# NIAC Status Report for the AIAA SCTC

January 16, 2002

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NASA Institute for Advanced Concepts

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# NIAC Charter

- **Focus on Revolutionary Advanced Concepts for Architectures and Systems**

- **Be an Institute Independent of NASA**
  - -- Management and guidance external to NASA
  - -- Non-NASA (mostly) peer review
  - -- NIAC issues and manages research grants/contracts
  - -- Contractually reports to GSFC with funding from NASA HQ

- **Operate as a Virtual Institute over the Internet (http://www.niac.usra.edu)**
  - -- Calls for proposals issued through NIAC website
  - -- Proposals only accepted electronically
  - -- All abstracts, reports, web links and presentations are available on NIAC website

- **Succinct Technical Proposal Requirements and Peer Review**
  - -- Phase I (12 pages), Phase II (25 pages)
  - -- Typical evaluation process, 2 - 2.5 months from receipt of proposal to award

'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*

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.)

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# Where have we been?

# Where are we going?

*We shall not cease from exploration*
*And in the end of all our exploration*
*Will be to arrive where we started*
*And know the place for the first time.*

– T. S. Eliot, "Little Gidding"

# NIAC Investments To-Date

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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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- Pursue the fascination of space and satisfy the human drive for exploration of the vastness of space, often at great risk.
- 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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- Mediate the effects of the space environment, such as microgravity and radiation, on humans and other living things,
- 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.

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# Highlights of CP 01-02

NIAC is particularly interested in receiving proposals for innovative and visionary concepts from disciplines that are normally focused on non-aerospace endeavors and may have the potential for innovative application in the aerospace sector. These concepts may be emerging at the interface of traditional disciplines where innovation often springs forth in non-aerospace fields.

**NIAC is specifically NOT interested in concepts that, for example, would:**

- Continue the development of technology concepts that by their very nature, are narrowly focused on the development and performance of subsystems or components;
- Develop a new specialized instrument;
- Develop a new, high performance material;
- Incrementally extend the performance of an aerospace system or previously studied concept;
- Accomplish an incremental system development, technology demonstration, or other supporting development program that is closely linked to an existing NASA program or mission and would be a near-term progression of the existing program or mission;
- Develop a concept that is solely based on technically unsubstantiated science fiction;
- Develop a program or workshop plan with no specifically described architecture or system;
- Solely perform research experiments with no connection to an overall architecture or system.

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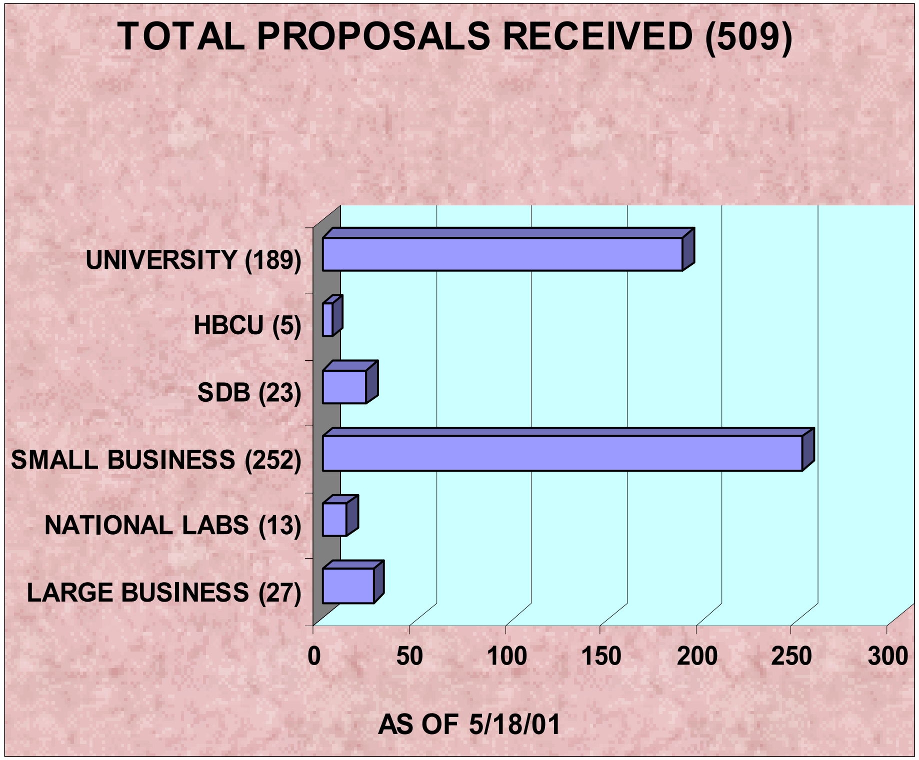
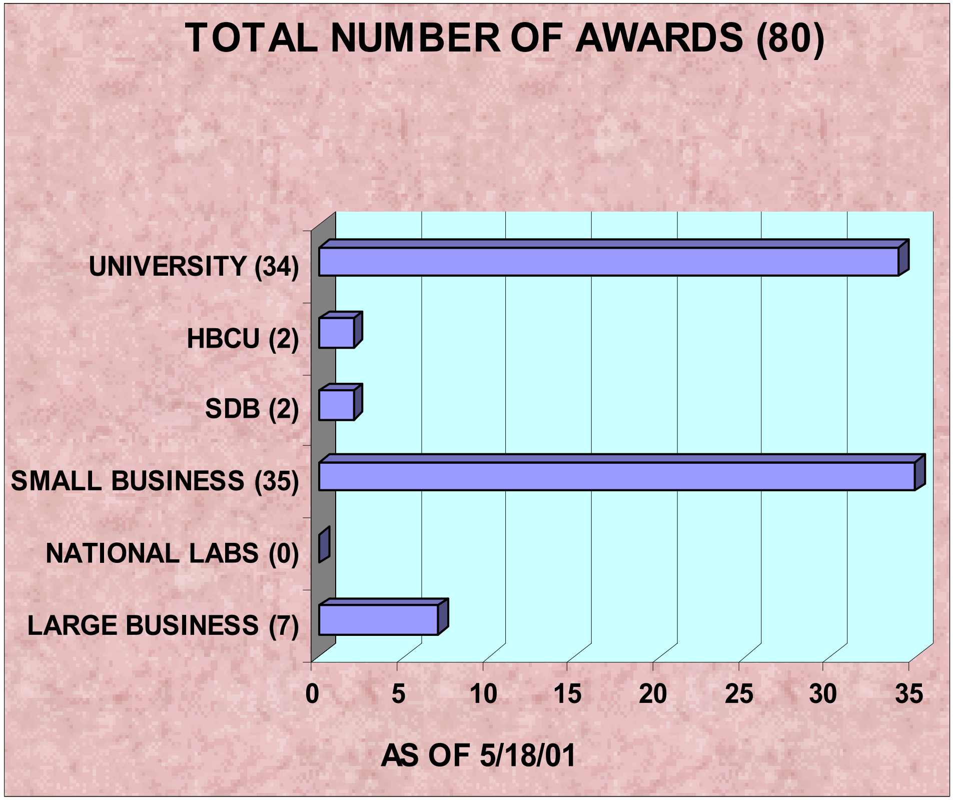
# Proposals Received and Awards

