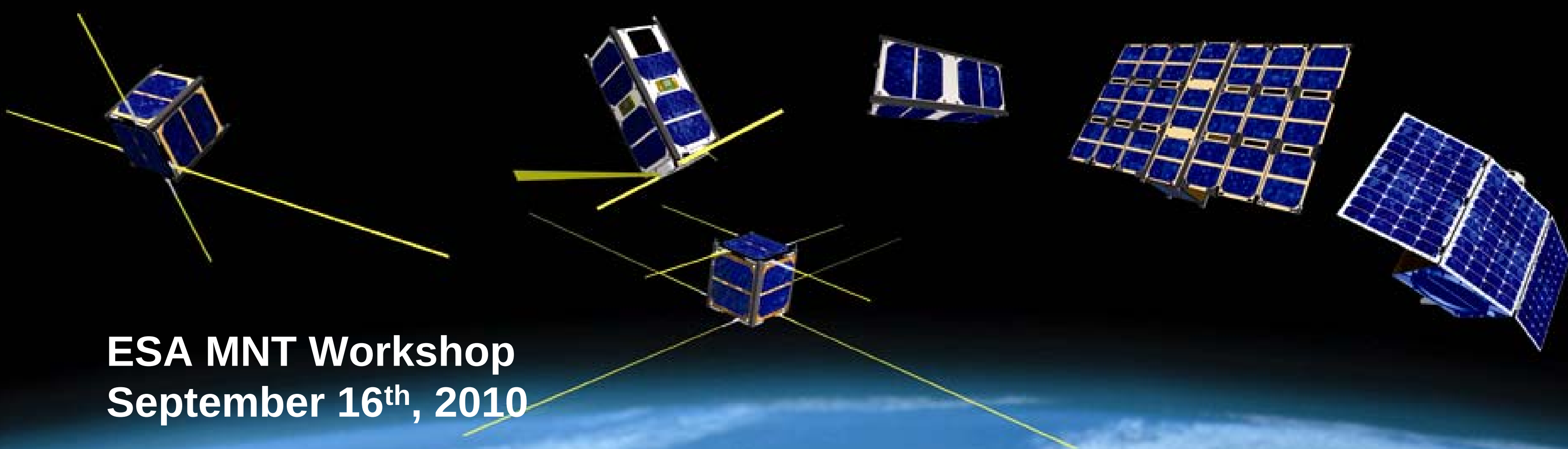
# High-Performance, High Reliability Subsystems for Nanosatellites

J. Rotteveel – ISIS
F. Brühn – ÅAC Microtek



**ESA MNT Workshop**
**September 16th, 2010**

# Company Overview

- Spin-off of Delfi-C3 nanosatellite project of TU Delft
- Founded January 06, 2006
- Office locations:
  - Delft, near Delft University of Technology Campus
  - Noordwijk, in the European Space Incubator at ESTEC
- Current team: 20+ engineers, plus management, support
- Fully owned by the management team:

Jeroen Rotteveel
Managing Director

Abe Bonnema
Marketing Director

Wouter Jan Ubbels
Technical Director

Eddie van Breukelen
Financial Director

# Company Activities

# Nanosatellites

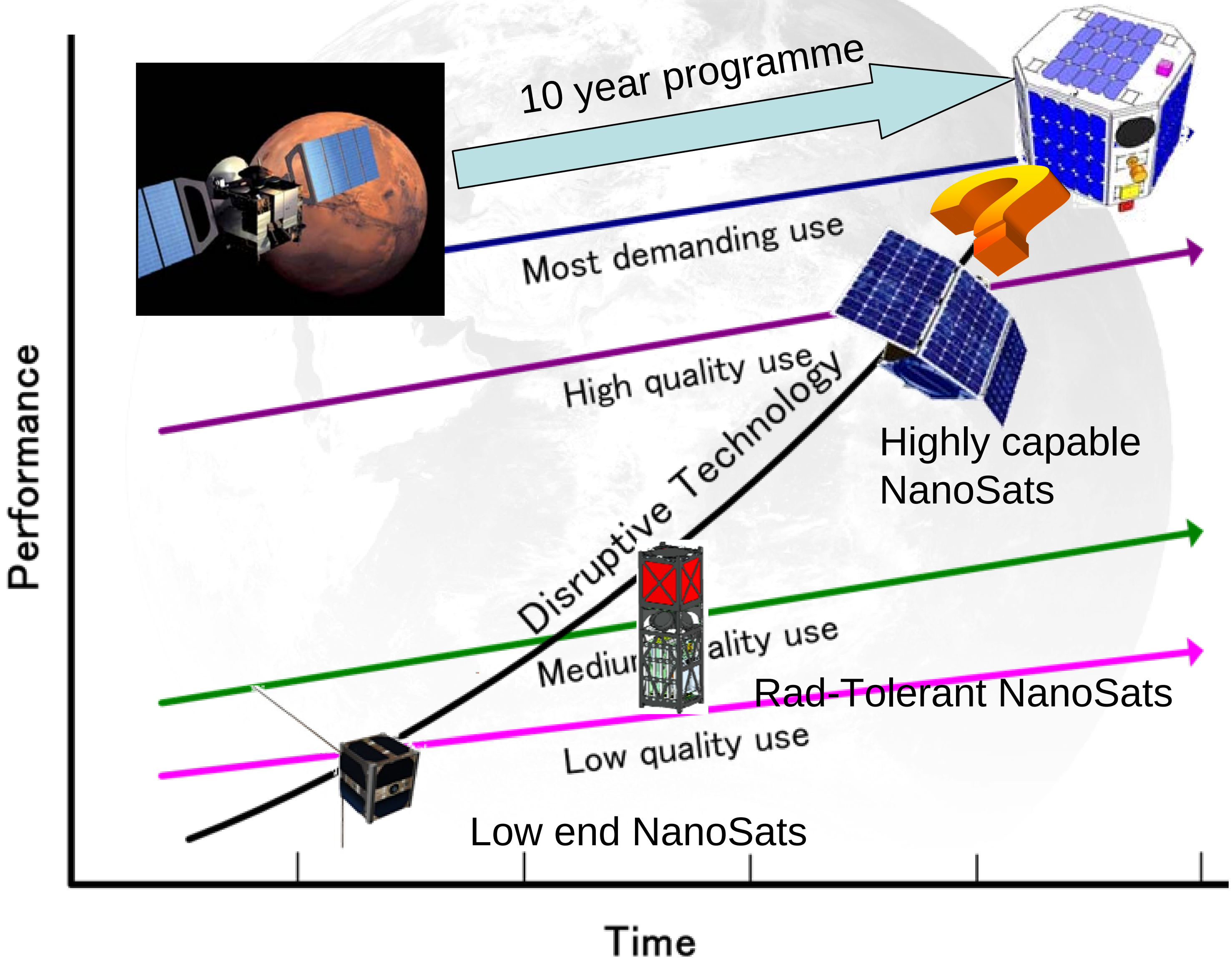
| category | mass range (kg) |
|---|---|
| large satellite | > 1,000 |
| medium-sized satellite | 500-1,000 |
| minisatellite | 100-500 |
| microsatellite | 10-100 |
| nanosatellite | 1-10 |
| picosatellite | 0.1-1 |
| femtosatellite | < 0.1 |

