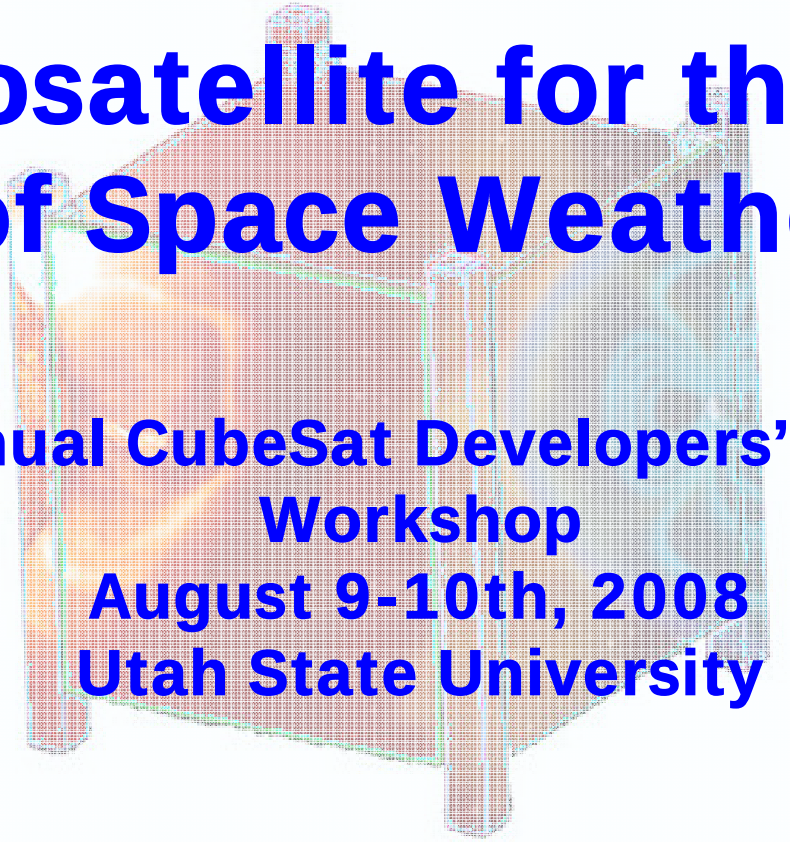
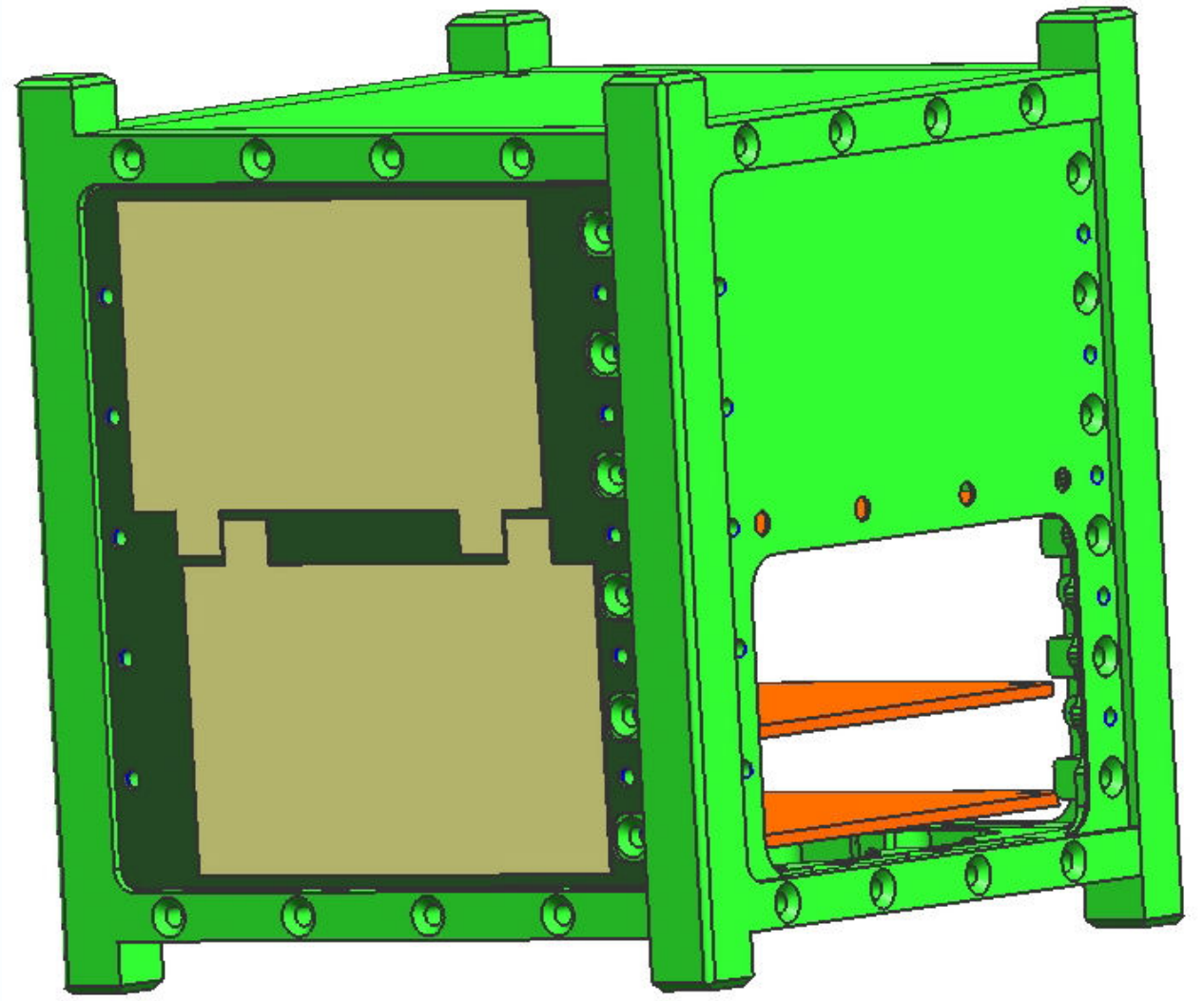
AtmoCube
A nanosatellite for the study of Space Weather

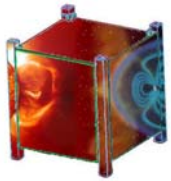


5th annual CubeSat Developers' Summer Workshop
August 9-10th, 2008
Utah State University

Alessandro Cuttin, assistant Project Manager
Marco De Din, Payload engineer
on behalf of the AtmoCube Development team

