ISIS – Innovative Solutions In Space B.V.

"Status and overview on very small satellites: definition, purposes, and projects"

Abe Bonnema, Marketing Director

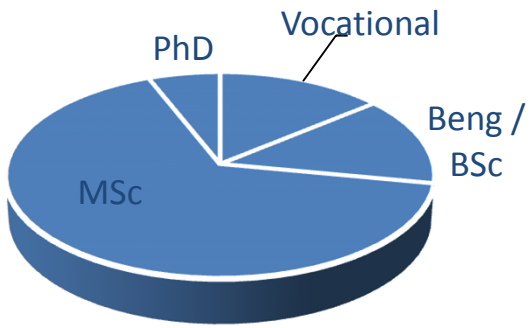
IISL-ECSL Space Law Symposium, Vienna, 24 March 2014

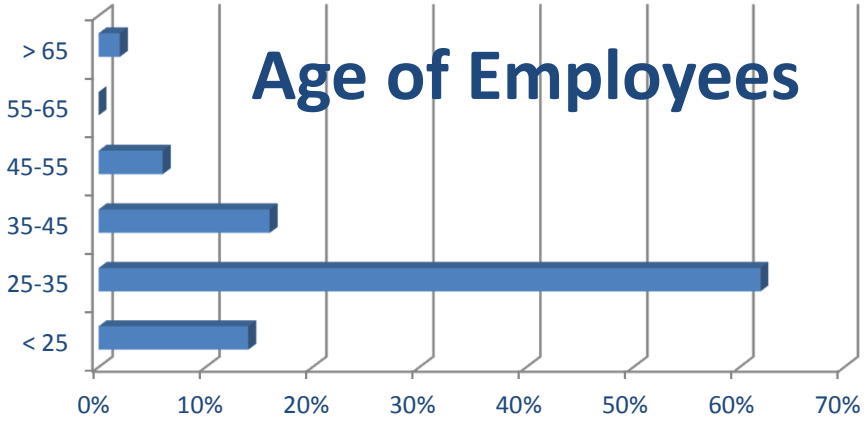
ISIS group - overview

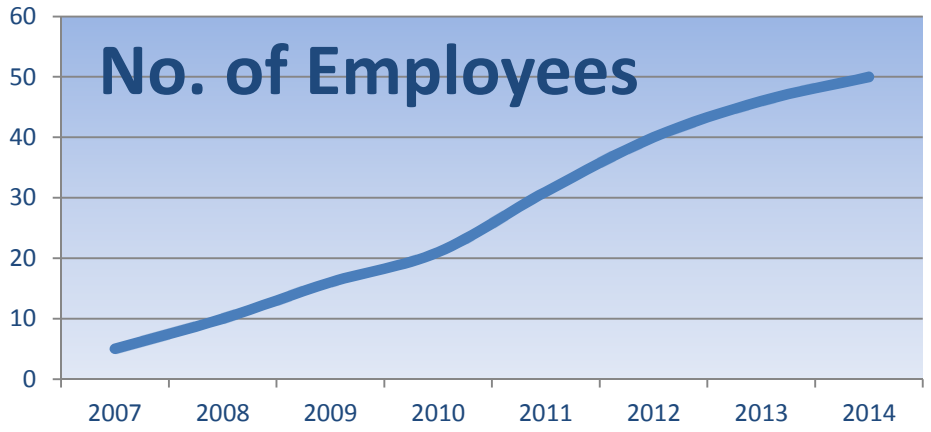
- Founded in 2006, spin-off from Delfi-C3 project
- Currently about 50 staff (FTE)
- Provider of small satellite products and services
- Vertically integrated small satellite company
- Offices in Delft, The Netherlands and Somerset West, South Africa
- 2013 highlights:
  - Triton-1 Satellite for SAT-AIS successfully launched
  - Responsible for launch 11% of all satellites in 2013
  - Record sales to 6 continents

People at ISIS

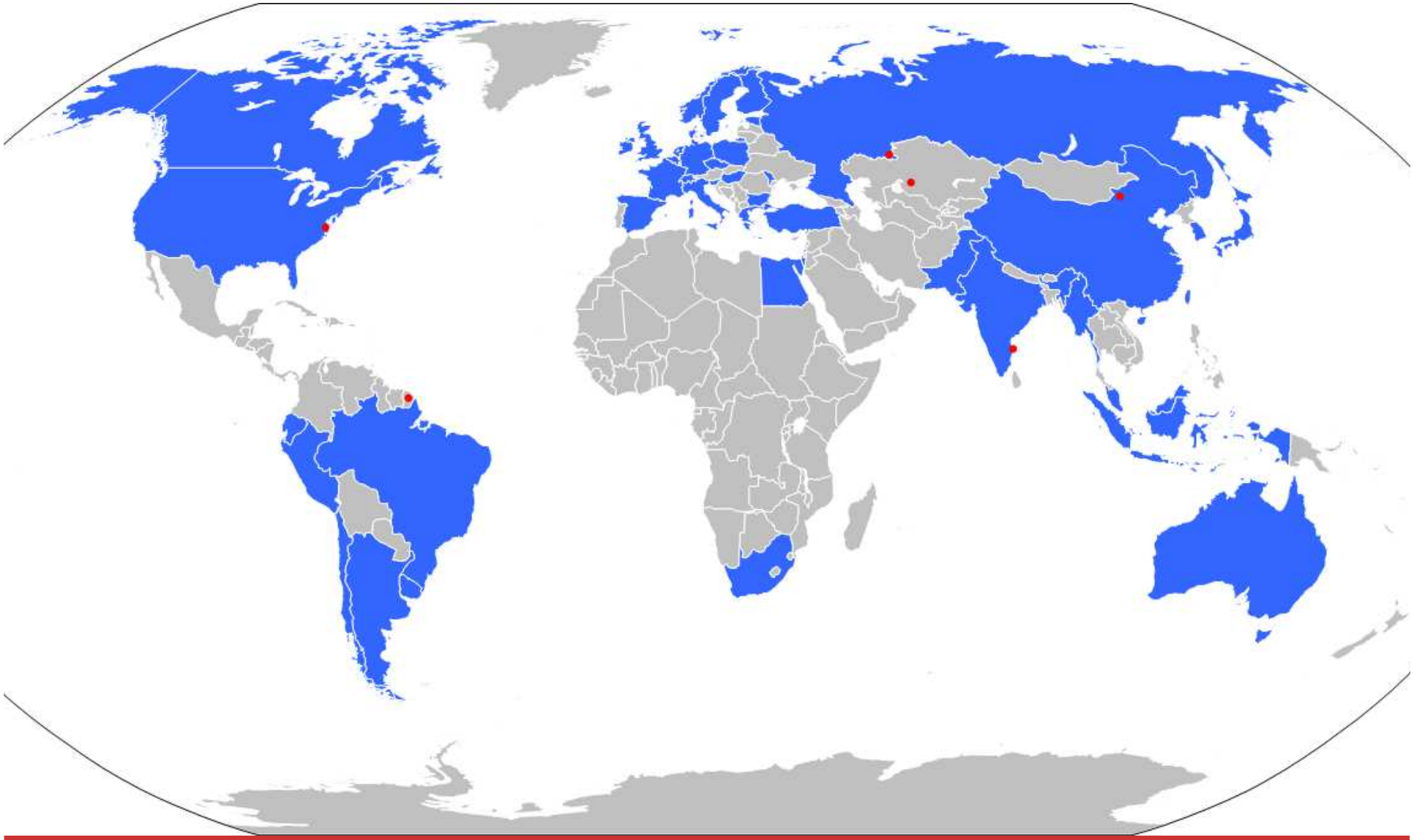
- 50 FTE
- 45% international
  - 20 Nationalities
  - 12+ languages







