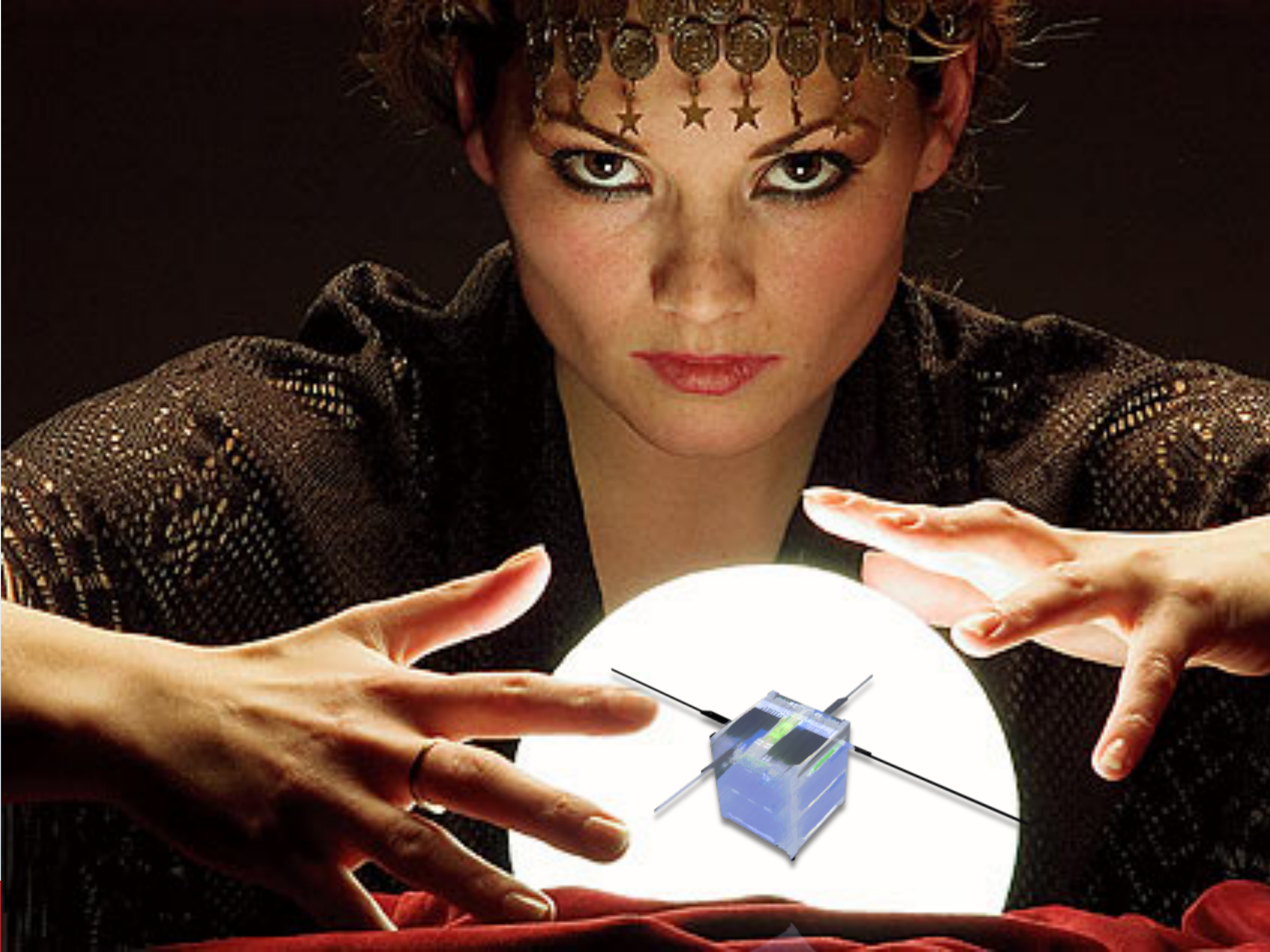
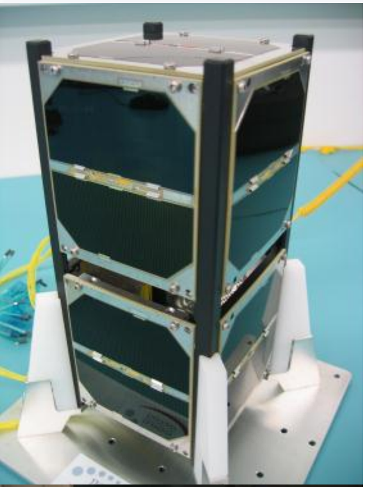
Beyond CubeSats:
Operational, Responsive, Nanosatellite Missions

