Visions of the Future In Aeronautics and Space

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Universities Space Research Association

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ANSER

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Universities Space Research Association

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NASA Institute for Advanced Concepts

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Wyn Wachhorst

The Dream of Spaceflight

It is at its frontiers that a species experiences the most perturbing stress. The urge to explore, the quest of the part for the whole, has been the primary force in evolution since the first water creatures began to reconnoiter the land. We humans see this impulse as the drive to self-transcendence, the unfolding of self-awareness…

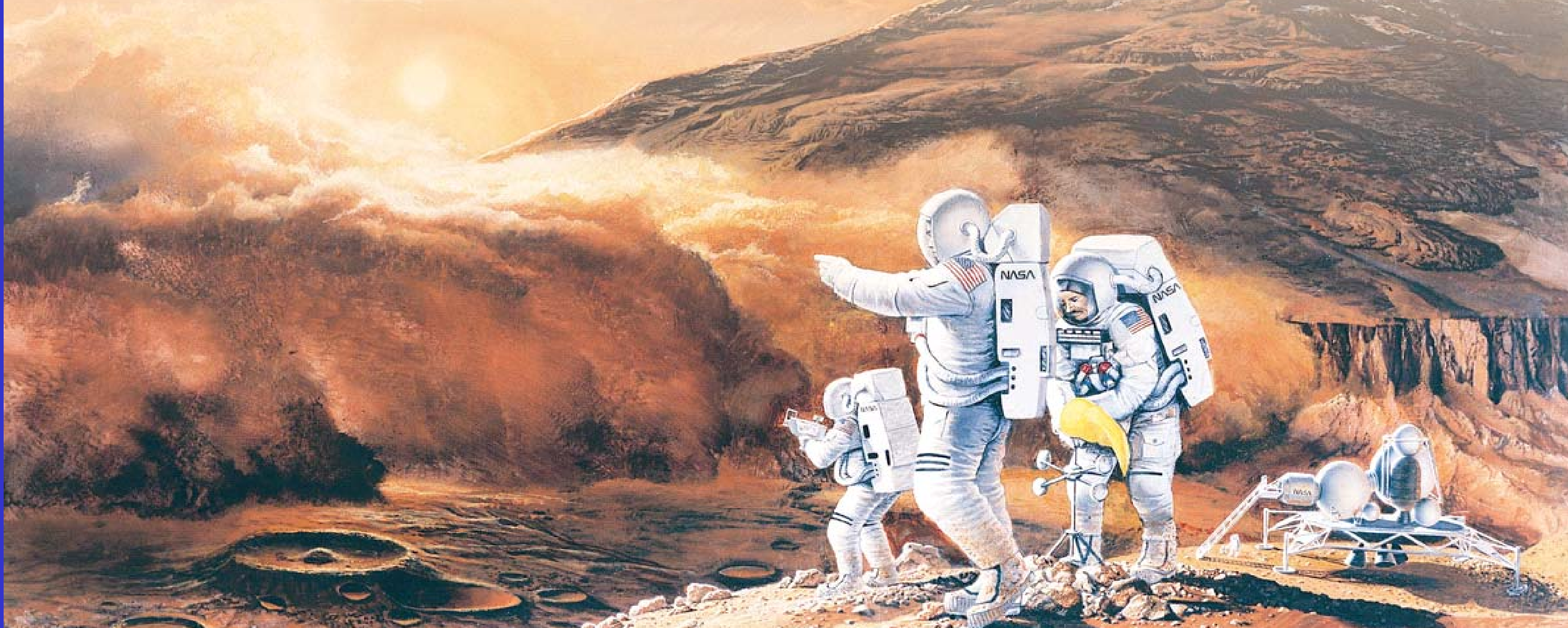
Living systems cannot remain static; they evolve or decline. They explore or expire. The inner experience of this imperative is curiosity and awe. The sense of wonder—the need to find our place in the whole—is not only the genesis of personal growth but the very mechanism of evolution, driving us to become more than we are. Exploration, evolution, and self-transcendence are but different perspectives on the same process.

Wyn Wachhorst, The Dream of Spaceflight

The frontier, like the world of the child, is a place of wonder explored in the act of play. Work is self-maintenance; play is self-transcendence, probing the larger context, seeking the higher order…

Joseph Campbell has observed that in countless myths from all parts of the world the quest for fire occurred not because anyone knew what the practical uses of fire would be, but because it was fascinating. Those same myths credit the capture of fire with setting man apart from the beasts, for it was the earliest sign of that willingness to pursue fascination at great risk that has been the signature of our species. Man requires these fascinations, said the poet Robinson Jeffers, as "visions that fool him out of his limits."

Like the capture of fire, the longing for space-flight is rooted less in means than in meaning itself.




The visions we offer our children shape the future.
It matters what those visions are. Often they become
self-fulfilling prophecies. Dreams are maps.
– Carl Sagan, 1994, "Pale Blue Dot"
DaVinci
Galileo
Kepler
Verne
JULES VERNE
EXTRAORDINAIRES
E=mc²
limit of balloon, 20 miles
limit of atmosphere, 200 miles
Goddard
Tsiolkovsky
Einstein
Oberth
Korolev
Lee
2001 a space odyssey
Von Braun
Clarke
Sagan
O'Neill
Margulis


Kitty Hawk
V-2
X-1
Sputnik
X-15
Vostok
Apollo
Gemini
Skylab
Pioneer
Salyut
Venera
Viking
Voyager
Space Shuttle
Mir
Galileo
Hubble
ISS

Now | 10 years | 20 years | 30 years | 40 years

NASA PLANS & PROGRAMS

- **NASA Enterprises**
  - *Aerospace Technology*
  - *Space Sciences*
  - *Earth Sciences*
  - *Human Exploration & Development of Space*
  - *Biological & Physical Research*
- **Operational Missions**
- **Planned Programs & Missions**

NIAC Mission

Revolutionary Advanced Concepts

Architectures

- Overall plan to accomplish a goal.
- A suite of systems, and their operational methods and interrelationships, capable of meeting an overall mission or program objective.

Systems

- The physical embodiment of the architecture
- A suite of equipment, software, and operations methods capable of accomplishing an operational objective.

Technology

Enablers to construct the system: Devices, subsystems, components, design techniques, analysis and modeling generally associated with engineering and scientific disciplines (e.g., aerodynamics, materials, structures, electronics, sensors, chemistry, combustion, plasma dynamics, etc.)

Where have we been?

Where are we going?

Future Challenges and Emerging Technical Trends?

"Visions of the future may affect our interpretation of and appreciation for the present. Our focus on the future turns our minds towards possibilities and away from more immediate conflicts and helps to remind us that there will be a future."

Robert A. Cassanova

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Future Interests and Challenges

- Fulfill the human desire to understand our place in the universe.
- Seek knowledge to understand how we evolved and what is our destiny.
- Search for life in the universe and understand cosmological phenomena.

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- Make possible the safe, affordable and effective exploration, development and self-reliant habitation of our solar system – and eventually space beyond our solar system – by humans and their agents.
- Mediate the effects of the space environment, such as microgravity and radiation, on humans and other living things,

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- **Provide seamlessly integrated, safe, reliable, fast and efficient transportation network from the Earth's surface to distant locations in space as well as portal to portal on the Earth's surface.**

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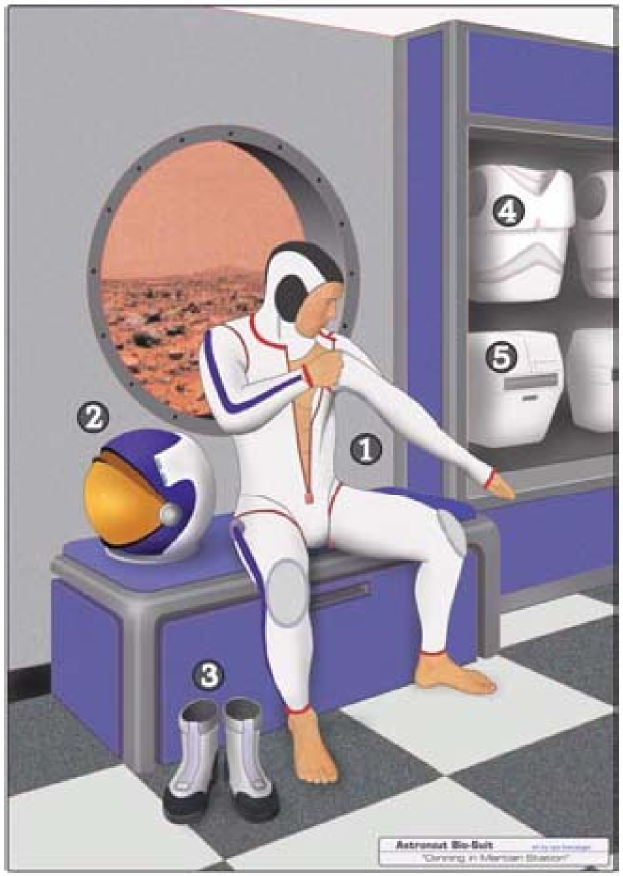
- Provide seamlessly integrated, safe, reliable, fast and efficient transportation network from the Earth's surface to distant locations in space as well as portal to portal on the Earth's surface.
- **Understand the influence on the Earth system of the actions of mankind, the natural cyclic phenomena in the Earth's system and the interaction of the Sun-Earth system.**
- **Create tools and techniques to access, visualize and interpret data and model findings.**
- **Predict the future evolution of the Earth system and its relationship to natural phenomena and human activity, and validate this predictive capability.**

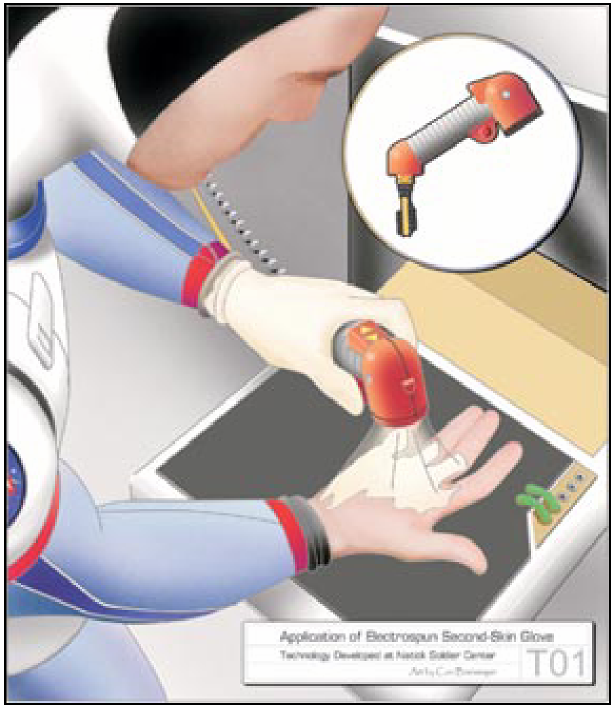
Examples of Advanced Concepts Selected and Funded by NIAC

Astronaut Bio-Suit System for Exploration Class Missions

Dava Newman, Massachusetts Institute of Technology



An astronaut on Mars donning the comfortable elastic bio-suit layer (1). The hard torso shell (4) is donned next and seals with couplings at the hips and shoulders. The hard backpack, or portable life support system, (5) attaches mechanically to the hard torso shell, and provides gas counter pressure. Gas pressure flows freely into the helmet (2) and down tubes on the elastic bio-suit layer to the gloves and boots (3). The bio-suit layer is lightweight and easy to don and doff. It is custom fitted to each astronaut using a laser scanning/electrospinlacing process (Natick Soldier Center). Remaining suit elements are simple, functional, interchangeable and easy to maintain and repair.



