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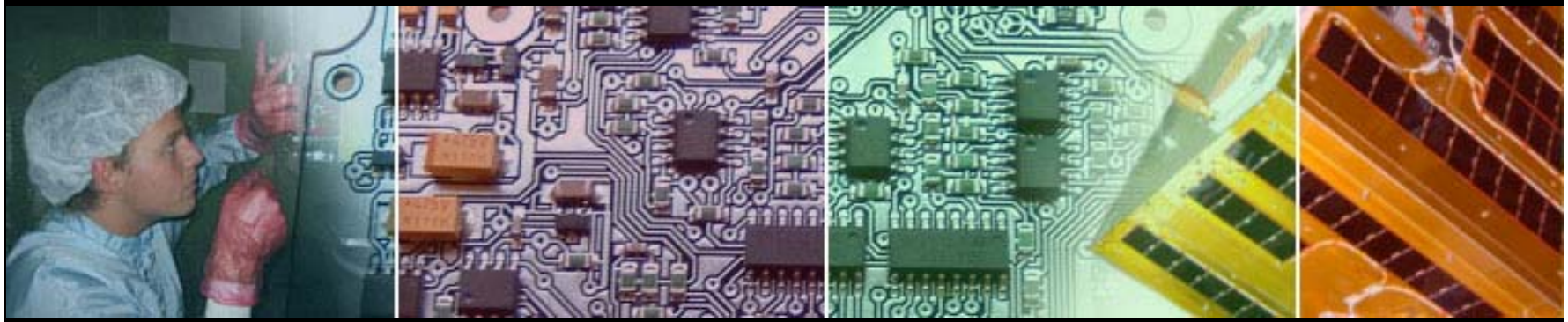
Perspectives for Pico-Satellites in European Research and Development Programmes

6th ESA Round Table on Micro & Nano Technologies for Space Applications



Karl Kaas Laursen, M.Sc. EE.

ESA/ESTEC Noordwijk 2007

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Outline of Presentation

- Review the history of European pico-satellite missions
- Discuss the current status of the technology with pointers to remaining critical research areas
- Describe how pico-satellites can add value to European R&D programmes; specifically for flight demonstration of micro- and nano-technologies
- Specific proposals for missions will be given

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- Jeroen Rotteveel, Abe Bonnema,
  Eddie Van Breukelen and Wouter Jan Ubbels (ISIS)

ISIS

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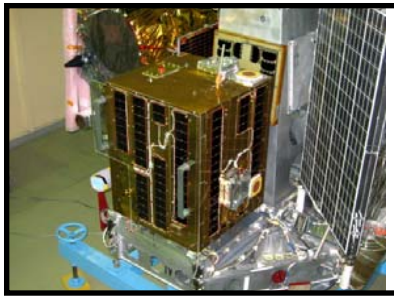
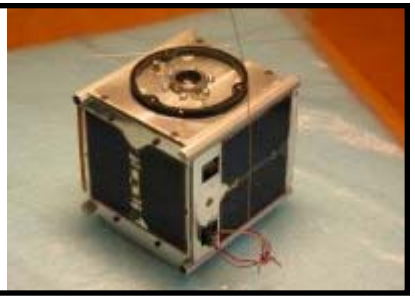


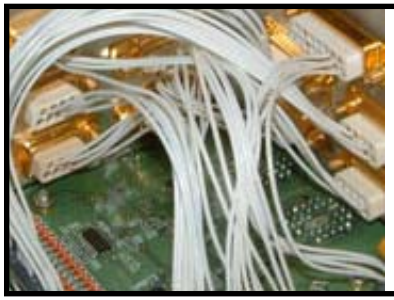
SSETI Express

OBC, ADCS, CAM, CDH, Consulting, Operations, FAR

AAU Cubesat

OBC, EPS, COM, CDH, AIV, Ground Segment, Operation



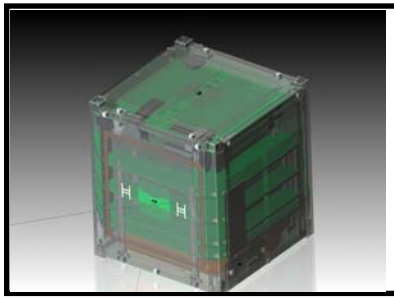


Baumanetz

OBC for Russian Microsatellite

MIEMA

Microgravity Isolation using Electro Magnetic Actuation



AAUSAT-II

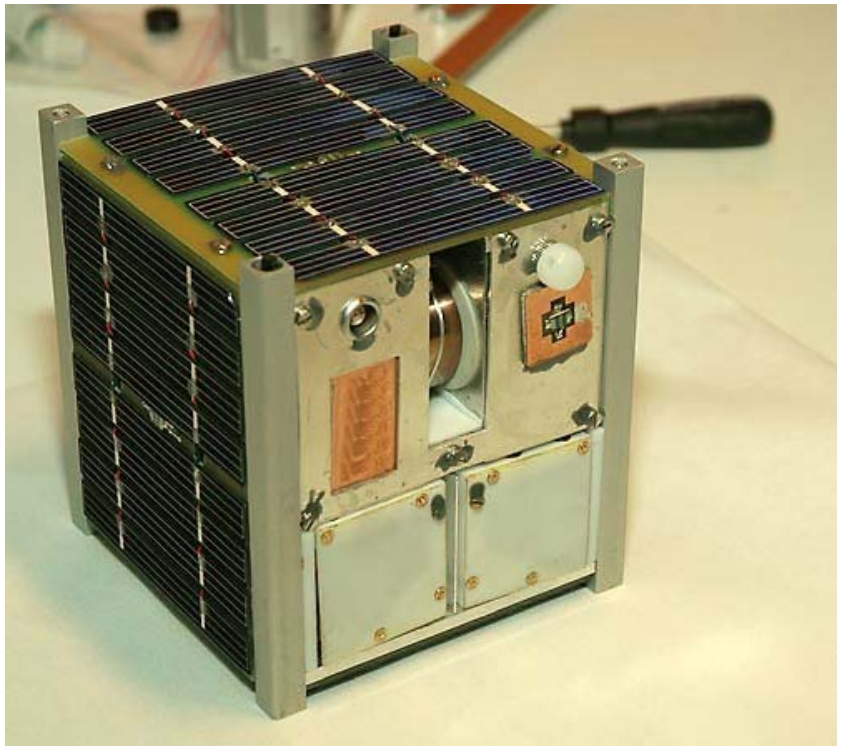
Hardware and software, Integration, Consulting