9th annual CubeSat Developers' Workshop

Jeroen Rotteveel



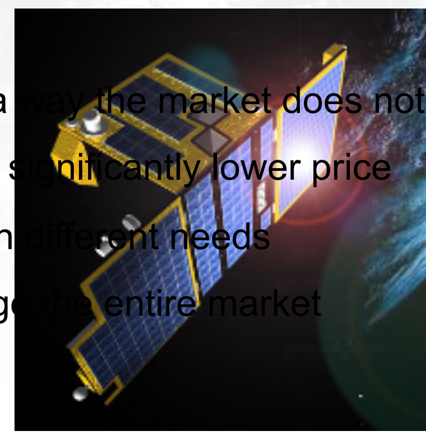
Nanosatellite Applications

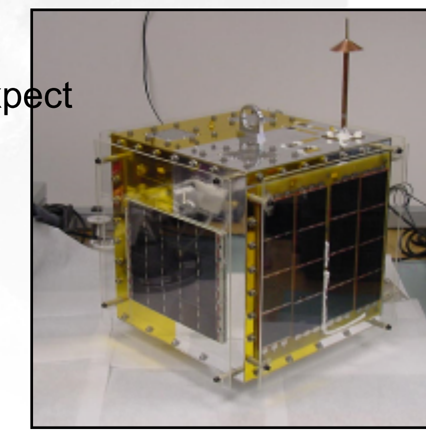


- Nanosatellite Market growing rapidly
  - Cubesats: Conception in 1999
  - First missions launched in 2003
  - 10-20 projects in 2004
  - >250 projects ongoing now (estimate)
- Change of users from educational and institutional to application focussed
- The hype is a bit over, now let’s figure out what we can do with these things!

Disruptive technology

Mainframe Mini-Computer PC





Disruptive technology:

-Improve a product or service in a way the market does not expect

- Often at low performance but at significantly lower price

- Often targeted at customers with different needs

- Has the ability to radically change the entire market

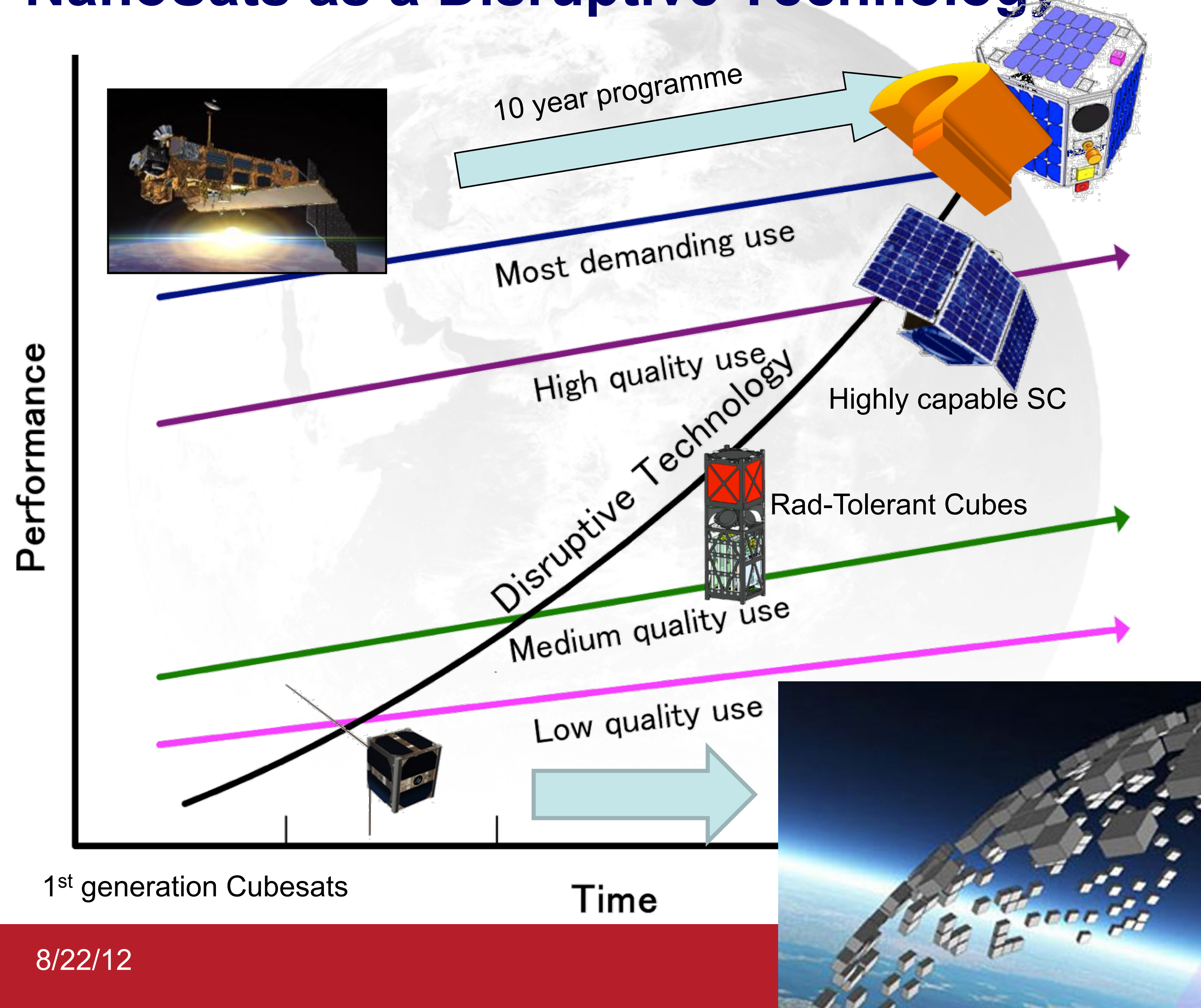
Large Spacecraft Microsatellite Nanosatellite

