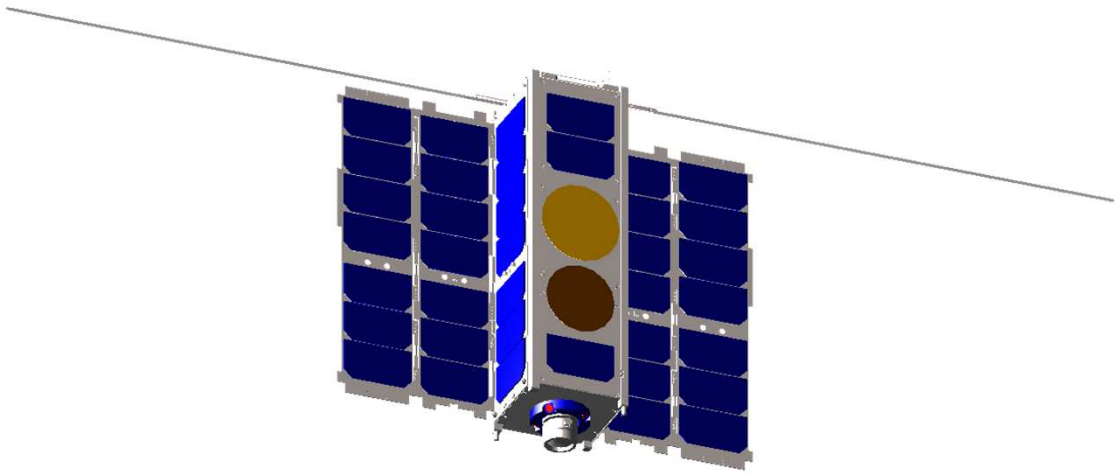

OPS-SAT - An Advanced Nanosatellite Mission by European Space Agency

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Presentation Overview

- Background, Motivation
- Phase A/B1 Overview
- Architecture Overview
- Satellite Bus
- Payload
- Ground Segment
- Experiment Evaluation
- Summary

Background & Motivation (1)

- New ideas are generated by ESA and European industry for evolving mission control
- Patents, studies, prototypes & breadboards are produced
- But the majority do not make it near a real mission

- Why ….
  - Has never flown - will never fly problem
  - Risk aversion: healthy when dealing with large missions but not good for innovation

Background & Motivation (2)

- In 2011 ESOC‘s Advanced Operations Concepts Office had an idea to change the current situation
- A low cost, in-orbit demonstrator for mission control based on a COTS CubeSat bus - OPS-SAT
- In January 2012 a CDF Study funded by GSP (with CNES participation) declared the idea feasible
- In May 2013 an Open Call for OPS-SAT Experiments was run by ESA
  - Over 100 experiment ideas from 17 ESA member states
  - OPS-SAT Open Day in June 2013 attracted 100+ guests

IT Evolution versus Space

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IN CONGRESS, JULY 4, 1776
The unanimous Declaration of the thirteen united States of America

When in the Course of human events it becomes necessary for one people to dissolve the political bands which have connected them with another and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. - That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, - That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect

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Packet Utilisation Standard: ESA PSS-07-101 Issue 1 May 1994

Motivation / History (3)

- A Phase A/B1 contract under GSTP was awarded to:
  - Prime Contractor

  - Substantial CCN to include the experiment requirements from the open call into the design process was funded by GSP
  - Kick-off: 1 July 2013
  - Final Presentation: 29 January 2014

OPS-SAT Mission Statement

“OPS-SAT is a safe, hard/software laboratory, flying in a LEO orbit, reconfigurable at every layer from channel coding upwards, available for authorised experimenters to demonstrate innovative new mission operation concepts.“