International Focus



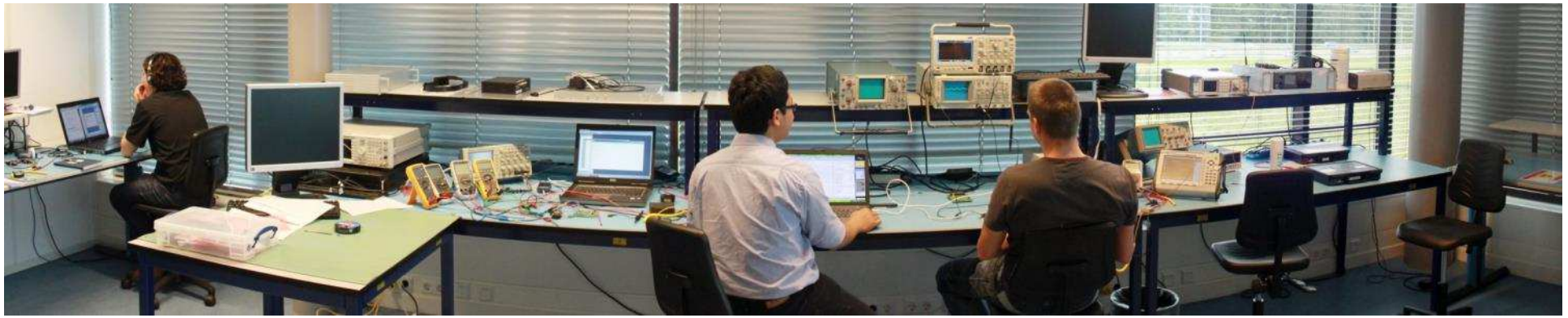
Capabilities and competencies

Systems Engineering

Radio Frequency Engineering

Attitude Control Engineering

Embedded Software



MAIV Expertise

Electrical Engineering

Mechanical Engineering

Flight Software Engineering

Main Activities

Products

- CubeSat Avionics
  - Radios
  - Antennas
  - Solar Arrays
  - OBCs
  - Etc.
- Ground Stations
- Operations Centers
- Support equipment
- Software Tools

Build and deliver spacecraft component

Launches

- Launch Services
  - DNEPR
  - Soyuz
  - Long March
  - VEGA
  - ANTARES
  - Falcon-9
  - PSLV
- Piggy back
  - CubeSats
  - Nanosats
  - Microsats
- Associated Services

Launch 3rd party Satellites on 3rd party rockets

Missions

- Turn key solutions
  - CubeSat platforms
  - Payloads
  - Ground segment
  - Launch
  - Operations
- Fast implementation times
- Including training, knowledge transfer and co-development

Deliver turn-key Space solutions To 3rd parties

Applications

- Based on satellite networks
  - Radio Astronomy
  - Maritime Monitoring
  - Agriculture
  - Communications
- Global Coverage
- High revisit times
- Fully integrated solutions

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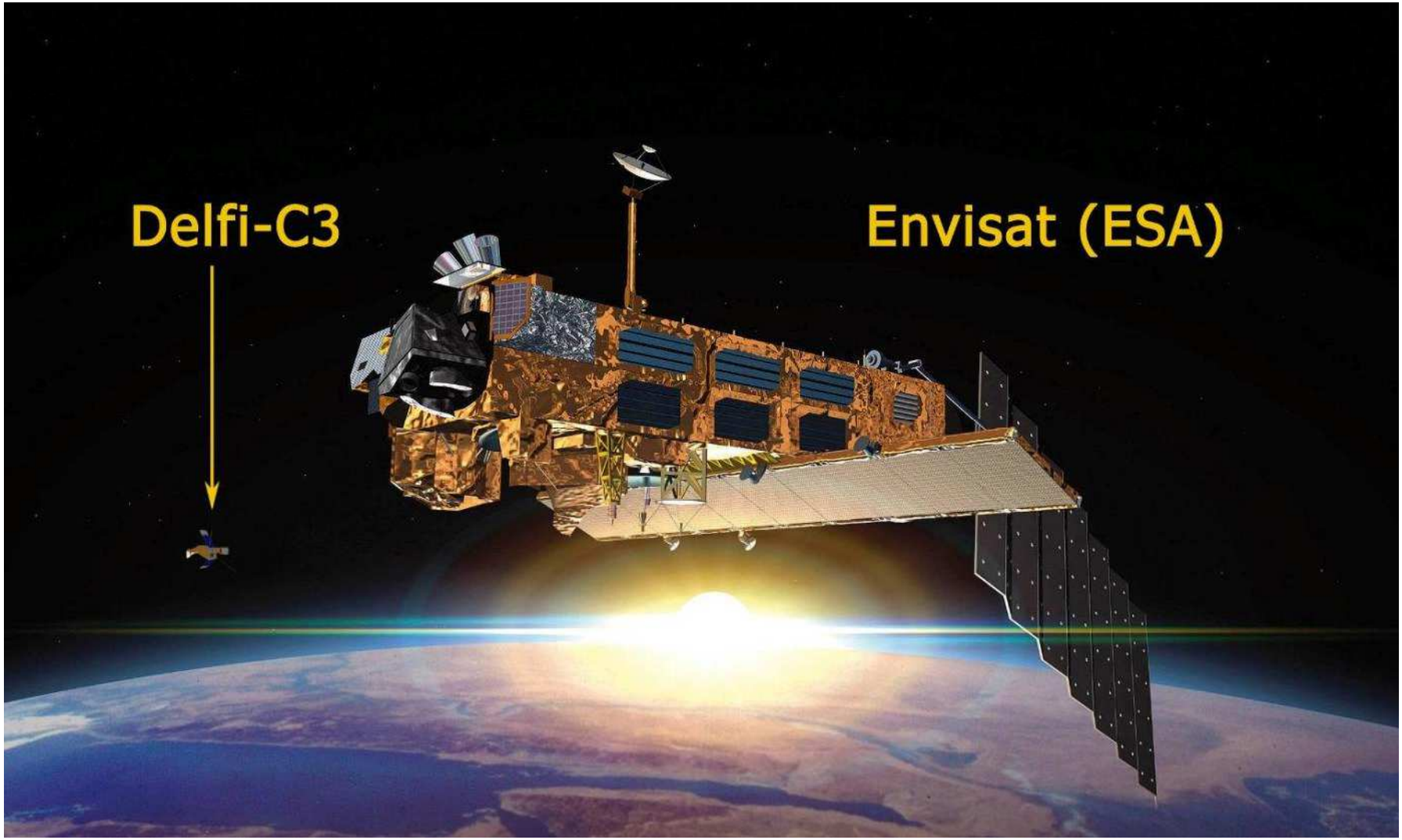
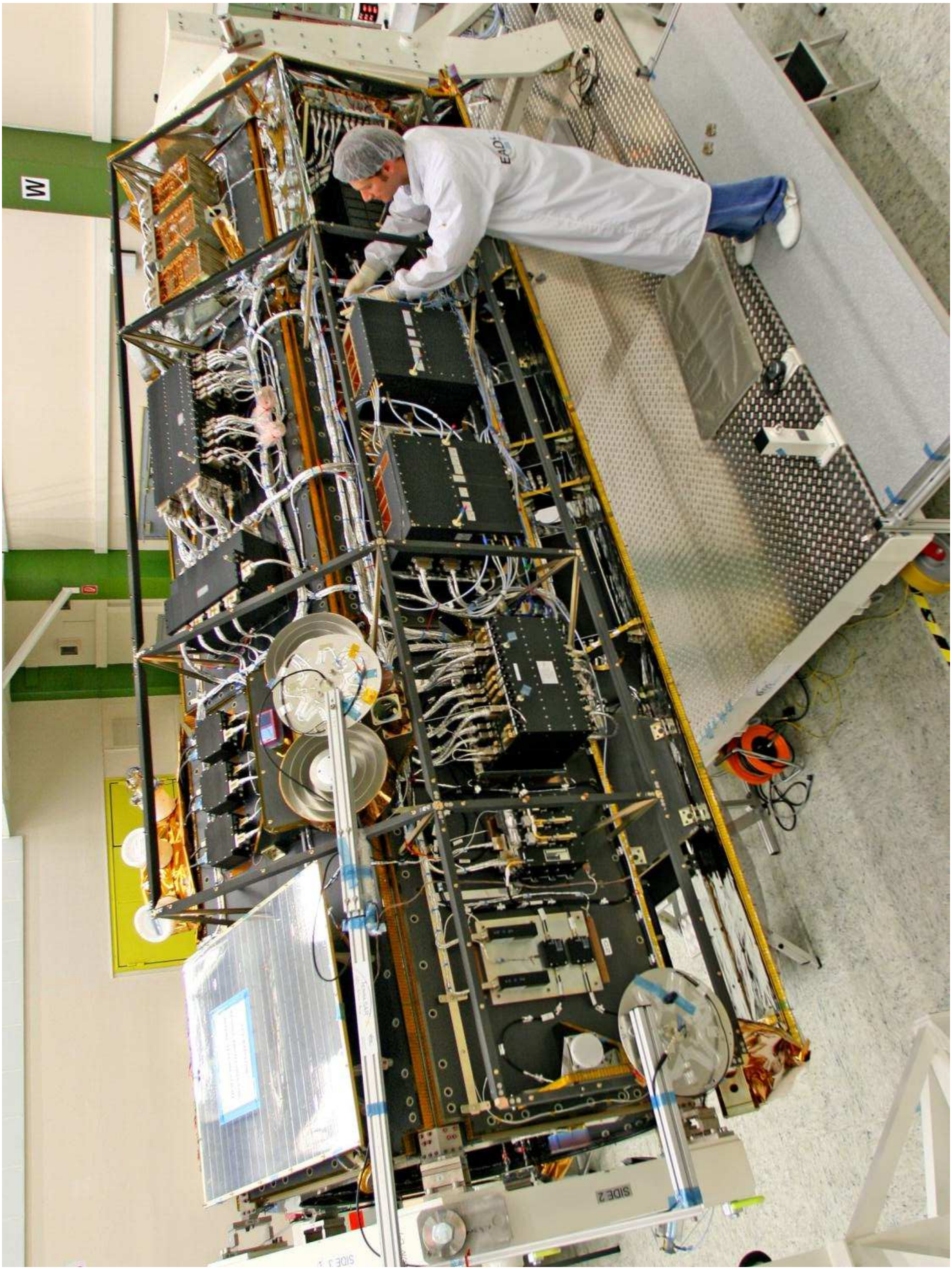
WHAT IS ‘A VERY SMALL SATELLITE’?

