The EADS micropack project

A novel, modular approach to packaging integrated microsystems for exciting future mission applications in space

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5th ESA Round Table on Micro/Nano Technologies for Space

3-5th October 2005

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O. Coumar – EADS ST

K. Haria – Ex-Cranfield University

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Outline

- Micropack Programme Overview, Vision and Objectives
- Early Micropack prototypes
- Current Miniaturised Micropack prototype
- Micropack space applications
- Possible Missions
- Conclusion
- Questions

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The Micropack Programme overview

- MEMS systems have a high function/mass ratio and very high levels of integration
- EADS realise that many aerospace applications can benefit
- ‘EADS Micropack programme’ was a vision started in 2002:
  - to harmonise research into MEMS by all EADS businesses
  - to develop approaches to packaging microsystems
  - to demonstrate that complete microsystems can be created and combined together into high performance systems, e.g. space
  - to identify and solve industrialisation and integration issues raised by MEMS.
  - to target aerospace applications which can benefit from an increased function over mass ratio.
- Micropacks would include suites of COTS MEMS sensors, packaged and integrated into a system platform.
- Idea was to tailor the micropacks to the needs of each user, e.g. Astrium, Sodern, EADS ST, MBDA etc

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Micropack Vision

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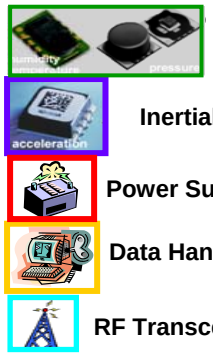
1 – To build MEMS modules with dedicated functions

MEMS



Atmospheric Module

Inertial Module

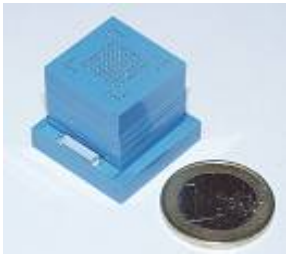
Power Supply Module

Data Handling Module

RF Transceiver Module

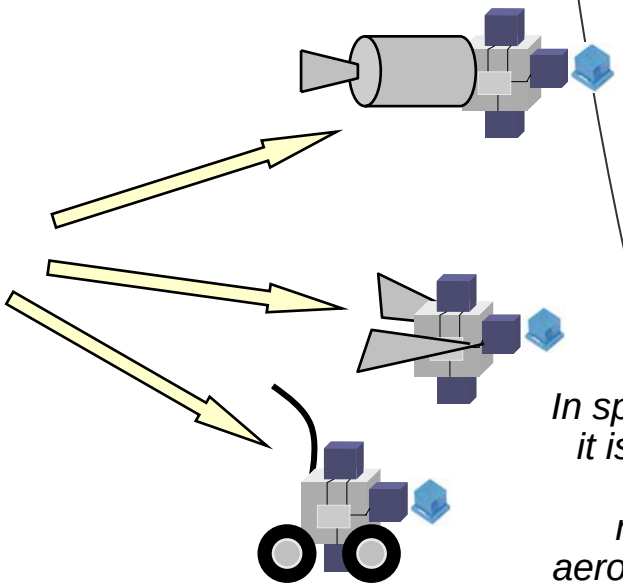
2 – To integrate the modules into a micropack

package



Interconnect, structure, etc..

3 – To incorporate the micropack into an aerospace system with specific R&D purposes



In space applications it is potentially the core of a nanosatellite, aerobot, micro-probe or micro-rover.

Micropack Historical Overview

- Early work
  - Definition of EADS business unit user requirements
  - Identification & procurement of COTS MEMS devices
  - Integration of MEMS devices into PCB micropack breadboards
  - Functional and environmental tests of micropacks.
- By end of 2003, EADS CRC had completed 2 micropack demonstrators packaged in PCB with bluetooth link to remote PC:
  - an atmospheric micropack
  - an inertial measurement unit (IMU) micropack.
- From 2004 EADS is developing a novel modular approach to packaging miniaturised integrated microsystems
  - Project now spearheaded by Astrium through EADS CRC
  - Focus on space applications and miniaturisation
  - Current breadboard prototype is an LTCC (Low-Temperature Co-fired Ceramic) package for enhanced miniaturisation
  - Demonstrator should be ready by end of 2005

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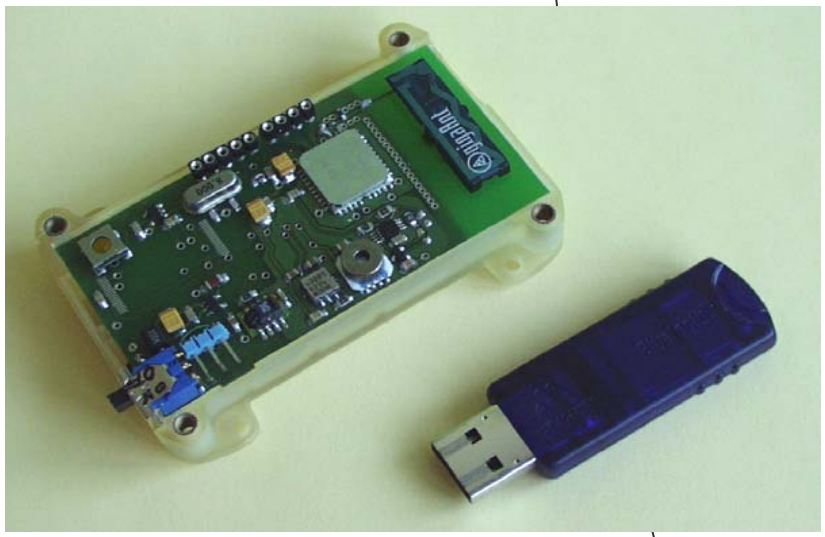
2003 Atmospheric Micropack

