

QB50-a Nanosatellites Constellation for Thermosphere Research

a disruptive technology and international collaboration for science

15th Feb. 2016

speaker: Jan Thoemel (Project Manager)
von Karman Institute, Belgium

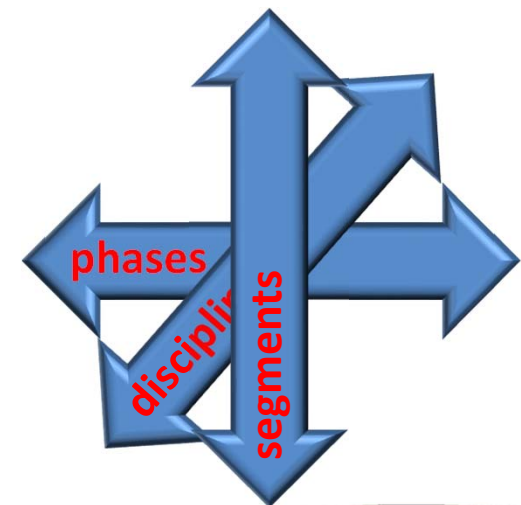


QB50 – what is it?

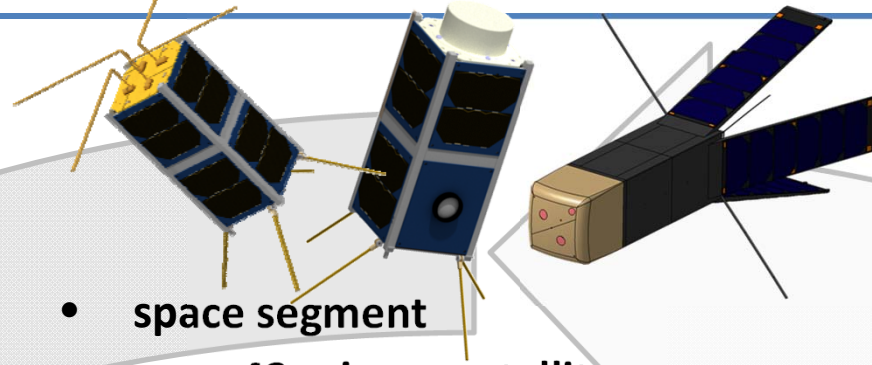
QB50

- invited 50+ international universities to join and to carry-out an unprecedented science campaign
- probes the thermosphere
- demonstrates new technologies
- is managed by a consortium of 15 partners
- supports cubesat teams with:
 - provision of sensor units
 - guidance on satellite development and operations
- carries out a test flight since June 2014

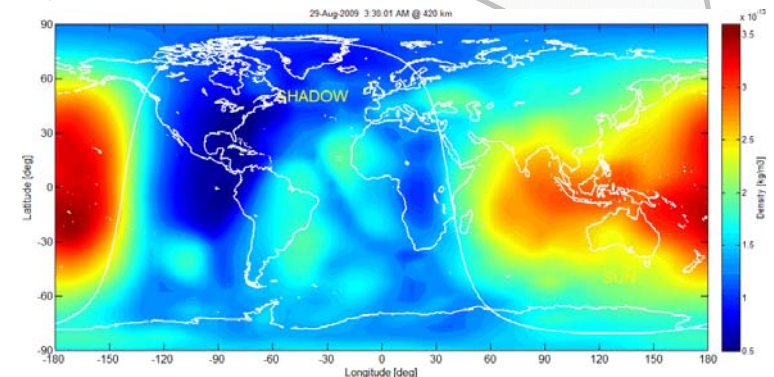
-> a space mission from end-to-end³



Mission Architecture



- **space segment**
 - ~42 science satellites
 - ~8 additional IOD satellites
- **science (segment)**
- **launch segment**
 - modular, versatile deployment system
 - launcher
 - launch campaign
- **ground segment**
 - combination of 50 amateur ground stations
 - DPAC



QB50 Objectives



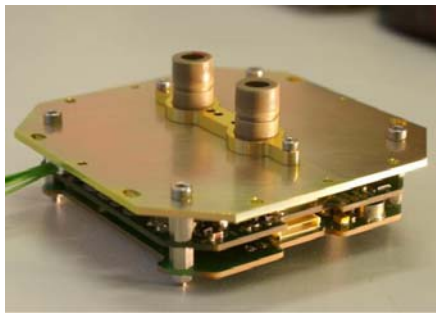
QB50 Science Goals

- fundamental science:
 - understand the dynamics of thermosphere and improve modeling
- technology:
 - miniaturization of satellite technology
 - facilitating access to space
 - in-orbit demonstration of new space technology

