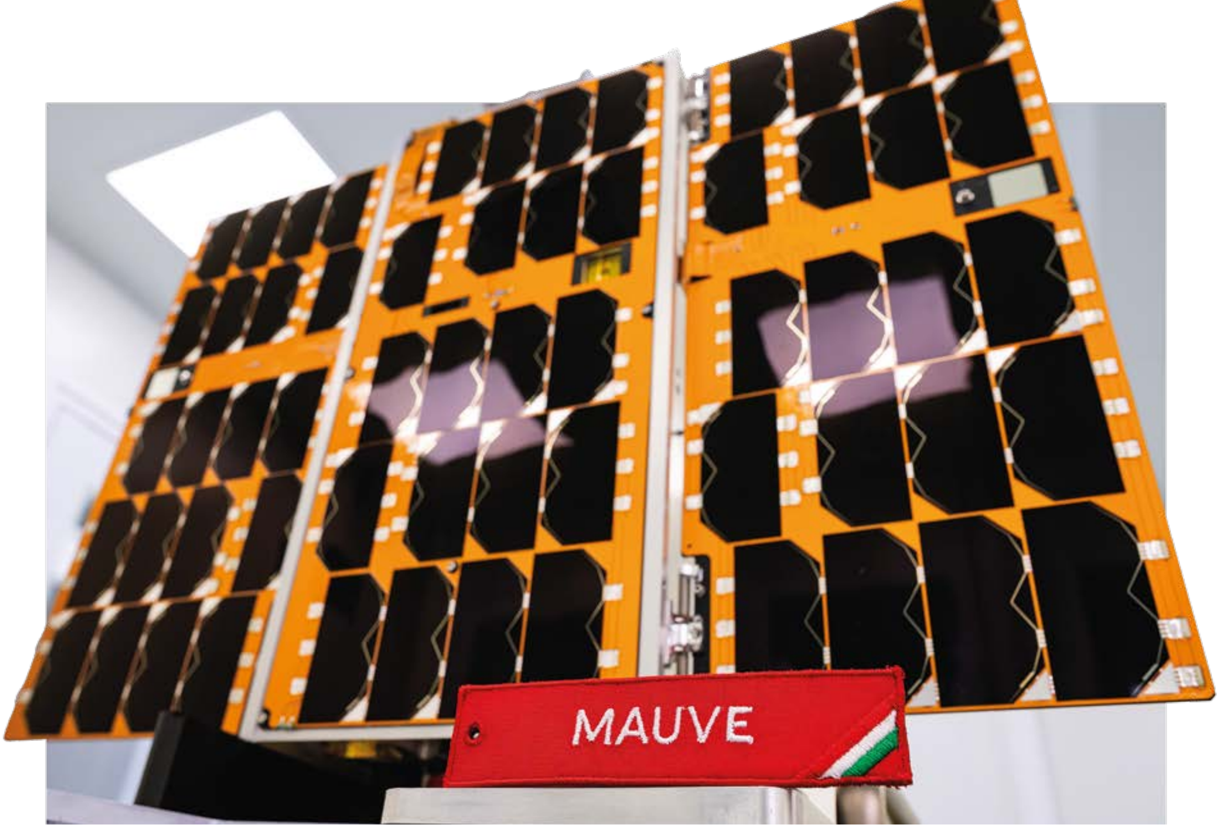


Small satellite, big ambitions

Jonathan Tennyson and The Blue Skies Science Team tell the story of this fast-track ultraviolet satellite to study stars in the time domain

Mauve is a science satellite scheduled to launch on SpaceX's Transporter-15 in October 2025. Through a radically different approach to performing space science, this small satellite with big ambitions is to study the near-ultraviolet and visible spectra of hundreds of stars. Small satellites like Mauve, built with commercial-off-the-shelf components, can deliver significant science data affordably and flexibly: these can complement large facilities and support multi-wavelength studies through follow-ups, long-baseline observations and multiple revisits to targets of interest. Small satellites can rapidly adapt to new scientific questions, fill observational gaps, and provide critical support to flagship missions.