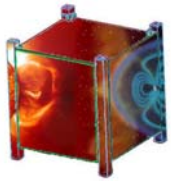
This is AtmoCube





Outline

- AtmoCube Executive Summary
  - Students' work
  - Mission requirements
  - The scientific case & Instrumentation
  - Vega Launcher
  - Mission analysis
- AtmoCube Systems
  - S/C description and structure
  - Power system
  - Telecommunication system
  - OBDH
- The AtmoCube Team
- Milestones
- Education and outreach
- Conclusions

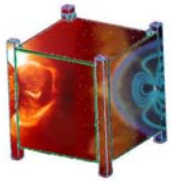


The AtmoCube Mission: executive summary

A satellite for:

- Involving students in a real Space Mission
- Studying the Space Weather and to map
  - the radiation flux (soft X-rays and protons)
  - the Earth magnetic field
  - the atmospheric density
- Proto-typing very low cost scientific applications
- Proto-typing very low cost space applications

See also www.units.it/atmocube



The students' work (www.units.it/atmocube)

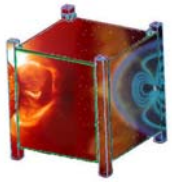
University of Trieste Cubesat project

Home | Mission | News | The Team | Outreach | Supporters | Contact us | Downloads

Thesis

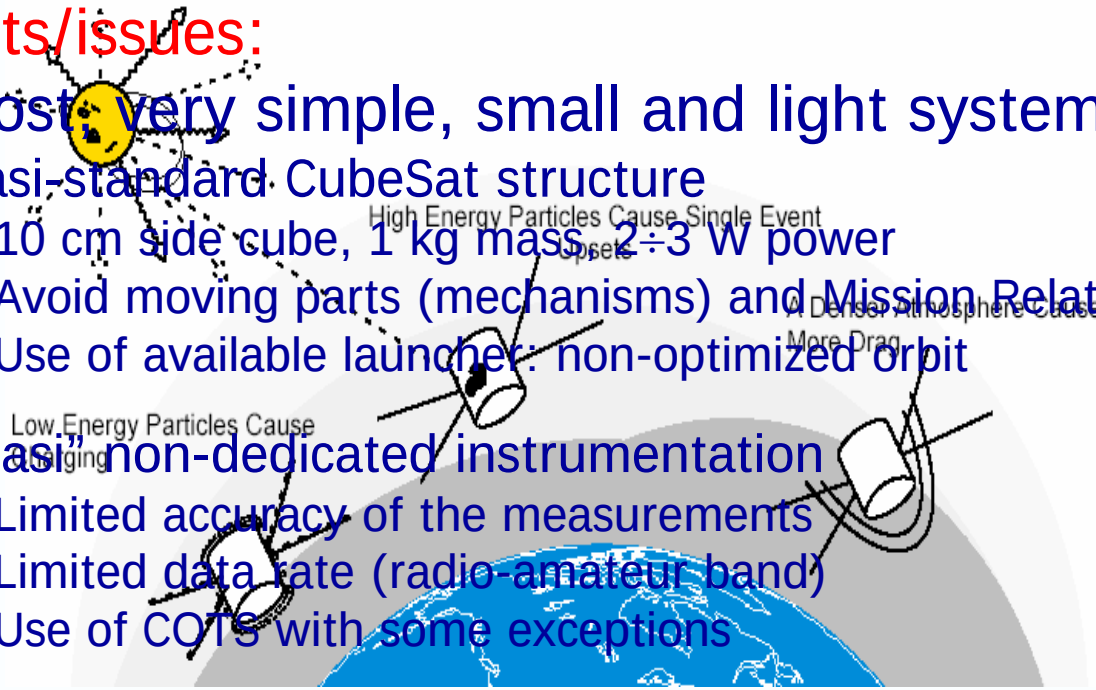
Alessandro, 8 July 2008 (created 8 July 2008)

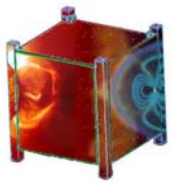
Name	Department	Title	Abstract	Presentation
Daniele Tavagnacco	**Physics Department**	Results analysis of the atmospheric density		
Valentina Alberti	**Physics Department**	Analysis of the Earth Magnetic Field		
Manuela Ciani	**Physics Department**	System for the settlement of the satellite AtmoCube with magnetic actuators		
Elena Orlando	**Physics Department**	First analysis of a satellite for the study of the earth atmosphere		
Xenja Santarelli	**Physics Department**	The radiation flux		
Claudio Zamberlan	**Physics Department**	Orbital analysis of the satellite AtmoCube		
Veronica Baldini	**DEEI**	Study about the **AtmoCube** Ground Station		
Lorenzo Moretti	**DEEI**	Design of ground station receiver		
Alessandro Cuttin	**DEEI**	System project of the AtmoCube satellite, system and communication architecture		Available
Samuele Falcomer	**DEEI**	Antenna design for the AtmoCube satellite	Available	
Marco De Din	**DEEI**	Preliminary study about the energy management of the AtmoCube satellite	Available	
Bruno Pendalo	**DEEI**	Final design of power supply system for satellite **AtmoCube**		
Walter Caharija	**DEEI**	Power supply system of the AtmoCube	Available	Available
Alessandro Corradini	**MED**	The **AtmoCube** structure		
Simone Manzato	**MED**	The **AtmoCube** structure		
Manuel Tommasini	**DEEI**	Design of LNA amplifier for the receiver of the satellite		
Emilio Montagnana	**DEEI**	Hardware design of the microprocessor for the housekeeping and data handling of the satellite AtmoCube	Available	
Stefano Punis	**DEEI**	Hardware design of the microprocessor for the control of the PLL		Available
Giovanni Gobbesso	**DEEI**	Design of low power stage of the **AtmoCube** transceiver		
Mauro Popesso	**DEEI**	RF power amplifier of the satellite transmitter	Available	Available
Fabio Sanvido	**DEEI**	Design of LNA amplifier for the receiver of the satellite		
Maurizio Ziani	**DEEI**	RF class E power amplifier of the satellite transmitter		
Giovanni Biancuzzi	**DEEI**	PLL synthesizer design		Available
Stefano de Fabbris	**DEEI**	Design and implementation of a Digital demodulator on DSP		Available



