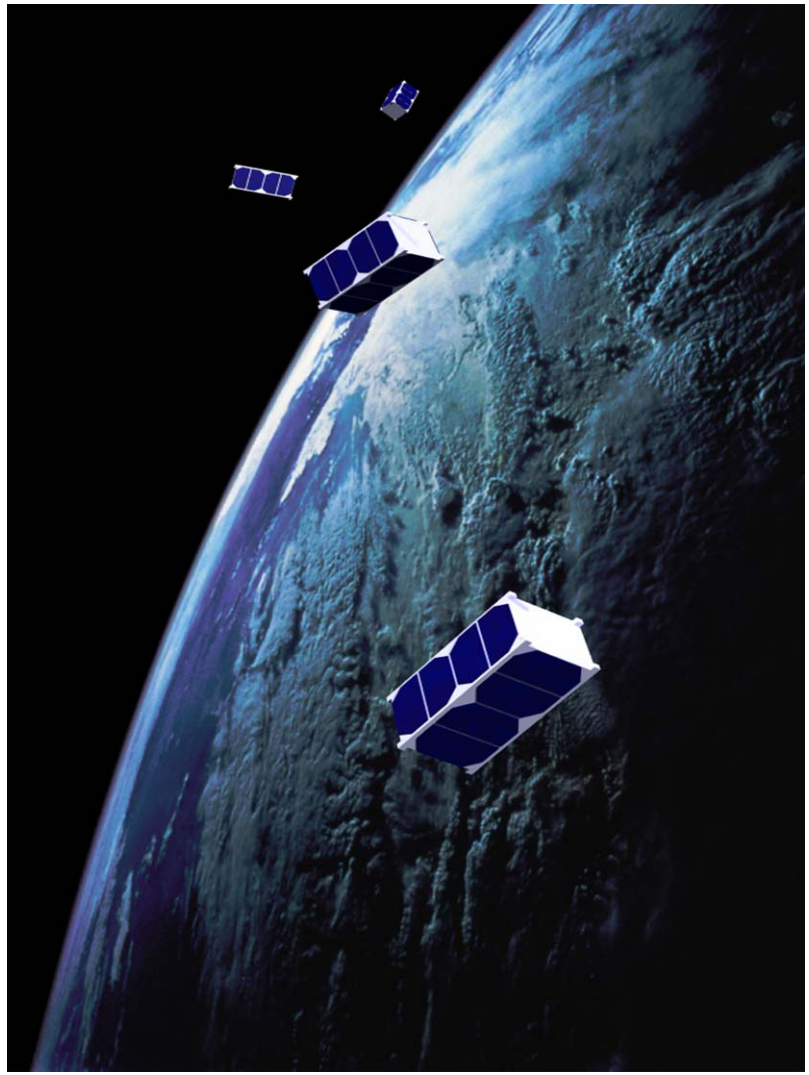
QB50

An international network of CubeSats



J. Muylaert
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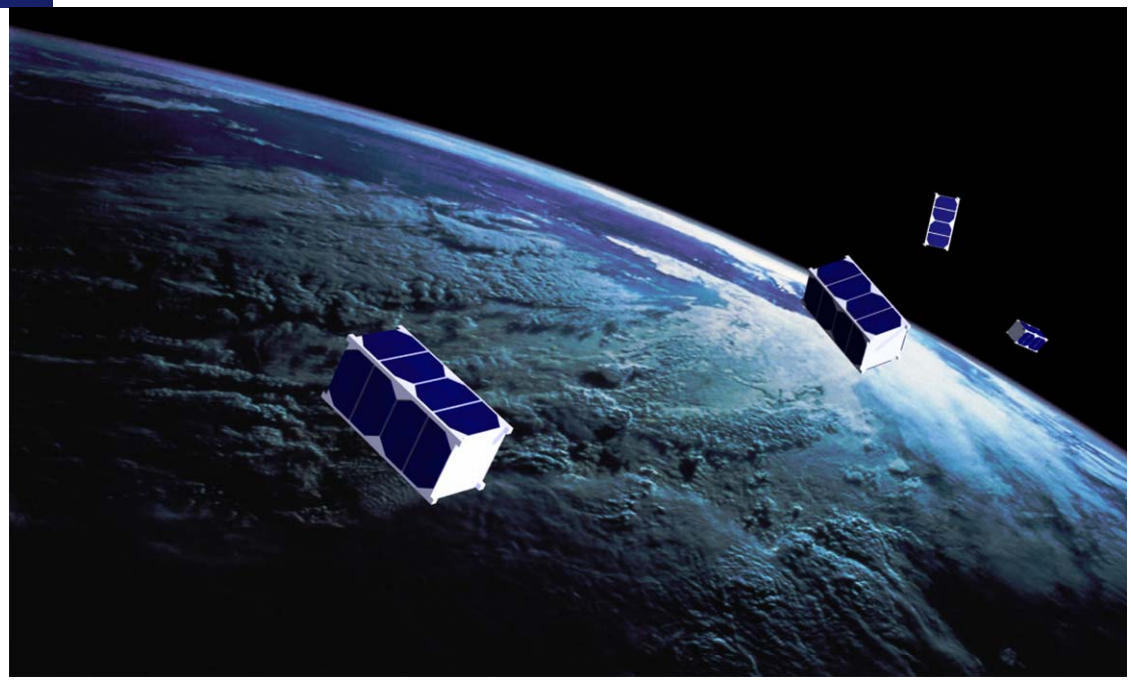
Rhode-Saint-Genèse (Brussels)