NanoSats as a Disruptive Technology

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

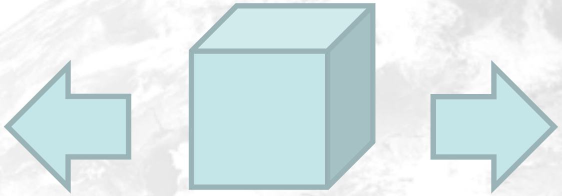
Design to Cost
-Focused Missions
-New risk approach
-Low entry barrier

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



"The two schools of CubeSats"

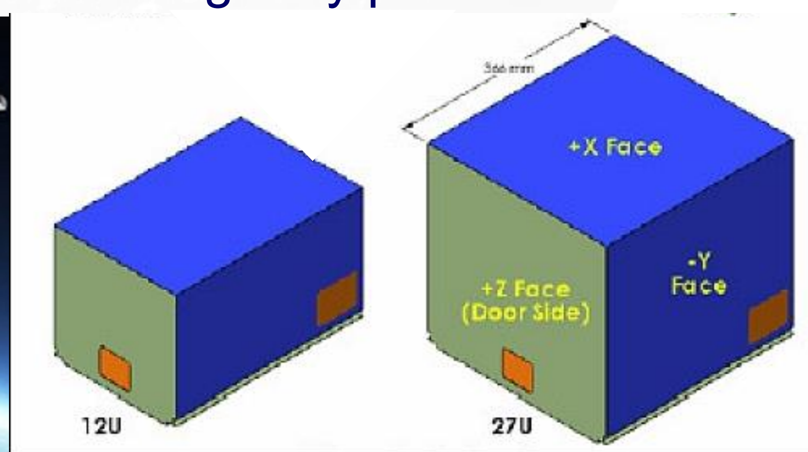
Less



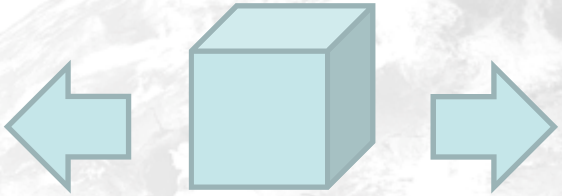
More

- Femto sats
- Chipsats
- Minimizing unit cost while maintaining utility
- A satellite for everyone, enabling a more broader awareness and adoption of space system use

- Small microsats
- 12-U / 24U / 27U /48 U
- Maximizing utility while maintaining cost advantage
- Serving high-demand customers under budgetary pressure



Characteristics

Less  **More**

Less

- Great way of exposing the general public to space systems and their possible uses
- Little operational utility
- Regulations and policy do not scale
  - Launch cost
  - Permits
  - insurance

