



# Space Science Technology Challenges

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California Institute of Technology

# **Space Science Technology Challenges**

## **Science Challenges and Opportunities**

- 1. Establish a permanent robotic presence on Mars to study the geologic and biological evolution of our sister planet.**
- 2. Analyze possible organic-rich environments in the Solar System.**
- 3. Image, explore and understand the evolution of neighboring solar systems in detail.**
- 4. Further our understanding of the origins of galaxies and the universe and the laws governing that evolution.**
- 5. Continue the study of Earth and its dynamic environment with satellite sensing systems.**
  - I lied! We'll talk about Earth Science too!**

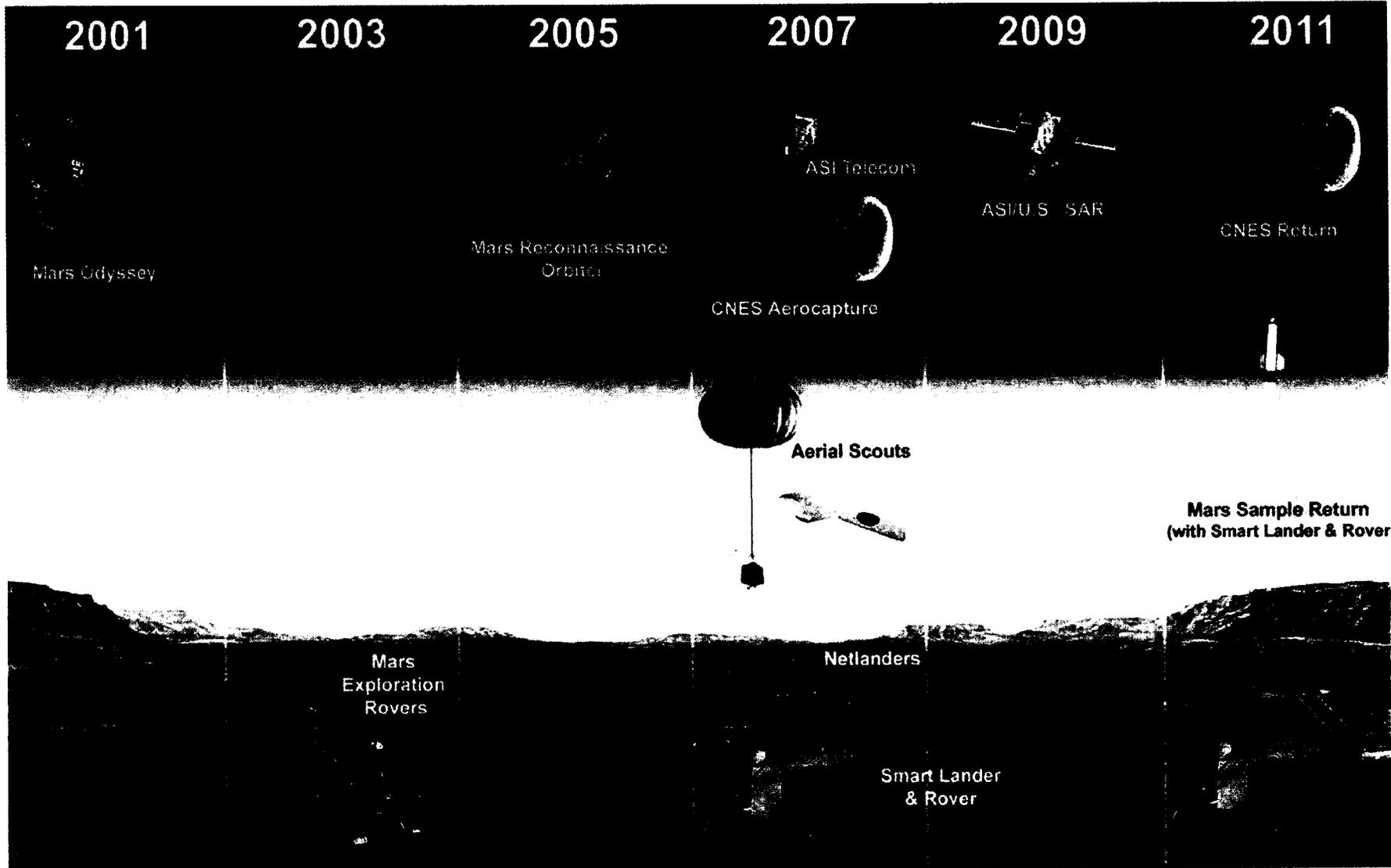


# Space Science Technology Challenges

## 1. Establish a permanent robotic presence on Mars



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# Space Science Technology Challenges Mars technology program



