HYPERION TECHNOLOGIES

FEB, 2017

KIVI SYMPOSIUM – KLEINE RUIMTEVAART

New commercial potential for Small satellites in Low Earth Orbit

Traditional satellites

Envisat example:

- Mass: ~8,200 kg
- Revisit time: 35 days
- Total cost: ~€ 2,300M
- Launch cost: ~€ 500M
- Orbit: 790 km
- Lifetime: 10 years
- Technology lag: 12+ years

Small satellites

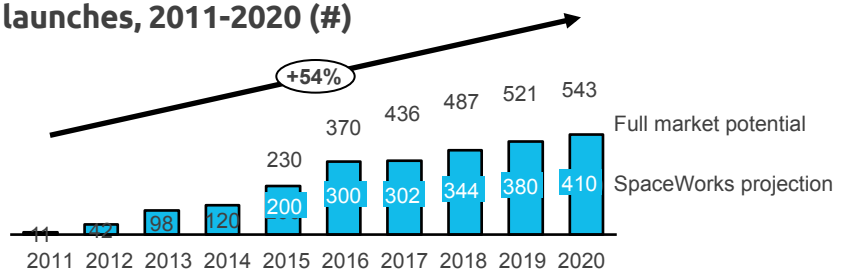
3U cubesat example:

- Mass: ~4 kg
- Revisit time: 1 – 3 hours (in constellation)
- Total cost: ~€ 1M
- Launch cost: ~€ 30k/kg
- Orbit: 300-500 km
- Lifetime: 2-3 years
- Technology lag: ~3 months

Benefits of small satellites

- Revisit time
- Production time
- Launch cost
- Mass
- Technology lag

Market projection of small satellite launches, 2011-2020 (#)



Source: SpaceWorks, 2014

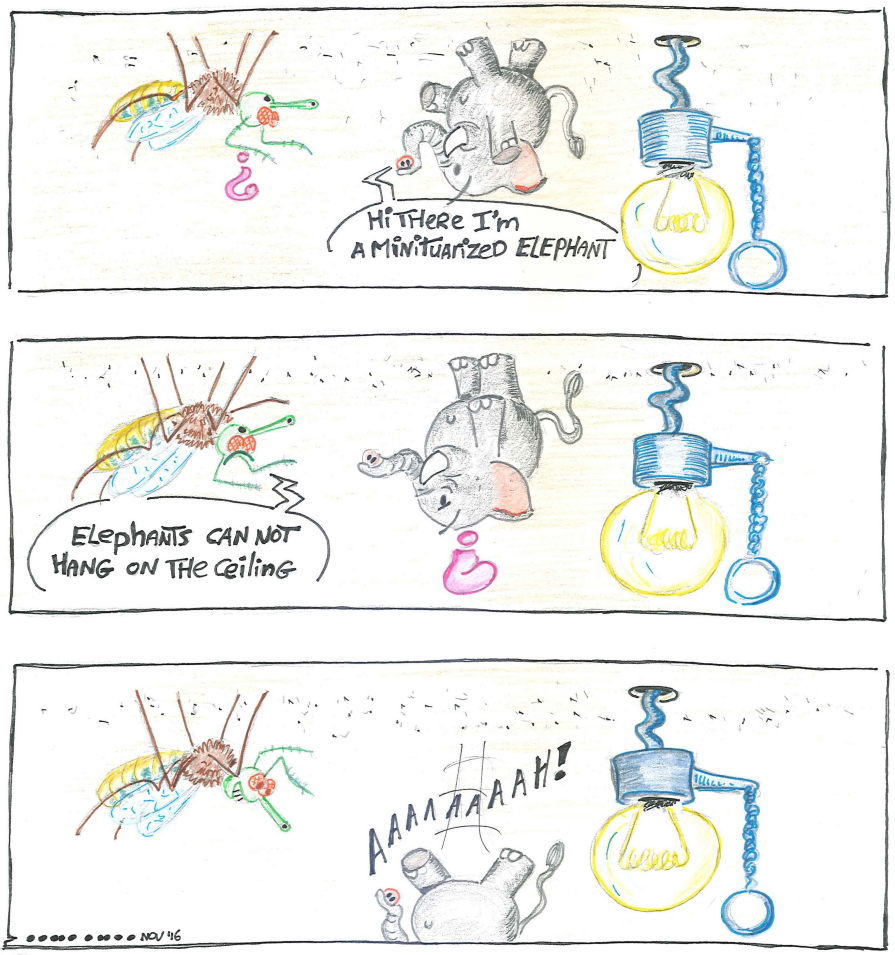
Are small satellites derivatives of large satellites?

