Margaret Meixner
Space Telescope Science Institute,
Johns Hopkins University
on behalf of the FIRS Science Technology Definition Team
asd.gsfc.nasa.gov/firs
From the Rise of Metals to Water for Habitable Worlds

NASA Mission concept for 2020 Decadal review; launch 2030ish
6 μm – 1000 μm (ish), Large aperture 8-15 m
Study Chairs: Margaret Meixner & Asantha Cooray
NASA Mission concept for 2020 Decadal review; launch 2030ish

10 μm – 1000 μm (ish), Large aperture 8-15 m

Study Chairs: Margaret Meixner & Asantha Cooray

Comes from the NASA Astrophysics Roadmap, Enduring Quests, Daring Visions
Community Chairs:
Margaret Meixner, STSCI, Asantha Cooray, UC Irvine

NASA Study Center:
Goddard Space Flight Center (GSFC): Ruth Carter, David Leisawitz, Johannes Staguhn, Michael Dipirro, Anel Flores, Joseph Howard, James Corsetti, Andrew Jones, James Kellog, Louis Fantano

NASA Head Quarters (HQ) Program Scientists (non-voting):
Kartik Sheth and Dominic Benford

Ex officio non-voting representatives:
Susan Neff & Deborah Padgett, NASA Cosmic Origins Program Office; Susanne Alato, SNSB; Douglas Scott, CAS; Maryvonne Gerin, CNES; Itsuki Sakon, JAXA; Frank Helmich, SRON; Roland Vavrek, ESA; Karl Menten, DLR; Sean Carey, IPAC

Members appointed by NASA (> 90 applications):
Lee Armus, NASA IPAC; Cara Battersby, Harvard-Smithsonian CfA; Edwin Bergin, University of Michigan; Matt Bradford, NASA JPL; Kim Ennico-Smith, NASA Ames; Gary Melnick, Harvard-Smithsonian CfA; Stefanie Milam, NASA GSFC; Desika Narayan, University of Florida; Klaus Pontopiddan, STSCI; Alexandra Pope, University of Massachusetts; Thomas Roellig, NASA Ames; Karin Sandstrom, UC, San Diego; Kate Y. L. Su, University of Arizona; Joaquin Vieira, University of Illinois, Urbana Champaign; Edward Wright, UC Los Angeles; Jonas Zmuidzinas, Caltech
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From the Rise of Metals to Water for Habitable Worlds

Tracing the signatures of life and the ingredients of habitable worlds

Origins will trace the trail of water from interstellar clouds, to proto-planetary disks, to Earth itself facilitating understanding of the abundance and availability of water for habitable planets.

Unveiling the Growth of Black Holes and Galaxies over Cosmic Time

Origins will reveal the co-evolution of super-massive black holes and galaxies, energetic feedback, and the dynamic interstellar medium from which stars are born.

Charting the Rise of Metals, Dust, and the First Galaxies

Origins will trace the metal enrichment history of the Universe, probe the first cosmic sources of dust, the earliest star formation, and the birth of galaxies.

Characterizing Small Bodies in the Solar System

Origins will chart the role of comets in delivering water to the early Earth, and conduct a survey of thousands of ancient Trans Neptunian Objects (TNOs) in the outer reaches of the Solar System.
Telescope Parameters

<table>
<thead>
<tr>
<th>Aperture Diameter</th>
<th>FOV</th>
<th>Diffraction Limited at</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-15 m</td>
<td>0.5-1 square degree</td>
<td>40 μm</td>
<td>~4 K</td>
</tr>
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</table>
**Technical Definition**

**Actively-Cooled Large Aperture**
Will attain sensitivities 100–1000x greater than any previous far-infrared telescope.

**Potential Wavelength Coverage**
- From 5 \(\mu m\)–1 mm

**Capabilities & Characteristics**
- **Origins Space Telescope**
- **Herschel**
- **Spitzer**
- **Webb**
- **Hubble**
- **WFIRST**

**Timeline of IR Space Telescopes**
- **Origins** will be an actively cooled telescope covering the infrared spectrum.
- **Spectrographs and imagers** will enable 3D surveys and discover and characterize distant galaxies, exoplanets, and the outer reaches of the Solar System.