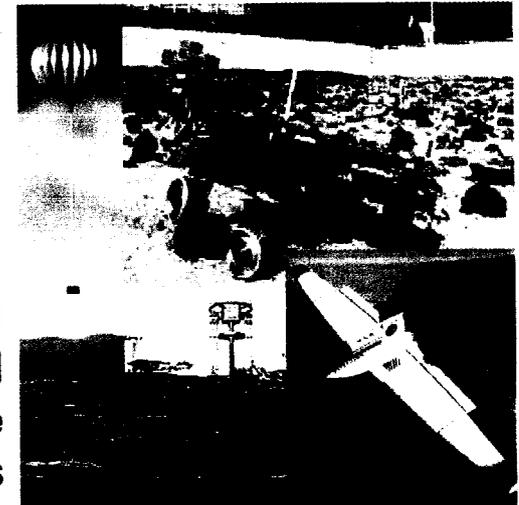
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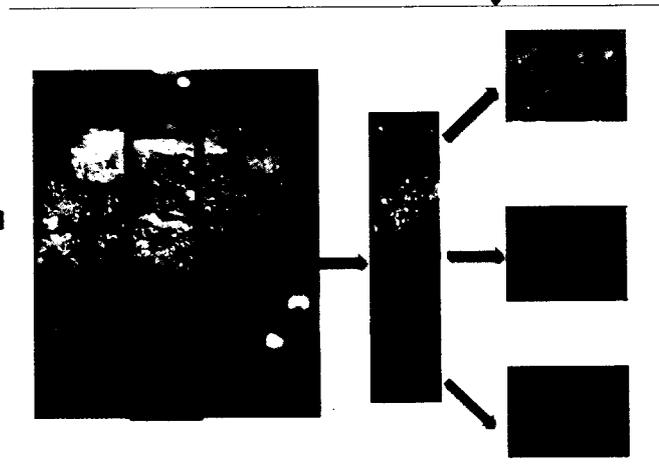
**Safe Landing**