Size Matters



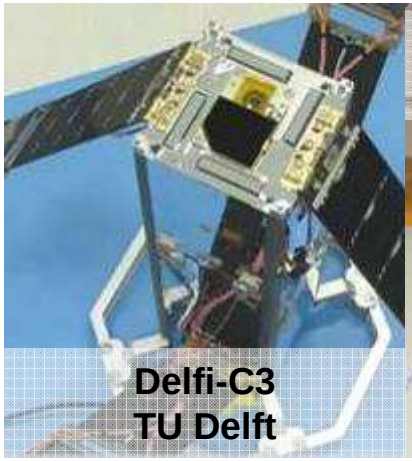


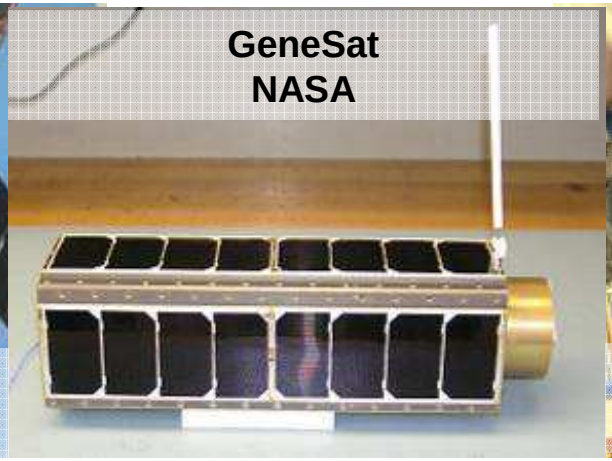
Nanosatellites

Small Satellite Classifications

Mini satellite	**100-500kg**
Micro satellite	**10-100kg**
Nano satellite	**1-10kg**
Pico satellite	**0.1-1kg**
Femto satellite	**<100g**

CubeSats





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WHY ARE NANOSATS DIFFERENT?

- **The technology used**
- **The way they are built**
- **Cost versus Risk**
- **Who develops them**
- **How they are launched**

Technology Base: spin-in

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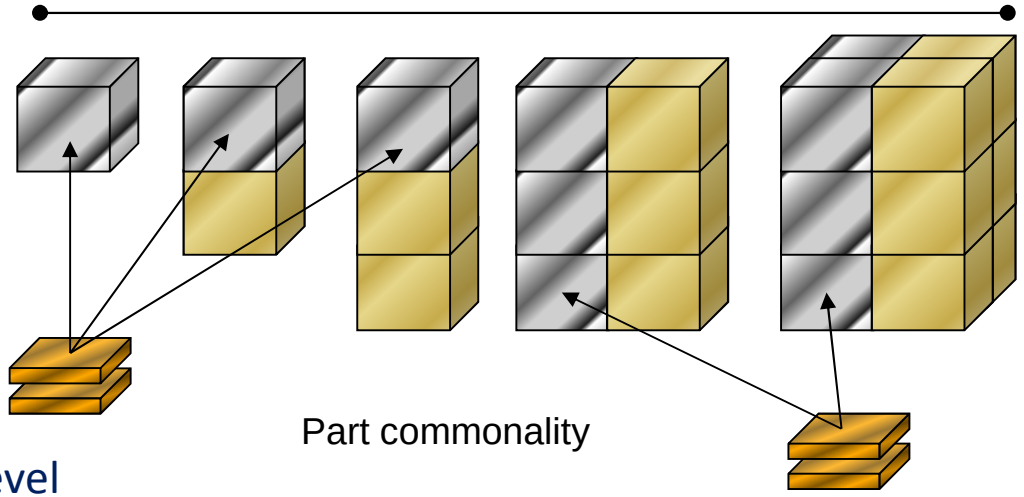
Modularity

