Material Technologies for Space Structures and Mechanisms

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All the space you need

EADS astrium

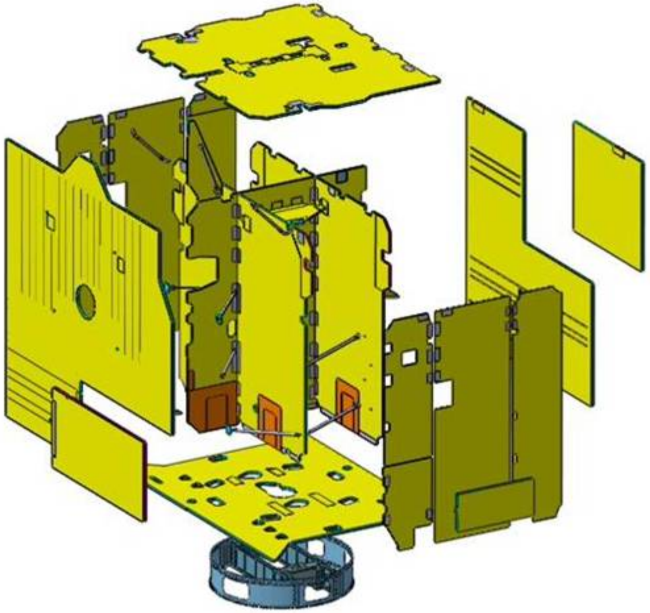
ENVISAT Launch

Courtesy ESA

Introduction - Structures

- **Structure - function**
  - Mounting location for equipment and payload
  - Load paths
  - Stiffness
  - Environmental protection e.g. radiation, micrometeroid
  - Alignment for equipment and payload
  - Thermal and electrical conductance paths
  - Accessibility
- **Material Properties**
  - Specific strength
  - Specific stiffness
  - Thermal characteristics (conductivity, CTE)
  - Fracture and fatigue (NDT)
  - Ease and safety of manufacture
  - Magnetic characteristics
  - Outgassing properties
  - Cost

Typical Structures



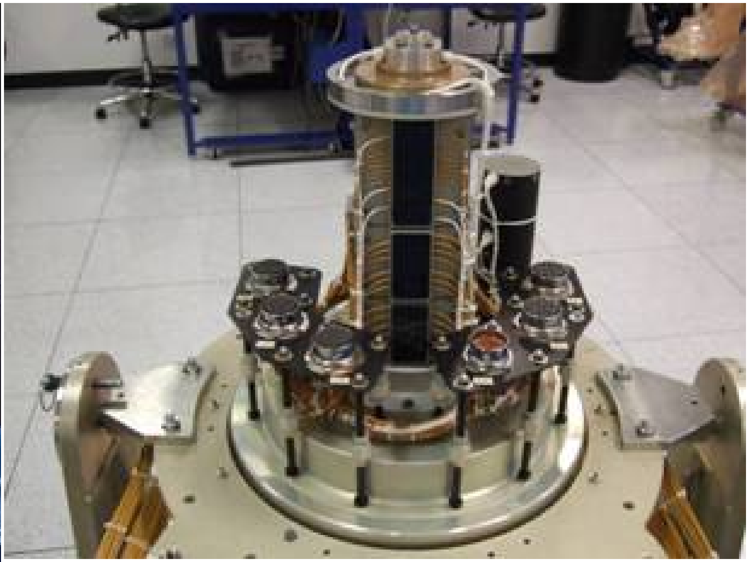
Eurostar E3000 Structure

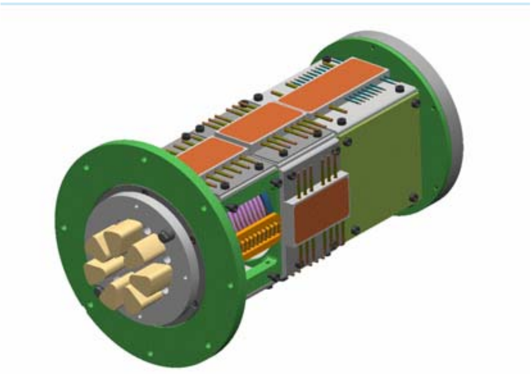
Herschel SiC Mirror

Structures – Material Applications

- **Aluminium Alloys**
  - Sandwich panel face-skins
  - Forged rings
  - Brackets
  - Honeycomb
- **Titanium**
  - Bolts
  - Strut fittings
  - Special brackets
- **Beryllium**
  - Mechanisms
- **Composites**
  - Primary structures (CFRP)
  - Struts (CFRP)
  - Antenna reflectors (CFRP & kevlar)
  - Brackets (GFRP)
  - Honeycomb (Nomex, kevlar)
- **Silicon Carbide**
  - High stability mirrors
  - Optical benches

