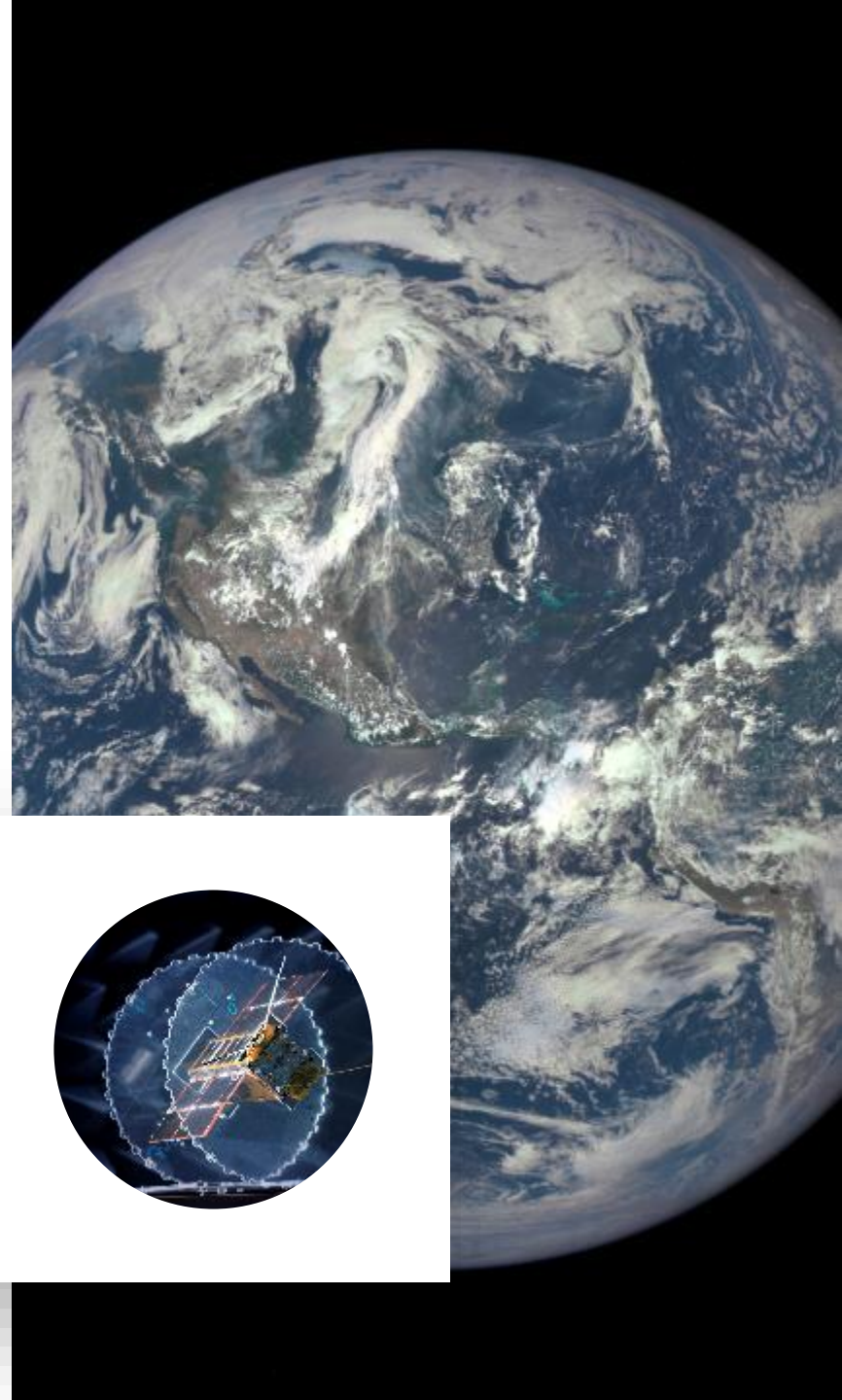
More than 10 years
in space industry

C3S

From reliability to traffic management in the world of nanosatelittes



SECURITY, DEFENCE AND OUTER SPACE CONFERENCE

9-10 May 2023

Facts about Earth orbiting satelites

Low Earth Orbit, spanning an altitude range of about 200 to 1500 km, has a total volume of around one trillion (10^{12}) cubic kilometres.