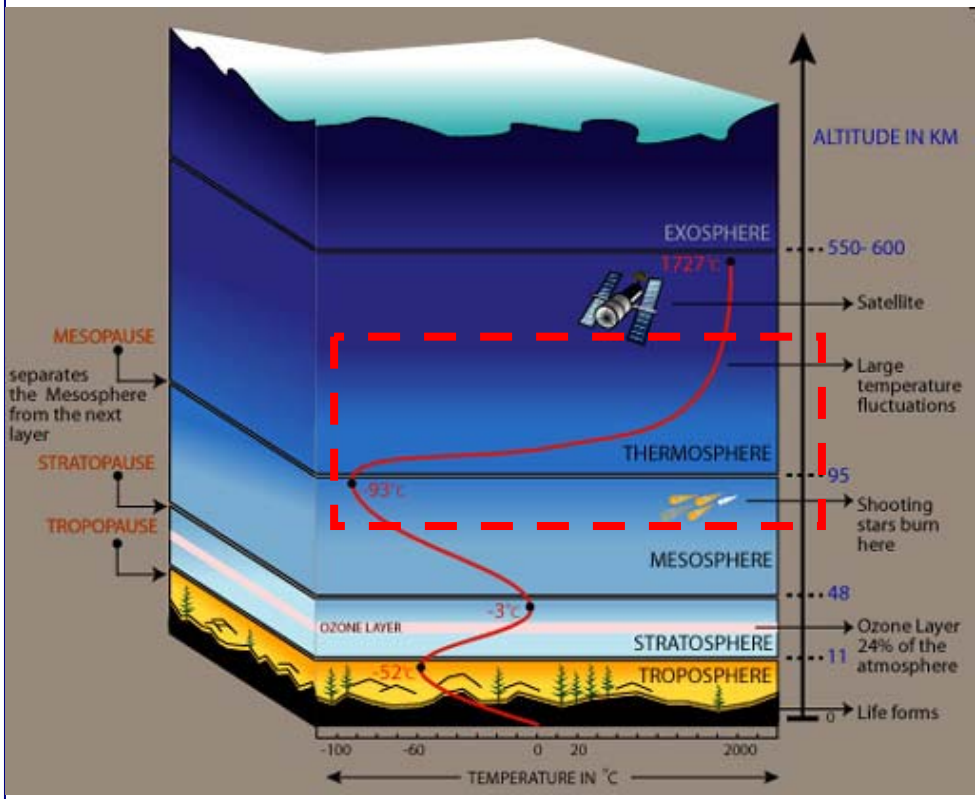
UNCOPUOS
Technical and Scientific Committee
15 Feb 2013
Vienna , Austria

QB50 - THE IDEA



- An international network of 50 CubeSats for multi-point, in-situ, long-duration measurements and in-orbit demonstration in the lower thermosphere
- A network of *50 CubeSats* sequentially deployed
- Initial altitude: 350 km (circular orbit, high inclination)
- Downlink using the QB50 Network of Ground Stations

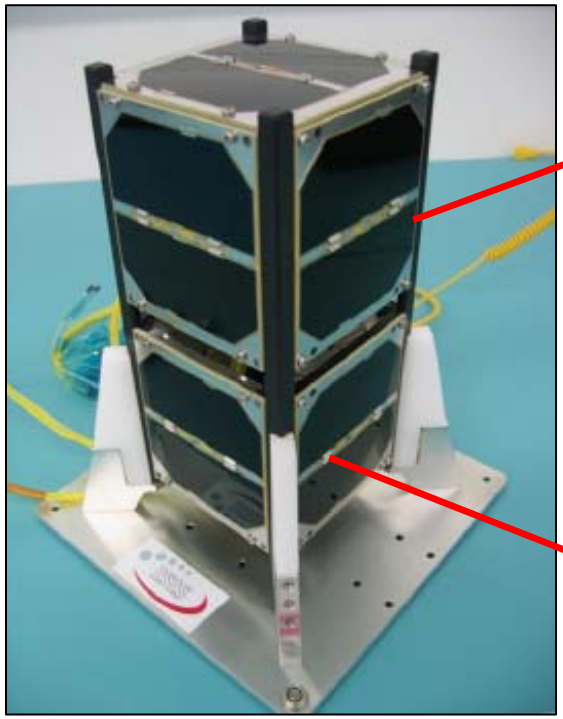
90 – 330 km: Why Lower Thermosphere?