More

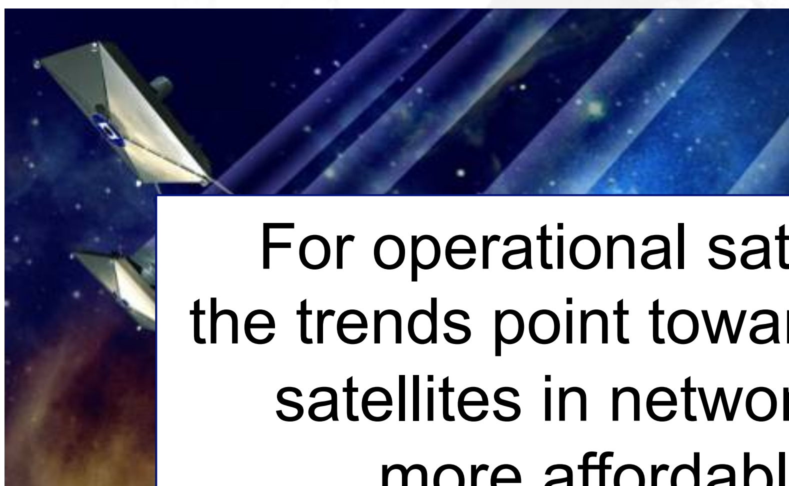
- Great way to entice traditional space users into innovative, riskier mission solutions
- Requires performance and functionality not available in typical CubeSat components
- At the edge of usefullness of CubeSat paradigm.

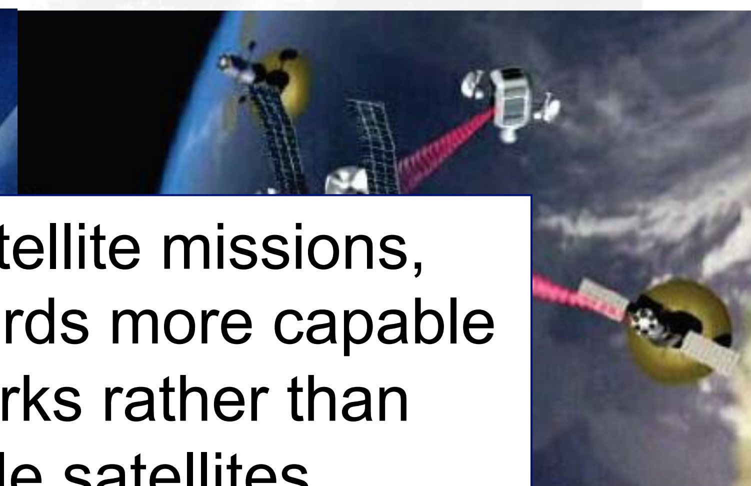

DO YOU KNOW WHERE
TO PLACE YOUR BETS?
100
50
SMS
5

A 3rd school as middle ground

- Networks of CubeSats
- Focus on minimizing cost for system elements
- Focus on maximizing utility for the full system

- AIS constellations
- ADS-B
- Space Weather
- Darpa F6
- Etc.