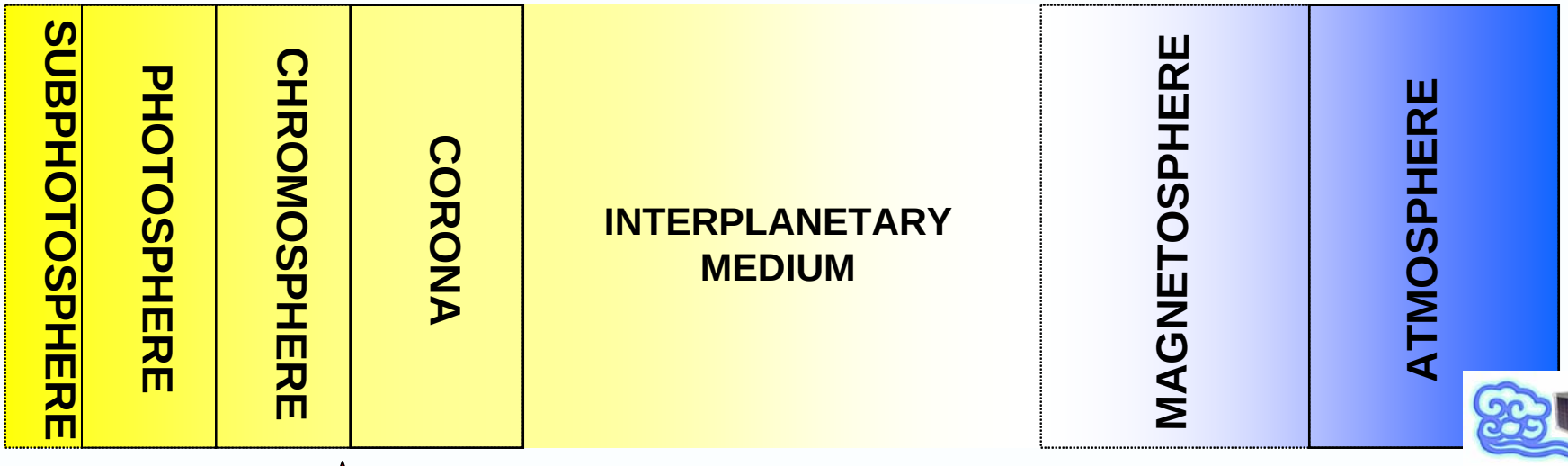
AtmoCube Requirements

- Scientific Measurement, “SPACE-WEATHER” studies
  - Radiation flux: Spectro-Dosimeter
  - Earth magnetic field: Magnetometer
  - Atmospheric density: GPS
- Constraints/issues:
  - Low cost, very simple, small and light system
    - Quasi-standard CubeSat structure
      - 10 cm side cube, 1 kg mass, 2÷3 W power
      - Avoid moving parts (mechanisms) and Mission Related Objects
      - Use of available launcher: non-optimized orbit
    - “Quasi” non-dedicated instrumentation
      - Limited accuracy of the measurements
      - Limited data rate (radio-amateur band)
      - Use of COTS with some exceptions





AtmoCube Scientific Case



Flare → X, UV → 8 min
- Enhanced ionization: SID
- Heating + expansion: Drag

Protons → mins-hrs
- Enhanced ionization @ poles: PCA
- Enhanced particle level in Magnetosphere

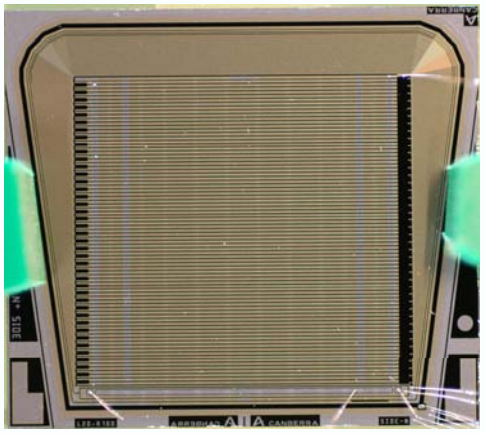
Prominence → CME → hrs-days
- Current system perturbation: Geomag. Storm

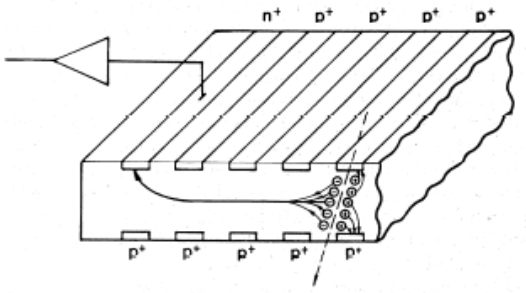
Coronal Hole → Fast S.W. Streams → hrs-days
- Ring currents perturbation: Geomag. Storm

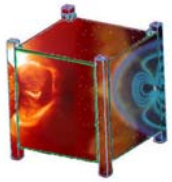
Messerotti (1999, 2001)

AtmoCube Scientific Payload

- The Radiation Environment
  - Soft X-rays (up to 70 keV)
  - Charged particles (protons)
- A Silicon Drift Detector to measure these fluxes
  - (expected events rate: 10^2 Hz)
- Added value: test-bed for future space missions

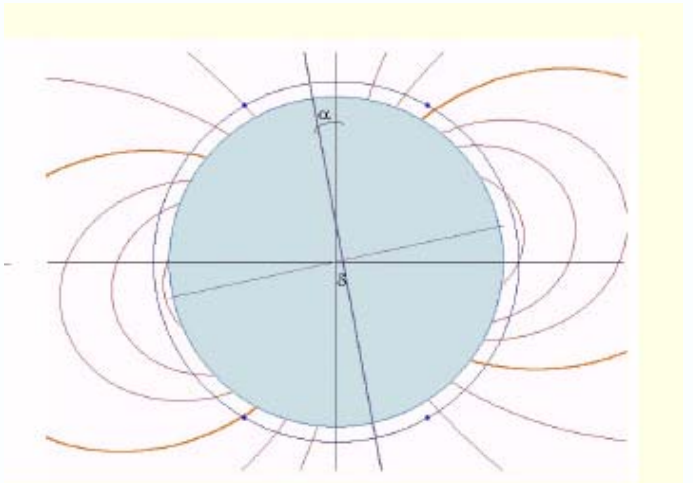


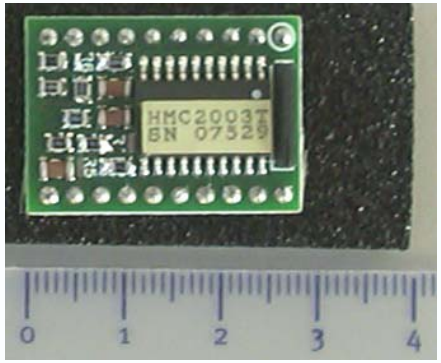


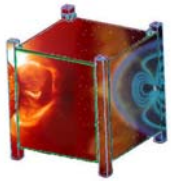


AtmoCube Scientific Payload

- The Earth Magnetic Field
  - Solar conditions 0.5%
  - Day/night 0.15%
  - Season 0.15%
- HMC2003 magnetometer
  - Accuracy 4×10^{-10} T



