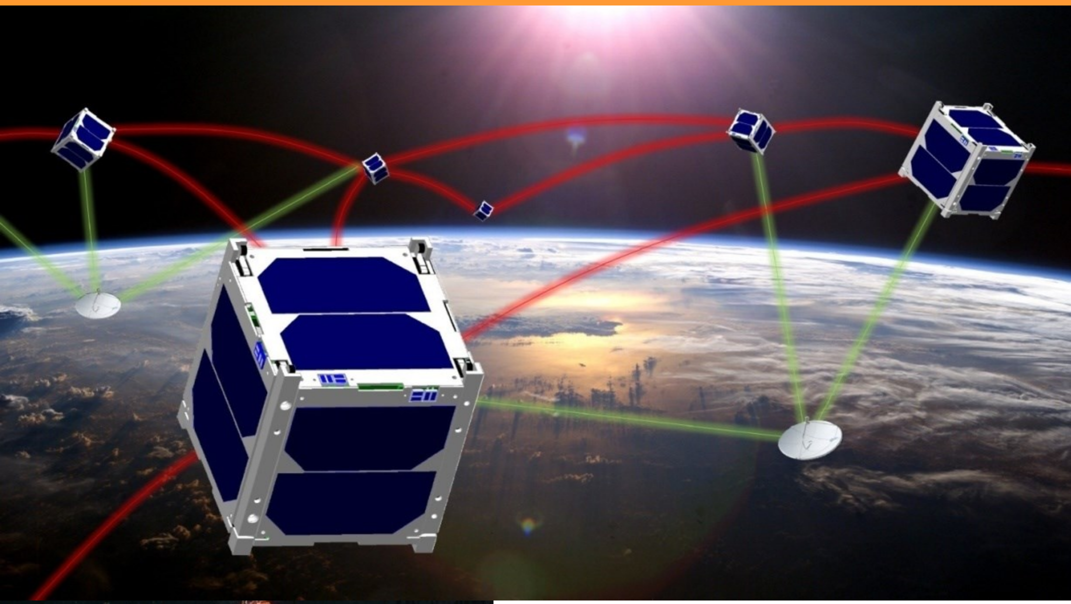
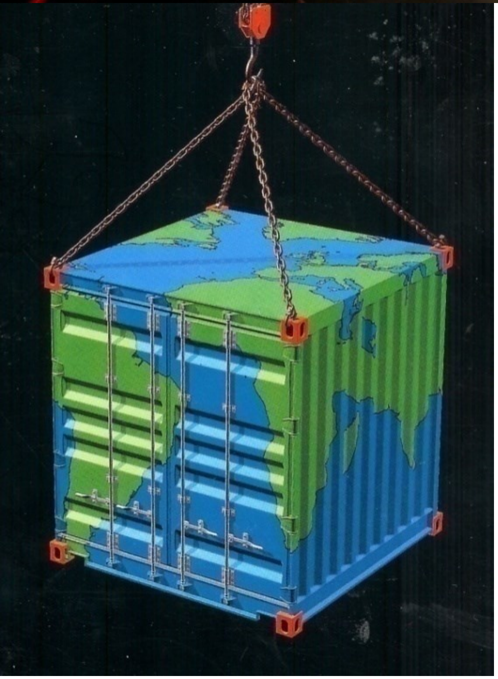
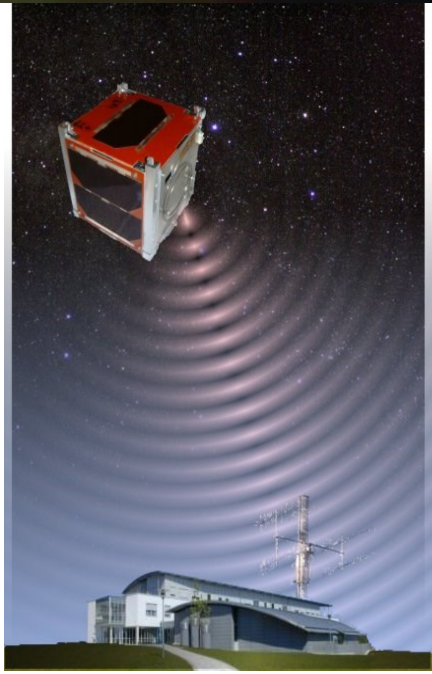




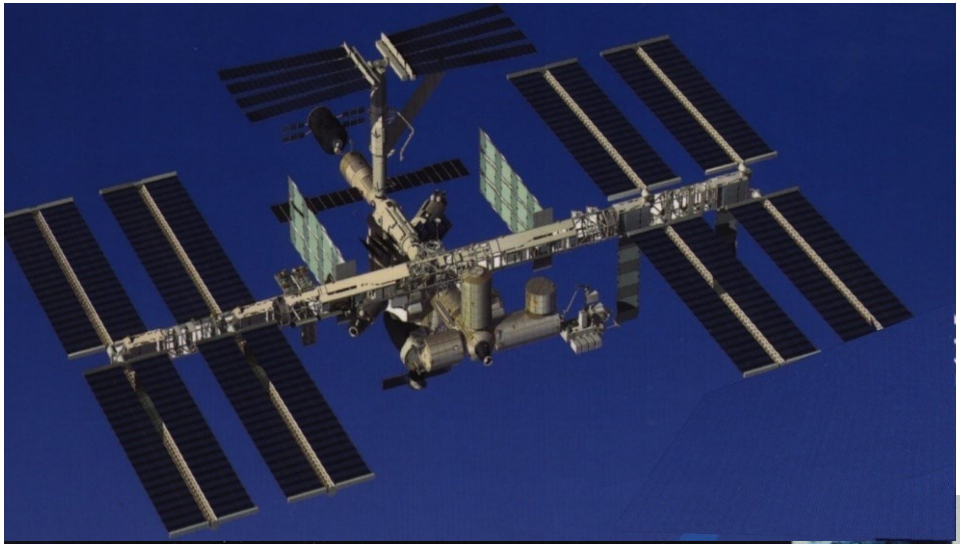
Nano-Satellite Review Procedures for UWE