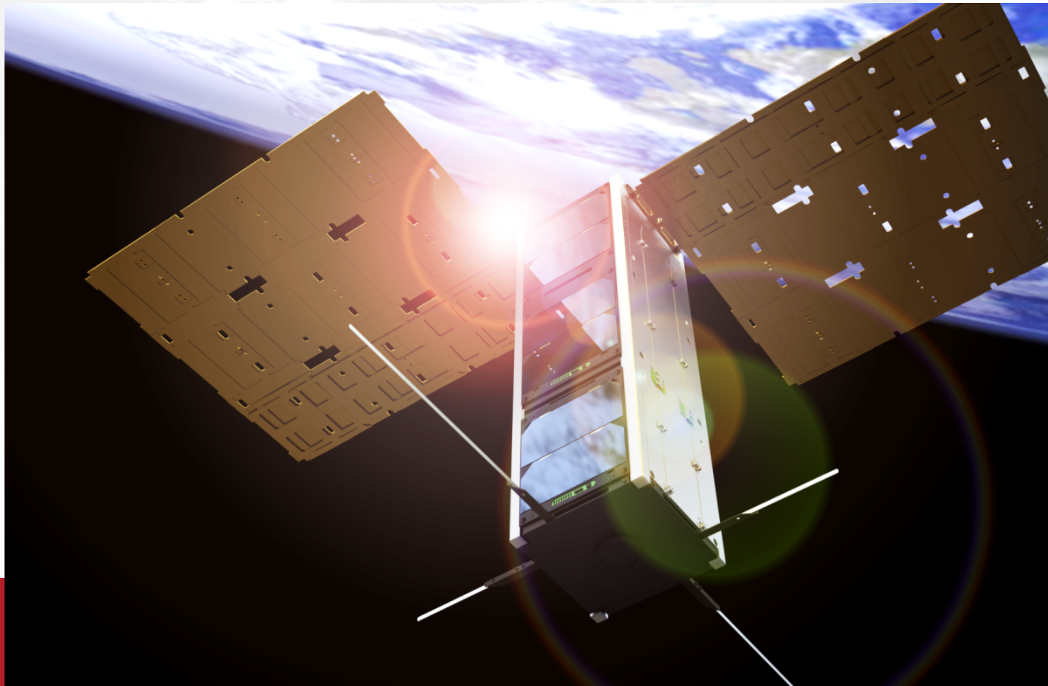


For operational satellite missions, the trends point towards more capable satellites in networks rather than more affordable satellites

Operational Needs

- Availability: ➔ power positive
  - More efficient electronics ➔ helps
  - Larger Solar Arrays ➔ helps a lot
- Onboard Data Processing
  - Smart, efficient algorithms ➔ Helps
  - Large procesing module ➔ Helps a lot

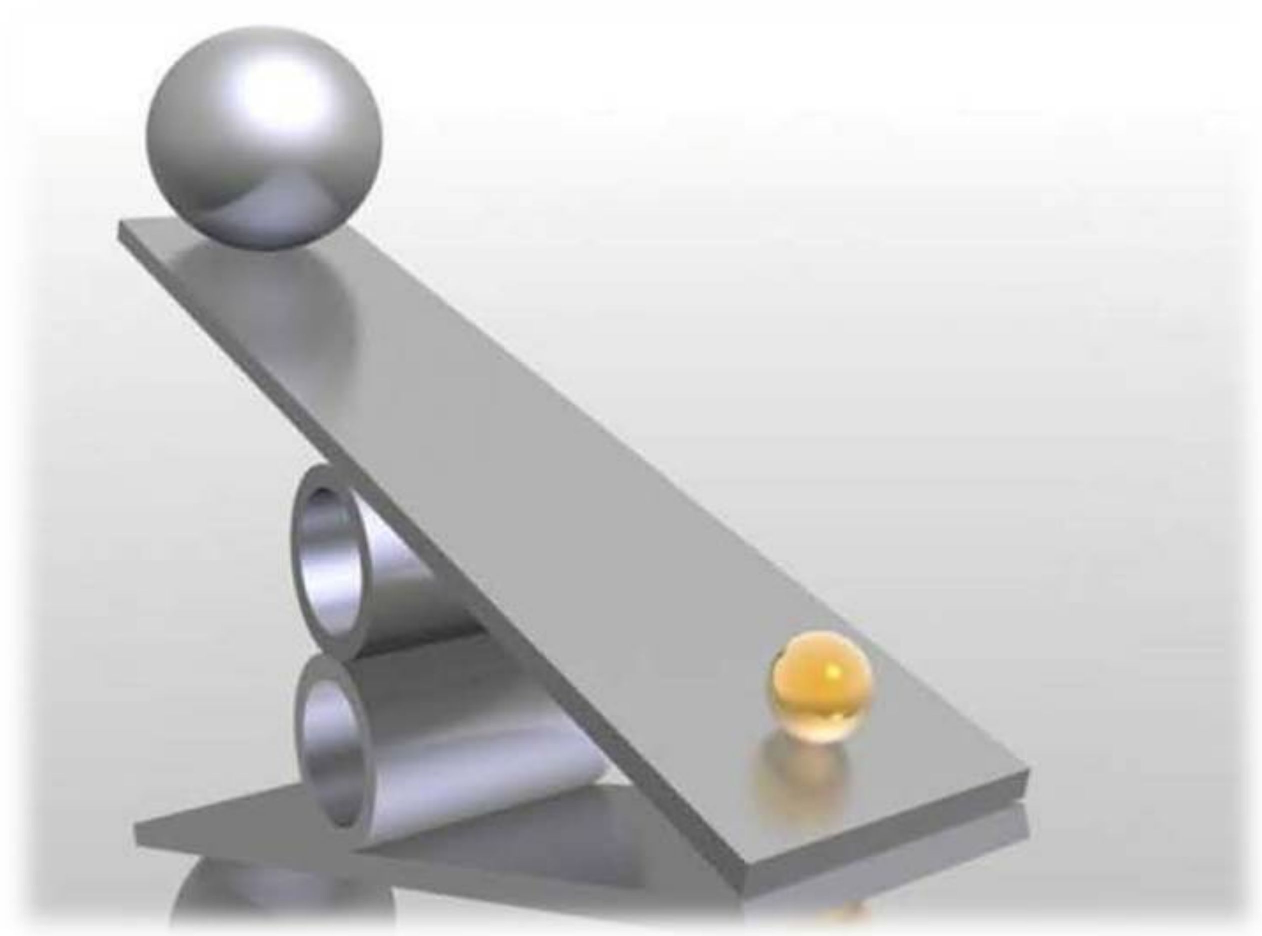
- Reliability
- Redundancy
- Shielding
- Etc.