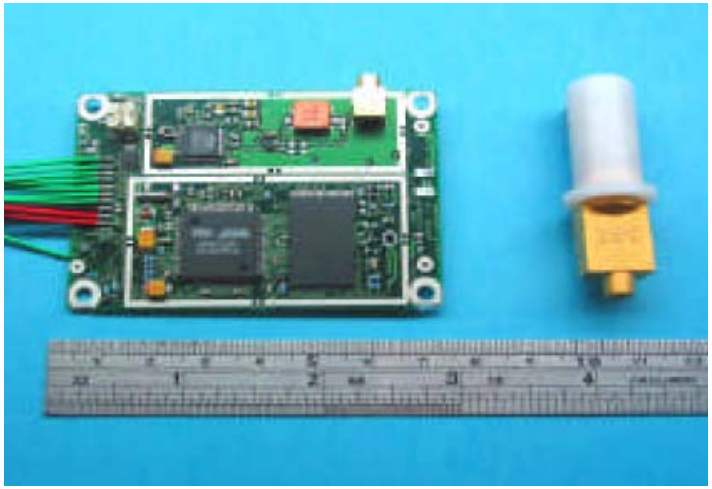




AtmoCube Scientific Payload

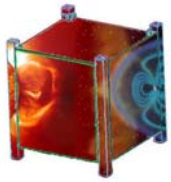
➢ The Atmospheric Density

variable	Solar minimum	Solar average	Solar maximum
a_{drag} (m/s^2)	-2.9×10^{-6}	-8.8×10^{-6}	-2.1×10^{-5}
Δa /revolution (m)	-4.9	-14.5	-34.6
Δe /revolution	-6.1×10^{-7}	-1.8×10^{-6}	-4.3×10^{-6}



SSTL SGR-05 SERIES
SPACE GPS RECEIVERS

Dimensions: 70 x 45 x 10 mm
Mass: 20 g
Power: 0.5-0.8 W @ 3.3 V
Position accuracy: 10 m



The launcher: VEGA

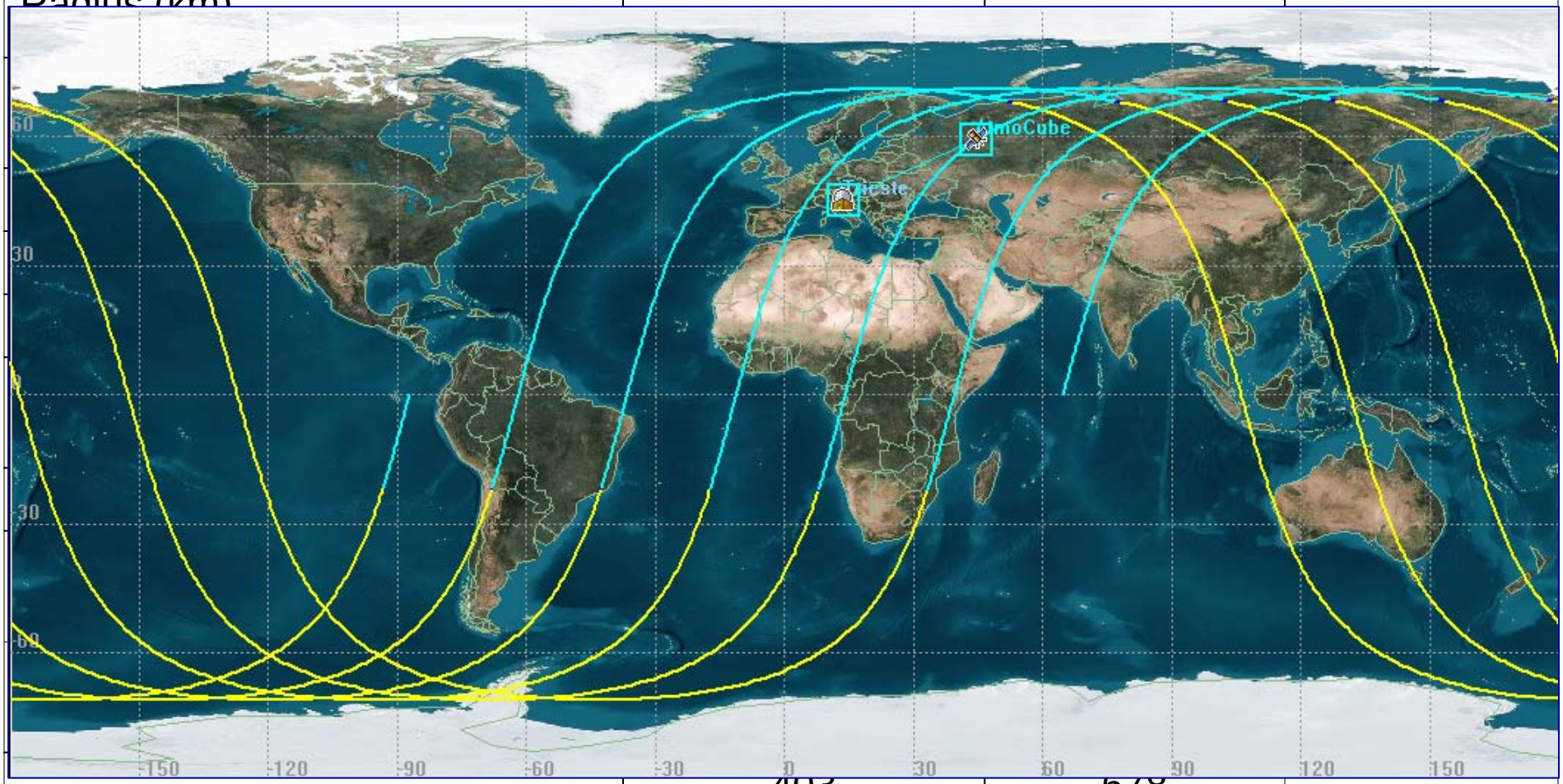
- Proposal submission at the Vega Maiden Flight CubeSat Workshop (Jan, 2008)
- Selected to be flown on the Vega Maiden Flight with other 8 European CubeSats
- Launch scheduled for November, 2009
- Elliptic, 71° inclined orbit

