ORIGINS Roadmap 2003

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IEEE Aerospace Conference 2003 Big Sky M. Devirian

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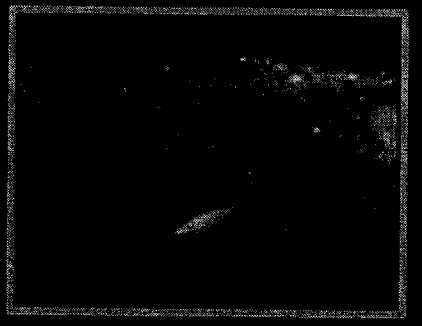

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We seek …

… to observe the birth of the earliest galaxies, the formation of stars, to find all the planetary systems in our solar neighborhood, to find planets that are capable of harboring life, and to learn whether life does exist beyond our solar system.

We do this to understand the origins of our world. We do this to answer two questions:

Where did we come from?
Are we alone?

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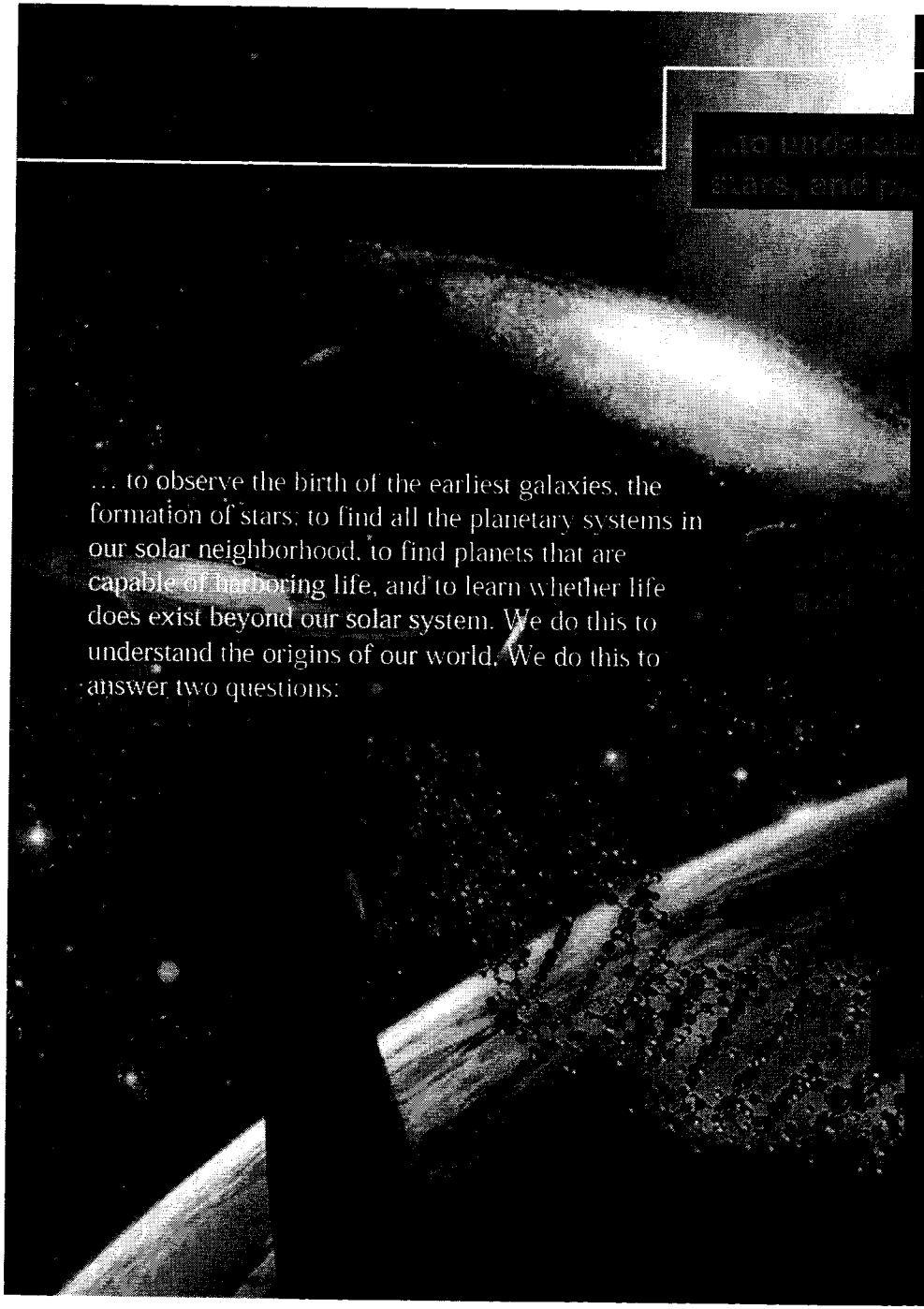
- was written by the Origins Subcommittee of NASA's Space Science Advisory committee, working with substantial input from the community.

