High Precision and Large Mechanical Components

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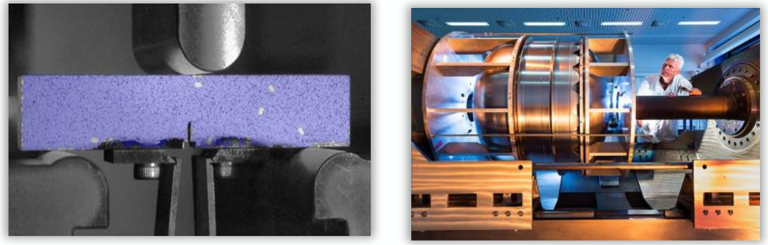
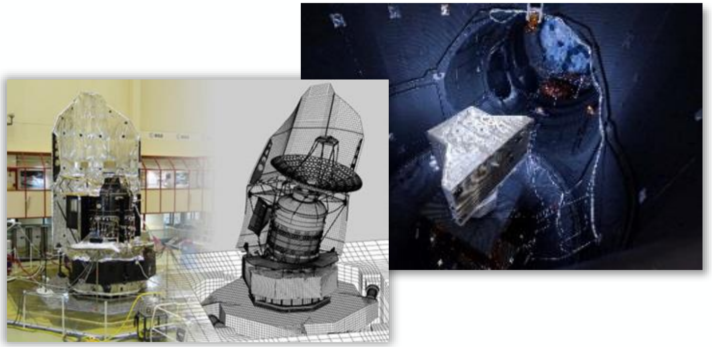
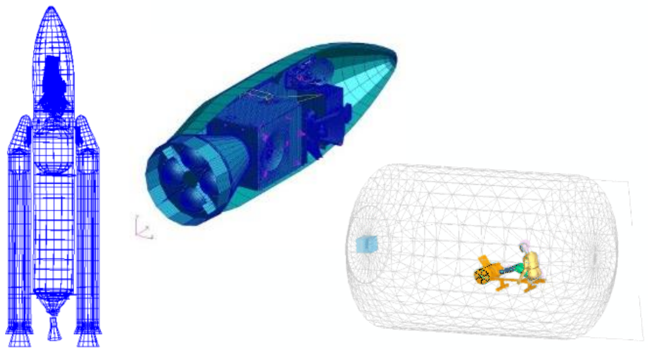
The Division's Mandate



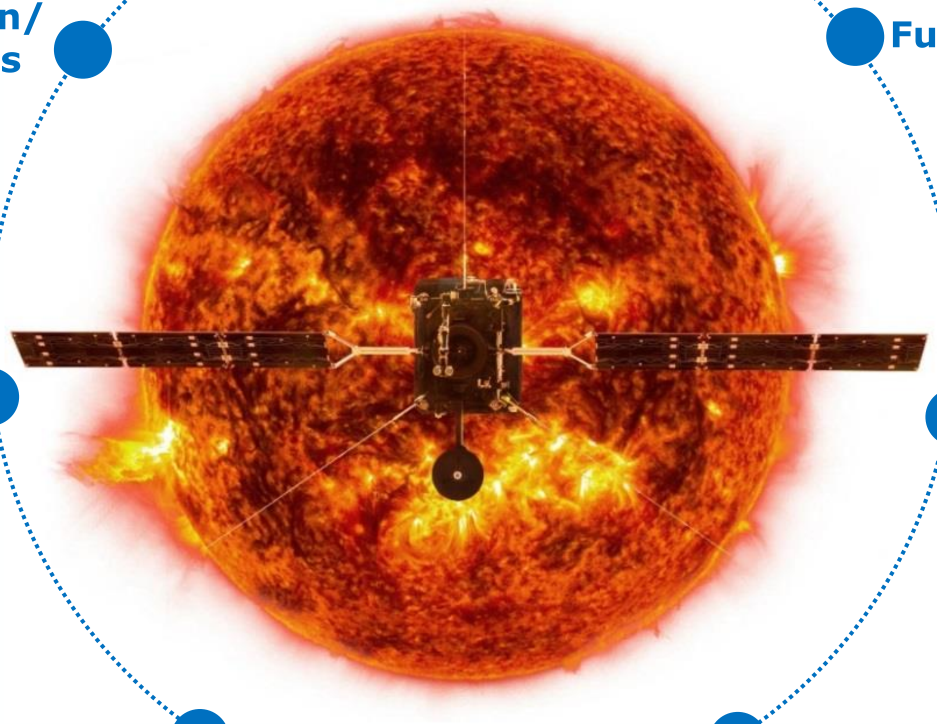
Materials and Processes/Failure Investigation