- Atmospheric Sensors (pressure, temperature, humidity)
- Acceleration sensor,
- Flash memory,
- Micro-controller,
- Battery
- Bluetooth communications system
- Packaged in synthetic/PCB: FR4.
- Volume 78 x 53 x 18.5mm^3,
- Mass is 58g.
- Power 180mW peak, 13mW active
- Operating Time 100h
- Range 10m

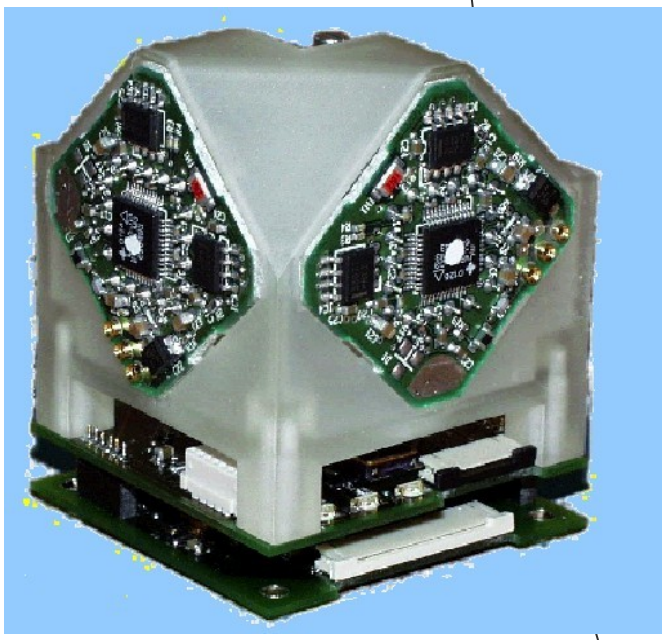


2003 Atmospheric Micropack with Bluetooth USB

Sensor-related data:	Range	Resolution
Acceleration Sensor	±2g (2-axis)	2mg
Humidity Sensor	0-100%	±0.5%
Temperature Sensor	-40°C to 123.8°C	±0.04°C

2003 Inertial Micropack

- 3 micro-gyros (Silicon Sensing CRS 03)
  - measurement range 100°/s
  - resolution of 0.05°/s
- 3 accelerometers (VTI),
  - measurement range 1.7g
  - resolution better than 6mg
- Packaged in synthetic/PCB: FR4.
- Size 40x40x65mm^3
- Overall mass 65g.
- Power 2.56W power up, 1.18W active
- No RF and battery included



2003 Inertial Micropack

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Objectives of current miniaturised prototype

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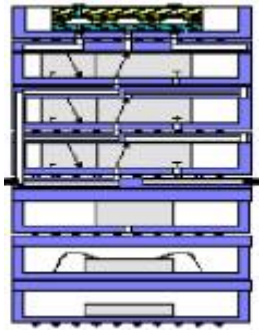
- Focus on Space applications
- Achieve major size reduction by advanced 3D LTCC packaging
- Use a standardised modular design to increase flexibility
- Use a packaging technology that is suitable for harsh environments
- Reduce overall power consumption with new RF concept
- Networking/routing capability