UAV

Hardware and software, integration, control, estimation

Pico-Satellites revisited

"Picosatellite or "picosat" is usually applied to the name of an artificial satellite with a wet mass between 0.1 and 1 kg " [Wikipedia]



Ncube-2

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Pico-Satellites Revisited

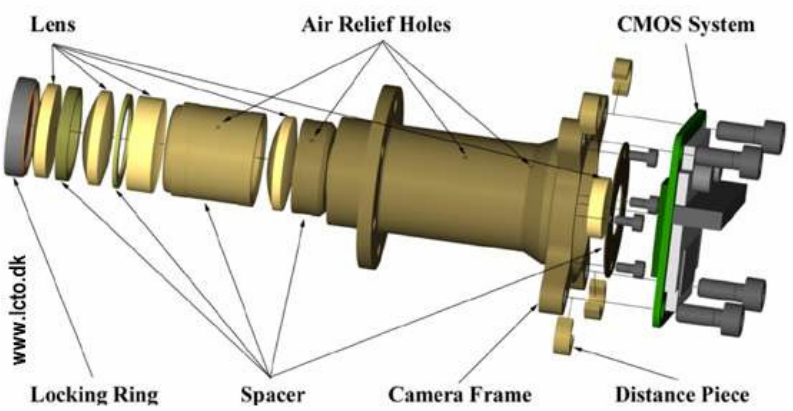
"Picosatellite or "picosat" is usually applied to the name of an artificial satellite with a wet mass between 0.1 and 1 kg " [Wikipedia]