- sets out a plan for a twenty year period, with particular emphasis on the near-term (2005 – 2010) or mid-term (2010 – 2015) time frame.

- became basis for significant parts of Space Science and NASA Strategic Plans



... to observe the birth of the earliest galaxies, the formation of stars; to find all the planetary systems in our solar neighborhood, to find planets that are capable of harboring life, and to learn whether life does exist beyond our solar system. We do this to understand the origins of our world. We do this to answer two questions:

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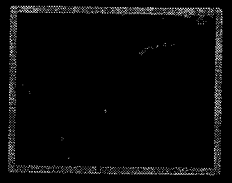
Stars began to form even before the first galaxies, and what had been a calm, near formless sea began to surge with the froth of complex forms of matter and energetic processes. Today the universe is full of structure, from the giant but simple galaxy to a minuscule but complex single living cell. Our objective is to understand how this came about, how stars and planets form, how the chemical elements are made, and ultimately how life originates.

During the past three decades, we have used both ground and space based facilities to look inside the nurseries where stars and planets are born. Parallel studies conducted in the solar system with planetary probes and of meteorites have revealed clues to the process that shaped the early evolution of our own planetary system. An overarching goal of science in the 21st century will be to conduct what we observe elsewhere in the universe with objects and phenomena in our own solar system.

We have found many extrasolar planets. Most are unlike those in our solar system. But might there be near twins of our solar system as well? Are there Earth like planets? What are their characteristics? Could they support life? Do some actually show signs of past or present life?



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Emergence of the Modern Universe

Stars and Planets

Habitable Planets and Life

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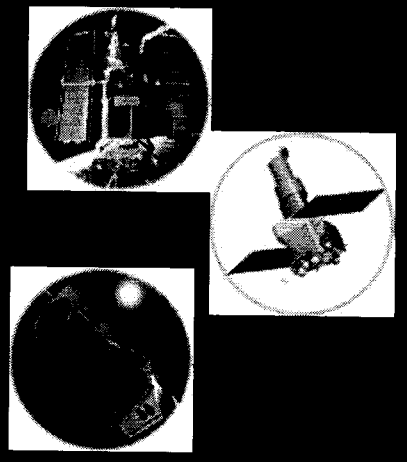
...to build on the past, and leave a legacy for future missions

The central principle of the Origins mission architecture has been that each major mission builds on the scientific and technological legacy of previous missions, while providing new capabilities for the future. In this way, the complex challenges of the theme can be achieved with reasonable cost and acceptable risk.