**Regional  
Mobility and  
Subsurface  
Access**



**Rendezvous  
and Sample  
Capture/Return  
to Earth**



**In-situ Life Detection**



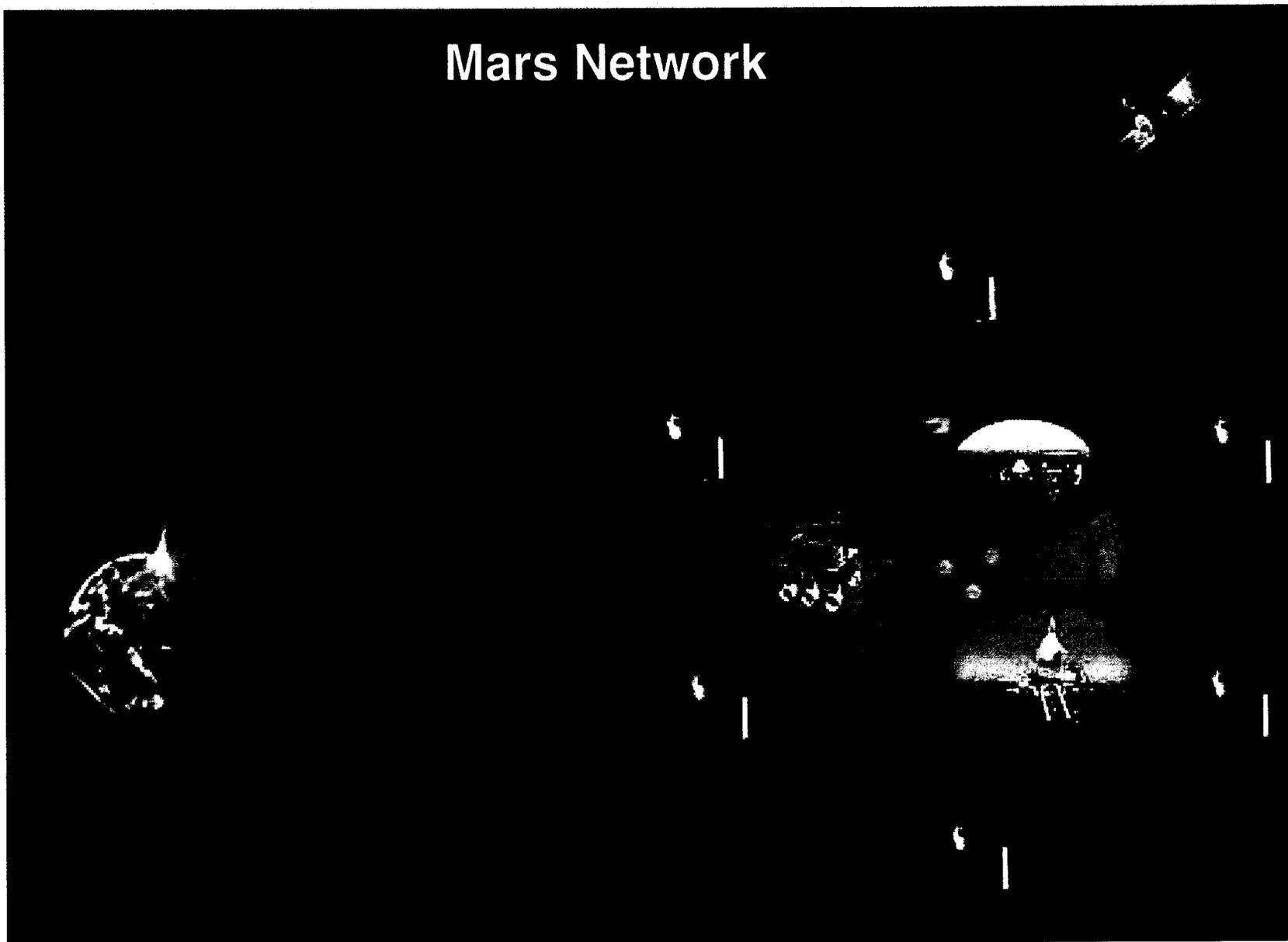
# Space Science Technology Challenges

## Communication with Mars



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### Mars Network



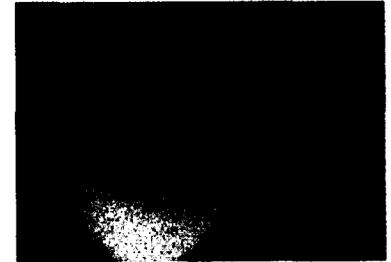
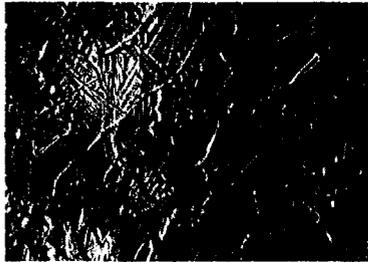


# Space Science Technology Challenges

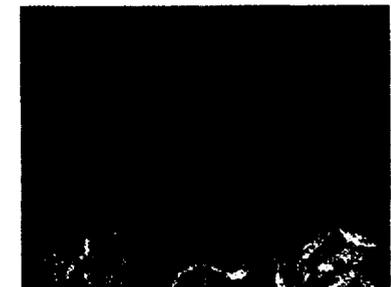
## 2. Analyze possible organic-rich environments



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- The solar system exploration program seeks answers to fundamental questions about the solar system and life:
  - How do planets form?
  - Why are planets different from one another?
  - Where did the makings of life come from?
  - Did life arise elsewhere in the solar system?
  - What is the future habitability of Earth and other planets?





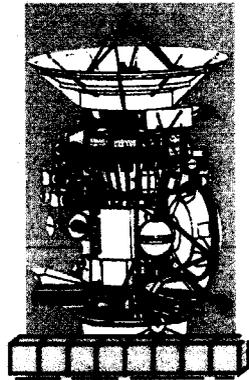
# Space Science Technology Challenges



## Key technology developments for solar system exploration

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Cassini  
6.7 m



Avionics Bays

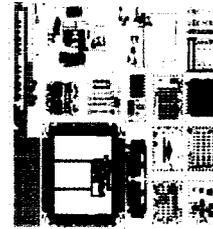
Europa  
Orbiter  
3.5 m



X2000 Bays

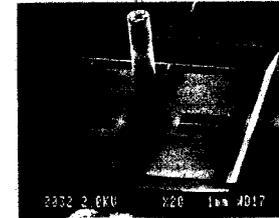
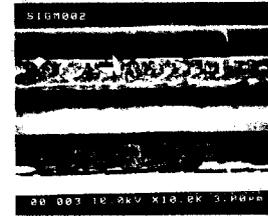
### X2000 Avionics:

Low mass, rad hard, high performance



System on a chip

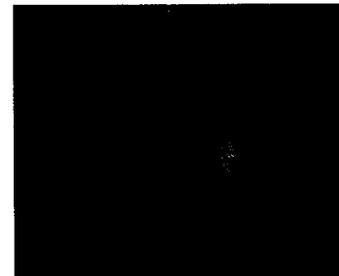
### Magnetic On-Chip Microinductors



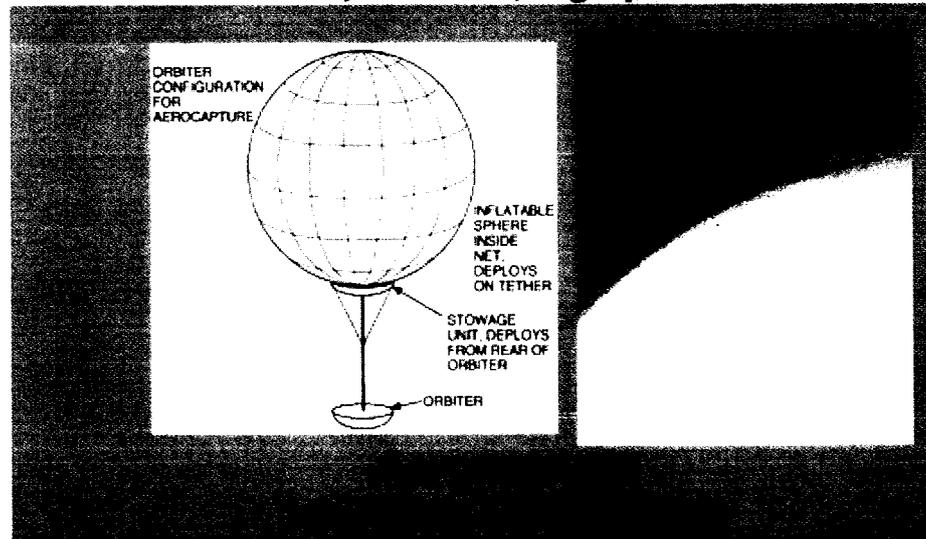
Microgyroscope

### Highly integrated, survivable microsystems:

Smarter, more reliable spacecraft



Advanced power sources



### Advanced Propulsion:

Shorter flight times and smaller launch vehicles



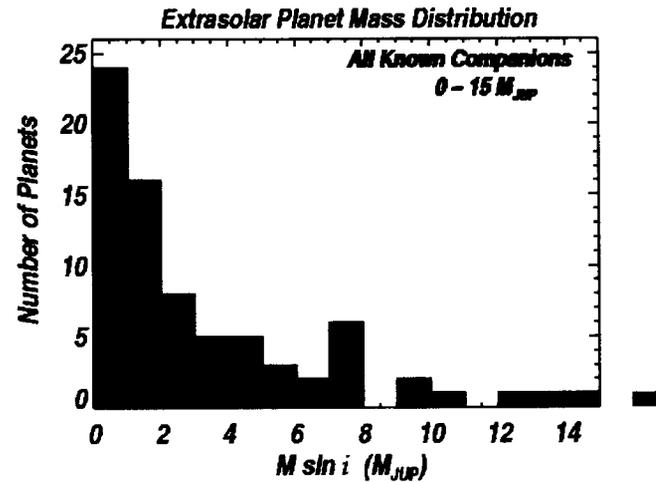
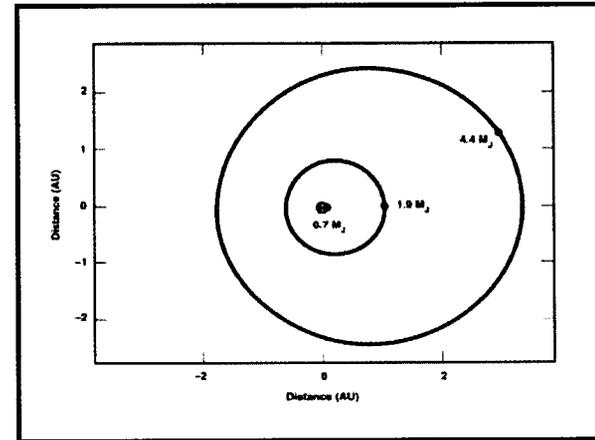
