The Pandora SmallSat: Multiwavelength Characterization of Exoplanets and their Host Stars

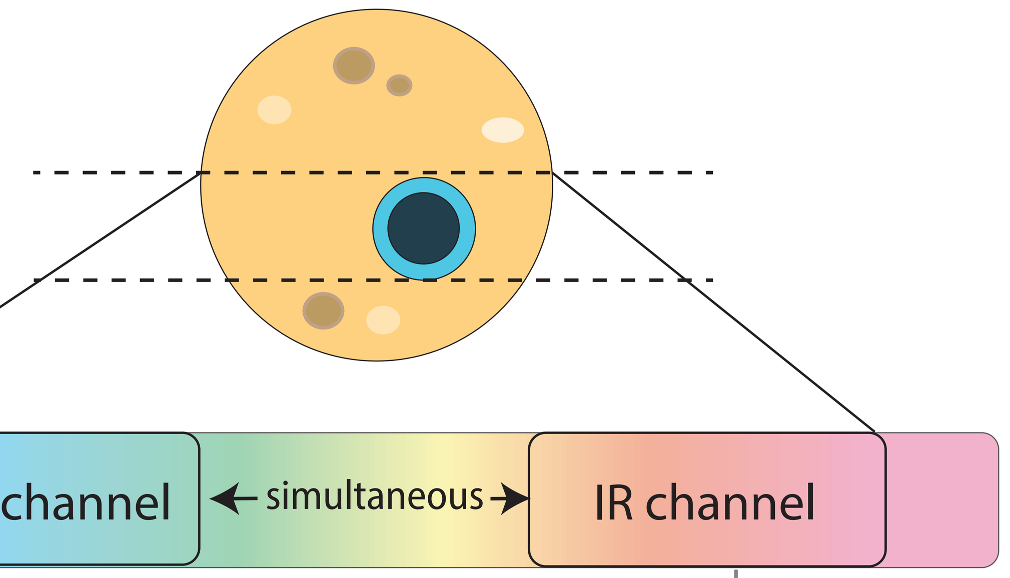
Thomas Barclay, on behalf of the Pandora Team
University of Maryland, Baltimore County and NASA Goddard Space Flight Center

Mission At-A-Glance

Pandora provides unique, continuous dual-band data to determine stellar photosphere properties and disentangle star and planetary signals in trans-mission spectroscopy.

Mission Overview

Launch Date	Mid-2020s
Payload	Telescope (0.45m)
Channels	Visible photometry IR spectroscopy
Orbit	Sun-sync LEO
Science Operations	1+ years



Wavelength: Visible channel ← simultaneous → IR channel

What do we measure? Time-varying star brightness (in visible band where stellar variability has high contrast) | Time varying spectrum (in IR band where water is strong molecular absorber)

What do measurements provide? Star spot and faculae brightness contrasts (from visible) and covering fractions (from Vis+IR) as a function of time & stellar rotation

What do we learn? Stellar atmosphere contribution to planetary spectrum + deeper understanding of stellar heterogeneity → Star-corrected planet spectrum revealing composition of intrinsic planetary atmospheres (water, hydrogen, clouds)

Why are the data unique? Pandora will produce the first long-duration dataset with simultaneous visible photometry and IR spectroscopy of exoplanets and their host stars.

Why Now? Pandora will inform JWST exoplanet transmission spectroscopy analyses, and operate concurrently with JWST.

The Pandora Mission

Pandora is a SmallSat is designed to study the atmospheres of exoplanets. Transmission spectroscopy of transiting exoplanets provides our best opportunity to identify the makeup of planetary atmospheres in the coming decade. Stellar brightness variations due to star spots, however, can impact these measurements and contaminate the observed spectra. Pandora's goal is to disentangle star and planet signals in transmission spectra to reliably determine exoplanet atmosphere compositions.

Pandora will collect long-duration photometric observations with a visible-light channel and simultaneous spectra with a near-IR channel. The broad-wavelength coverage will provide constraints on the spot and faculae covering fractions of low-mass exoplanet host stars and the impact of these active regions on exoplanetary transmission spectra.

