



ISIS – Innovative Solutions In Space B.V.

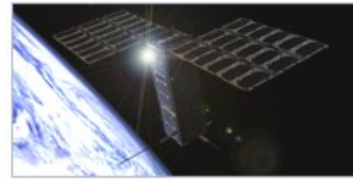
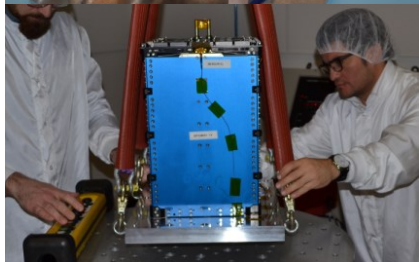
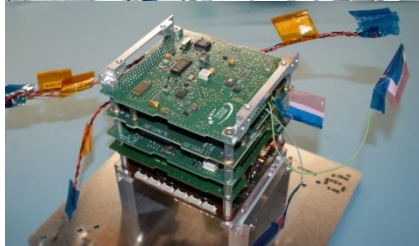
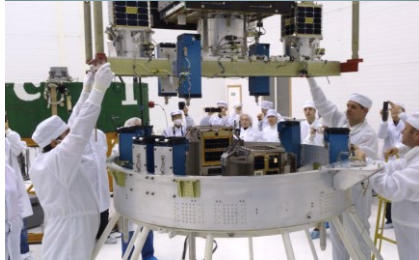
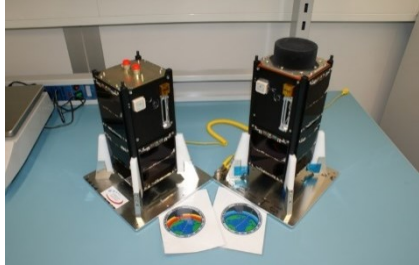
Setting the scene: enabling small satellites to utilize their full potential (*or: does satellite size matter?*)

Wouter Jan Ubbels

ITU Symposium and Workshop on small satellite regulation and communication systems, Prague, Czech Republic, 2-4 March 2015



ISIS – Innovative Solutions in Space



turnkey missions



products and services



launch services



now on cubesatshop.com

- Founded in 2006, spin-off from Delfi-C3 project
- Currently about 50 staff (FTE)
- Offices in Delft, The Netherlands and Somerset West, South Africa





Main Activities

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**

Products

- CubeSat Avionics
 - Radios
 - Antennas
 - Solar Arrays
 - OBCs
 - Etc.
- Ground Stations
- Operations Centers
- Support equipment
- Software Tools
- Both standardized and custom developments