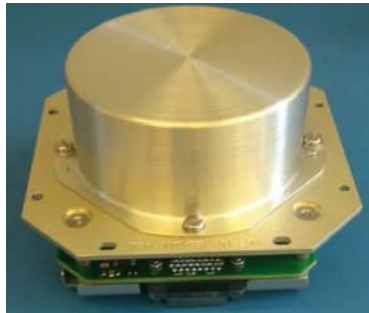


Science: Sensors

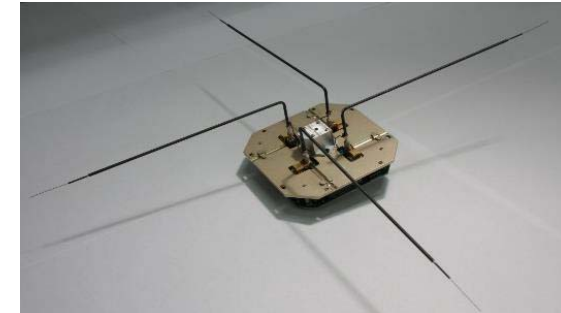
- sensors: ~ 43 fragmented sensors
 - 19 FIPEX: AO and O₂
 - 11 multi Needle Langmuir probes (MNLP): e- and Te
 - 13 Ion and Neutral Mass Spectrometers (INMS): O, O₂, NO, N₂ (and ions)



FIPEX (TU-Dresden, D),



INMS (MSSL, UK),



MNLP, deployed (UiO, Norway)



Science Working Group

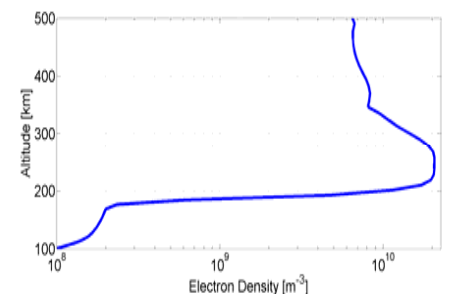
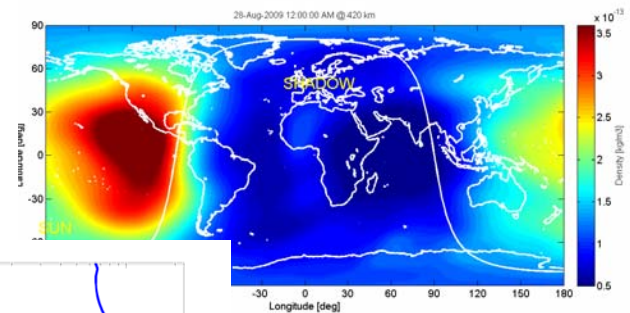
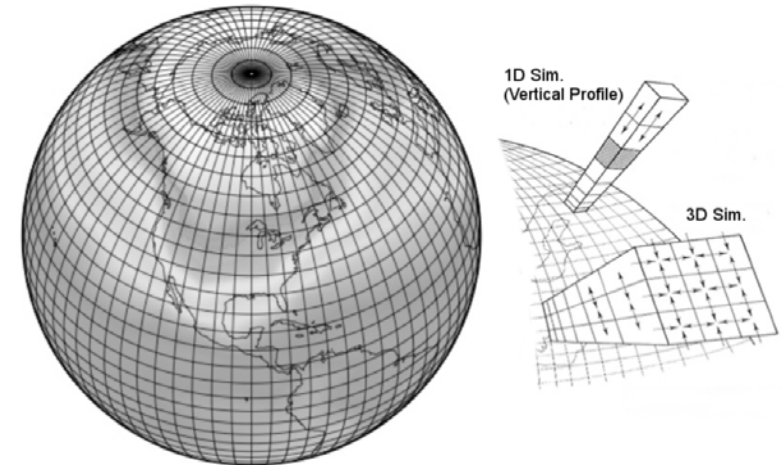
- Prof. Alan Smith (UCL)
- Dr. Dhiren Kataria (UCL)
- Dr. Anasuya Aruliah (UCL)
- Dr. Robert Wicks (UCL)
- Dr. Esa Kallio (Aalto Univ.)
- Dr. Espen Trondsen (Univ. Oslo)
- Dr. Tino Schmiel (Dresden Univ.)
- Prof. Scott Palo (CU-Boulder)
- Prof. Jeff Forbes (CU-Boulder)
- Prof. Aaron Ridley (UMich)
- Prof. Franz-Josef Lübken (IAP)
- Dr. Jens Hildebrand (IAP)
- Dr. Ian Mann (Alberta Univ.)
- Dr. Raphaël Garcia (ISAE)
- Dr. Eelco Doornbos (TUDelft)
- Dr. Davide Masutti (VKI) (chairman, secretary)
- Dr. Jan Thoemel (VKI)



Science: Predictions - Model

Global Ionosphere Thermosphere Model (GITM)

- ❑ Physics-based 3D model developed at University of Michigan*;
- ❑ Solver of Navier-Stokes equations for density, velocity, and temperature for neutral and ions;
- ❑ Solutions in 3D or 1D (with no horizontal transport assumption)
- ❑ Inputs:
 - Solar flux (F10.7)*
 - Solar wind velocity*
 - Hemispheric Power Index (HPI);*
 - Interplanetary Magnetic Field data (IMF);*
- ❑ Outputs:
 - 6 neutrals and 5 ions species, neutral winds, ions velocities and electrons;*
- ❑ Particular aspects:
 - Non-constant gravity acceleration (i.e. centrifugal & Coriolis force terms);*
 - non-steady state chemical reaction solved explicitly.*
- ❑ Work in progress code that potentially could benefit from QB50 measurements.