Pandora will subsequently identify exoplanets with hydrogen- or water-dominated atmospheres, and robustly determine which planets are covered by clouds and hazes. Pandora will observe at least 20 exoplanets with sizes ranging from Earth-size to Jupiter-size and host stars spanning mid-K to late-M spectral types.

Pandora is designed for long stares at exoplanet host stars. The whole sky is accessible during the 12 months of science operations, and most regions of the sky are accessible for over 100 days per year.

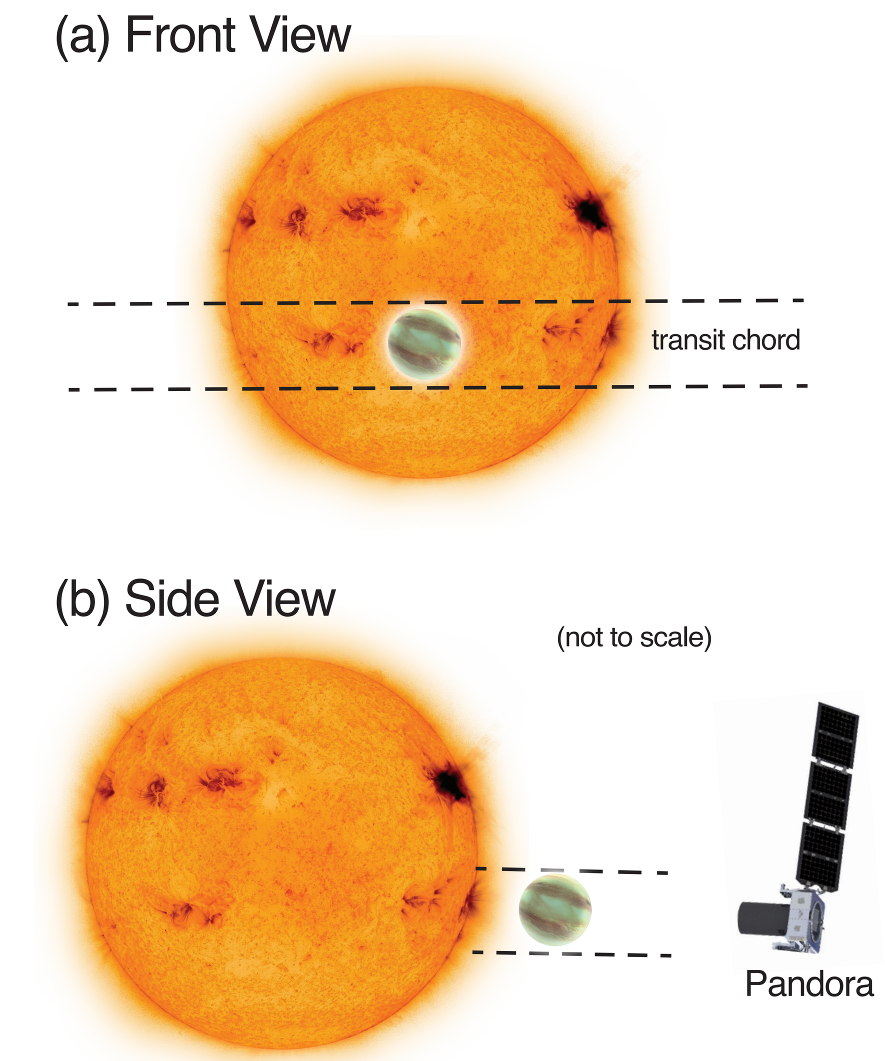


Figure 1: Spectral features from the unocculted stellar regions contribute to stellar contamination of the transmission spectra, which Pandora is designed to measure.