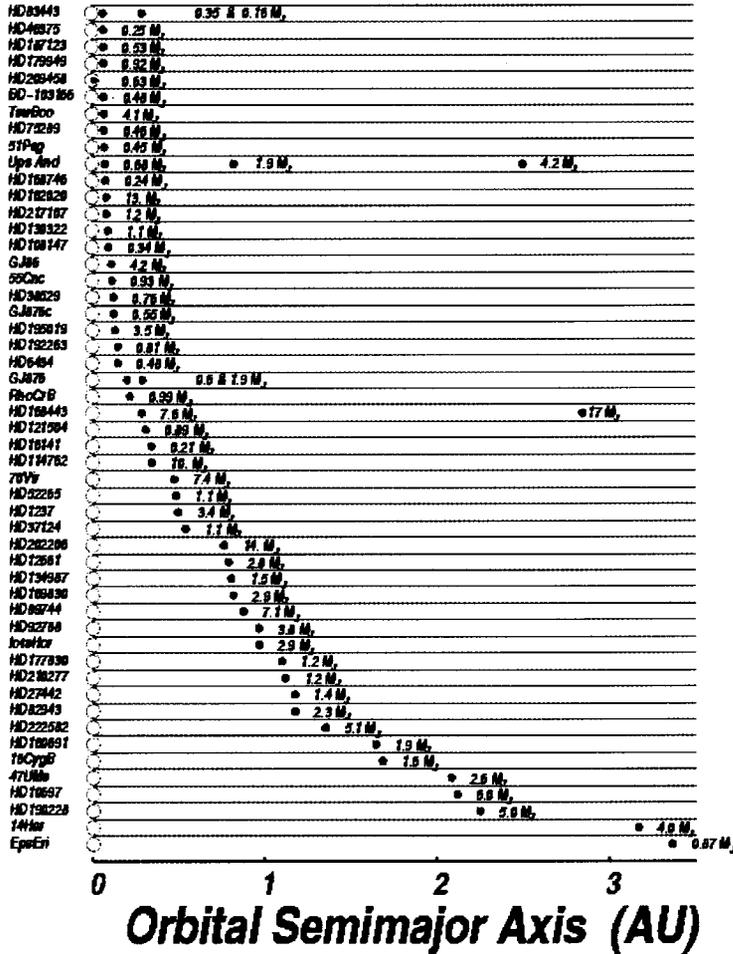
# Space Science Technology Challenges

## 3. Image, explore and understand neighboring solar systems



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### Seventy planets NOT in our solar system



Marcy, Butler, Fischer, Vogt



# Space Science Technology Challenges

## Optics technology highlights



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- Mirrors, Mirrors and More Mirrors**