Miniaturization no goal on itself

Should bring advantages

- Mission capability
- Price
- Enhanced performance
- Fitting performance

System view on miniaturization



Limits of miniaturization (1)

Theoretical

- Diffraction limit
- Volumetric scaling (mass/area ratio)

Practical

- Machining accuracies
- Material properties
- Efficiency (required power)

Constraints

- Cost of miniaturization
- Lack of scale (limited number of satellites)

Limits of miniaturization (2)

Electronics: Moore's law

- Information coded in voltages, currents, charge
- Low mass (electrons)
- Next step: photonics

Mechanics: Manufacturing limits

- Piece-by-piece manufacturing
- Launch loads

Optics:

- Diffraction limit
- Number of photons (signal-to-noise ratio)

Antennes

- Received power

Diffraction limit

The minimum angular separation of two sources that can be distinguished by a telescope depends on the wavelength of the light being observed and the diameter of the telescope. This angle is called the **diffraction limit**.

6m resolution at 1000 km (600 nm light; ideal case)

Vision of Hyperion

- Develop high-performance, best-in-class systems for small satellites
- Use of COTS components when available and possible
- Extensive testing
  - Thermal vacuum
  - Vibration
  - Radiation
- High Performance and High Reliability
  - Robust
  - Failure tolerant
  - Similar to professional systems

Satellite components

- Payload
- EPS
- Radio (payload data & telecommand)
  - Transmitter (power)
    - Antenna (size)
  - Receiver (signal power, noise)
    - Antenna (size)
- ADCS
- Propulsion

Components for small satellites

- Lowering of materials cost
- Lowering of launch cost
- Following state of the art
  - COTS
  - Newer materials
  - Better machining available
  - Competition
- New types of satellites
  - Small sats
- Required by the application

Payload dominance

Payload should dominate

- Size
- Mass
- Power consumption

If not:

- Suboptimal design
  - Improve non-payload parts
  - Improve performance of payload

Or reflect on alternative performance metrics

- Life time
- Robustness

Current small systems (Hyperion products)

- Star trackers
- ADCS
- Imagers
- Propulsion

Hyperion’s star trackers

ST200-(T/D): currently available for CubeSats

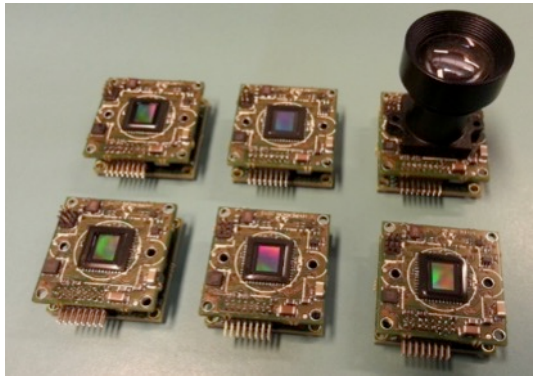
- World’s smallest star tracker
- Standalone device
- < 30 arcseconds accuracy(3-sigma)
- 5 Hz update rate
- Magnitude 6 stars
- 600 mW average power consumption

Each version can be delivered with:

- Integrated IMU
- Baffle
- Full qualification

ST400-D: currently available for Microsatellites

- Modified version developed for application on an ISS payload
- < 15 arcseconds accuracy(3-sigma)
- < 700 mW average power consumption



ST200

World’s smallest star tracker

Stand alone device

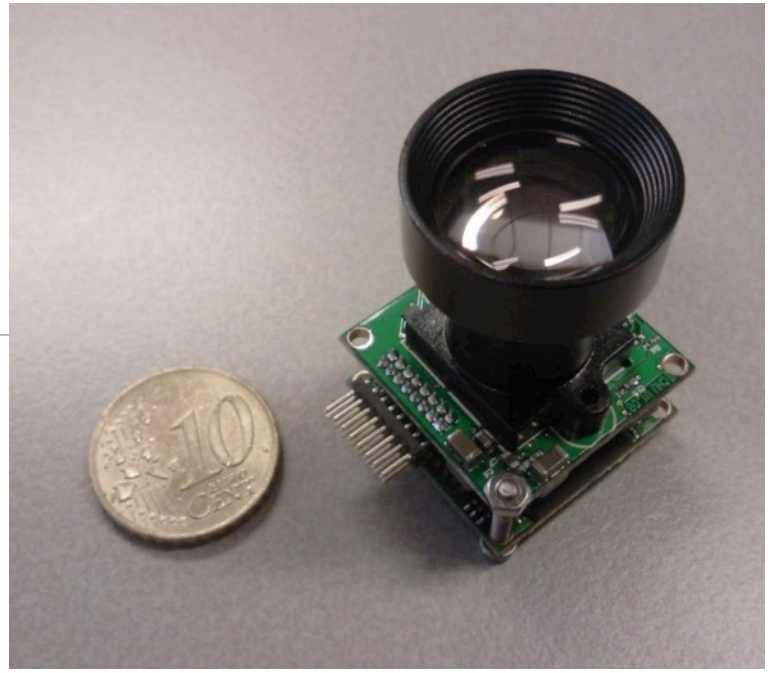
< 30 arcseconds resolution (3-sigma)