Some things don't scale well

- A tiny satellite is still a satellite and treated as such
  - Space Debris Mitigation
  - Legislature and Permits
  - Launch cost is mainly paperwork and logistics
- Cost and schedule impacts for frequency allocation
- Testing cost are based on test time, not just on size
- etc.

Leveraging CubeSat Enabling Technologies the next generation of CubeSat Applications



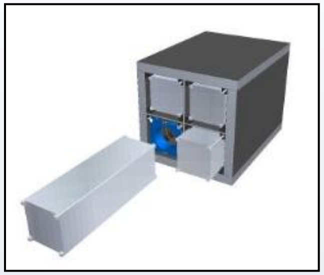
Enabling Technologies:
CubeSat building blocks

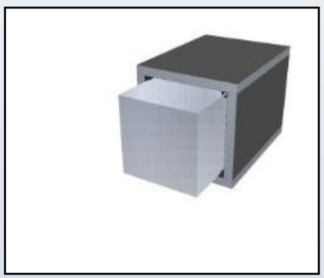


- The biggest strength of specifically CubeSats is not their size, but their modularity and standard interfaces.
  - Enables many system providers and ensures compatibility
  - Provides a generic building block for much bigger systems

“There are few useful applications for a 1U mission, but an unlimited amount of applications for systems based on the systems one finds in a 1U system”

Enabling Technologies:
6-packs & 12-packs





- Size matters
  - Increase in platform sizes
  - from 1-3 kg or liter
  - to 6-12 liter

- More payload carrying capability
  - EO payloads
  - Biggers comms payloads

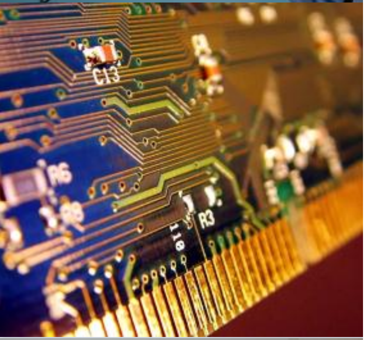
- More surface area for solar panels and deployables: more power -> more capabilities

Enabling Technologies:
Communication



- Biggest bottleneck perceived
  - €/bit is metric to be optimized for effective systems
- Current downlinks fairly slow
- S-Band emerging for payloads
  - Up to 1-5 being deployed and used
  - Up to 5-10 Mbit in next 24 months
- Move to X-Band and beyond before 2015?
- More powerful platform can support these higher data rate systems

Enabling Technologies:
ADCS



- New generation of ADCS products enables better performance
- Heritage:
  - Magnetic determination & control
- Now:
  - Magnetic, Star tracker determination
    - Earth horizon sensors, gyros also available
  - Magnetorquer, reaction wheels
  - Integrated ADCS packages incl CPU

Enabling Technologies:

Payloads

- Big market for platform technologies
  - Traditional customers want to develop their own payload (tech-demo/university missions)