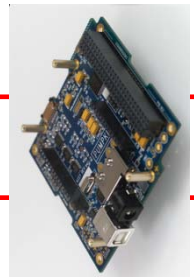


- The ***least explored*** layer of the atmosphere
- Stratospheric balloons go up to 42 km max.
- Remote-sensing by ground based lidars and radars up to 105 km.
- Remote-sensing by Earth observation satellites in higher orbits (600 – 800 km) only observe constituents in the troposphere, stratosphere and mesosphere (lower thermosphere is too rarefied).
- In-situ measurements by sounding rockets in the mesosphere and lower thermosphere (MLT Region) provide only occasional (a few times per year) single-line measurements

QB50 - The CubeSat

On a Double CubeSat (10 x 10 x 20 cm^3):



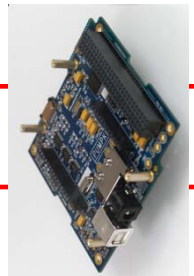


Science Unit:

Lower Thermosphere Measurements

Sensors designed by MSSL

Standard sensors for all CubeSats



Functional Unit:

Power, CPU, Telecommunication

Optional Technology or Science Package

Universities are free to design the functional unit

Sensor Selection

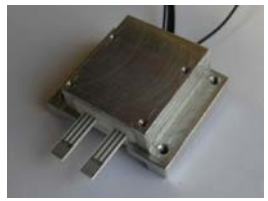
Set 1
Ion-Neutral Mass Spectrometer (INMS)
2 corner cube laser retroreflectors (CCR)*
Thermistors/thermocouples/RTD (TH)

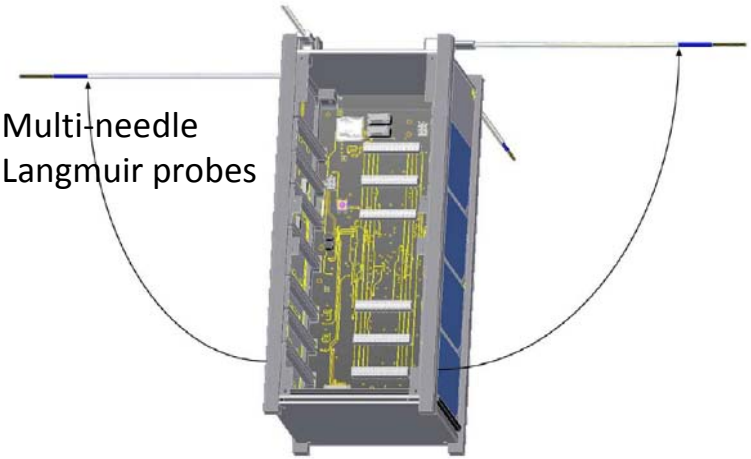
Set 2
Flux-Φ-Probe Experiment (FIPEX)
2 corner cube laser retroreflectors (CCR)*
Thermistors/thermocouples/RTD (TH)

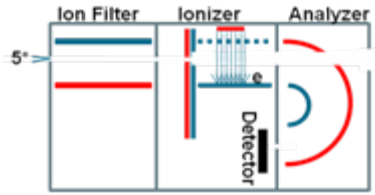
Set 3
A set of 4 Langmuir probes (MNLP)
2 corner cube laser retroreflectors (CCR)*
Thermistors/thermocouples/RTD (TH)

* Offered as an option

FIPEX sensor



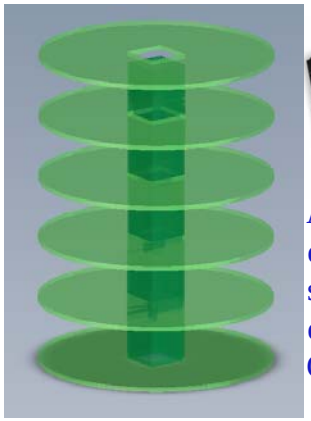




Schematic of the principle of working of the INMS

Miniaturised charged particle analyser along with the Improved Plasma Analyser

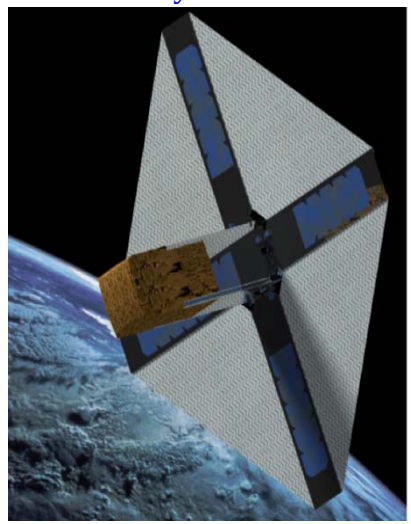
In-Orbit Demonstration



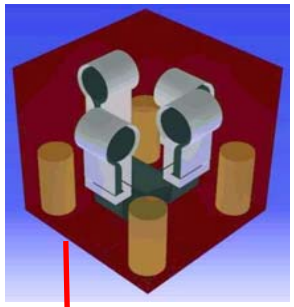
A modular deployment system for double and triple CubeSats