# NanoSats as Disruptive Technology

Start simple
- Low pointing
- Low complexity
- Fast time to market

Design to Cost
-Focused Missions
-New risk approach
-Low entry barrier

Stepwise Improvements
~3 year lifecycles
-Formation Flying
-Better Pointing
-Lifetime (rad hard)
-Reliability



# The NanoSat Challenge

Pros

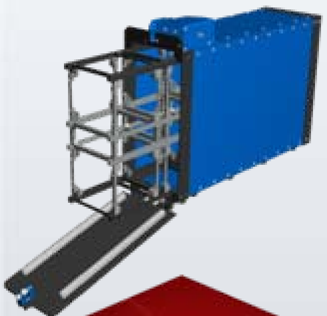
- Lower absolute costs (€ / mission)
- Short development time
- Reduced complexity
- Low launch cost
- Lightweight, compact spacecraft

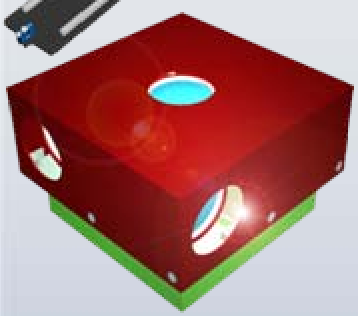
Cons

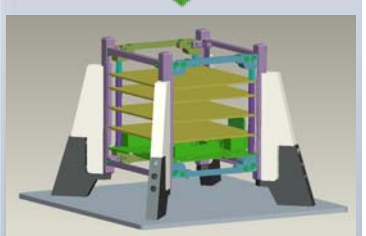
- Higher specific cost (€ / kByte useful data)
- Short Mission Lifetime
- Reduced capability
- Piggy-back constraints
- Limited onboard resources