Design Goals

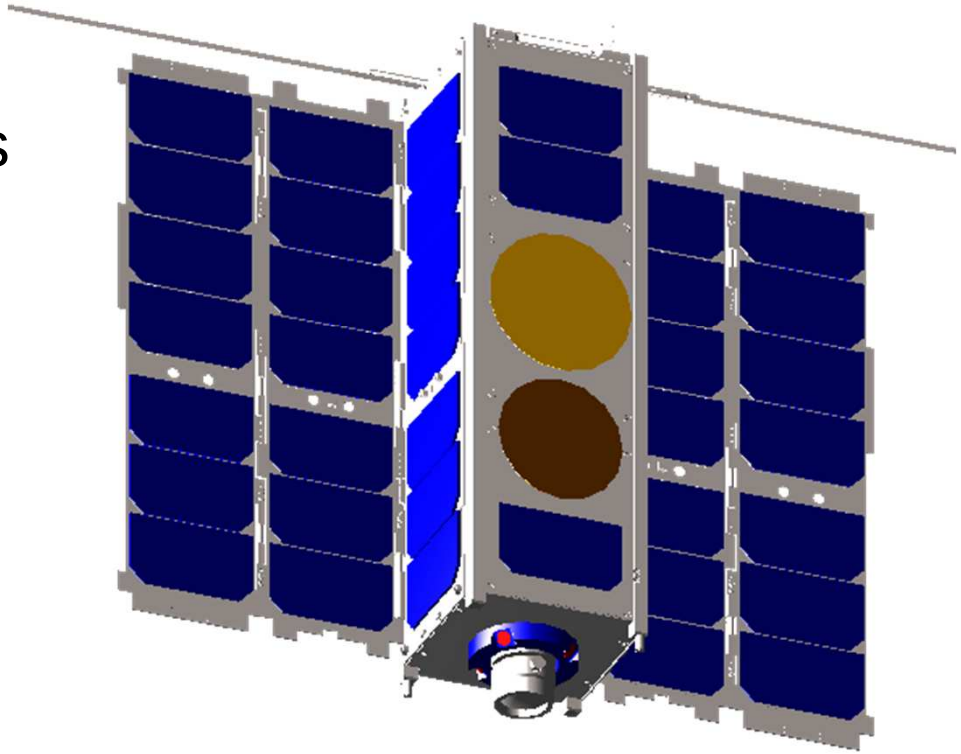
- Derived from experiment evaluation

- Powerful processor needed
  - SoM (dual ARM 9, FPGA)
  - Large RAM / mass storage (1 GB DDR3, 8 GB SD)
- Linux support
- High-resolution camera
- Fine-pointing ADCS incl. GPS

- Orbit compliant with space-debris guidelines

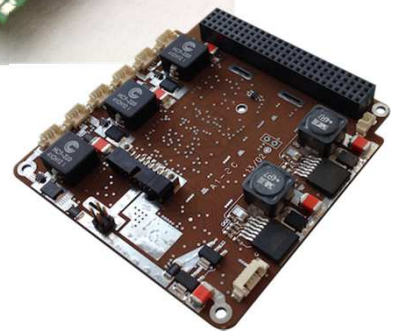
Spacecraft

- Triple CubeSat (10x10x30 cm)
- Mass: ~ 6 kg
- Power: ~ 30 W
- Deployable solar arrays on both sides



Satellite Bus

- CubeSat COTS components
  - OBC & FDIR
  - UHF communications system
  - Coarse ADCS system
  - Electric Power System (EPS)
    - Deployable solar arrays
    - Batteries
    - Charge/discharge regulators



Satellite Payload

- Processing Platform (Austria)
- Altera Cyclone V System on Module 4x
  - Dual ARM processor
  - FPGA
  - SDRAM
  - ECC