Ncube-2 being prepared for flight by someone

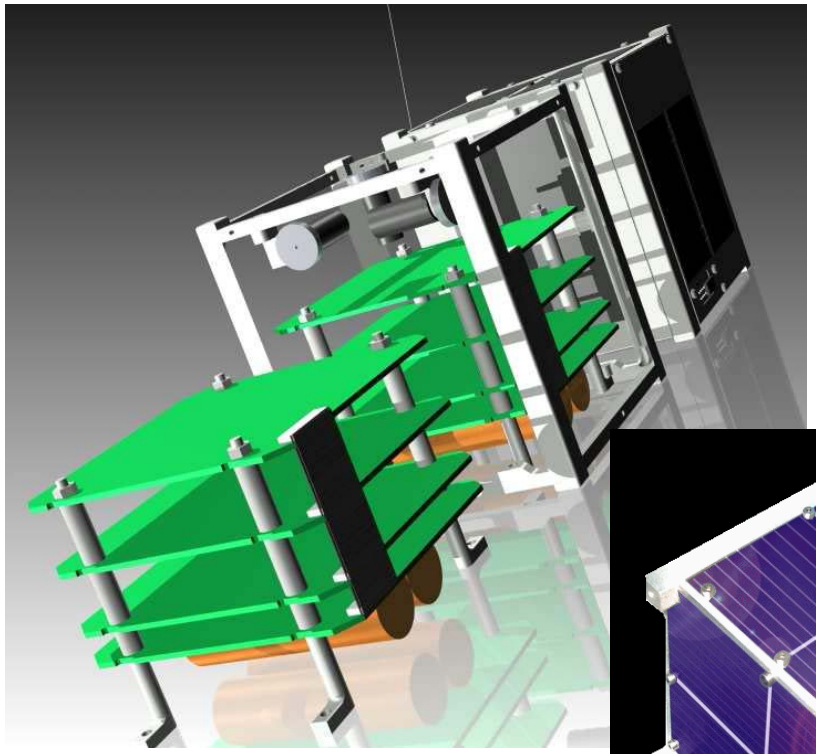
History of European Pico-Satellites

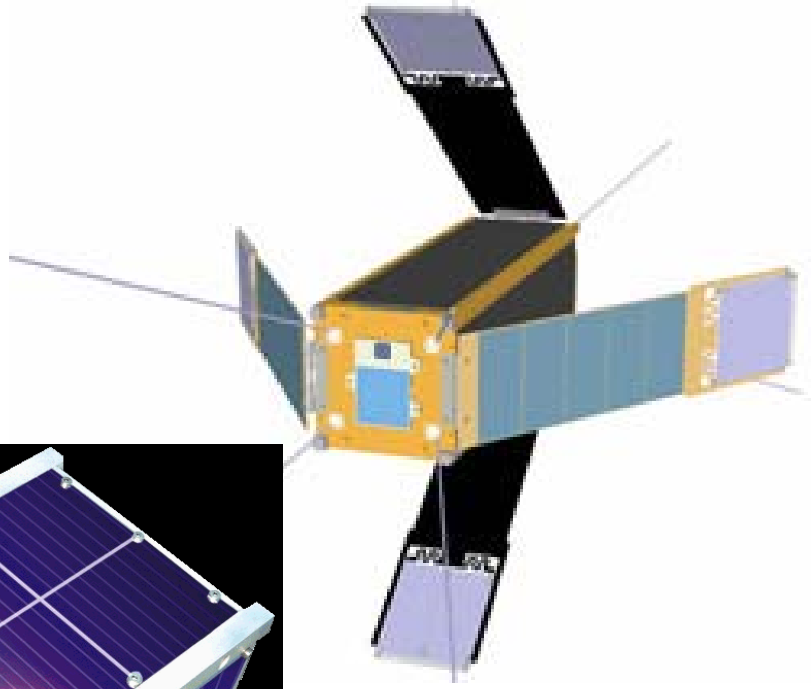
Previously Flown Technologies

- DTUSat
  - Electro Dynamic Tether for de-orbiting: UNTESTED
- AAU CubeSat
  - Danionics Lihium/Polymere batteries: PARTIAL SUCCESS
  - Highly compact active magnetic ACS: UNTESTED
  - COTS based FM spacelink: SUCCESS
  - COTS CMOS image sensor: UNTESTED
- UWE-1 ?



Upcoming European Pico-Satellites





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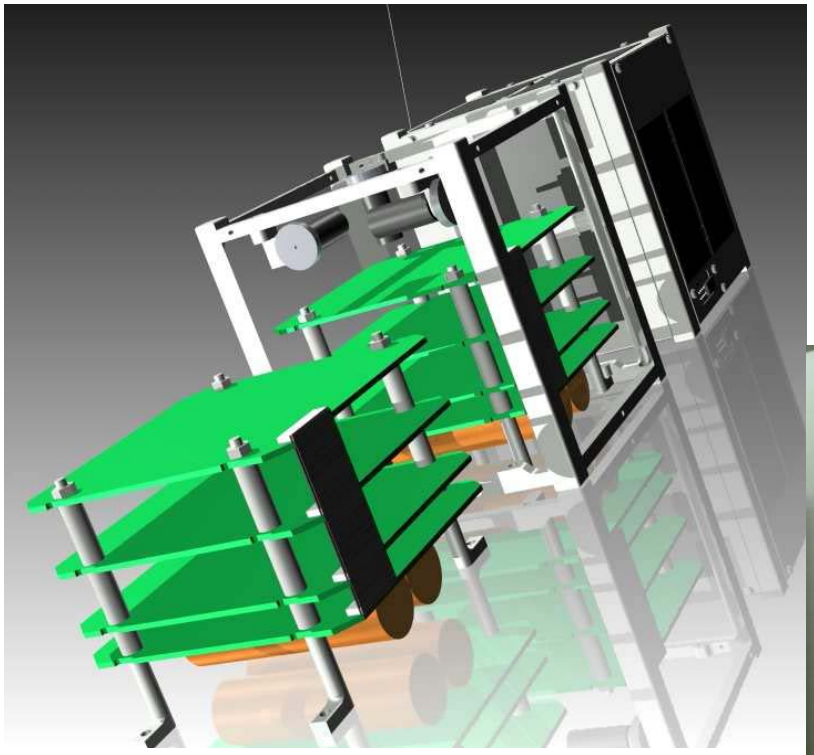
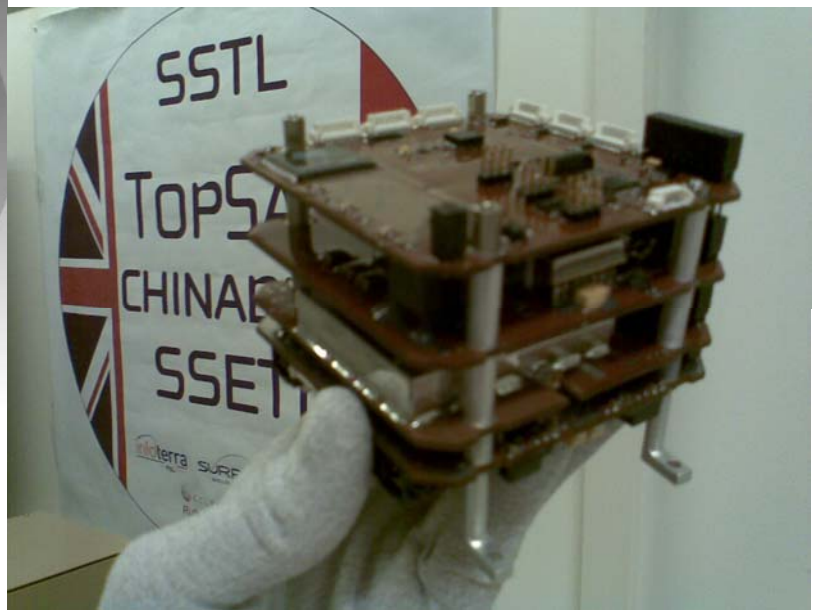
Upcoming European Pico-Satellites