Center for Telematics &
University Würzburg

schi@informatik.uni-wuerzburg.de

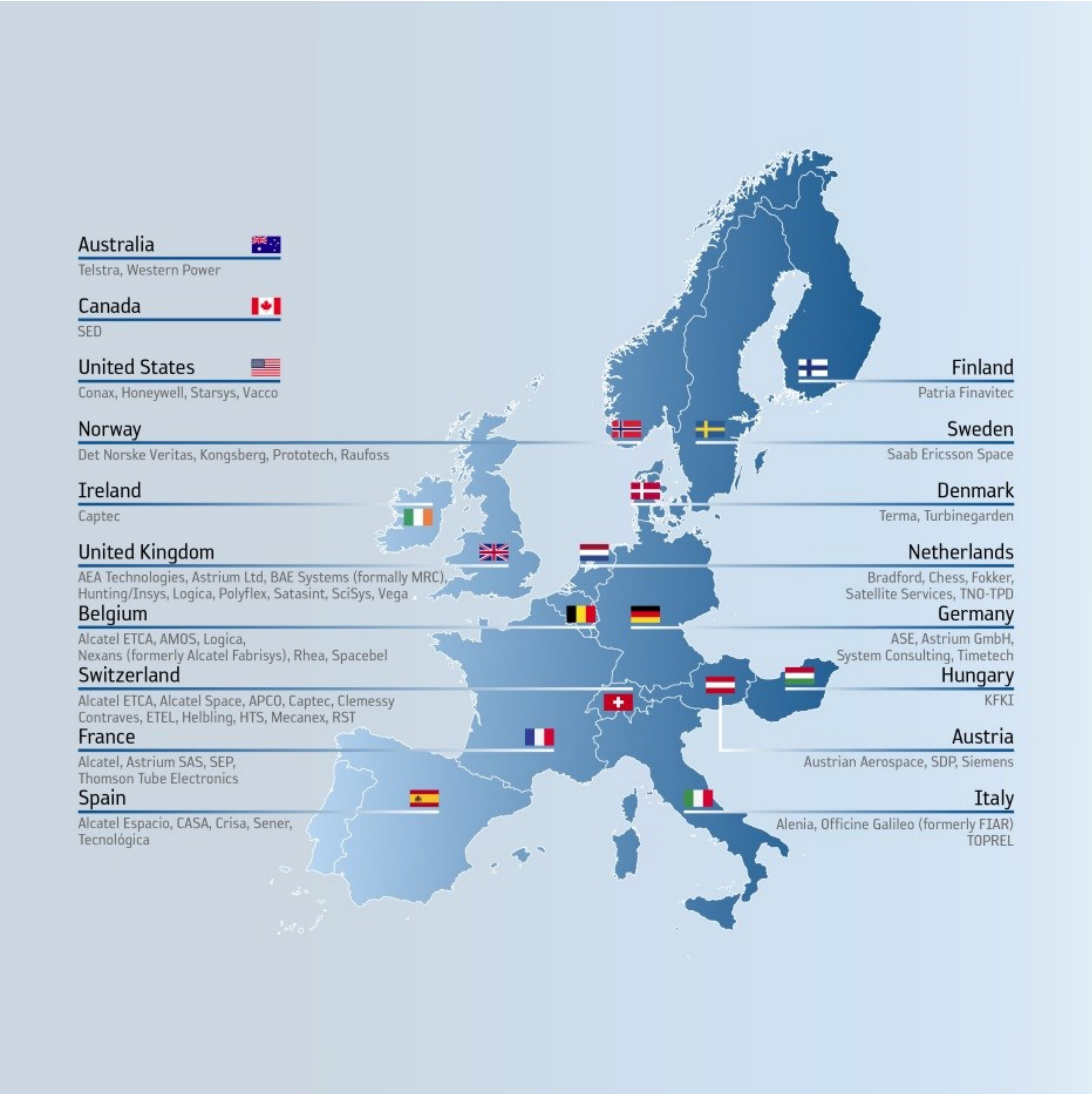


CASSINI_HUYGENS



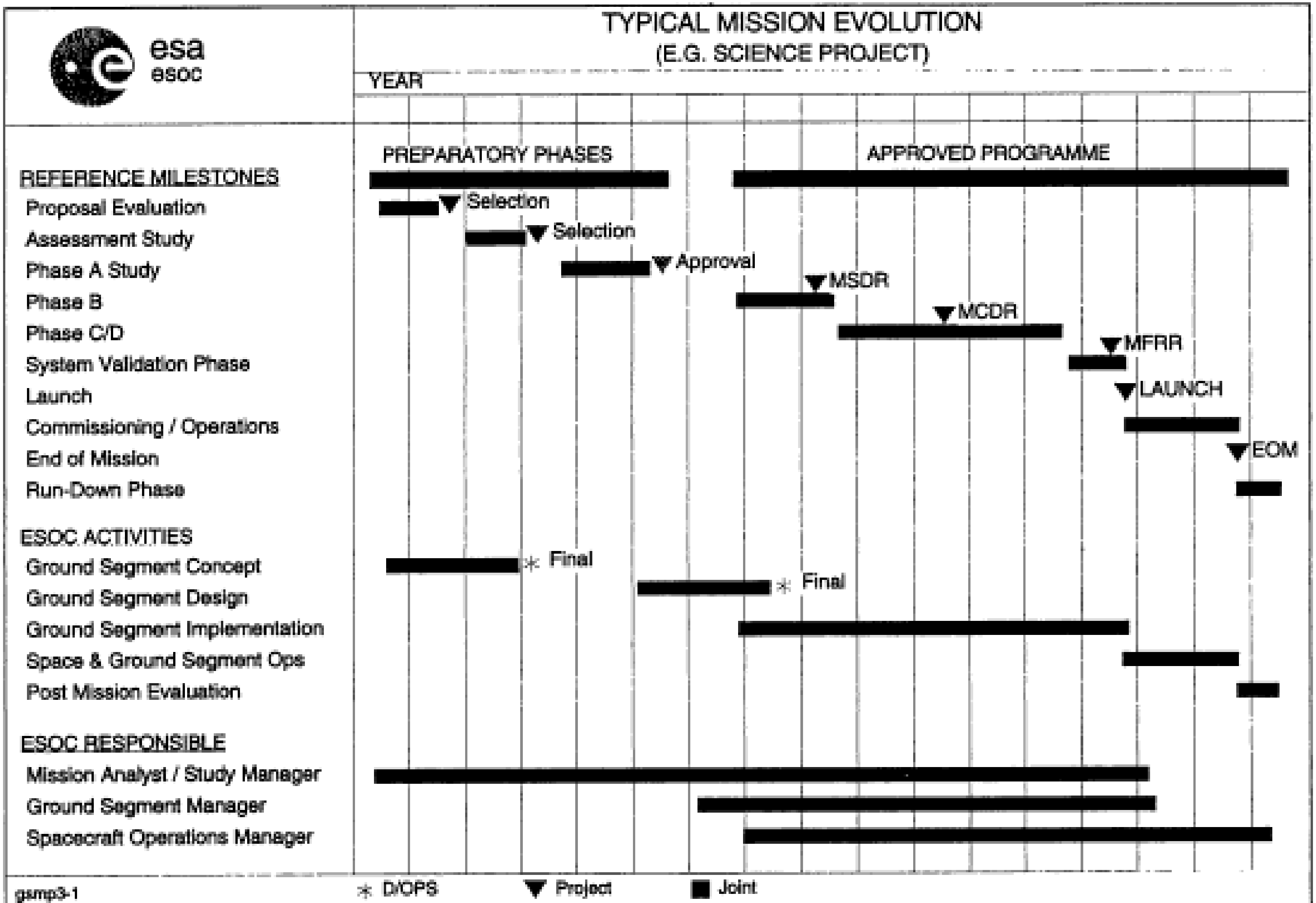
ROSETTA

Earlier Involvement in Space Projects for ESA



50 contractors from 14 European countries and the USA. Major subcontractors were Astrium Ltd. who built the spacecraft platform, Astrium France who supplied the spacecraft avionics and Alenia Spazio, Turin, Italy, for assembly, integration and verification.

The industrial consortium of “Rosetta”



Thanks to:
M. Warhaut (ESA)
Mission Operations management into the 21st Century

Approaches for Planning and Management in Big Space Projects

ZfT /Uni Würzburg: Roadmap for distributed networked pico-satellite systems

ZENTRUM FÜR TELEMATIK E.V.

(UWE = ***U***niversity ***W***ürzburg's ***E***xperimental satellites)

2017/18 NetSat-1 to NetSat-4 Formation Flying Mission