Science data from space is essential for understanding the universe and our place within it, underpinning discoveries that range from the origins of galaxies to the conditions on potentially habitable planets. Despite the great advancements of space astronomy in recent decades, UV observatories remain scarce and are often oversubscribed (e.g. the Hubble Space Telescope). The UV region of the electromagnetic spectrum is extraordinarily rich from an astrophysical perspective for studying ionic, atomic and molecular transitions. The opacity of Earth's atmosphere in the UV, however, makes it necessary to have access from space.

Mauve is a small satellite dedicated to time-domain spectrophotometry in the near-UV and visible spectral ranges, scheduled for launch in October 2025. Designed, managed and operated by Blue Skies Space, Mauve was conceived to address a number of science questions in time-domain astronomy (TDA), including (but not limited to) the characterisation of the non-photospheric emission from stars and the physics of stellar flares. TDA develops understanding of physical processes that would otherwise be undetected in the single 'snapshots' that have so far constituted the bulk of astronomical observations. Studying time evolution of different phenomena enables both access to different physics – time encodes spatial information invisible in static observations – and to detect and understand rare phenomena that would typically not be seen in single observations.

TDA requires dedicated facilities. Observing time on major high-performance space- and ground-based facilities is heavily oversubscribed, thus long-lasting, monitoring observations are difficult to obtain. Luckily, many transient phenomena, while short-lived, are extremely bright, and thus they can be studied with small facilities like Mauve.

Telescope	13cm Cassegrain
Satellite weight	23.6kg
Spectral range	200 – 700nm
Spectral resolution	10nm (max R = 65)
Sky coverage	–46.4 to 31.8° ICRS coord. (ep=J2000)
Orbit	Sun-synchronous LEO 500km
Pointing solution	High-performance Star-tracker + Gyro 12" high frequency stability

1 *Technical specifications of the Mauve satellite, with an internal view (Mauve)*

> *"Small satellites like Mauve, built with commercial-off-the-shelf components, can deliver significant science data affordably and flexibly"*

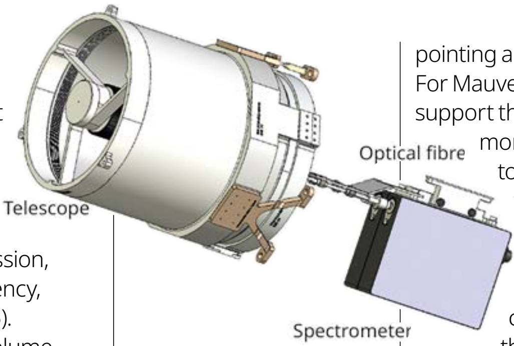
Satellite design

Mauve's satellite architecture is based on the CubeSat standard and is built around a 16-unit (16U) platform developed by C3S (Hungary), incorporating flight-proven hardware from ISISPACE (The Netherlands) for attitude control and orbit determination. To meet the demands of its UV-visible time-domain mission, it prioritises pointing stability, thermal consistency, and component redundancy (Stotesbury 2025).

The 16U platform provides the necessary volume and mass to accommodate both the optical payload and redundant systems for mission-critical functions, as seen in figure 1. Key platform modules feature built-in redundancy to ensure continued operation in the event of component failure. Deployable solar panels are used to generate power across the intended field of regard, with enough resilience to operate through partial degradation (e.g., the failure of a solar cell string) even at end of life.

Internally, the satellite is divided into two principal sections: a platform bay and a payload bay, simplifying integration and thermal isolation. Thermal management follows a passive strategy with the payload thermally isolated from the platform to operate at a cooler and more stable temperature. The spectrometer is also fed by a fibre, which both simplifies the design and removes a potential source of thermo-elastic distortion (TED). It was also deemed prudent to help minimise TED for the satellite's star trackers and telescope by using a payload interface panel as a common mounting point. The platform is designed for a minimum three-year operational lifetime, with a goal of exceeding five years.