Magnitude 6 stars

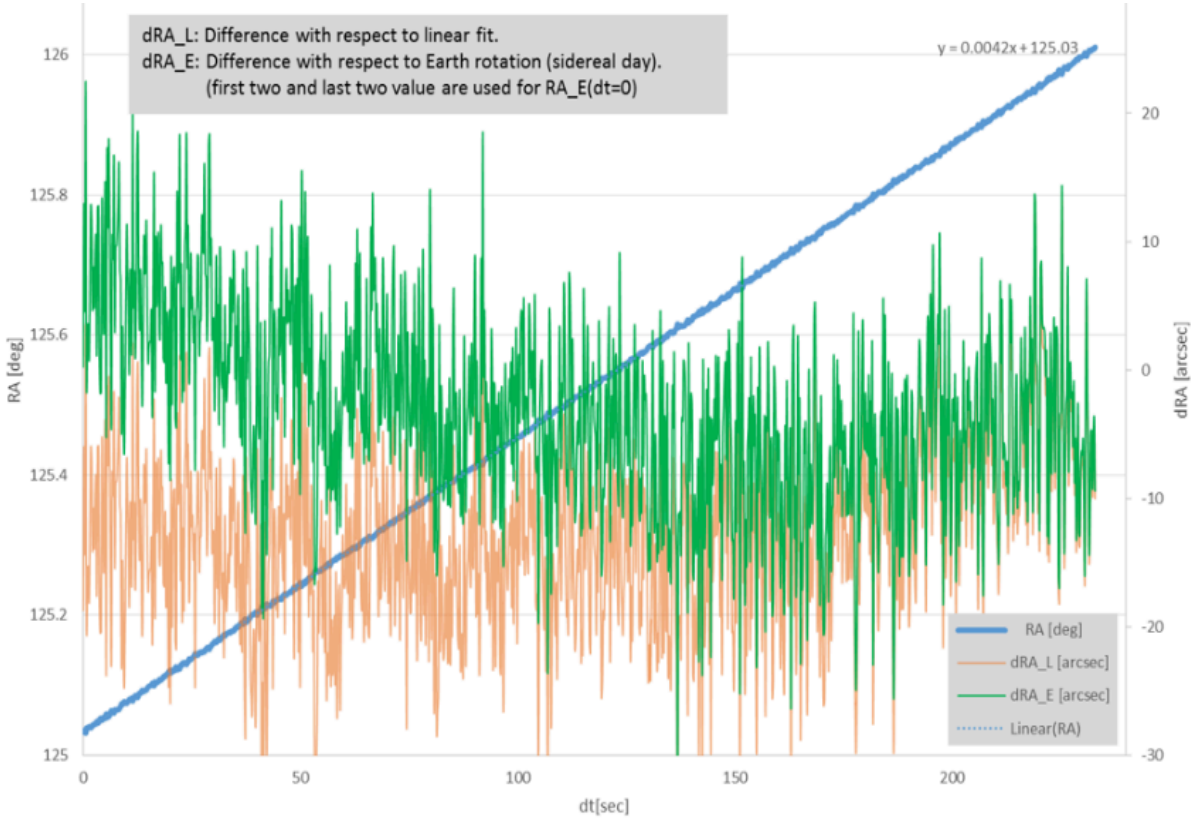
600 mW average power consumption

5 Hz update rate

Standard and custom baffles available



Star tracker



Datasheet value:

10 arcseconds RMS (1-sigma)

Measured:

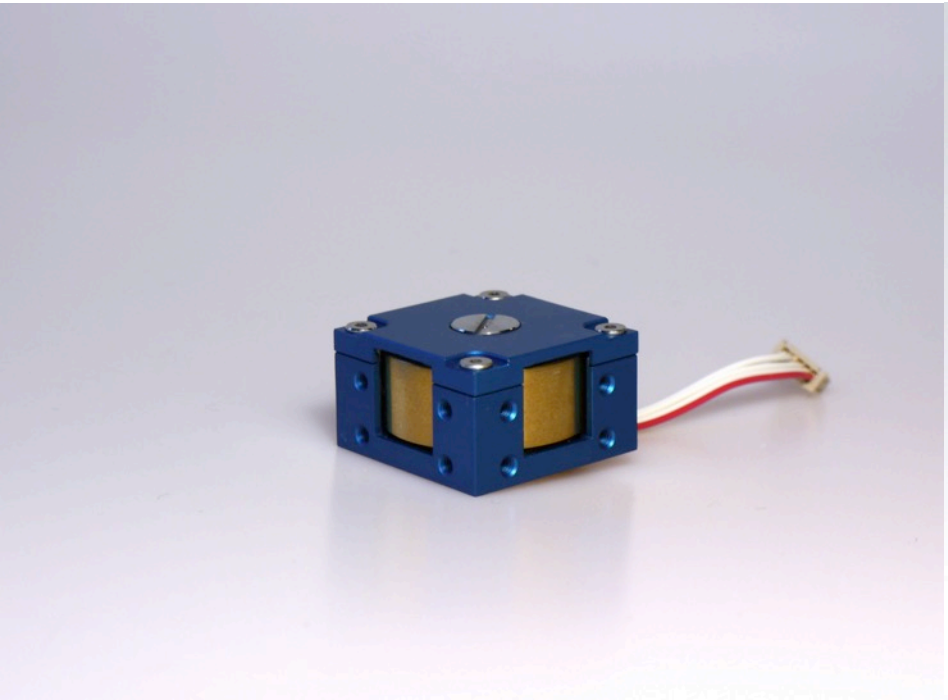
7-8 arcseconds RMS (1-sigma)