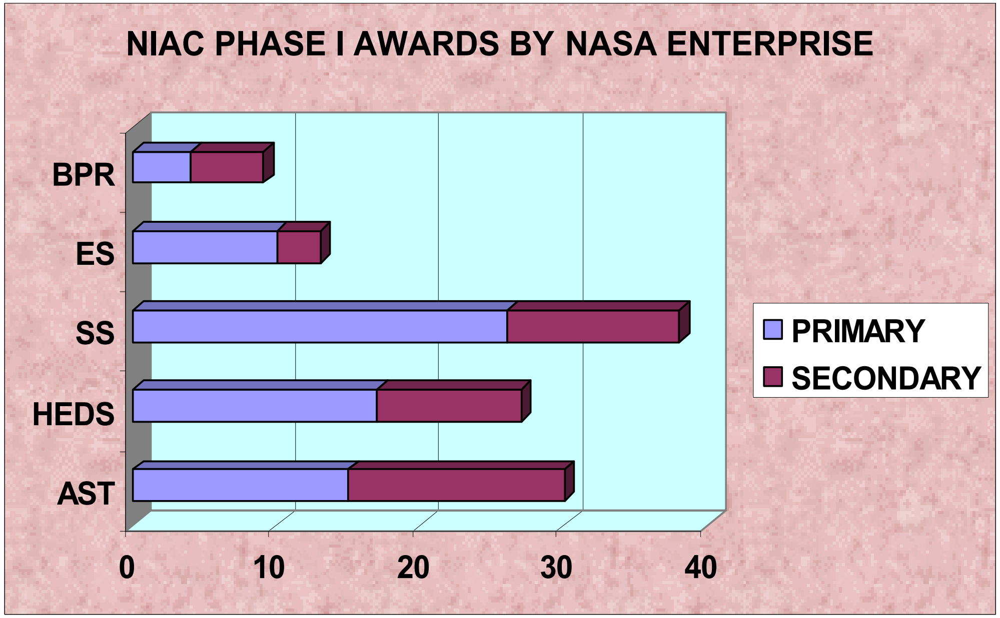
*(through May 18, 2001)*

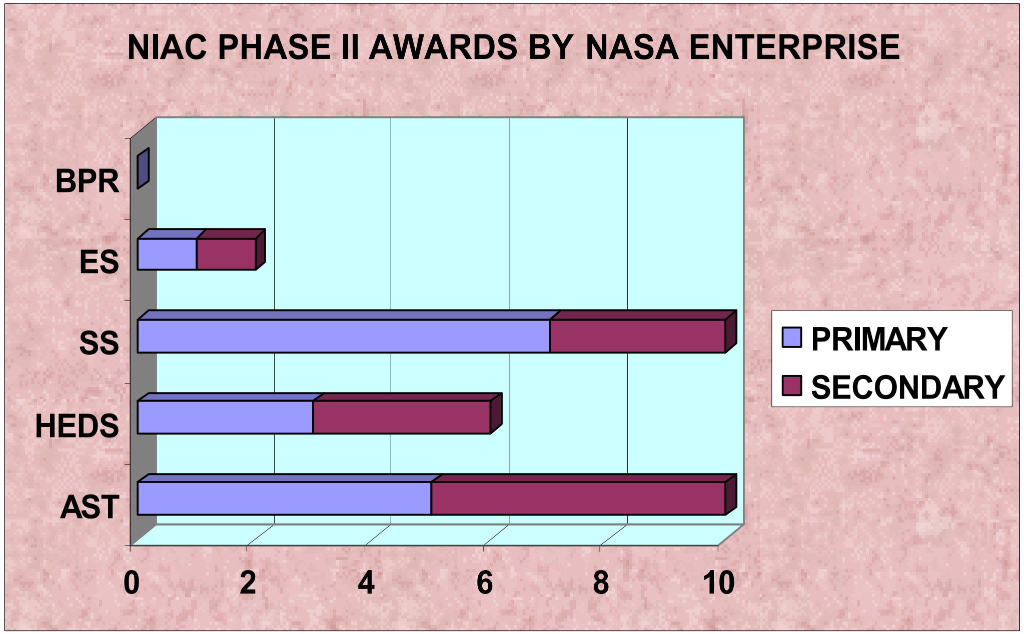


# NIAC Awards

*(through May 18, 2001)*



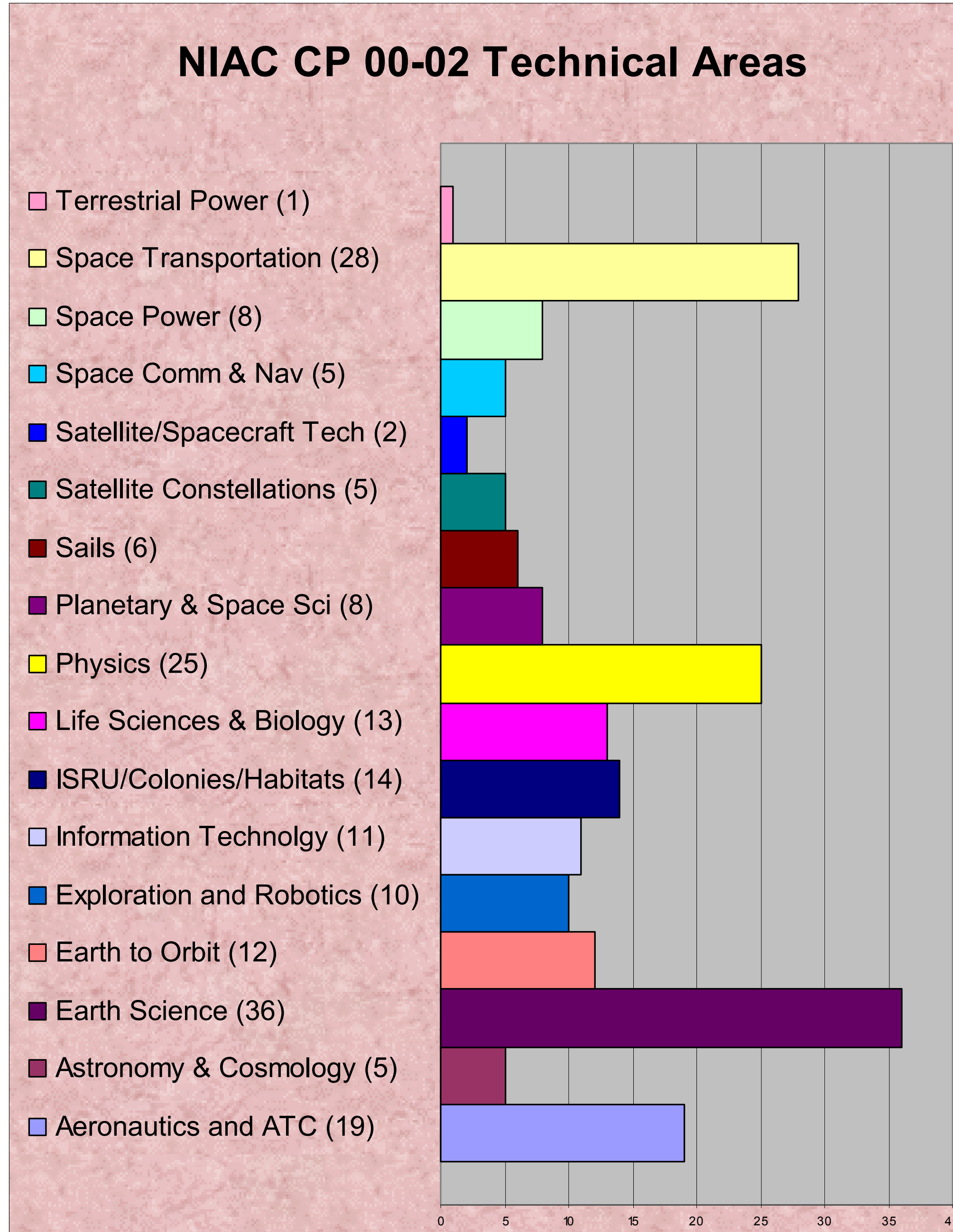
# Phase I Awards

Call for Proposals: CP 00-02

Performance Period: June 1 – November 30, 2001

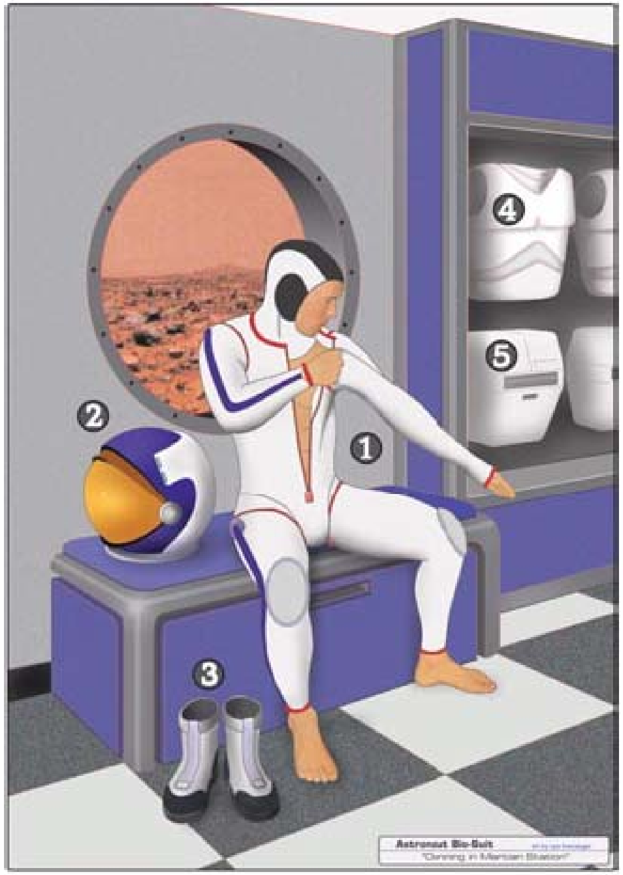
# CP 00-02 Proposals

Total Proposals = 172
Some are double counted
In multiple technical areas

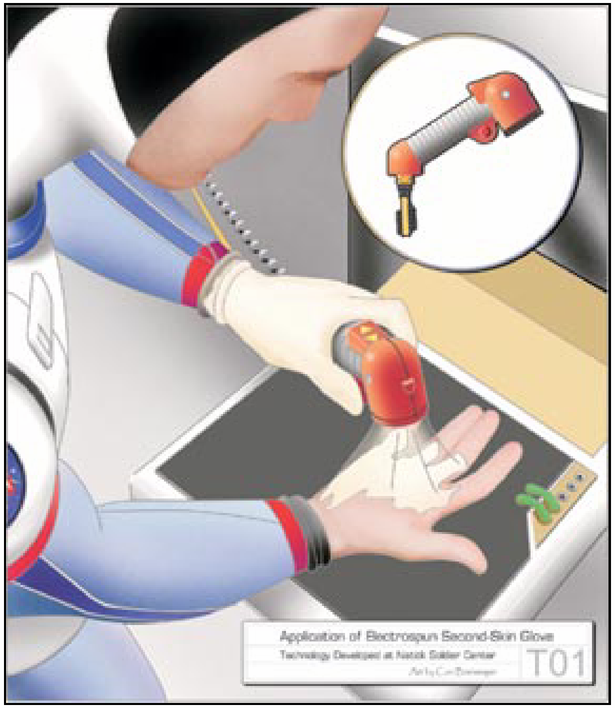


# Astronaut Bio-Suit System for Exploration Class Missions

**Dava Newman,** Massachusetts Institute of Technology



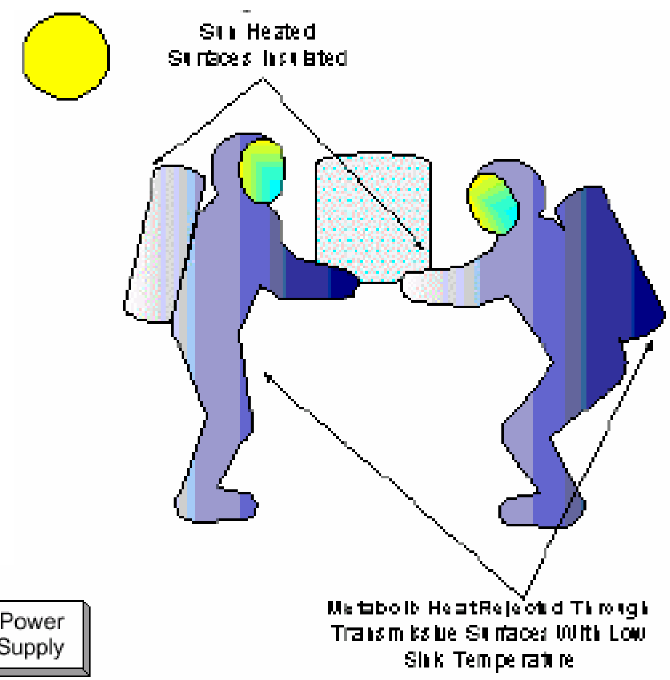

An astronaut on Mars donning the comfortable elastic bio-suit layer (1). The hard torso shell (4) is donned next and seals with couplings at the hips and shoulders. The hard backpack, or portable life support system, (5) alttaches mechanically to the hard torso shell, and provides gas counter pressure. 