**Build and deliver
spacecraft
components**

Launches

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

**Launch 3rd party
Satellites on
3rd party rockets**

Applications

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



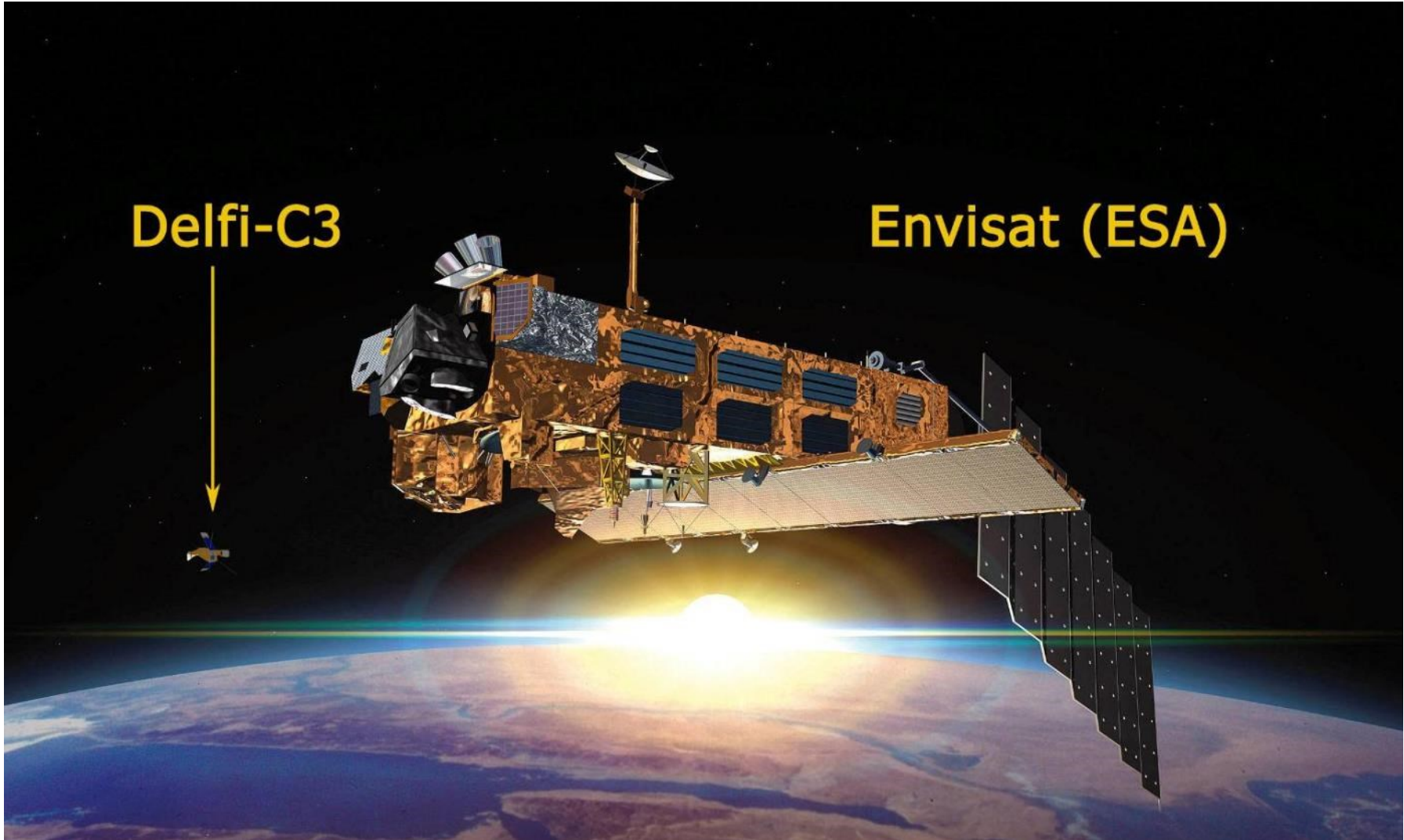
Nanosatellites, picosatellites, small satellites... but