Electrospinlacing is a process where a multi-filament fiber of polymer is sprayed onto a grounded surface, which is achieved by charging a suspended drop of polymer with tens of thousands of volts. At a characteristic voltage the droplet forms a Taylor cone, and a fine jet of polymer releases from the surface in response to the tensile forces generated by interaction of an applied electric field with the electrical charge carried by the jet. The projected polymer can be collected as a continuous web of fibers in a range of thicknesses. Application can be made directly to the skin as shown, or to advanced 3D forms from laser scans. Wearable computers, smart gels and conductive materials could be embedded between polymer layers in future space suit applications. Electrostrictive gel is used to create a seamless mechanical counter-pressure (MCP) layer. A simple hand-held spray device is used for self application.

A Chameleon Suit To Liberate Human Exploration of Space Environments

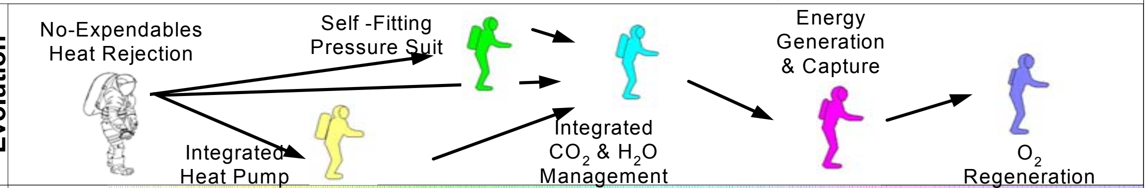
Edward Hodgson, Hamilton Sundstrand

- Integrated micro heat pumps to expand operating environment capabilities
- Mechanically active materials to enhance suit protective and mobility performance
- Chemically-assisted transport to reject metabolic waste CO_2 and H_2O
- Energy harvesting to capture incident solar energy and usable portions of metabolic waste heat
- Integrated advanced energy storage techniques
- Biomimetic chemical conversion derived from artificial photosynthesis to recover respirable oxygen from metabolic waste products.

Chameleon Suit Concept Evolution Roadmap

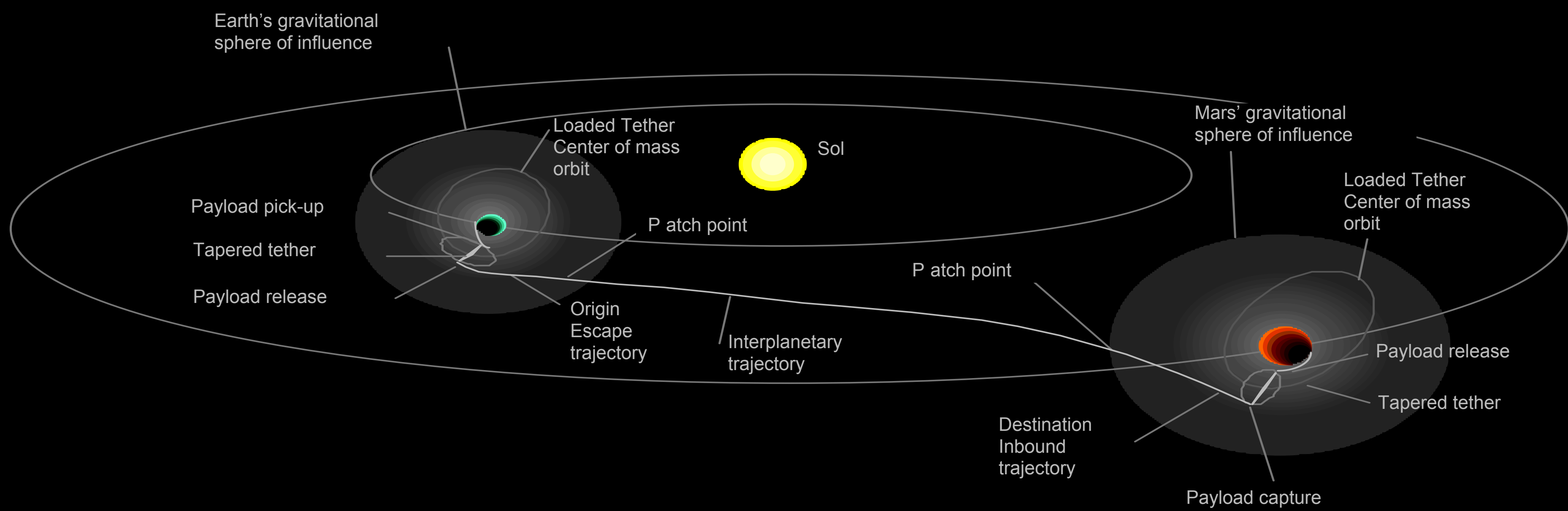
2010 → 2040

Concept Evolution



Enabling Technologies	Smart Polymers MEMS Wearable Electronics	Polymeric Thermo-Electrics Microturbines / Micro-channel HX	High Force Active Polymer Advanced Joint Designs	Chemical Transport Smart Polymers - Selective Membranes	Polymer Photo- & Thermo-Electrics Advanced Energy Storage Biomimetic Technologies Artificial Photosynthesis
Research Needs & Directions	Active Polymer Space Environment Tolerance High Performance IR Electro-chromics Fabric - MEMS Integration Large Scale Wearables Integration	Flexible, Light Weight, Thermo-electric Heat Pump Efficient Integrated Micro-Fluid Systems	Electro-Active Polymer Molecular Design Advanced Structural Design and Modeling Controlled Anisotropic Materials	Chemically Enhanced Transport Membranes Transport Control Mechanisms Integration With Active Polymers	High Efficiency Photo Conversion Extended Life Metastable States Enhanced Charge Transfer Broad Spectrum Photo-Energy Capture High Efficiency Thermal Energy Conversion Low Energy Cost Reactions Oxygen Recovery Carbon Fixation