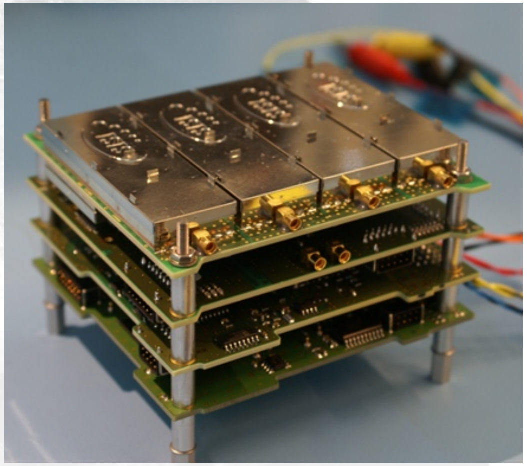
But…

- For application focussed systems the nanosat payload market needs to grow
  - Very few ‘useful’ COTS payloads available
  - Many possibilities for downscaling larger existing payloads (single spectral camera, transponders, partial payloads, etc)

Micro-payloads are needed

- RF payloads
  - AIS Receivers
  - ADS-B
  - Transponders

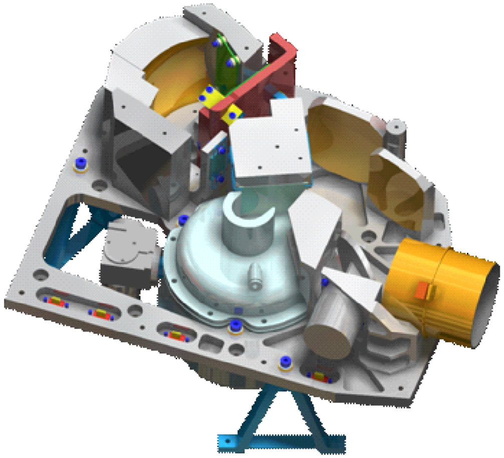
  - Mass < 1kg
  - Power ~ 2- 10 W



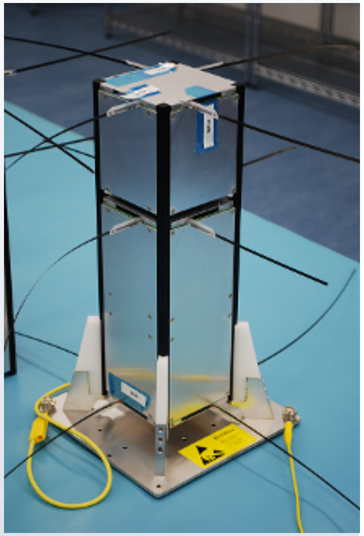
- Micro Optical payloads
  - Infrared
  - Stereo Imaging
  - Multi- / Hyperspectral

  Mass: < 10kg

  Power: ~10-20W



Next Generation Platform



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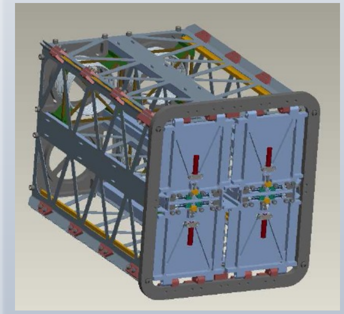
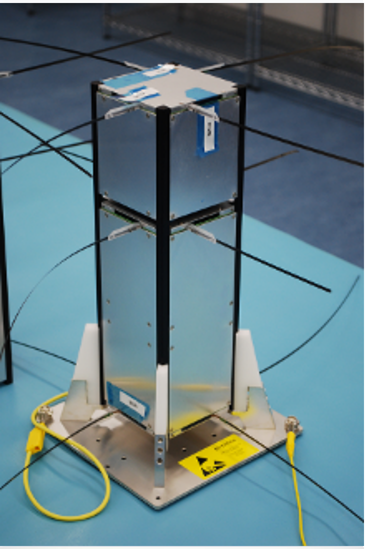


- Next generation platform specification: (expected mid 2013)
  - 12-Pack Nanosatellite
    - ~ 340x200x200 mm3
    - ~ 10-20 kg
  - Deployable arrays; 25-50 W OAP
  - 1 Mbit/s S-band to 10+Mbits/s X-Band
  - Configurable level of fault tolerance
  - Platform delivery time <6 months
  - Platform cost <2 MEuro

