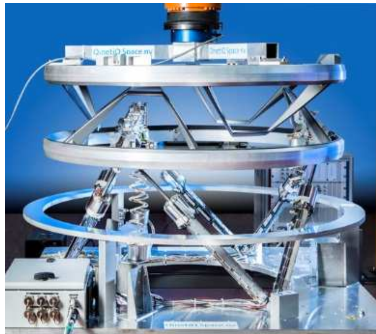
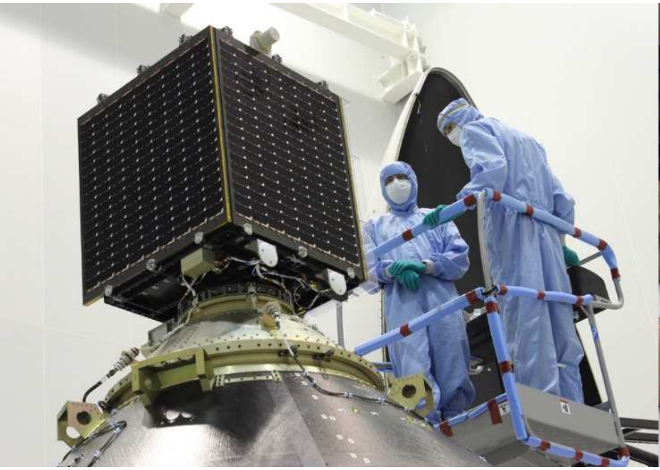


CleanSat - Technology priorities for small satellites



24/10/2017

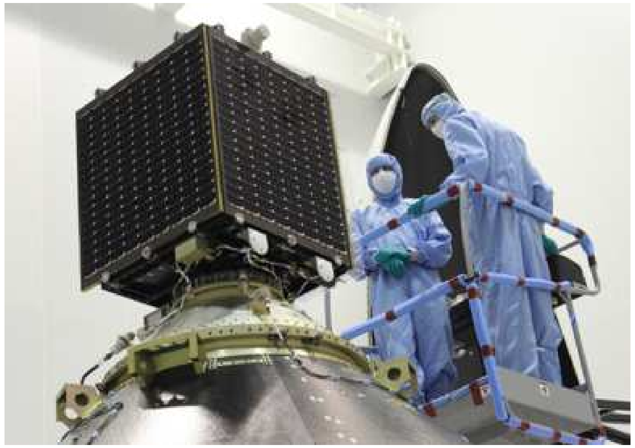
Outline

COMMERCIAL IN CONFIDENCE

Introduction and context – Small satellites at QinetiQ Space

QINETIQ

Small satellites at QinetiQ Space

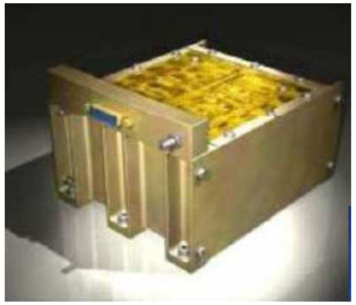


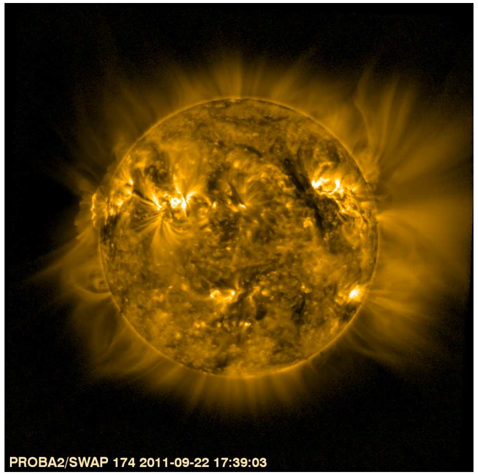
1. **PROBA = PRoject for OnBoard Autonomy**
   - Maximum automation in flight and ground segment
   - Built by a consortium led by QinetiQ Space for ESA

2. **Series of small, cost-effective satellites (100-150 kg)**
   - Future up to ~400kg range

3. **High scientific/technology return for low operational cost without increasing the risk**

4. **Technology demonstration missions (often small mission enablers)**
   - Li-ion battery
   - LEON2 processor
   - NAND flash
   - ADS-B from space
   - GaN X-band transmitter
   - +25 tech demo units