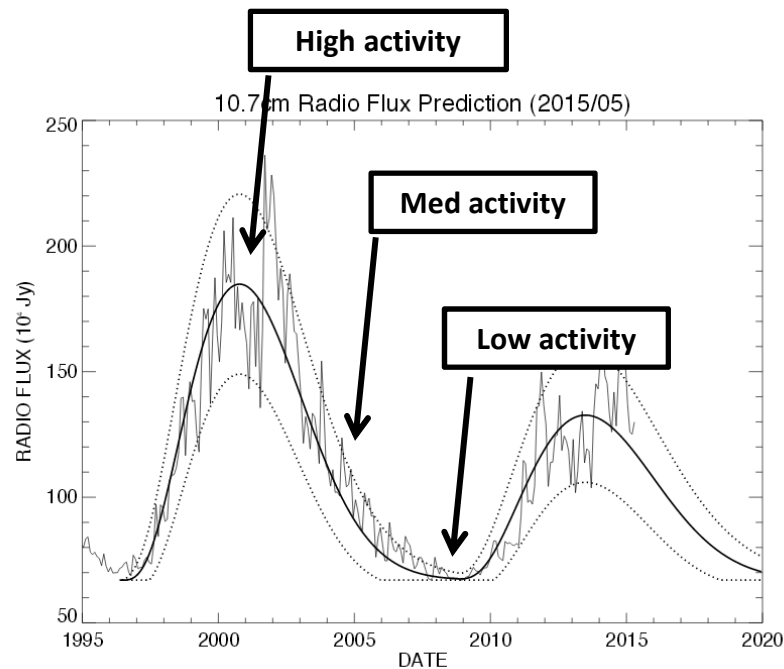


Science: Predictions, Flight Data Comparison

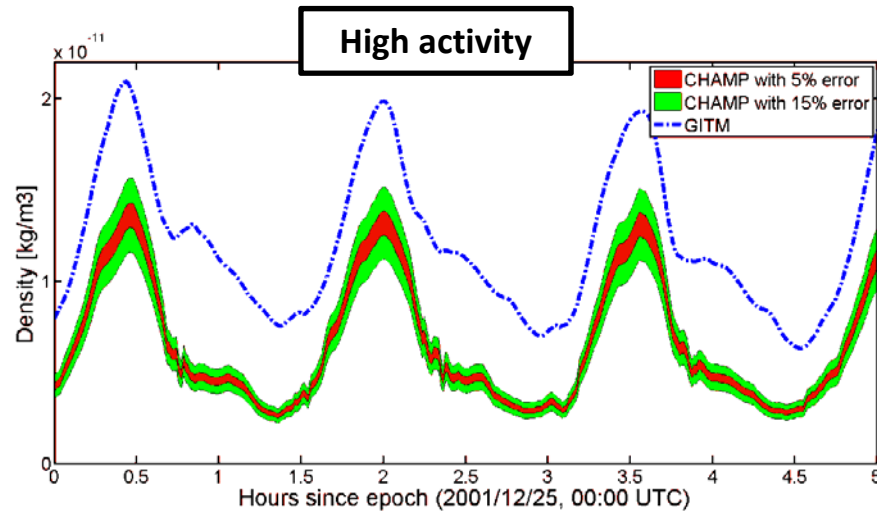
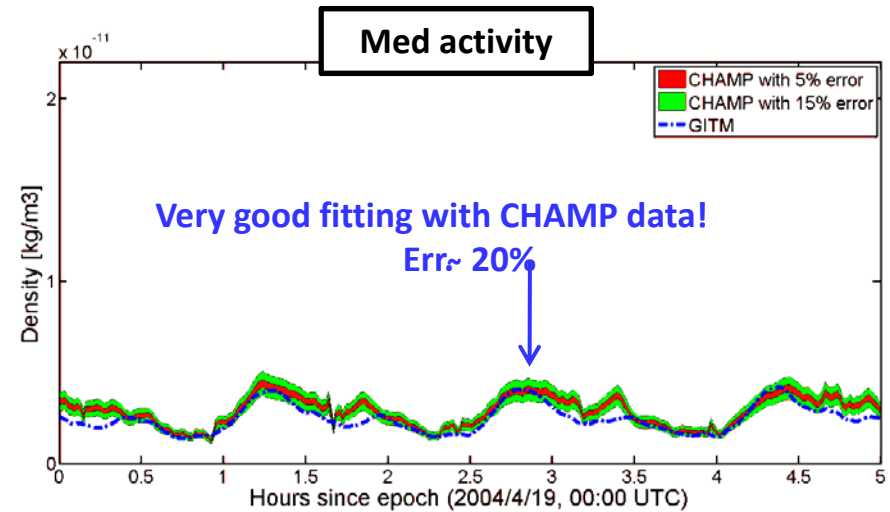
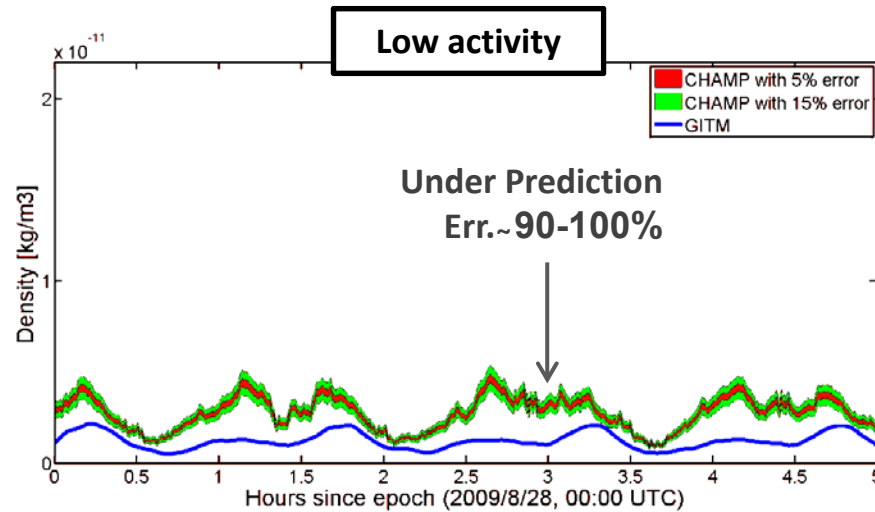