MNT can exploit these Pros and potentially overcome the Cons of Nanosats

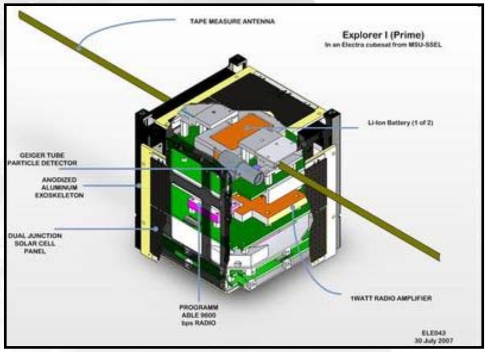
# Design Aspects

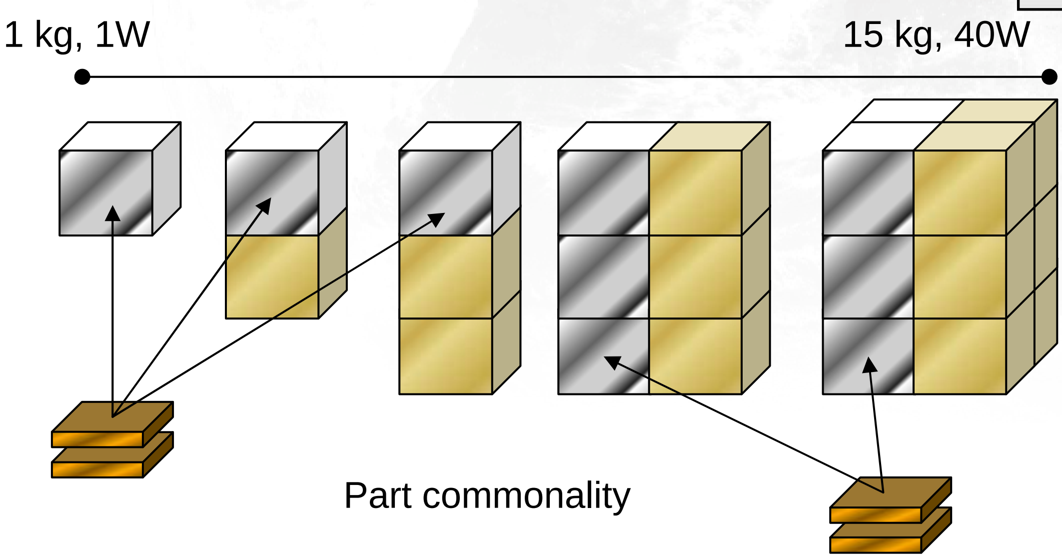






- Small Teams
- Short Mission Lifecycles
- Modular systems
- Standard avionics modules and interfaces
- Mission Specific Avionics and systems
- Plug and Play Payload capability
- Off-the-shelf systems



# The CubeSat Challenge

Ground Breaking Science

Maintaining Strategic Capabilities

**10x10x10 cm**

**1.0 kg**

**Piggyback launch**

**<2 W OAP**

**< 500 kByte / day**

**<200,000 Euro**

**<24 months**

Technology Demonstration

Education and Training

Highly Profitable Business

First Steps In Space

Securing the Safety of Citizens

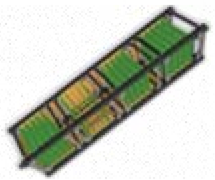
# CubeSats grow in size…

1-Unit

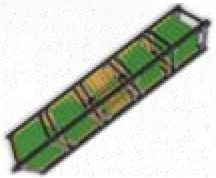
1.5-Unit

2-Unit

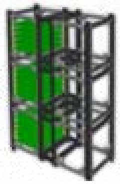
3-Unit



4-Unit



5-Unit



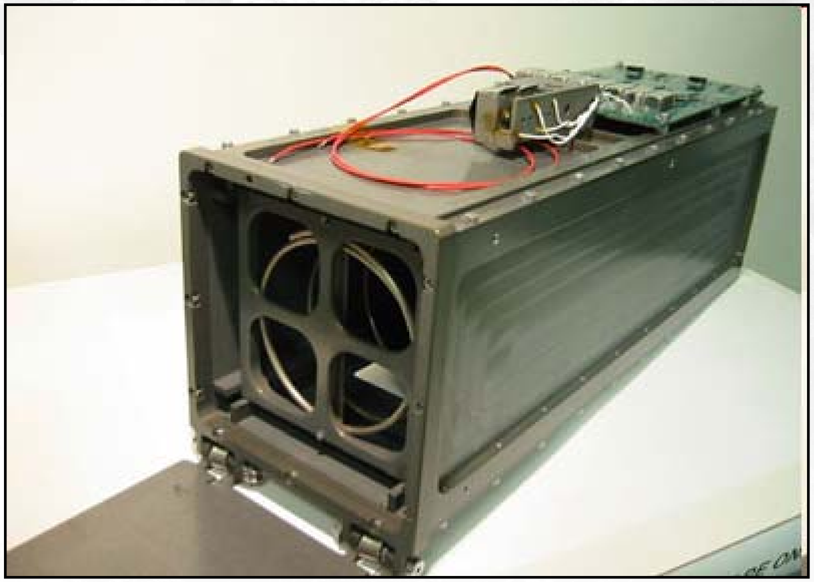
6-Pack

?

# …And Standards Evolve…

- Initial CubeSat Design Specification (CalPoly / P-POD)
  - 1-Unit = 1.0 kg max
  - 3-Unit = 3.0 kg max
- Current CubeSat Design Specification (CalPoly / P-POD)
  - 1-Unit = 1.33 kg max
  - 3-Unit = 4.0 kg max
- ISIS CubeSat Deployers
  - 1-Unit = 2.0 kg max
  - 3-Unit = 6.0 kg max
  - Additional envelope for Apertures and Deployable arrays

# But ultimately size is limited



CubeSat NanoSats are limited by availability of standard deployment canisters

# Application Evolution

First Steps In Space

Education

Tech demo

Need for increased:

Performance

Reliability

Robustness

Science

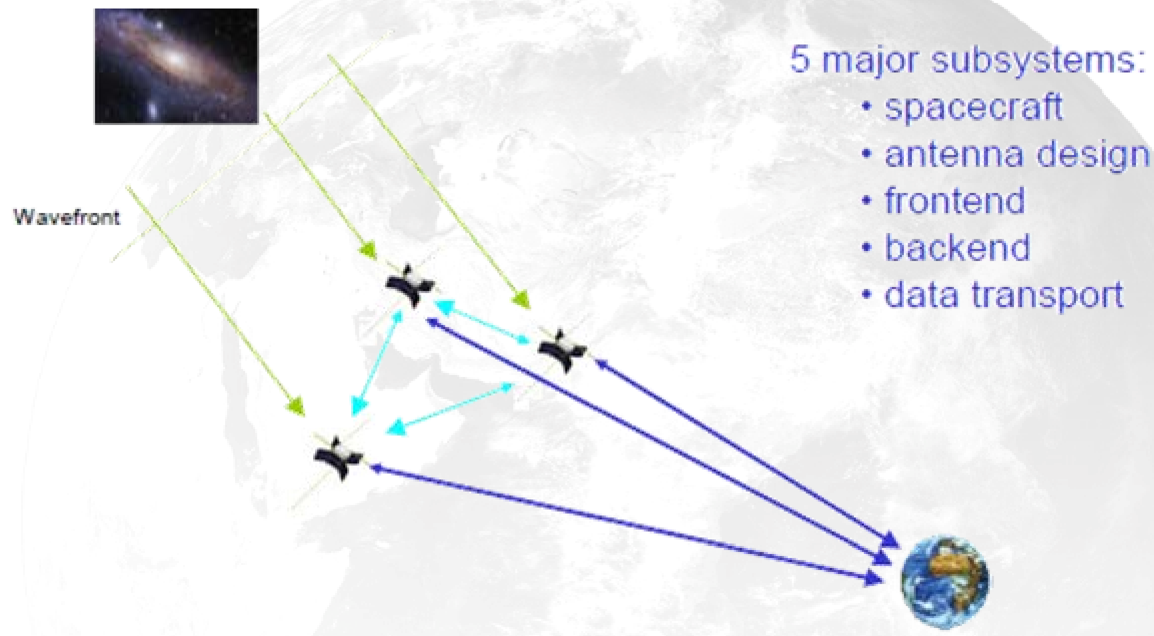
Commercial

Security

Military

Often as swarms or constellations

# Advanced Application - OLFAR

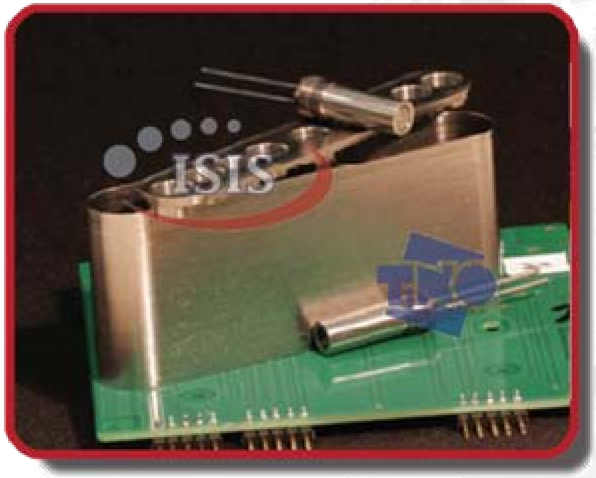



- OLFAR is a new concept of a low frequency radio telescope in space using small satellites.
- Correlation must be done in space.
- Distributed processing with centralized downlink transmission is the preferable option.
- Inter satellite link is the communication challenge.

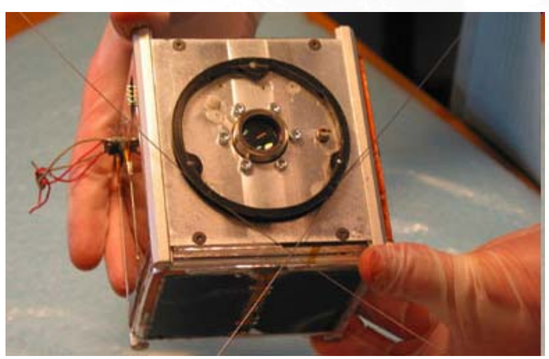
# Constellation and Swarm aspects

- In orbit delivery and control
  - Deployment systems
  - Propulsion
  - De-orbit systems
- Improved Robustness of the system
  - Autonomy
  - Redundancy schemes
  - In-orbit spares
- Improved communication
  - Intersatellite links
  - Ground networks