INTERPLANETARY TRANSPORT USING ROTATING TETHERS

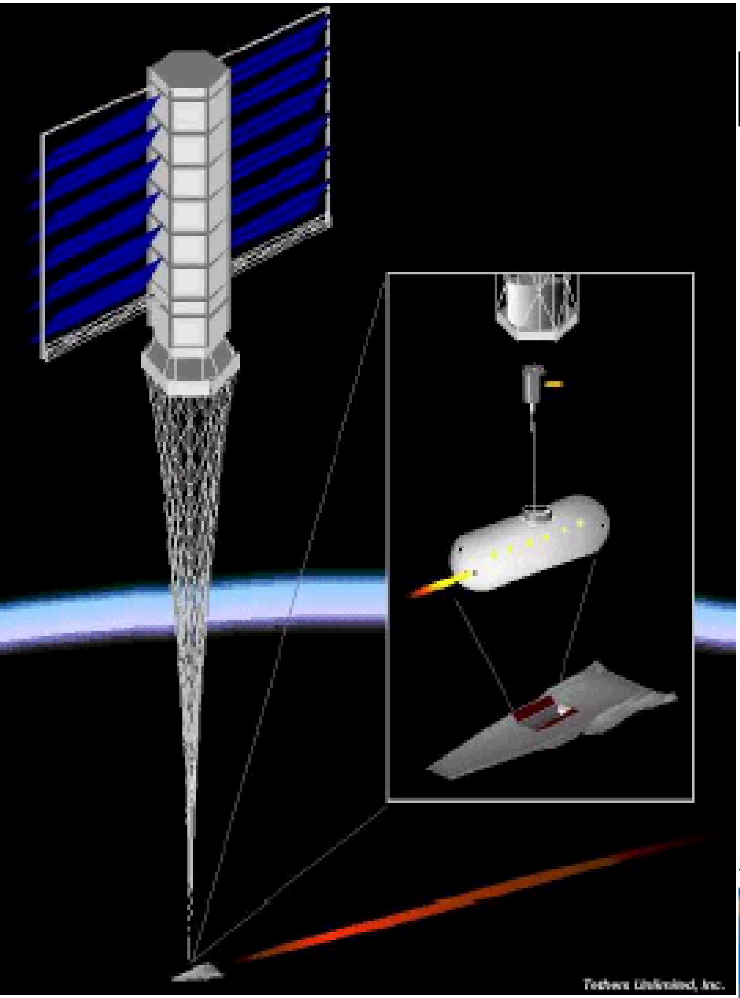


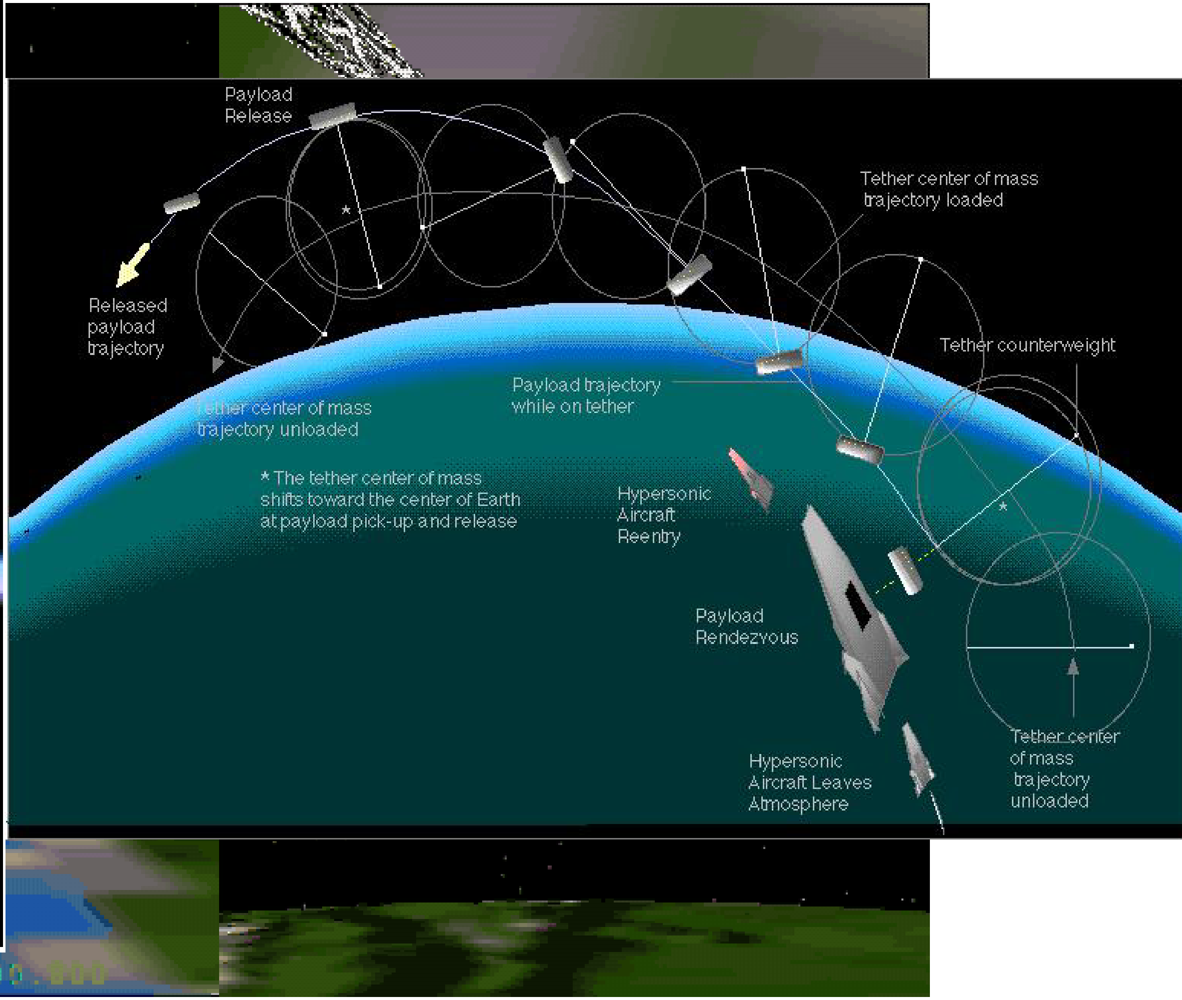
Cislunar2000.MOV

Hypersonic Airplane Space Tether Orbital Launch – HASTOL

John Grant, The Boeing Company

Phase II Performance Period: April 1, 2000 to September 30, 2001



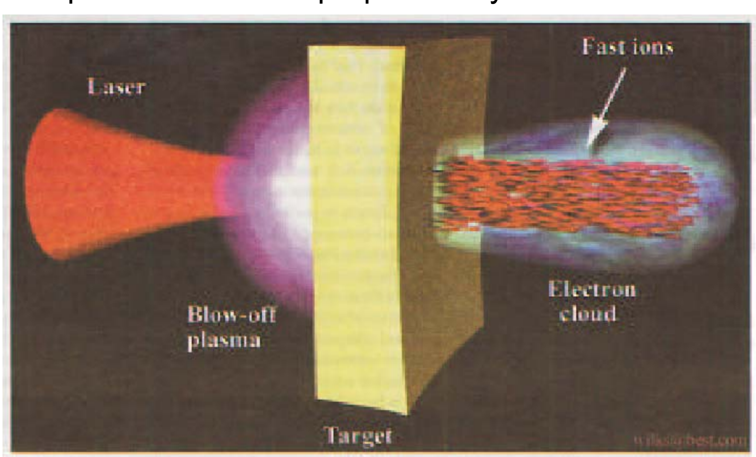


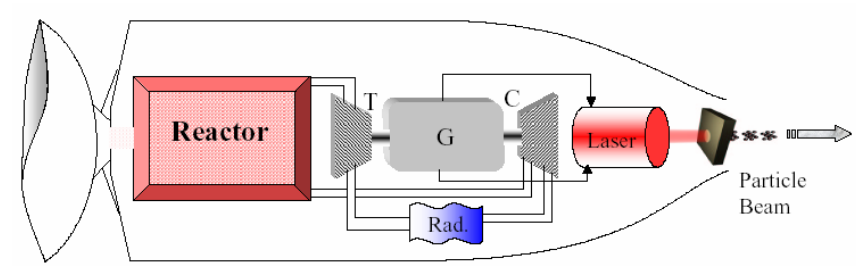
HASTOL Rendezvous.mov

Ultrafast Laser-Driven Plasma for Space Propulsion

Terry Kammash, University of Michigan

- Examination of the underlying physics reveals that intense lasers are capable of accelerating charged particles to relativistic energies when focused on small focal spots in very thin targets.
- Experiments at the University of Michigan and other world-wide laboratories have demonstrated dramatically the production of nearly collimated beams of protons at mean energies of several MeV when lasers of intensities of ^{3} 10 18 W/cm 2 , at about one micron wavelengths, are made to impinge on focal spots of several microns in radius in solid targets with few microns thickness.
- Capable of producing specific impulses that exceed million seconds albeit at very modest thrusts.
- This phase II proposal is aimed at enhancing the thrust that can be generated by LAPPS without seriously degrading the specific impulse.
  1) by increasing the number of particles in the beam;
  2) by increasing the rep rate; and
  3) by increasing the velocity of the ejected charged particles.
- The current University of Michigan 10 TW laser, and its upgrades of 100 TW and petawatt will be utilized in the span of the next two years to establish the feasibility of this approach.
- The performance of a propulsion system will be evaluated with parameters that emerge from this investigation.





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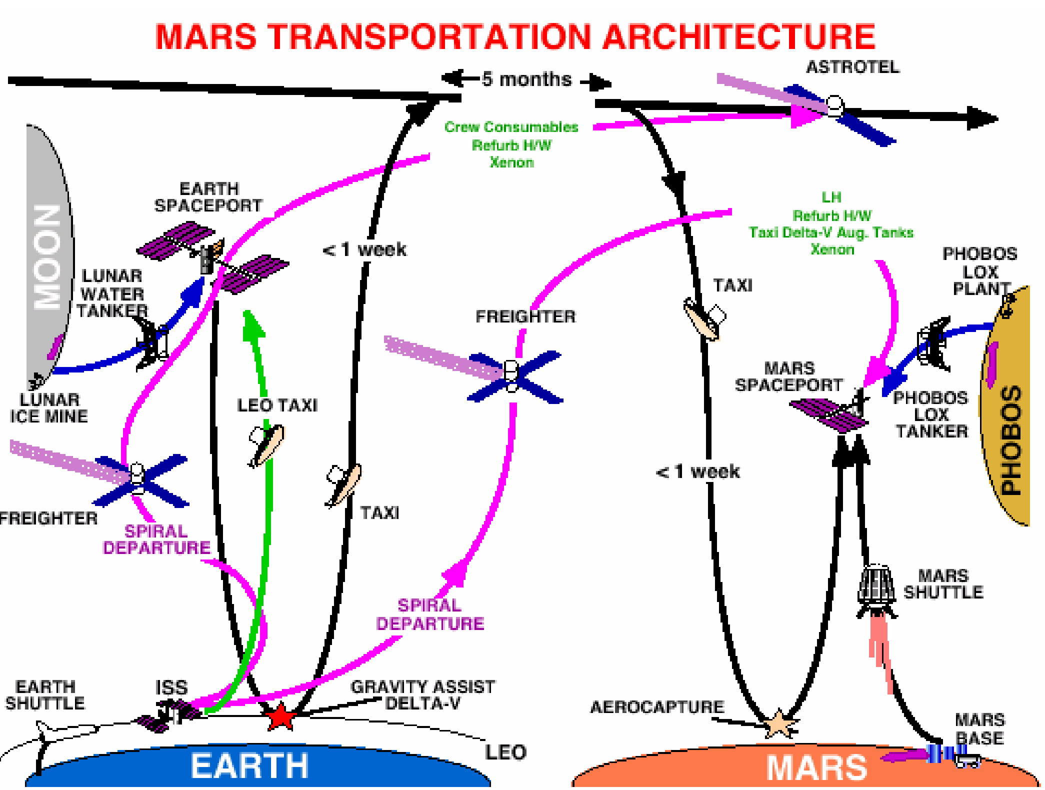
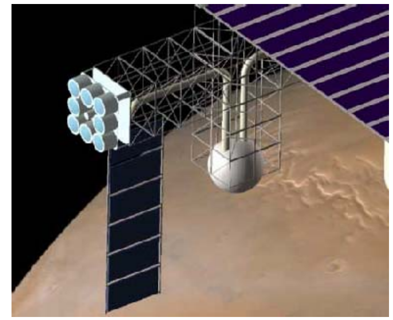
Cyclical Visits to Mars via Astronaut Hotels

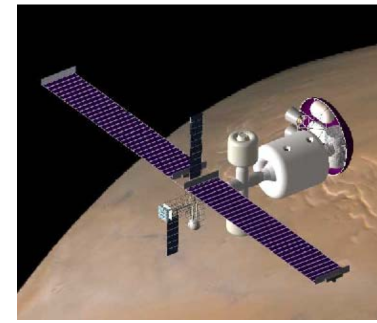
Kerry Nock, Global Aerospace Corporation

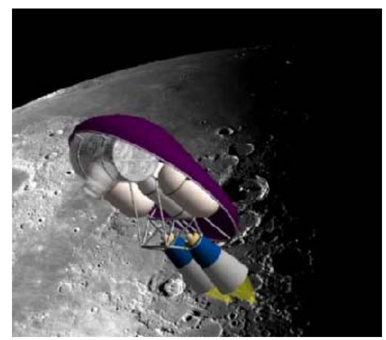
Phase II Performance Period: March 1, 2001 to January 31, 2003