Mauve's Attitude Determination and Control System (ADCS), provided by ISISPACE, ensures precise pointing and orientation throughout the mission. For Mauve, enhancements have been made to support the fine-pointing accuracy required for stellar monitoring. These include two star trackers to improve pointing availability and expand the accessible sky, and a high-performance gyroscope that allows arcsecond-level pointing stability, essential for this type of mission. The gyroscope enhances control by minimising rate errors, providing the stability required to ensure consistent spectral capture during long-duration observations.



2 *Mauve's payload design: a 13cm Cassegrain telescope connected via an optical fibre to a spectrometer housing a CMOS linear array.* (Mauve)

"The platform is designed for a minimum three-year operational lifetime, with a goal of exceeding five years"

The payload (figure 2) has three main components. The telescope is a 13cm aperture Cassegrain telescope developed by Media Lario (Italy), originally designed for in-orbit optical communications. This telescope has already passed extensive qualification tests – thermal, vibrational and optical – and only required two minor adaptations to support Mauve's science goals: mounting an optical fibre interface and adjusting the anti-reflection (AR) coating to match the target wavelength range. Secondly, fibre optics: an optical fibre links the telescope to the spectrometer, transmitting light efficiently while isolating the payload components from mechanical stress and temperature gradients. Thirdly, the spectrometer is a commercial, off-the-shelf unit, operating across 200–700nm in a single channel, illuminating a CMOS linear array supplied detector. This spectrometer is widely used in terrestrial applications, including biomedicine and semiconductor diagnostics and has been selected for its reliability and spectral performance. A second spectrometer is available for redundancy. The optical components are housed separately from platform systems to minimise thermal drift and mechanical interference, supporting precise and stable operation across multiple orbits.

The spacecraft is optimised for a 10:30am local time of ascending node (LTAN) Sun-synchronous polar orbit, favouring deep-space observations perpendicular to the orbital plane. This is consistent with the planned launch with SpaceX's Transporter-15.

This is a data delivery mission, in which the company Blue Skies Space manages spacecraft scheduling and science ground segment operations, while Mauve science team members define the scientific themes, target lists, and cadence requirements. Raw and calibrated data sets are delivered via Blue Skies Space's Stardrive platform under a shared data policy. Stardrive is a collaborative workspace platform that integrates tools for scheduling, simulation and data management in a single intuitive interface. Stardrive allows member scientists to actively shape observational campaigns, access mission data, and engage with global working groups.

Science programme

Mauve's science programme will be centred on spectrophotometric monitoring of bright stellar sources in the near-UV and visible wavelengths (200–700nm) to detect variability on timescales ranging from minutes to weeks and months. Mauve will therefore be in a unique position to study flares in nearby active stars.

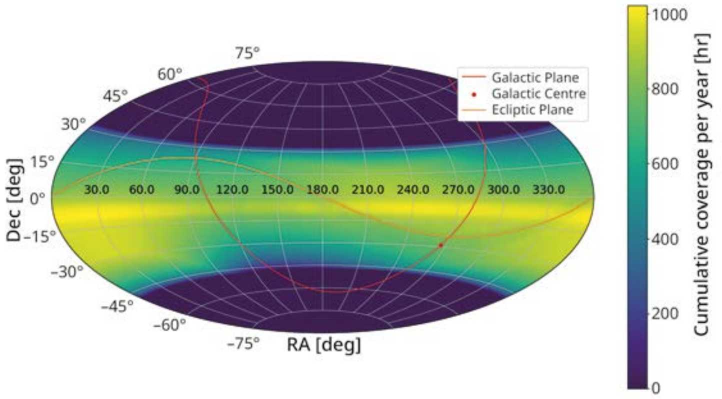
The physics of flares can be observed both in the X-ray (where emission from the flaring coronal arc is visible) and in the UV region (where emission from the transition region and chromosphere, and reprocessed emission from the heated photosphere are visible). Flares are stochastic events, with a power-law distribution of their intensity, so that the most intense (and most interesting) events are also the rarest