- **Distributed Computing Capabilities**
- **Formation Control**
- **DTNs, MANets**
- **…**

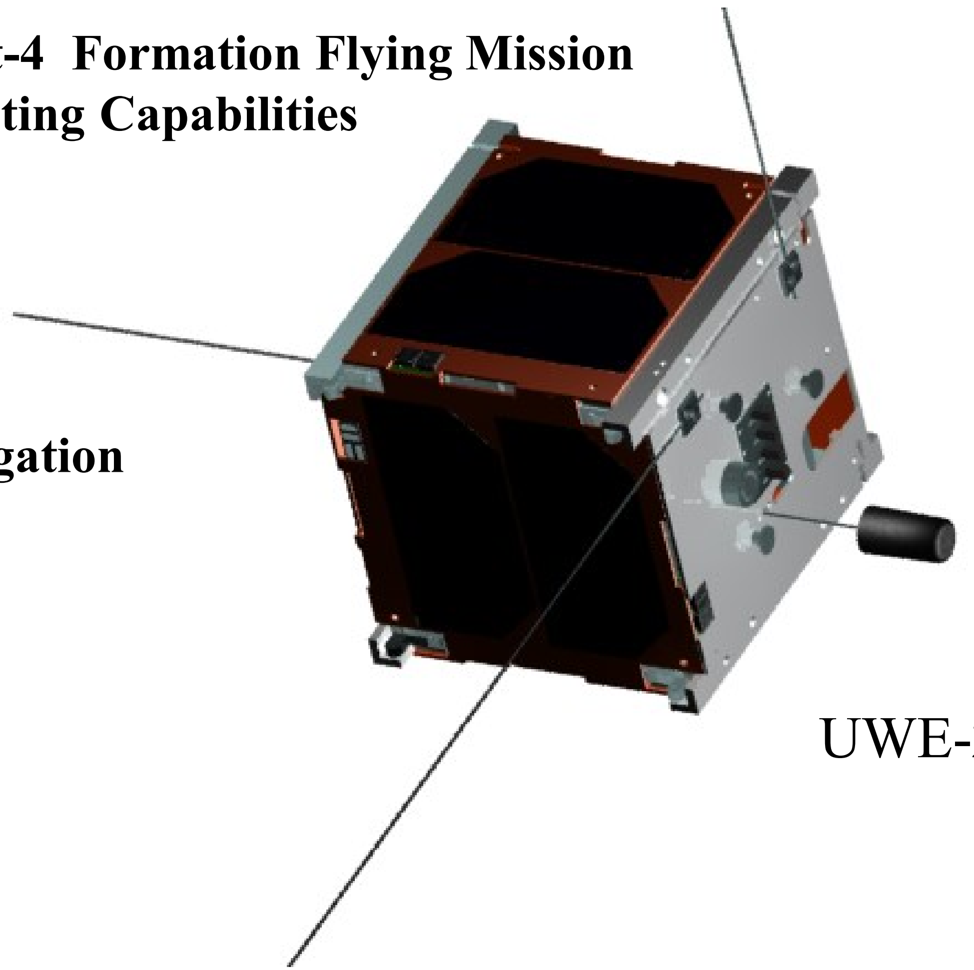
2016 NetSat-0
- Relative Navigation

2016 UWE-4
- Position Control

2013 UWE-3
- Attitude Control

2009 UWE-2
- Attitude- and Orbit Determination

2005 UWE-1
- Telecommunication "Internet in Space"



UWE-2

Implementation Principles

- Program based on small incremental increase of mission complexity
- Design inheritage from precursor missions, all subsystems implementations and system integration performed inhouse
- Satellite design improvements from in-orbit experiences of precursor mission
- Transfer of knowledge: Students who participated in Bachelor or Master thesis, continue as coordinators and PhD-students in a future satellite design
- Intensive cooperation in a team placed in one place
- Early setup of test plan to reach mission objectives