www.esa.int/SPECIALS/Launchers_Home

Photo: ESA

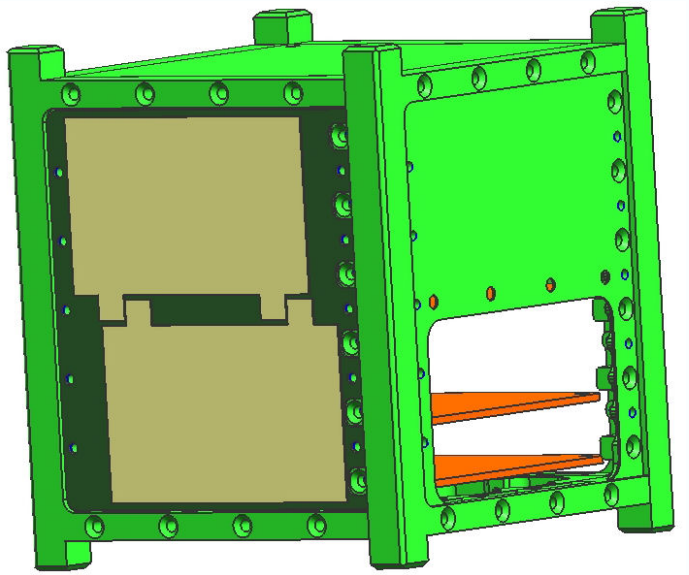
Mission Analysis

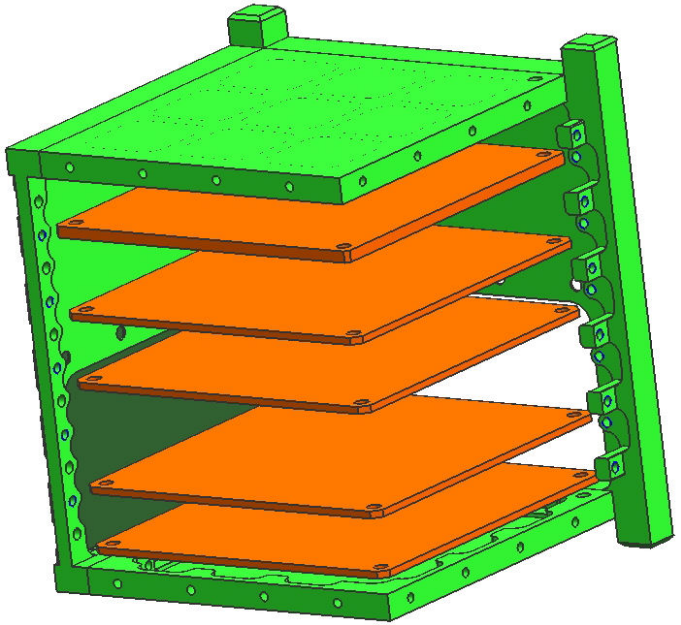
Radius (km)	7153.14	6728.14	7578.14
Visibility at Ground Station (s)	403 (average)	678 (max)	
Visibility gap (s)	24,388 (average)	84,053 (max)	4,974 (min)



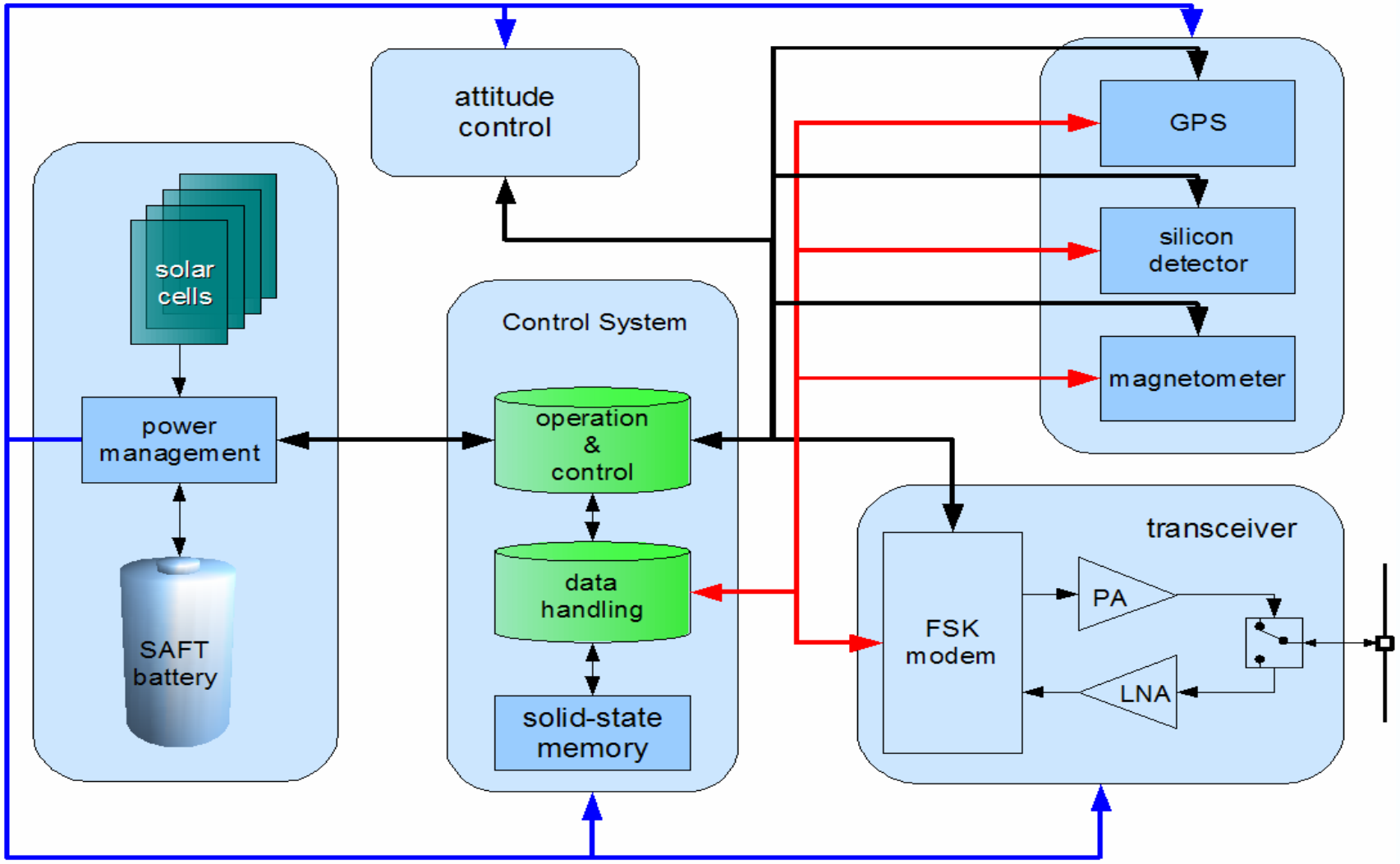
AtmoCube Description & Structure

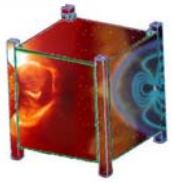
- CDS compliant
- Five boards
  - RF board for TC
  - Power supply & battery
  - Magnetometer & GPS
  - OBDH
  - Spectro-Dosimeter
- Total mass ~700 g (battery and boards included)



