# PLATO: An ESA mission to search for habitable exoplanets orbiting Sun-like stars

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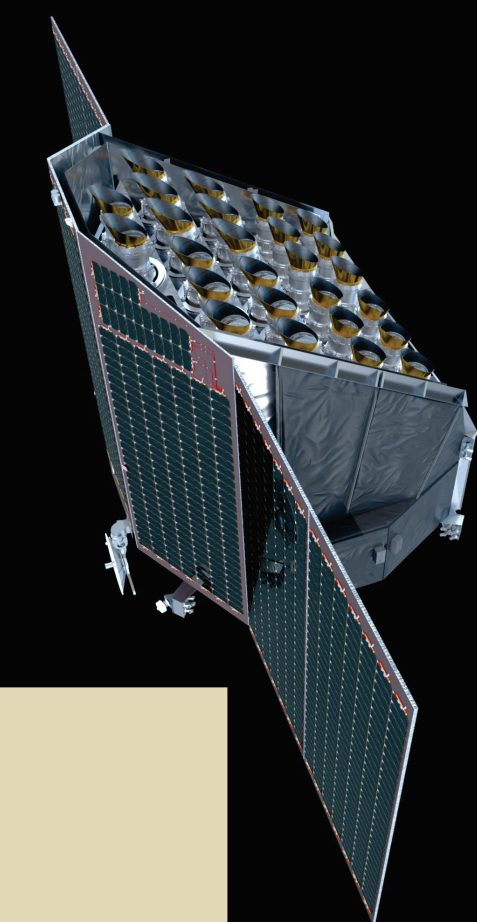
## Summary

PLATO (PLAnetary Transits and Oscillations of stars) is the third medium class mission (M3) in ESA's Cosmic Vision programme. Scheduled to launch in 2026, PLATO's main objective is the study of down to Earth-size planets orbiting up to the habitable-zone of Sun-like stars. PLATO will be complementary to TESS, which focuses primarily on shorter period planets and therefore explores the habitable zone of late type dwarf stars.

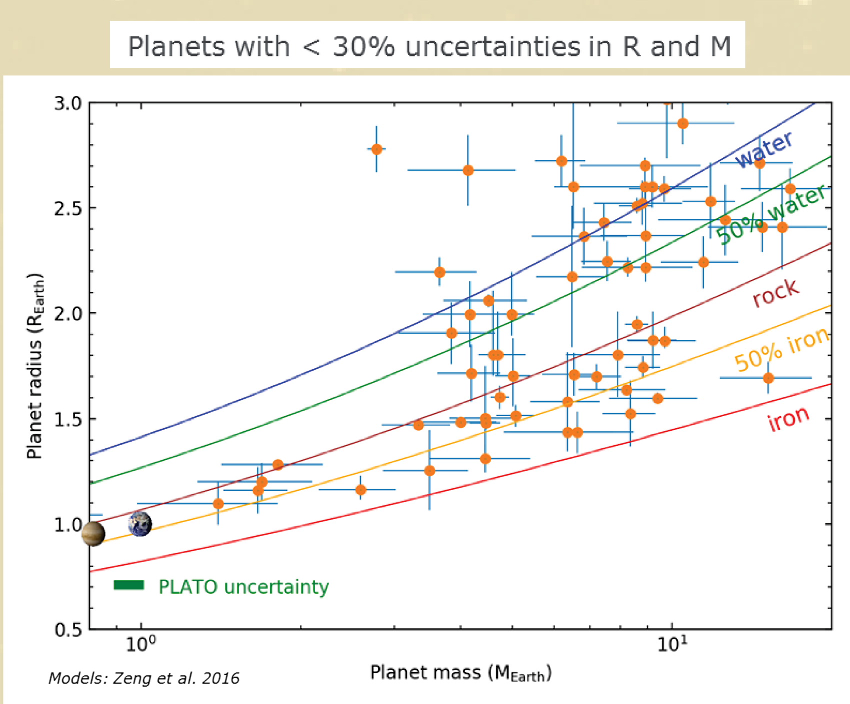
At present the transit method is the only proven technique that allows us to detect and characterise rocky, long period planets. PLATO will use the transit method for the detection and characterisation of exoplanets, combined with the asteroseismic analysis of their host stars. PLATO's core observing sample will consist of bright Sun-like stars of $m_V < 11$, which will enable us to determine with unprecedented accuracy stellar ages and the bulk properties of small planets, including their masses from radial velocity measurements at ground-based observatories.

For statistical studies, PLATO will also monitor a large sample of Sun-like stars with $m_V < 13$ and a sample of cool late-type dwarfs with $m_V < 16$, along with a small sample of bright stars distributed over the HR diagram observed in two colour bands.