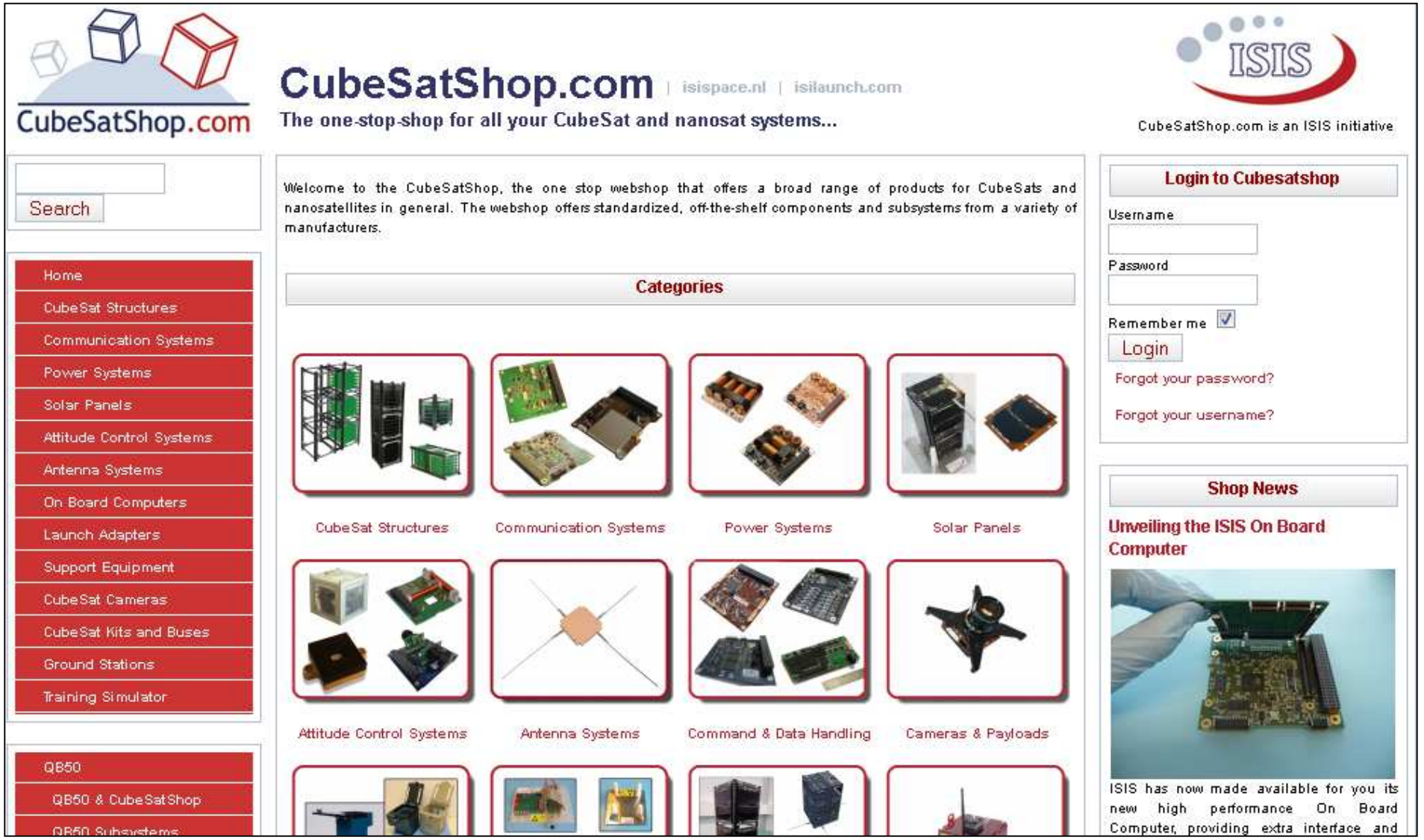
- On Module Level
  - Highly modular concepts
  - Line-replaceable unit



- On Satellite Level
  - Satellites with common interface
  - Can launch on using multiple launch systems

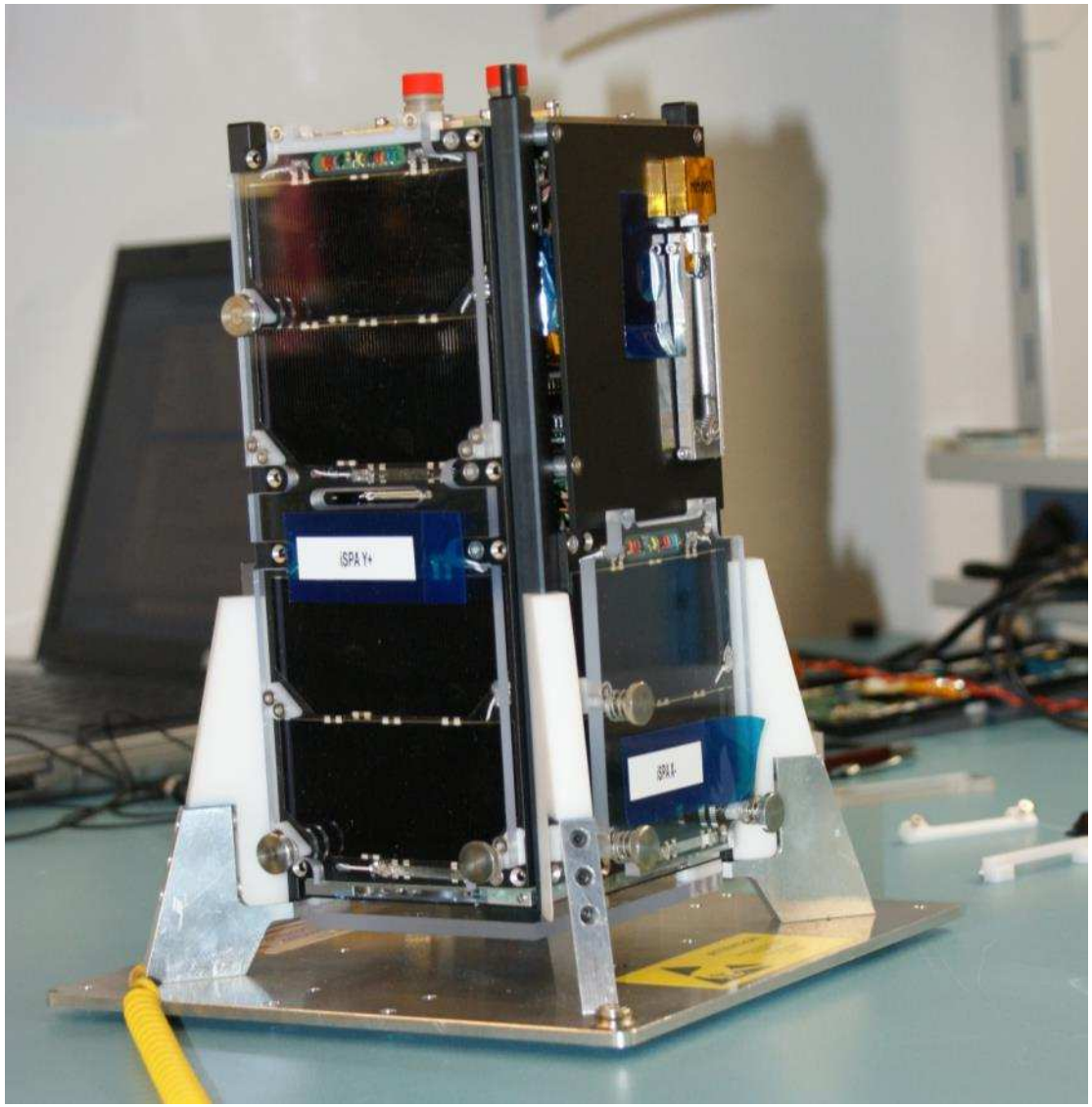
- Not so much on regulatory level
  - Operating licenses
  - Frequency coordination
  - Export Licensing

Transparancy



Short timelines – QB50p

- KoM (T0)
- PDR (T0 +1
- CDR (T0 +2,5)
- TRR (T0 +5)
- FRR (T0 +6)
- Launch (T0 +7)



Low cost structure

Platform Specifications

Mass: 2 -3 kg
Power: 5W peak, 3W AOP
Downlink: 10 kbps
Pointing knowledge: < 5°
Pointing Accurary: <10 °
Orbit determination: -
Propulsion: -
Cost: 200 – 400 k€

