ORIGINS Space Telescope

From the first stars to life

National Aeronautics and Space Administration

Origins Space Telescope Concept 2: Trades, Decisions, and Study Status

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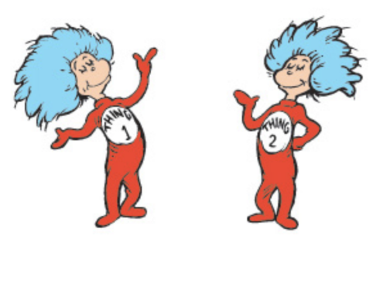
Abstract:

The Origins Space Telescope (OST) will trace the history of our origins from the time dust and heavy elements permanently altered the cosmic landscape to present-day life. How did the universe evolve in response to its changing ingredients? How common are planets that support life? The OST, an advancing concept for the Far-Infrared Surveyor mission described in the NASA Astrophysics Roadmap, will be designed to answer these questions. As envisaged in the Roadmap, *Enduring Quests/Daring Visions*, OST will offer sensitivity and spectroscopic capabilities that vastly exceed those found in any preceding far-IR observatory. The spectral range of OST was extended down to 5 microns to allow measurements of biomarkers in transiting exoplanet spectra. Thus, OST is a mid- and far-IR mission.

OST mission Concept 2 will inform the Science and Technology Definition Team's understanding of the "solution space," enabling a recommendation to the 2020 Decadal Survey which, while not fully optimized, will be scientifically compelling, executable, and intended to maximize the science return per dollar. OST Concept 1, described in poster 355.24, would satisfy virtually all of the STDT's science objectives (poster 355.11 and adjacent posters) in under 5 years. Concept 2 is intentionally less ambitious than Concept 1, but it still includes a 4 K telescope, enabling exquisitely sensitive far-IR measurements.

Here we present some of the architecture options considered for OST Concept 2 and describe the factors that led to the chosen design parameters. Lessons from the Concept 1 study influenced the STDT's choices. We report progress on the Concept 2 study to date.

Lessons from the Concept 1 Study



Now completed, the OST Concept 1 study serves as a valuable information source as the OST team embarks on a second mission concept study.

Concept 1 experience	Lessons for Concept 2
Concept 1 was intended to maximize OST's science yield without regard to mission cost. The estimated cost exceeds the projected 10-year integrated budget for a large Astrophysics mission.	Science value per dollar and affordability are both important. The costs of past astrophysics missions can serve as a rough guide when scoping the concept to be studied. Concept 2 will be deliberately less ambitious than Concept 1. Flight system mass will be used as a proxy for cost as the study progresses, and the study will be managed to prevent runaway cost growth.
The Concept 1 instruments have more capability than justified by adopted mission science requirements, and they exceeded planned resource (mass, volume, power) allocations. The former led to a breakdown in science traceability.	All instruments, instrument subcomponents, and operating modes must be traceable to at least one adopted mission science requirement. During the Concept 2 study, the instrument leads will work closely with STDT scientists to avoid requirements creep and ensure traceability. Instrument resource constraints will be enforced. The STDT will be regularly apprised of issues and options.
The Concept 1 far-IR direct detection spectrometers - HRS and MRSS - both depend on large gratings for spectral dispersion. These components drive instrument volume and mass.	Borrow the best features of HRS and MRSS and design a single far-IR direct detection spectrometer that achieves prioritized science goals within the allocated volume, mass, and power.
A high-resolution direct detection far-IR spectrometer may not reach astrophysical background-limited performance with next-generation detectors.	Ambitious but realistic detector performance assumptions will be adopted and applied uniformly across the OST instruments. The assumptions will be consistent with an adopted detector technology development roadmap.

Architecture Trades

The OST study team considered a variety of launch options and telescope sizes and configurations, aiming to maximize measurement capability at a cost NASA can afford. Heritage, complexity, and manufacturability are among the key technical discriminators.

Launch vehicle (LV) - An LV with a 5 m diameter fairing has lower development risk and costs less than a larger LV. Such a fairing can accommodate a monolithic telescope with light collecting area ~20 m^2 (equivalent to a 5 m diameter circle) if the primary mirror is elliptical. The James Webb Space Telescope (JWST) design demonstrates that a telescope with ~25 m^2 collecting area would fit into such a fairing if the primary mirror were segmented and folded. Commercial LVs in various stages of development, and NASA's Space Launch System (SLS), offer larger-diameter fairings that can hold larger telescopes and reduce the need for deployable system components.

Segmented vs. monolithic primary mirror - Existing industrial facilities can produce individual mirror segments up to ~3 - 4 m in diameter, but prioritized OST science goals require more light collecting area. The Herschel Space Observatory had a 3.5 m diameter telescope comprised of SiC segments brazed together to form a monolithic mirror. Actuators provide position and radius-of-curvature control to JWST's primary mirror segments. A segmented mirror can be folded and deployed after launch, or it can be launched in its operational configuration. The segments can be made in a variety of shapes, hexagonal being common.

Shape-controlled mirror segments - JPL mirror shape control technology can be used if it reduces integration and test time or risk to the mission's success. On the other hand, it should be possible to take advantage of the OST telescope's nondemanding wavefront error budget to reduce cost without shape control.

Obstructed vs. unobstructed primary mirror - A telescope with an unobstructed primary mirror is less susceptable to stray light (e.g., radiation from the Galactic plane entering through sidelobes) and has maximum collecting area for a given aperture size. However, on-axis designs are more compact and may be easier to package for launch.

Primary mirror shape - The primary mirror can be elliptical if desired to package a telescope with the desired aperture area into a given fairing without folding the mirror and depending on deployment after launch. A telescope with an elongated mirror will have a non-axisymmetric point spread function, which can be exploited to improve the telescope's angular resolution if sources can be viewed from different angles.