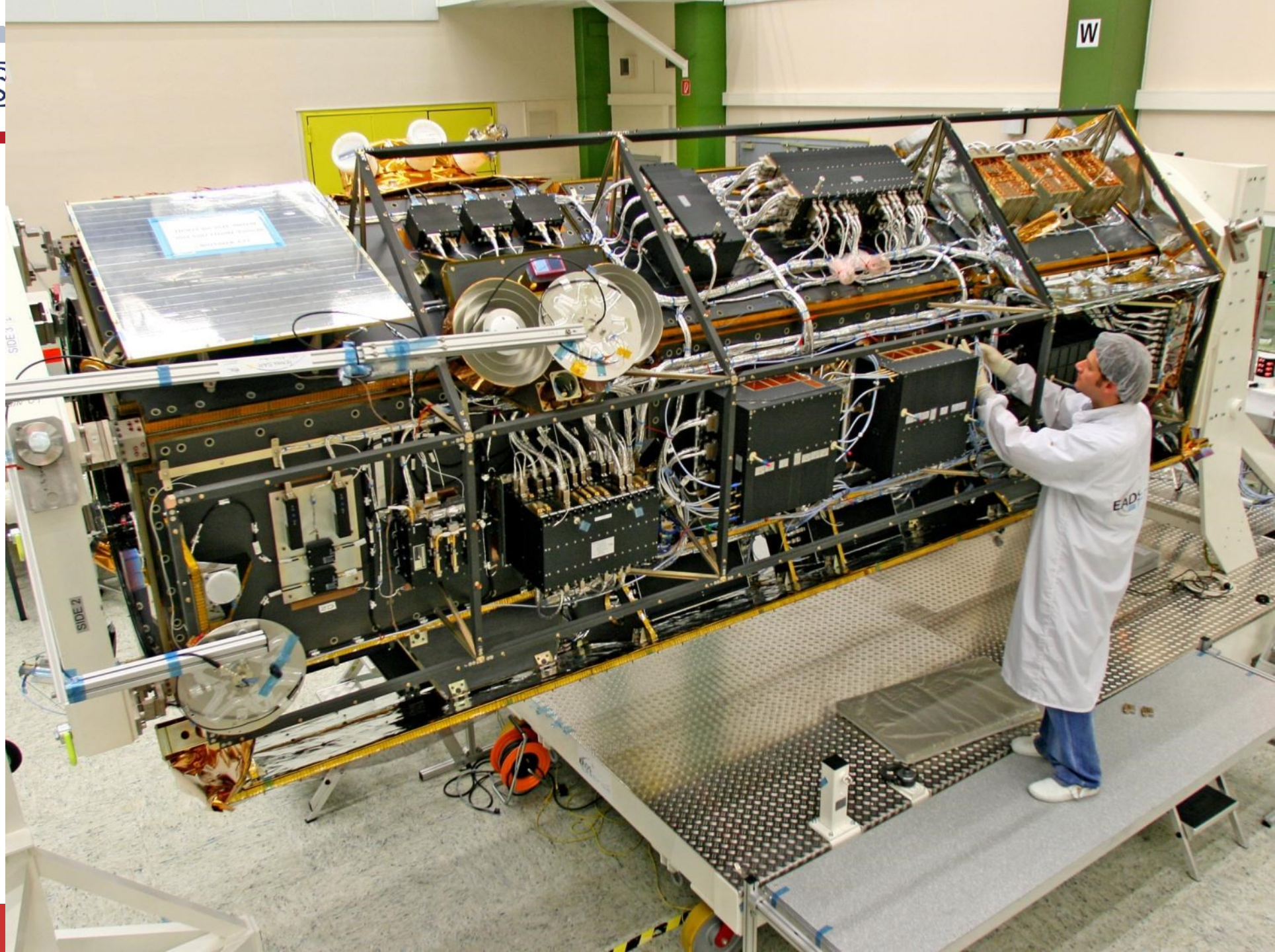
WHAT IS 'A SMALL SATELLITE'?

DOES SATELLITE SIZE MATTER?



Size Matters...









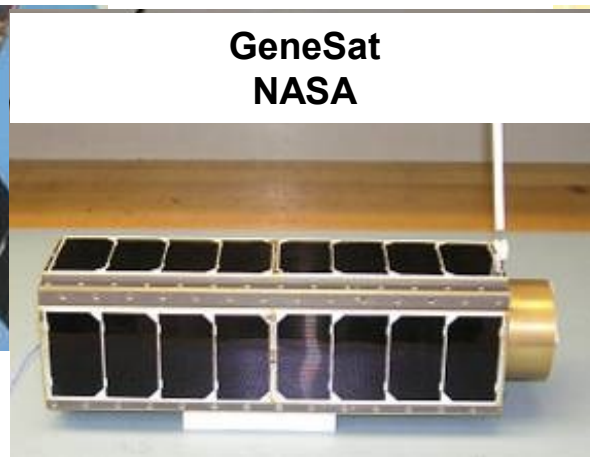
Mass classification

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

CubeSats



Delfi-C3
TU Delft



GeneSat
NASA



CSTB-1
Boeing



SNAP-1
SSTL



SO... WHAT ARE THE OTHER DIFFERENCES BETWEEN NANO & PICOSATELLITES AND “TRADITIONAL” SATELLITES

- **The technology used**
- **Short timelines**
- **Who develops them**
- **How they are launched**