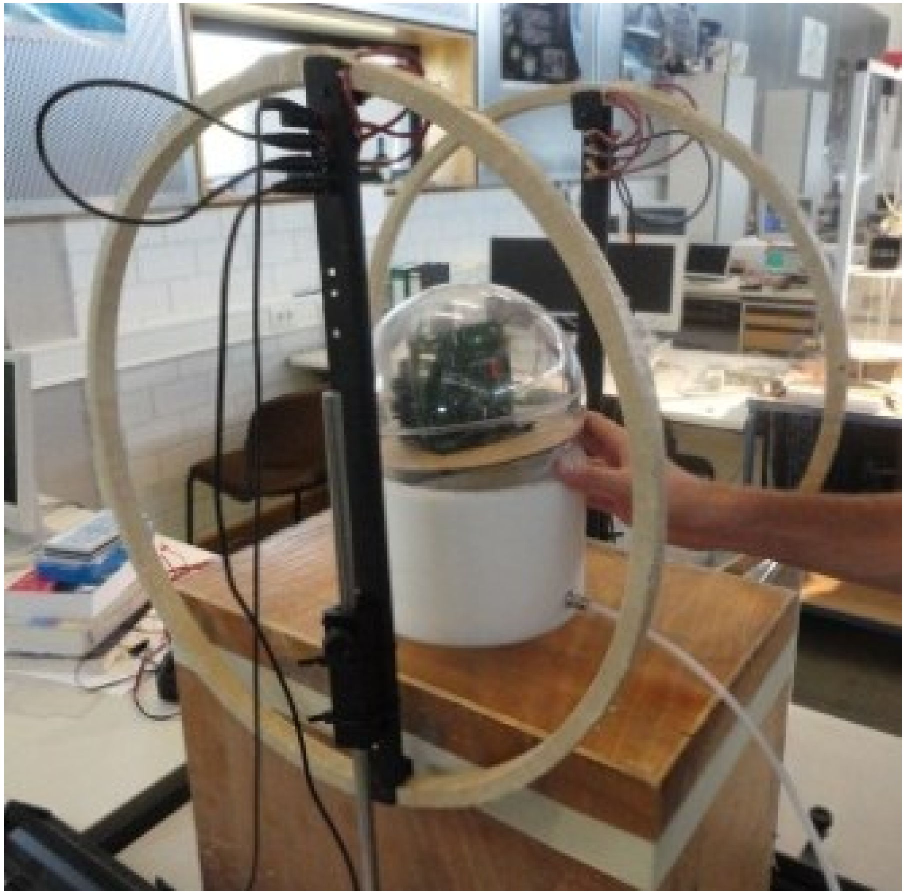
Review Procedures

All UWE-satellites were completely build inhouse and operated by ONE small team, a general baseline with minimum review efforts was implemented:

- **Framework :** A team usually consisted of
  - two PhD-students as coordinators and PIs, coordinating weekly meetings
  - about 10 full-time students (MSC thesis) and
  - about 10 part-time student contributors (Bachelor thesis)
- **Implementation Duration :** Planned realization of the satellite about 1 year; launch schedule delays often offered additional time for improvements
- **Review Plan :** On UWE-1 we had a "System Integration Review" with invited industrial specialists before Testing was initiated, this was abandoned later. Now test plan established in beginning, reviews after each test
- **Test Plan :** Before specific tests were initiated appropriate preparations for readiness are in place to keep risks for damages at minimum
  - inhouse: thermal vacuum (static and cycling) and control performance
  - external: vibration and thermal vacuum