AAUSAT-II

- Flight qualification of a novel Gamma Ray Detector



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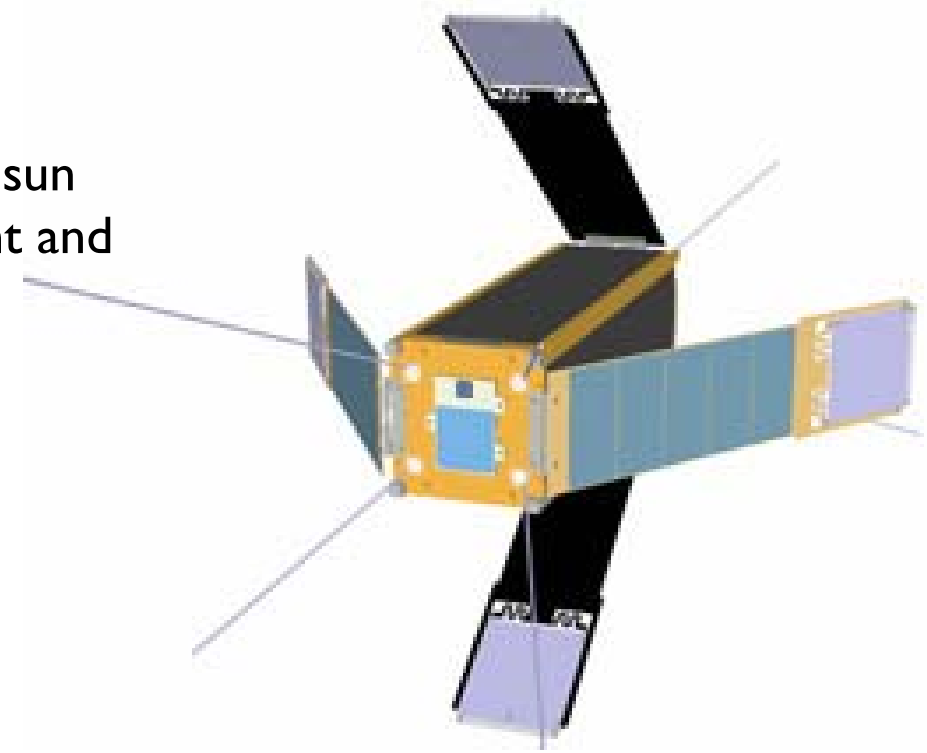
Upcoming European Pico-Satellites

Delfi-C3

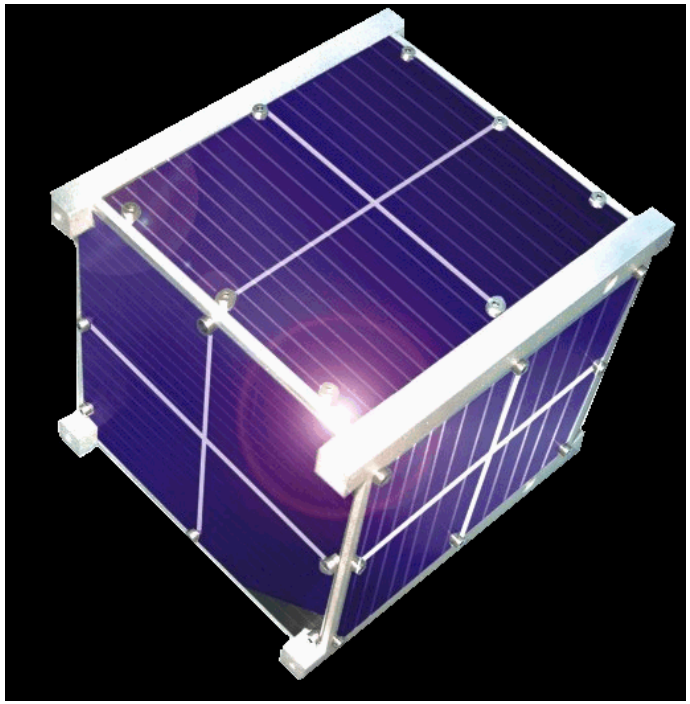
- Flight qualification of novel sun sensor, antenna deployment and solar cells



Upcoming European Pico-Satellites

Compass-1

- Validation of GPS receiver and flight qualification of Lithium-Polymer batteries for energy storage



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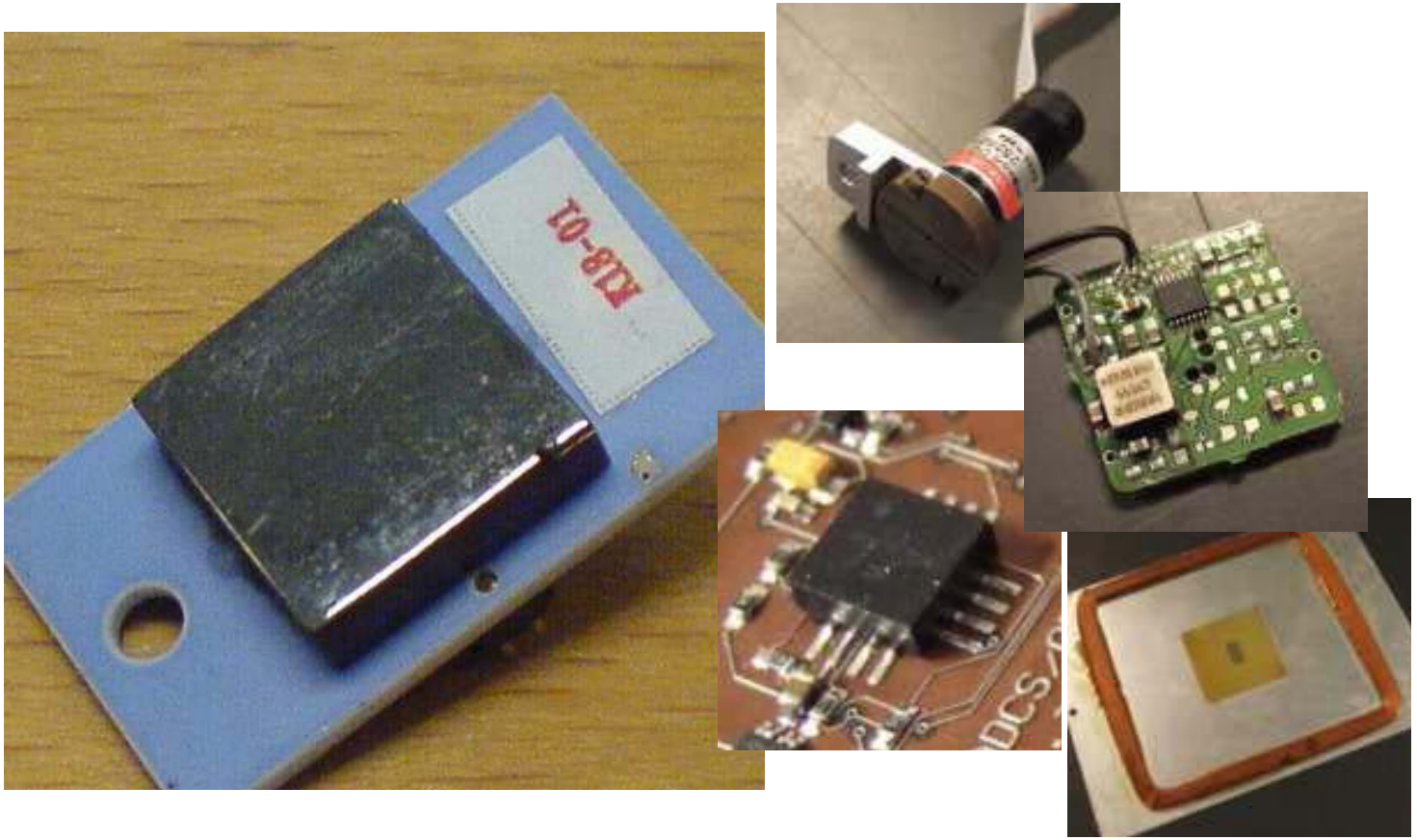
Technologies Flying on AAUSAT-II