Astrotel IPS





Taxi departing

Taxi during Mars Aerocapture

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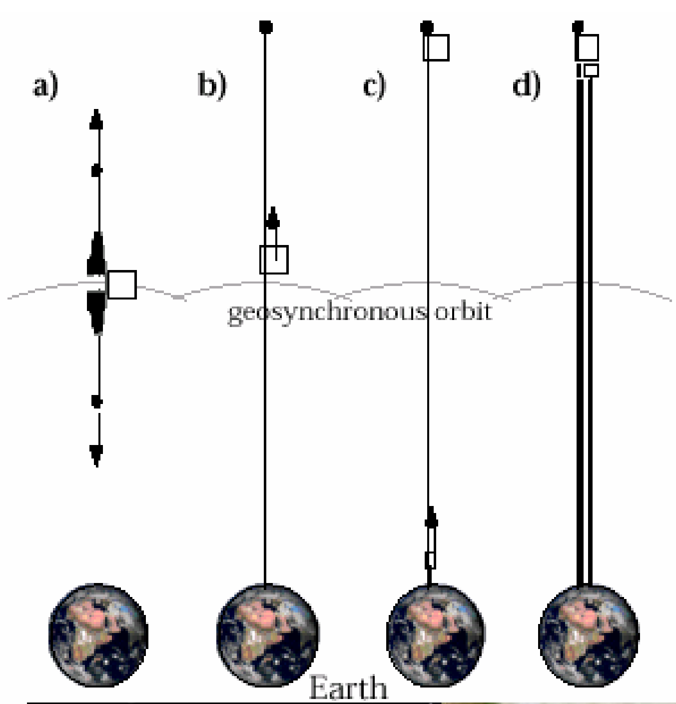
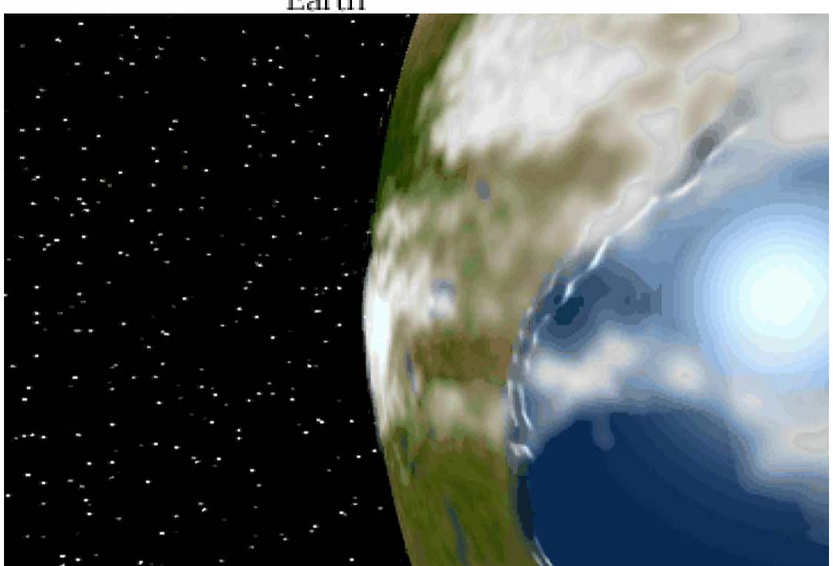
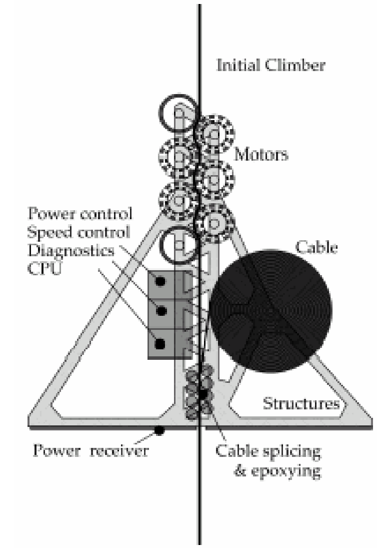
The Space Elevator

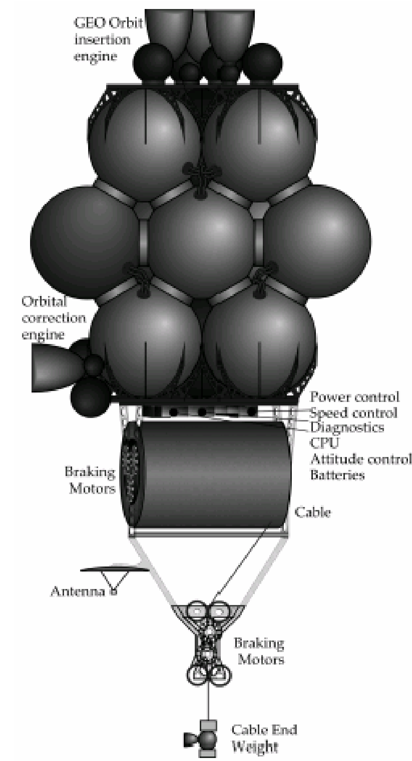
Bradley Edwards, Eureka Scientific

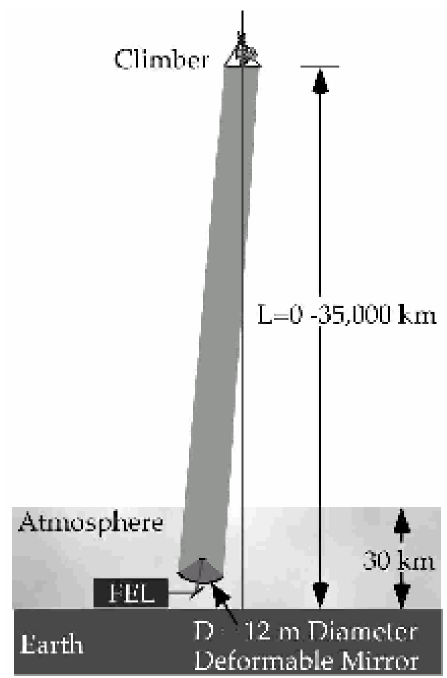
Phase II Performance Period: March 1. 2001 to January 31, 2003









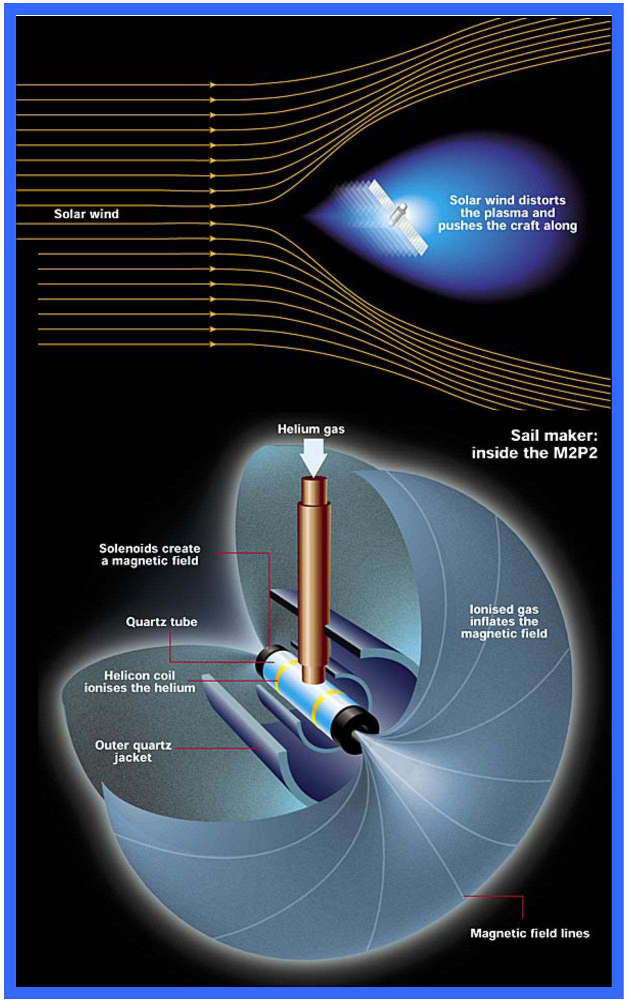


The Mini-Magnetospheric Plasma Propulsion System, M^2P^2

Robert M. Winglee, University of Washington

Phase II Performance Period: August 1, 1999 to July 31, 2001

Concept for interstellar propulsion and radiation shielding



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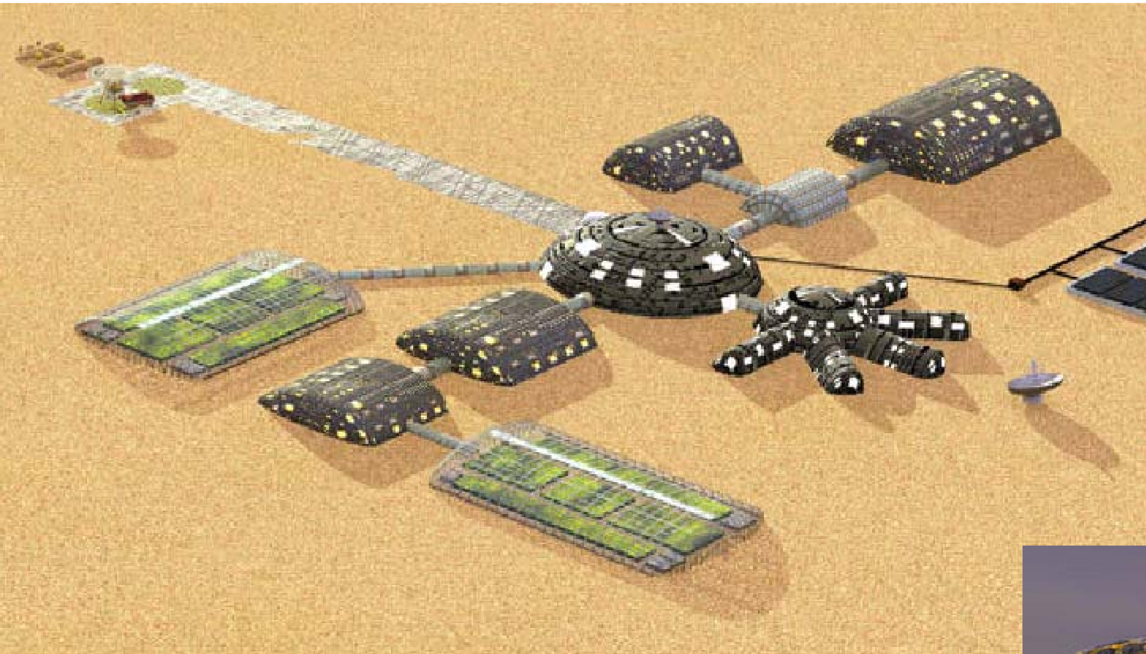
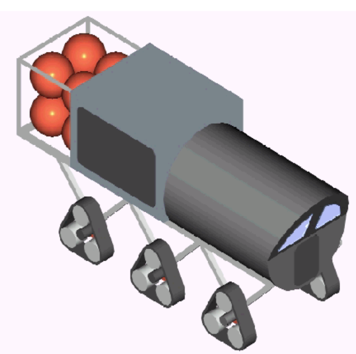
Advanced System Concept for Total ISRU-Based Propulsion and Power Systems for Unmanned and Manned Mars Exploration