- Number of satellites placed into Earth orbit (LEO, MEO, GEO)*
  About 15 430
- Number of these still in space
  About 10 290
- Number of these still functioning
  About 7 600
- Total mass of all space objects in Earth orbit
  More than 10 800 tonnes

(ISS is 450 tonnes and the rest is about 29 pcs of Airbus A380)

*https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

Artistic impression of the satellites around Earth

Current problems of space traffic from an industry point of view

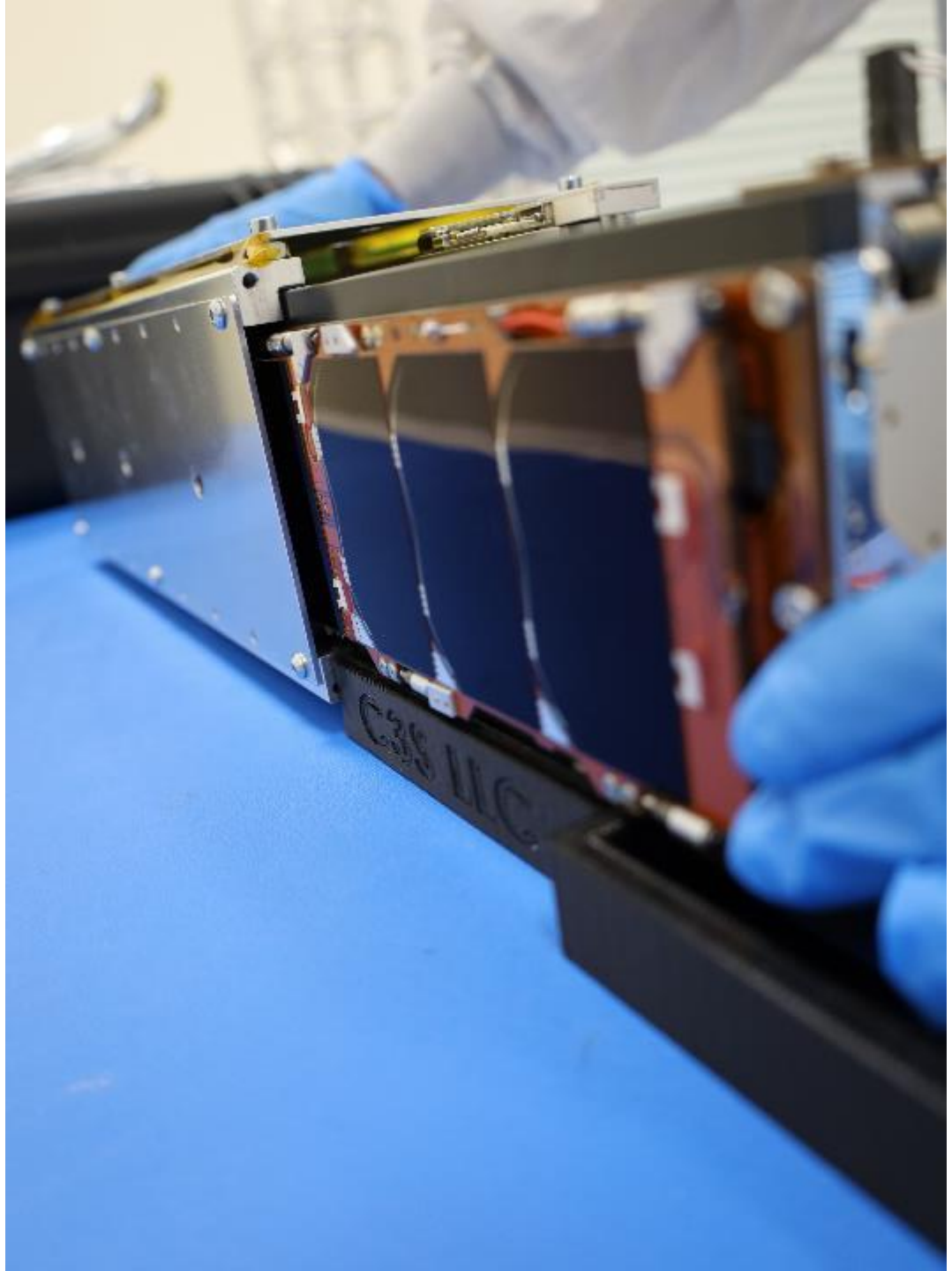
1) **Out of 10 290 satellites only 7 600 is working** (30% is waste)