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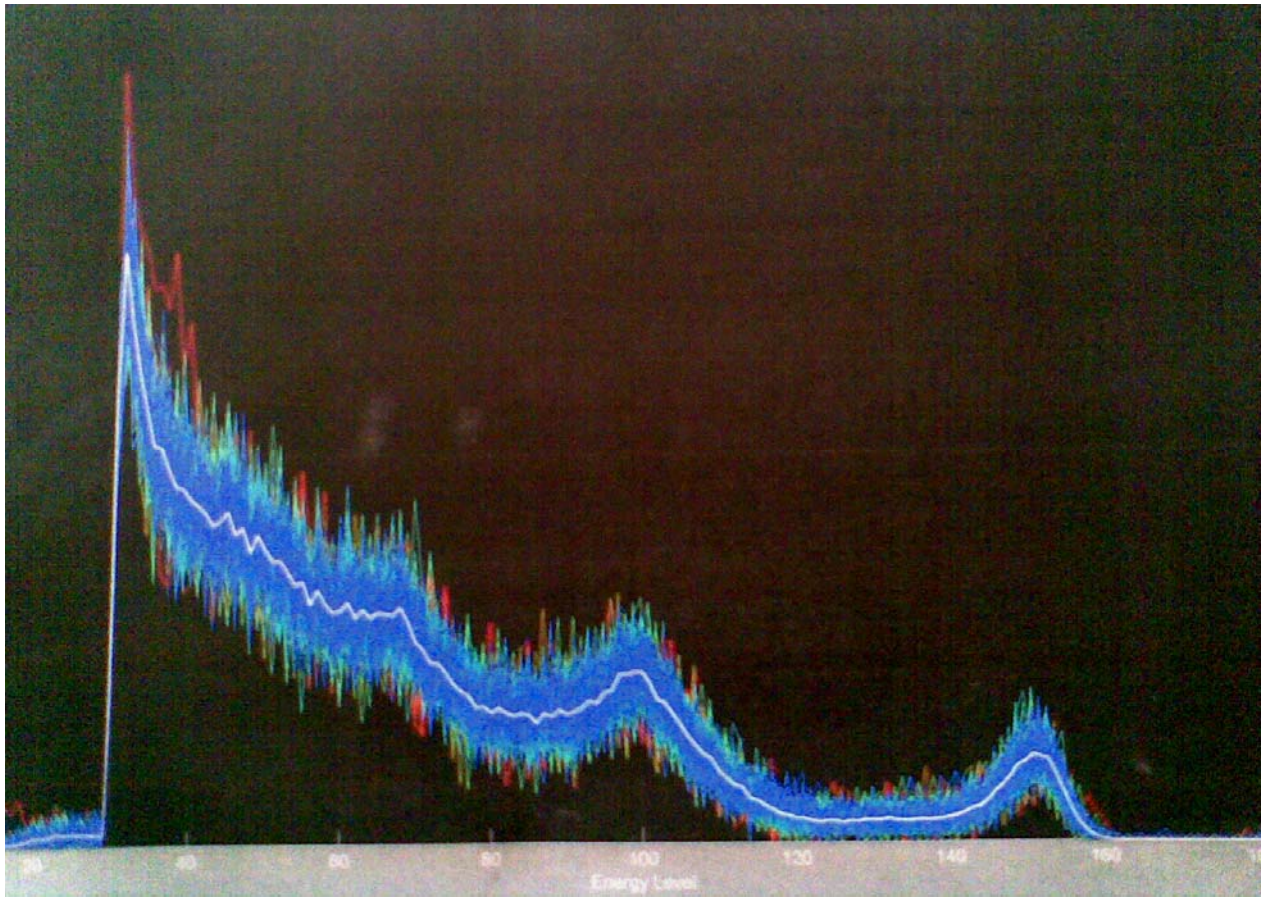
Technologies Flying on AAUSAT-II