CHAMP (Challenging Minisatellite Payload)

- $p = 6823\text{km}$
- $\text{Ecc.} = 7\text{E-}4$
- $\text{Incl.} = 87.18^\circ$
- Overall density with the STAR accelerometer
- Electron density with the Planar Langmuir Probe (PLP)



Science: Comparison Results

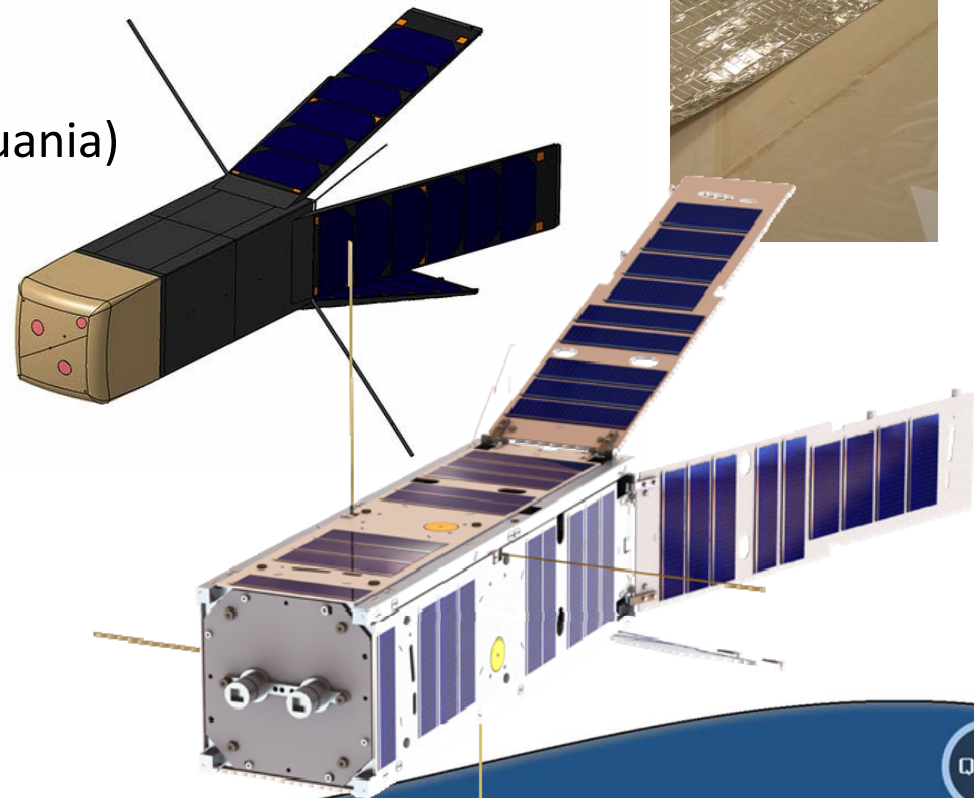
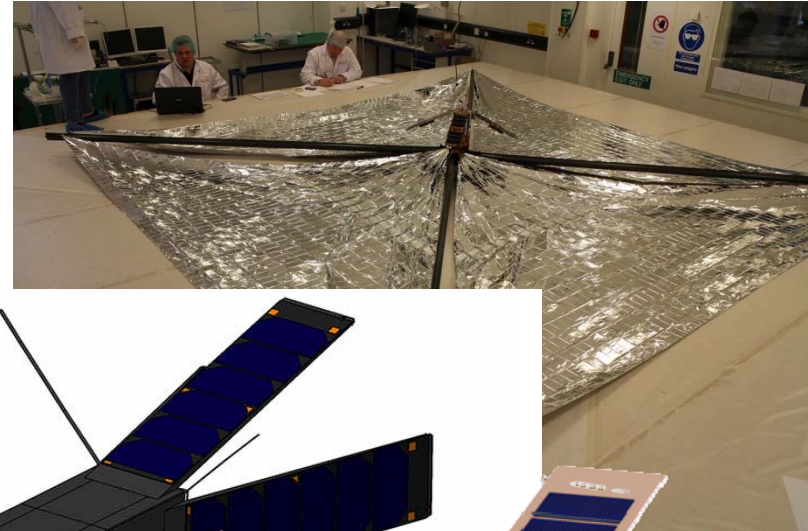