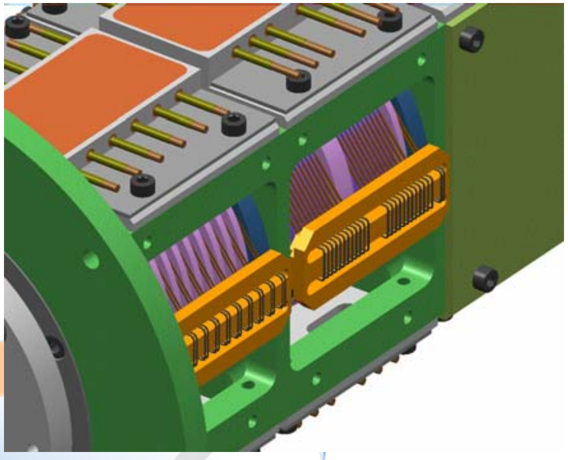
Mechanisms – Solar Array Drive Mechanism





Eurostar 3000 SADM

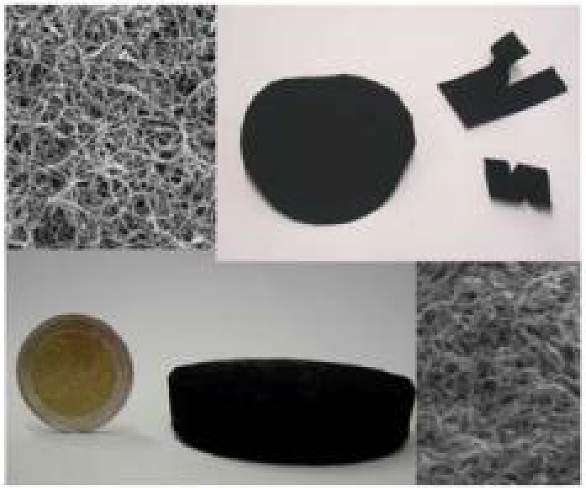
28kW Power Transfer
21A per circuit at 110V
15 years operation, 1 rotation per day
Array inertias : 190 to 560 Kgm2, 0.23 to 0.085HZ
Capacity 1.5kN axial, 4.5KN radial, 450Nm torque
Mass < 15Kg



Mechanism – SADM Design Drivers

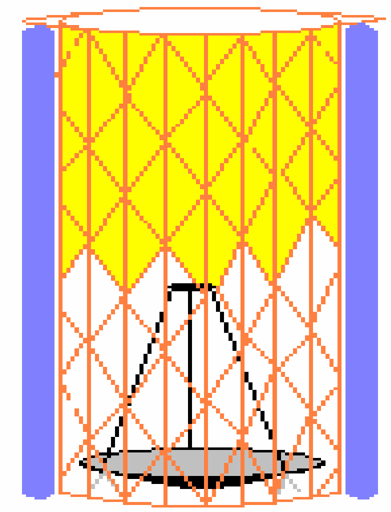
Physical properties of contact system	Function of	Effects
Contact ohmic resistance	Contact force, brush E, ring E, slip ring resistivity, brush resistivity	• dissipation and hence Temperature • Voltage drop • Current capacity
Slip ring ohmic resistance	Geometry and material resistivity	• dissipation and hence Temperature • Voltage drop • Current capacity
Brush & brush support ohmic resistance	Geometry and material resistivity	• dissipation and hence Temperature • Voltage drop • Current capacity
Slip ring resistivity	Material	Affects contact resistance
Brush resistivity	Material	Affects contact resistance
Slip ring thermal conductivity	Geometry and material resistivity	Affects hot spot temperature and overall dissipation
Brush and brush support thermal conductivity	Geometry and material resistivity	Affects hot spot temperature and overall dissipation
Brush hardness	Material	Affects wear life
Brush modulus (E)	Material	Affects contact resistance
Ring hardness	Material	Affects wear life
Ring modulus (E)	Material	Affects contact resistance
Contact Electropotential	Ring vs brush material	Possible corrosion contribution, misleading volt drops
Contact force	Compliance and configuration	Affects wear
Brush geometry	Required contact force, space, mass	Effects contact force, mass
Slip ring geometry	Required contact force, space, mass	Effects contact force, mass

Future Materials



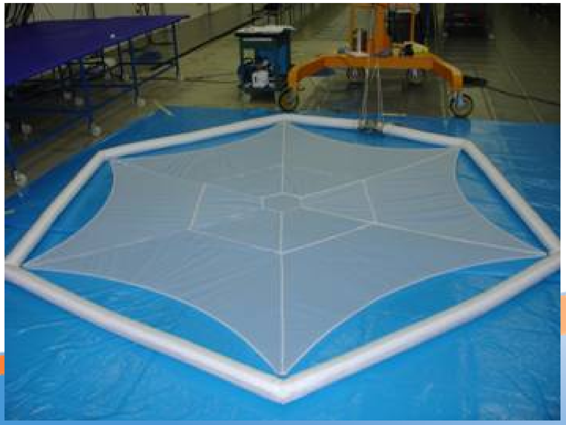
Foams and ribbons made of Carbon Nanotubes