Full Scale Testing Support

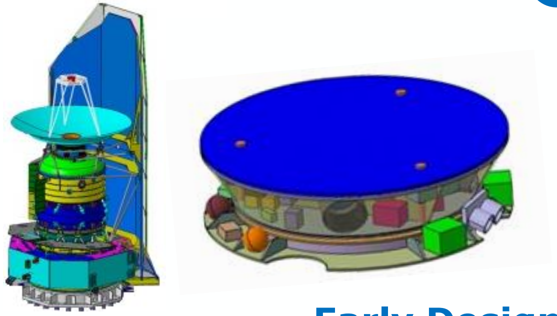


Vibro-Acoustic Environment Prediction/
Launcher Coupled-Multibody Analysis

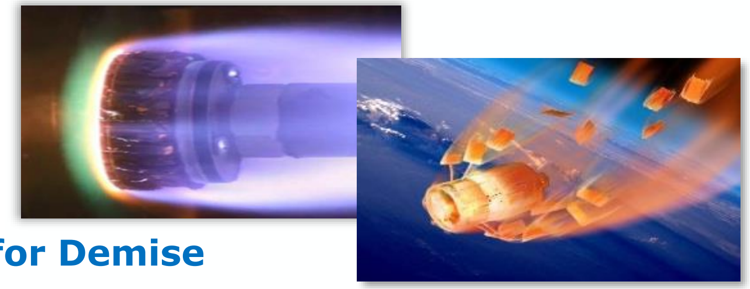


Flight Acceptance/Operations

Detailed Stress Analysis



Early Design Phases



Design for Demise

Future Mega-Trends

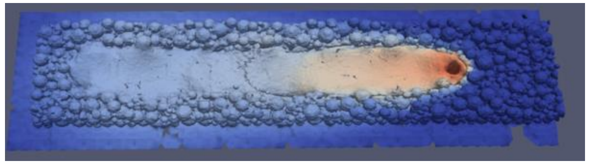
Digitalization

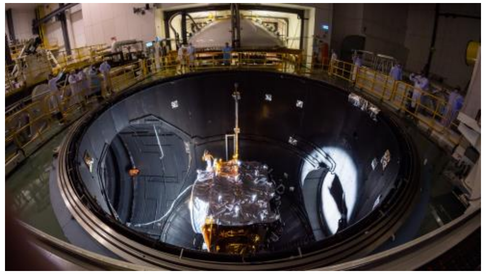
Structures:

- Reusability / Smart Structures
- Demisable Design for “undemisable structures” + Design Guidelines and Tools
- Virtual Testing and Verification Methodologies
- Margins Reduction Methodologies
- Advanced Analysis Methodologies and Tools / End-to-End Digitalization

Mechanisms:

- Closed loop control / low micro-vib / Micro-vib isolation
- Artificial Intelligence, Big data / Machine Learning (e.g. initiative on common ball bearing data base)
- Multi-Physics / Multi-Body Analysis
- Dust Management for on Planet (Moon/Mars) Mechanisms
- Digital twins / Hardware in the loop / Digitalisation
- COTS / Building Blocks / Standardisation
- Technology Transfer (from Space to Ground application)
- Mega constellations needs / Packing density
- Health Monitoring
- High Precision/High Accuracy/Long Life (for e. g. Intersatellite Links, etc.)
- Out of earth manufacturing / In-orbit servicing



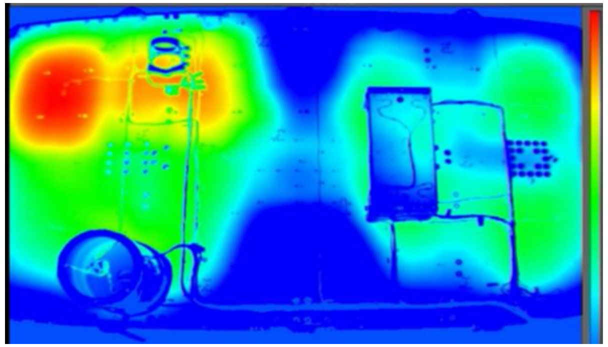


Future Mega-Trends

Digitalization

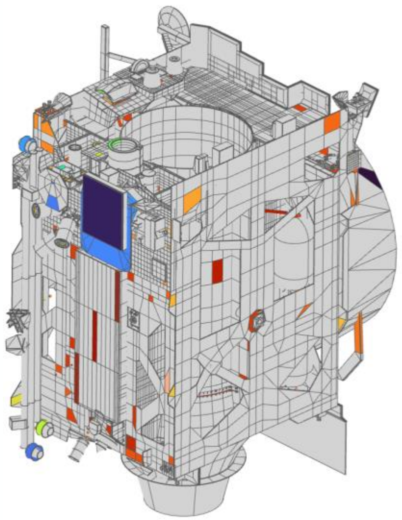
Materials:

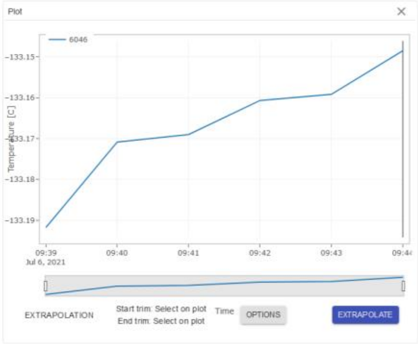
- Digitalization and Materials Modelling
- Manufacturing Data Acquisition and Manipulation / Machine Learning and Repair + NDI Strategies
- Manufacturing Digital Twin ➔ Input for Virtual Testing (reducing lead time/time to market)
- 4D Printing
- Biomimicry
- Smart Factory Manufacturing (Megaconstellations + Launchers)
- Out of Earth Manufacturing (ISRU, Recycling, Assembly, etc.)
- Materials Demisability Enhancement and Testing
- Cleanliness and Contamination Control as a System Approach + Modelling and IOD



Thermal:

- Deployable radiators – heat rejection
- Thermal switches
- Mechanically Pumped 2 phase loops – heat transport
- Leverage on new materials and manufacturing processes for increased performance
- Cryocoolers
- Heatshields – thermal protection
- Digitalisation of Thermal Engineering Process
- Thermal digital twin

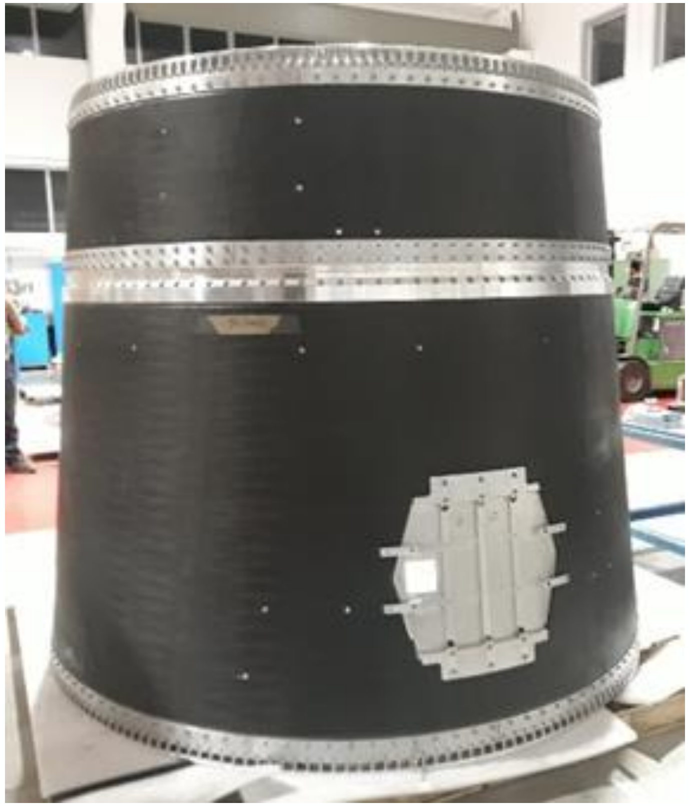




Examples of Advanced Manufacturing

Herschel Space Telescope primary mirror integrated (left) and the constituent SiC petals (right), the largest ever build with the selected manufacturing process.