- Experimental errors in CHAMP data are given by the limitations in the modelling of both the satellite geometry and the aerodynamic interactions



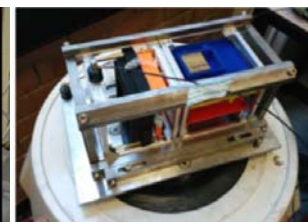
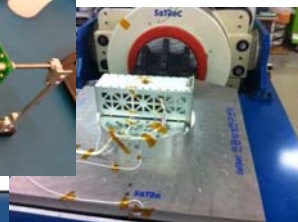
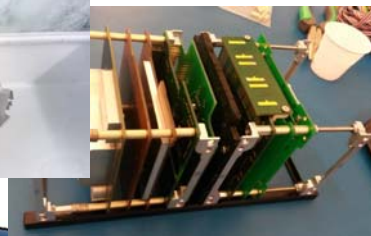
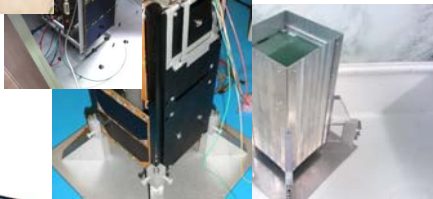
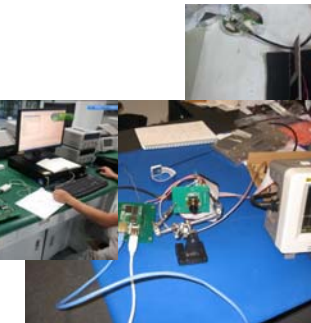
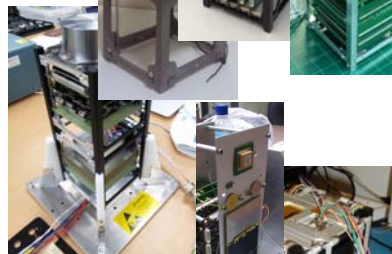
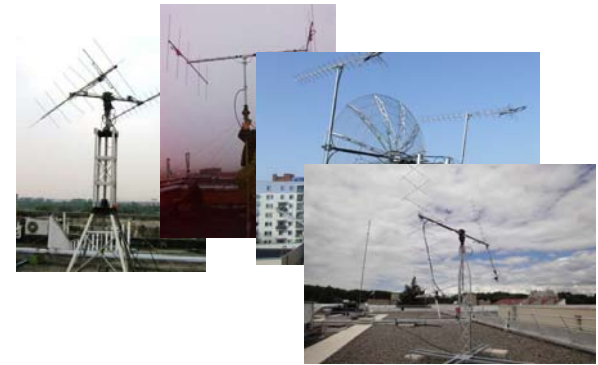
Technology: IOD

- DragSails:
 - InflateSail(University Surrey, UK)
 - DragSail (FHTW Aachen, Germany)
 - Propulsion
 - Ursa Maior (La Sapienza, Italy)
 - LituanicaSat-2 (Vilnius Univ., Lithuania)
 - Reentry
 - Qred (University Porto, Portugal)
 - ReentSat (Supaero, France)
 - Qarman (VKI, Belgium)
- + testing of new sensors, drag maneuvering and further



Status Satellites

- assembly phase:
 - all FMs in assembly phase
 - end-to-end test performed with a selected satellite