Payload Accommodation

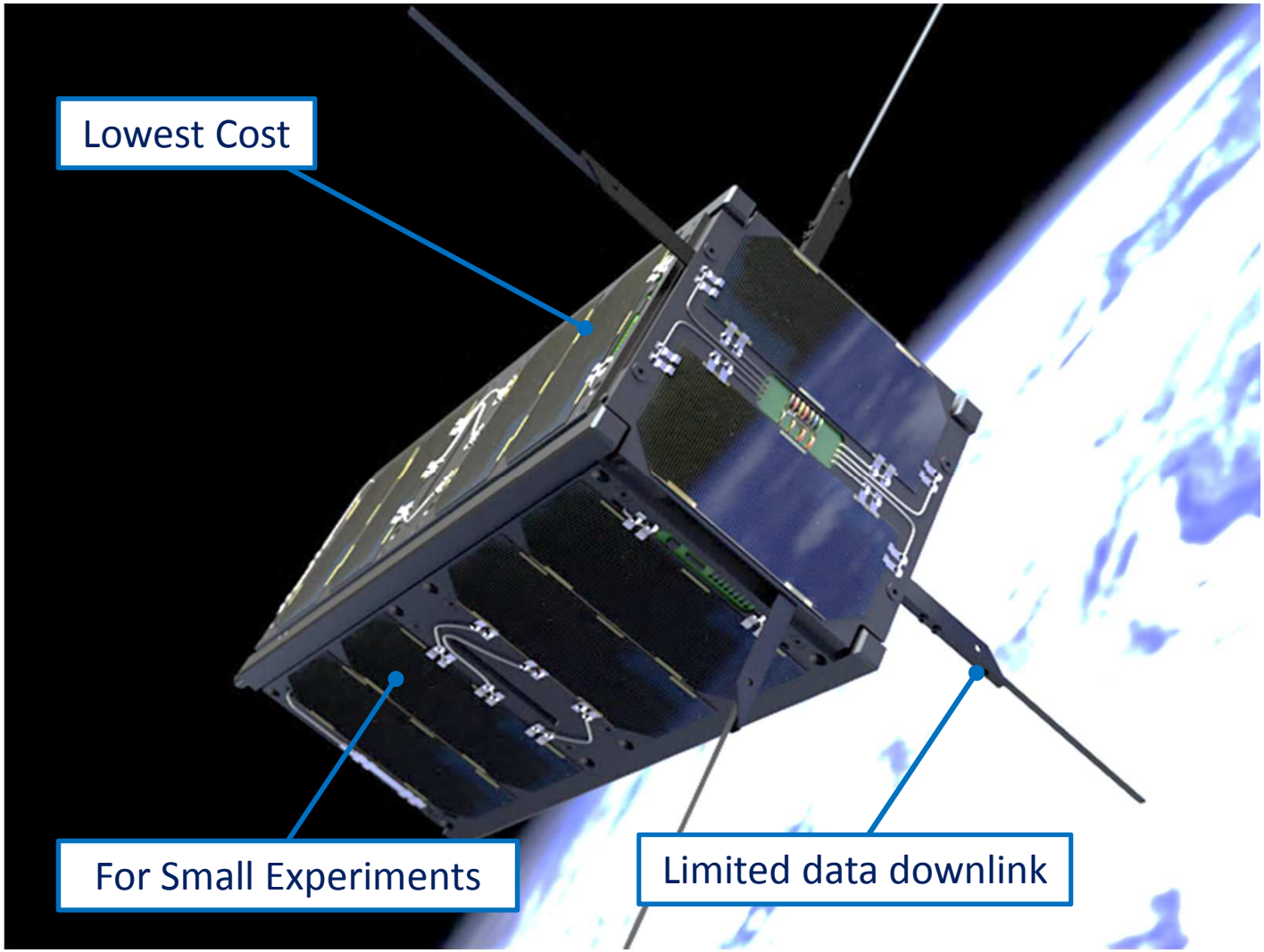
Mass: 1 kg
Power: 4W peak, 1,5W AOP
Data Storage: > 2 Gbit

Possible Payloads

Small camera
Technology demonstrator
Space Weather

Launch Options

Dispenser: ISIPOD
Cost: 125 - 175 k€



Risk Philosophy

- Technical Risk vs Financial Risk
- Risk = probability * impact
- Low impact allows higher probability of failure
  - Allow space systems to fail
    - Non-space parts
    - Rapid replacement
  - Fewer high-reliability components required
  - Flying modified consumer / industrial electronics

Various developers

Early Adopters

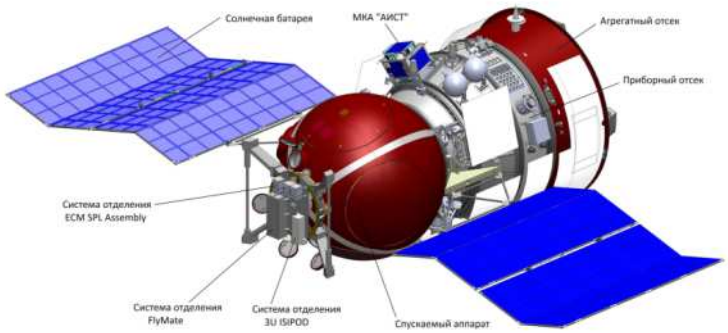
- University Groups (TU Delft)
- SME's (ISIS, GomSpace, etc.)
- STEM Foundations (AMSAT)

Followers

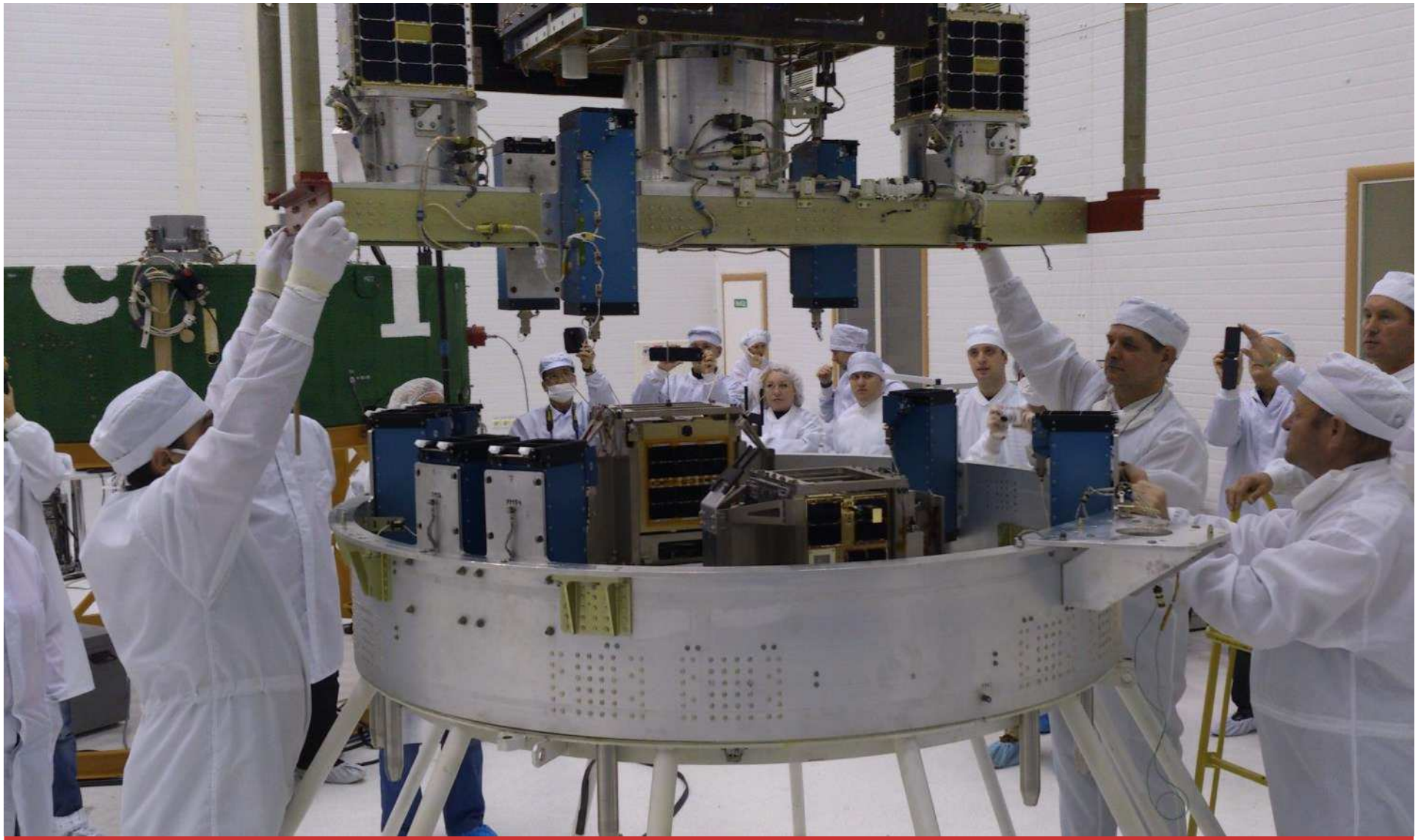
- Space Agencies and research institutes
- NRO, Air Force, Navy, Army
- VC Backed entrepeneurs
- Large Systems Integrators