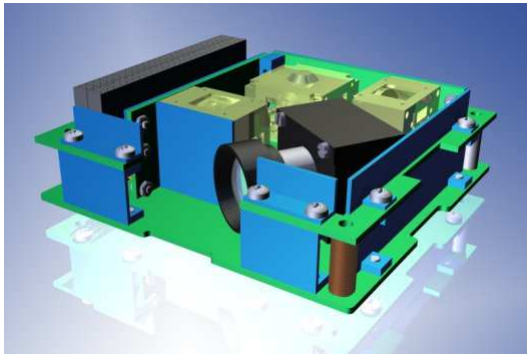
Payload
Processing Platform Software

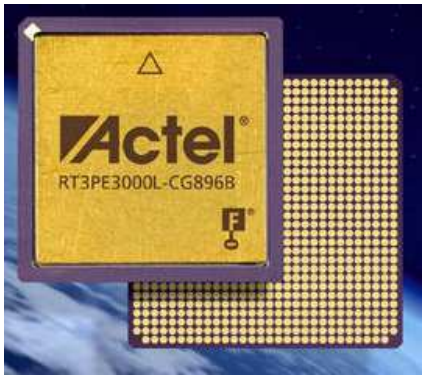
- OS: Linux, Android, QNX, …
- Custom Linux OS can be generated
  - Using Yocto / openembedded
- Standard Image
  - Linux Operating System
  - Java Virtual Machine
  - Standard FPGA Image
  - Libraries provided for Linux
    - Acess to peripherals (drivers)
    - API to OBC
  - Changes possible
    - Altera DS-5
    - Cross Compile Development Environment

yocto PROJECT

Satellite Payload

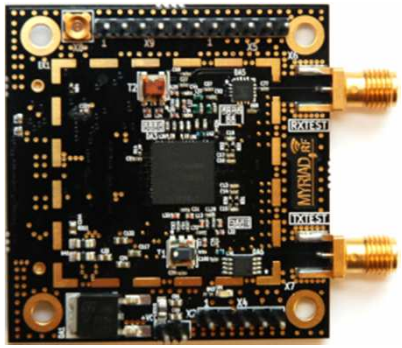
- HD Camera
- Fine-pointing ADCS (Germany)
- GPS
- S-Band Transceiver (France)
- CCSDS-Engine (Poland)