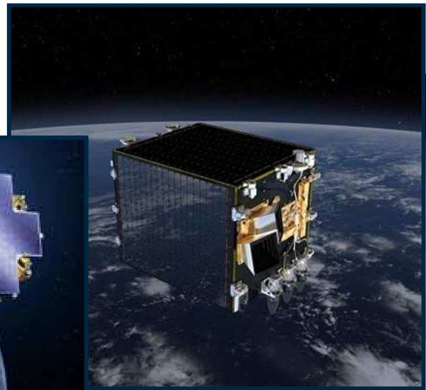


Small satellites at QinetiQ Space

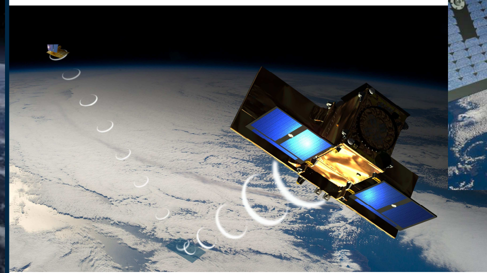
PROBA-1 (2001)

PROBA-2 (2009)

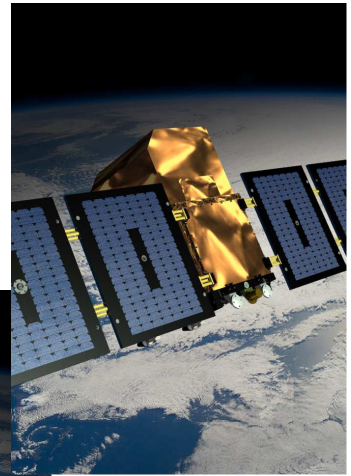
PROBA-3 (2020)



PROBA-V (2013)



SAOCOM-CS (cancelled)



ALTIUS (2020)

+ studies and missions in various stages of maturity

With launched satellites, accumulated > 25 years of in-orbit operation & all satellites still operational.

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Effect of space debris mitigation on small satellites

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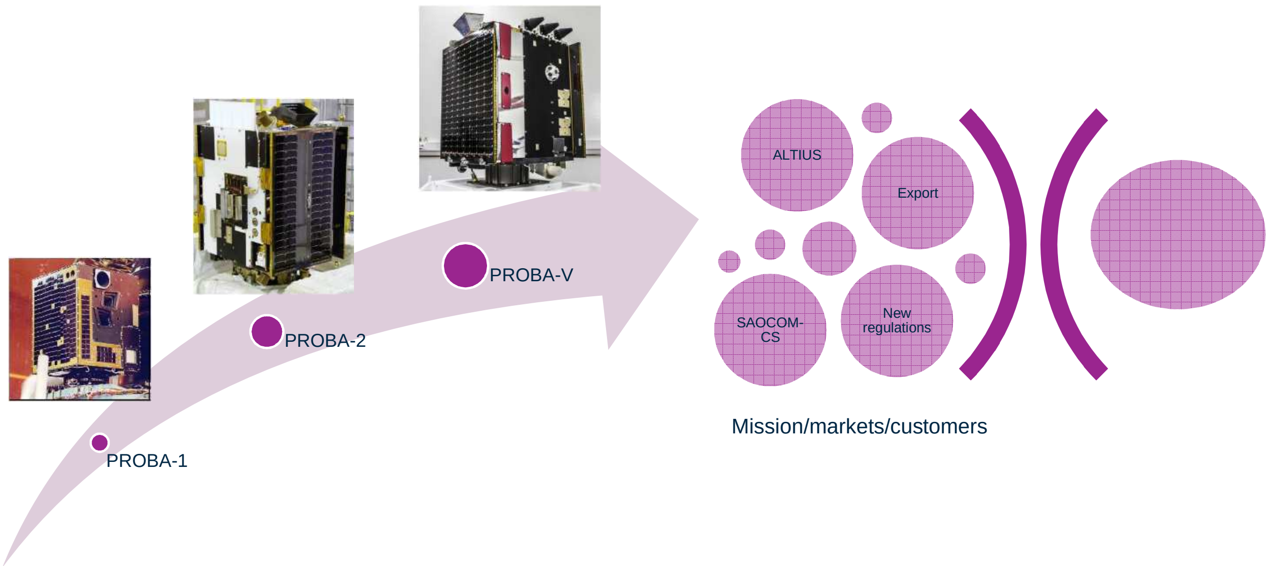
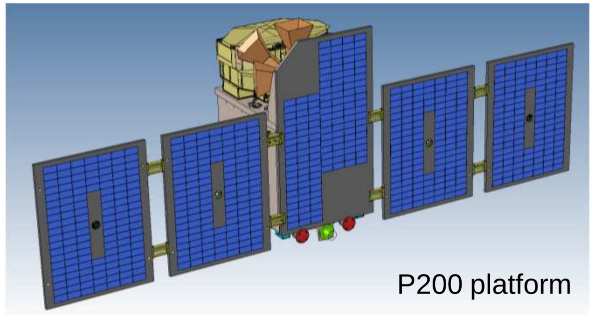
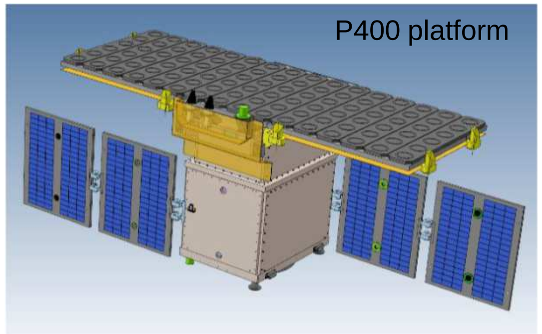
Small satellite bus evolution – driven by new regulations