- New Innovations**

- Progress Toward 1kg/m<sup>2</sup>**





# Space Science Technology Challenges

## Terrestrial Planet Finder candidate architectures



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### Interferometers

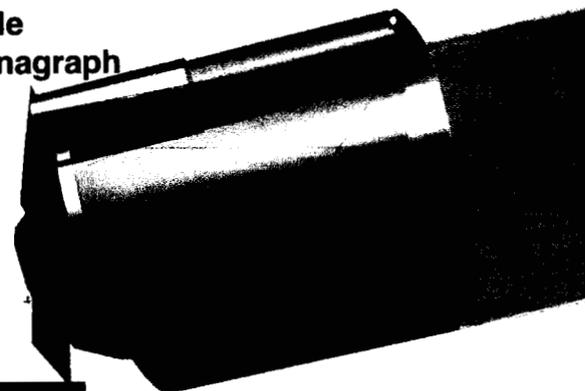
Separated S/C  
IR Interferometer



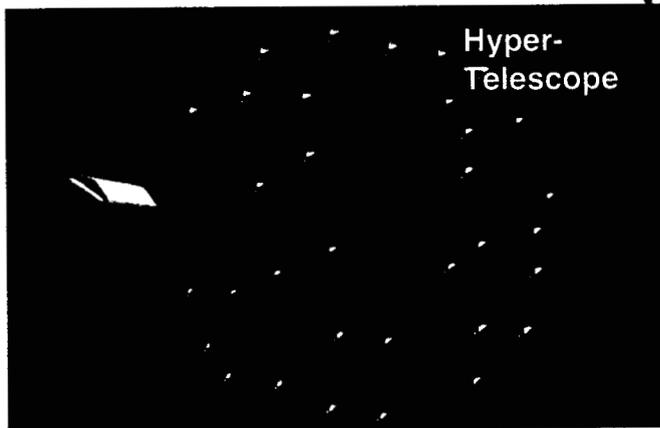
IR Interferometer  
On a Boom



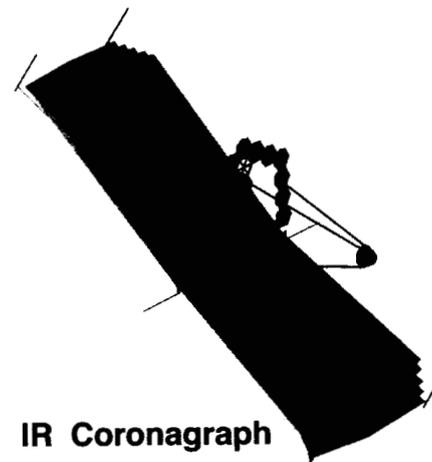
Visible  
Coronagraph



Hyper-  
Telescope



### Coronagraphs



IR Coronagraph

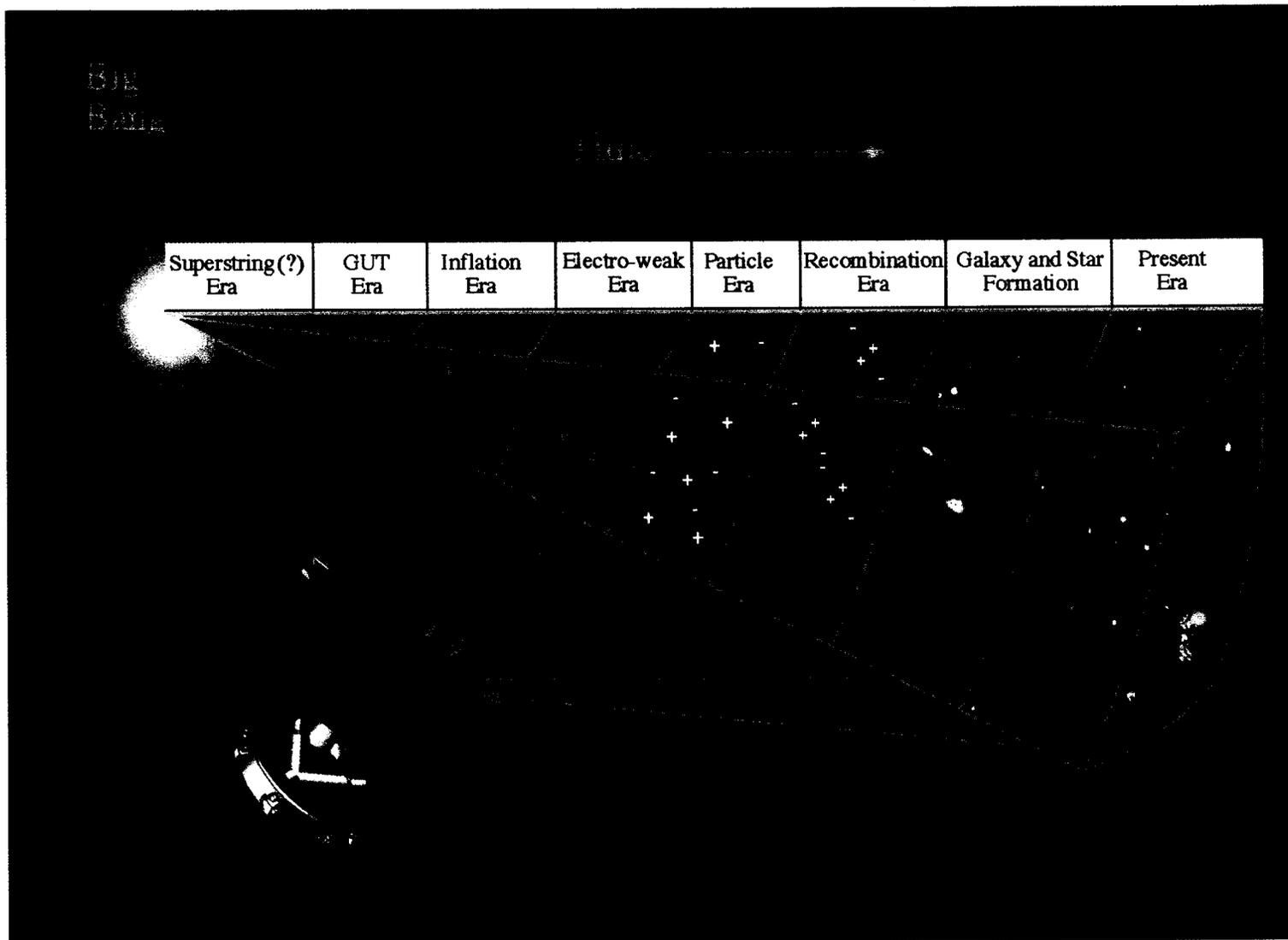