Hyperion's reaction wheels

The reaction wheels allow for control the attitude of the satellite

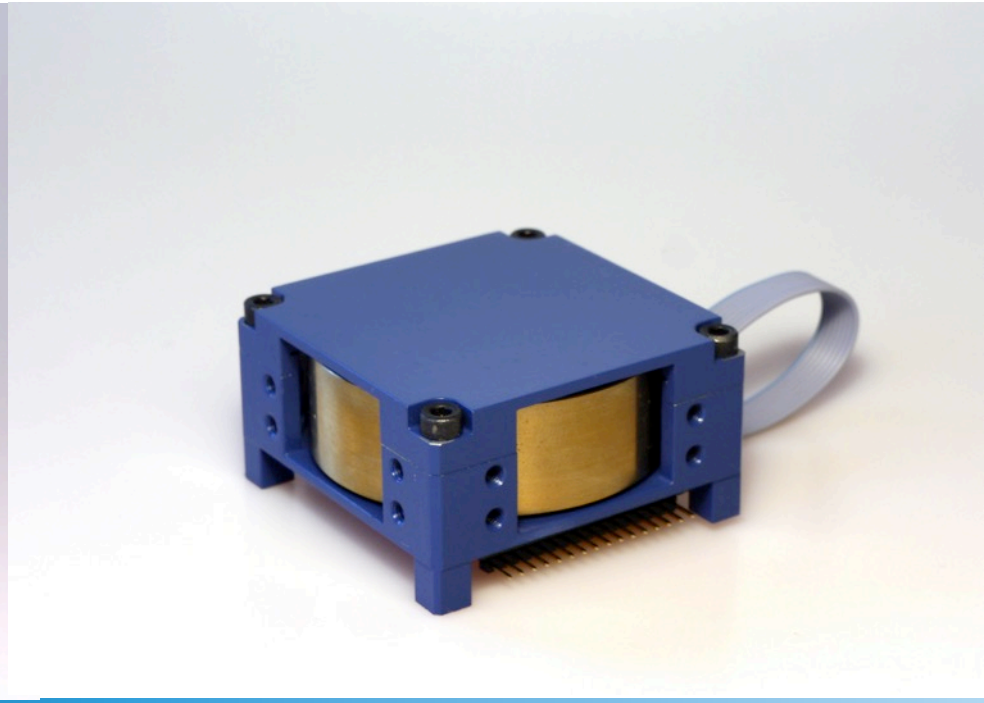
HT-RW210: optimized for 1-3U cubesats

- Dimensions: 25x25x15 mm^3



HT-RW400: Optimized for 6-12U cubesats

- Dimensions: 50x50x27.5 mm^3



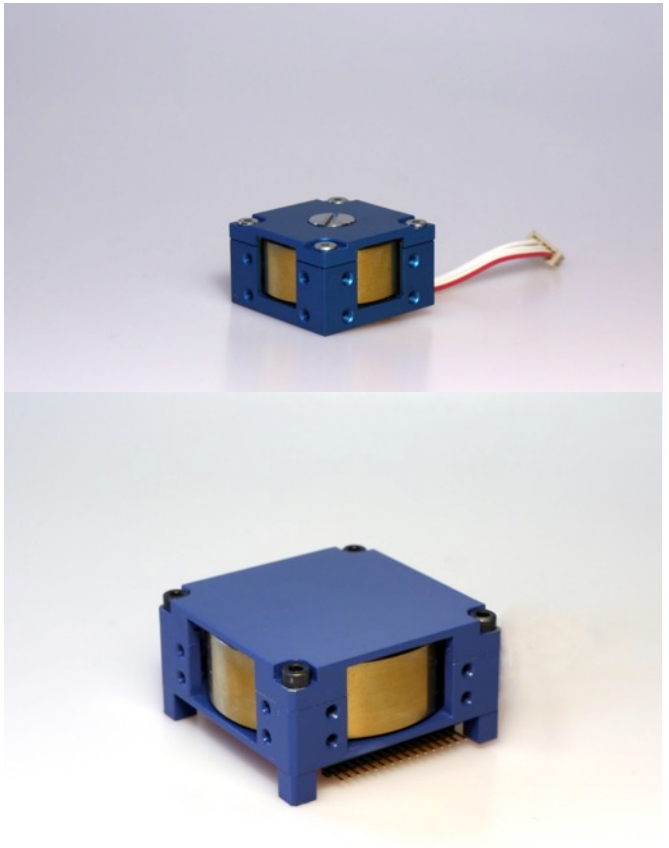
Reaction Wheels

HT-RW210 Series

- 25x25x15 mm^3
- Intended for small (up 4U) CubeSats
- Three models:
  - HT-RW210.15: 1.5 mNms
  - HT-RW210.30: 3.0 mNms
  - HT-RW210.60: 6.0 mNms

HT-RW400 Series

- 50x50x27.5 mm^3
- Intended for 6-12U CubeSats
- Three models planned:
  - HT-RW400.30: 30 mNms
  - HT-RW400.30P: 30 mNms, higher torque, reduced vibration
  - HT-RW400.60: 60 mNms



Magnetorquers

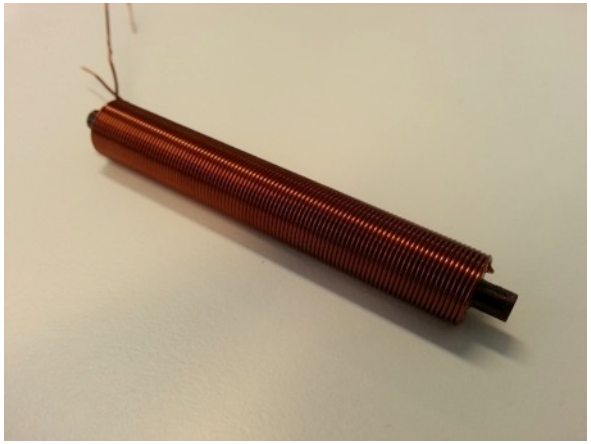
HT-MTQ200 Series

- 80x11x11 / 25x19x19 mm^3
- Intended for small (up 4U) CubeSats
- Highly efficient
- Two models:
  - HT-MTQ200.20: 0.2 Am^2 , 100 mW, boost to 1 Am^2
  - HT-MTQ200.15: 0.15 Am^2, 300 mW, boost to 0.25 Am^2