Technology used – spin in



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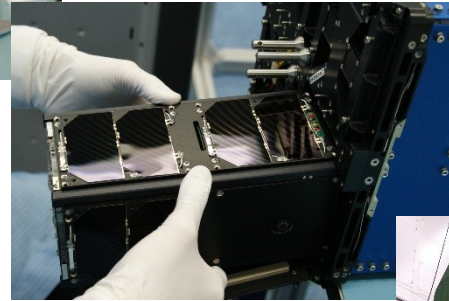
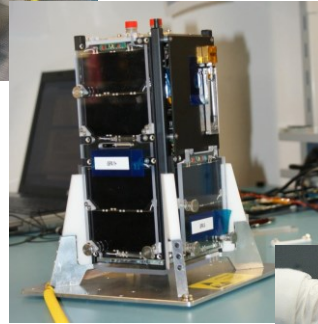
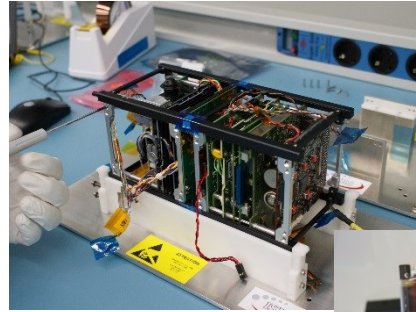
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Short development timelines – QB50p

- KoM (T0)
- PDR (T0+1 month)
- CDR (T0+2.5 months)
- TRR (T0+5 months)
- FRR (T0+6 months)
- Launch (T0 + 7 months)





Who develops them

Early Adopters

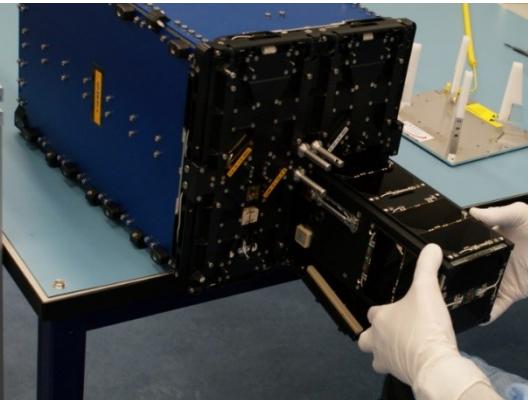
- University Groups
- SME's (ISIS, GomSpace, and many more)
- STEM Foundations (AMSAT)

Followers

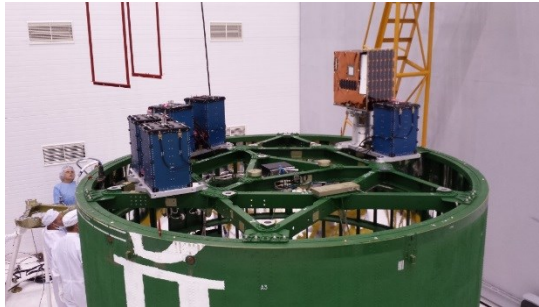
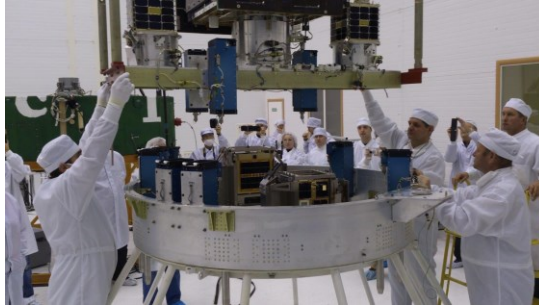
- Space Agencies and research institutes
- Venture capital backed entrepreneurs
- Large Systems Integrators
- Military



The way they are launched



Standard Launch Vehicle interface



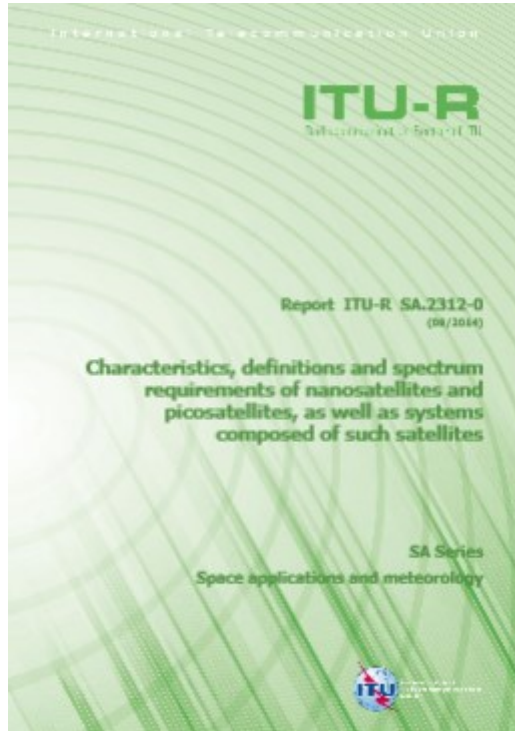
“Piggy back” on various launch vehicles...