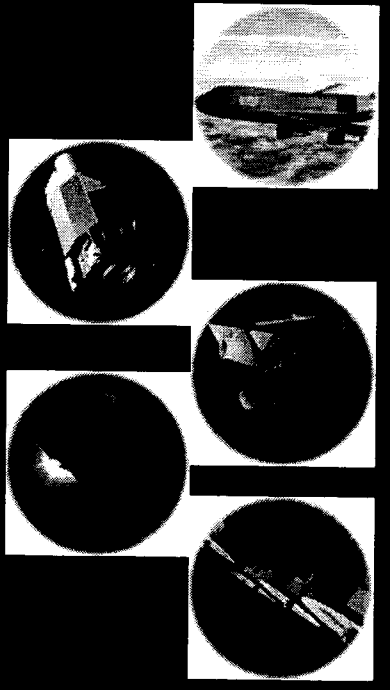
- Major arteries: linking strategic missions with science results and technology enablers
- On ramps: competitively selected missions from Discovery, Explorers, etc.
- Off ramps: descopes to strategic mission capabilities



Hubble Space Telescope – 2.5-meter telescope in low Earth orbit collecting images and spectra in the visible and neighboring bands studying the early phases of the modern universe.

Far Ultraviolet Spectroscopic Explorer – space telescope in low Earth orbit working in the far ultraviolet band exploring the hydrogen isotope ratio created in the big bang and the chemical composition of galaxies.

Space Infrared Telescope Facility – 0.85-meter cryogenic telescope in solar orbit, aimed at understanding structure and composition of molecular clouds and the early stages of star and planet formation.



Stratospheric Observatory for Infrared Astronomy – 2.5-meter telescope flying on a modified Boeing 747 collecting data on the properties of the clouds of gas and dust that lie between stars in a galaxy.

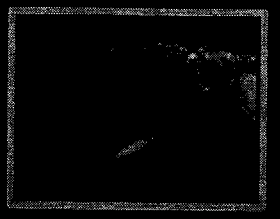
Kepler – photometric survey telescope in space, selected in the Discovery program, to survey the extended solar neighborhood to detect and characterize planets down to Earth size.

Space Interferometry Mission – 10-meter baseline optical interferometer in solar orbit looking for evidence of Earth-size planets around nearby stars.

James Webb Space Telescope – infrared telescope, at least 6-meter diameter, in solsr orbit aimed at exploring the earliest galaxies.

Terrestrial Planet Finder – infrared interferometer or visible-light coronagraph, to directly detect and characterize potential atmospheres of planets like Earth.

Mid-Size Competed Missions – futrue new initiative; PI-led, ~$500-750M;



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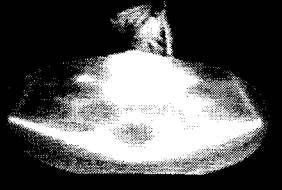
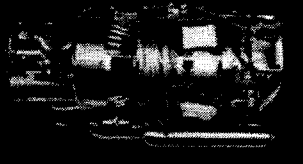
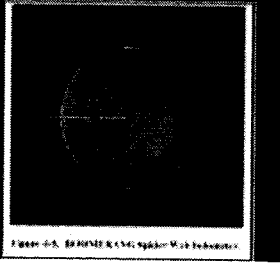
...to invent the tools for a new age of discovery

The Origins' technology program will develop the means to achieve the most ambitious and technically challenging measurements ever made. These developments envisage: new methods to gather signals from distant sources, precise control of optical elements to a precision of one-thousandth of a human hair, and measurements of distances between optical elements to width of a hydrogen atom. Such exquisite techniques require methods and tools that do not exist today. Building spacecraft of the future incorporating these technologies will exploit the creative inventiveness of our scientists as well as the care and precision of our engineers.







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...to develop new experiment concepts, and to create and to test theories of our Origins

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The Origins Research and Analysis (R&A) program provides scientists with the opportunity to explore innovative ideas and technologies that lead to better understanding of astrophysical concepts and methods. This fundamental research is crucial to achieving the scientific goals of the Origins program, and provides the basis for many future mission concepts.