2) There are **no traffic** rules in place and **the technology used is not standardized or readily available.**

- In the most crowded area (LEO) the averge speed is 7 km/sec.
- The average collisional velocity in LEO is 10 km/sec.
- There are already a lot of fragments:
  - 36 500 space debris objects greater than 10 cm
  - 1 000 000 space debris objects from greater than 1 cm to 10 cm
  - 130 million space debris objects from greater than 1 mm to 1 cm

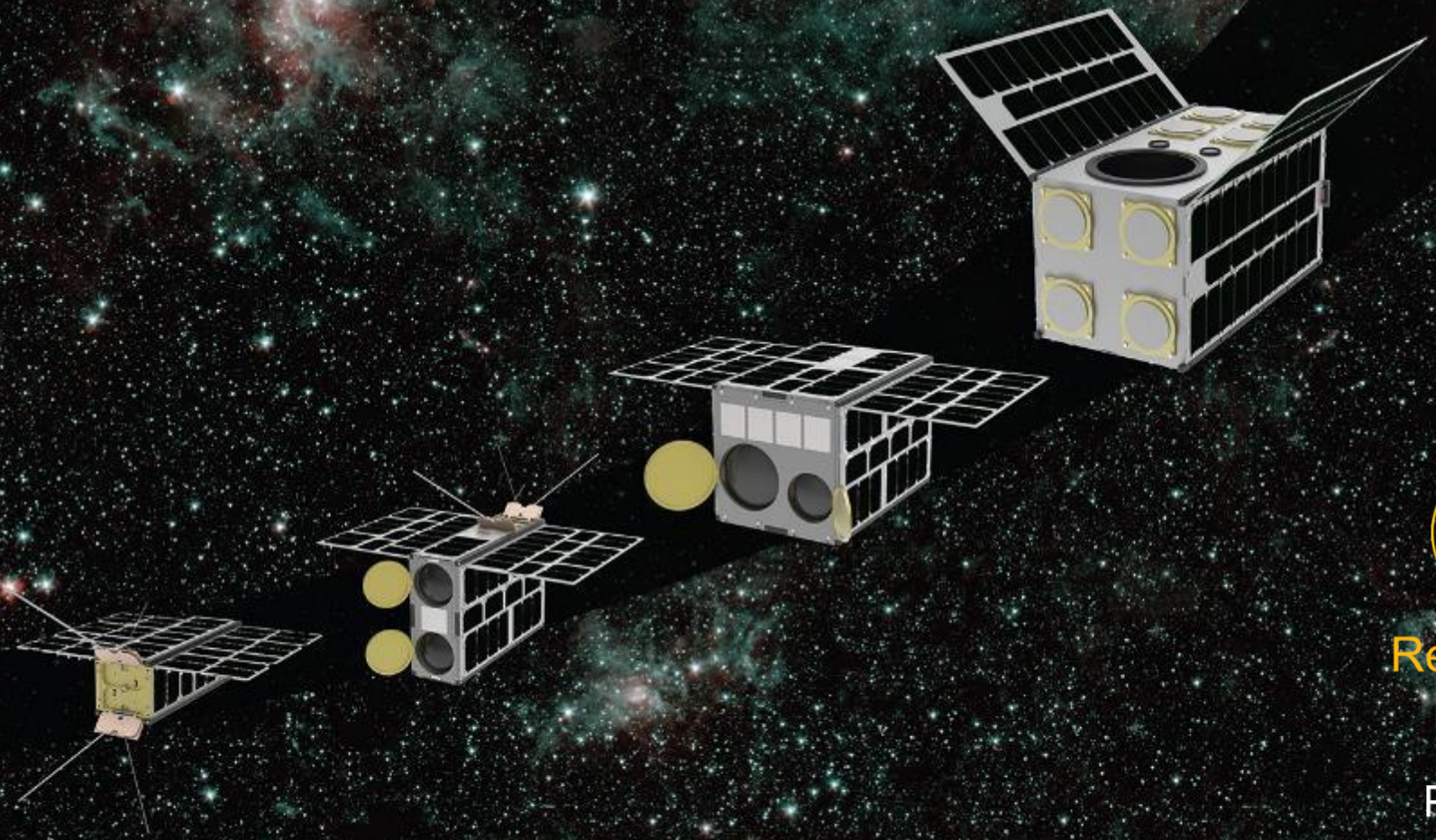
https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