Eric Rice, Orbital Technologies Corporation

Phase II Performance Period: April 1, 2000 to March 31, 2002





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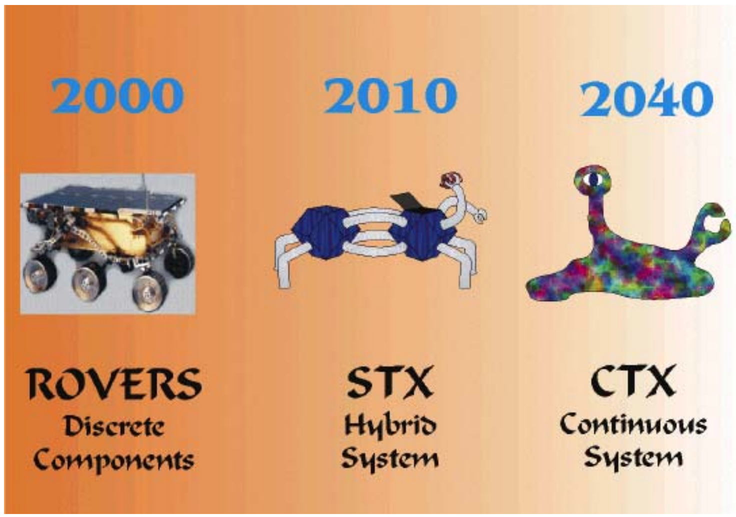
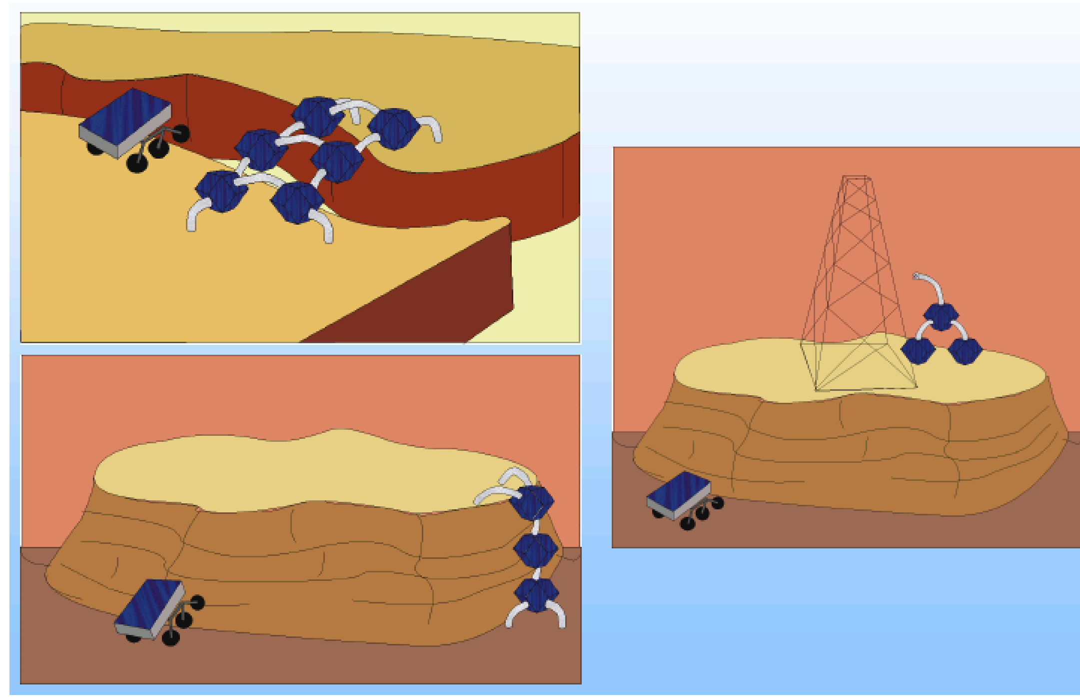
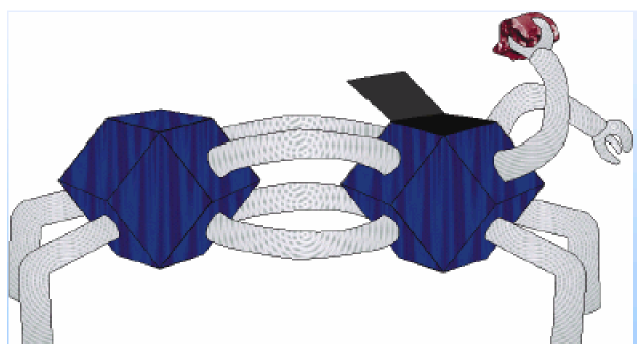
Self-Transforming Robotic Planetary Explorers

Steven Dubowsky, Massachusetts Institute of Technology

Phase II Performance Period: September 1, 1999 to August 31, 2001







The STX c.2010

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System Feasibility Demonstration of Caves and Subsurface Constructs for Mars Habitation and Scientific Exploration

Penelope Boston, Complex Systems Research

Innovation	Application	Current TRL*
Caves as extraterrestrial science targets	Science & Exploration	2
Earth cave technology test beds	Science, Human Exploration & Colonization	4
Planetary protection issues in caves	Science, Planetary Protection Protocol Development	4
Self-deploying, microrobotic incave communication system	Science, Exploration, Human Habitation, & Resource Use	3
Foamed-in-place airlocks	Human Habitation & Resource Use	4
Inflatable cave liners with sensing/regulating properties	Human Habitation, Science & Resource Use	5
Inert gas pressurization of caves	Human Habitation, Resource Use & possibly Science	2
Breathable inert gas mixtures	Human Habitation & Colonization	2
Bioluminescence/oxygen system	Human Life Support	2
Homosymbionts	Human Colonization	1
Exploitation of trapped cave volatiles	Human Colonization & Resource Use	4
Micromining via bioinjection/nanoinjection	Human Colonization & Resource Use	1

- ***Inflatable cave liners***
- ***Communication infrastructure***
- ***Airlocks***
- ***Mars-derived breathable mixtures and incave created inert atmospheres***
- ***Light-mining and light-piping***
- ***Bioluminescent light and oxygen generation***
- ***System integration and control of gas balance, power, water, waste control***
- ***Lab-in-a-box***
- ***Potential test cave sites in Oregon, Arizona and New Mexico***

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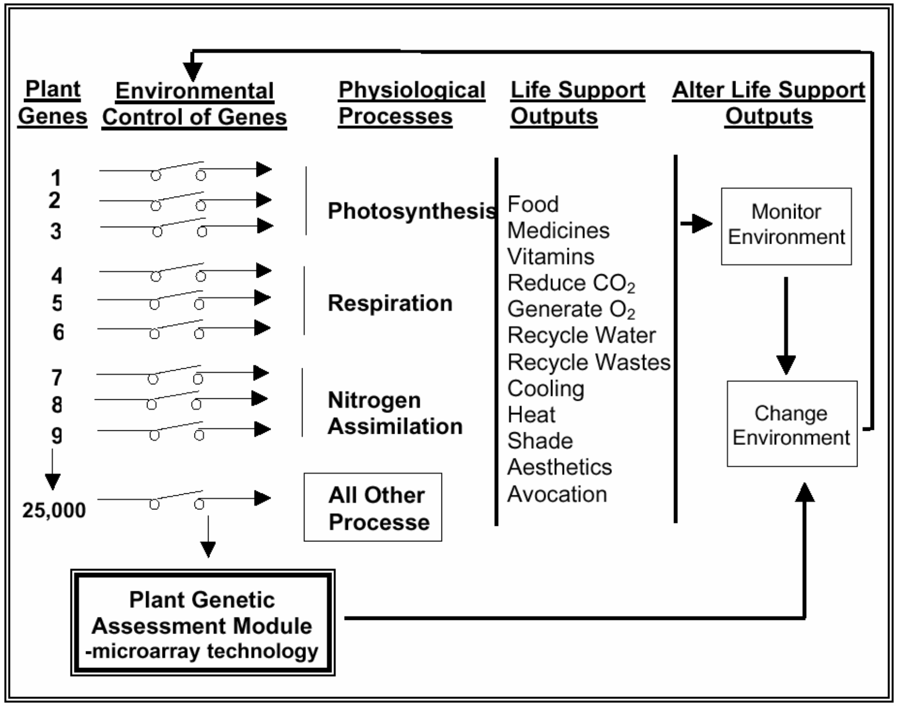
Developing a Plant Genetic Assessment and Control System for Space Environments

Terry Lomax, Oregon State University

- Harsh environments in space will provide stresses for plants that can limit their capacity to fulfill life support functions.
- Space travel poses new stresses for which there is neither the capacity for experimentation on Earth, nor an evolutionary history for plants.
- Impacts of stresses unique to space environments, such as microgravity and space radiation, are not known for plants.



System for assessing the status of plant gene expression and using that information to both regulate the bio-system environment and control the expression of plant genes with environmental cues

Arabidopsis will be used as the model plant

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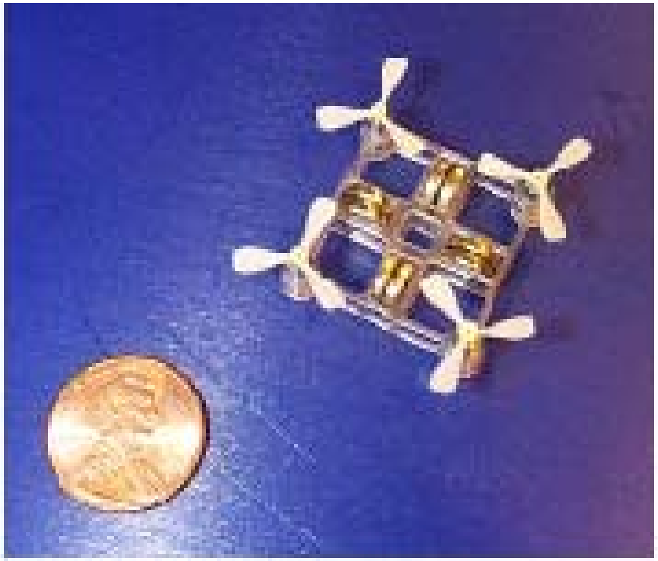
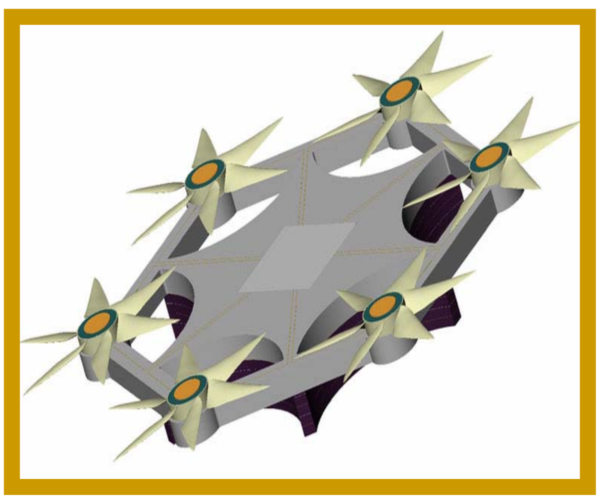
Meso-Scale Flight Vehicle for Atmospheric Sensing

