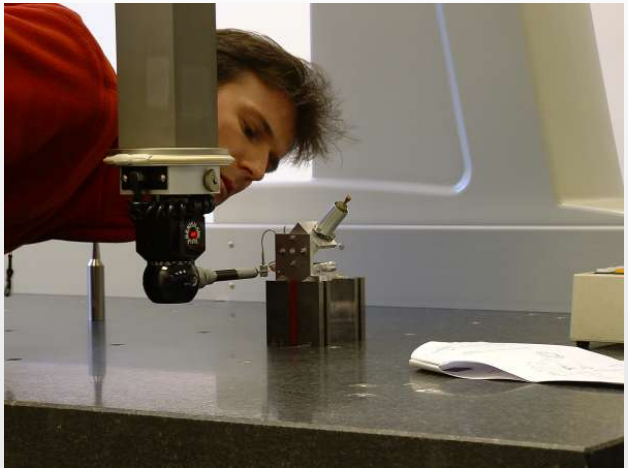
Rocket motors, or ‘Thrusters’



Low power resistojet







Current challenges

The ‘small’ spacecraft world

- Low cost, dimensionally stable composite structures – athermal for larger and larger optical telescopes
  - The supply of carbon fibre
- Lightweight mirror materials
- Titanium structures and ‘blanks’ e.g. forgings for propellant tanks
- Radiation resistant / shielding materials
- Lightweight structures for deep space missions
- Use of MEMS / microsystems to benefit very small spacecraft

‘Big’ spacecraft?

- A different set of challenges

Questions?

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