Approach: Learning from in-orbit experiences and improving on the next mission

UWE-3 Attitude Test Facilities

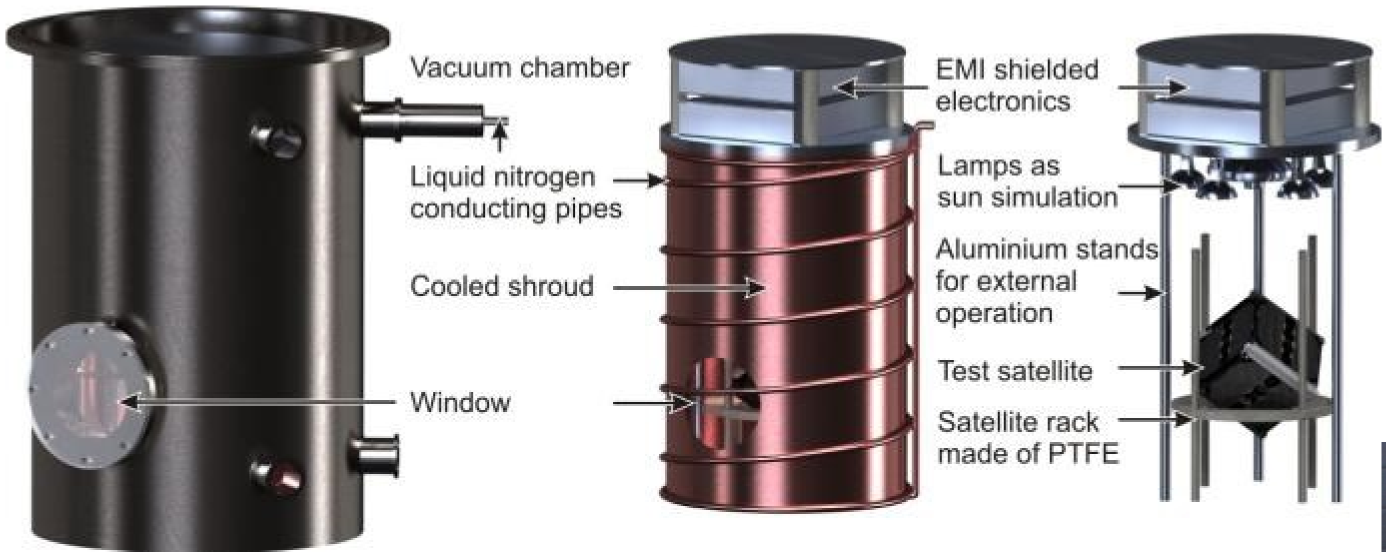


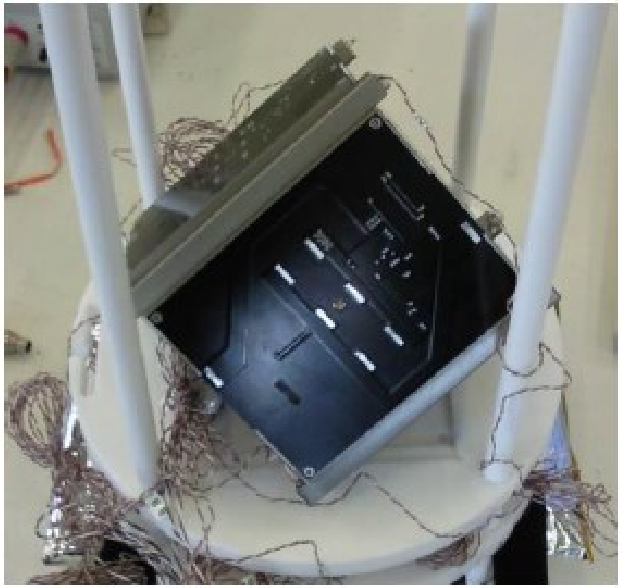
Attitude control tests of the magnetic torquers in interaction with external magnetic coils.

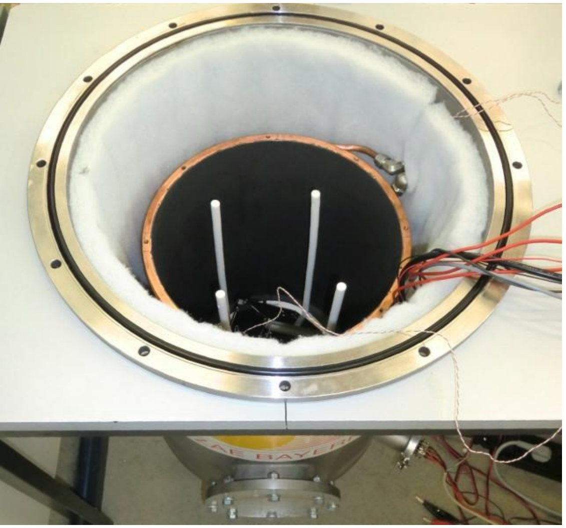
Turntable to characterize along one axis the attitude determination properties.