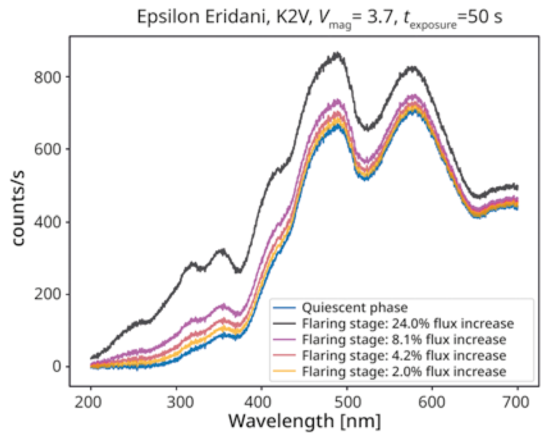
Blue Skies Space

Blue Skies Space's vision is to accelerate and expand the availability of science datasets to researchers worldwide, complementing the facilities delivered by space agencies (Archer *et al.* 2020). The company is planning a fleet of science satellites that leverage recent advances in space technology and the rapidly evolving global scientific landscape, enabling a significant reduction in satellite development time and costs. Data from these satellites will be delivered to scientists through a membership access model similar to that used by many ground telescopes (for example, the Sloan Digital Sky Survey). Following the launch of its first satellite, Mauve, Blue Skies Space will launch Twinkle, which will aim to characterise exoplanets, planetary systems and solar system bodies using visible and infrared spectroscopy (Stotesbury *et al.* 2024). In addition, the company is exploring the delivery of a larger ultraviolet telescope (Mauve+) as well as satellites to study radio signals from the cosmic dark ages.

The company has seen strong global interest in this new way of delivering science data from space, with 19 institutions from 12 countries already participating in Mauve and Twinkle. These satellites are open for participation. For more information, visit www.bssl.space.

[Mauve]





3 *Cumulative coverage per year, across Mauve's field of regard. The gradient from blue to yellow represents increasing cumulative coverage per year. The orange line shows the ecliptic plane and the red line the galactic plane, with the galactic centre shown as the red dot.* (Mauve)

4 *Simulated 50s-long observations of flares on the K2 star Epsilon Eridani (Vmag=3.7) obtained with MauveSim, the Mauve instrument simulator. The flaring spectra are simulated assuming an additional blackbody component with a temperature of 10000K on top of the quiescent stellar spectrum.* (Mauve)

(Kowalski 24, 25). Large flares are often accompanied by Coronal Mass Ejections (CMEs), that hurl large amounts of material into interplanetary space.

CMEs can be highly disruptive of the planetary environment (Pillitteri *et al.* 2022), and our own Earth has experienced such disruptions, even though on a modest scale, at least in modern times to date. But large CMEs like the XIX century Carrington event, and the more intense Miyake events inferred from isotopic data in tree rings and ice cores ^{14}C analysis can be truly disruptive of civilisation. Understanding how frequent significant events (and CMEs) are and the relation between flaring and CME frequency has a large practical interest in addition to the purely scientific one. Flares are optimally observed in the UV, and the post-flaring dips visible in the UV are one of the few diagnostics of CMEs in stars. The science that will be achieved with Mauve i.e., characterising a sample of solar-type stars with long monitoring observations is a scientific enterprise highly complementary to existing space situational awareness monitoring observations of our own Sun.

Mauve's wide field of regard covers the entire ecliptic plane and parts of the galactic plane, including the centre as shown in figure 3. This enables extended observation campaigns, accounting for Earth obscuration, to support in-depth studies of stellar variability.

Mauve's observational priorities are collaboratively decided by members of the scientific consortium, with possibilities for high-risk, high-reward science unconstrained by traditional proposal cycles. Blue Skies Space manages the science operations of the satellite and maintains data pipelines, but plays no role in determining the science programme. Some of the planned science cases (Mauve Science Team 2025) by Mauve's members include:

- Spectral energy distributions (SEDs) for classical Be and Ae stars: Mauve's broad wavelength range allows it to monitor the brightest of these objects, which emit most of their radiative output within the UV-visible spectral window. By systematically acquiring multi-wavelength SEDs for a statistically significant sample of bright classical Be and Ae stars, Mauve's survey will provide critical empirical tests for contemporary models of disc formation and evolution.
- Monitoring of Herbig Ae/Be stars: With hundreds of hours of homogeneous UV-visible observations, the survey will allow investigation of the temporal behaviour of accretion processes in these intermediate-mass pre-main-sequence stars (Hartmann *et al.* 2016).