The nominal duration of the mission is 4.25 years, with consumables available for 8.5 years. The mission is currently in development, phase B2.



## Required accuracies

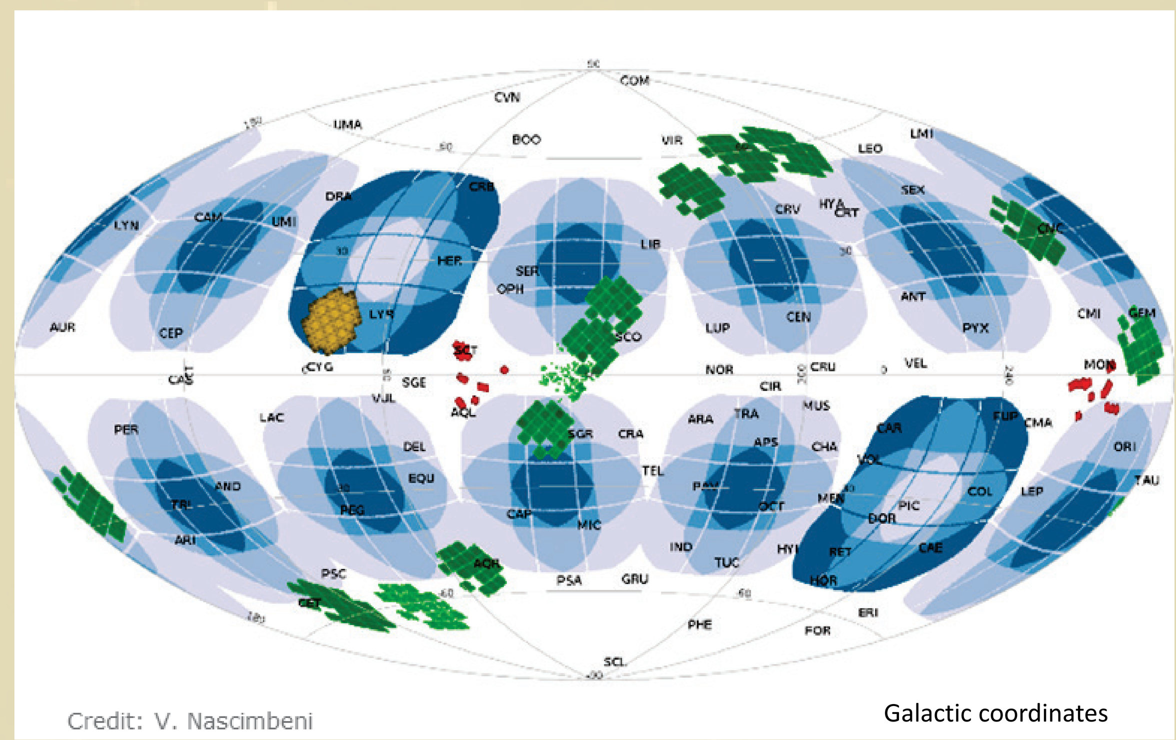



PLATO will determine:

radii (3% accuracy)
masses (10% accuracy)
ages (10% accuracy)

for Earth-size planets orbiting G0 dwarf stars with $m_V < 10$

## Observation strategy




For nominal science mission:

- 2 long pointings lasting 2 years each (fields with outer dark blue areas)