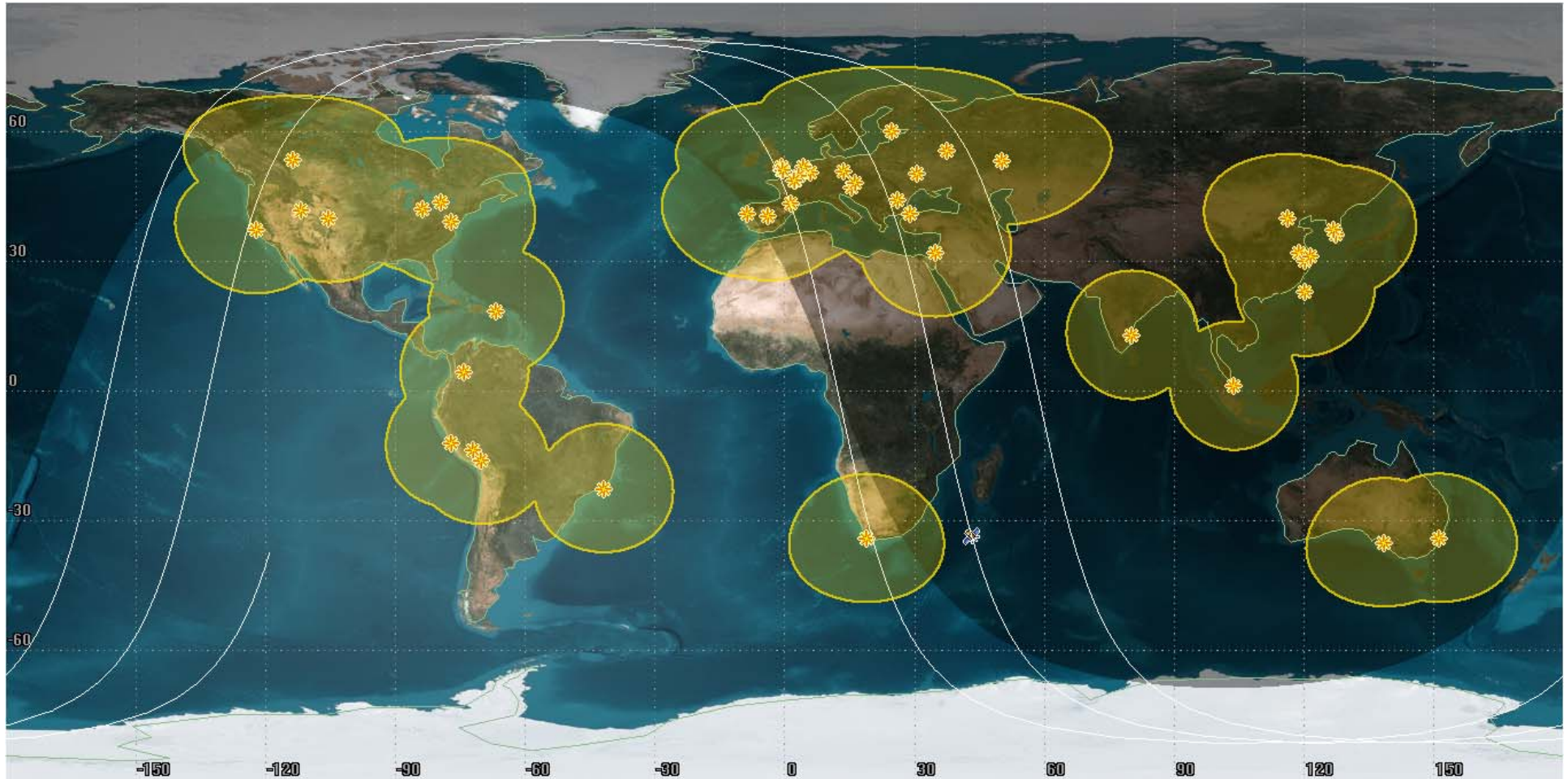
Ground Segment

QB50 Ground Segment consists of

- 50 amateur ground stations
- central functions:
 - Display, Processing and Archiving Centre for
 - storage of TLE, Science Data, WOD storage
 - coordination with USSTRATCOM/NORAD
- frequency coordination of
 - 50 UHF downlink and
 - 10 shared VHF uplink frequency
- Radio Amateurs coordination



Ground Segment



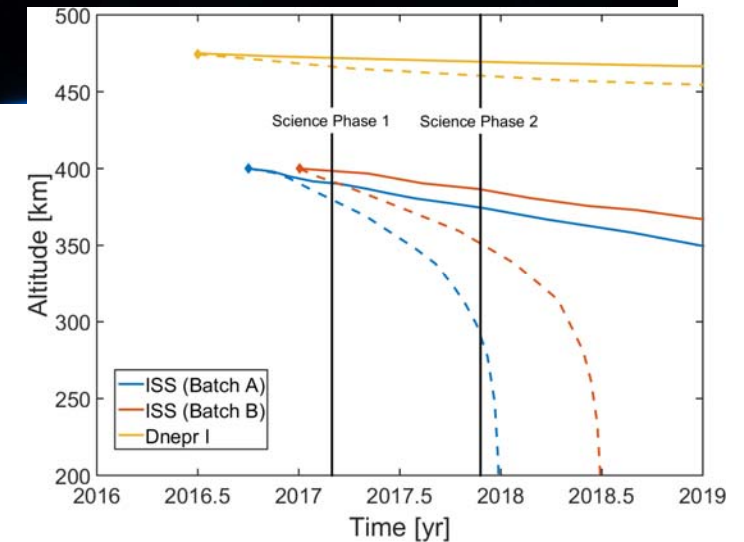
Distribution of baseline ground station and coverage for 380 km altitude