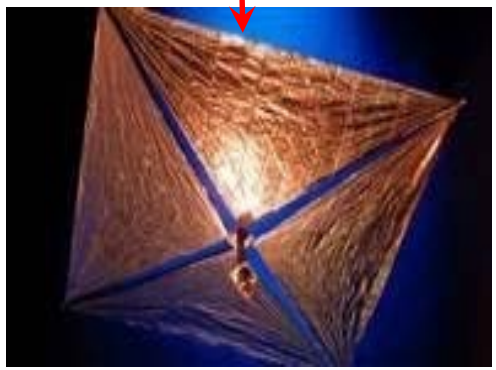
De-orbiting and aerodynamic stability

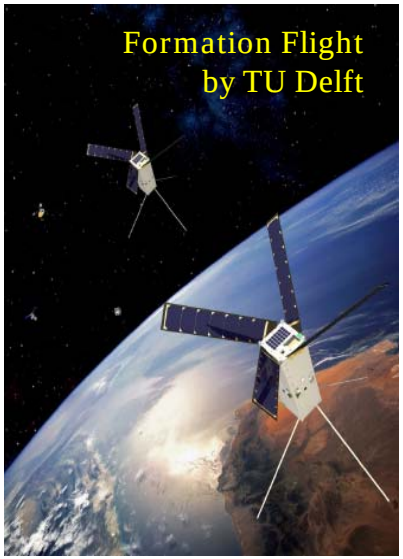
AeroSDS by VKI

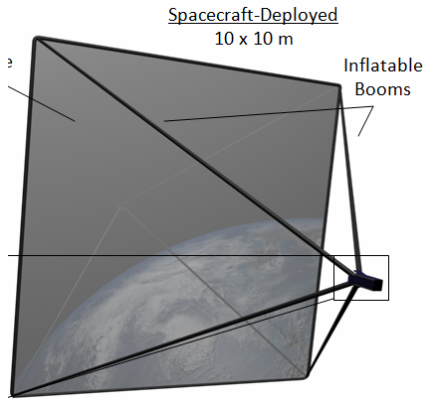


Gossamer-1 Solar Sail demonstration packagem DLR









InflateSail demonstration mission, SSC

Other In-Orbit Demos:

- End of life analysis, Debris
- Micro-propulsion systems
- Micro-g experiment

Formation Flying

DelFFI Project: with triple CubeSats “Delta” and “Phi”

• Delft University of Technology intends to provide two triple-unit Cubesats, both being equipped with a highly miniaturized propulsion system in addition to the standard science payload.

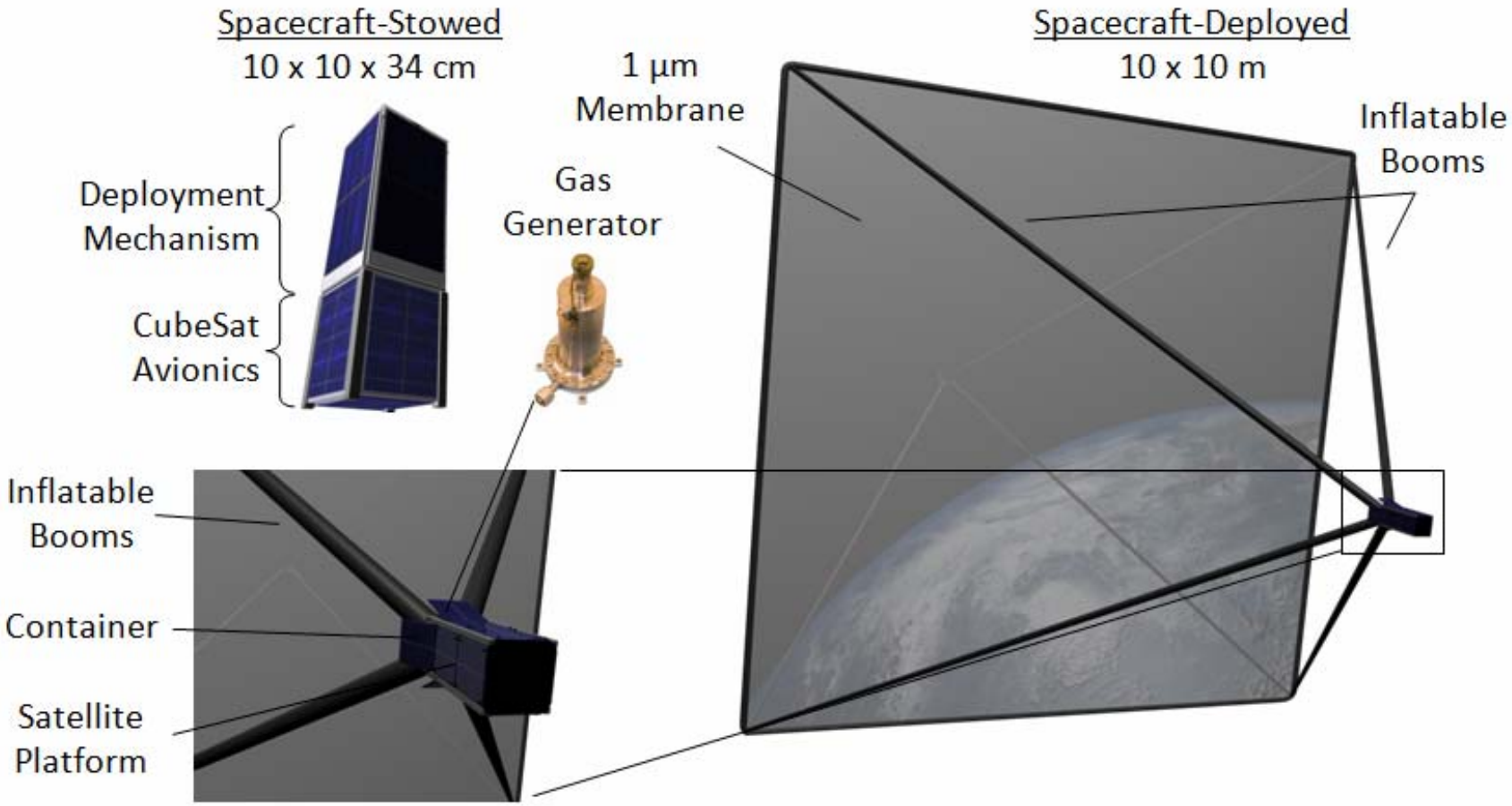
•This allows for a coordinated formation flying of these two satellites using baselines, which can be realized, maintained and adjusted during the mission based on scientific and technological needs.