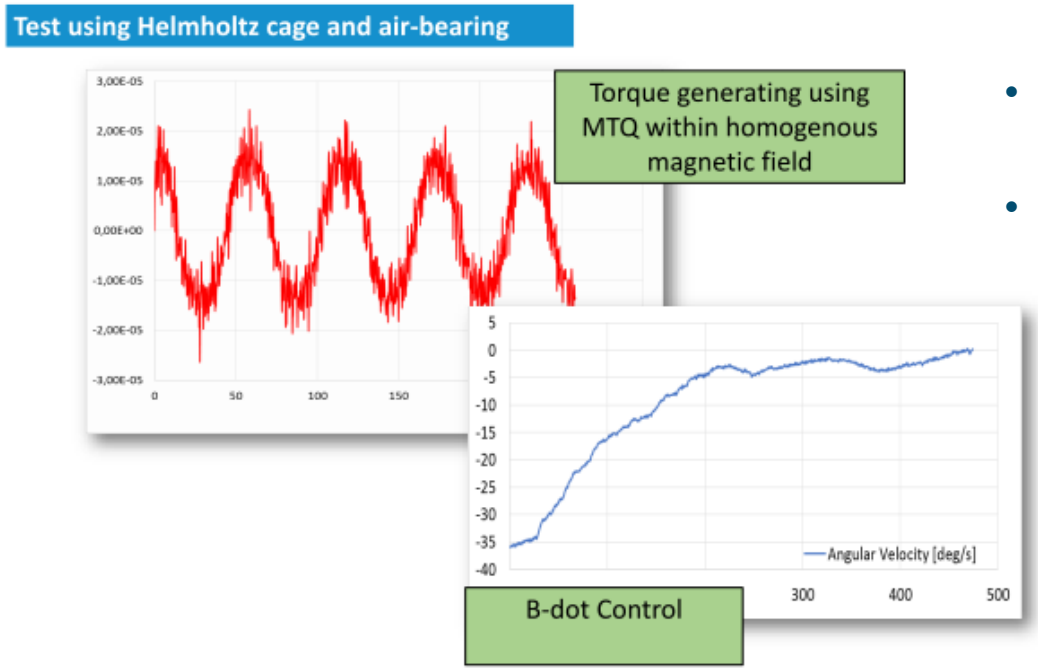
HT-MTQ400 Series

- 80x12x12 / 65x16x16 mm^3
- Intended for 6-12U CubeSats
- Highly efficient
- Two models:
  - HT-MTQ400.40: 0.4 Am^2, 300 mW, boost to 2 Am^2
  - HT-MTQ400.50: 0.5 Am^2, 500 mW, boost to 1.5 Am^2

Drive electronics can be tailored to application.



Magnetorquers



- Fully controllable dipole moment
- Very high energy efficiency at nominal dipole strength
- “Boost” mode, to allow fast operations, if power supply permits
- Tested at BST : De-tumbling of a 3U CubeSat:
  - Within 200 seconds to within wheel range
  - Within 500 seconds to near stand still

Hyperion's iADCS

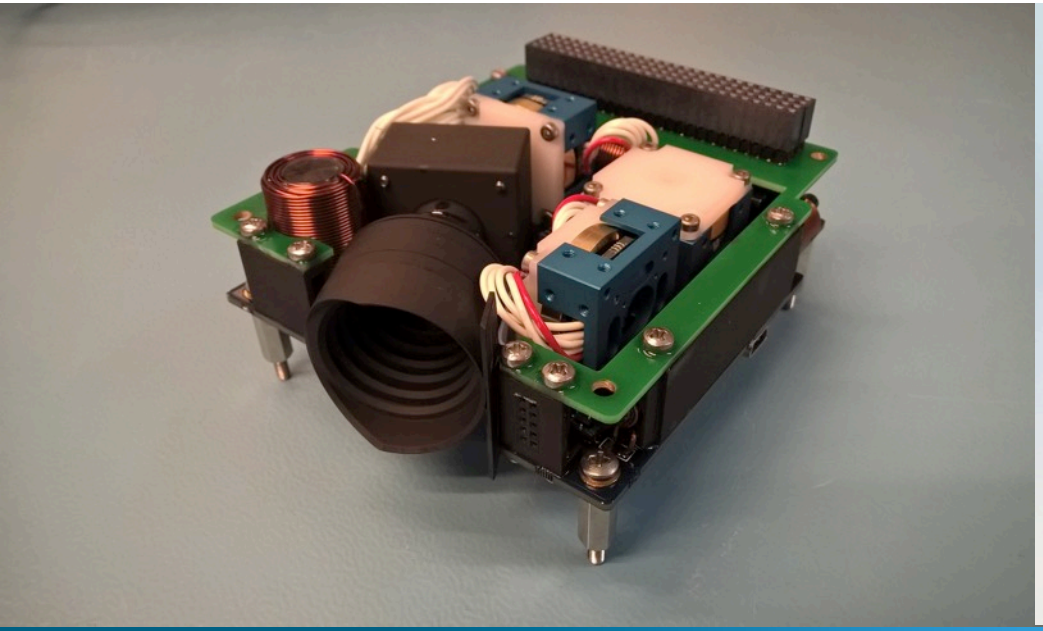
The integrated ADCS determines and controls the attitude of the satellite