An astronaut aboard the ISS captured an image of a Starlink batch.



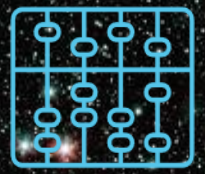
How to build a working nanosatellite for space based services?

Use traditional space industry knowledge



Unique combination of

Redundant Design



Component Density

Thermal Optimization

Provides higher reliability, availability and much longer life than competitors.

Major competencies and focus areas

C3S LLC is a determining player in the international nanosatellite industry. Our mission planning activity encompasses 3...16U, high-reliability platform, and subsystem design, as well as the prelaunch simulation software and mission operation.

Beyond the world of CubeSats, we participate in large satellite projects as the designer of power distribution systems and payload synchronization. Long lifecycle and high availability are the characteristics of our in-house developed, and redundant subsystems.

Power distribution

Custom made DCDC converter and **power distribution systems** for medium- and large satellites

Thermal design

Solutions focused on thermal problem solving.

Turnkey solution

From idea to space data: mission planning, platform manufacturing, integration testing, launch management, satellite operation.

In-house manufacturing

ESA certified hand soldering, transformer winding, EGSE.

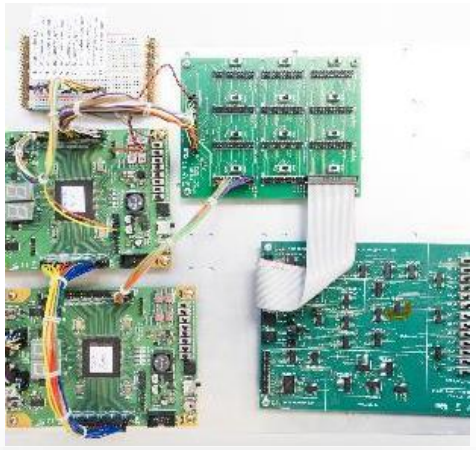
ESA Technology domains	C3S LLC.
TD 1 On-Board Data Systems	✓
TD 2 Space System Software	✓
TD 3 Spacecraft Electrical Power	✓
TD 6 RF Payload and Systems	✓
TD 8 System Design & Verification	✓
TD 9 Mission Operation and Ground Data Systems	✓
TD 12 Ground Station System and Networks	✓
TD 15 Mechanisms & Tribology	✓
TD 18 Aerothermodynamics	✓
TD 20 Structures & Pyrotechnics	✓
TD 21 Thermal	✓
TD 25 Quality, Dependability and Safety	✓

Crucial background beyond nanosats

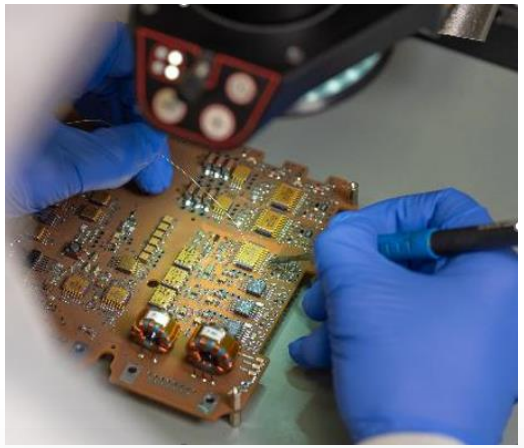
Close cooperation with ESA / TAS / Airbus / OHB / MSI's:

- ✓ Custom DC-DC converter up to 200W (TRL7), Custom DC-DC converter up to 750W (TRL5)
- ✓ Further parallelization available: used in a 1.5kW system
- ✓ FPGA/uC Based OBDH
- ✓ Payload control unit design and MAIT
- ✓ Full sub-system design support with mechanical and thermal design and analysis

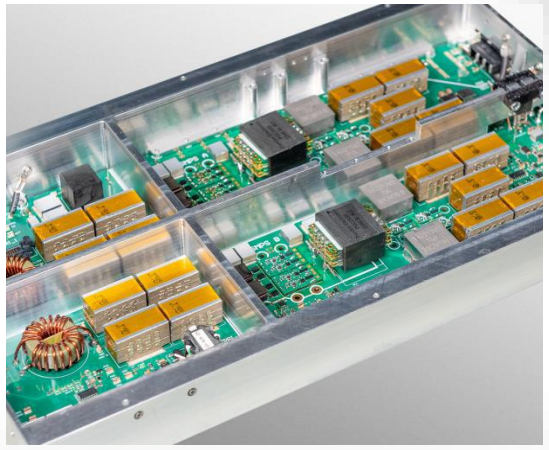
Custom Power Supply



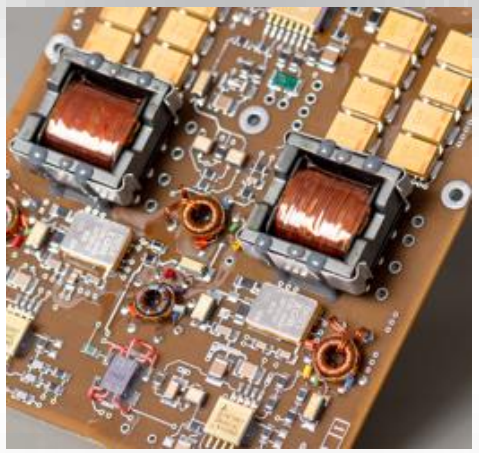
PLATO 2.0 AEU



Custom Power Supply (EQM)



GRASSHOPPER



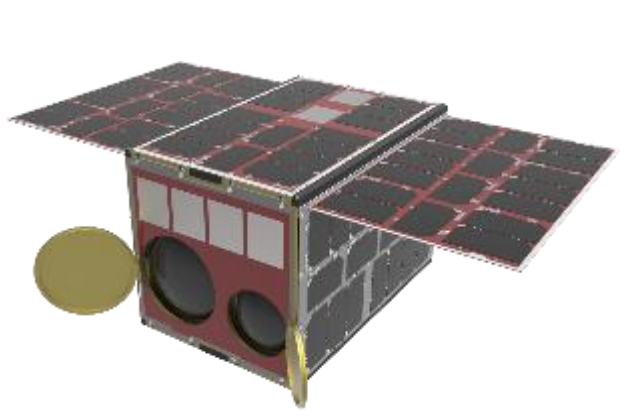
Component rework at C3S for JUICE Power System Card

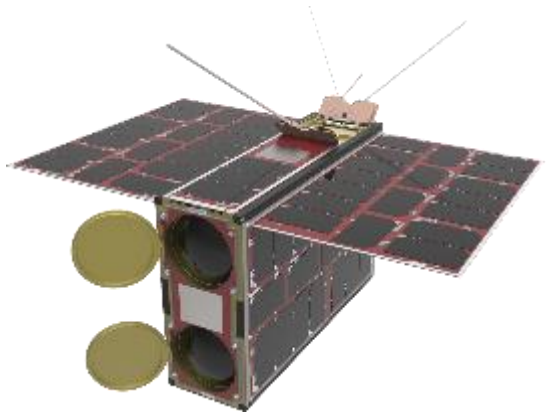
SMILE PSU

10 out of 10 CubeSat platform

Main features

- ✓ Flight heritage
- ✓ Single point of failure tolerance
- ✓ Double redundancy in all subsystems
- ✓ High reliability and high availability
- ✓ In-house developed subsystems based on ECSS standards
- ✓ Stackable design as seen on *NASA State-of-the-Art of Small Spacecraft Technology* report
- ✓ Developed in close cooperation with the European Space Agency
- ✓ Unique wiring system, moderate cable usage need
- ✓ Easy to scale up (3U…16U)