... or from the ISS



Size matters?



DN Report ITU-R SA.2312:

- Low RF power → but still high PSD due to small bandwidth
- Omnidirectional antennas – may make coordination more difficult
- Applicable Radiocommunication services, class of station: NO DIFFERENCE
- Protection criteria and status as defined in ITU-R Recommendations apply as for any other satellite
- No clear correlation between satellite size and RF parameters such as EIRP or frequency use
- Technical differences will diminish further as technology advances

Not from the perspective of the Radio Regulations!

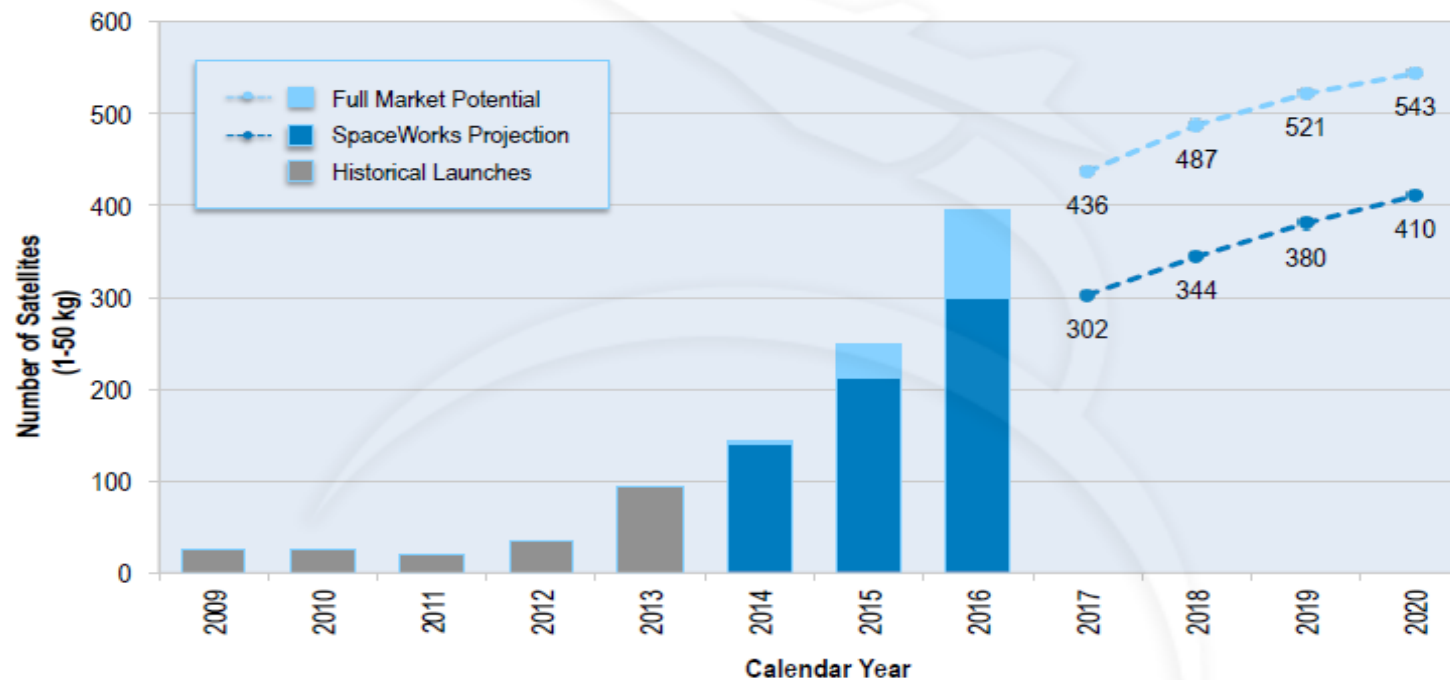


Size matters!