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.

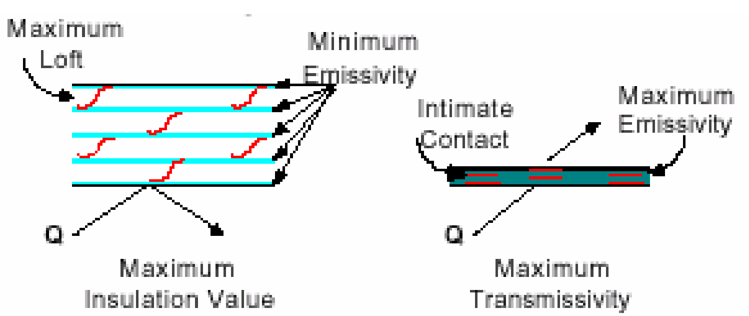


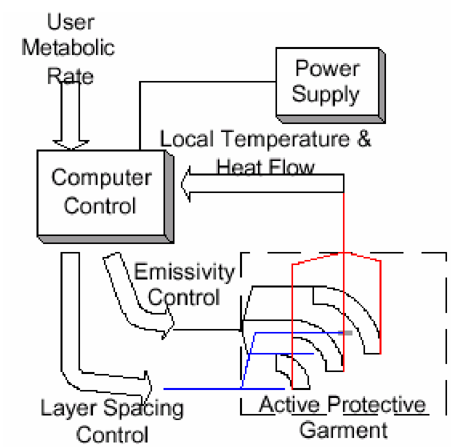

Electrospinlacing is a process where a multi-filament fiber of polymer is sprayed onto a grounded surface, which is achieved by charging a suspended drop of polymer with tens of thousands of volts. At a characteristic voltage the droplet forms a Taylor cone, and a fine jet of polymer releases from the 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 Space Systems International**



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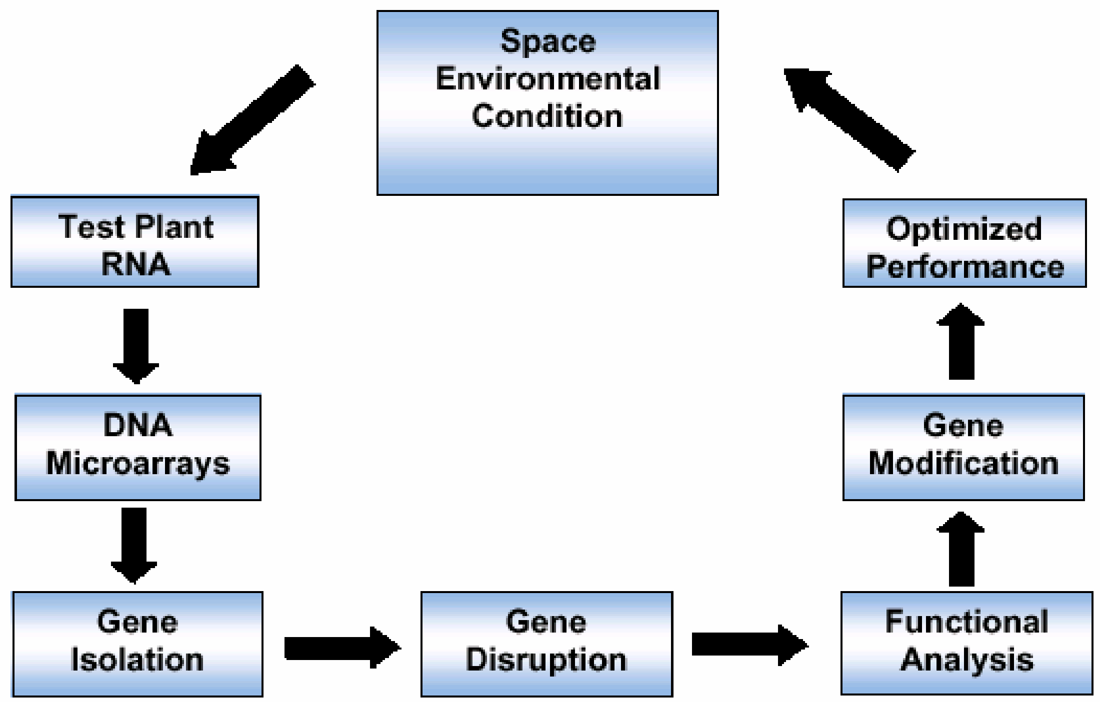
# A Flexible Architecture for Plant Functional Genomics in Space Environments