- Ground and Space Observations
- Archival Research
- Theory
- Technology
- Mission Concepts

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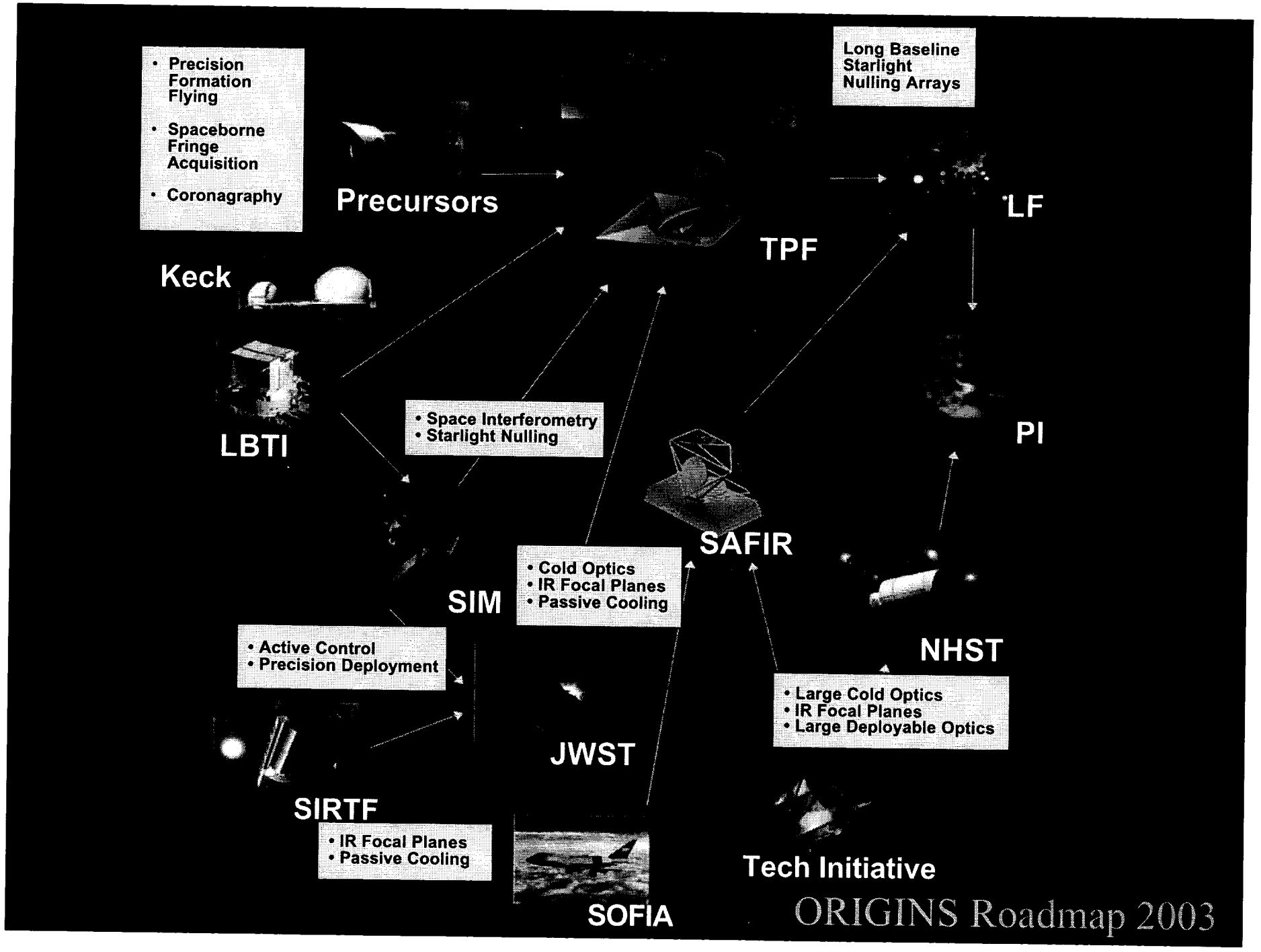
... to share, to inspire, to educate all Americans in the adventure of discovering our Origins

The goal of the Origins Public Engagement Program is to share our stirring quests and findings with people of all ages and backgrounds, conveying the thrill of scientific discovery and technological accomplishment in space. We strive to inspire Americans, enhance scientific literacy nationwide, and improve science, mathematics, and technology education at all levels.