• The position of the satellite will be determined by GPS. The inter-satellite communication will be realized by ground stations

•Therefore, formation flight will be possible at any distance

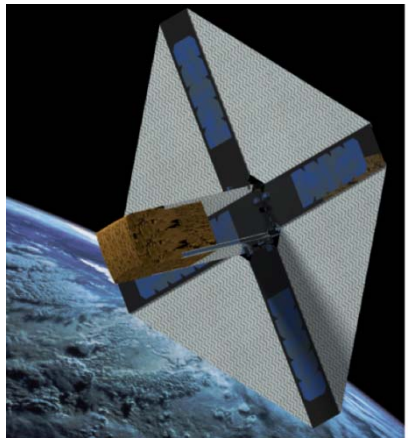
Inflate-Sail

for testing a solar sail with inflatable booms



AeroSDS

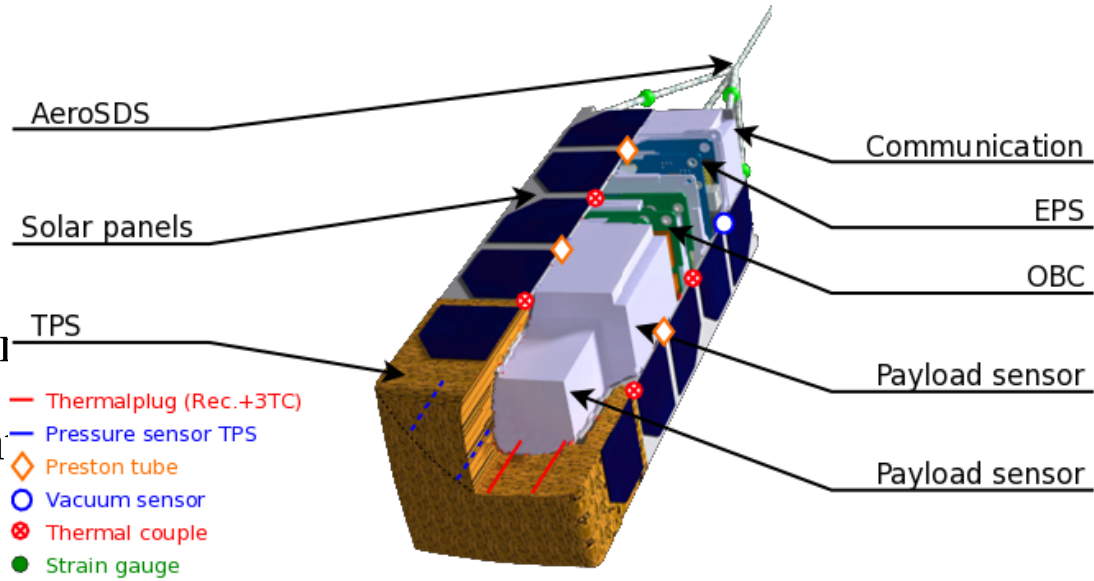
- low-cost, passive and permanent stability
  - -powered only during deployment
  - -standard COTS systems
- two modes for rarefied & entry phase



- flexible sizing according to desired entry conditions and lifetime

QARMAN Subsystems

- Measurements for Satellite Re-Entry Trajectory Rebuilding:
  - Ablation
  - Radiation
  - TPS Efficiency
  - Shear Force & Transitio
  - Off-Stagnation Tempera
  - Rarified Flow
  - Stability