Terri Lomax
Oregon State University

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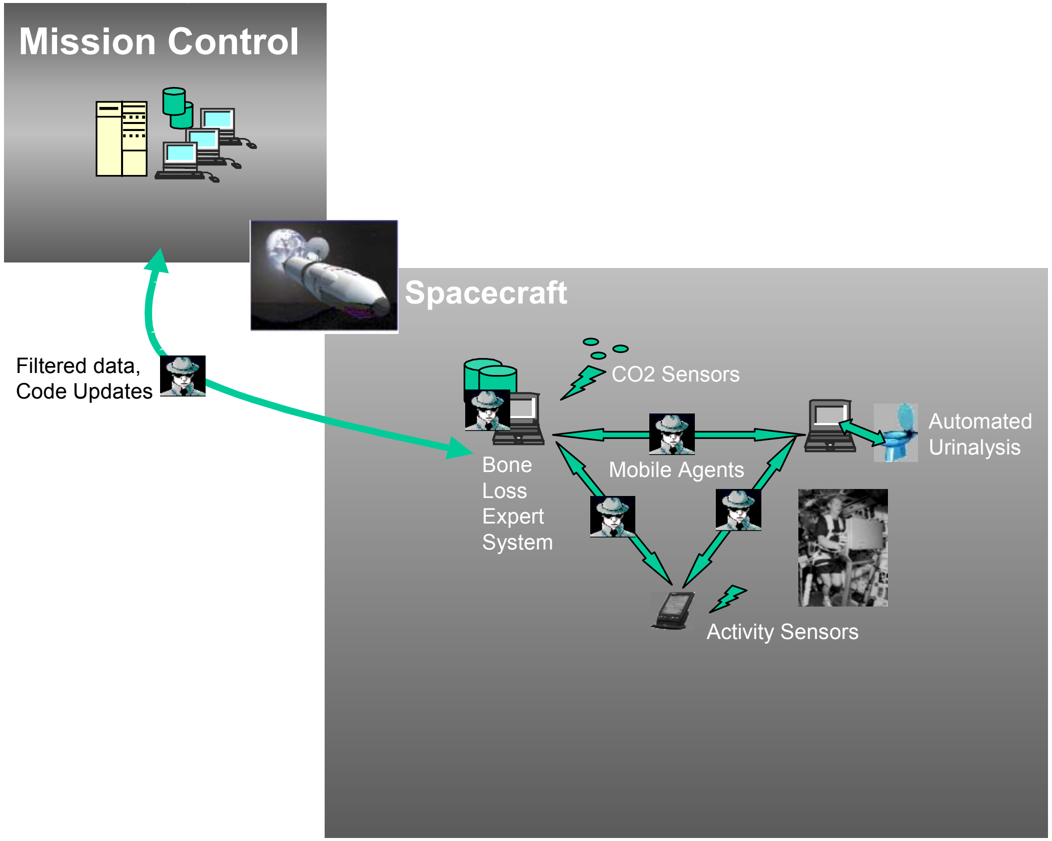
# A Novel Information Management Architecture for Maintaining Long Duration Space Crews



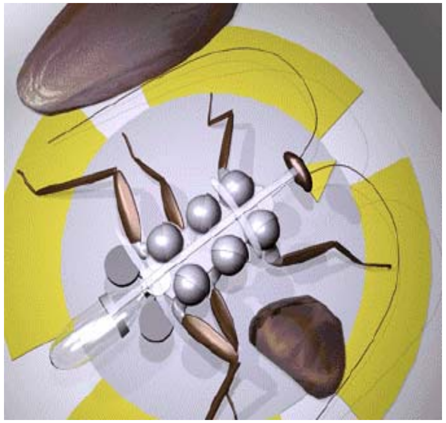


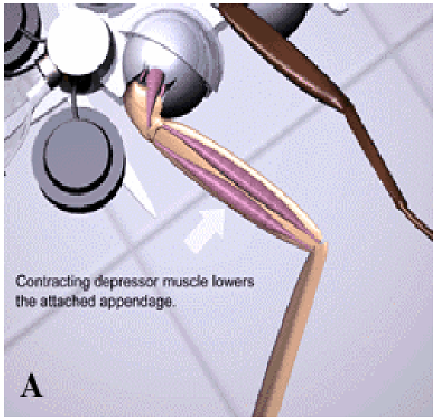
**George Cybenko**
**Dartmouth College**

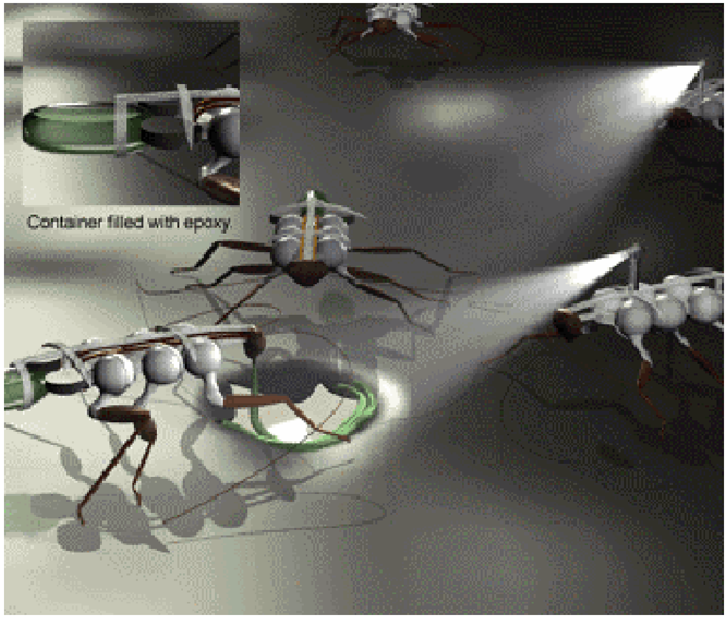

- *Agents transmit information to and from Mission Control.*
- *Agents ability to analyze information prior to moving saves bandwidth.*
- *Code and data can be updated throughout the mission, enabling increased performance and adaptation to mission conditions.*

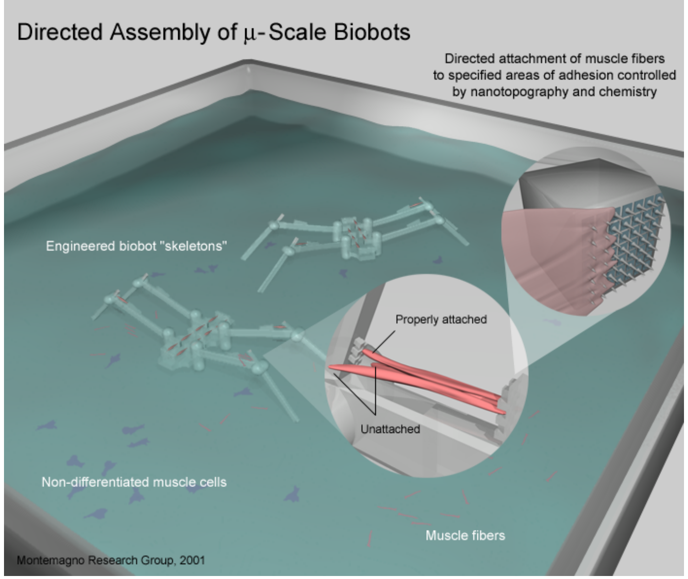
# Directed Application of Nanobiotechnology for the Development of Autonomous Biobots