# Space Science Technology Challenges

## Gravitational Waves: a New Window on the Universe



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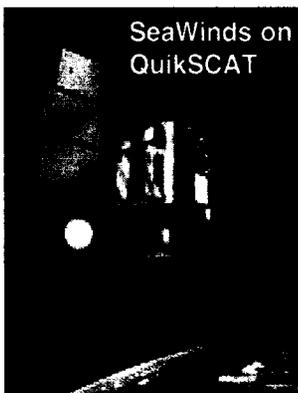


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## 5. Continue the study of Earth and its dynamic environment

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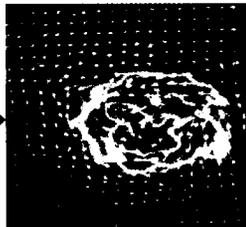
SeaWinds on QuikSCAT



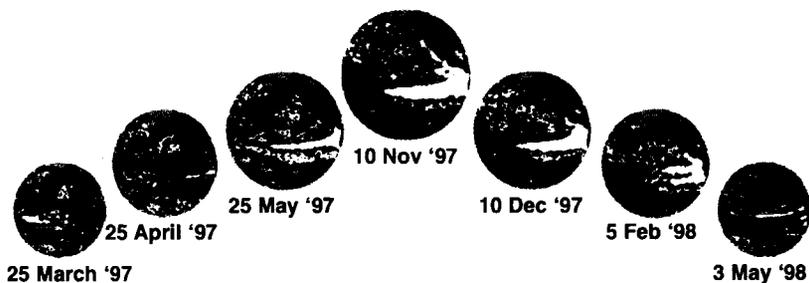
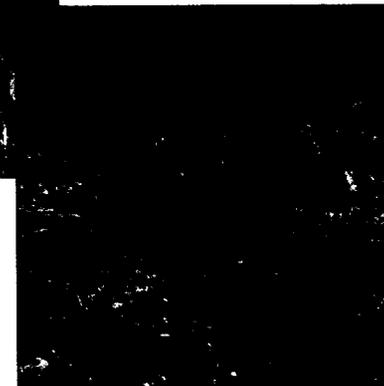
NSCAT