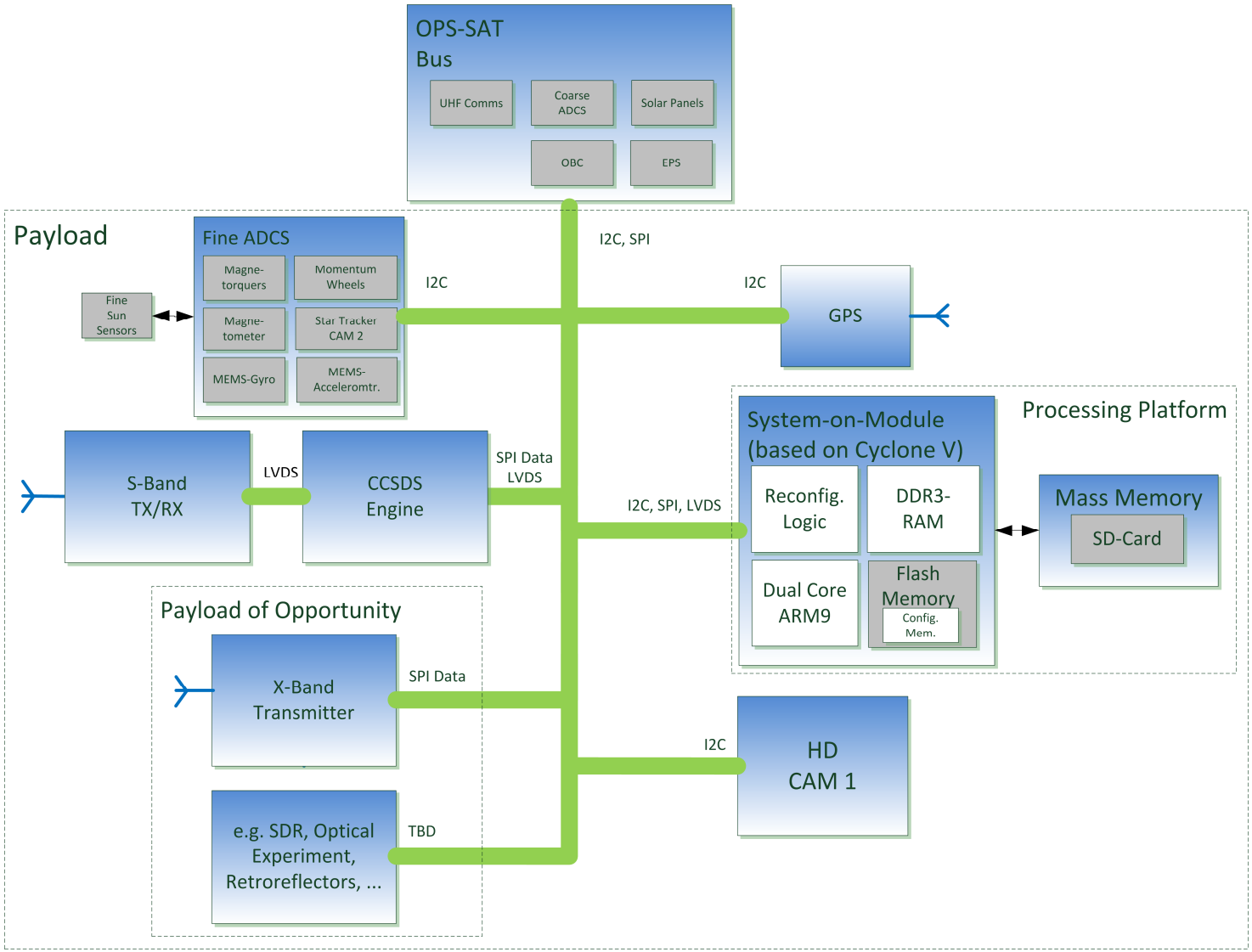


Payloads of Opportunity

- X-band Transmitter (France)
- Retro-reflectors
- Optical Receiver
- Software Defined Radio Receiver



OPS-SAT On-Board Architecture Overview



Satellite Deployer

- ISIPOD Standard 3-Cubesat deployer
- Flight heritage provided

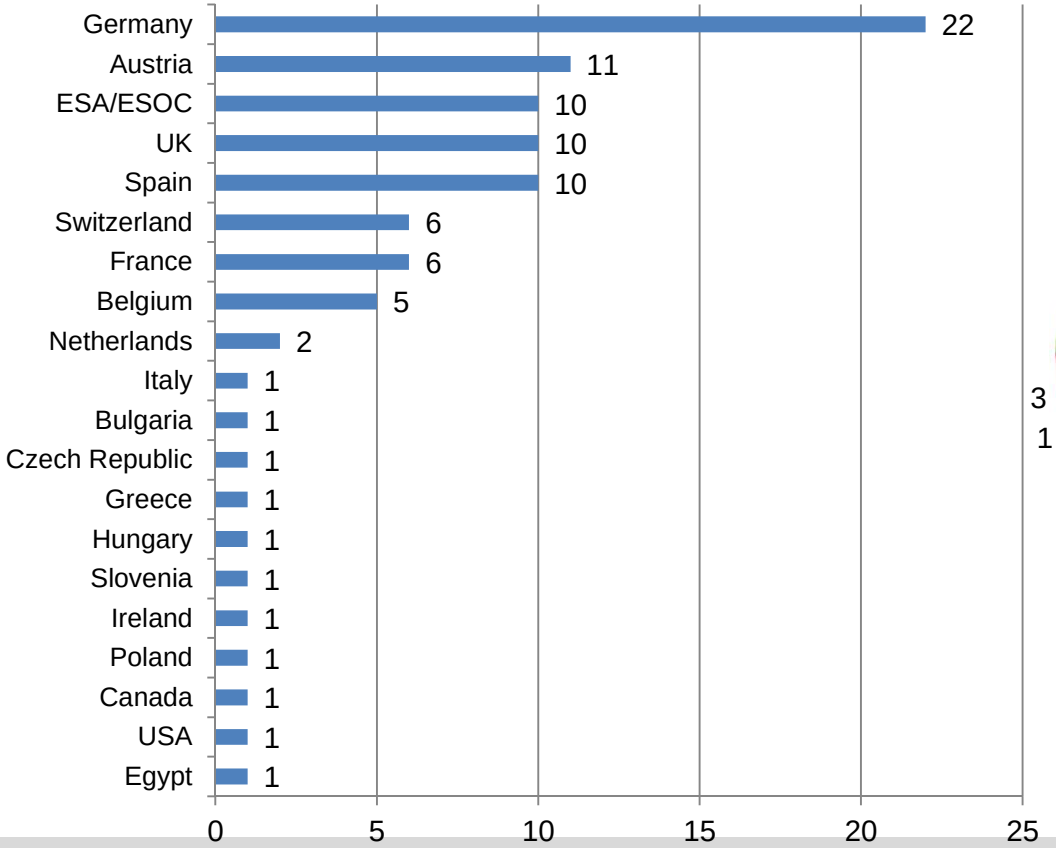
Ground Segment

- Ground Stations
  - NGS-1: primary TT&C / S-band
  - ESTRACK Station: S-band backup
- Mission Control Centre
  - ESOC SMILE facility to be used
  - Core MCC: SCOS 2000
  - Baseband: GNU Radio/URSP (s/w radio + FPGA)
  - CubeSat MCC (UHF TT&C)