C3S CubeSat Space heritage

Name	Launch date	Unique solution	Satellite Platform	AI on board	EO + camera	IoT
RADCUBE (3U)	2021	The second European Space Agency's commercial CubeSat platform, where C3S led development. Handling simultaneously four payloads. The primary payload is a space weather (radiation) measurement instrument. The satellite is in orbit and has worked faultlessly since August 2021.	✓			
VIREO (3U)	2023	Earth observation mission. The mission demonstrates two different Artificial intelligence-based software and novel onboard hardware tailored for Neural Network based use cases. The satellite tests out four different cameras.	✓	✓	✓	
WREN (6U)	2023	Earth Observation satellite for drought monitoring with 16/32/25m resolution multi-spectral and SWIR cameras.	✓	✓	✓	✓
OWL (1/4 U)	2023	Satellite tracking with GPS & platform-independent subsystem developed together with European Space Agency. The subsystem will have the capability to collect IoT data as well.				✓
MAUVE (16 U)	2025	Space astronomy satellite for scientific use in Low Earth Orbit. It is similar to Earth Observation but facing In the opposite direction to Earth and collecting information from distant planets and galaxies.	✓		✓	✓

12

ESA Projects

Out of 12 contracts, seven are **successfully closed**, and the rest are on schedule. C3S won on **an open competition** tender last year.

30+

Custom Space - subsystem designs

Electrical, mechanical software FPGA, test equipment etc...

57

Months spent in space

Faultless operation with its own mission operation centre and ground station

40

Team

Our **skilled engineers** from different areas and specializations work on **space industry related developments.**

C3S Earth Observation Projects

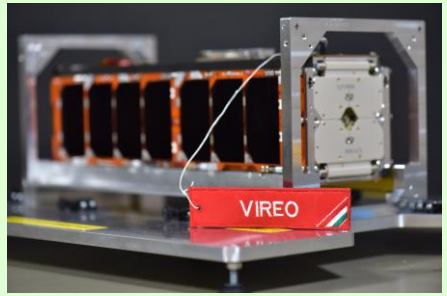
Currently

VIREO

Size: 3 Unit
Start: 15.04.2023
Mission AI on board IoD
New subsystem: IPC
New launch system: OTV
Camera A
- ✓ Sensor resolution: 640 x 448
- ✓ RGB
- ✓ FOV: 18.3 °
- ✓ approx. GSD: cca. **60-70 m**

Camera B
- ✓ Sensor resolution: 640 x 448
- ✓ RCCB (Red-Clear-Clear-Blue)
- ✓ FOV: 18.3 °
- ✓ approx. GSD: cca. **60-70 m**

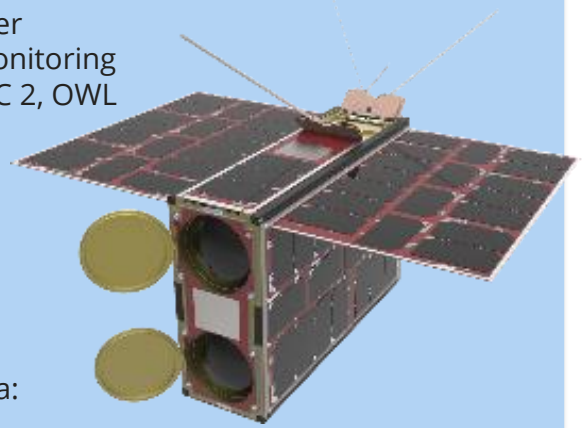
Camera C & D
- ✓ Sensor resolution: 1920 x 1080
- ✓ RGB
- ✓ FOV: 14.3 °
- ✓ approx. GSD: cca. **40-50 m**



End of 2023

WREN

Size: 6Unit
Start: 2023 November
Mission: Drought monitoring
New subsystems: IPC 2, OWL



Multispectral camera:
- ✓ GSD: **16 m**
- ✓ Image Swath @500km: 32km
- ✓ Optical field of view 4°
- ✓ Up to six spectral bands
- ✓ Image data format: Raw (up to 16 bit/pixel), JPEG2000 lossless or JPEG200 lossy