Added propulsion capabilities in new platforms



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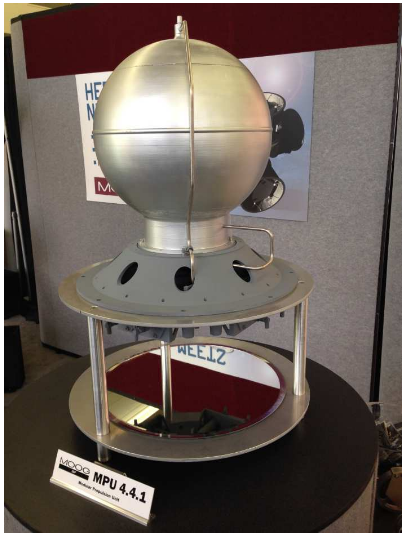
Effect of space debris mitigation on small satellite design

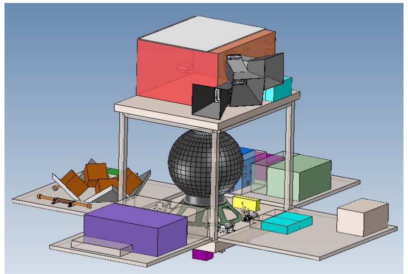
1. Added <u>de-orbit</u> capability

- Smaller satellites typically didn't have propulsion on-board so
  - no avoidance capability
  - no de-orbit capability



2. Added <u>passivation</u> capabilities

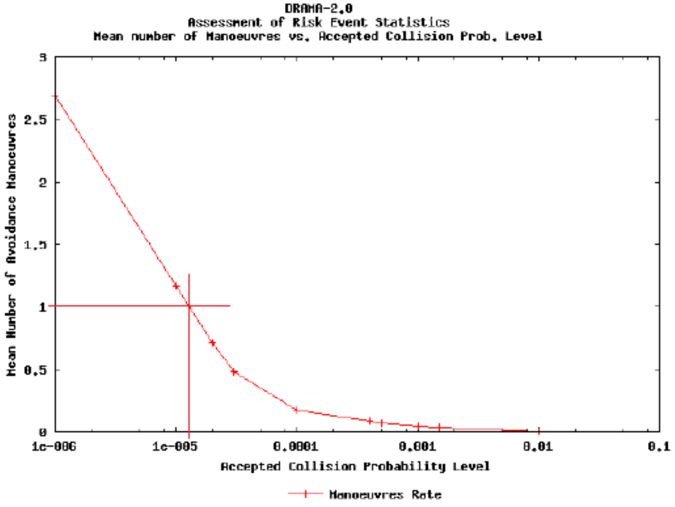
- Propulsion
- Energy storage



3. Various measures coming from risk analysis

- Fragmentation & explosion risk
- Particle release
- On-orbit collision risk

Case study – SAOCOM-CS



1. Collision avoidance maneuvers (~400kg spacecraft)

- ~1 CAM/year for ~1e-5 ACPL
- When in close formation with SAOCOM-1B, 1 CAM/years added
- Total DV – 1,7m/s

2. Disposal analysis

Case	Comment	ECSS (solar cycle 23)	Latest prediction
DEORBIT_1	Worst case un-deployed	49.3years decay 23.7m/s delta-V	24.97 years decay 31.8m/s delta-V
DEORBIT_2	Worst case deployed	18.5years decay 0m/s delta-V	24.97years decay 10.24m/s delta-V