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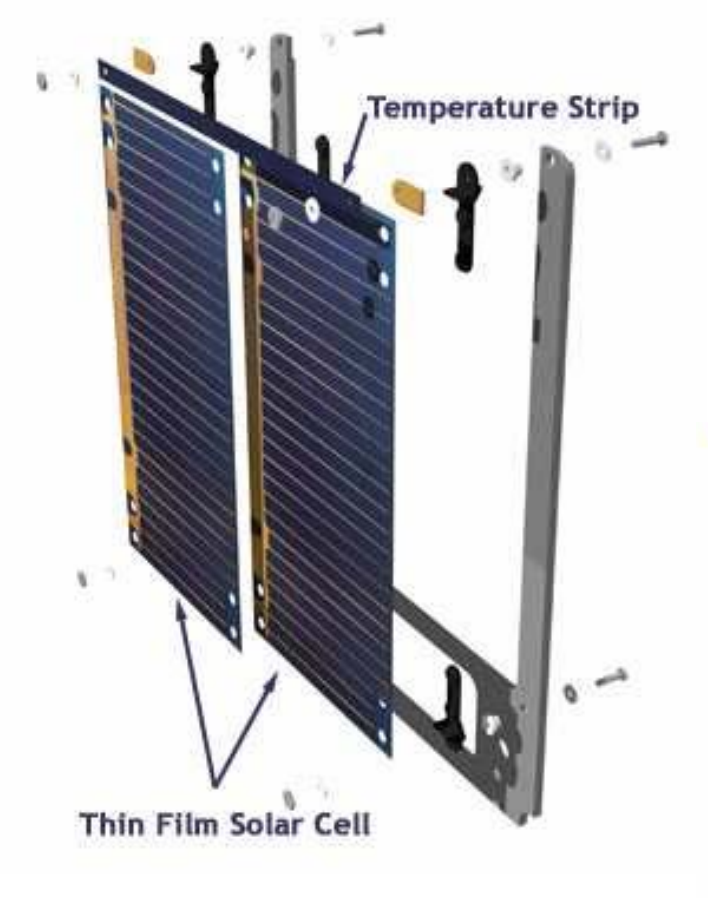
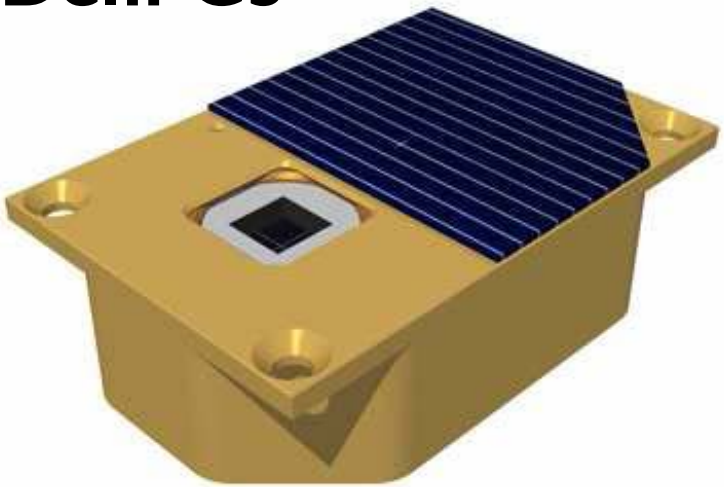
Technologies Flying on Delfi-C3