Carlo Montemagno
Cornell University



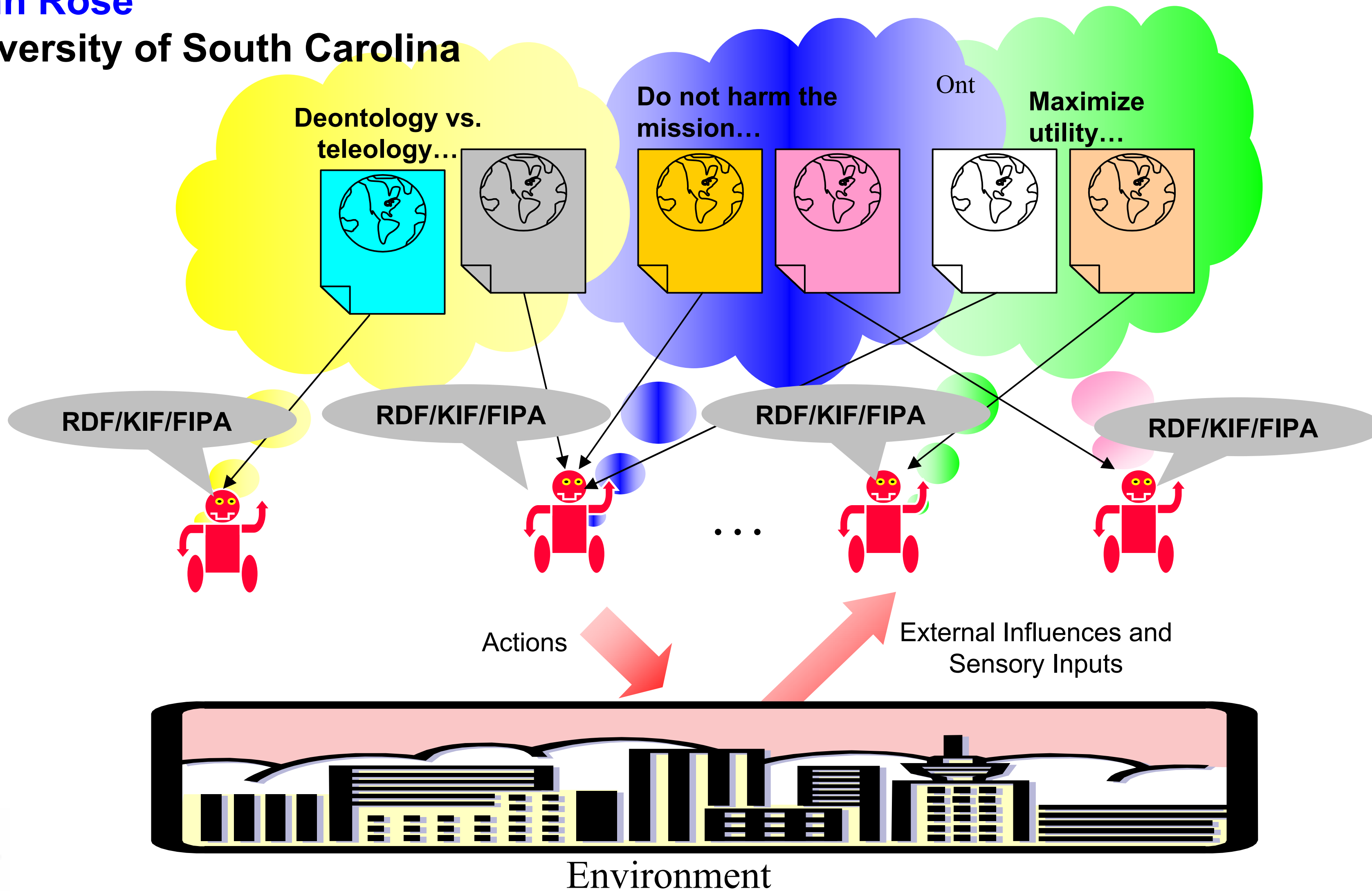


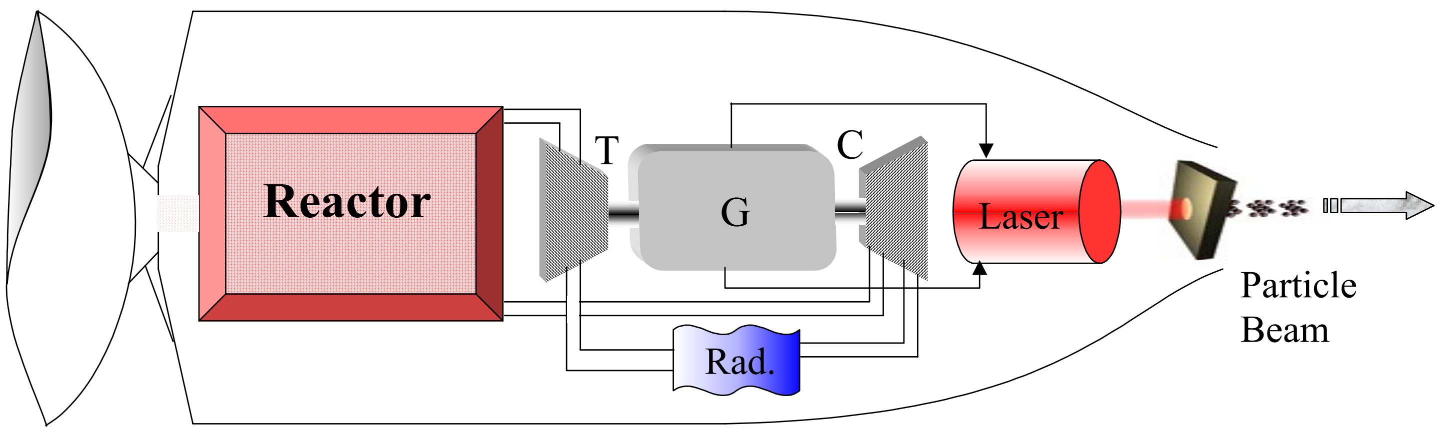
# Achieving Comprehensive Mission Robustness

John Rose
University of South Carolina



# Ultra-Fast Laser-Driven Plasma for Space Propulsion

**Terry Kammash**
**University of Michigan**




Laser-Accelerated Plasma Propulsion System (LAPPS)

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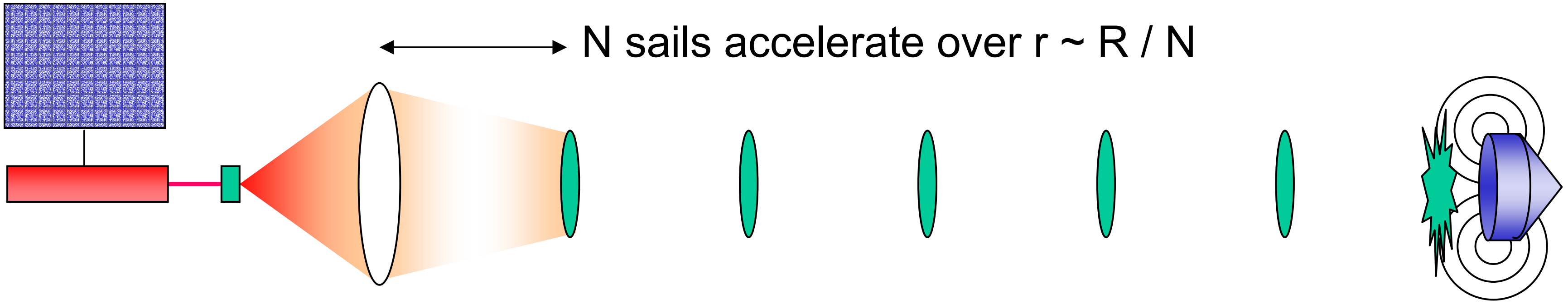
# High Acceleration Micro-Scale Laser Sails for Interstellar Propulsion