However, their small size has been one of the key factors in their proliferation and growth in numbers

Nano/Microsatellite Launch History and Projection (1 - 50 kg)

Projections based on announced and future plans of developers and programs indicate between 2,000 and 2,750 nano/microsatellites will require a launch from 2014 through 2020

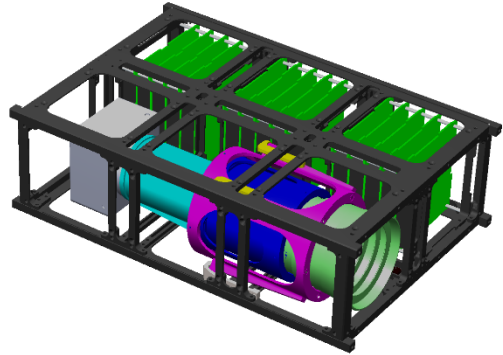


The Full Market Potential dataset is a combination of publically announced launch intentions, market research, and qualitative/quantitative assessments to account for future activities and programs. The SpaceWorks Projection dataset reflects SpaceWorks' expert value judgment on the likely market outcome.

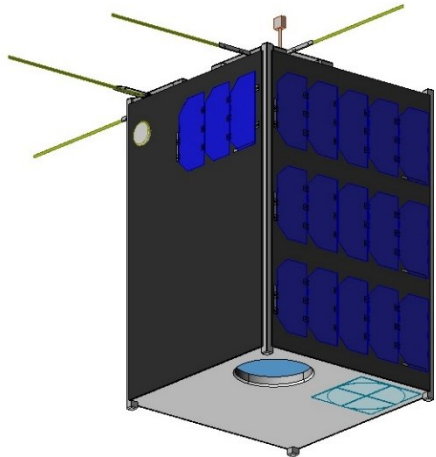
Source: Spaceworks inc.



Size matters – the “sweet spot”

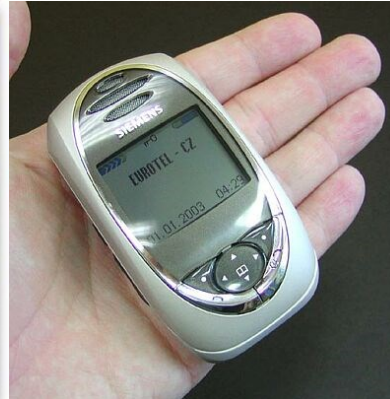


6U



12U

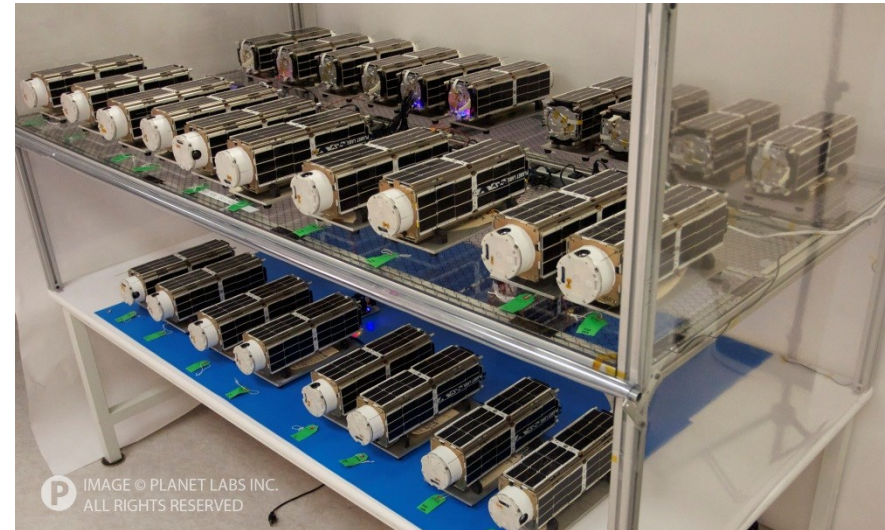
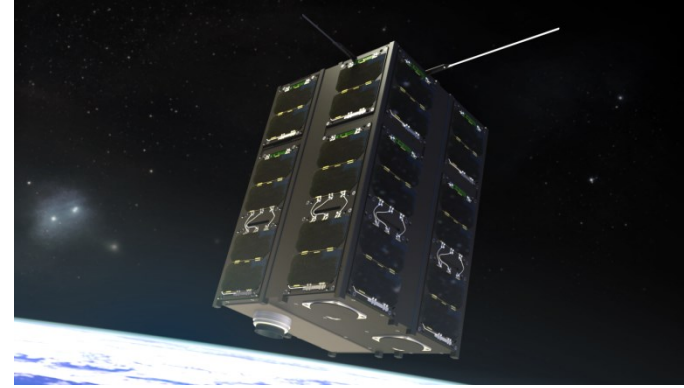
- 1U to 3U cubesats are now widely used for technology demonstrations and education
- For more operational missions 6U to 12U nanosats are more suitable
 - Payloads less constraint
 - Maintain benefits of cubesats (modularity, launch cost)
- Similar trend as observed in mobile phones
 - Started out large, then became very small, and now are larger again (but partly replacing the pc)