Payload

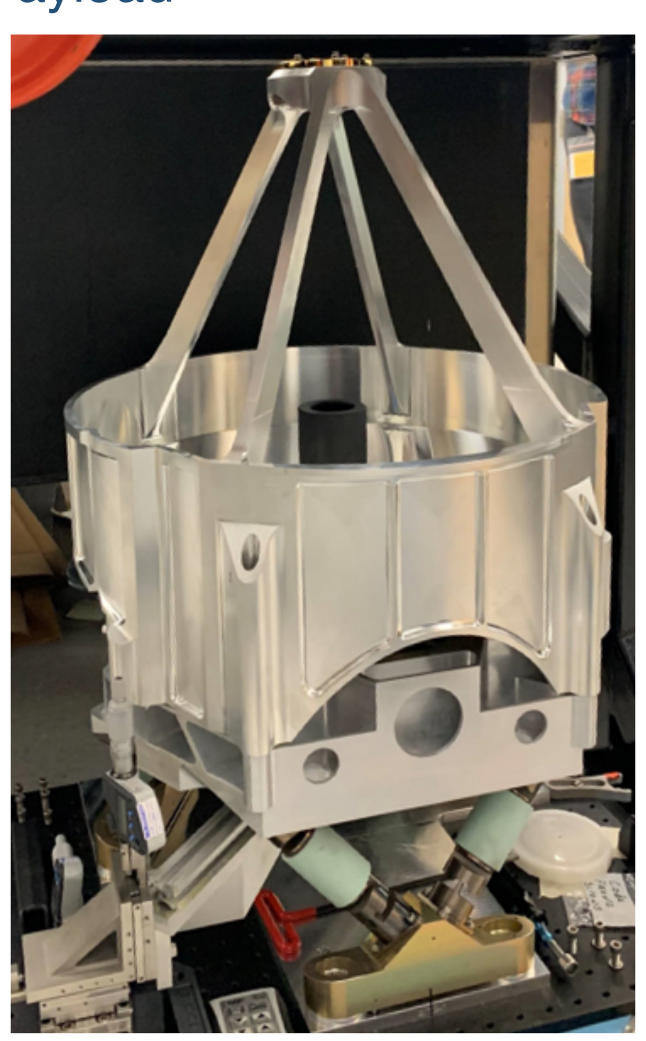


Figure 2: Pandora uses an all-aluminum 0.45-m Cassegrain telescope.

Pandora uses a 0.45-m Cassegrain aluminum telescope. The telescope is designed to address the challenge of procuring high-performing imaging space systems in a ride-sharing form-factor that are low cost and have rapid acquisition. A qualification unit telescope is shown in Figure 2.

The instrument package has two channel: a visible CMOS sensor, and a IR-sensitive Teledyne Imaging Sensors H2-RG, which is a flight spare from the NIRCam instrument on the James Webb Space Telescope. A schematic of the payload design in Figure 3 (with external baffle not shown).