Jordin Kare
Kare Technical Consulting

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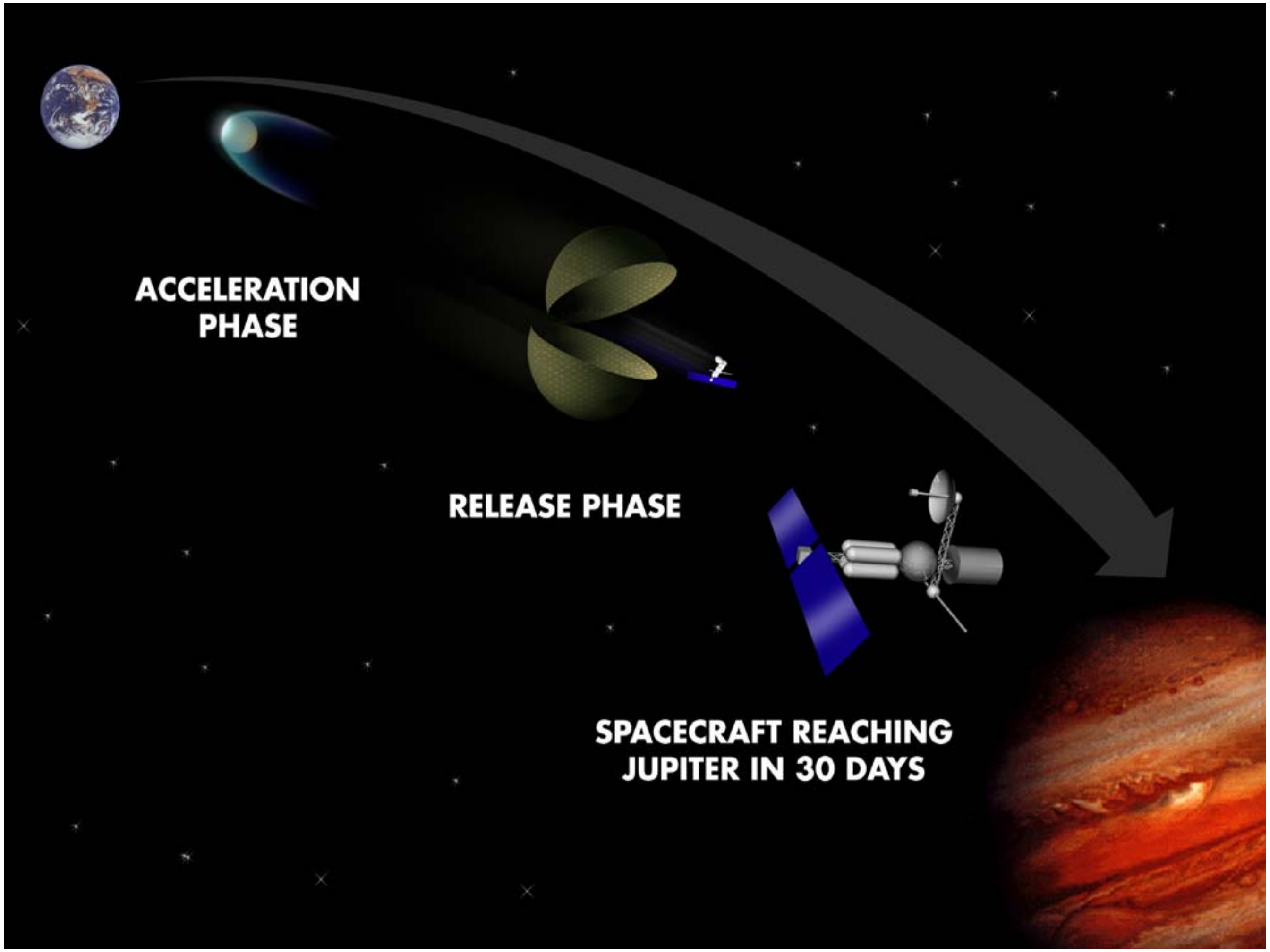
# High Speed Interplanetary Tug / Cocoon Vehicles (HITVs)


Nick Omidi
Scibernet, Inc.

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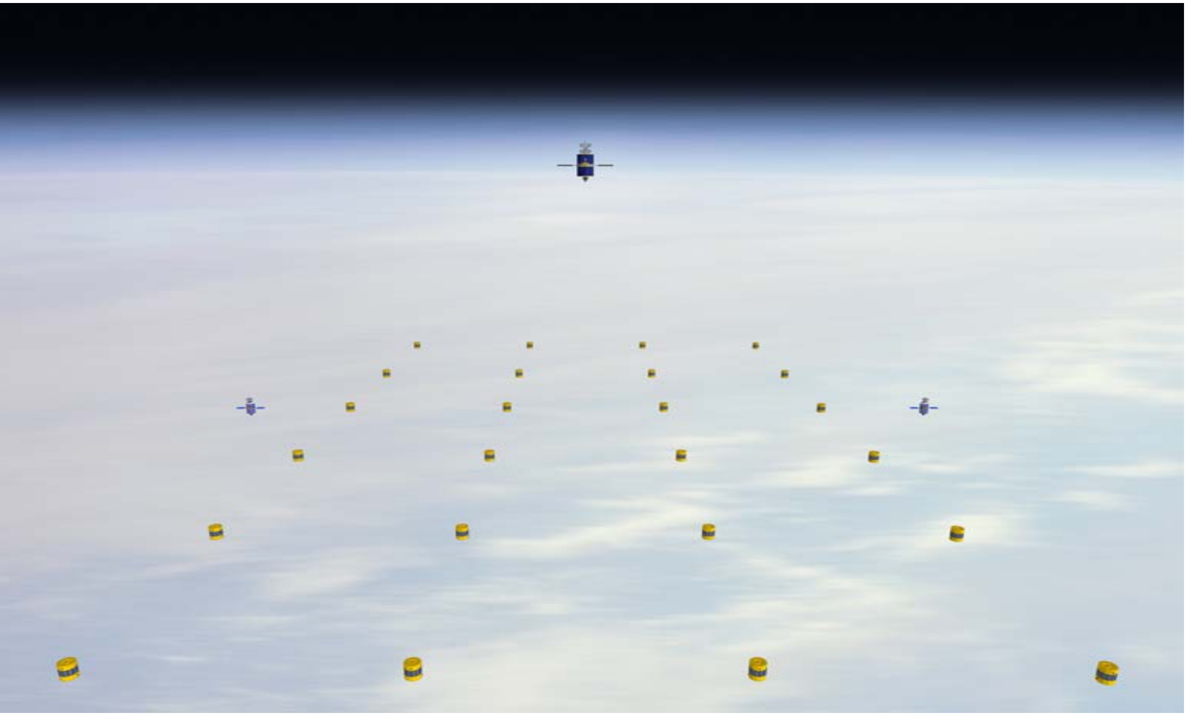
# Formation Flying with Shepherd Satellites

**Michael LaPointe,**
**Ohio Aerospace Institute**



- **Proposed shepherd satellite concept is based on established optical gradient force trapping techniques**
- **Focused electromagnetic radiation from shepsats interacts with applied dipole moments on microsats, providing electromagnetic gradient forces to position and maneuver the formation-flying array**
- **Individual microsats can devote their limited mass and power to instrumentation and observation**