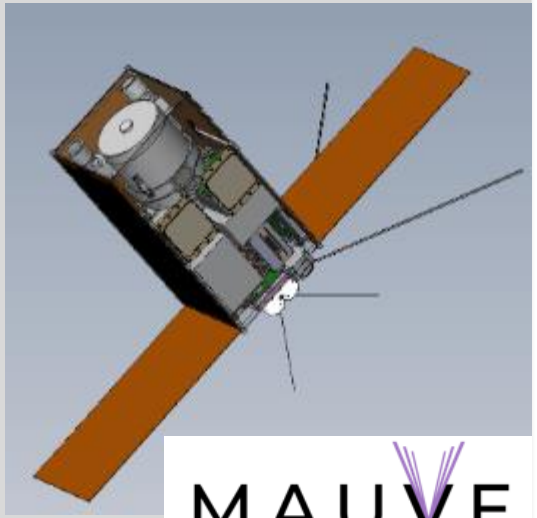
SWIR camera
- ✓ Resolution: 0.3 MP
- ✓ Spectral range: 900-1700 nm
- ✓ GSD: **25 m**
- ✓ Ground image footprint: ~16x13km
- ✓ Optical field of view: ~2°

End of 2025

MAUVE

Size: 16 Unit
Start: 2025
Mission: Space astronomy

Payload:
- ✓ 13 cm diameter space telescope,
- ✓ UV spectrometer



Is the industry ready for space traffic regulation?

Not, but there are some promising solutions available!

Already in use

- ✓ Radar-based tracking and collision avoidance system (NORAD, private companies) however it is not precise and not real-time.
- ✓ Satellite ID and documentation,
- ✓ Recognition of what satellite has what ID but it is slow (sometimes it takes weeks)

Some companies use

- ✓ Miniaturised propulsion systems (low number of operators using it)
- ✓ Automated collision avoidance system for some satellite types but there is no real coordination between the affected parties.

What is needed?

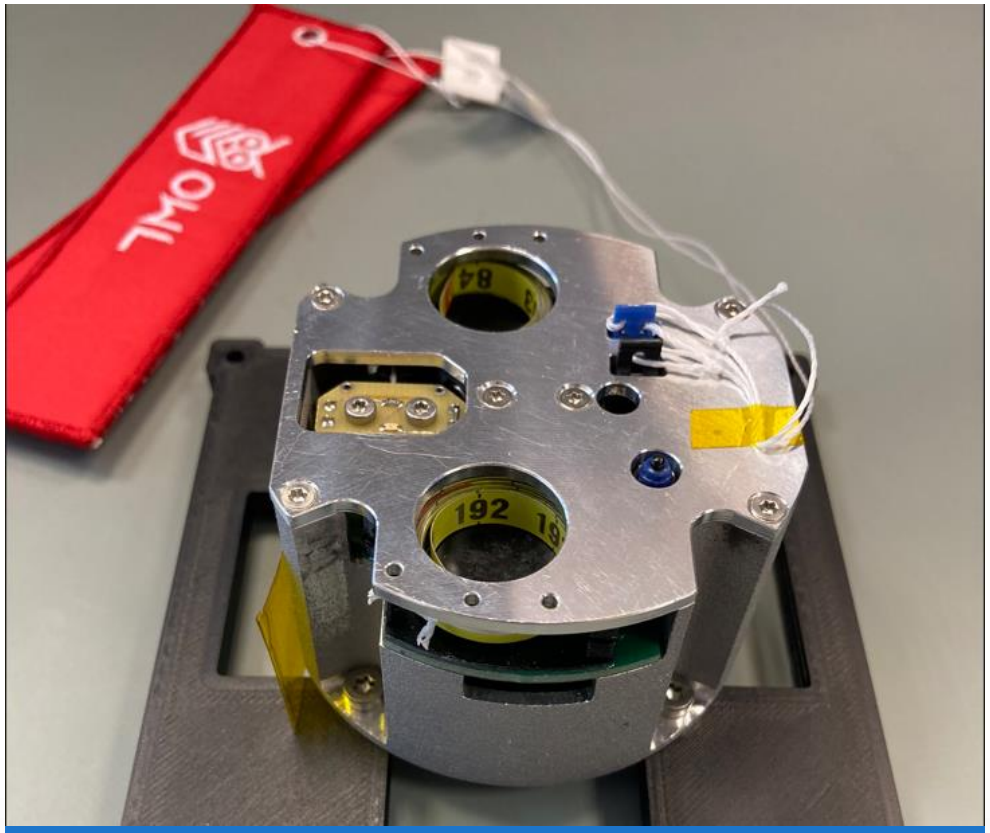
- ✓ Identification (and clear ownership) for all objects, just after the separation
- ✓ A solution that works if the satellite has a failure
- ✓ A solution that works for non-functioning objects (like rocket parts)
- ✓ Coordination between the parties or automated rule-based avoidance