# NanoSat propulsion Systems




MEMS Valves
Micro-Machined Thrusters
Micrometer thin solar sails



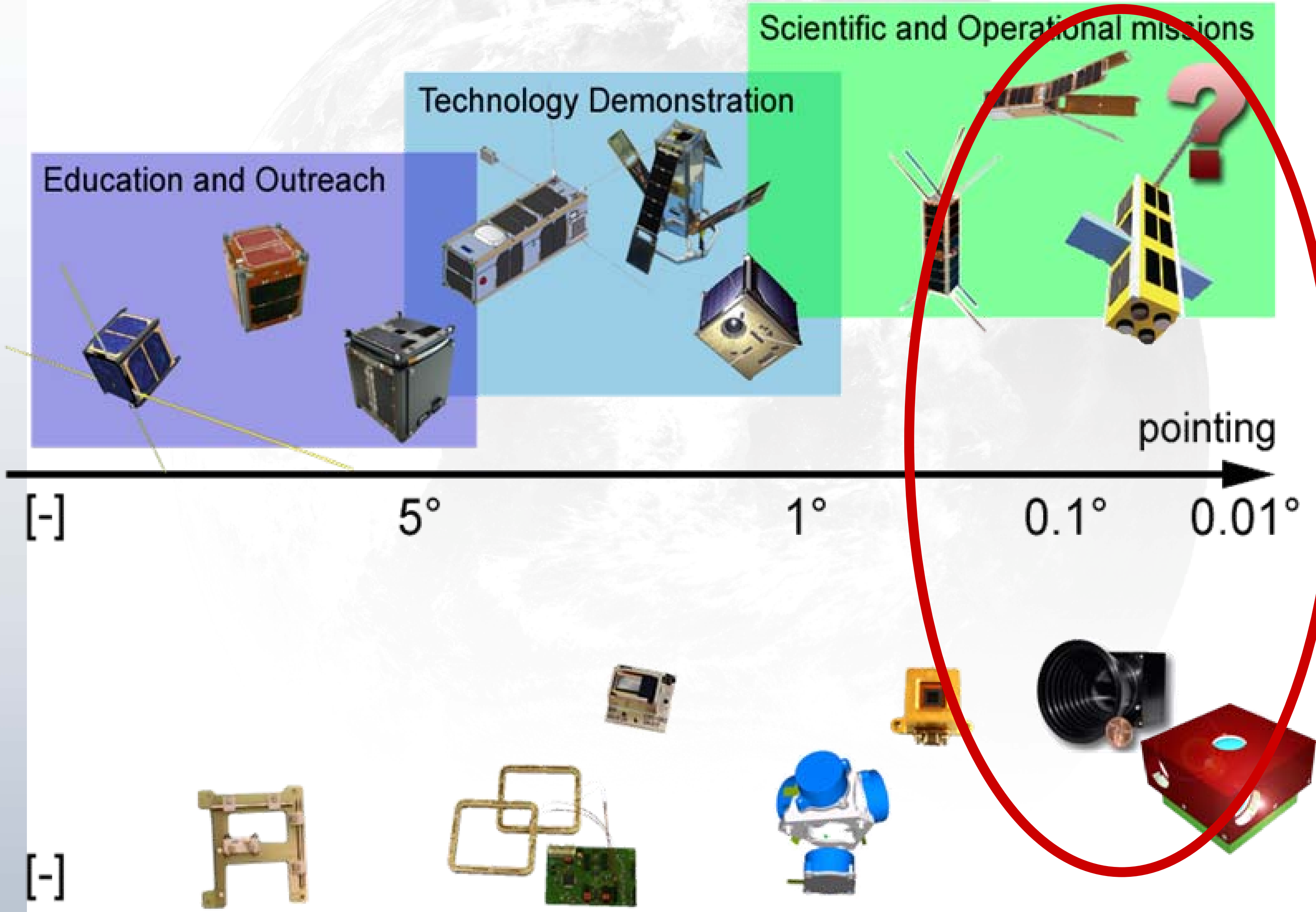
# Spacecraft level aspects

- Need for better control of the spacecraft
  - Attitude Determination
  - Attitude Control and Pointing
  - Formation Flying
  - (de-)Orbit Control

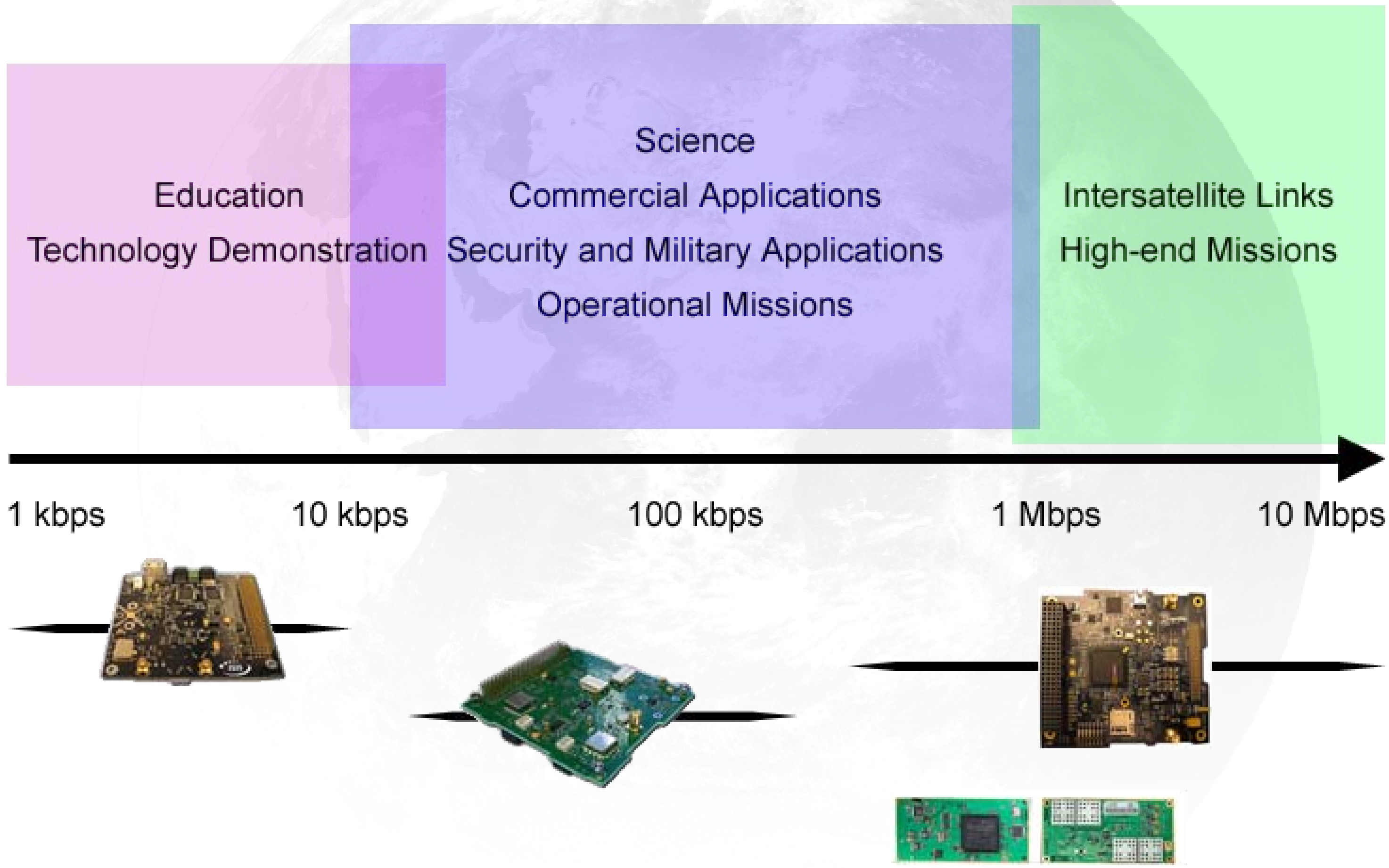
- Improved Reliability of systems
  - Radiation Tolerance
  - Improved QA / PA in the system design
  - Redundancy schemes