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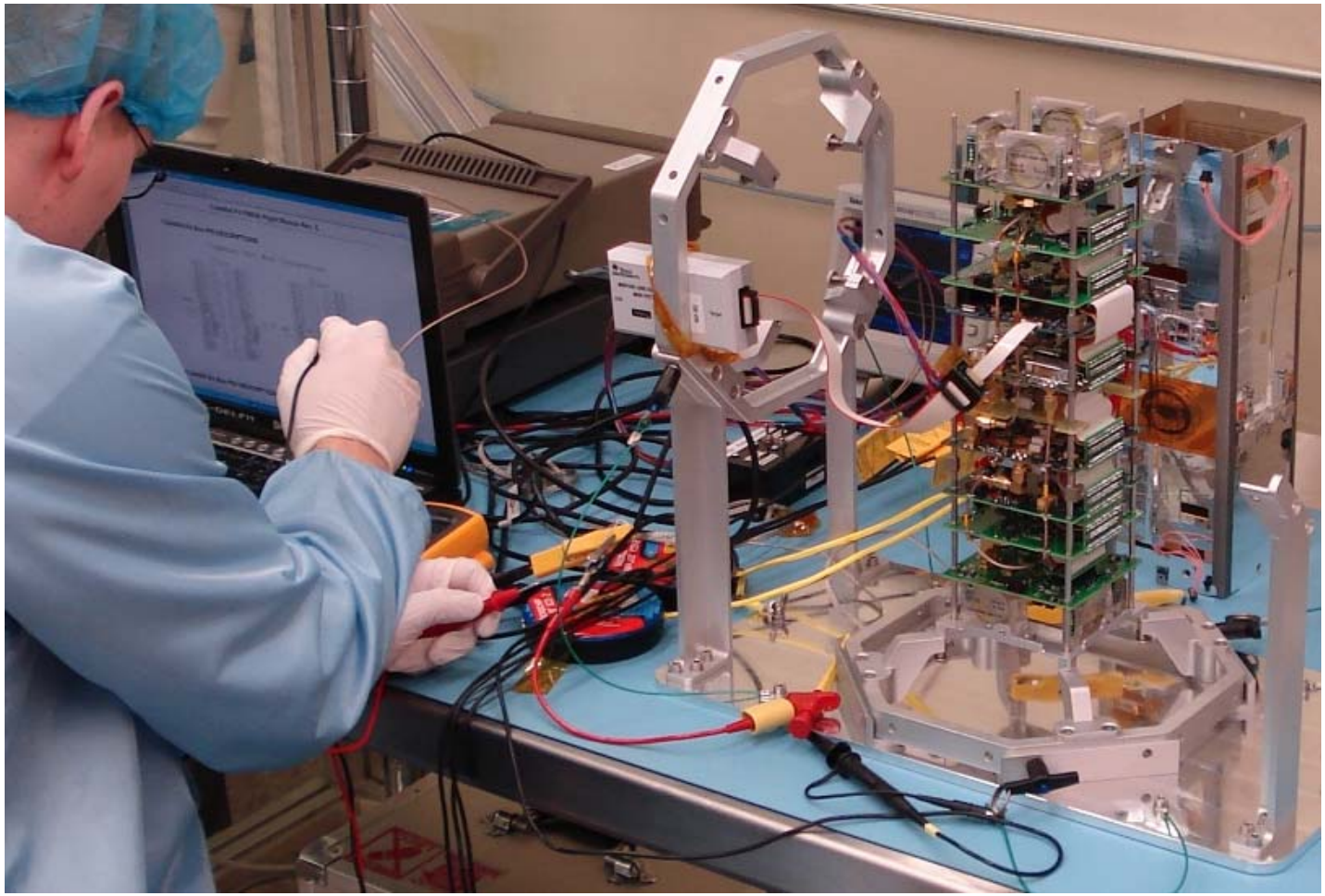
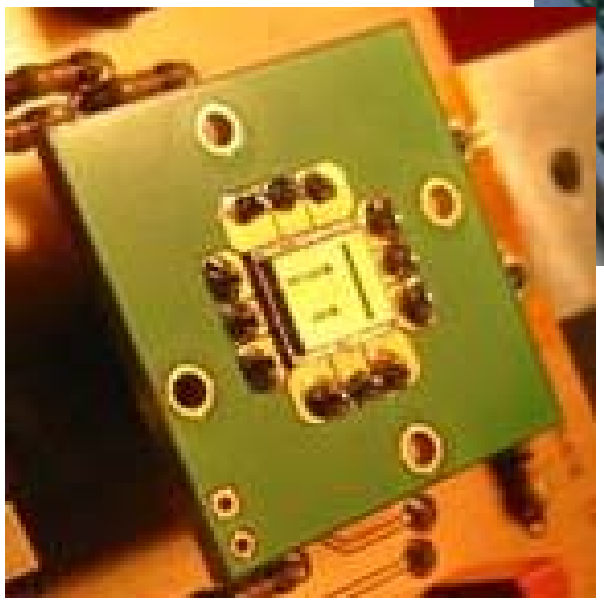
Technologies Flying on Delfi-C3



Technologies Flying on Compass-1



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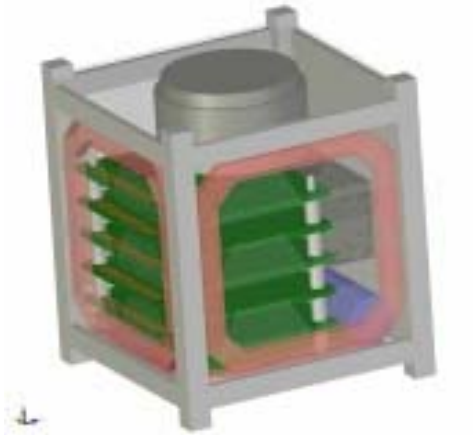
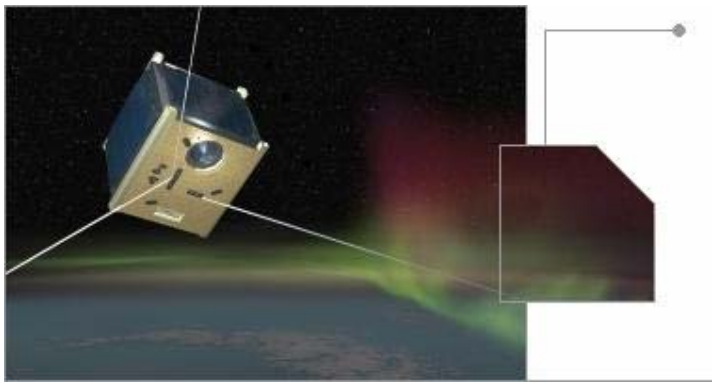
Next Generation of European Picos

- **SwissCube** – Prove of Concept of a CMOS image sensor using air glow measurements for horizon detection
- **AAUSAT3** – Prove of Concept of an AIS receiver in space
- **BeeSat** – BeeSat will demonstrate the use of coin size micro wheels
- **TIsat-1** – Learning mission – no new technologies
- **SOMP** – Measurement of atomic oxygen and testing thin film solar cell
- **Albert** – Learning mission – no new technologies
- **DTUSat-2** – Tracking of bird migration





Outcome from Pico-Satellite Missions

What:

- A lot of innovative components have been developed
- So far no completely succesful platform has been launched

Why have better results not been obtained so far:

- Until now it has been a pioneering endeavour
- Built as (part) student projects with no programmatic approach, professional management or quality assurance mechanisms

The way ahead:

- Base-platform to be developed by professional companies with the expertise, professionalism and quality assurance required
- Payloads, both science and technology, to be contributed by research institutions

Next Generation Technologies to Test

- MEMS thrusters
- Alternative power sources: Hydrogen fuel cells
- High-speed downlink using diode laser
- Inter-spacecraft links using e.g. Iridium or Globalstar
- MEMS IMU devices
- Star Trackers based on COTS cameras
- Alternative deorbiting mechanisms (like electro dynamic tethers)
- Orbcomm spacelink
- 3-axis high-precision attitude control
- Micro-mechanical deployment systems
- Inflatables (re-entry devices, optical systems, etc)
- Satellite-On-A-Chip / Satellite-On-A-PCB
- ...