• Precision Formation Flying
• Spaceborne Fringe Acquisition
• Coronagraphy
Precursors
Long Baseline Starlight Nulling Arrays
LF
TPF
Keck
LBTI
• Space Interferometry
• Starlight Nulling
PI
SAFIR
• Cold Optics
• IR Focal Planes
• Passive Cooling
SIM
• Active Control
• Precision Deployment
NHST
• Large Cold Optics
• IR Focal Planes
• Large Deployable Optics
JWST
SIRTF
• IR Focal Planes
• Passive Cooling
Tech Initiative
SOFIA
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...Perhaps our descendents will praise us for our initiatives, perhaps they will curse the relentless curiosity that propels humans into greater accomplishments and greater peril, but our part in this drama is preordained, its resolution beyond our time and imagination, barely within our dreams. We go on.

– Alan Dressler

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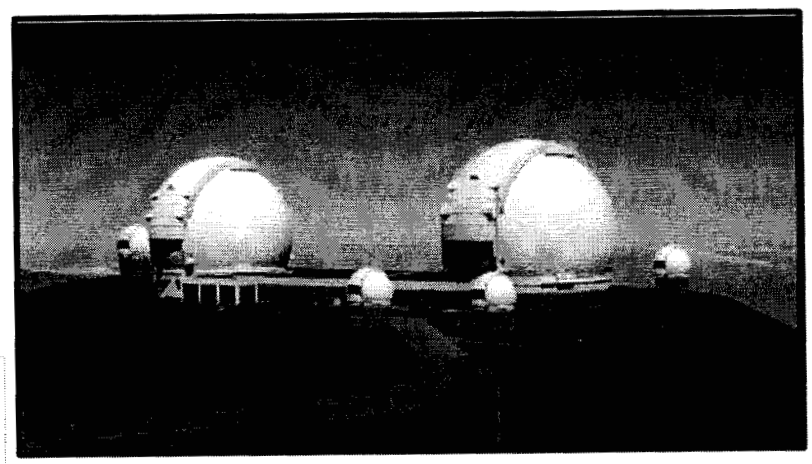
- Space Interferometry Mission (SIM)
- Terrestrial Planet Finder (TPF)
- Single Aperture Far Infrared Observatory (SAFIR)

Roadmap at http://origins.jpl.nasa.gov/

Keck Interferometer



Salient Features

- The two 10-m Keck telescopes + four 1.8m outrigger telescopes
- 85-meter baseline between the two Kecks
- Wavelength: 2 μm and 10 μm
- Imaging resolution: 5 μas at 2 μm
- Astrometric accuracy: 30 μas

Objectives

- Direct detection of brown dwarfs and warm Jupiter-mass planets
- Null the star and study zodiacal clouds around nearby stars
- Indirect detection of Uranus-size planets via astrometry
- High-resolution imaging of disks in which planets may be forming

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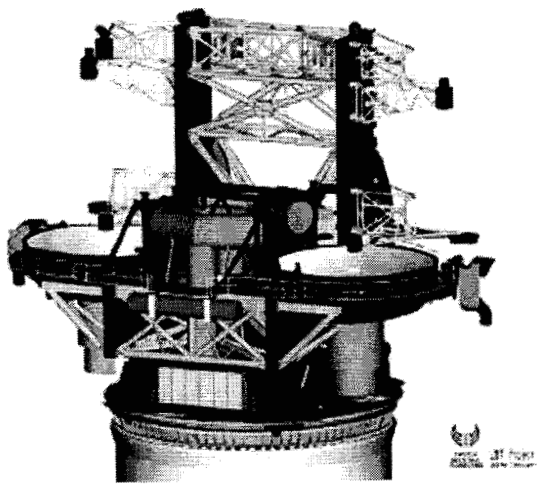
Large Binocular Telescope Initiative