Ocean Vector Winds

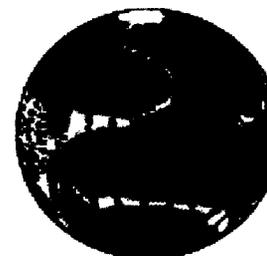
Hurricane Forecasts



Topography and Topographic Change



El Niño/La Niña



Pacific Decadal Oscillation

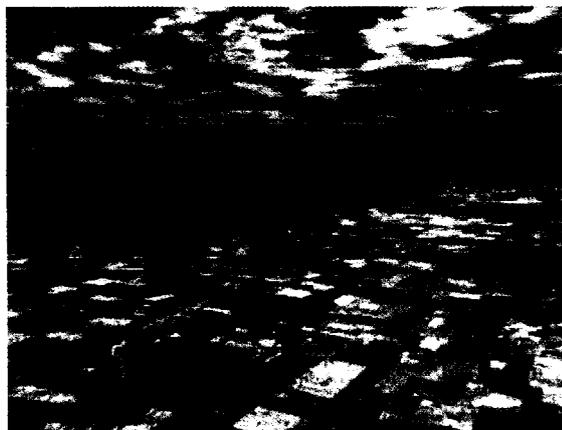


# Space Science Technology Challenges



## California as viewed by Shuttle Radar Topography Mission

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**San Joaquin Valley**



**San Fernando Valley**



**Mt. Pinos and San Joaquin Valley**



**Santa Barbara**



**Antelope Valley**



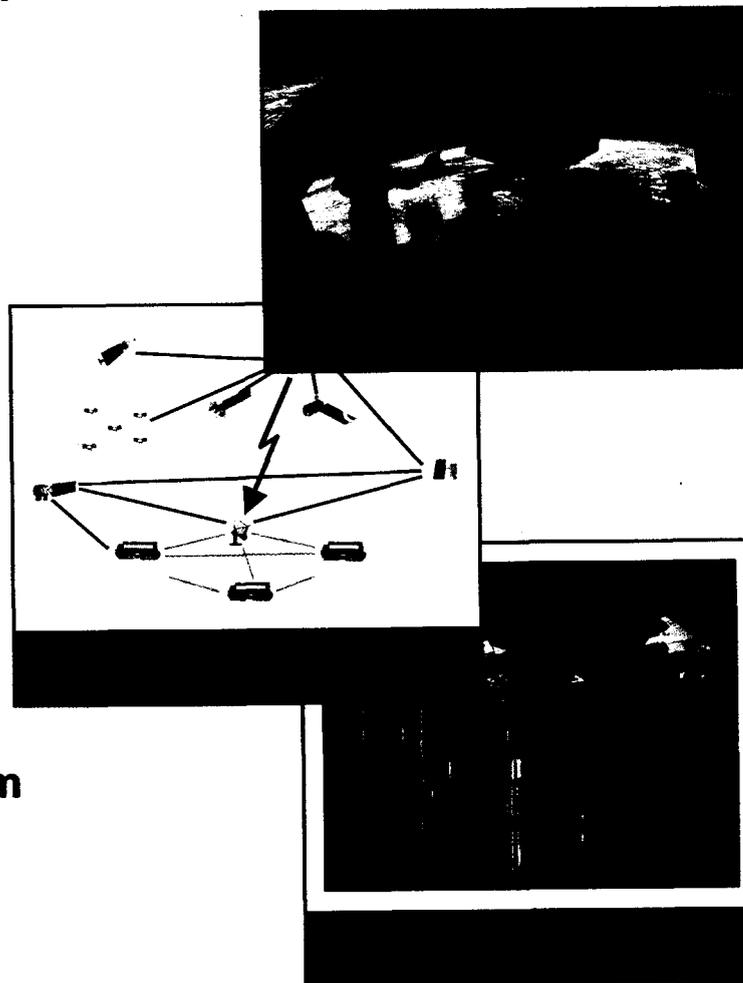
# Space Science Technology Challenges

## Earth Science technology emphasis areas



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- **Technologies enabling Earth System Science:**
  - Active microwave
  - Submillimeter/thermal IR
  - Interferometry
  - Large aperture precision deployables
  - 4 deg K coolers, sensors and detectors
  - Precision formation flying
  - Laser/LIDAR remote sensing
  - GPS technologies
  - Sensor web integration and sensor networks
  - Evolvable systems
  - Synthetic aperture radar
  - Quantum gravity radiometer and quantum sensors
  - Miniature in situ sensor package
  - Subsurface exploration techniques
  - High fidelity simulation and modeling





# Space Science Technology Challenges

## Examples of Technology Transfer to U.S. Industry



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### Communications



Technology, adopted by industry, has enabled a global communications network including



### Digital Imaging



Technology, adopted by industry, has made possible medical imaging, entertainment, photography, and the



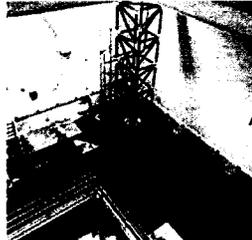
### Safety



Advanced algorithms will be used worldwide for the safety of aircraft



### Interferometry



Applying this technology to Earth-based astronomy, NASA's investment in companies like Ball Aerospace and Martin to create instruments that will lead to new discoveries