Launch Segment

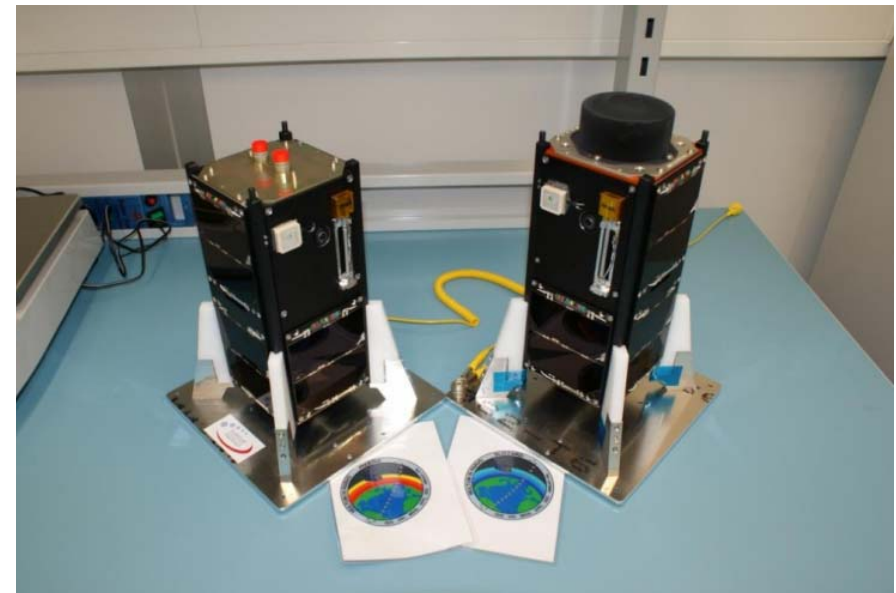
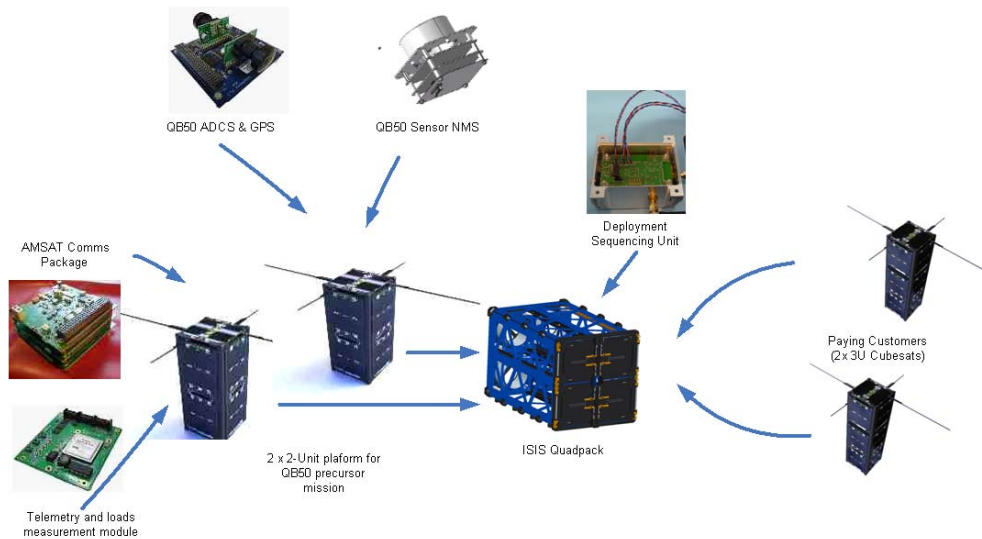
split launch scenario:

- DneprScience:
 - ~98 degree 575 km altitude
 - 3x2 satellites for each Sensor Unit
 - Launch: ~July 2016
- ISS:
 - 52 degrees, 400 km altitude
 - 40 satellites with Sensor Units
 - 1 upload: ~August 2016
 - 1st deployment 20 sats after 1 month
 - 2nd deployment 20 sats after 4 month
- DneprIOD
 - 2 satellites with DragSails
 - Launch: from November 2016