UWE-3 Internal Thermal Vacuum Tests

ZENTRUM FÜR

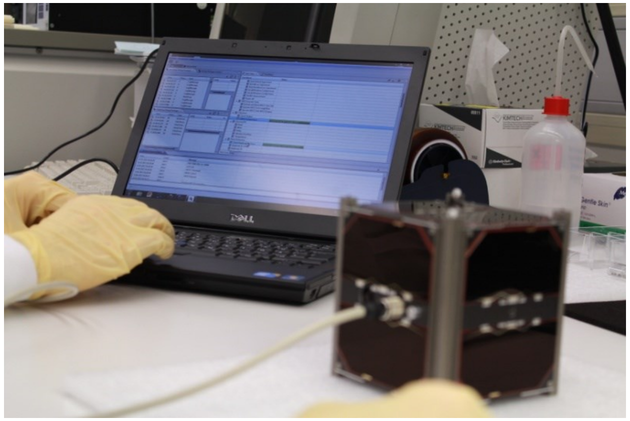


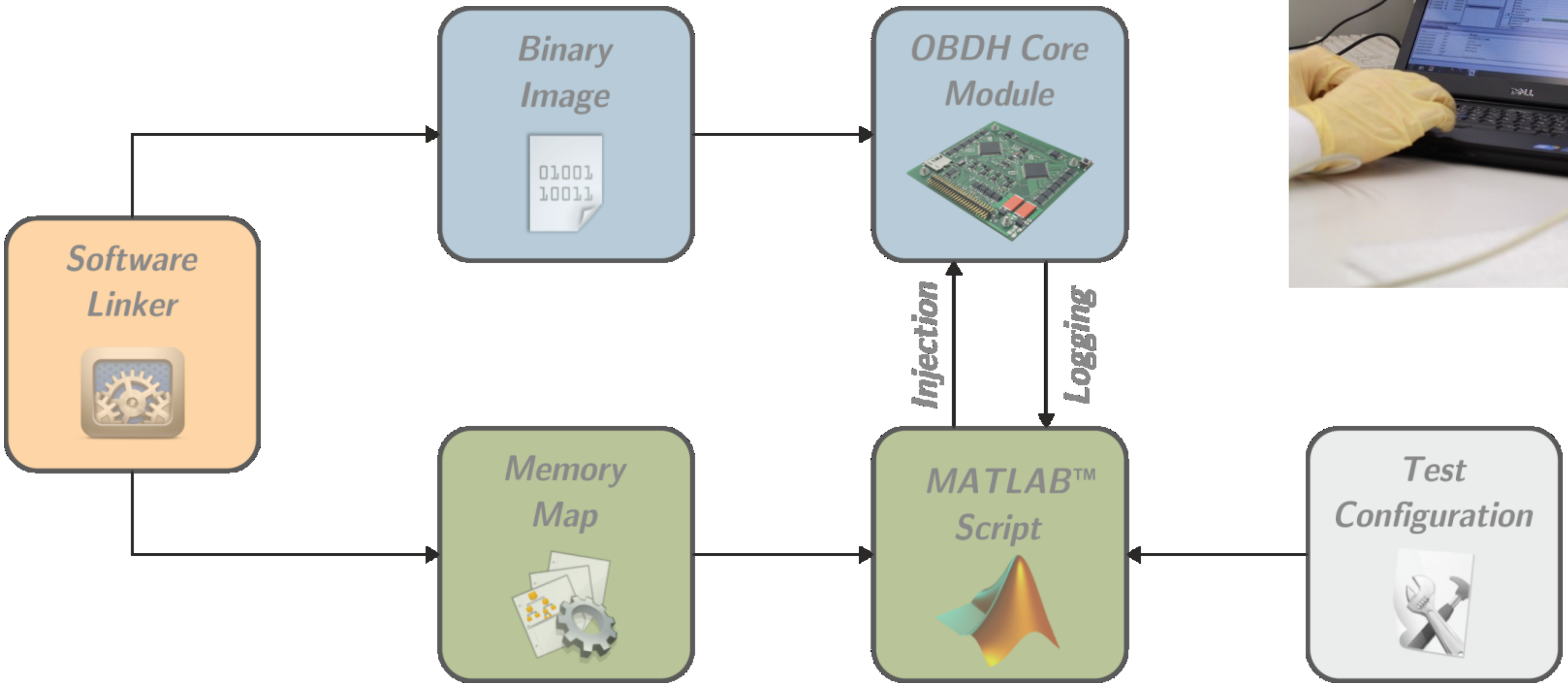




OBDH Core Module

- Software Implemented Fault Injection (SWIFI)
  - Inject random bit errors in specified target regions in RAM or Flash or periphery registers to test
    recovery mechanisms

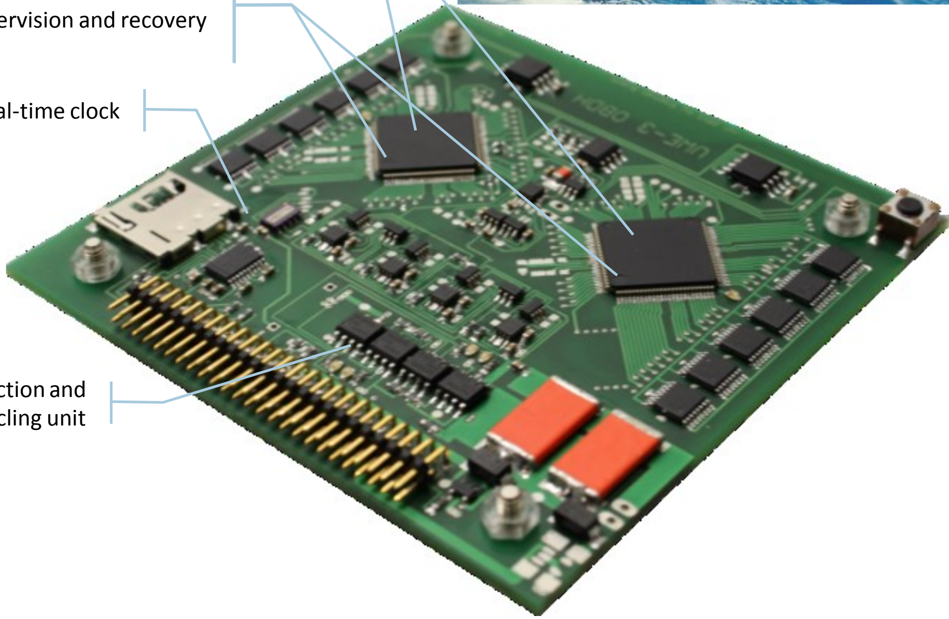




UWE-3: On Board Data Handling Subsystem Testing

Reliable Data Handling by Commercial Low Power On Board Microprocessors Using Radiation Shielding by Software

- Miniaturisation leads to higher susceptibility to space radiation environment
- Only commercial of the shelf electronics was used
- Fault detection, identification and recovery by software and simple watch-dog function



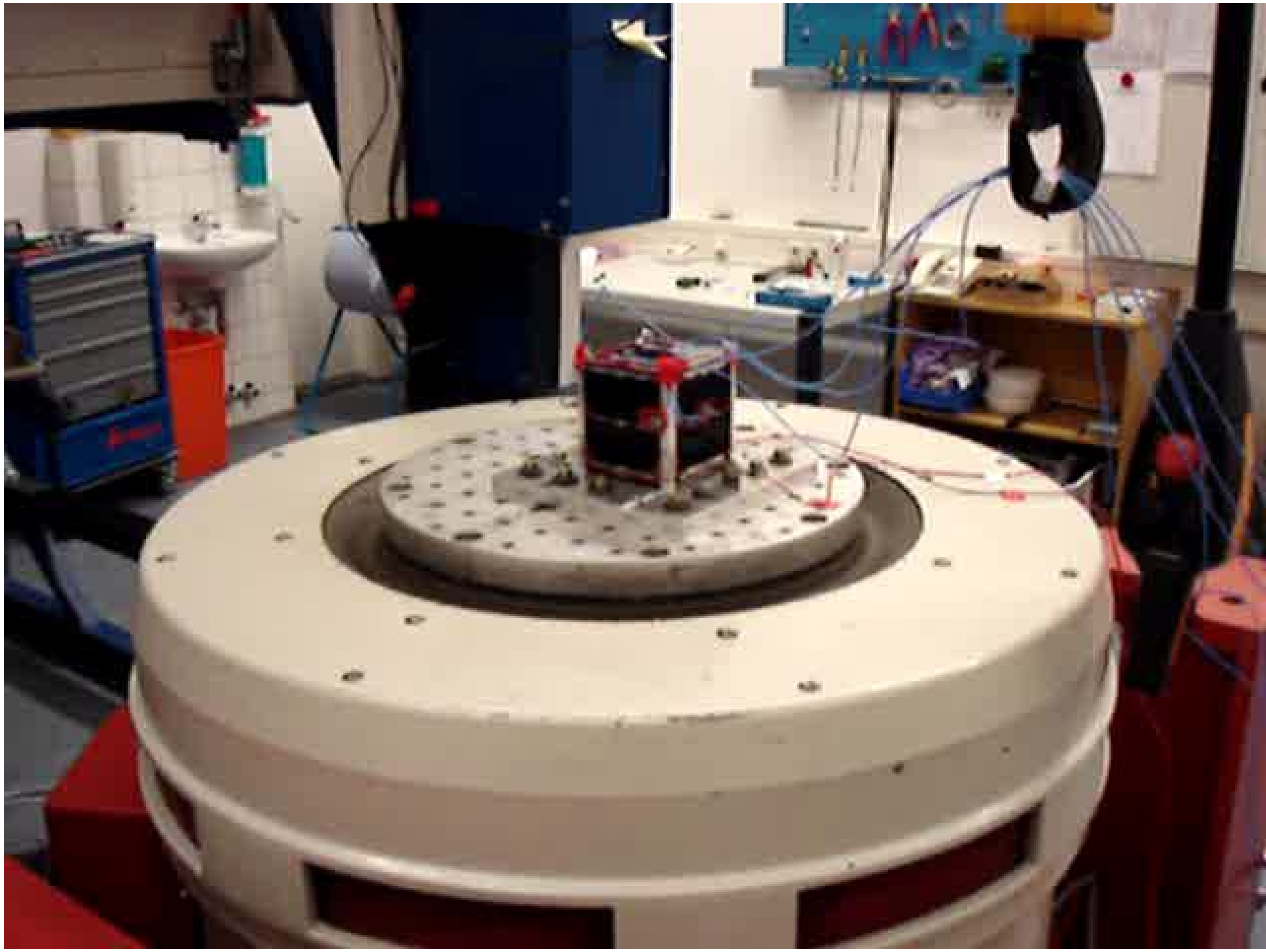
Despite significant radiation encountered, UWE-3 runs now since launch for more than 2 years without any interruption, despite SEUs and latchups