- Improved onboard resources
  - Improved onboard power (up to 50W arrays)
  - Improved data processing capabilities
  - Improved data downlink (from 10 kbps to 10 or 100 Mbps

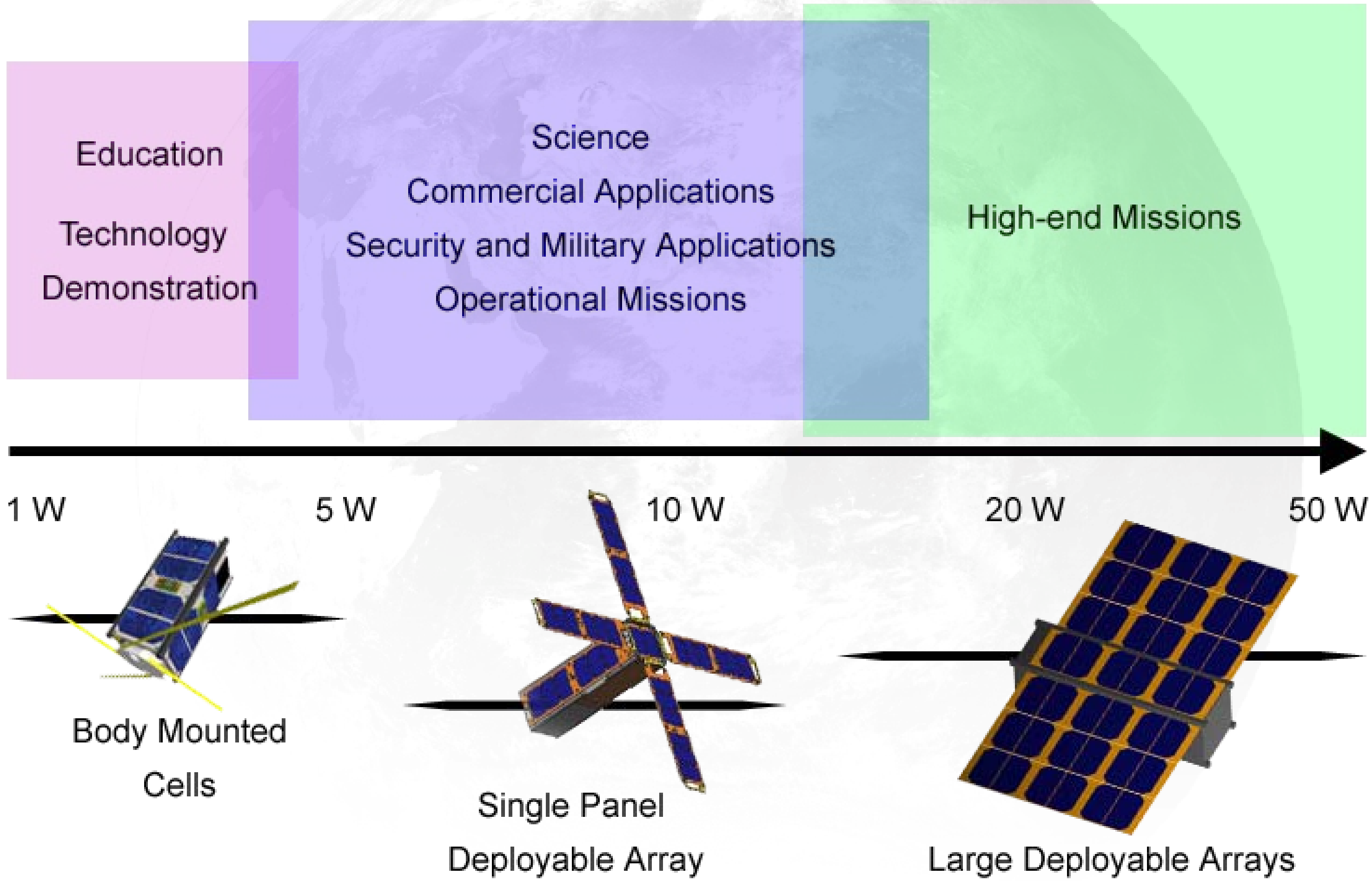
# CubeSat Pointing Trends



# Telecommunication Trends



# Onboard Power Generation



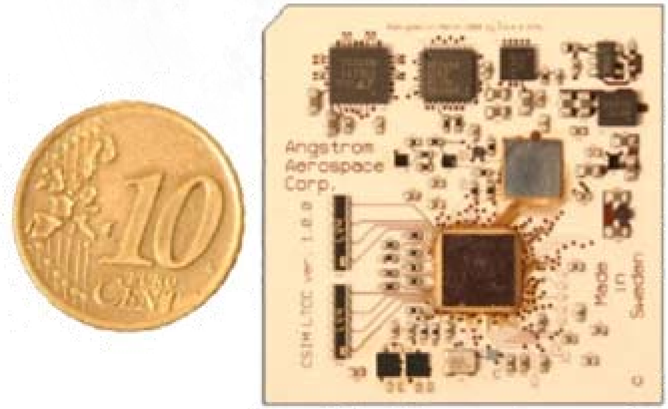
# On a subsystem level

- Miniaturization
  - Microelectronics & MEMS
  - Improved performance per mW / cm3
  - Integration of many subsystems into single boards
- Interface Standardization and modularization
  - Allows for gradual improvement
  - Drop-in replacement
  - Self discovery and configuration
- Improving reliability and robustness
  - Latch-up protection
  - Radiation tolerance
  - Better testing of parts and components

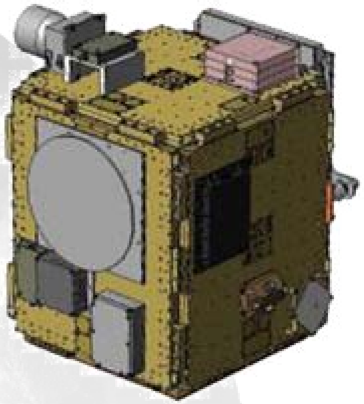
# Miniaturization and integration

Plans for single board with:

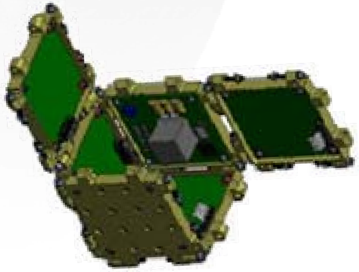
- Remote Terminal Units as OBCs
- Miniaturized SDR radios
- Power conversion
- Attitude determination