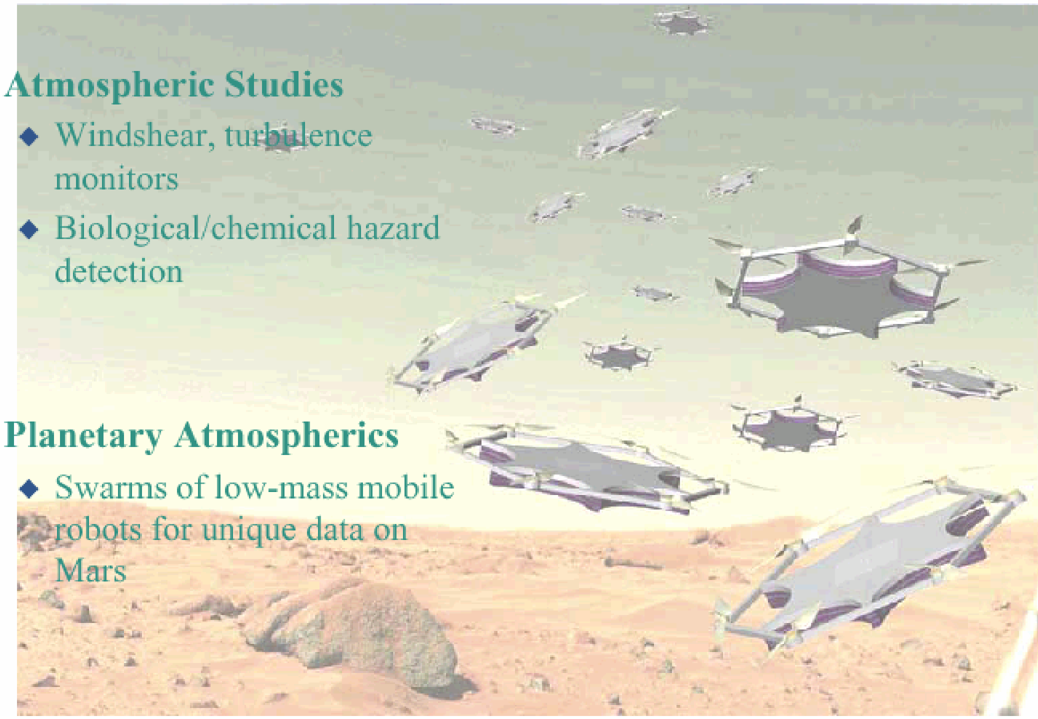
Ilan Kroo, Stanford University

Phase II Performance Period: August 1, 1999 to July 31, 2001





The Concept: Applications



- Atmospheric Studies
  - Windshear, turbulence monitors
  - Biological/chemical hazard detection
- Planetary Atmospherics
  - Swarms of low-mass mobile robots for unique data on Mars

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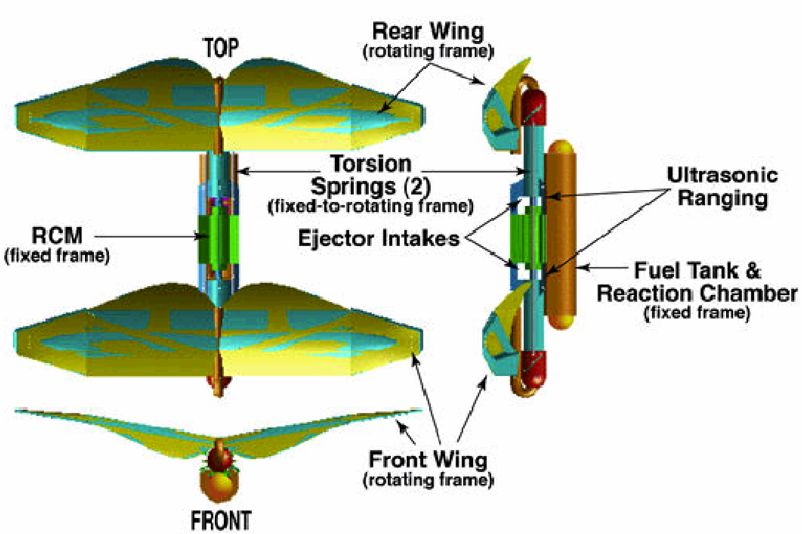
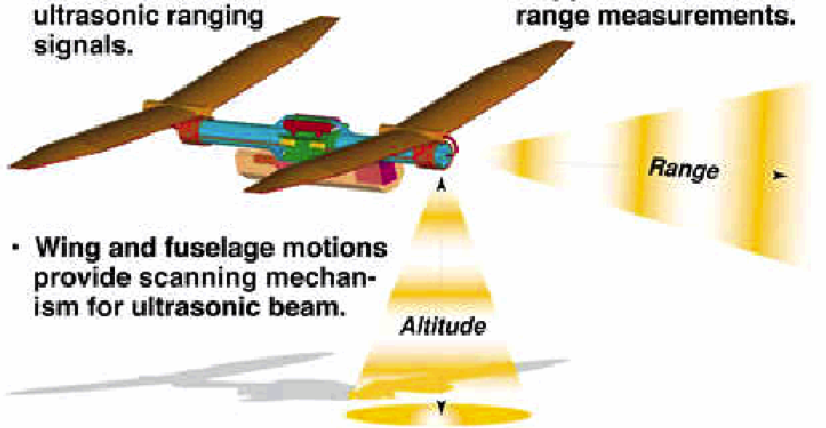
Planetary Exploration Using Biomimetrics

Anthony Colozza, Ohio Aerospace Institute

Phase II Performance Period: March 31, 2001 to August 31, 2002



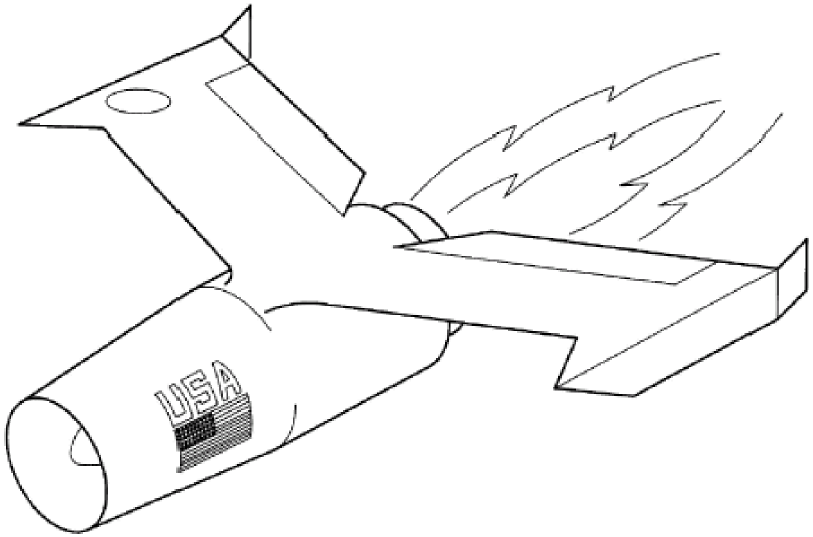
- Gas used to drive wings can be reused to create ultrasonic ranging signals.
- FMCW waveform allows Doppler insensitive range measurements.
- Wing and fuselage motions provide scanning mechanism for ultrasonic beam.



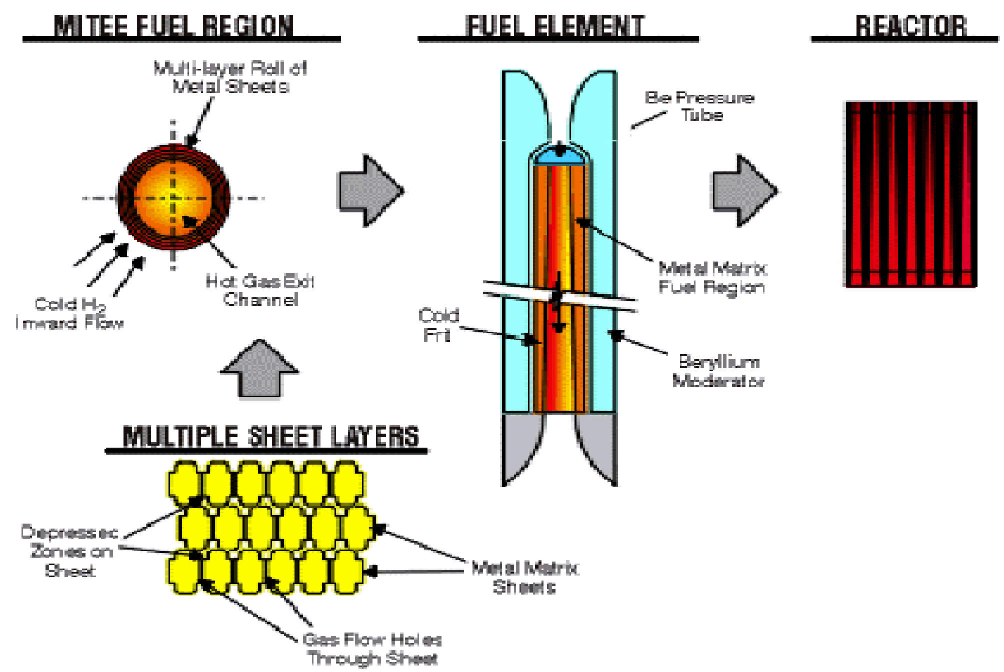
Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer

George Maise, Plus Ultra Technologies, Inc.