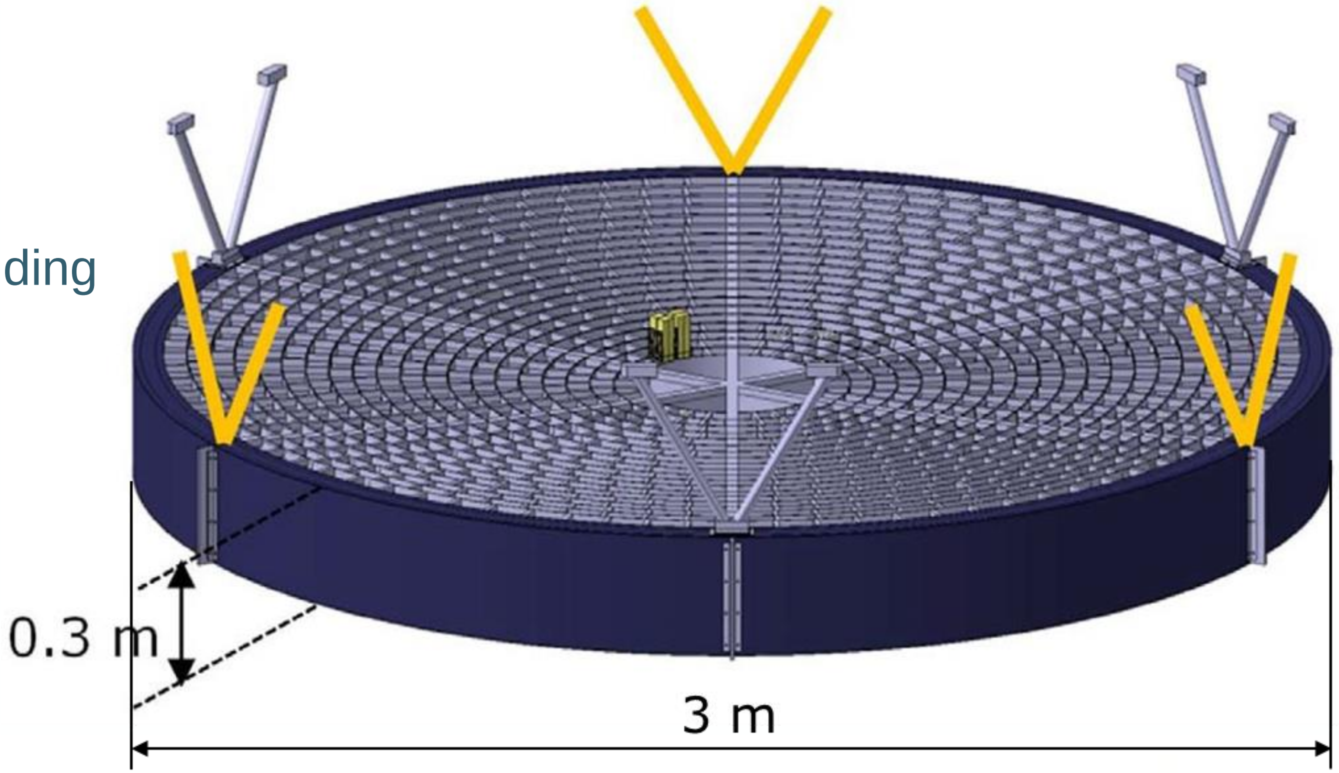
Examples of Advanced Manufacturing

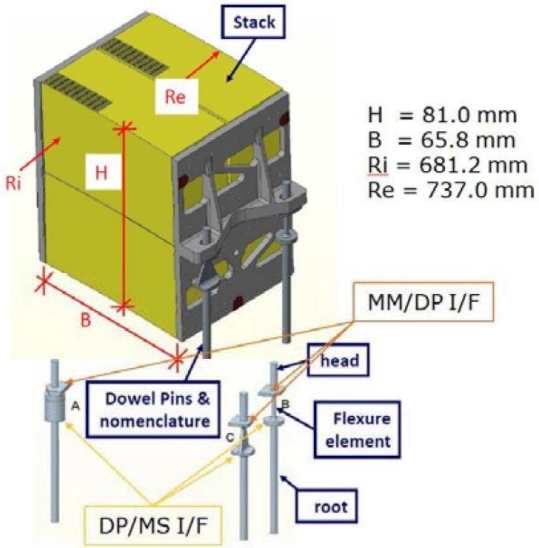


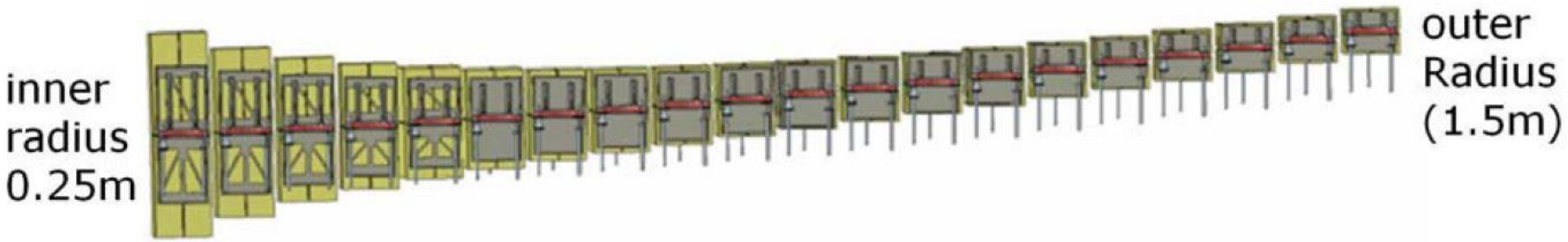
The interstage 2-3 of VEGA C Launcher manufactured using a composite grid structure technology