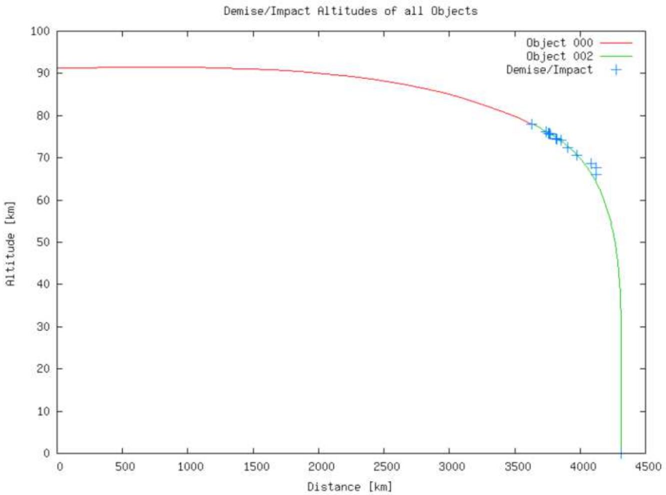
3. Passivation

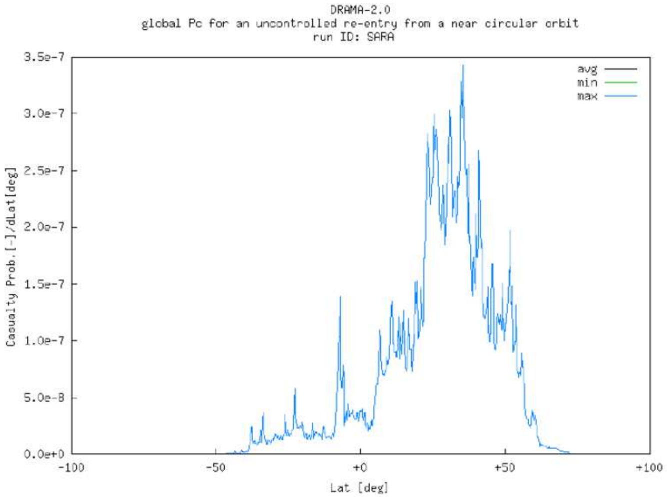
- Battery depletion to <5% (very low EoC)
- Tank depletion

Case study – SAOCOM-CS

4. Re-entry

- Small size beneficial for break-up of all items except
- Ti propulsion tank survives re-entry
- Casualty risk ~9x10-6





Technology priorities for small satellites

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Technology priorities for small satellites

1. **Drag augmentation systems**
   - Inclusion of propulsion capabilities has major impact on small satellite design
   - Because of small dimensions, alternative “drag augmentation” systems are feasible and potentially more cost-effective

2. **Battery passivation**
   - Assess safety of batteries at < 5% SoC
   - Ensure we don’t create a “weakest link”

3. **Improved demisable propulsion tank.**

4. **Eventually, autonomous system are needed.**

Other priorities for small satellites

1. Awareness

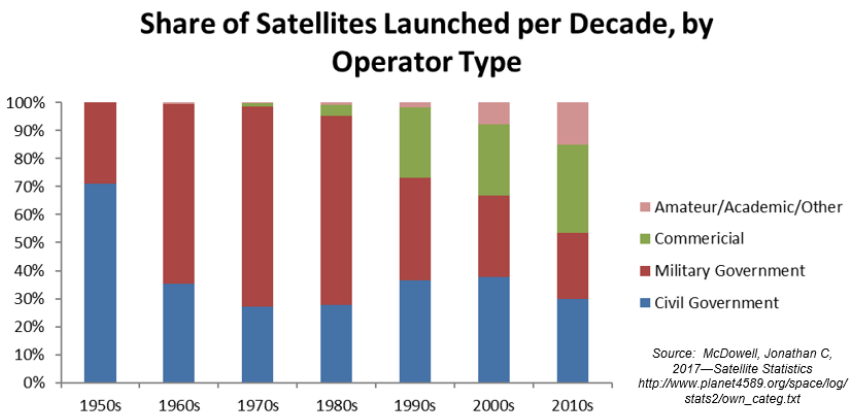
1. Promote “responsible behavior”/”best practices”
   - Increasing number of (private!) actors in space industry
   - Main mechanism to address short term challenges

2. Regulatory
   - Longer term, need for global consensus on hard laws

2. EoL service

1. Active debris removal - Mega-constellations potential risk for sustainability
   - Higher orbits > strong radiation environment > higher anomaly rate
   - Certain % of fleet will fail before completion of life without decommissioning

2. On-orbit servicing



Shift to non-governmental missions
Also increase in absolute numbers for small sats

Summary & conclusions

Summary and conclusions

1. **We all need to be "good citizens" in space**
   - Certainly for those of us working in private sector, responsible behavior lies with industry
   - People skills might get us further than technology…

2. **Specifically for small satellites**
   - Elegant simple (& autonomous) de-orbit devices
   - Promote lower altitudes
   - Improve general survival rate of CubeSats/Small satellites

3. **EoL services**

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Peter Holsters (Business Development & Sales Manager Satellites)

+ 32.3250.1425

peter.holsters@qinetiq.be

www.QinetiQ.be