Launching very small satellites

BION-M1 – April 2013



DNEPR – November 2013

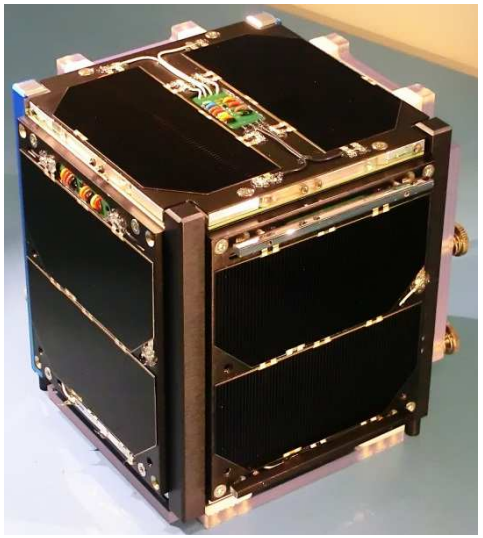


Launched from ISS

June ‘14 – DNEPR – 23 satellites

SO WHAT CAN YOU DO WITH VERY SMALL SATELLITES?

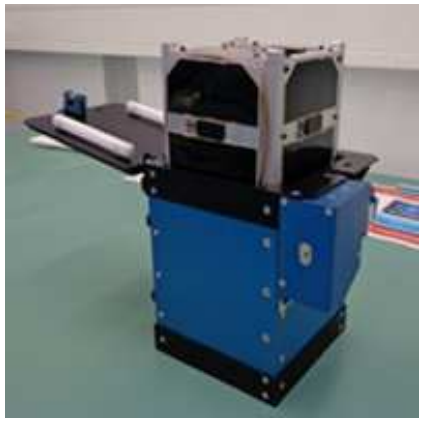
Education and training



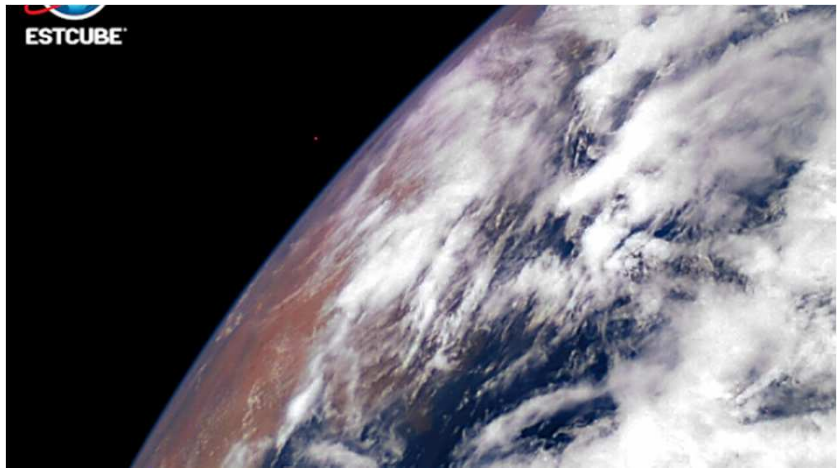
- FUNcube-1
- Built under cooperation between ISIS and AMSAT UK/NL Radio Amateurs
- Launched Nov 2013
- Used for educating school children how satellite communication works

Capability building

- First steps in becoming a spacefaring nation

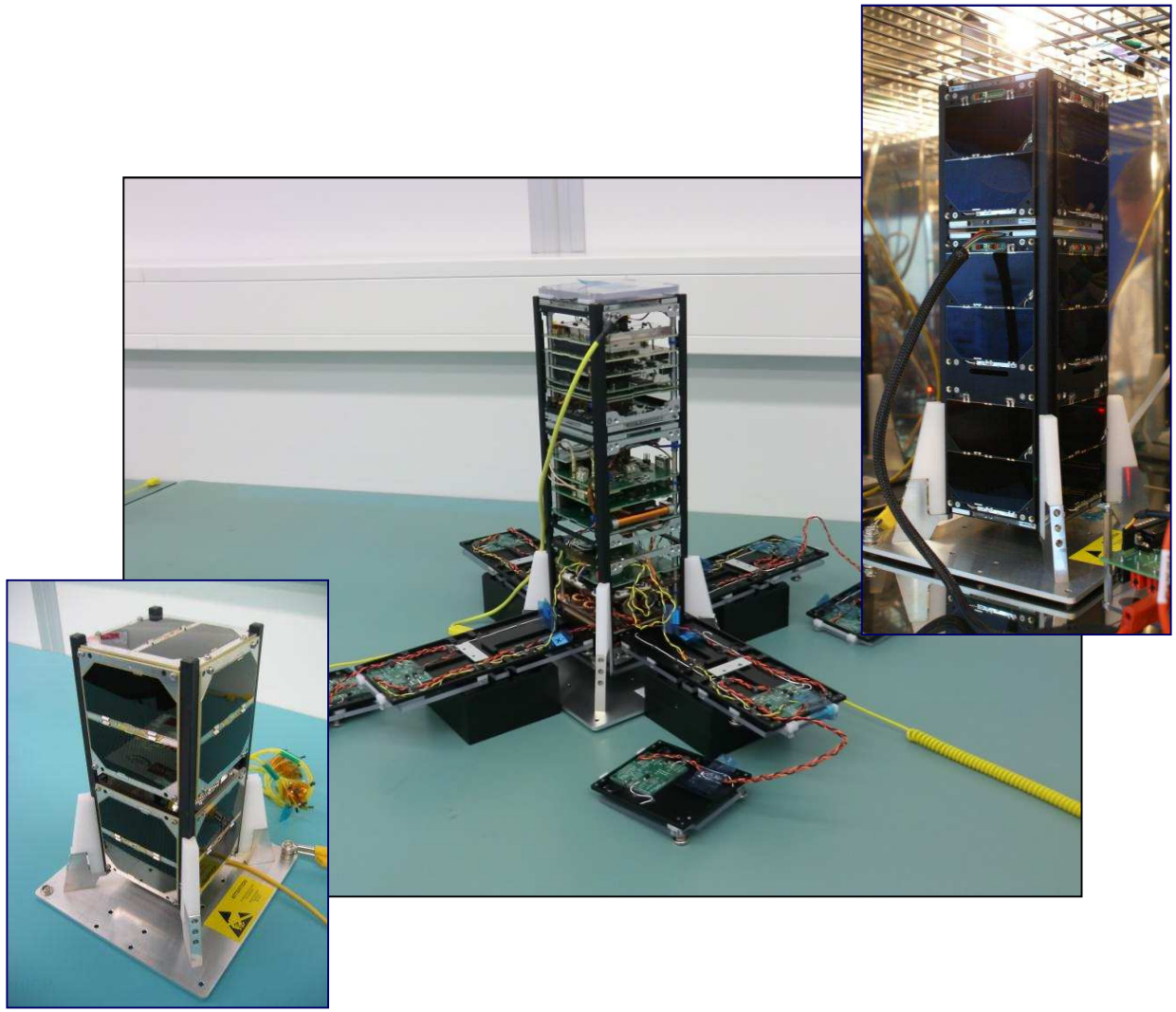


- In past years, ISIS helped launching:
  - First Swiss built satellite
  - First Ecuadorian satellite
  - First Estonian satellite