Size:
78x53x18.5 mm³

Power Con.:
180mW



Size:
20x20x(5x5) mm³

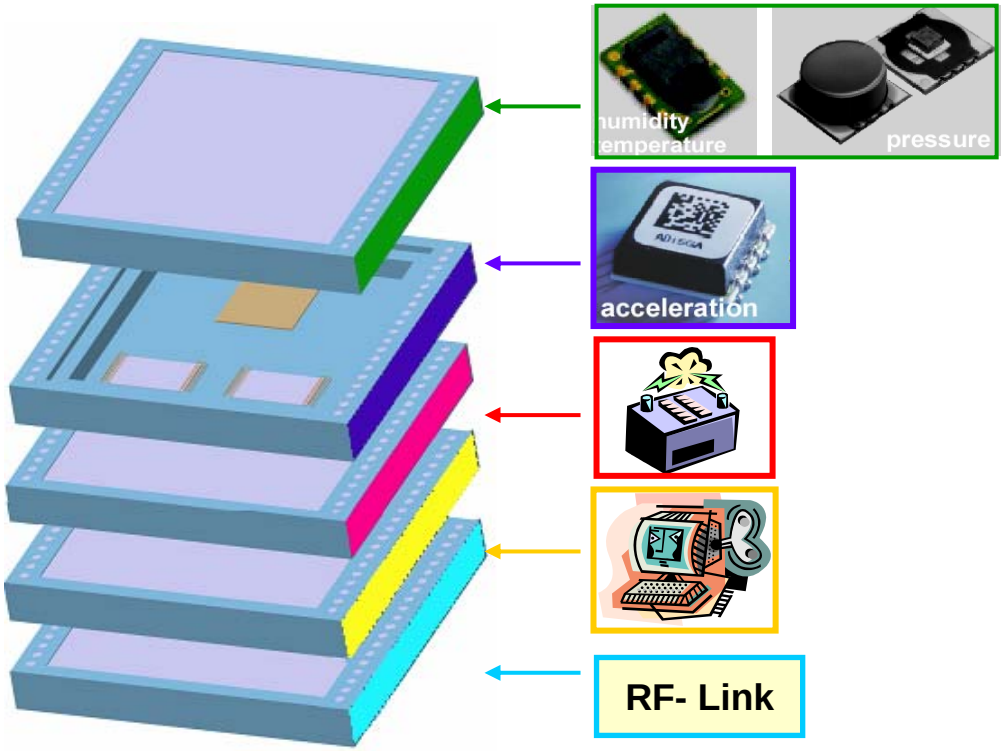
Power Con.:
< 100mW

2003 Micropack Demonstrator

2004 / 2005 Modular Micro-Pack

Discrete LTCC Modules

- Flexibility by using modular multi-layer LTCC package



Atmosphere sensor unit (Temp/Humidity/Pressure)

Inertial sensor unit (2dual axis Acceleration sensors, 3 axis detection)

Power supply unit (Li Polymer battery)

Data handling unit (16Mbit) (TI MSP430 micro-controller)

Chipsize RF transceiver unit with antenna laminated into LTCC ceramic with RF link - IEEE 802 15.4 (250kbps, 2.45GHz)

- MatchX-Technology
  - Construction kit for developing modular microsystems
  - Standardized electrical/mechanical interface between modules for microsystem-applications
- Future applications (e.g. gas analysis sensor) can easily be added/exchanged with an existing package

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2004 miniaturised Micropack specifications

- Volume 20 x 20 x 25mm^3,
- Mass is 25g,
- Power 8mW average,
- Operating Time 60h,
- Range 100m (more with power amplification)

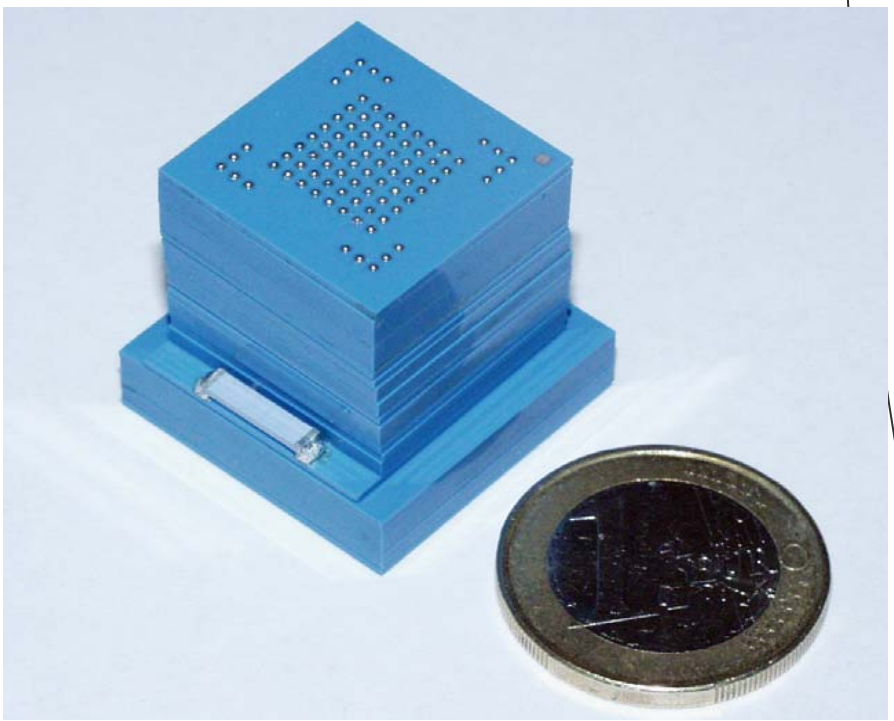

Photo of the the EADS micropack, next to a 1€ coin

Sensor-related data:	Range	Resolution
Acceleration Sensor	±2g (3-axis)	2mg
Humidity Sensor	0 - 100%	±0.5%
Pressure Sensor	300 -1100mbar	± 1.5mbar
Temperature Sensor	-40°C to 123.8°C	± 0.04°C