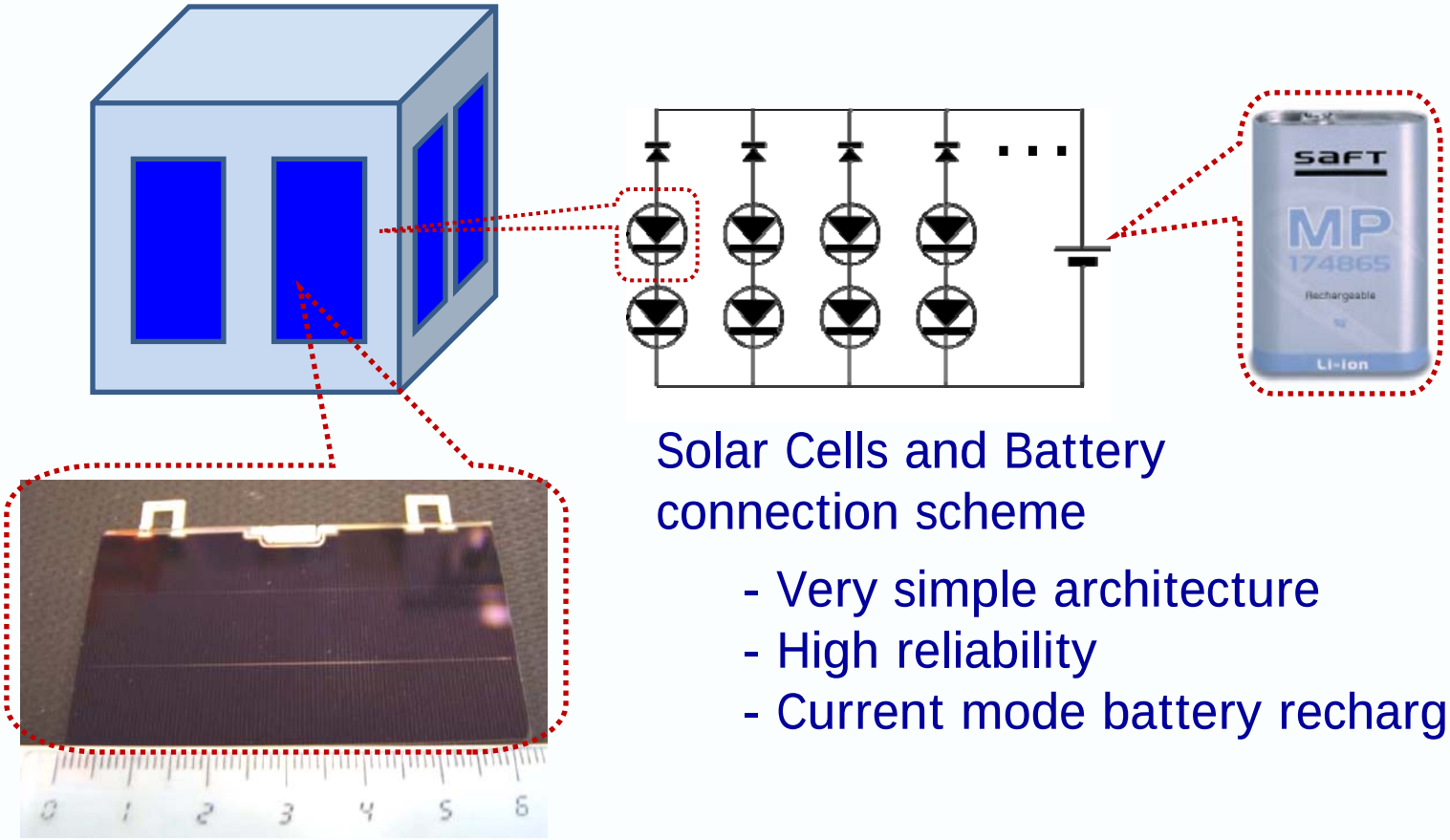


AtmoCube Subsystems





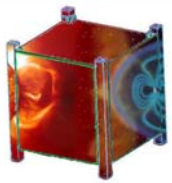
Power System



Solar Cells and Battery connection scheme

- Very simple architecture
- High reliability
- Current mode battery recharge

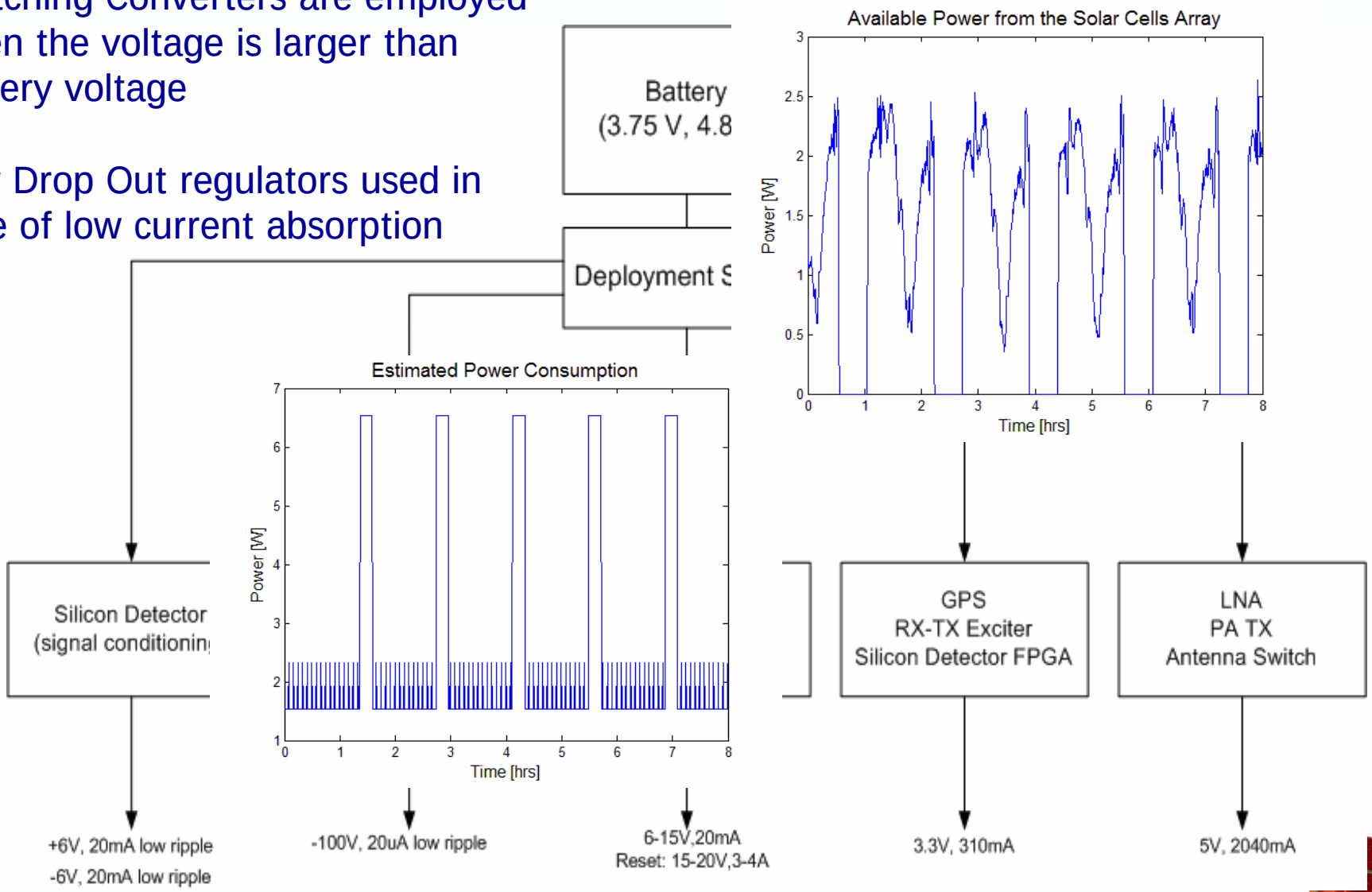
Tecstar GaAs 3-junction solar cells
63.4 × 38.7 × 0.36 mm