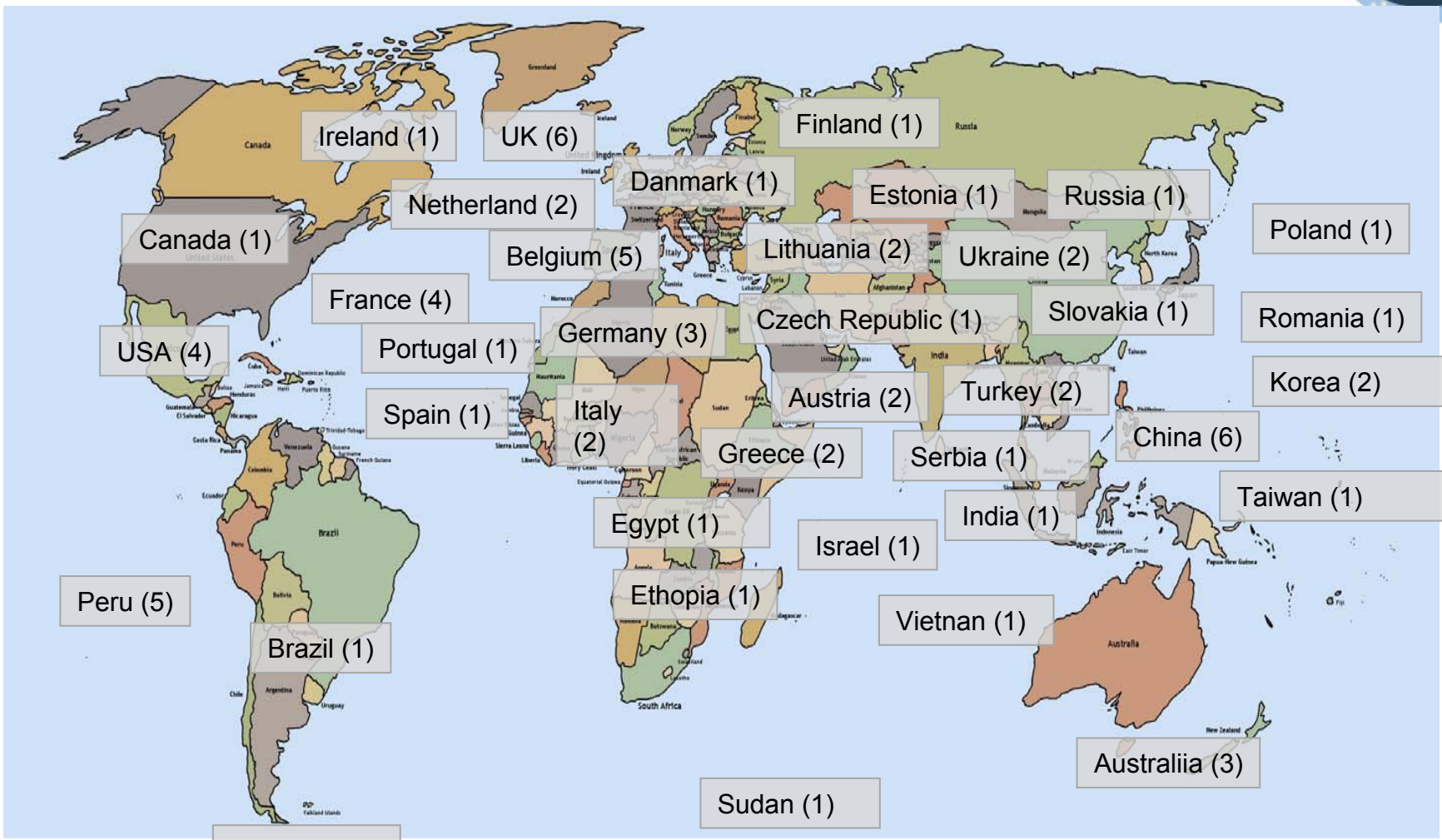


- Feasible Off-the-Shelf Subsystems: IRIDIUM Downlink
- Models for extrapolation of data: **Ground ⇔ Flight**

Selection of CubeSat Teams

- More than 70 proposals received
- Selection of the 50 CubeSats
  - about 40 double CubeSats for atmospheric research to be selected from 50 proposals,
  - about 10 double and triple In-Orbit-Demonstration CubeSats to be selected from 20 proposals, 4 of them already pre-selected (Delta, Phi, QARMAN, Inflatesail)
- Draft Contractual Agreement between the QB50 Consortium and the proposing universities
- Availability of funding and readiness at the PDR are critical issues in the selection process,
- There will be backup CubeSat teams as well

QB50 – CU Teams



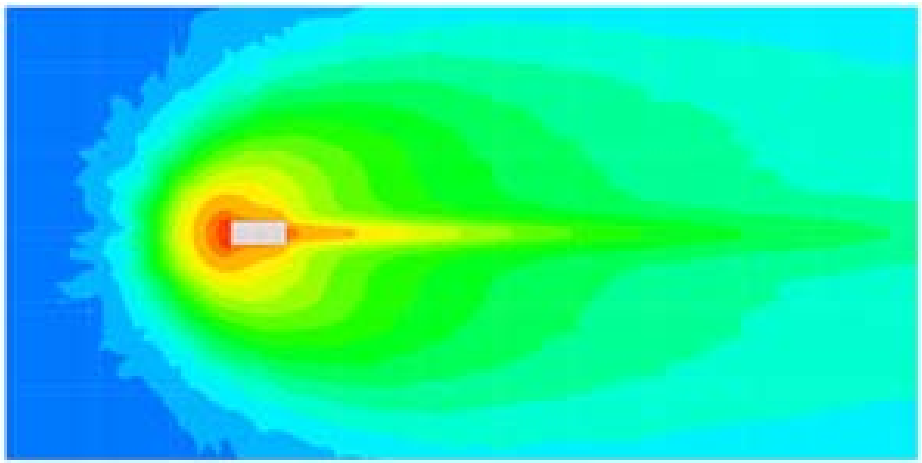
Status of QB50 Project

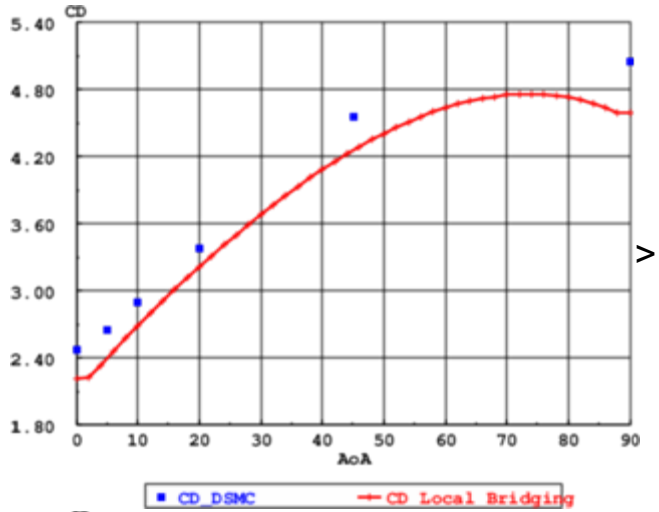
- Started working on the Project as of Nov 2011
- Kick-off was held at 22 Nov 2011