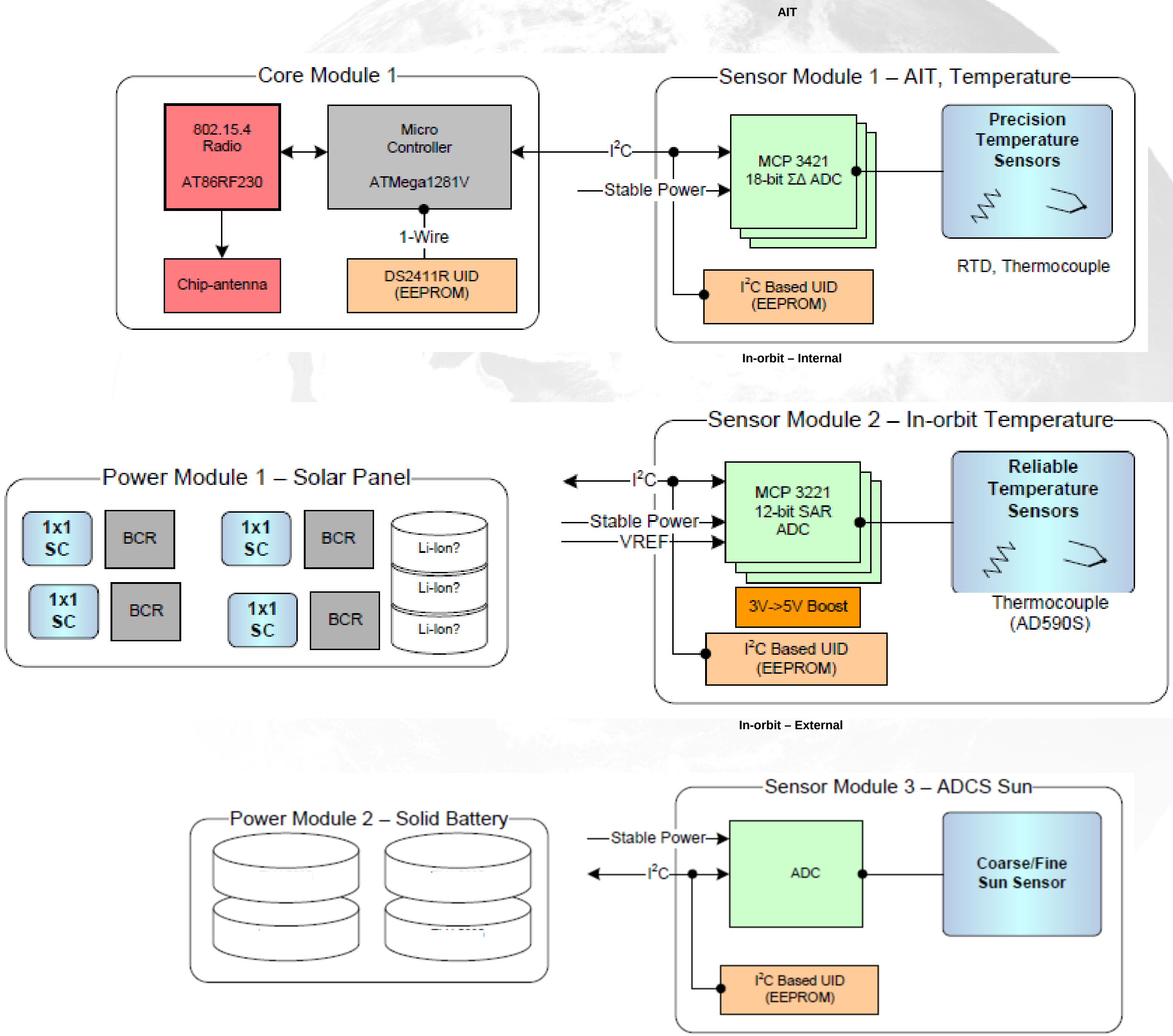

# Standardization and Interfacing



- Plug-n-play Capability
  - Self configuration
  - Self discovery
- Allows for more focus on mission design and instrument design
- USAFs PnP-Sat and CubeFlow
- ESA's Standard Modular Microsystems Interface project
- Evolving CubeSat Standards
- New data buses

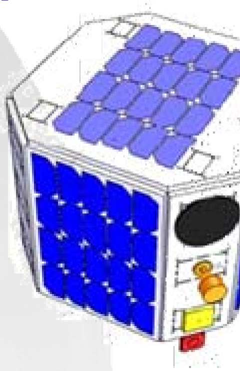


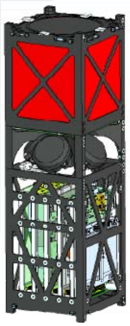
# Reducing Harness - Wireless

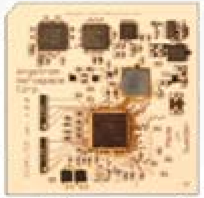


# Reliability Improvement

- Efforts going on to improve radiation tolerance for nanosats
  - ESA's NEOMEX initiative
    - Technology programme to develop highly capable, miniaturized satellite
    - Rad Tolerant
    - High performance
    - ESA qualified nanosatellite
  - USU's SDL Pearl CubeSat
    - Rad tolerant
  - Rad Tolerant OBC modules
    - Approved processes and components

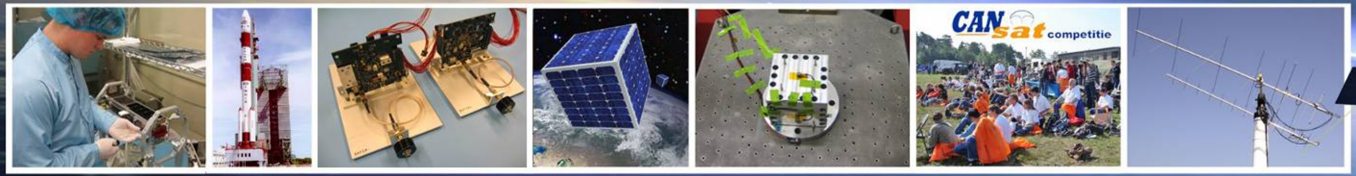






# Conclusions

- NanoSats have come a long way in the past decade
- More ‘mature’ applications are driving performance and reliability of nanosatellite space systems, spacecraft and subsystems
- MNT and highly integrated subsystems can satisfy this demand.