Power System: Power Supplies

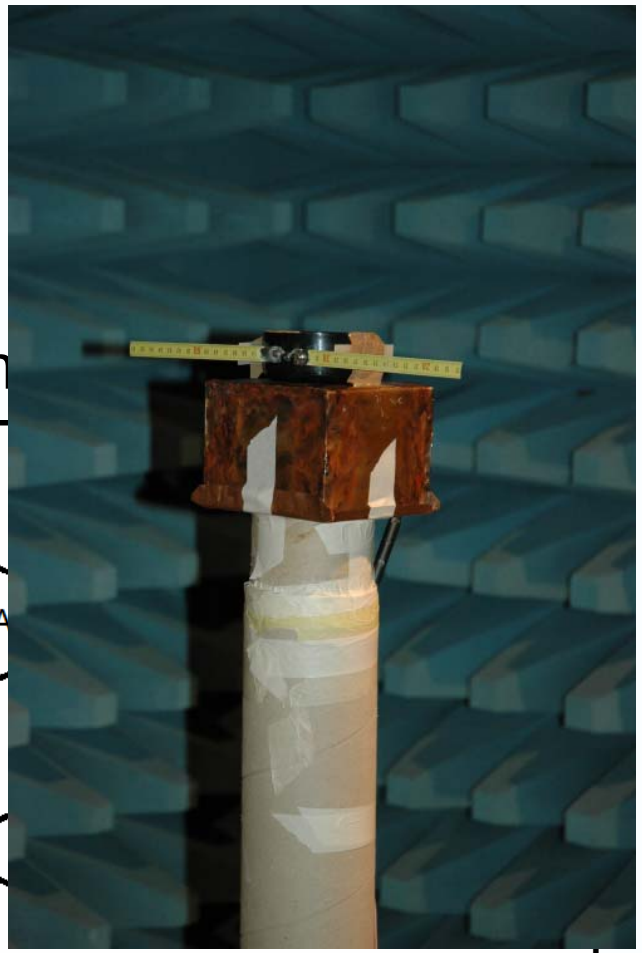
Switching Converters are employed when the voltage is larger than battery voltage

Low Drop Out regulators used in case of low current absorption

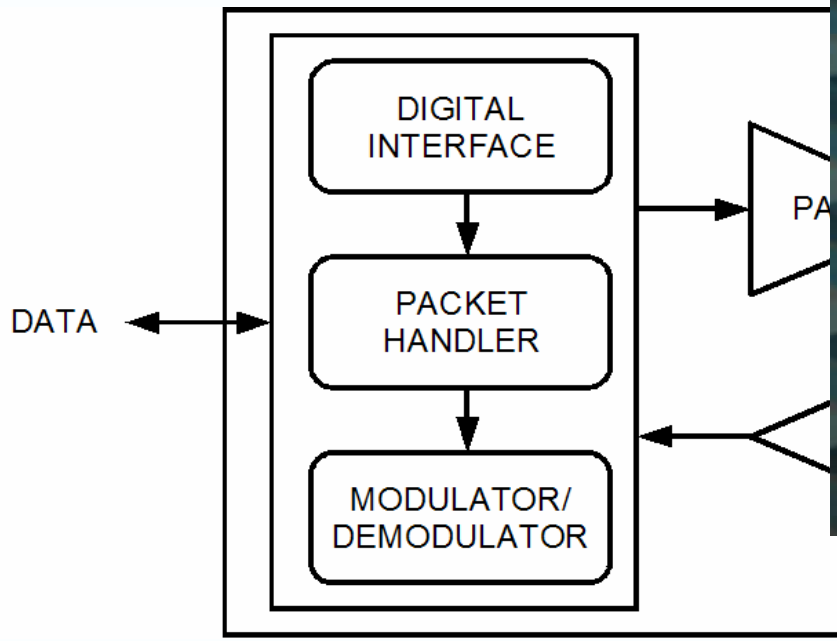


On board communication system

- transmission frequency
  - amateur band UHF 437 MHz
- FSK binary modulation
- communication protocol AX.25