- The Call for Proposals issued on the QB50 web site
- More than 70 proposals were received
- Major technical work accomplished on
  - Orbital dynamics
  - Sensitivity analysis on interaction with the atmosphere
  - Deployment strategy
  - Deployment system
  - Science payload design

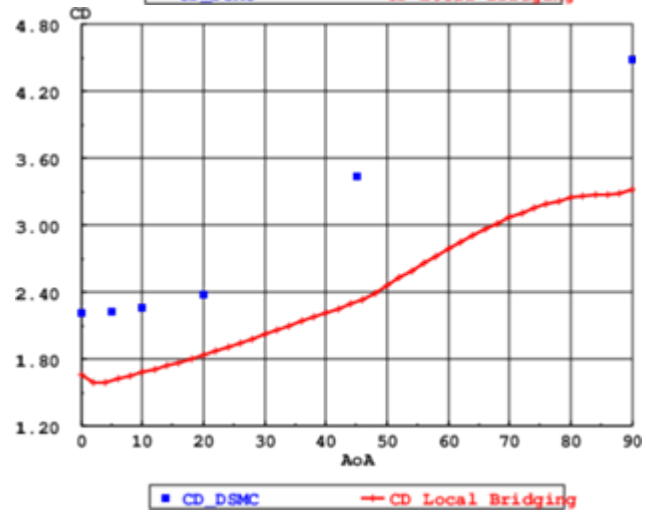
DSMC simulations for CubeSat – Atmosphere interaction

Preliminary computations for selected amount of points of re-entry trajectory were performed and aerothermodynamic characteristics of CubeSat were obtained in free-molecular, transitional, and near-continuum flow regimes and accuracy of the engineering methods was assessed by comparison with the results obtained by the DSMC SMILE code (ITAM & VKI)





> 100 km



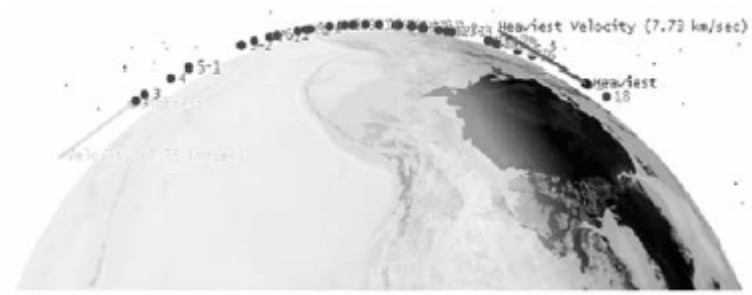
< 80 km

von Karman Institute for Fluid Dynamics

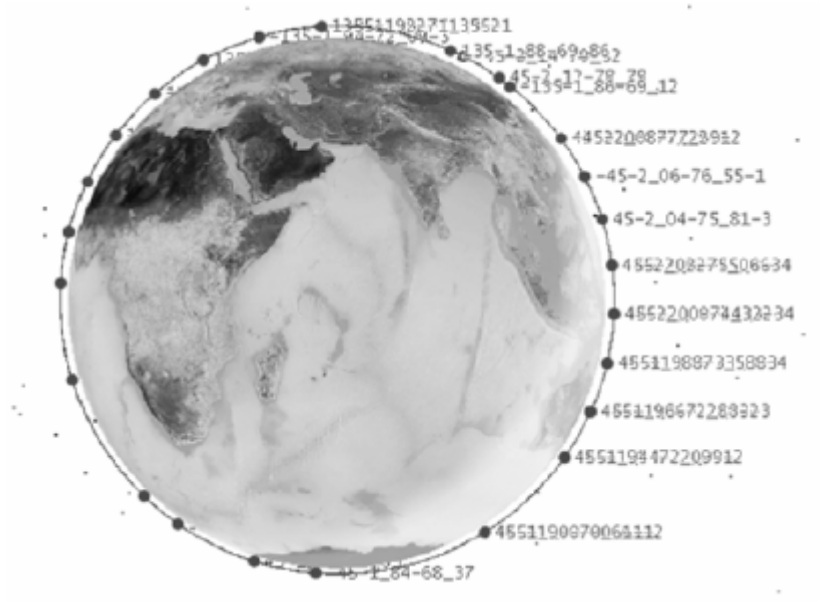
www.QB50.eu

Deployment Strategy

- How to deploy the 50 CubeSats with minimal collision risk and optimised distribution ?
- Detailed analysis covering ballistic coefficient, deployment direction, deployment frequency
- Best scenario to minimize risk in the first 8 hours, and to optimise a uniform network distribution – the developed strategy can be used directly with the ballistic coefficient database of the selected CubeSats.