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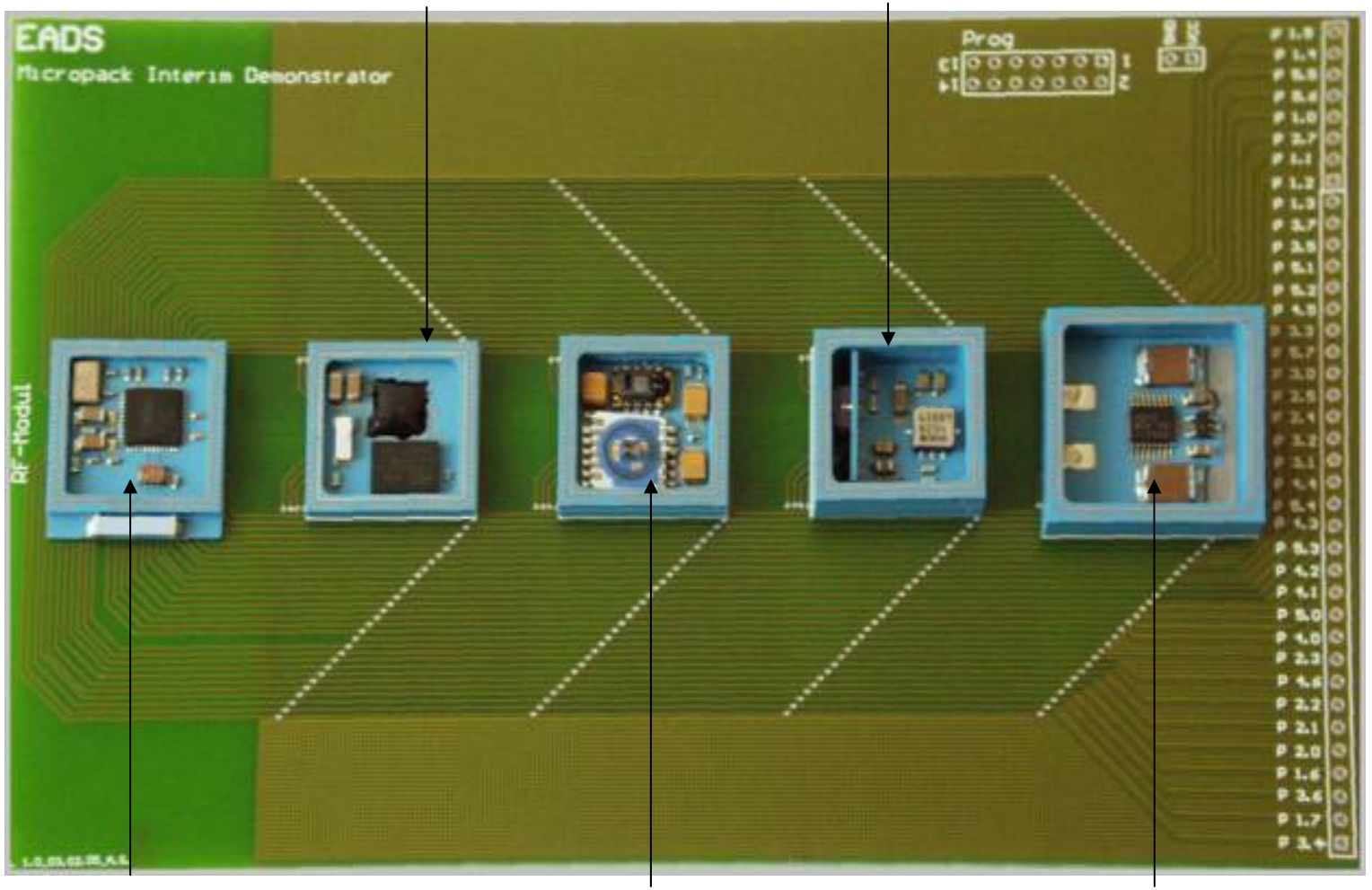
Interim Demonstrator



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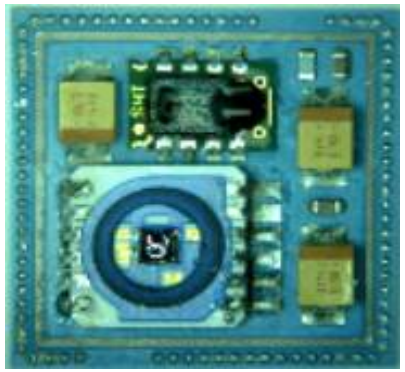
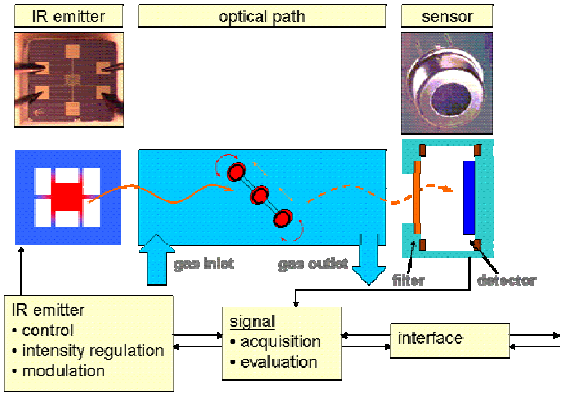
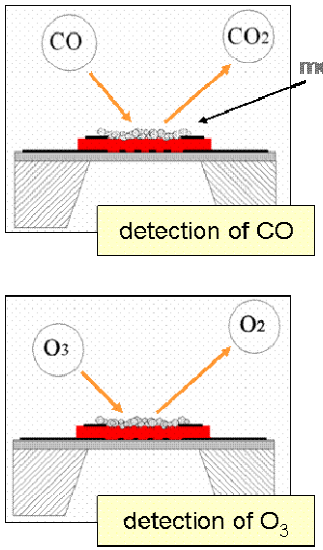
Scientific Sensor Modules

Today‘s payload:



Future Options:

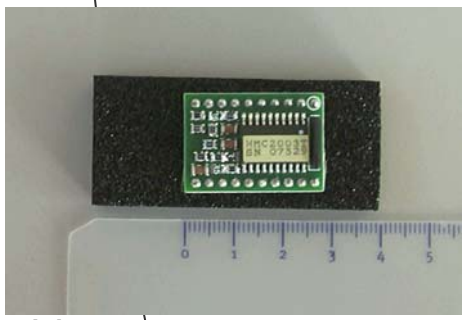




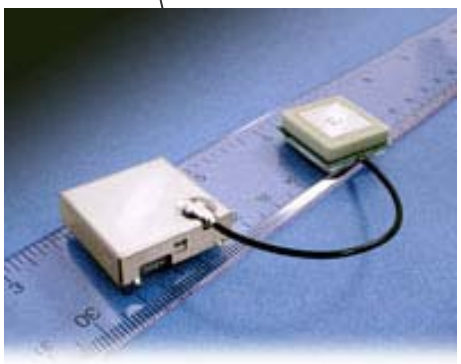
- **Humidity**
  - Measurement range: 0 –100 %RH
  - Resolution: typical 0.03 %RH
- **Pressure**
  - Operating pressure range: 0 –1bar
  - Sensitivity: typical 240 mV/bar
- **Temperature**
  - Measurement range: -40 to +123°C
  - Resolution: typical 0.01°C

Future Payloads:

- **Intelligent gas sensors for detection of planetary trace gases (above)**
- **Magnetometers (see right)**
- **Particle Analysers**
- **Debris Sensors (IRECIN 8g)**
- **Radiation detectors (Aero Corp. 4g)**
- **Optical sensors (bolometers , etc.)**
- **GPS (right)**



Miniature Magnetometer
Honeywell HMC 2003 – 4g



Miniature GPS
Trimble M-Loc MPM Module – 5.7g

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Micropack as a spacecraft solution?

- Very low mass, volume and power consumption
  - can dramatically reduce launch/mission cost.
  - can enable missions that would otherwise have been unfeasibly expensive with standard spacecraft.
  - can be highly integrated and hence a simpler overall system can be obtained
- Can operate in large numbers or swarms
  - large in-situ spatial coverage
  - increased redundancy spreads the risk
- Can be batch fabricated and hence large arrays of such systems can be produced at low cost.

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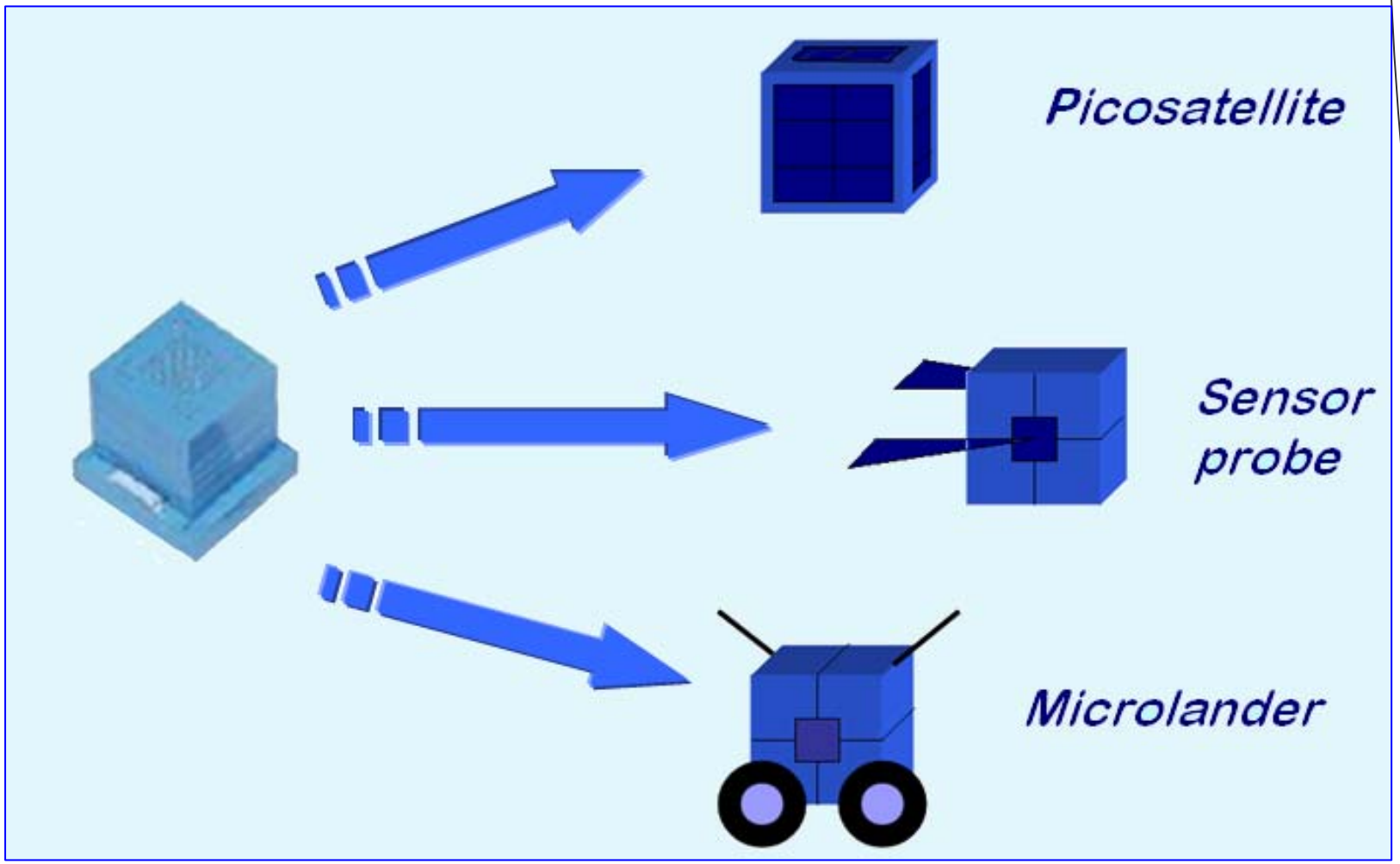
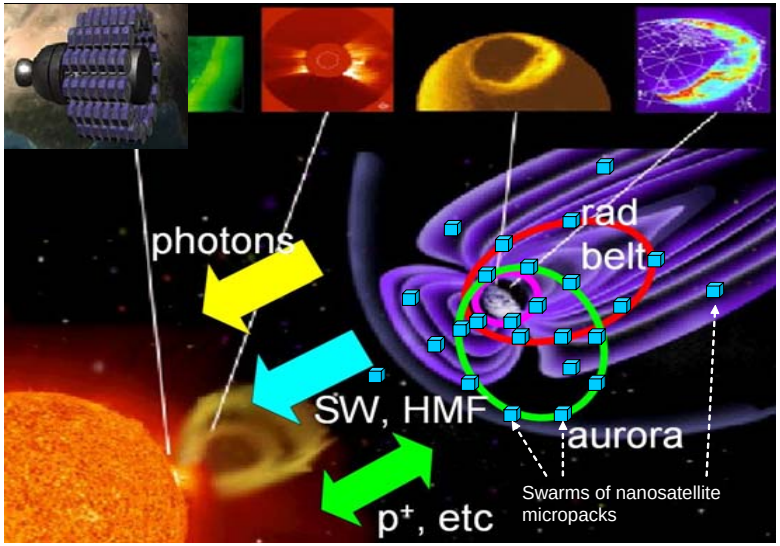
Micropack space applications