Proposed Exploitation of Picos: NanoDemo

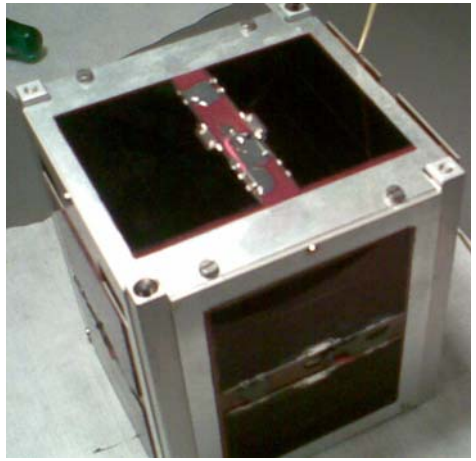
- A series of **nano-satellite** missions to provide a platform for European research institutions and companies to demonstrate new **advanced nano- and micro-technologies** for space use, e.g. technology intended for future use on satellite platforms for operational missions

- **Low-cost** satellite platform (e.g. a triple cubesat)
- Each customer **pays a share** of the total mission cost
- The missions will allow the customer to **gain flight heritage** for its product/experiment and hence rapidly make it commercially available
- Currently, the **customers do not have access** to missions/programs that can provide in-flight technology demonstration
- In-flight testing of such technologies will provide an **improved European technology capability** on which future ESA mission can be built

NanoDemo Payloads

- Each mission is expected carry around **10 nano-payloads** which must adhere to a set of standard specifications and interfaces. A preliminary idea of requirements for each payload is:

- <100g total weight
- <200cm^3 total volume
- <5W max. operating power - average dependent on power budget
- Can bus for data and control
- Temperature tolerance: -40 to +80 degrees
- Data budget: 50-500kB per orbit
- Vibration levels as per launcher requirements



NanoDemo Costumers and Cost

- **The target customer** group consists primarily of research institutions and companies within any field of micro- and nano-technologies that have a potential market place in the space business.

- **Estimated first mission cost:** <1 MEuro covering the platform, launch, and ground-station, as well as 6 months of operation.
- **Subsequent missions** can be significantly cheaper if the platform is reused unmodified.

Specific mission for a NanoDemo: ADCS Lab

- **Problem:** Verifying new approaches to attitude control is extremely difficult without weightlessness
- **Obstacle:** Newton and Einstein have forbidden the construction of anti-gravity machines
- **Solution:** Launch a platform that features all the latest, crazy technologies for attitude control and let engineers put their algorithms to the test – for real!
- **Profit:** Cutting-edge actuators, sensors, algorithms and ADCS processing units may be flight proven for a fraction of the cost of a typical commerical mission

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How to make it Happen?

- **The neo-classical way**: Universities launch educational missions with some ”new stuff” on board
  - **Pros:** It’s almost free due to the lack of labour cost
  - **Cons:** Quality assurance is down to a minimum and sucess-rate is low due to lack of education and the high rate of change in persons involved

- **The industrial way:** Private companies with the capabilities and infrastructure to carry out a low-cost cubesat mission take on the challenge funded by payload customers and perhaps European research programmes
  - **Pros:** Job is done by dedicated and educated people with experience who are there to see a project through
  - **Cons:** Labour is not free

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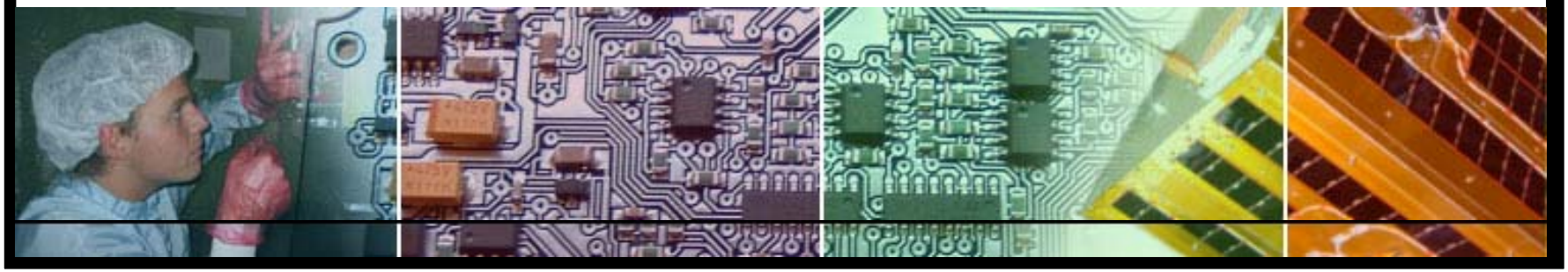
Conclusion

- The status of European pico-satelllite technology was reviewed
  - Many interesting technologies
  - No major succesful European missions so far
- The author's view on future activities was put forward
  - Pico-platforms to be developed by industry
  - Payloads, science and technlogy, to be contributed by research institutions
- Concrete ideas for mission concepts were presented
  - NanoDemo: Fast track demonstration of Nano/MEMS technology
  - ADCS Lab: Research in advanced attittude control



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