amplification

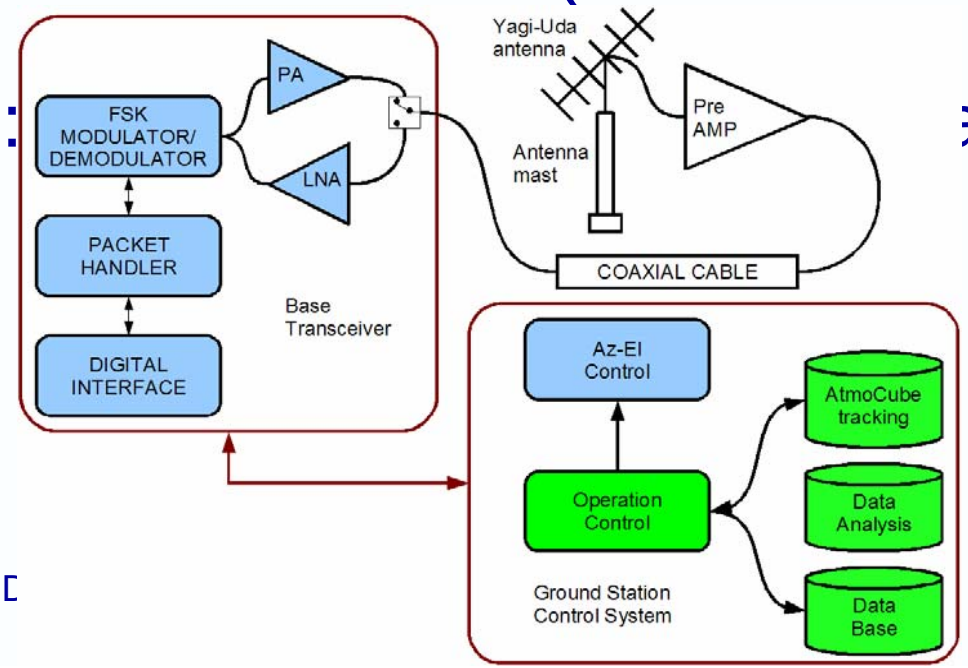


low power stage

antenna stage

The TeleCom System: Ground Station

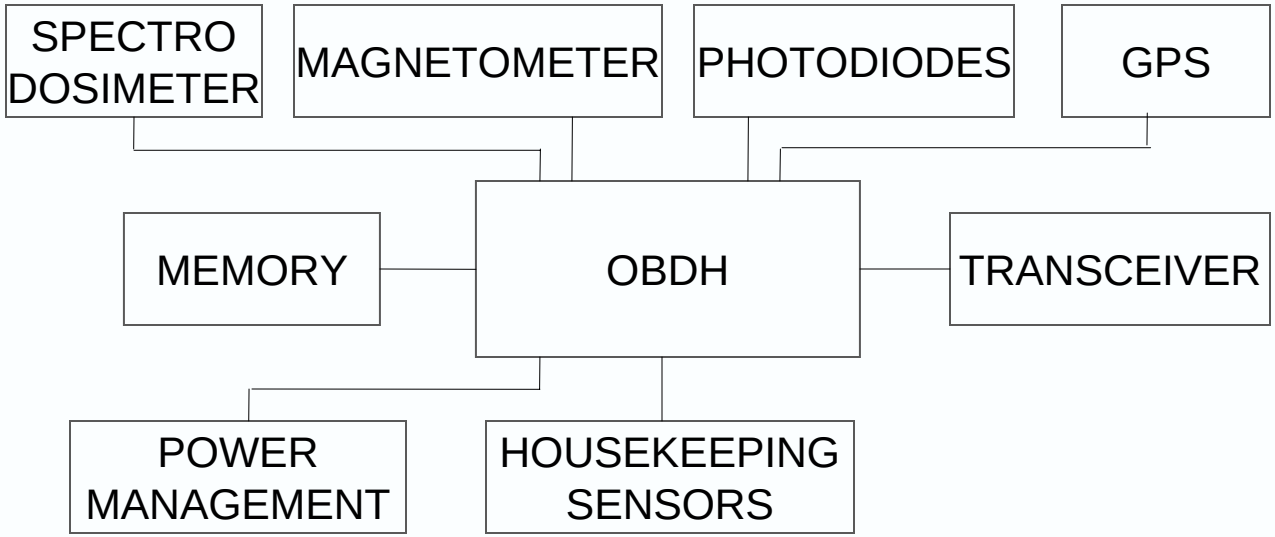
- Located in the OAT, Basovizza (Trieste)
- Instrumentation:
  - Yagi-Uda antenna [10 elements, 430 MHz frequency, circular polarization] with rotors,controller,preamplifiers
  - Transmitter receiver for amateur communication
  - Ground Station Server (for Database)
- GENSO: asible

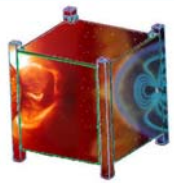


On-board Data Handling

OBDH is responsible of the management of the system:

- Acquire data from HK sensor to monitor S/C functionality
- Sub-system management (manage the activity of subsystems, collect data from sensors and store values in memory)
- Manage the connection to the ground station

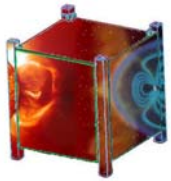




Data Volume Budgets

- Measurements every 300 s corresponding to 20 per orbit
- 10 orbits max visibility gap
- 9,600 bps rate
  - Time required for downlink: 250 s

Instrument	Data volume (bytes)
Drift Chamber	512
GPS	100
Magnetometer	15
HK	100
Photodiodes	12
Total	739
Total (margins)	1,000



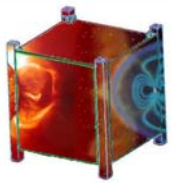
AtmoCube Milestones

Satellite:

- Start — January 2008
- End Design Phase — June 2008
- End EVB Phase — October 2008
- End Proto & Project — 1st quarter 2009

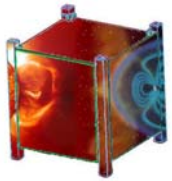
Ground station:

- Start — January 2008
- End EVB Phase — December 2009
- End Ground Station — 2nd quarter 2009



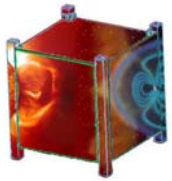
AtmoCube Development Team

- Principal Investigator — Anna Gregorio
- Co-Investigator — Sergio Carrato
- Project Manager — Mario Fragiacomo
- AtmoCube Scientist — Mauro Messerotti
- Steering Committee
  - AG, SC, MF, MM, W. Bonvicini, L. Bregant, A. Vacchi
- AtmoCube Development Team
  - 14 senior physicist and engineers
  - 21 students
  - 2 fellowships
- Up to now
  - 22 theses in AtmoCube
  - Work is in progress, at least one student on each S/C system



AtmoCube Collaboration

- Trieste University
  - Physics Department
  - Electronics Engineering Department
  - Mechanical Engineering Department
- INAF (National Institute for AstroPhysics)
- INFN (National Institute for Nuclear Physics)
- Area Science Park Industries:
  - ENTEOS
  - ELCON
  - ELIMOS
  - SICOM
  - SCEN



Education and Outreach

- University
  - Theses
  - Trainings
  - Job opportunities
- High School
  - Lectures
  - Stages
- General public
  - Public lectures
  - Media

Conclusions

AtmoCube is an effective tool for achieving the following goals:

- Involve students in a real Space Mission, at all educational level, from School to University
- Synergize interdisciplinary collaborations among different University depts., research institutions and companies
- Raising public awareness on space science
- Carry out small scientific experiments in the framework of Space Weather
- Proto-type very low cost scientific applications
- Proto-type very low cost space applications
- Involvement of industries for job opportunities for students and possible technological transfer