Phase II Performance Period: March 1, 2001 to January 31, 2003



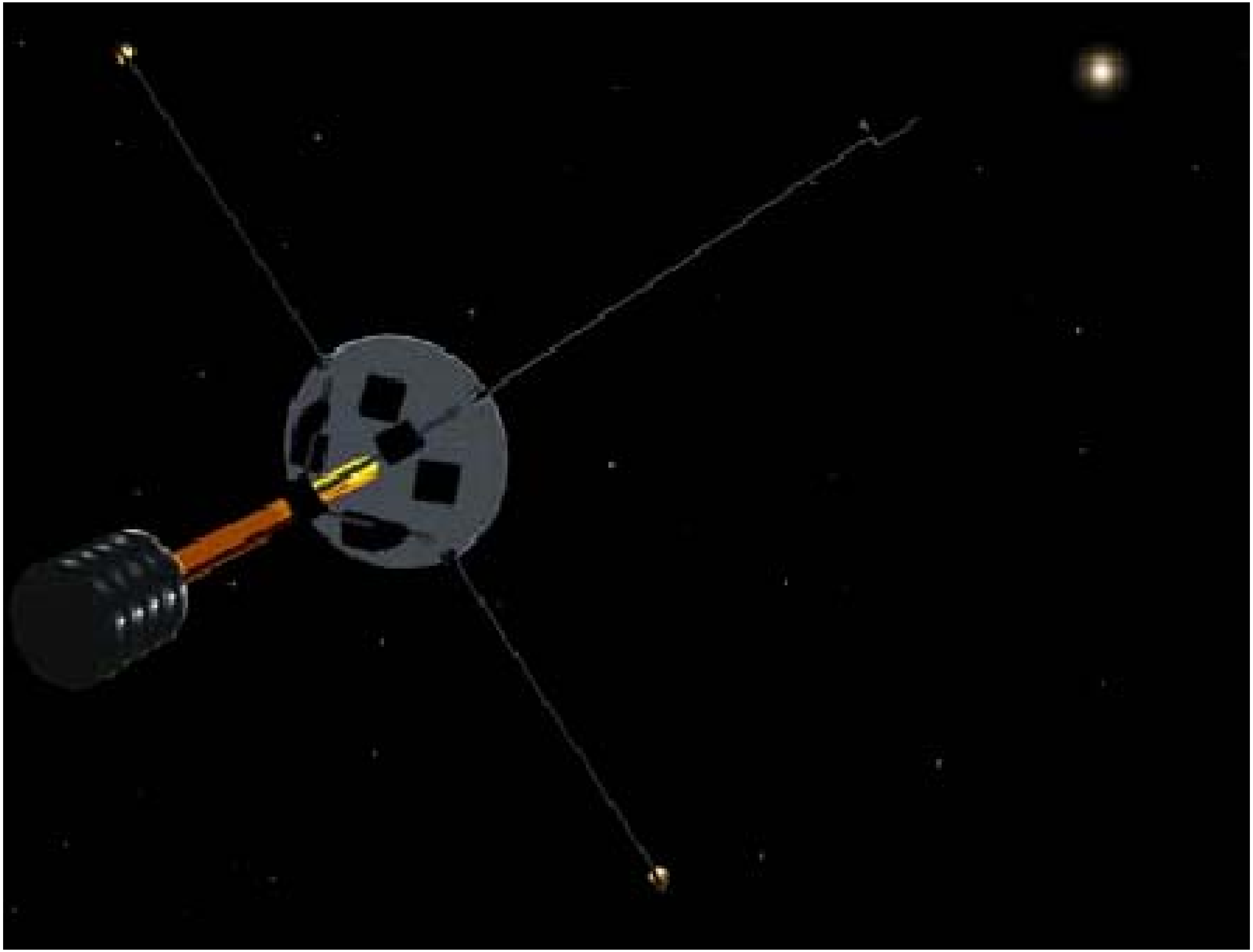
MITEE Nuclear Engine



A Realistic Interstellar Explorer

Ralph McNutt, Jr., Johns Hopkins Applied Physics Lab

Phase II Performance Period: April 1, 2000 to March 31, 2002



Very Large Optics for the Study of Extrasolar Terrestrial Planets

Neville J. Woolf, Steward Observatory, University of Arizona

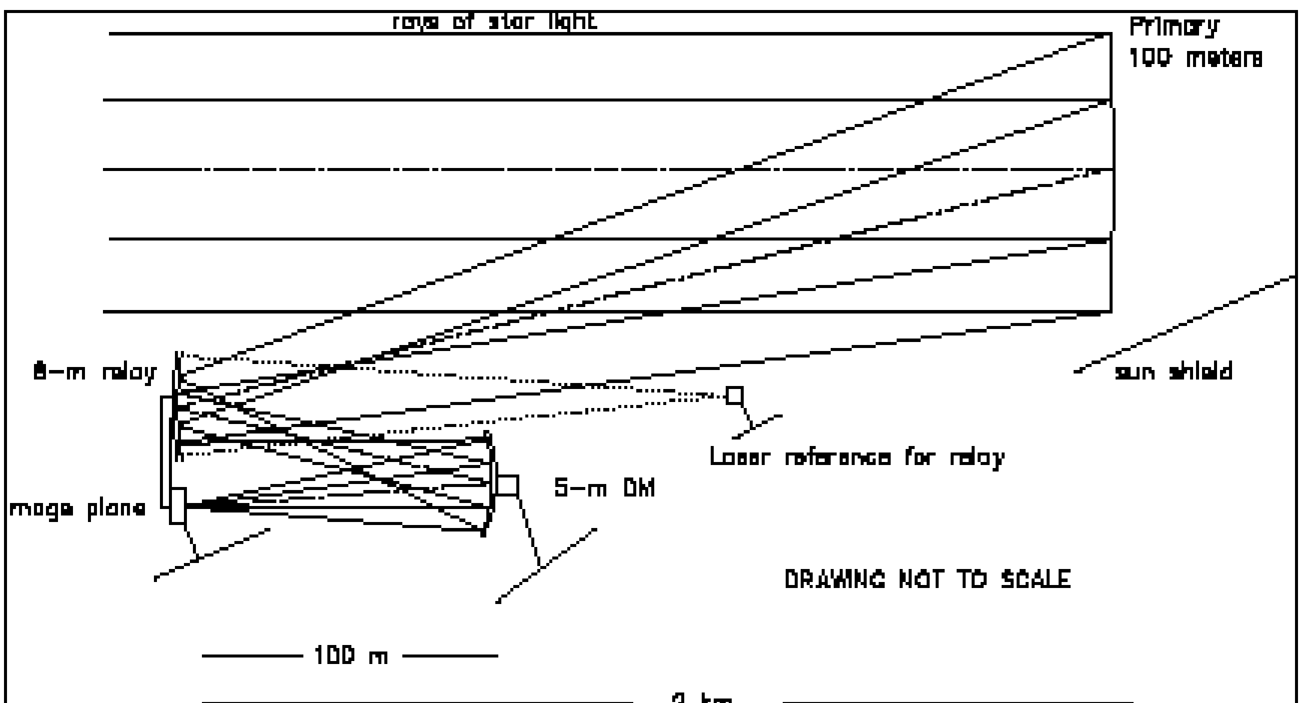
Phase II Performance Period: August 1, 1999 to July 31, 2001

Hubble Space Telescope (operational)

Next Generation Space Telescope (technology development)

Terrestrial Planet Finder (concept development)