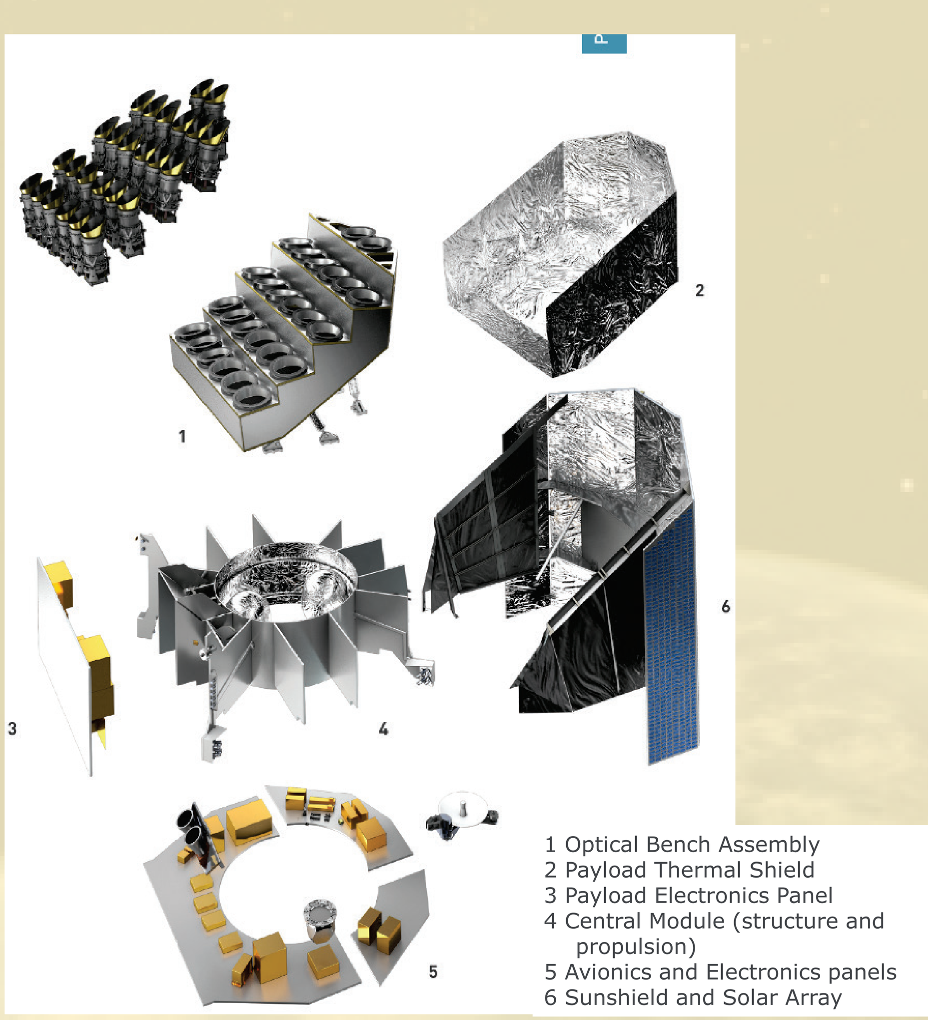
Alternative scenarios:

- 1 pointing lasting 3 years (outer dark blue fields) + 1 year step-and-stare (any of the other fields)
- 1 long pointing lasting 4 years

The final strategy will be decided 2 years before launch

*Red areas: CoRoT fields*
*Yellow area: Kepler field*
*Green areas: K2 fields*

## Spacecraft



1 Optical Bench Assembly
2 Payload Thermal Shield
3 Payload Electronics Panel
4 Central Module (structure and propulsion)
5 Avionics and Electronics panels
6 Sunshield and Solar Array

- Mass: ~2200 kg (including 80 kg launch vehicle adapter and 126 kg propellant and system/ maturity margins)
- Power generation: 2200 W
- Telemetry through X and K-band
- Average downlink capacity: ~ 435 Gb per day

- Launch with Ariane 6.2 in 2026 into an orbit around L2
- Mission nominal science operations: 4 years
- Satellite/instrument designed to last with full performance for 6.5 years
- Consumables will last 8.5 years

- 90˚ rotation around the line of sight every 3 months

OHB System AG has been selected as industrial prime for the spacecraft, with a core team comprising Thales Alenia Space (France and UK) and RUAG Space Switzerland

## Payload

Multi-telescope approach:

- 24 «normal» cameras, cadence 25 sec, operate in "white light" (500 – 1000 nm)
- 2 «fast» cameras, cadence 2.5 sec, red and blue cameras, also used as Fine Guidance Sensor

This concept achieves:

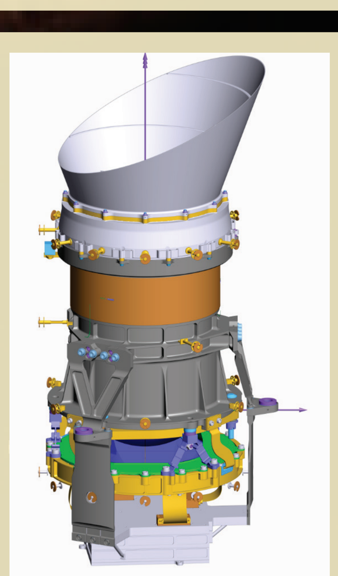
- Large FOV (large number of bright stars)
- Large total collecting area (high sensitivity)
- Redundancy

Dynamical range: $4 \leq m_V \leq 11$ (16)

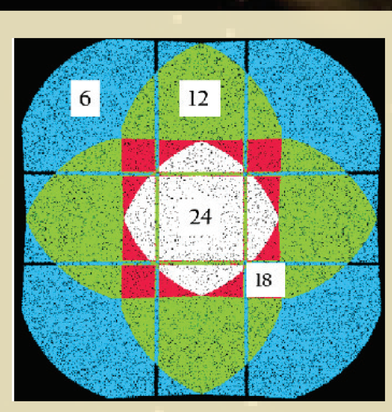
Camera characteristics:

- ~ 80 cm height
- ~ 30 cm diameter
- ~ 20 kg mass
- 12 cm entrance pupil

The Payload and part of the science ground segment is provided by the PMC, a Consortium of Universities and Institutes funded by national agencies and led by DLR

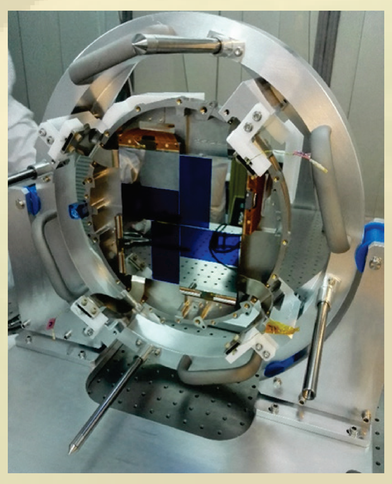


One of the 24 "normal cameras"




PLATO FoV ~ 2250 deg$^2$. The numbers show how many cameras overlap in each colour area

104 CCDs (4 CCDs per camera)
4510 x 4510 pixels
Pixel size 18 µm – 15" on sky
Built by Teledyne-e2v



Integration of the "fast cameras" CCDs in the Focal Plane Assembly prototype

## Stellar samples

| | | Core sample | | Statistical sample | | Colour sample |
|---|---|---|---|---|---|---|
| | | Sample 1 | Sample 2 | Sample 4 | Sample 5 | |
| Stars | | ≥ 15,000 (goal 20000) | ≥ 1,000 | ≥ 5,000 | ≥ 245,000 | 300 |
| Spectral type | | Dwarf and subgiants F5-K7 | Dwarf and subgiants F5-K7 | Cool late type dwarfs | Dwarf and subgiants F5-K | Anywhere in the HR diagram |
| Limit $m_V$ | | 11 | 8.5 | 16 | 13 | - |
| Random noise (ppm in 1 hour) | | ≤ 50 | ≤ 50 | - | - | - |
| Observation sampling times | Imagettes | 25 s | 25 s 2.5 s for a subsample | 25 s for > 5,000 targets | 25 s for > 9,000 targets | 2.5 s |
| | Light-curves | - | - | - | ≤ 600 s | - |
| | Centroid measurements | - | - | - | ≤ 50 s for 5% of targets | - |
| | Transit oversampling | - | - | - | ≤ 50 s for 10% of targets | - |
| Wavelength | | 500-1000 nm | | | | Red and blue spectral bands |

Plus Complementary Science Targets proposed through an open Guest Observer's Programme for 8% of the data rate, including a ToO option

## Data Products

**Level-0**

- Imagettes of selected targets for all individual telescopes
- Validated light curves and centroid curves of selected targets for all individual telescopes

**Level-1**

- Calibrated light curves and centroid curves per target, corrected for instrumental effects
- Processed imagettes of selected targets and images of sky regions

**Level-2**

- Planetary transit candidates and their parameters
- The results of the asteroseismological analysis
- Stellar rotation periods and stellar activity properties inferred from the light curves
- The stellar masses, radii and ages, with the highest precision and accuracy
- The planetary systems confirmed through the detection of Transit Time Variations (TTVs)

**Level-3**

The list of confirmed planetary systems, fully characterised by combining information from the planetary transits, the parameters of the planet-hosting stars, and the results of ground-based observations.

## Ground-Based Observations Programme

- The team performing these observations for the prime sample (GOP Team) will be selected through an open call by ESA
- The issue of the AO is planned for 3 years (TBC) before the PLATO launch
- The GOP Team will organise their respective telescope resources and execute the observations following the PLATO Mission Consortium requirements

## References

Magrin, D., Ragazzoni, R., Rauer, H., et al. 2018, Proceedings of the SPIE vol. 1069, "PLATO: the ESA mission for exo-planets discovery"

Marchiori, V., Samadi, R., Fialho, F., et al. 2019, A&A 627, id.A71, In-flight photometry extraction of PLATO targets. Optimal apertures for detecting extrasolar planets"

Nascimbeni, V., Piotto, G., Ortolani, S., et al. 2016, MNRAS 463, 4210, "An all-sky catalogue of solar-type dwarfs for exoplanetary transit surveys"

Rauer, H., Heras, A.M. 2017, Handbook of Exoplanets, Springer Living Reference Work, "Space Missions for Exoplanet Science: PLATO"

Rauer, H., Catala, C., Aerts, C., et al. 2014, Experimental Astronomy 38, 249, "The PLATO 2.0 mission"