Future developments address provision of distributed computational resources integrated on different spacecrafts of a formation

Testing of UWE-1 in industry

ZENTRUM FÜR TELEMATIK E.V.

Thermal vacuum test



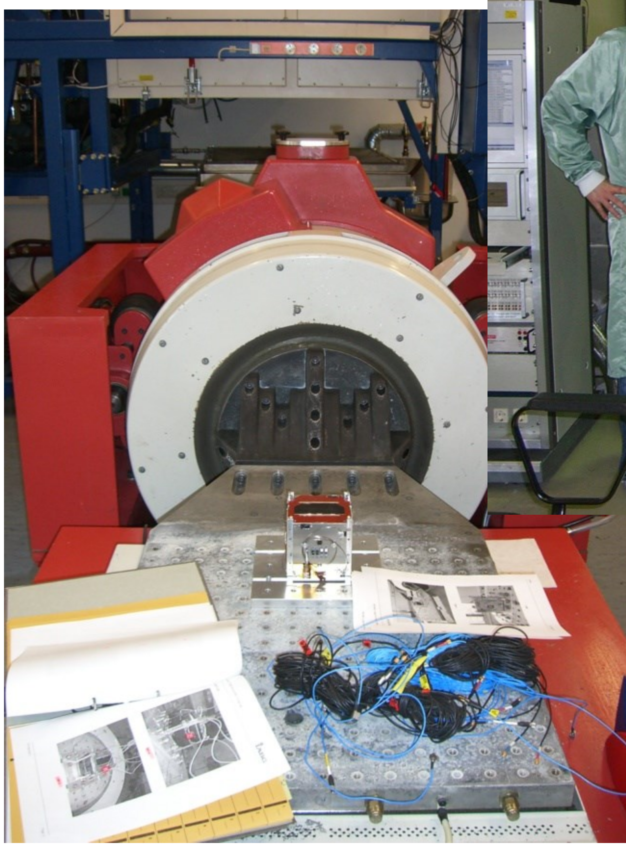
Vibration test

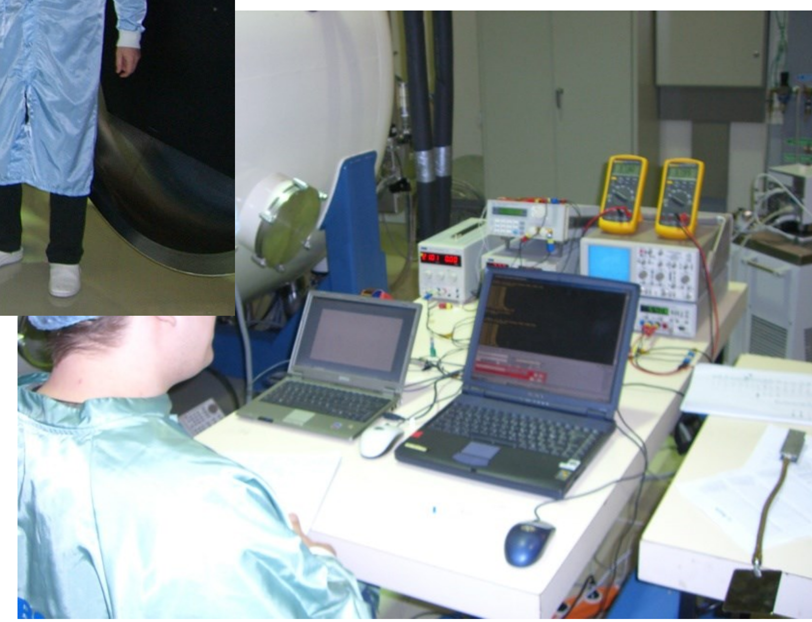
ZENTRUM FÜR TELEMATIK E.V.