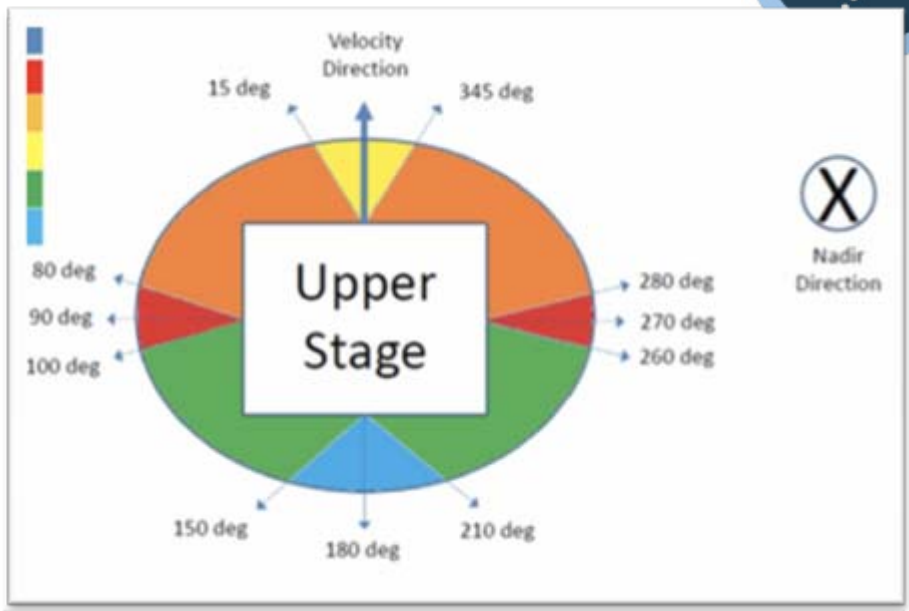
After 20 days



After 30 days

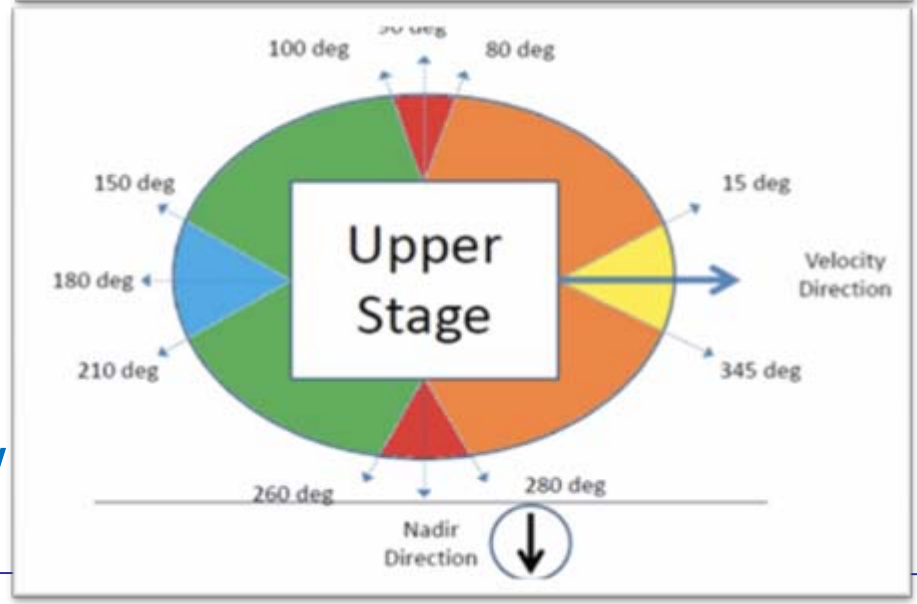
Deployment Strategy

TopView



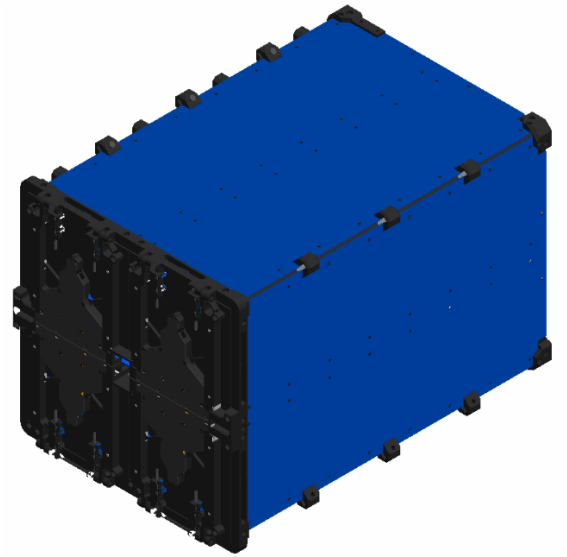
Risk Colors
High
High-Medium
Medium
Medium-Low
Low

Side View



Deployment System

Concept De-risk Prototype
Prototype



Precursor Flight
QuadPack

QB50
StackPack

Next Steps

- We are open to further collaboration
  - **The 5th QB50 Workshop was held on 29 Jan 2013 at VKI, inviting the CubeSat teams to**
    - **Signing of the contract with 50 CubeSat providers**
    - **QB50 requirements documents being processed**
    - **Get ready for PDR by the end-March 2013**
  - **Get in touch with our primary Point of Contact**

    Cem Ozan Asma, asma@vki.ac.be

Next Steps

- www.CubeSatSymposium.eu
  - Abstract submission: 15 Mar 2013
  - 6 June 2013: 6th QB50 Workshop at VKI, Brussels

ACKNOWLEDGEMENT

The QB50 Project, and all related activities are supported by the European Community Framework Programme 7, Grant Agreement no. 284427