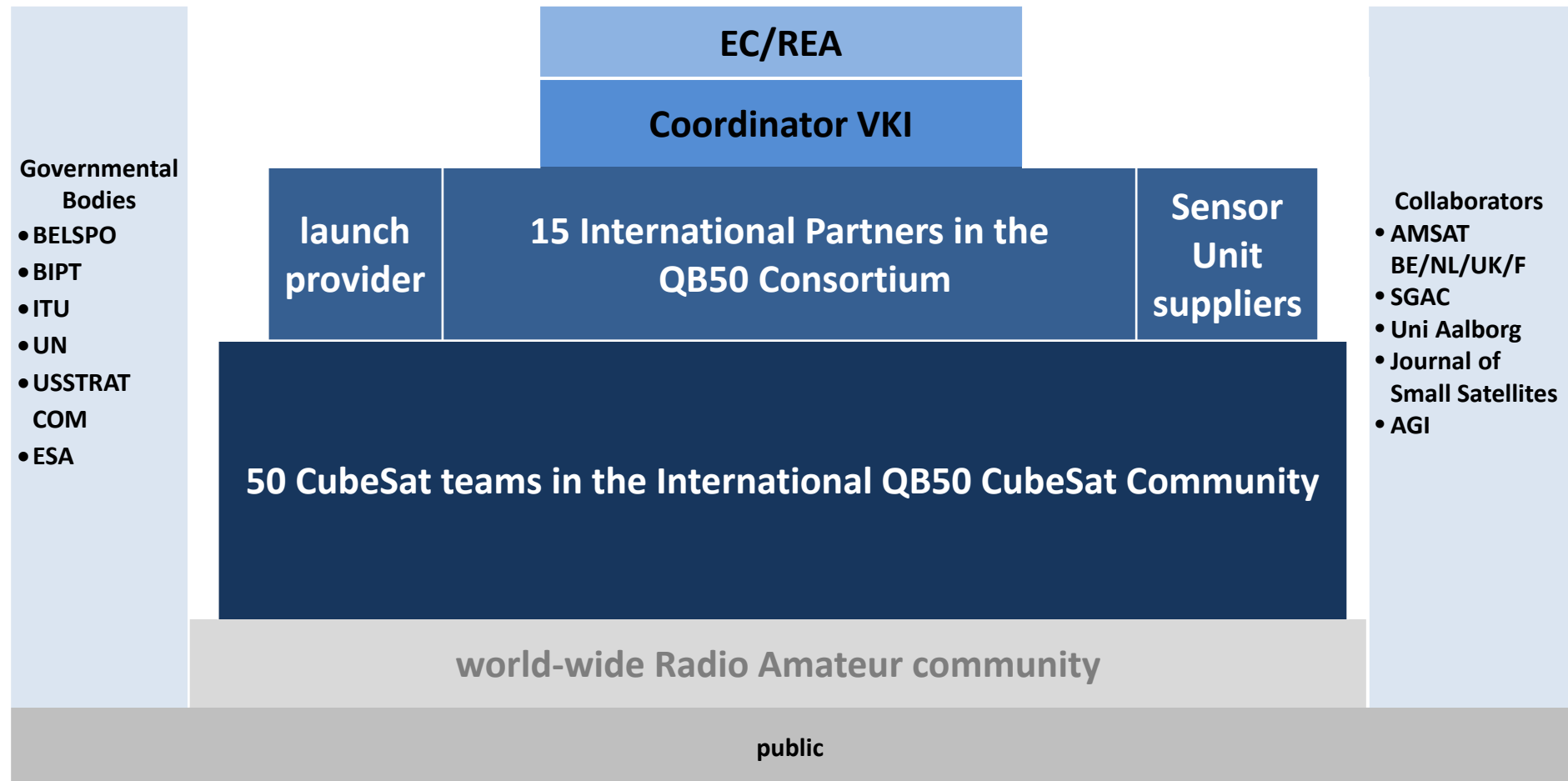


Precursor Derisking Campaign

- CubeSats are inherently more risky
 - >QB50 aimed to de-risk key technologies, engineering and legal processes
- status today:
 - measurements taken -> mission accomplished
 - one satellite defective (P2 with FIPEX sensor)
 - second satellite will be used for training purposes and AMSAT transponder operations.



Acknowledgments



We are grateful for the motivation and support of many individuals from about 90 organizations!




Symposium & Workshop

8th EUROPEAN CUBESAT SYMPOSIUM
Nanosatellites for Science and Technology Research
London, UK
7 - 9 September 2016


10th QB50 WORKSHOP
London, UK
6 September 2016
(by invitation only)

Meet CubeSat Enthusiasts and Friends!
For more information www.cubesatsymposium.eu

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FOR FLUID DYNAMICS**

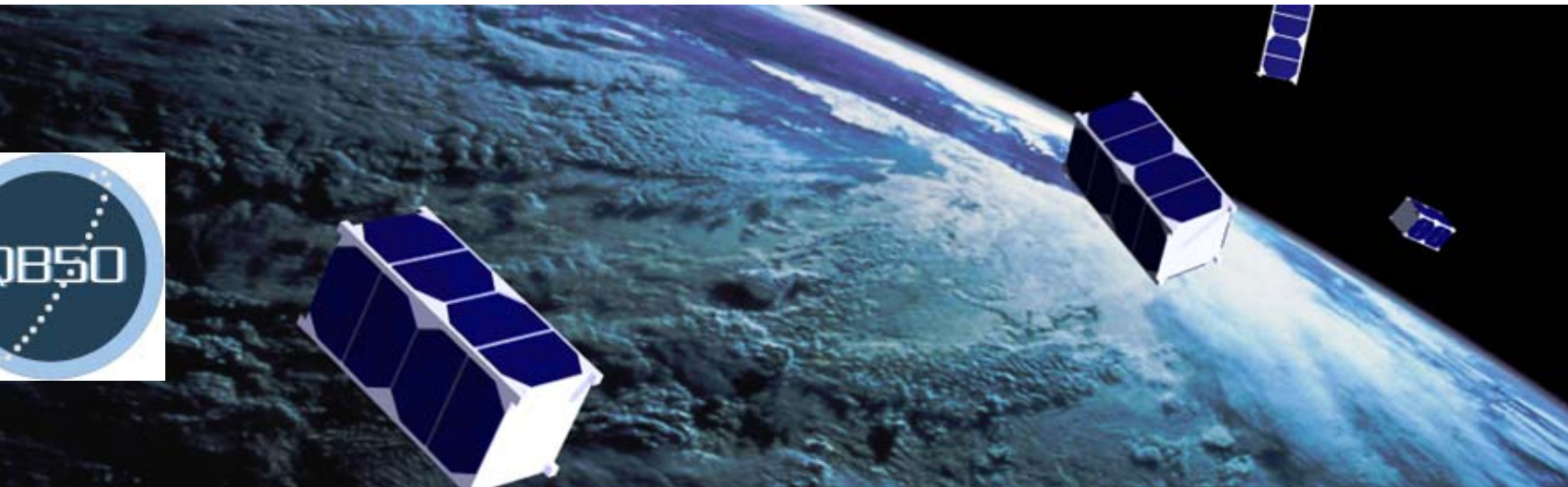


KTN
the Knowledge Transfer Network



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Thank you for your interest.
Questions?