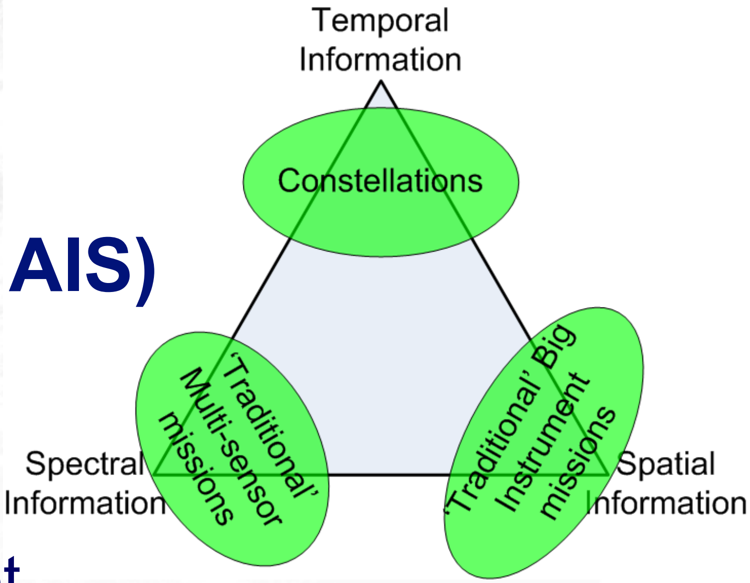
Enabling Applications:



- RF
  - Expected growth in existing market
  - Low data rate comms constellations
  - High data rate repeater nodes
- EO
  - Useful EO as new market
  - Rapid Response systems
- General
  - operational payload > more cost effective missions for all sorts of applications

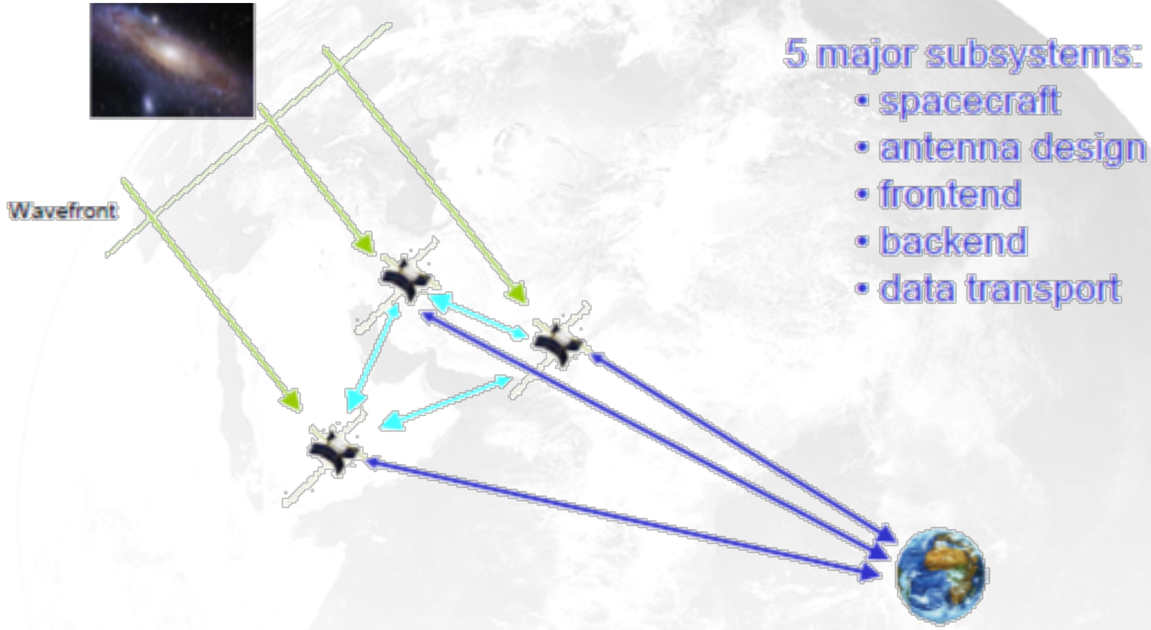
Nanosatellite Applications

- Nanosats and constellations fill a gap in the performance dimensions
- Spectral (Envisat)
- Spatial (GeoEye)
- **Temporal (QB50, AIS)**



- **Lower Cost**
  - <1000 k$ per asset
  - <500 k$ per asset for large constellations

Challenging example - 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.

Conclusions

- Nanosats will *not* replace big/microsats, but they will co-exist
- Operational Nanosatellite constellations and missions expected to have more capabilities to accommodate larger, more demanding payloads
- Traditional satellites now using standardized nanosatellite systems, next step is to miniaturize bigger payloads.
- Many suitable nanosat applications are possible -> size, performance and budget are not the limiting factor, but rather the human imagination of what can be done…

Thank you for for your attention!

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