Salient Features

- Interferometer for Consortium Sponsored LBT
- JPL Management of UA Implementation contract
- NASA Guest observer data management at ISC
- UA development and I&T of Nulling Infrared Interferometer
- UA Nulling Infrared Interferometer Instrument(LBTI): Universal Beam Combiner; Cryogenic Nulling Interferometer; Cryogenic Mid-Infrared Camera; Control and Monitoring System
- Operational Date: Late-2006

Objectives

- Will improve the knowledge of extrasolar planetary systems:
  - Survey of nearby stars for zodiacal dust disks
  - Capability to interface with a wide-field imaging (Fizeau) interferometry
- Survey up to 50 nearby stars down to a level of zodiacal dust corresponding to 3 times the dust in our own planetary system.

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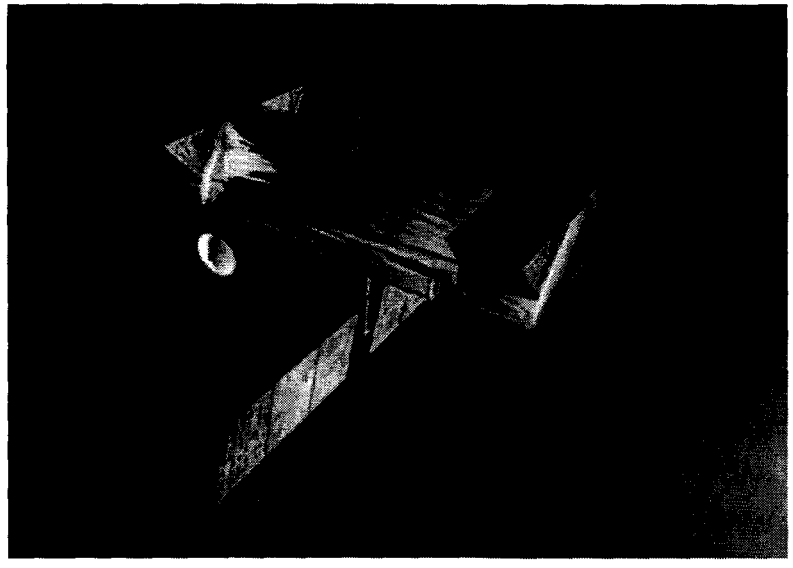
Space Interferometry Mission



Salient Features

- 3 collinear Michelson Interferometers
- 10 meter baseline; visible wavelength
- Launch Date: 2009
- Launch Vehicle: Space Shuttle or EELV
- Heliocentric, Earth-trailing orbit
- Operational Life: 5-10 years
- SIM is a JPL, Caltech, Lockheed Martin, TRW, and Science Community partnership

Objectives

- Survey 2000 nearby stars for astrometric signatures of planetary companions.
- Survey 200 nearby stars for orbiting planets down to terrestrial-masses.
- Improve best current catalog of star positions by >100x and extend to fainter stars.
- Study dynamics and evolution of stars and star clusters in our galaxy.
- Calibrate luminosities of important stars and cosmological distance indicators.

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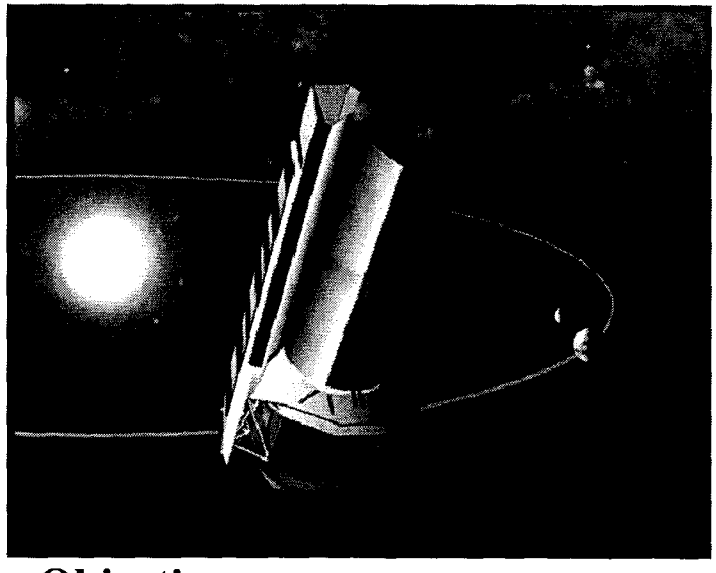
Space Infrared Telescope Facility