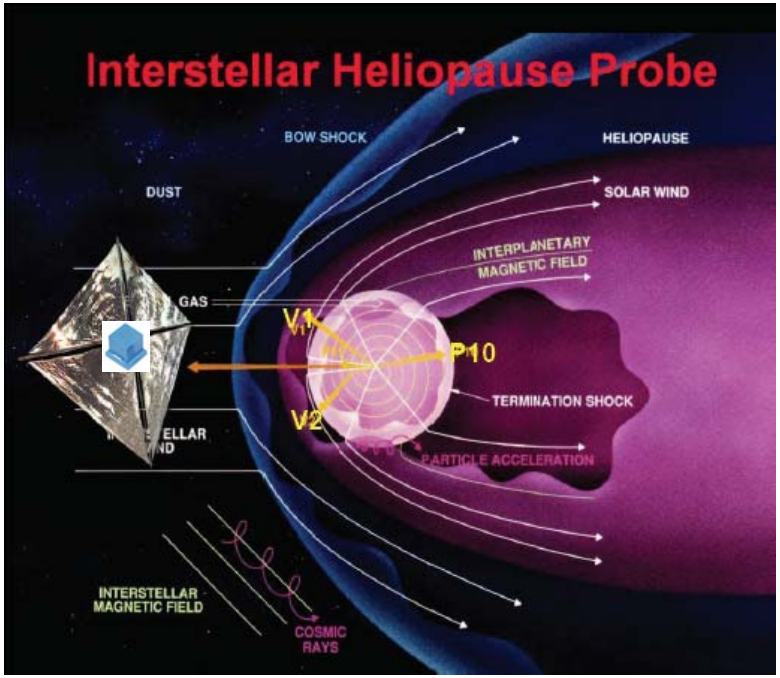


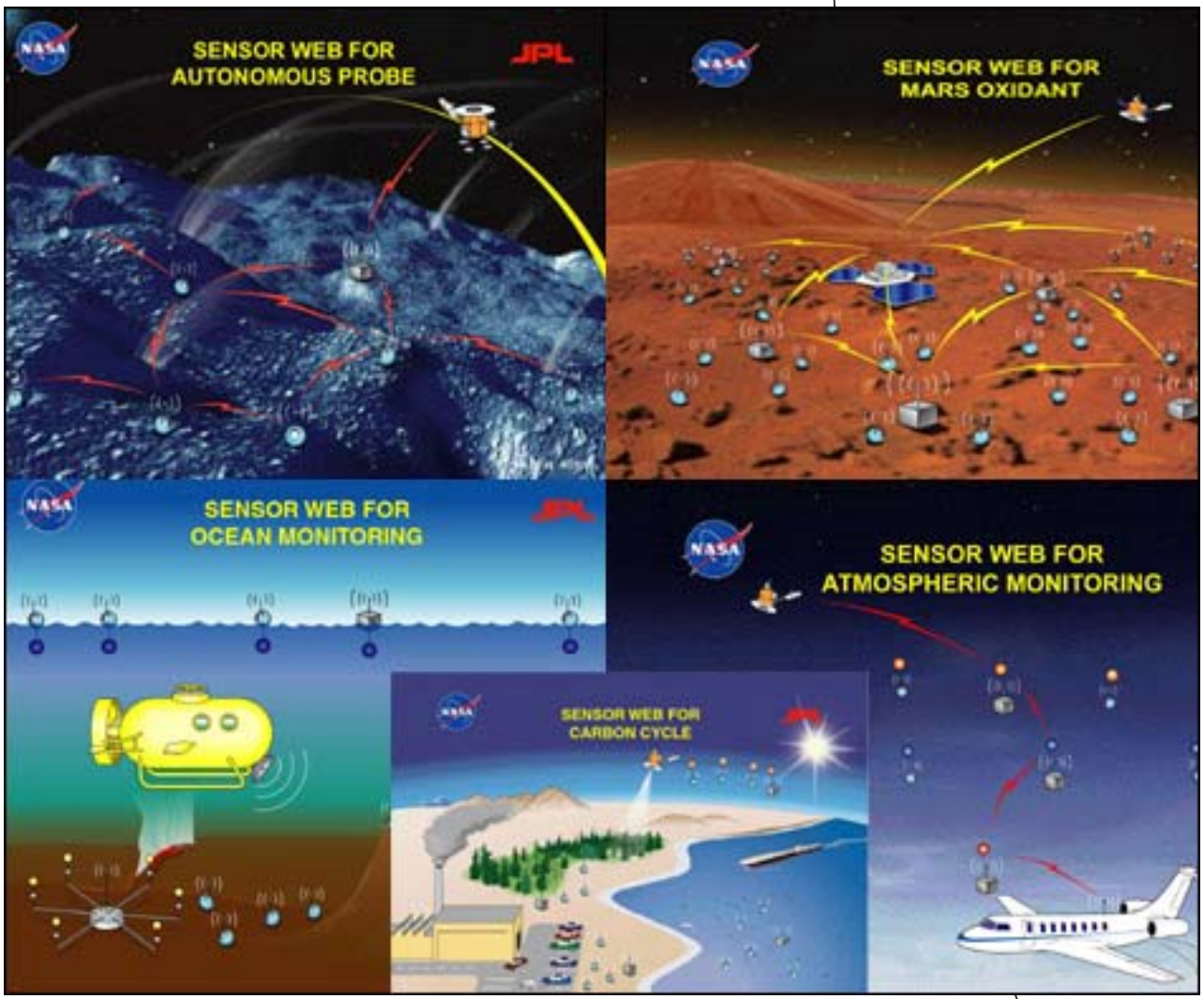
The micropack vision for space