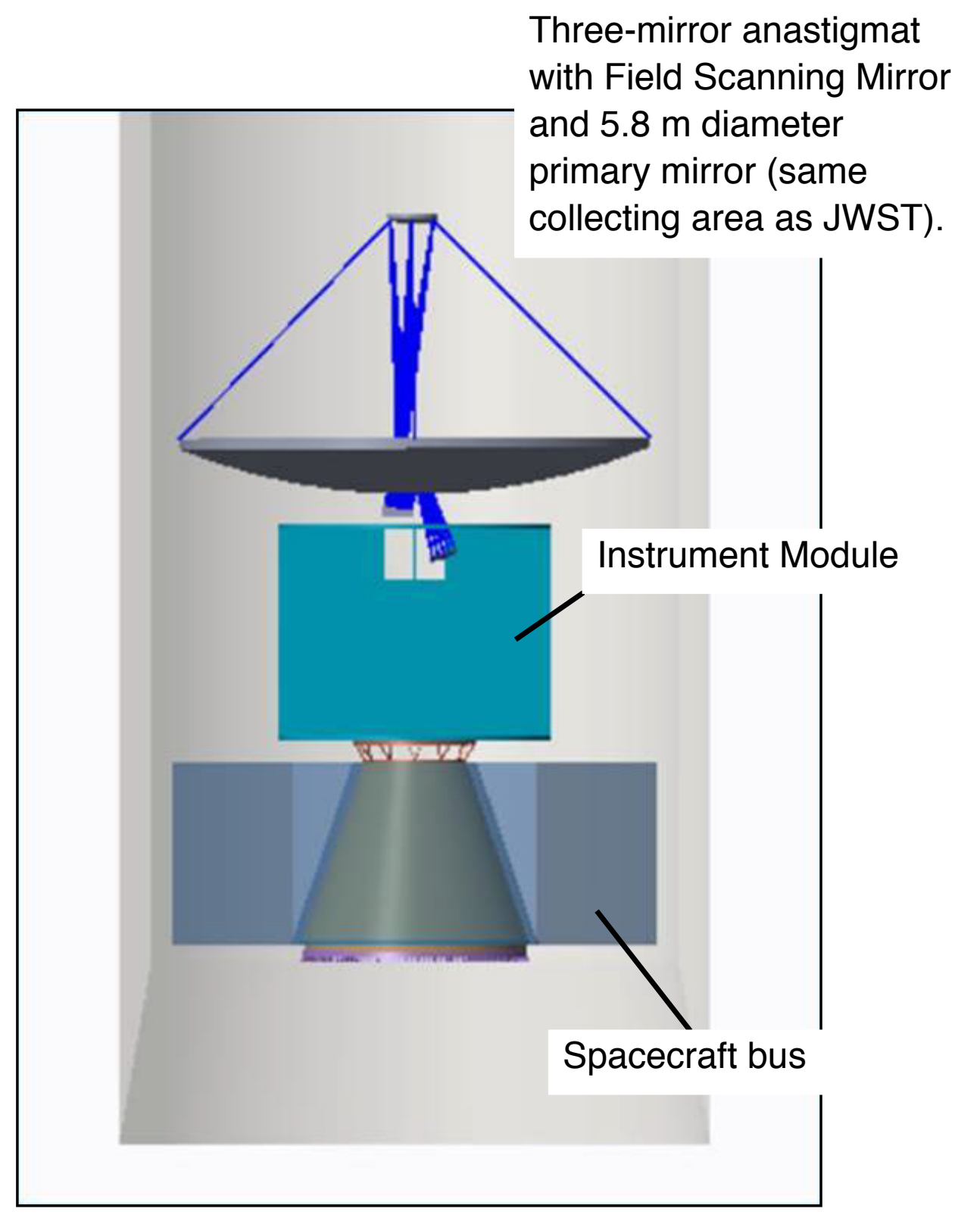
OST Concept 2 Parameters

Having consulted with the community, prioritized science goals for a space-based IR observatory that could fly in the 2030s, learned lessons from the Concept 1 study (left), and considered the architecture trades (lower-left), the STDT chose key parameters for OST Concept 2.

Telescope size - The Concept 2 telescope will be comparable to JWST in size and actively cooled to ~4 K to provide the sensitivity required to accomplish high-priority mission science goals (search for biosignatures; dust and heavy element buildup in the early universe).

Architecture - To minimize the dependence on deployments and allow ample volume for OST's instruments, Concept 2 will:
(a) have a Spitzer-like configuration, with a wrap-around sunshade (shell) and a circular primary mirror, and
(b) be designed for launch in a vehicle with 7 m diameter or larger fairing.

Figure at right - Notional Concept 2 flight system stowed for launch in a 7-m diameter fairing.



Concept 2 Instrument Suite

Instrument	Wavelength range (µm)	Observing Modes
Mid-Infrared Imager, Spectrometer, Coronagraph	5-38	• Imaging, spectroscopy • Transit Spectrometer (<10 ppm stability)
Far-Infrared Survey Spectrometer	30-660	• Multi-band Spectroscopy • High-resolution mode with R > 10^5
Far-Infrared Imager and Polarimeter	40, 80, 120, 240	• Broadband imaging • Field of view: 2.5'x5', 7.5'x15' • Differential polarimetric imaging
Heterodyne Receiver for OST	63-66, 111-610	• Multi-beam spectroscopy

The **Origins Space Telescope** is the mission concept for the **Far Infrared Surveyor**, a study in development by NASA in preparation for the *2020 Astronomy and Astrophysics Decadal Survey*.

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Secret OST Word: CONCEPT 2