Tests & FM Integration

- **UWE-2 vibration test & thermal vacuum test at IABG**

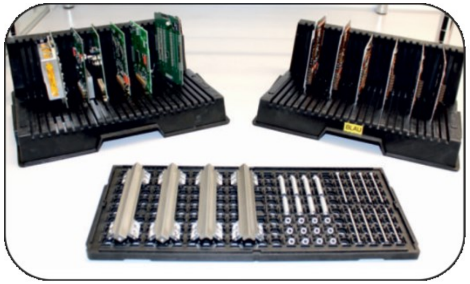
IABG





UWE-2 System Testing

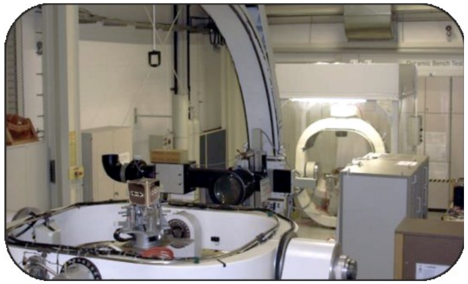
Advanced Manufacturing (Industry 4.0) at Specific Example of Small Satellite Integration



modular satellite bus architecture to support flexible integration an production

close worker / robot cooperation for efficient satellite system integration

flexible flow of materials between integration and testing areas by transport robots



automated tests for functionality and performance of the satellite

Specific advantages include

- high flexibility to variations of standard product
- fast integration of modular components
- respecting high quality requirements

Commercial Perspectives for Small Satellites in Earth Observation

example: Planet Labs, San Francisco

- founded 2011
- grown from 3 to 125 employees
- acquired up to now 160 Mio $ Venture Capital
- images with 3 – 5 m resolution at a high temporal frequency
- 100 satellites to be launched in 2016
- permanently 125 functional satellites in orbit


NEWS

FEATURES

Planet Labs co-founders Chris Boshuizen (*left*), Robbie Schingler (*middle*), and Will Marshall horse around with a Dove at their office in San Francisco, California.

STARTUP LIFTOFF

How flocks of small, cheap satellites, hatched in Silicon Valley, will constantly monitor a changing Earth

By **Eric Hand**, *in San Francisco, California*

Vats of homebrewed porter and brown ale ferment under a lunchroom table. In the corner lie a drum kit and guitar, property of Hank and the Doves, the company's pop cover band. Emma the dog roams—and sheds—freely. In some ways, Planet Labs is your typical Silicon Valley startup. But it's not where you'd expect to see the precision assembly of space satellites. "In terms of overall cleanliness, we just don't care," says co-founder Chris Boshuizen, who wears a droopy Santa hat in preparation for an office holiday party on this rainy December day in San Francisco.

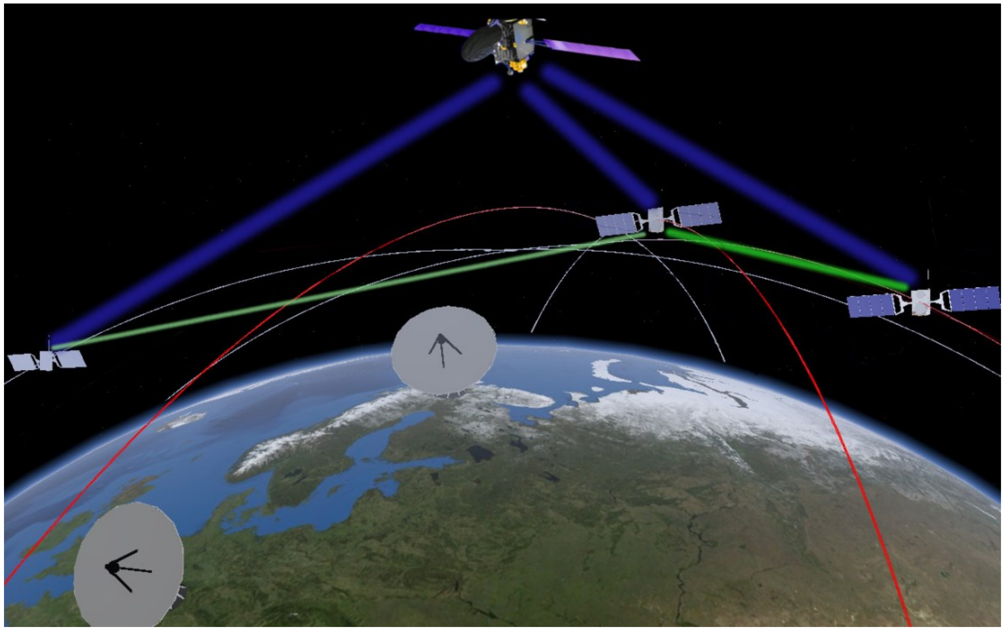
Boshuizen pushes aside strips of clear vinyl sheeting and enters what he calls the "clean enough" room. He stomps on a mat of sticky tape that helps eliminate static charges that could zap satellite electronics—a rare precaution. Beyond another line of tape, no alcohol is allowed. There a shelf is stocked with the company's product: space telescopes no bigger than a loaf of bread.

Two dozen of these telescopes, called Doves, already orbit the Earth, imaging the

Published by AAAS

Dramatically growing interest in commercial small satellites will also affect University satellite design and management approaches

Commercial Perspectives for Small Satellites in Telecommunications



Two US-consortia are on the way to establish an innovative, new communication infrastructure by small satelllites (ca 250 kg mass) with high potential to become a disruptive technology:

SpaceX Has Quietly Opened a New Office to Work on Internet-Providing Satellites

Written by **JASON KOEBLER (/AUTHOR/JASONKOEBLER)**

June 3, 2015 // 12:26 PM EST

SpaceX's new, Seattle-area satellite design office has quietly opened, and, presumably, early work has begun on Elon Musk's planned array of satellites (http://motherboard.vice.com/read/spacex-warns-paper-satellites-could-disrupt-its-space-internet-plan) that will be able to provide WiFi internet to any spot on Earth.

In January, Musk announced the plan (http://www.seattletimes.com/business/elon-musk-touts-launch-of-lsquospacex-seattlersquo/) to launch as many as 4,000 satellites into low-Earth orbit.

OneWeb and Airbus Space (USA) announced plans to launch a new satellite constellation to bring high-speed Internet to underserved areas around the World

SpaceX (with 1 Billion $ invest by Google) **:** Plans for 4000 Satellites to provide Internet everywhere

CASIC addresses in China: with „Fortune Star“ similar aims

Dramatically growing interest in commercial small satellites will also affect University satellite design and management approaches