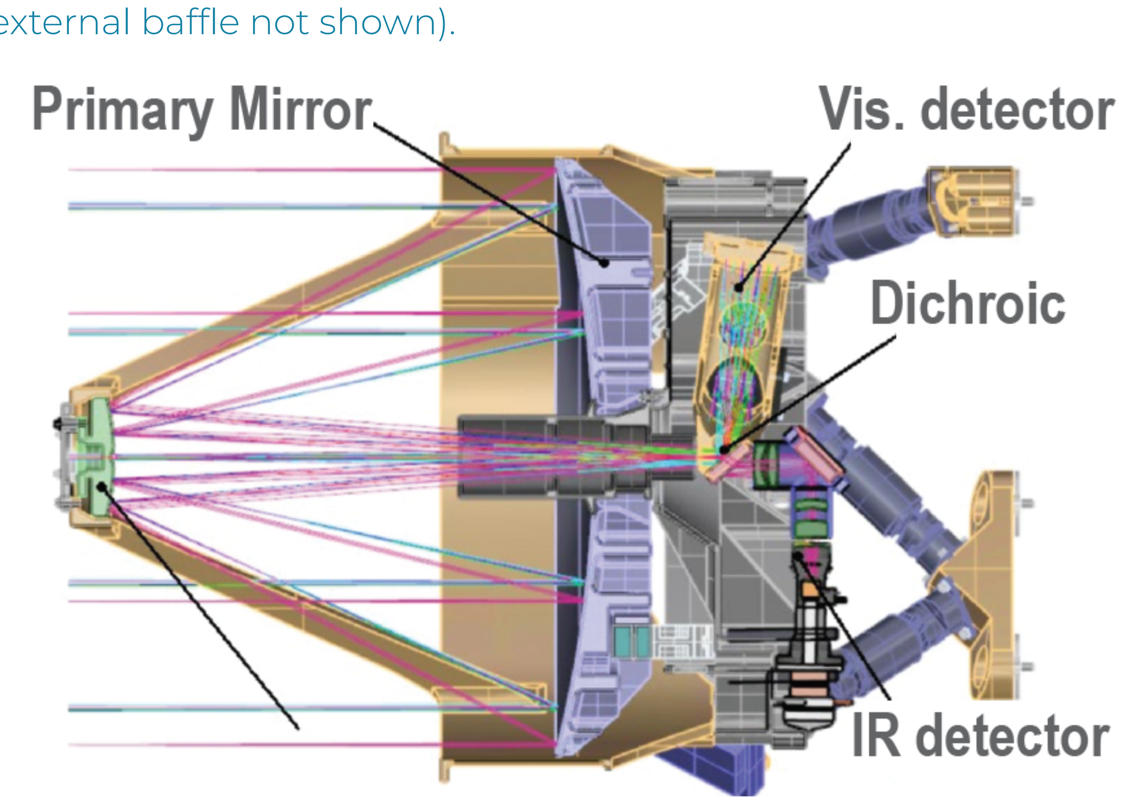


Figure 3: Pandora's optical system provides simultaneous multiwavelength capabilities in a compact, low-complexity design. Visible light is reflected off a dichroic coating, and a focusing parabola brings the visible light to the visible channel detector. NIR light is dispersed through a prism.

Observation Planning

Pandora was selected for initial formulation in early-2021 and is scheduled to be launch-ready in late-2024/early-2025. After launch as a secondary payload in Sun-synchronous low-Earth orbit, Pandora will execute a 12 month science mission.

The target list will be flexible, but the team created a design reference mission that includes 23 planets transiting 20 different stars. Pandora's top 20 notional target stars are highly accessible (enough to observe at least 10 transits per planet and at least 120 hours total per star). During science operations, observation sequences will be uploaded to the spacecraft up to twice weekly. Pandora will be assigned a single target for approximately 24 hrs before moving to the next target (the transit need not fall into the center of the 24-hr baseline). During this 24-hour period, Pandora will collect science data for at least 12 hours with breaks during data down-link, Earth-occultation, and Moon avoidance. This enable Pandora to collect significant out-of-transit baseline. For short-orbital-period planets, we may opt to stare at the targets for multiple days.

This primary science program can be executed in less than 9 months, leaving time available for ancillary science as well as providing margin.

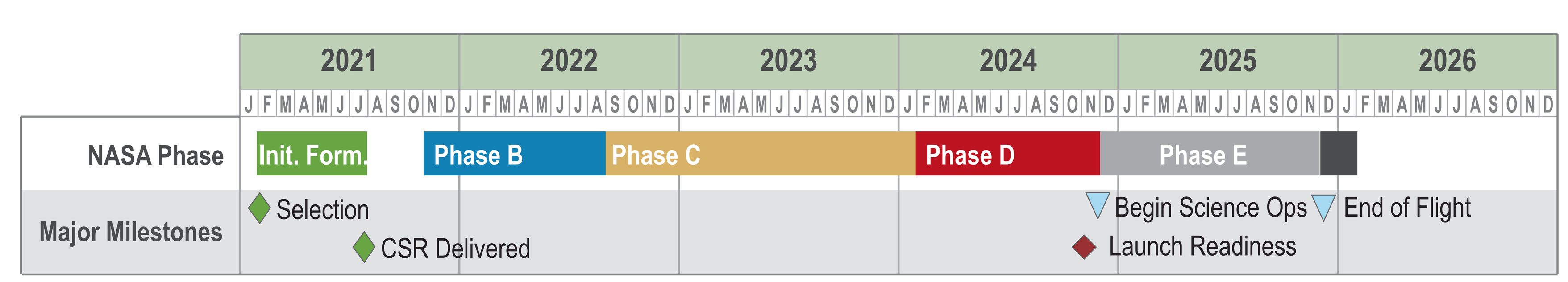


Figure 4: Pandora will complete the science objectives proposed, archive the data, and publish results within a 5-year timeline. Launch will be in the mid-2020s, although the precise timeline is dependent on the ride to space.

Acknowledgements

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