Example: OWL

The OWL is a beacon signal transmitter that transmits short, periodic RF messages (VHF), allowing the identification and localization of the hosting satellite:

- ✓ „Tuna Can" volume compatibility (CDS rev. 14)
- ✓ Hosting satellite independent operation from integrated battery
- ✓ Integrated GNSS module
- ✓ Hosting satellite health monitoring
- ✓ Wide external power voltage range: 3V...16.8V
- ✓ 293 bps raw data rate, GMSK modulation
- ✓ Omnidirectional receiver ground station

Currently: Passed FAR, TRL-9 closure is expected by the end of October

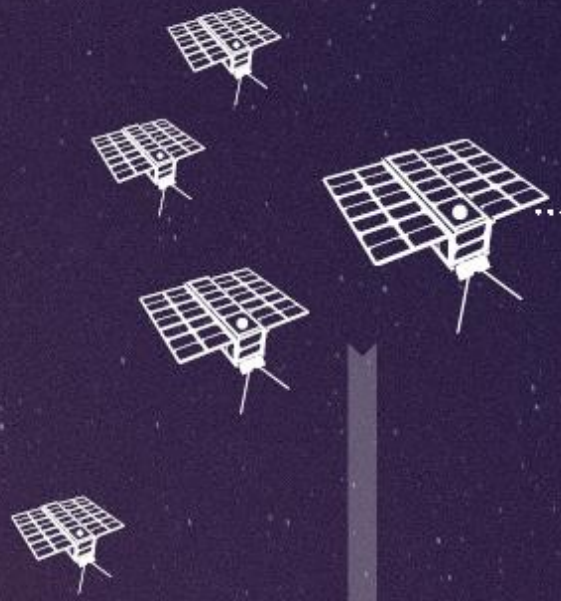


OWL

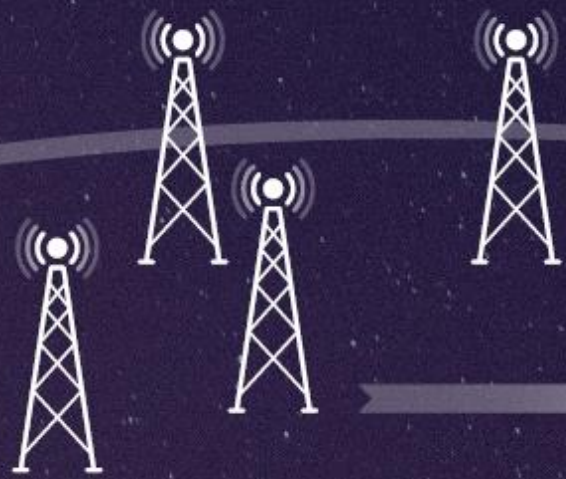
Flight Model

OWL

- Mass less than 150 g
- Dimensions 59x64x36 mm
- Comes with an integrated GNSS module, battery and an optional dosimeter
- Based on the RILDOS standard
- It can independentily measure TID and per-axis angular velocity
- It has a GNSS, and you can have onboard access to its data too!



MOC



01
IN-ORBIT CUBESAT WITH OWL

02
GROUND STATIONS

03
END USERS WITH MOC

Contact

Our headquarter is in a large office building / shopping mall. Please do not hesitate to contact us for detailed guidance in case of a personal visit.

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