ATHENA Optical Bench with Additive Manufacturing

- Materials trade-off: E/ρ → max, CTE → low
- TRP project: **Ti alloy** chosen due to **manufacturability**
- Produced through Laser Powder Build-up Welding (LPBW) at Fraunhofer IWS







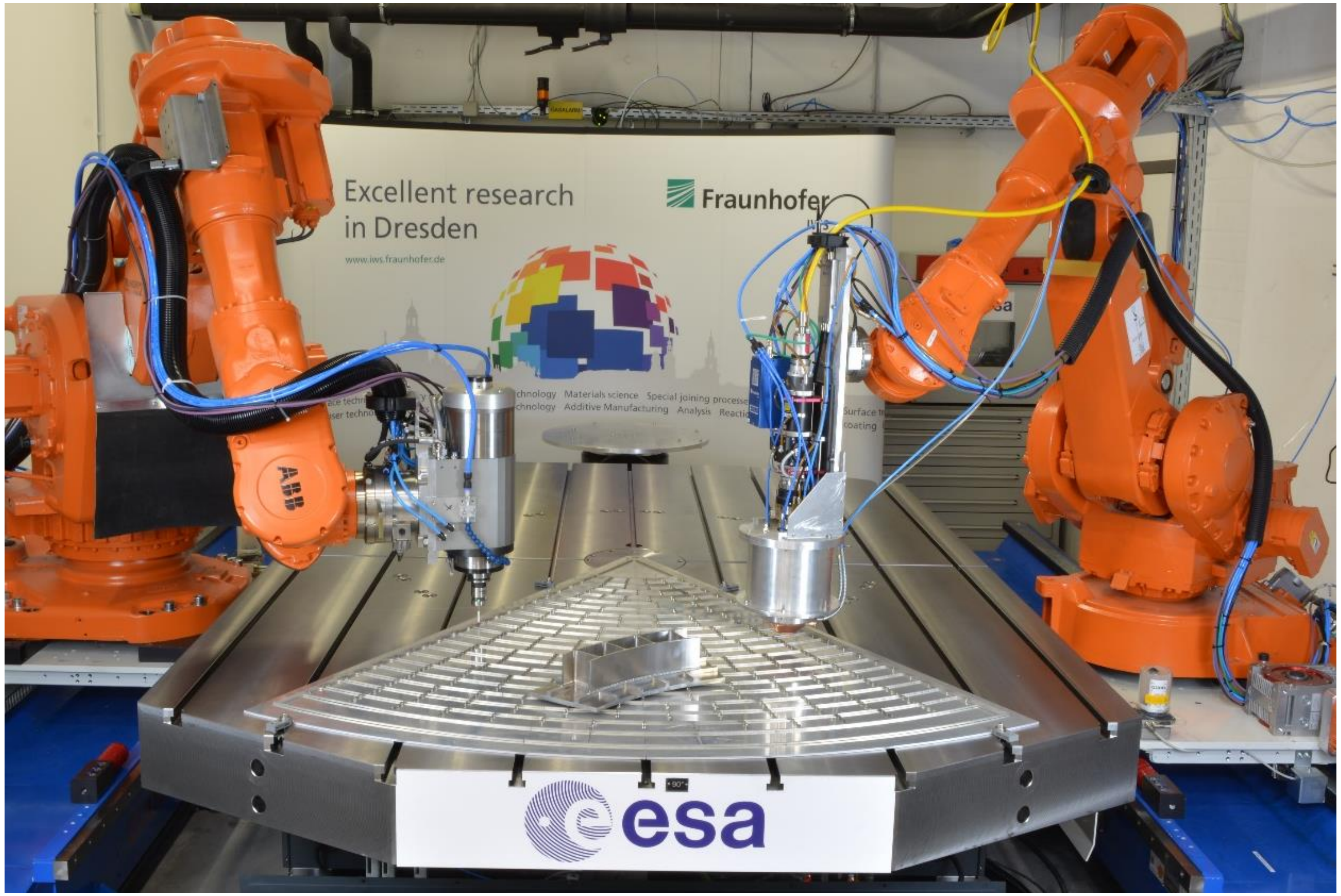
ATHENA Optical Bench with Additive Manufacturing

esa

- **16 axis twin robot** system
- Turn-tilt table
- 1-2 robots performs **AM** task
- 1 robot performs **milling** task