Technology demonstration

- Test new technology
- Try out new concepts
- Precursors to larger missions

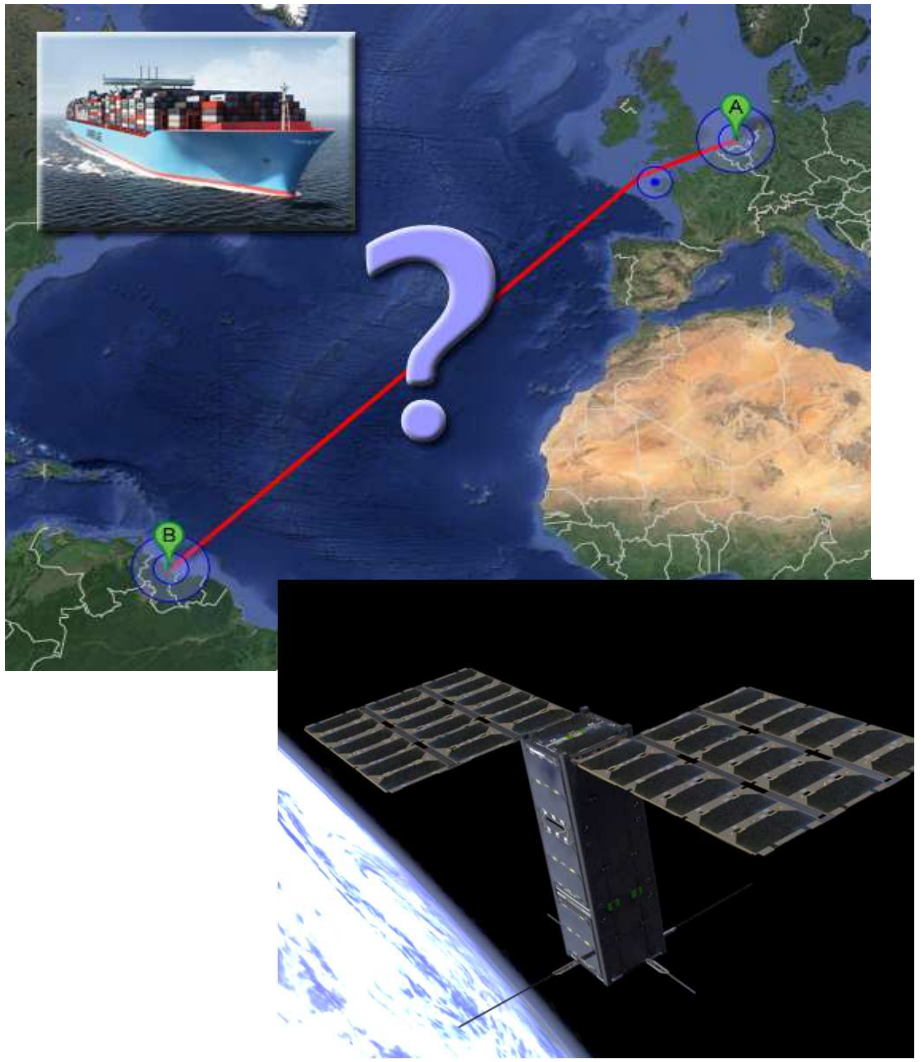


Science: example QB50

QB50, an FP7 Project

Commercial applications

- Tracking and Tracing
- Low data rate communication
- Earth Observation
- Microgravity



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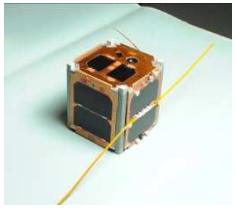
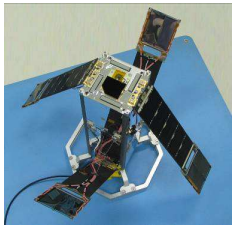
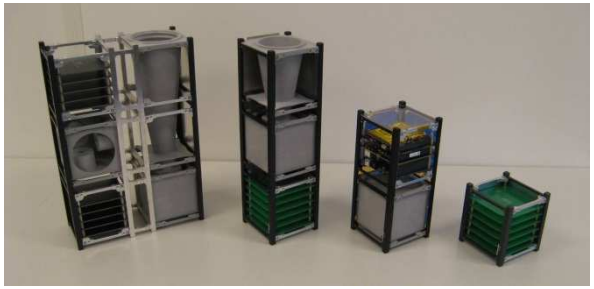
WHAT TO EXPECT IN THE FUTURE?

Trends: satellite numbers







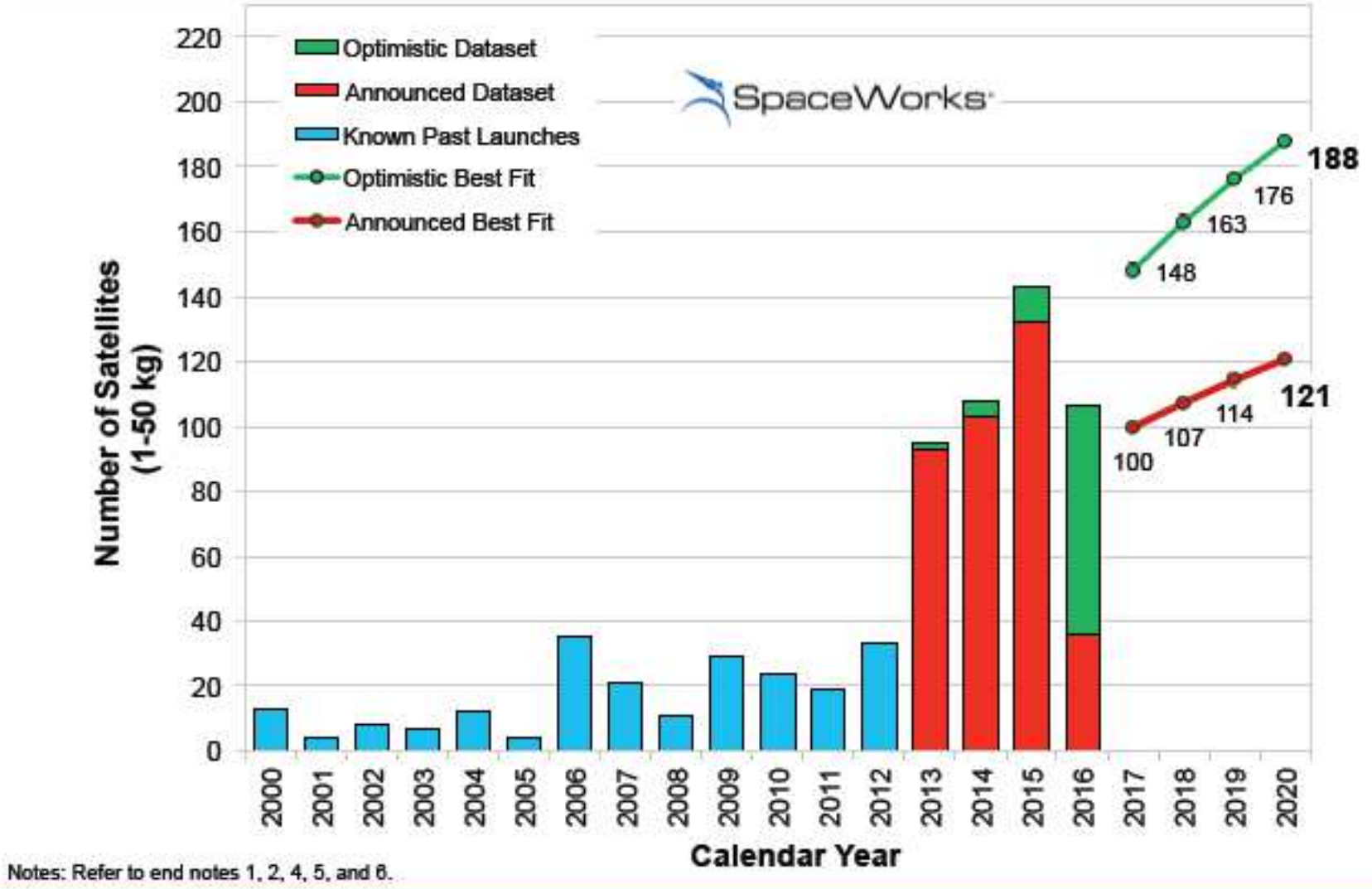
# of very small satellites just keeps increasing:

2005: few 1U/3U CubeSats (~10)
very few nanosatellites
occasional microsatellite

2010: many 1U/2U/3U CubeSats (~200)
various nanosats
tens of microsats

2014: few hundred of CubeSats
tens of nanosats
tens of microsats

Exponential growth



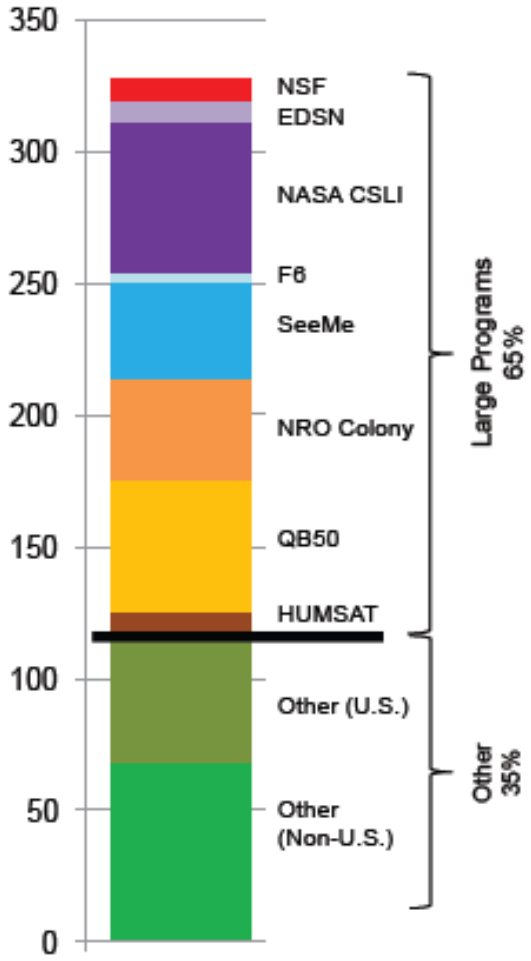
Notes: Refer to end notes 1, 2, 4, 5, and 6.

NanoSat Swarms are coming

Nano/Microsatellite Future Program Summary (1-50 kg)

Name of Program	Time	Organization	Country	Mass (kg)	No. Launched	Total Number
NSF Geospace & Atmospheric CubeSat	2010-2015	NSF	USA	1-3	4	12
NASA EDSN	2013-2014	NASA Ames Research Center	USA	3	0	20
NASA CubeSat Launch Initiative	2011-2014	NASA	USA	1-8	13	71
F6	2015	DARPA	USA	45	0	4
SeeMe and ALASA payloads	2014 -2015	DARPA	USA	45	0	36
NRO Colony I & II	2010-2016	NRO	USA	3-5	4	62
QB50	2015	Von Karman Institute / Various	Various	2	0	50
HUMSAT	2013 - 2014	University of Vigo / Various	Various	1	0	10

Large Program Breakdown for Announced Future Launches



Announced Future Launches 2013-2015

QB50: 50 satellites in one go

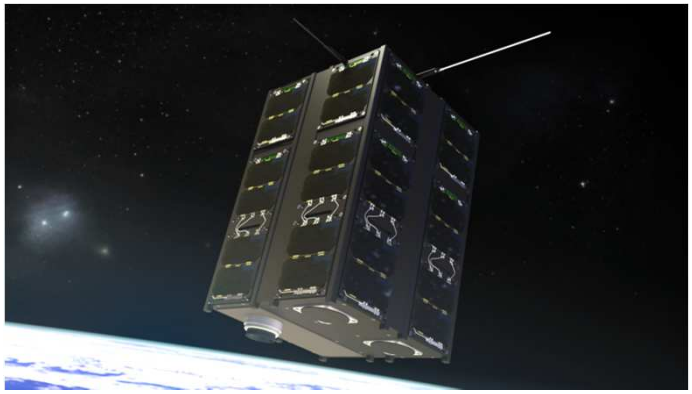
Belgium registered network,
funded by the EU to
execute a single mission

Deploy 50 CubeSats
in one mission coming
from 50 different providers
from various countries

Launched on a Brazillian-Ukrainian Rocket in 2016

Commercial constellations

- ISIS' Triton network
  - 20+ sats / few years
- Nanosatisfi:
  - 10 sats / year
- Planet Labs:
  - Earth Observation
  - 100+ sats/year
- Satellogic
- Outernet
- Others…



OLFAR

Orbiting Low Frequency Array

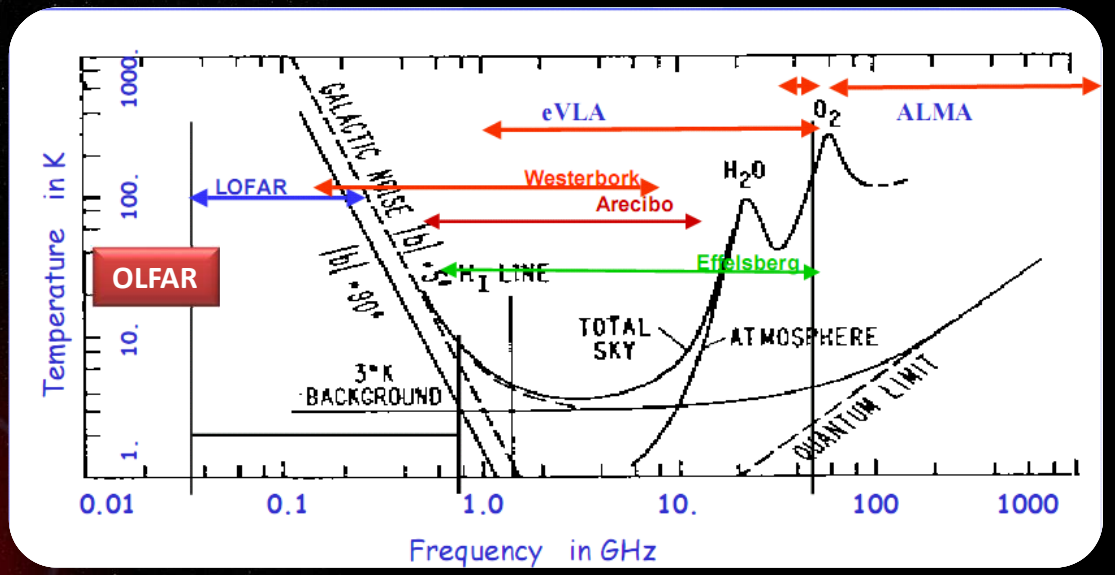
Swarm

Moon orbit

30kHz-30MHz

Self-propelled

to the moon



Deep space exploration – Asteroid mining

Opportunities vs Challenges

- New applications, new science, new business
- Fast implementation

But…

- Large numbers of satellites to launch
- Frequency / spectrum allocation
- Space debris mitigation
- Registration
- International / national legislation

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Thank you for your attention!

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