Deployable structures based on rope mesh with in-orbit rigidification features



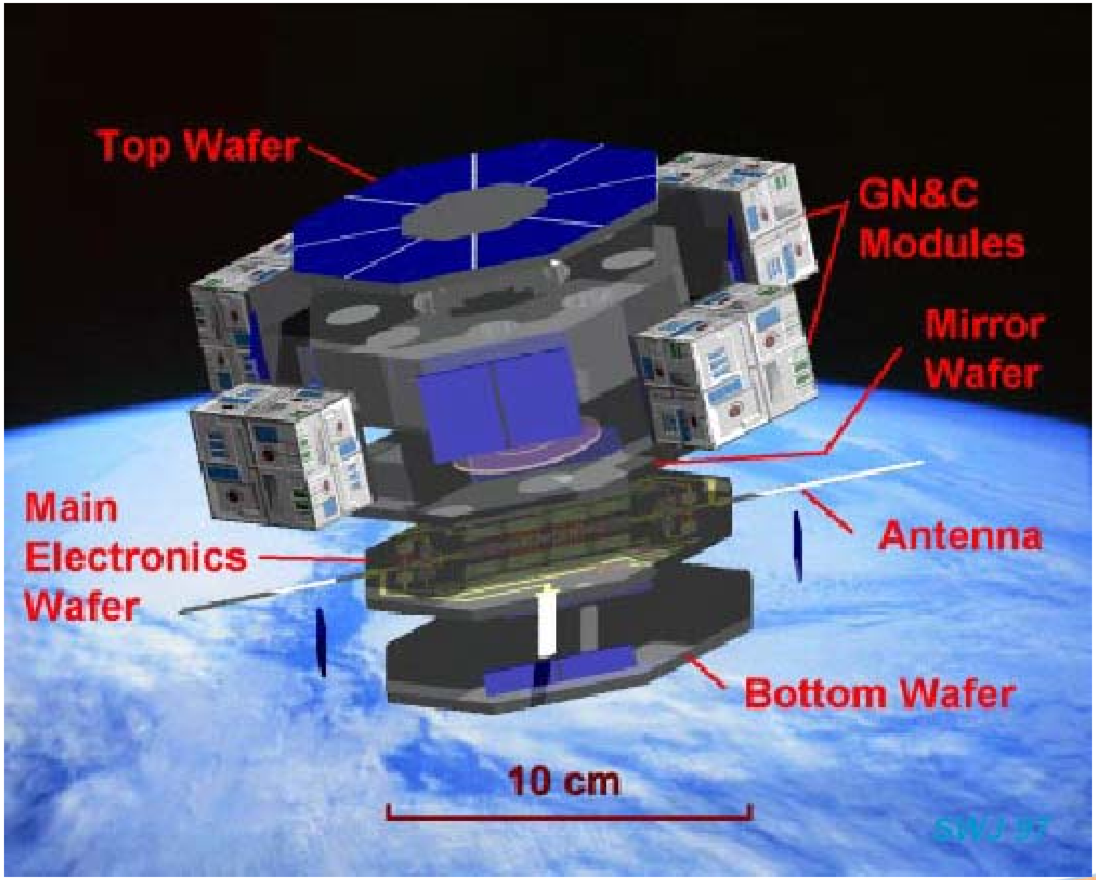
Deployable baffle for telescope

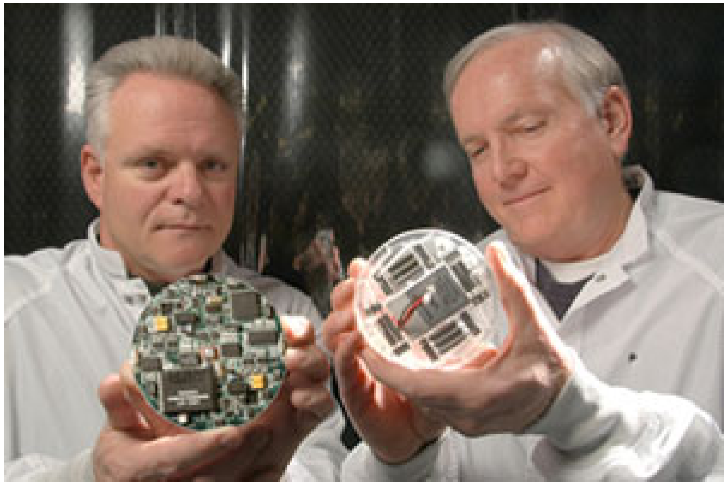
Inflatable structures



Future Spacecraft

The Wafer Satellite concept from Aerospace Corporation





Lee Steffeney, left, and Bill Hansen hold segments of the demonstrator glass-ceramic satellite developed at Aerospace for the Defence Advanced Research Projects Agency in December 2004.

Closing Remarks

- Mass optimisation and dimensional stability with temperature are major design drivers for structures
- Mechanisms require more detailed assessment of material properties
- Future developments dictate closer co-operation between engineers and material scientists particularly as multifunctional materials and structures are developed.

Sputnik

50 Years

Inmarsat 4

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Wafersat