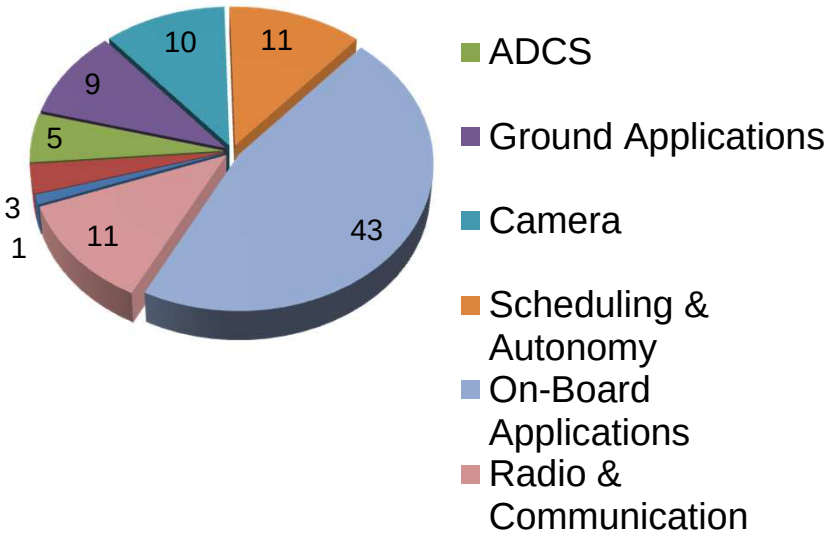
Experiments Evaluation

- More than 100 experiments were submitted to ESA Open Call
- 93 Experiments evaluated

No. of Experiments per country

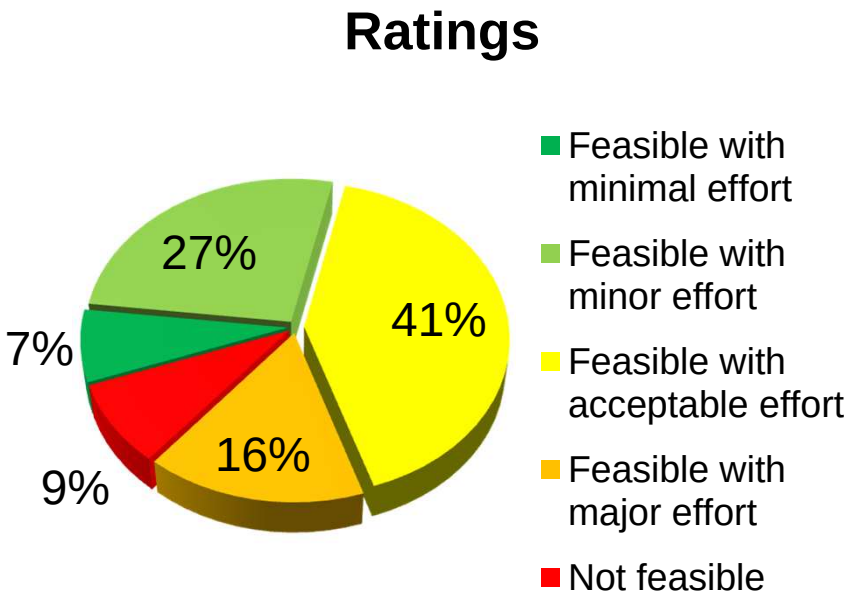


Experiment Category



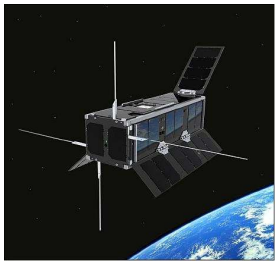
Experiments Evaluation Summary based on the presented design