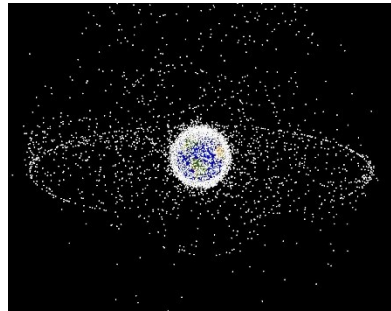




Size matters - the real potential is in constellations

- First nanosatellite based constellations are emerging:
 - Spire
 - Planet Labs
 - Satellogic
 - Others...
- The applications (and thereby the applicable frequency bands / services) vary
 - Earth Observation
 - Telecommunication
 - Tracking / tracing





Constellation enablers

1. Access to space – not so much of an issue anymore
2. Sustainable use of the space environment
 - Responsible use of the orbit and spectrum resource
 - Mitigation of space debris
 - Positive satellite control at all times
3. **Telemetry, tracking & commanding (TT&C)**
 - Growing number of small satellites requires a different TT&C paradigm



TT&C Solutions used so far

- Amateur satellite service
 - May work for some missions, no pecuniary interest
 - Commonly used bands:
 - 145.8-146MHz
 - 435-438MHz – non interference basis (5.282)
 - 2400-2450MHz – non interference basis (5.282)
- Experimental licenses
 - Terrestrial, non interference, no protection basis
- Iridium, Orbcomm modems
 - Frequency bands used are not intended for use by a subscriber unit in space
- ISM
 - Frequency bands used are not intended for space use
 - Non interference, no protection basis
- SOS / SRS allocations in VHF/UHF/S-band
 - 400.15-401 & 401-402MHz: space-to-Earth
 - 148-149.9MHz Earth-to-Space–subject to coordination under RR Art. 9 Sect. II & shared terrestrially
 - 2200-2290 space-to-Earth /2025-2110MHz Earth-to-space “S-band” – very crowded



2200-2290MHz / 2025-2110MHz SOS, SRS, EESS “S-band” allocation

- Excellent characteristics, modest antenna requirements for satellites with limited AOCS / or during early operations, therefore well suited to be used for small satellite TT&C
- Not subject to coordination under RR Article 9 section II
- But... heavily crowded by SOS, SRS and EESS applications, so difficult to coordinate between systems, especially for new entrants
- Shared with fixed, land mobile applications → often also national (terrestrial) coordination is required
- PFD limit (RR Table 21-4) applies



Shared or dedicated TT&C spectrum & access mechanism – WRC-19?

- Shared or dedicated TT&C (SOS) spectrum could be a solution
- Some use by SRS could also be foreseen
- Need for a common access mechanism which facilitates sharing between multiple users **and** eases coordination process
- Need for development of common (standardized) RF characteristics to allow sharing and ease coordination with incumbent users
- Access not bound to satellites adhering to a certain “class”, but rather on the basis of compliance with agreed and standardized RF characteristics which are relevant from a frequency management perspective
- Could allow smallsat GEO to LEO Data Relay opportunities
- Example access mechanism: CDMA
 - Can be used to keep pfd low, even with low data rates typically used for nanosatellites
 - CDMA has been proven in the space environment (this idea is not new)
 - Provides for relatively simple integration of ranging functionality to allow orbit determination
 - May aid in performing simultaneous TT&C for multiple satellites in view over one groundstation
- Technically, this is feasible!
 - SDR allows rapid and flexible implementation both on board the satellite as well as the Earth station side of the link



Thank you for your attention!

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