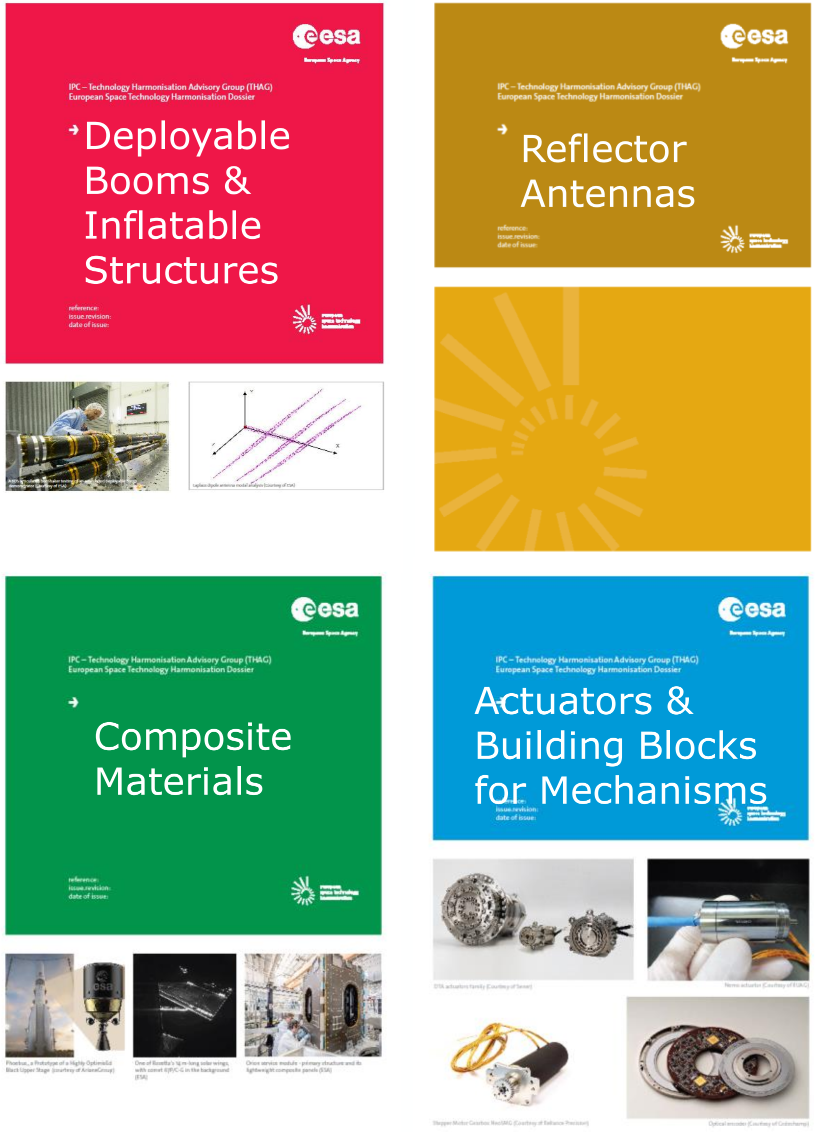
Fraunhofer IWS

AIRBUS DEFENCE & SPACE



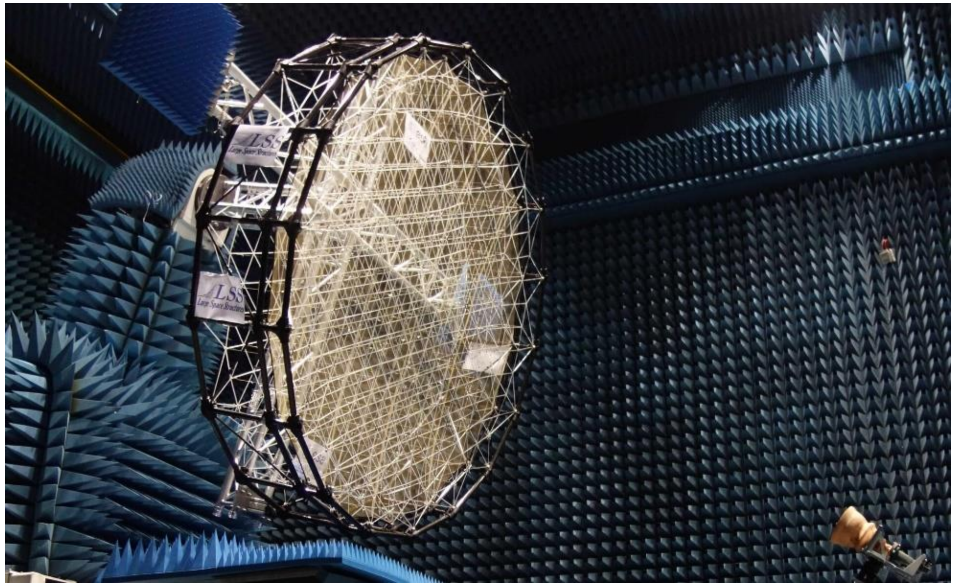
Technology Harmonisation

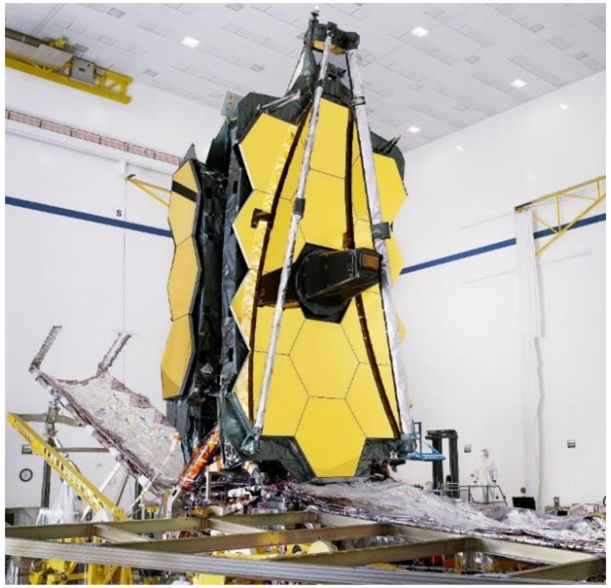
*Eurospace, SME4Space, ESRE, EARTO, etc..



Current Approach - Manufacturing for Space 1/2

- Design and manufacturing of spacecrafts for launch on ground
  - Launcher fairing **size limitation** → Spacecraft structure (e.g. solar array, antennae) size limitation → **performance limitation**
  - Design to resist launch loads → i.e. added mass, long qualification