Potential future Micropack Missions



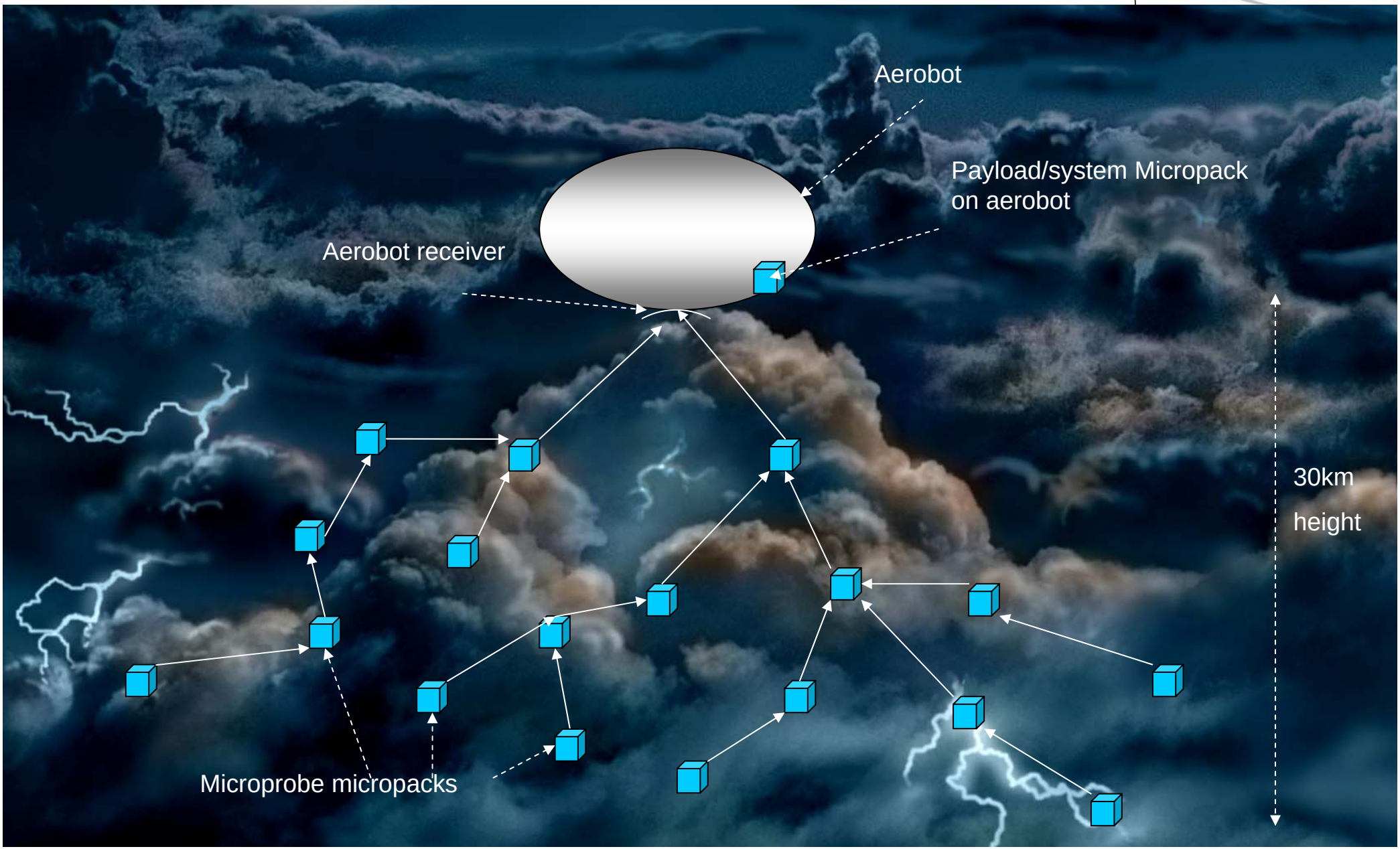
Solar Terrestrial Physics/Space Weather constellations