# Propellantless Control of Spacecraft Swarms using Coulomb Forces

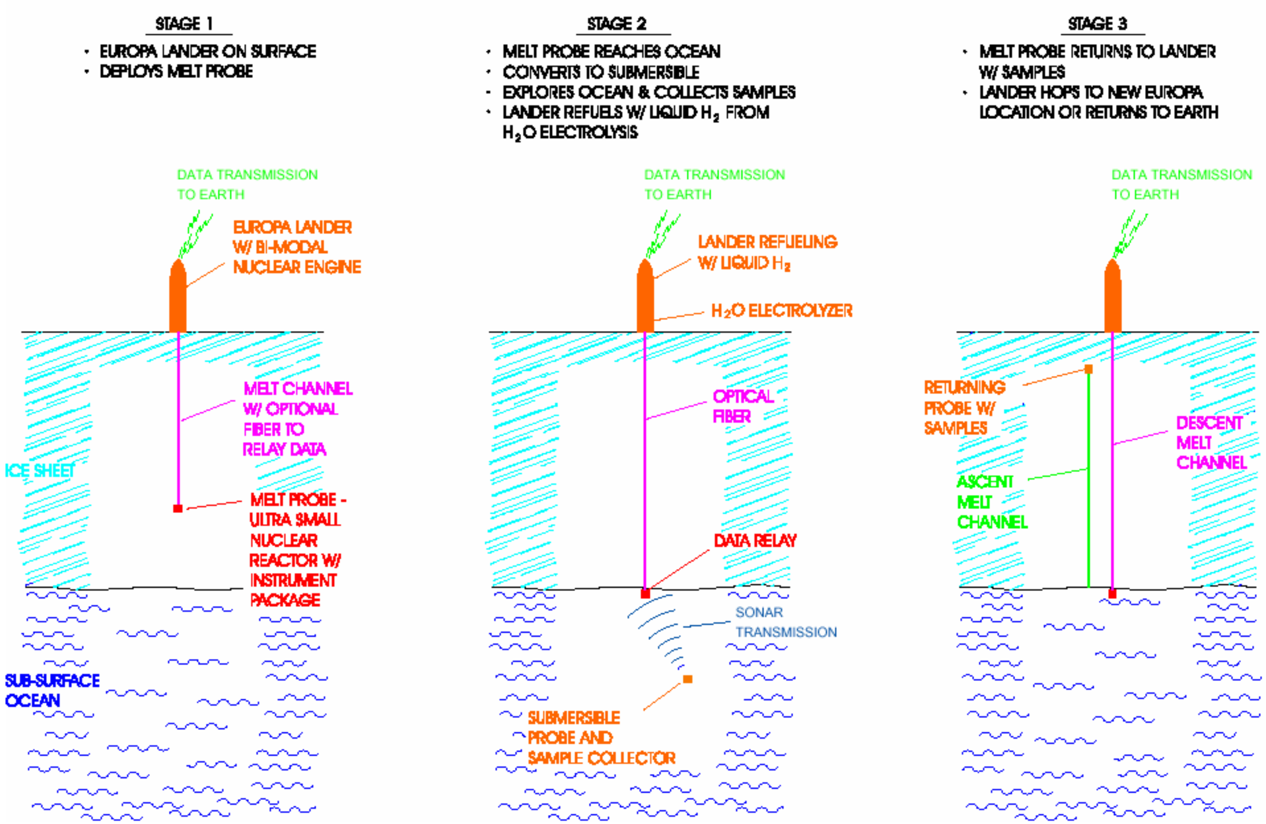
**Brad King**
**Michigan Technology University**

- Potentially feasible to generate tens of micro-Newtons of attraction and repulsion between spacecraft separated by tens of meters.
- Net spacecraft charge can be controlled by harvesting ambient space-plasma electrons or actively emitting electrons.
- Mutually interacting Coulomb spacecraft will be oriented in stable minimum energy arrays that can be configured using active control.
- Advantages
  - Circumvent need for micro-thrusters in satellite swarms
  - Increase formation mission lifetimes by harvesting in-space resources
  - Greatly improve fine position-keeping through active feedback
  - Facilitate wider range of satellite formation
  - Increase swarm robustness through fault-detection and reconfiguration

# Europa Sample Return Mission utilizing High Specific Impulse Propulsion Refueled with Indigenous Resources


John Paniagua
Plus Ultra Technologies, Inc.


## EUROPA EXPLORATION AND SAMPLE RETURN MISSION



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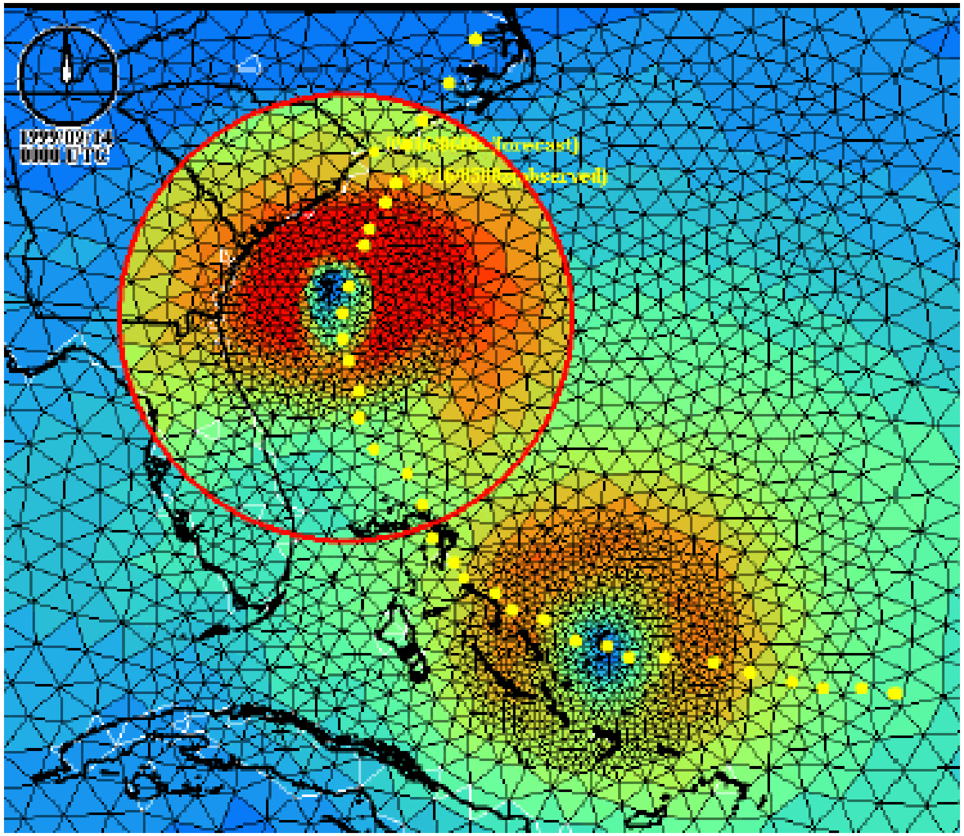
# Adaptive Observation Strategies for Advanced Weather Prediction

**David Bacon**
**SAIC, Center for Atmospheric Physics**

**Michael Kaplan**
**North Carolina State University**



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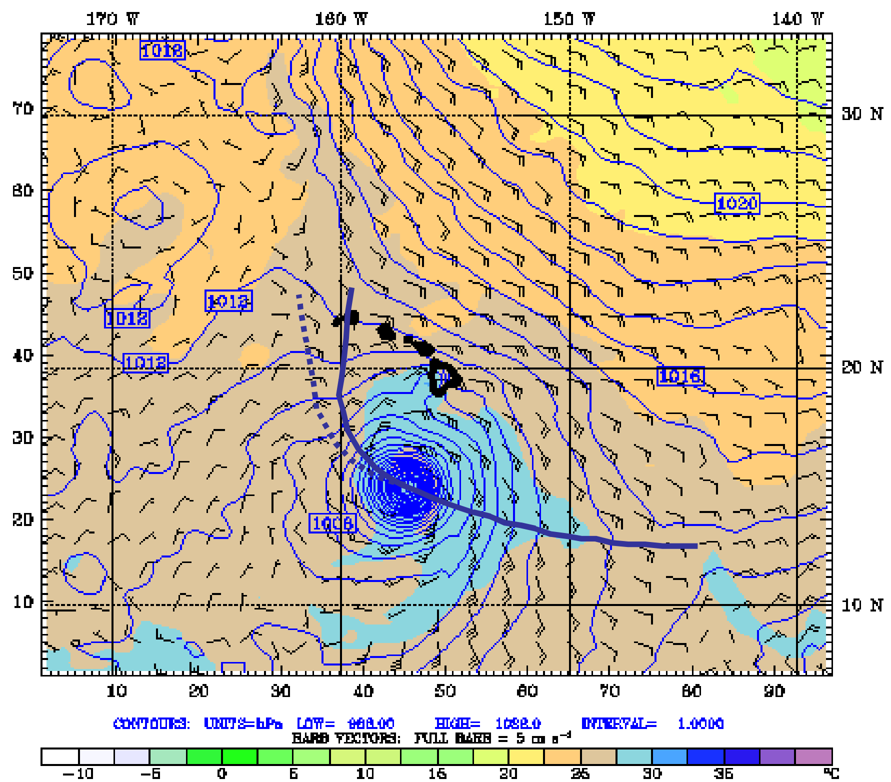
# Controlling the Global Weather