**Contact us**
- **email:** OST_info@lists.ipac.caltech.edu
- **twitter:** @NASAOrigins
- **web:** origins.ipac.caltech.edu  •  asd.gsfc.nasa.gov/firs
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Wavelength Coverage (μm)</th>
<th>Spectral Resolution ($\lambda/\Delta\lambda$)</th>
<th>Field of view #spatial pixels</th>
<th>Typical Required Sensitivity:</th>
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## Instrument Specifications

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<td>low-res(\sim)500 high-res(\sim)10⁴</td>
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<td>(10^{-21}) W/m² (spectral line)</td>
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<th>Typical Required Sensitivity: $W/m^2$ (spectral line)</th>
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<td>50 to 500</td>
<td>low-res ~ $8 \times 10^4$ high-res~$5 \times 10^5$</td>
<td>100</td>
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Technical Definition

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<td>Heterodyne Spectrometer</td>
<td>150 to 500</td>
<td>~10⁷</td>
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<td>150 to 500</td>
<td>~10^7</td>
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<td>Far-infrared imager</td>
<td>35 to 500</td>
<td>R~15</td>
<td>100,000</td>
<td>1 μJy - 10 mJy (confusion limit)</td>
<td>5 to 10 channels, polarimetry, spectral line filters</td>
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<td>Mid-Infrared Instrument</td>
<td>6 to 40</td>
<td>imager: R$\sim15$, spectrometer: R$&gt;500$</td>
<td>$10^6$</td>
<td>photometric: 1 $\mu$Jy @10 $\mu$m</td>
<td>coronagraph$\sim10^{-6}$ @ 0.5&quot; @ 10 $\mu$m</td>
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<tr>
<td>New Technology</td>
<td>New Capability</td>
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<tr>
<td>Space</td>
<td>Wavelength coverage JWST&lt;→&gt;ALMA</td>
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<tr>
<td>Cold Mirror</td>
<td>Spectroscopic line sensitivity</td>
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<tr>
<td>Large Telescope</td>
<td>Spatial resolution and sensitivity</td>
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<td>Large Detector Arrays</td>
<td>Wide field imaging</td>
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<td>Compact Gratings &amp; Integrated Spectrometers</td>
<td>3D mapping</td>
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<td>Mid-IR Coronagraph</td>
<td>Exoplanet+Disk Characterization</td>
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Primary Mirror (M1)
Secondary Mirror (M2)
Tertiary Mirror (M3)
Fine-steering mirror (FSM)
Technical Definition: Telescope Design

- Secondary Mirror (M2)
- Fine-steering mirror (FSM)
- Primary Mirror (M1)
- Tertiary Mirror (M3)
Off-Axis 9.3m Diameter
Projected Area: ~56m²
37 Segments
Segment Flat to Flat: 1320mm
Mass Rough Estimate: 3462 kg

5m x 19.8m Fairing
Inst: 48m³
Bus: 38m³

Backplane Depth: ~495mm
Technical Definition: Secondary & Shade

On-Axis Notional Secondary and Sun Shade

DTA

Secondary
Zodi@Ecliptic Pole + Telescope Flux

Tele. Emissivity = 0.05

Min. = 5.00E-15 at 393.2 μm

- Zodi Alone
- Zodi+(Toptics = 3.0 K)
- Zodi+(Toptics = 4.0 K)
- Zodi+(Toptics = 7.0 K)
- Zodi+(Toptics = 10.0 K)
STDT Schedule

• **January to July 2017:**
  – Complete preliminary designs for telescope and instruments
  – Secure instrument design contributions
  – Identify technology drivers

• **August to September 2017**
  – Define required technologies
  – Complete preliminary mission design

• **January to March 2018:**
  – Finalize Telescope and Instrument Designs
  – Finalize mission design including spacecraft bus

• **April to August 2018:**
  – Identify de-scope options
  – End-to-end Mission cost estimations

• **January 2019:**
  – Submit the final study report to NASA HQ

• **March 2019:**
  – Far-IR Study Results presentation to Decadal Committee
What’s happening now:

- Five science working groups: membership is open to the community (US and foreign)
- Deciding on science questions in the post-JWST, 15 years of ALMA operations in an era of Extremely Large Telescope (ELT) and guiding instrument and telescope design.

**Solar System:** Stefanie Milam

**Planet Formation and Exoplanets:** Klaus Pontoppidan and Kate Su

**Milky-Way, ISM and Local Volume of Galaxies:** Caran Battersby and Karin Sandstrom

**Galaxy and Blackhole Evolution Over Cosmic Time:** Lee Armus and Alexandra Pope

**First Billion Years:** Joaquin Vieira, Matt Bradford