"Observational priorities are collaboratively decided, with possibilities for high-risk, high-reward science unconstrained by traditional proposal cycles"

- Young exoplanet host stars: By observing stars between 1 and 500 million years old, Mauve will gather essential data on stellar activity during critical phases of planetary development. The expanded coverage is essential for developing representative, broadband SEDs of exoplanet host stars, which are crucial inputs for atmospheric modelling and photochemical studies.
- Flares on solar analogues: The mission is also uniquely placed to capture flares on young solar analogues, which have yet to be sampled in time-resolved UV data. High-cadence UV observations will help characterise flare frequency, intensity, and impact on planetary atmospheres (Kowalski *et al.* Segue *et al.* 2010). Figure 4 presents a simulation of what one can expect using Mauve to monitor a flare.

Mauve will also be used in coordinated observing campaigns with other ground and space observatories, providing UV-visible coverage to complement data in the X-ray, infrared, and radio regimes.

Blue Skies Space is capitalising on the rapidly changing nature of the space sector globally to deliver more science satellites (as described in the Box). With commercial launch vehicles, commoditisation of satellite platforms, commercial ground services as well as a renewed interest in the Moon, the space sector is rapidly evolving and opening new possibilities. ●

AUTHORS
Prof Jonathan Tennyson Blue Skies Space Ltd., 69 Wilson Street, London EC2A 2BB, UK and University College London, UK; **Dr Marcell Tessenyi** Blue Skies Space; **Prof Giovanna Tinetti** Blue Skies Space and King's College London, UK; **Prof Giorgio Savini** Blue Skies Space and UCL; **Philip Windred** Blue Skies Space; **Richard Archer** Blue Skies Space; **Dr Parul Janagal** Blue Skies Space; **Ian Stotesbury** Blue Skies Space; **Dr Arianna Saba** Blue Skies Space; **Ben Wilcock** Blue Skies Space; **Dr Fatemeh Zahra Majidi** Blue Skies Space; Italy **Lawrence Bradley** Blue Skies Space; and **Yoga Barrathwaj Raman Mohan** Blue Skies Space.

ACKNOWLEDGEMENTS
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101082738 and is supported by the UK Research and Innovation (UKRI)'s Horizon Europe Guarantee Scheme.

REFERENCES
Archer R *et al.* 2020 *Nature Astronomy* **4** 1017
CASCA 2009 *Final Report on Wide-Field Imaging from Space* Canadian Astronomical Society. Canada. tinyurl.com/4862kyd2
CORDIS 2022 *Mauve – a UV satellite for space science* tinyurl.com/2s3j3uhm
Harrison F A 2023 *Pathways to Discovery in Astronomy and Astrophysics for the 2020s.* Washington, DC: The National Academies Press
Hartmann L *et al.* 2016 *Ann. Rev. Astron. Astrophys.* **54** 135
Kowalski A F *et al.* 2024 *Astrophys. J.* **978** 81
Saba A *et al.* 2025 *MauveSim: the instrument simulator software for the Mauve mission RAS Tech. Instr.* (submitted); arXiv:2502.01389
Segura A *et al.* 2010 Astrobiology 10(7) 75
Stotesbury I *et al.* 2024 *Space Telescopes and Instrumentation 2020: Optical, Infrared, and Millimetre Wave* **40** https://doi.org/10.1117/12.3018791.
Stotesbury I *et al.* 2025 *Mauve Technical Note* in prep
STScI 2024 *Annual Reports - By the Numbers* 2024 STScI. tinyurl.com/bddwxu99
The Mauve Science Team 2025 *Mauve Science Paper* in prep