Planetary Sensor-Webs

Jupiter Micropack Microprobe Network to Aerobot



Conclusion

- Impressively light and compact sensor package
- Novel modular approach to Microsystems packaging.
- Modular approach means that additional sensors/hardware can easily be included/exchanged
  - MEMS gyros
  - Scientific instruments,
  - Advanced micropower techniques
  - Advanced data communication networking
  - Microcomputer-on-a-chip (with autonomous capability).
- For specific applications; modification, qualification and testing is required, e.g.
  - Thermal
  - Radiation
- Micropack could be a key technology for range of future missions

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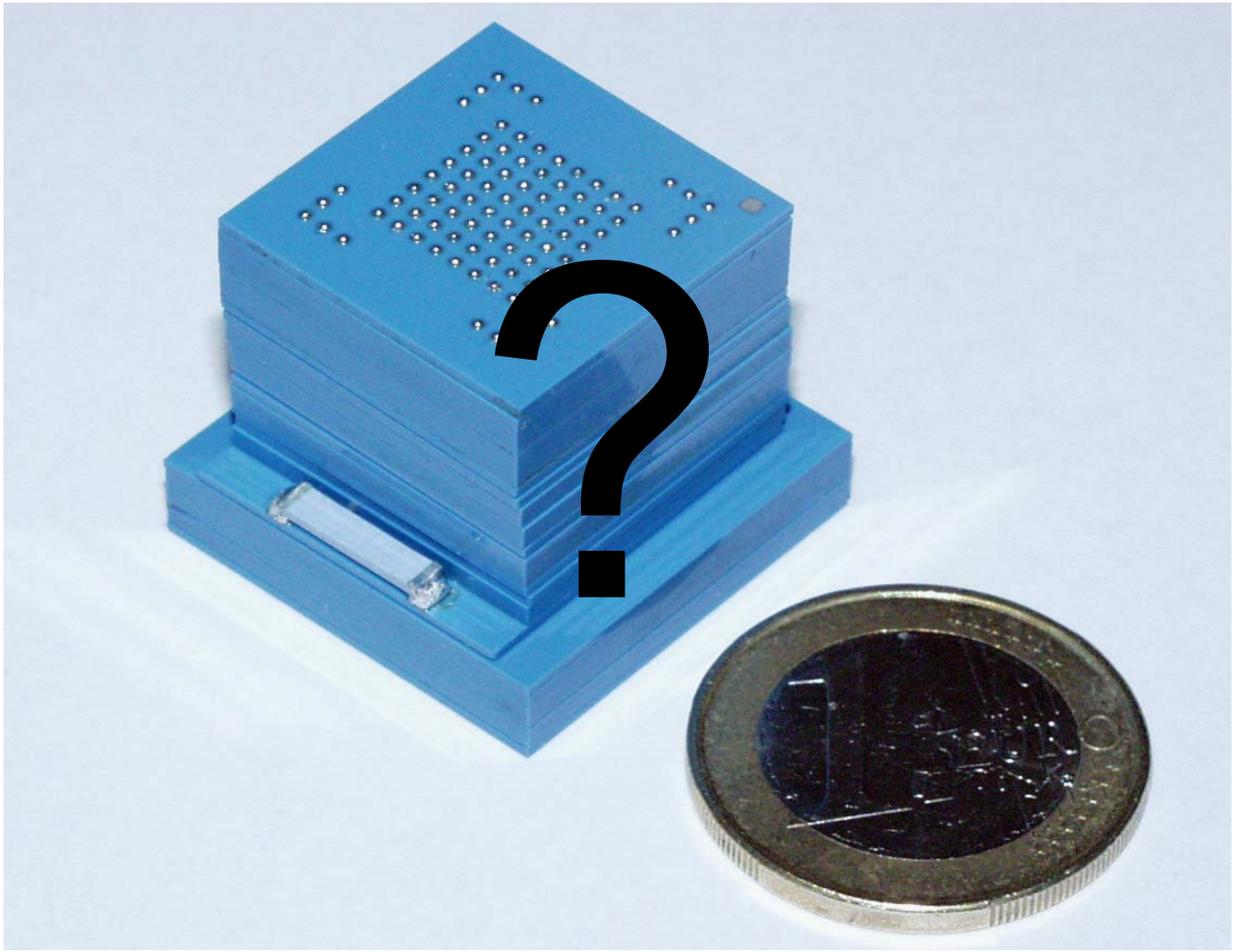
Questions?



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