  - Long **time to market**
- Alternative: Deployable structures → Complexity, **long lead time**



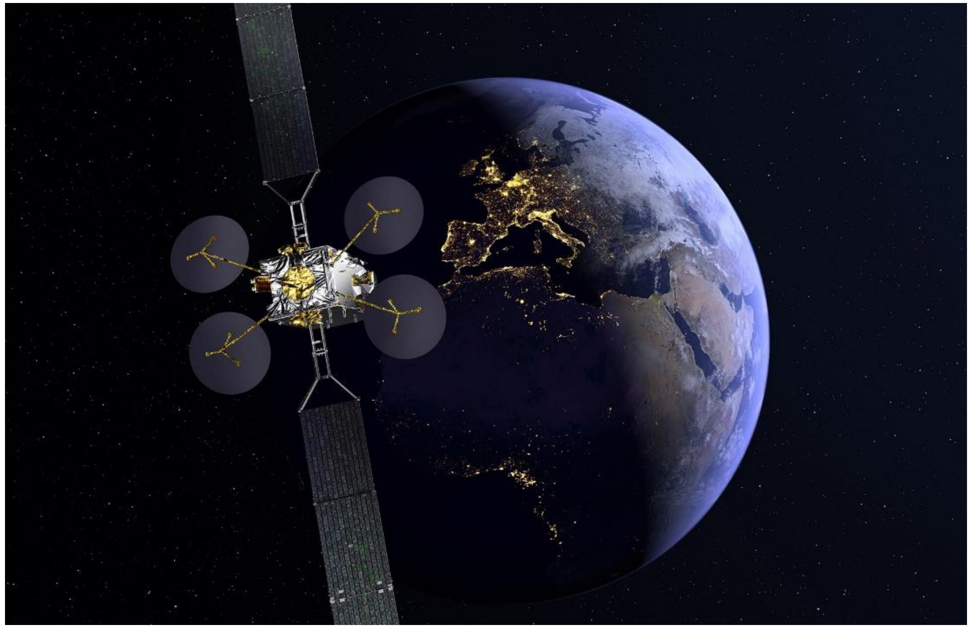


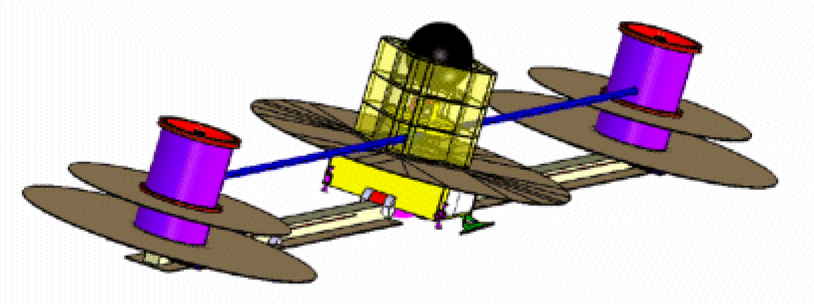

Current Approach - Manufacturing for Space

- Infrastructure and supplies for human exploration missions are provided from Earth, as redundancy payload or through regular cargo missions:
  - Significant amount of **supplies not used** (in addition to packaging, etc…)
  - **Launch costs** associated to cargo missions
  - Not practical for future missions to **remote destinations** (e.g. Mars)