Salient Features

- Heliocentric orbit trailing the Earth
- 85 cm Beryllium telescope operating at 5.5 K
- 3 instruments with 3-180 micron wavelength coverage operating at 1.5 K
- Launch date: January 9, 2003
- Operational life: 2.5 year requirement
- Observing time avail. to general community: > 75%

Objectives

- Search for brown dwarfs and super-planets, and to understand the contribution of sub-stellar objects to the mass of the Galaxy.
- Study protoplanetary and planetary debris disks, and to assess the frequency of planetary-system formation around nearby solar-type stars.
- To determine properties of ultra-luminous galaxies and active galactic nuclei, and to understand the mechanisms which power these extremely energetic objects.
- Study normal galaxies as they were when the Universe was less than one-quarter of its current size and age.

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James Webb Space Telescope

Salient Features

- 8m Primary Mirror
- 0.6-10+ μm Wavelength Range
- 5 year Mission Life (10 year goal)
- Passively Cooled to <50K
- L2 Orbit

Objectives

- Detect and Characterize the First Stars and Galaxies to Form after the Big Bang
  - *"First Light" Machine*
- Measure the Complete Formation Processes of Galaxies and the Creation of Heavy Elements
  - *Visiting a Time When Galaxies Were Young*
- Study the Details of Star and Planet Formation in our Galaxy
  - *Prolog to Astrobiology*

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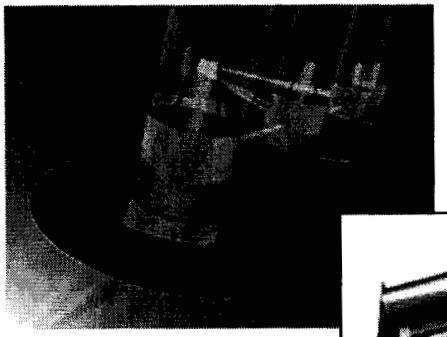
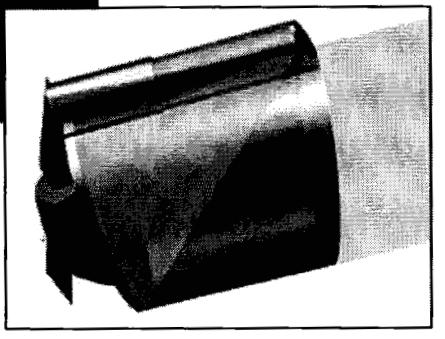
Terrestrial Planet Finder



IR Separated Spacecraft Interferometer Concept



Visible Coronagraph Concept

Salient Features

- IR Separated Spacecraft Interferometer or Visible Coronagraph
- Starlight suppression to 10^{-6} (IR) or 10^{-9} (vis)
- Launch Vehicle: EELV class
- L2 or Heliocentric, Earth-trailing orbit
- 5 year mission life with 10 year goal
- Potential collaboration with European Space Agency IRSI/DARWIN Mission

Objectives

- Survey 250 nearby, solar type stars for Earth-mass planets.
- Make low resolution spectral observations of ~50 of the brightest planets looking for evidence of a *habitable* planet using signatures such as CO_2 and H_2O.
- Make very sensitive, low resolution spectral observations of ~10 of the most interesting planets, looking for signposts of a planet inhabited by primitive life
- Carry out a program of general astrophysics.

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