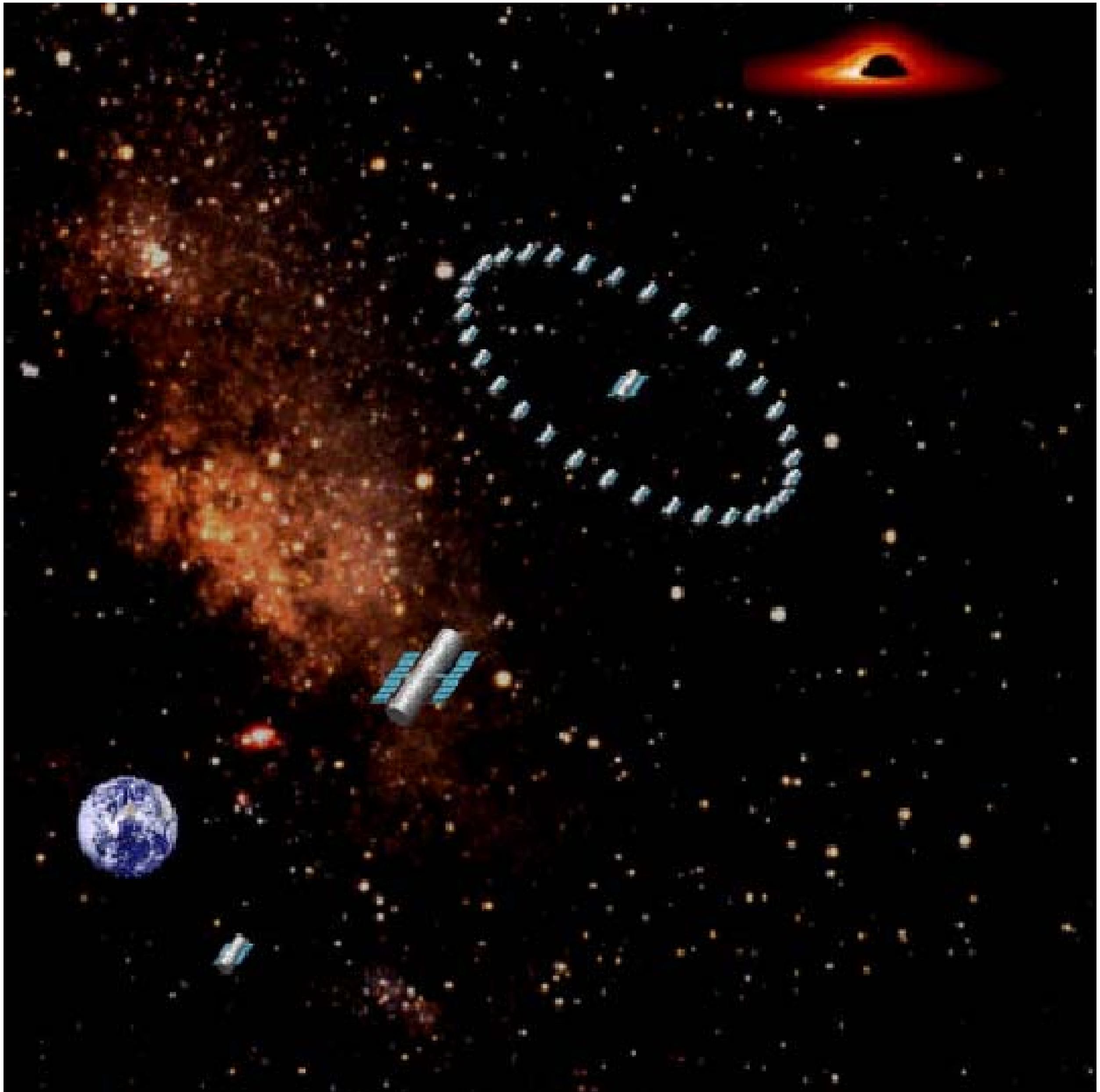
Life Finder



X-ray Interferometry - Ultimate Astronomical Imaging

Webster Cash, University of Colorado

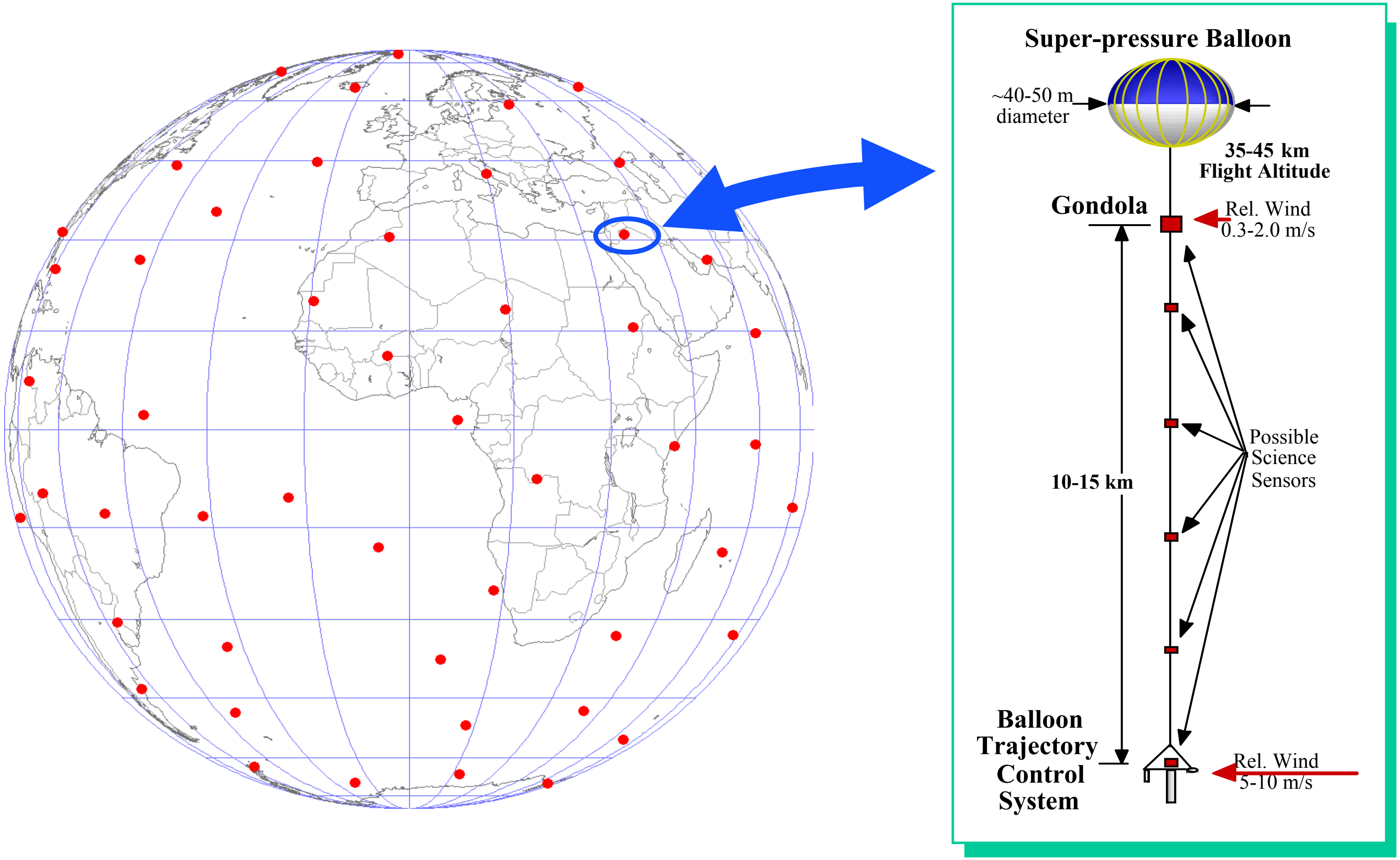
Phase II Performance Period: April 1, 2000 to March 31, 2002



Global Constellation of Stratospheric Scientific Platforms

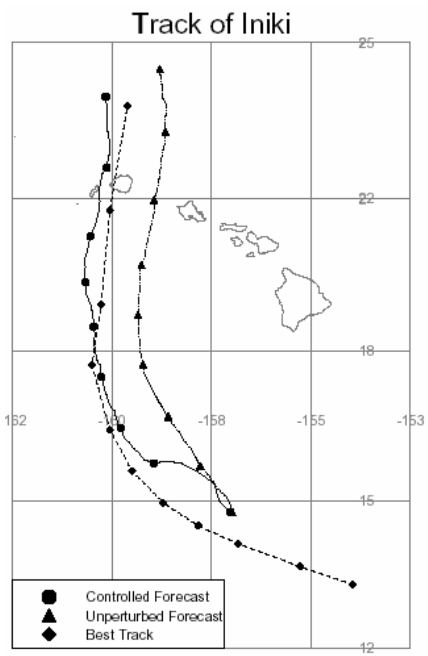
Kerry Nock, Global Aerospace Corporation

Phase II Performance Period: April 1, 2000 to February 28, 2002



Controlling the Global Weather

Ross Hoffman, **Atmospheric and Environmental Research**



Theoretical Basis

- *The Earth's atmosphere has been hypothesized to chaotic*
- *Chaos implies that there is a finite predictability time limit*
- *Chaos also implies sensitivity to small perturbations*
- *A series of such perturbations to the atmosphere might be devised to effectively control*

•*the evolution of the atmosphere*

Key Questions

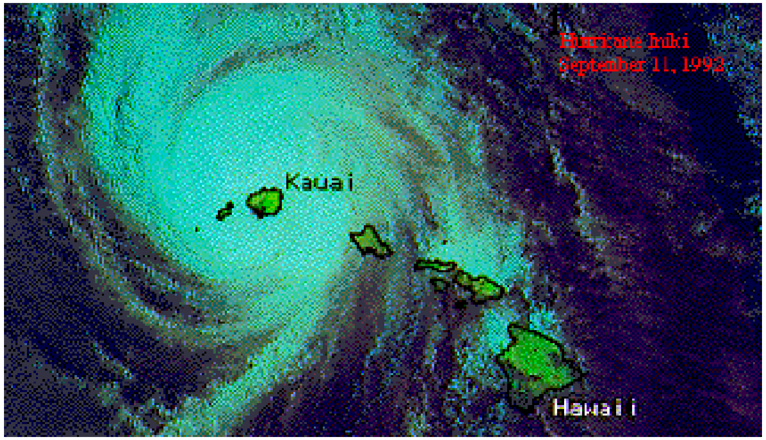
1. *Is it possible to control the weather and by what means?*
2. *If we could control the weather, how should we use, or not use, this capability*

Phase I Objectives

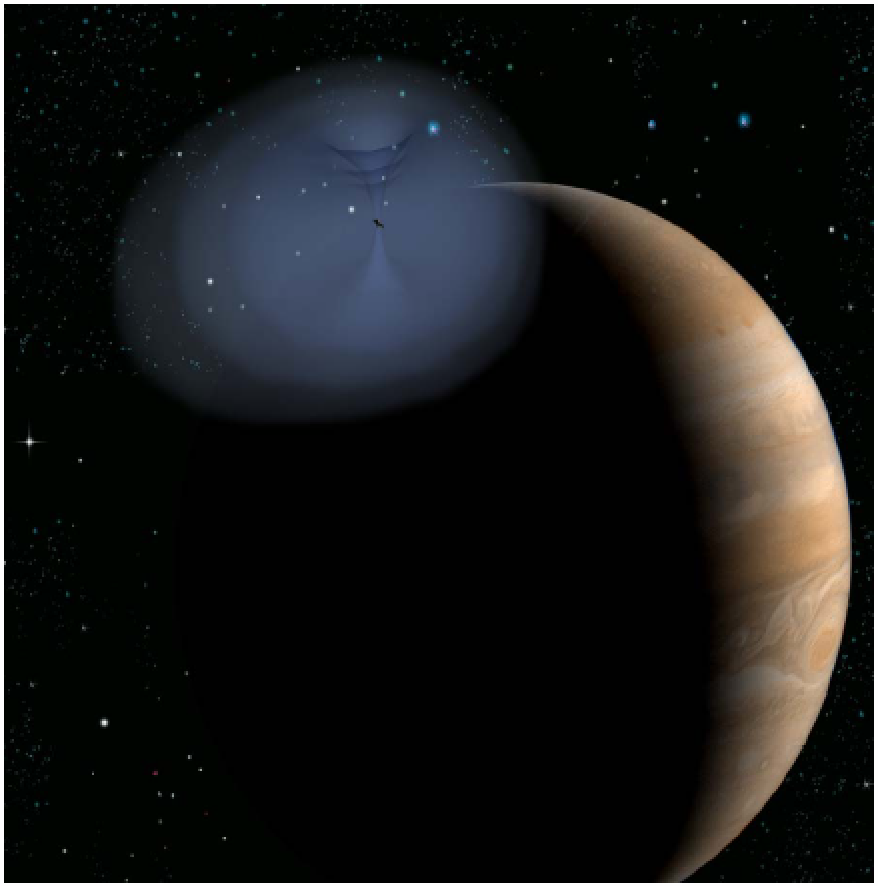
- *Develop a method to calculate the perturbations needed to control the track of a hurricane*
- *Quantify the size of the perturbations needed to do this.*

Examples of Devices for Atmospheric Perturbation

- *Aircraft contrails*
- *Space solar reflectors*
- *Space solar power*
- *Wind Power*



Annual Report



February 2002

Available for viewing and downloading from the NIAC website at: http://www.niac.usra.edu

NIAC Fourth Annual Meeting

June 11-12, 2002
Lunar and Planetary Institute
Houston, Texas

Keynote Speakers: Dr. Harley Thronson
Dr. Jack Stuster
Dr. Donna Shirley

Presentations by all currently funded Phase II NIAC Fellows

Will be a live webcast

The webcast link is available from the webcast section of the NASA Technology Portal at:

http://nasatechnology.nasa.gov/index.cfm

The page also includes a link to the email address for participants to submit questions to the speakers:

niacwebcast@larc.nasa.gov