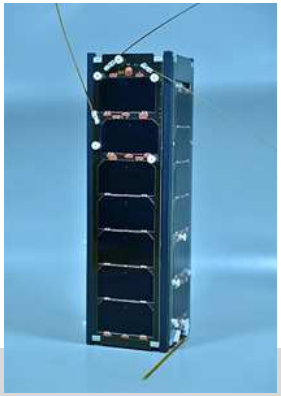
- Rated according to current baseline design
- Evaluations showed
  - 75% feasibile with moderate or small effort
  - 16% feasible with major effort
  - Only 9% not feasible



Reuse from other Cubesat Missions

- UWE-3
  - Launched in November 2013
  - Uses redundant OBC
- GOMX-1
  - Launched in November 2013
  - Uses GomSpace Bus Components Nanomind, Batteries, EPS, NanoCom (UHF), SolarPanels
- UKube-1
  - Will launch in 2014
  - Uses ClydeSpace 3U Solar Panels
- TurkSat-3USat
  - Launched 26 April 2013
  - Uses ISIS 3U Structure, ISIPOD





Development Process

- Start with CubeSat COTS systems
- Integrate FDIR system
- Gradually build Flatsat with payload
- Test and qualification of subsystems
- Integrate in flight configuration (PFM)
- Environmental tests and qualification
- Build experimenter flatsat

Programmatics

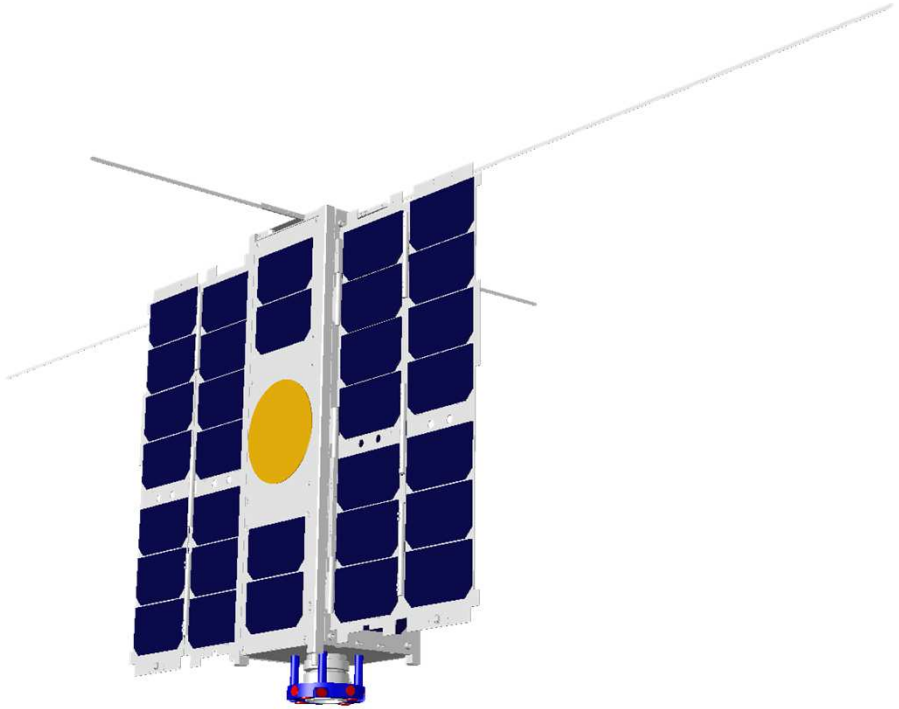
- Phase C/D will start in Fall 2014
- Consortium composed of organisations/companies from
  - Austria
  - Poland
  - Germany
  - Denmark

Summary

- OPS-SAT offers a unique opportunity to test, demonstrate and validate novel operational concepts in flight
- Experimenters will have a unique opportunity to change flight/ground software and reconfigure flight/ground hardware during this mission
- We have designed a mission that can allow this to take place with minimal risk and at minimal cost

Acknowledgements

The authors wish to thank the colleagues from TU Graz, Zentrum für Telematik, MAGNA STEYR Engineering, MEW Aerospace, GOMSPACE, ESOC and ESTEC for their valuable contributions



Thank you for your attention!