# Thank you for your attention!

# Questions?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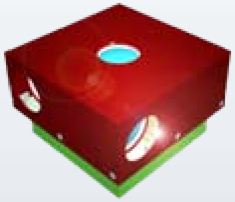
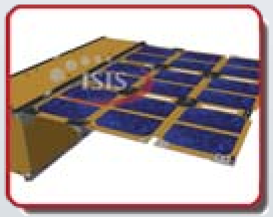
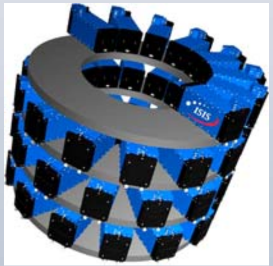
# Current Activities



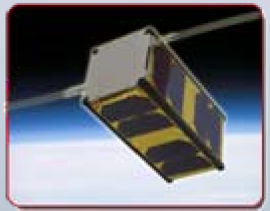




- Ongoing Product Developments:
  - Communication Systems (UHF, VHF, S-Band)
  - ISIPOD Deployer systems in various form factors (e.g. 6-Pack)
  - Test & Ground Support Equipment Kits

- Ongoing R&D Projects:
  - Track & Trace payloads (with various Dutch partners)
  - Miniaturized Star trackers (with TNO/cosine/Bradford/SystematIC)
  - Deployable nanosatellite Solar Arrays (with Dutch Space)
  - Modular Payload Deck Elements (with Stork/Fokker/Mecon)
  - Wireless Sensor Networks (with TUD / Aerospace Wireless)
  - NEOMEX SMMI (With international partners)

# Current Activities

- Ongoing Missions & Platforms:
  - Triton-1 Tech Demo Mission (with SystematIC / NLR)
  - Triton-2 AIS Demo Mission (with ClydeSpace / GomSpace)
  - FUNcube Platform and MAIV (for AMSAT UK)
  - De-Orbit Sail Demo Mission (EU project with SSC, DLR, ASTRIUM, Universities in Greece, Turkey, South Africa)
  - Delfi-n3Xt (Payload Partner of TU Delft)
  - 2U environmental monitoring mission (for Indian University)