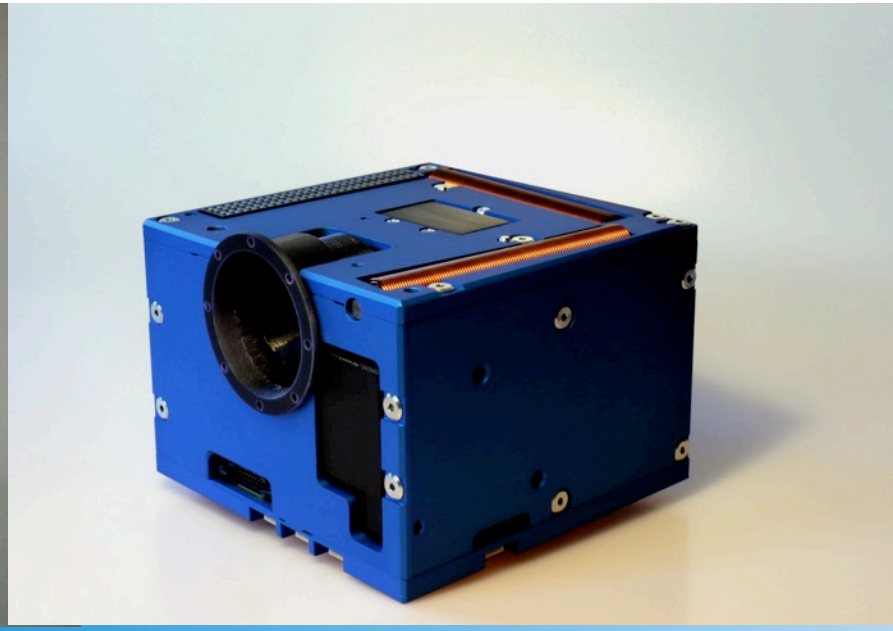
HT-iADCS100: intended for 1-3U cubesats

- Dimensions: 90x96x32 mm^3

HT-iADCS400: intended for 6-12 U cubesats

- Dimensions: 96x96x66 mm^3





iADCS-100

¼ unit CubeSat compatible

Pointing knowledge < 30 arcseconds

Pointing accuracy << 1 degree

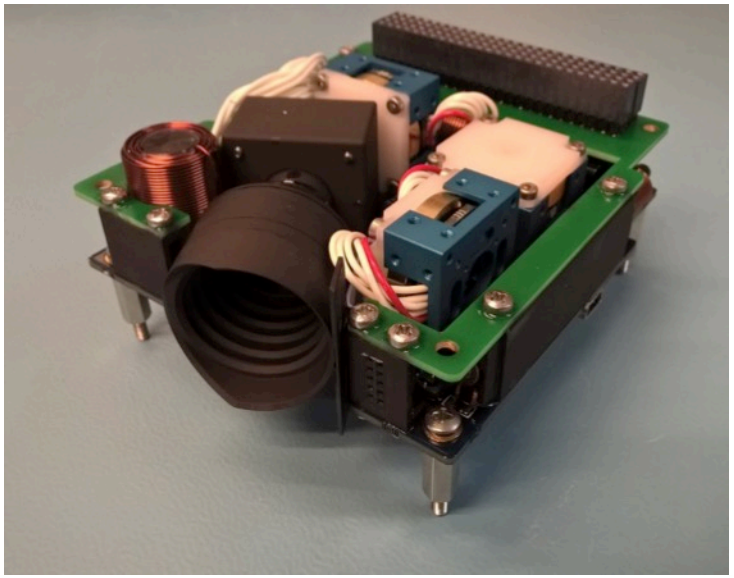
< 1.8 W power consumption (< 3W peak power)

Fully autonomous modes:

- Target tracking
- Sun pointing
- De-tumbling
- Nadir pointing

3 axes stabilization for up to 3U CubeSats

- Reaction wheels
- Magnetorquers



iADCS-400

0.7 unit, CubeSat compatible

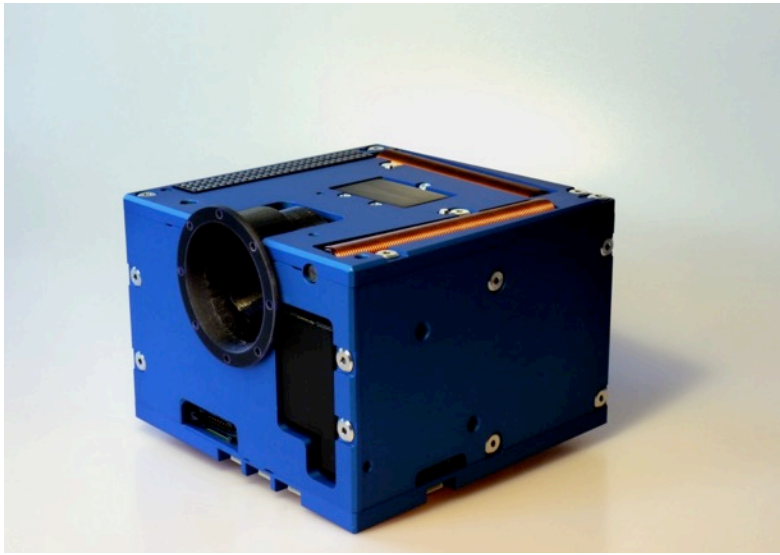
Pointing knowledge < 30 arcseconds

Pointing accuracy << 1 degree

< 6 W power consumption (peak power)

Fully autonomous modes:

- Target tracking
- Sun pointing
- De-tumbling
- Nadir pointing



3 axes stabilization for 6-12U CubeSats

- Reaction wheels (30 mNms, up to 2 mNm torque. 60 mNms is optional)
- Magnetorquers (0.5 Am2)

Hyperion’s propulsion systems

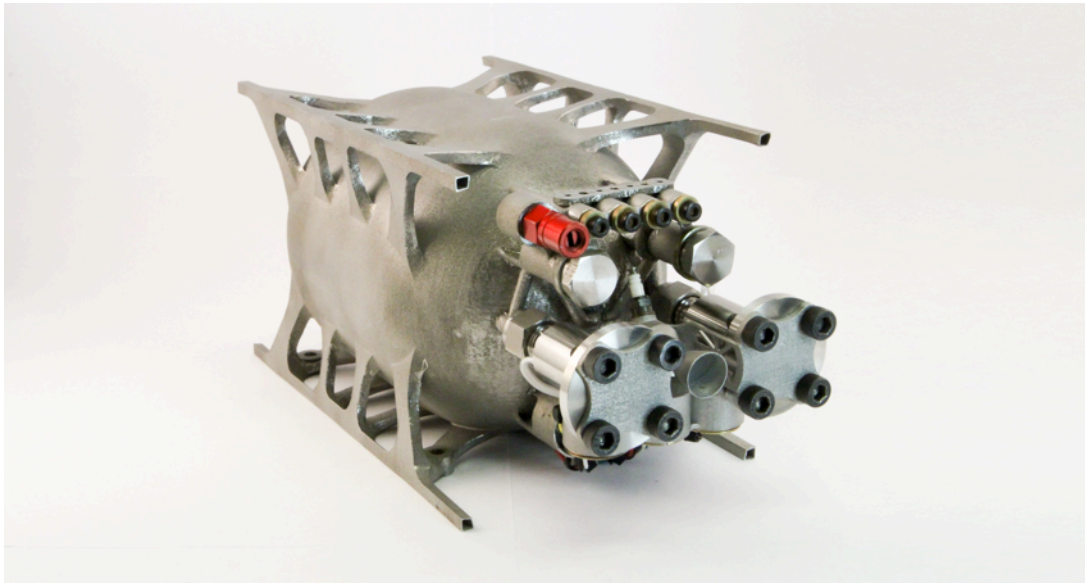
Increasing mission life time from days to years

PM400 Propulsion unit

- Dimension: 2U
- Thrust: 1N
- Bipropellant
- 3D printed
- Safe and non-toxic

Your satellite where it has to be

- Orbit maintenance
- Orbit control
- De-orbiting



Hyperion's imager

The imager is based on star tracker heritage

HT-IM.200.16: currently available for CubeSats

- Dimensions: 30x32x38 mm^3
- 5 Hz image rate
- 4 Mpixel resolution
- Fast USB-interface available
- Monochrome or color version available

Hyperion's payload processor

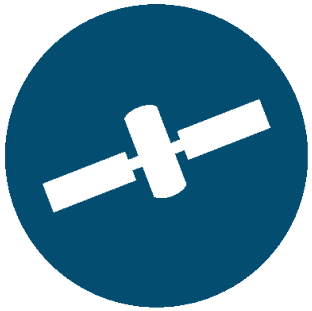
The payload processor allows for high performance flexible computing with a small footprint

CP400.85: currently available

Dimensions: 50x20x5 mm^3

- 500 MHz
- 512 MB Ram
- Plug and play ready design
- Linux based operating system
- "Desktop computer in a satellite"

Contact information



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