New Paradigm: On-Orbit Manufacturing

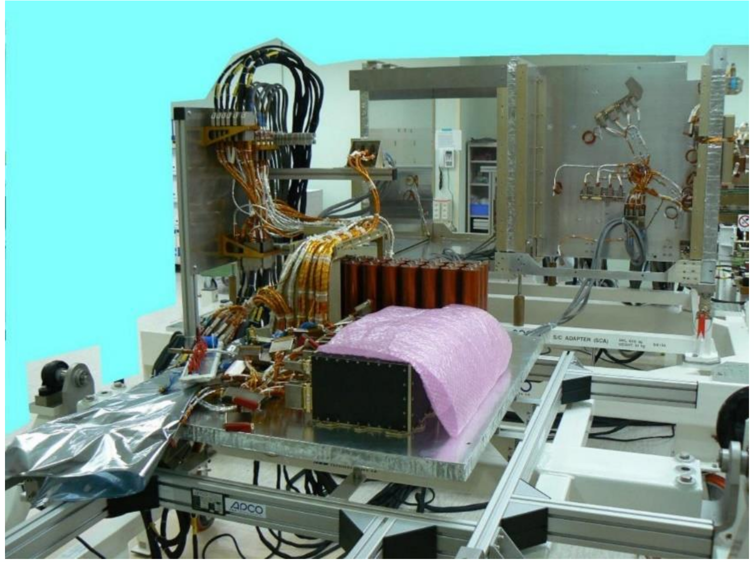
- Larger structures (no fairing size limitation), e.g.:
  - Solar arrays → higher power and **higher payload capacity** for a given class of satellites, **higher performance-to-launch-cost**
  - Antennae reflectors → narrower emitted beam, higher gain, **higher data throughput** for telecommunications
  - Large aperture Telescope, large Interferometer → **higher science return**

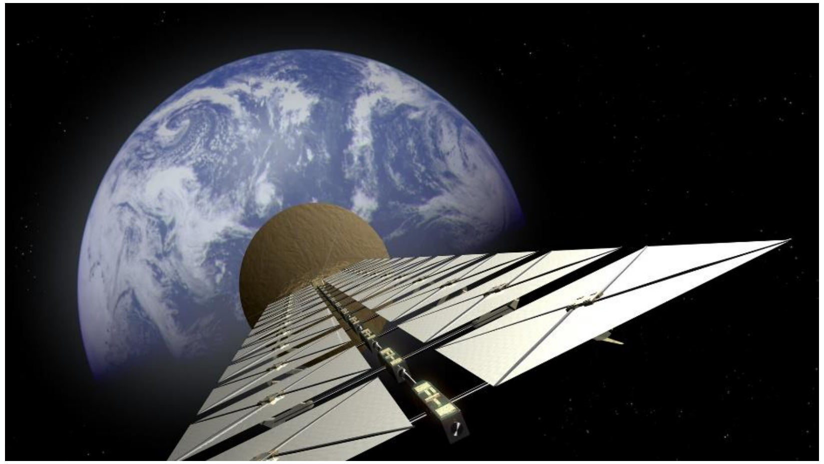




New Paradigm: On-Orbit Manufacturing

- Spacecraft on-orbit refurbishment and upgrade enabled → **life extension**, cost savings compared to launching new assets
- Longer term: leasing of assets (e.g. reflectors), decoupled payload and platform → payload update on orbiting platforms; platforms leasing
- Long term: manufacturing and maintenance of very large structures (e.g. space-based solar power)
- Benefits **applicable to a wide range of missions** for Telecom, Earth Observation, Navigation, Science, Exploration





New Paradigm: On-Orbit Manufacturing

- On-demand manufacturing and recycling of spare parts, tools during long term human exploration missions → **simplified maintenance logistics** → savings in resupply missions and materials
- In-situ manufacturing and assembly e.g. of cubesats → flexibility and redundancy in mission planning
- In-situ construction of infrastructure, in-situ propellant production and in-situ manufacturing of hardware (e.g. tools) for human exploration to the lunar (and Martian) surface → enabling capabilities for **sustainable** surface exploration, longer term **commercial activities**
- **Use of space conditions** for production of materials with enhanced properties (i.e. without defects associated to terrestrial conditions) for **commercialization** on Earth