**Ross Hoffman,** **Atmospheric and Environmental Research, Inc.**

Unperturbed Initial State of MM5
Hurricane Iniki, valid 06 UTC 10 September 1992

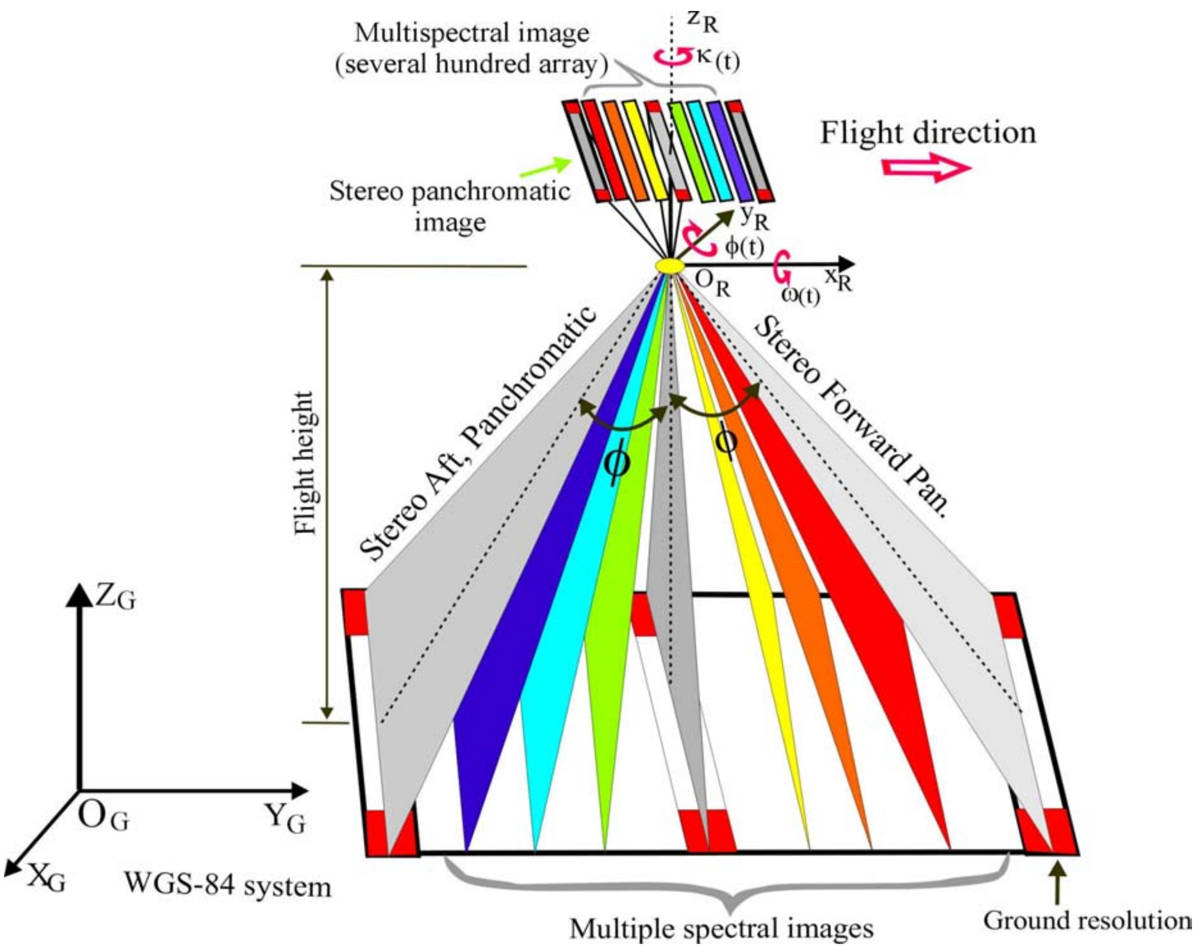



SLP (contoured), 1000-hPa wind (barbs) and temperature (shaded)

Observed track ............... Perturbed track

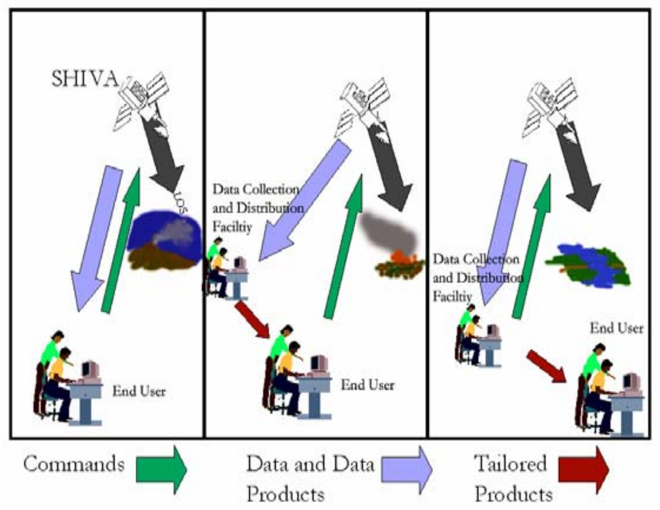
# Architecture of "Intelligent" Earth Observation Satellite for Common Users in 2010-2050

Guoqing Zhou
Old Dominion University

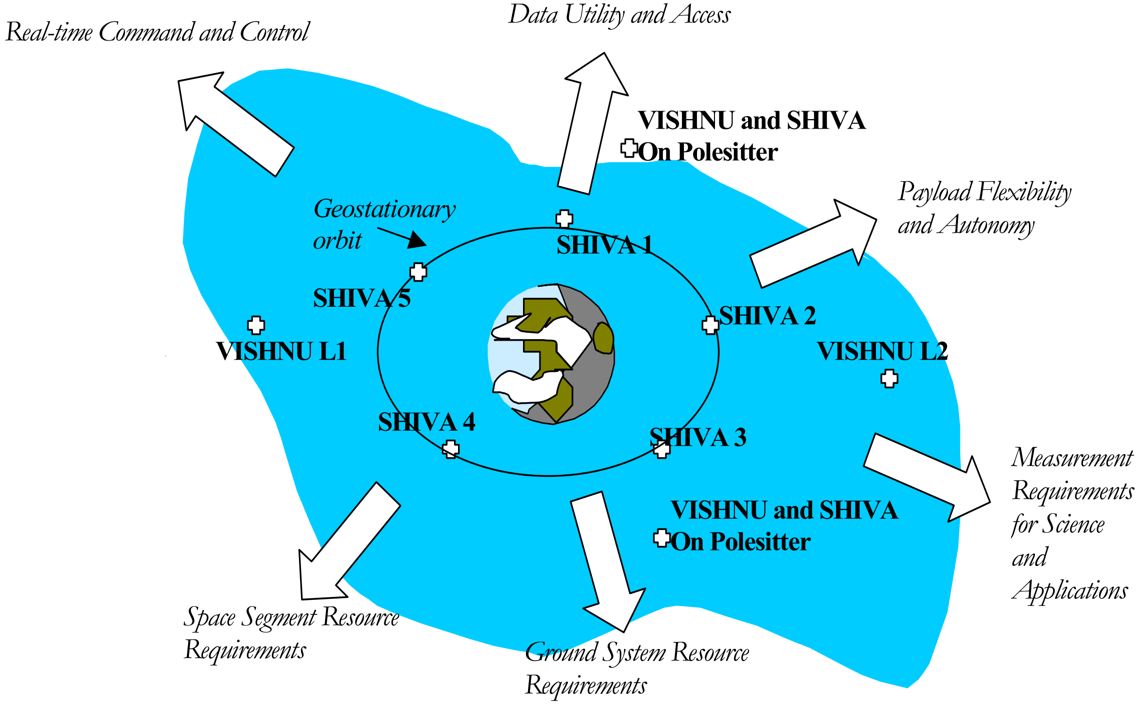


# Global Observations and Alerts from Lagrange-Point, Pole-Sitter, and Geosynchronous Orbits (GOAL&GO)


**Larry Paxton**
**Johns Hopkins University**
***Applied Physics Laboratory***


*The SHIVA system uses multiple, selectable bands as commanded by remotely located users to search for, identify, and report geophysical events. A pointed telemetry system reduces the ground system requirements.*

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# 3D Viewing of Images on the Basis of 2D Images

**H. John Caulfield**
**Fisk University**

- Analogous to how nature allows you to see a 3D image using only one eye at a hyperfocal distance from your eye
- Connected set of computer programs that start with any digitized 2D image and convert it into a pair of images for 3D visualization
- Will be tested on telescopic and microscopic images in Phase I
- Feasibility established for simple objects in the near field
- Will record simulated scenes of interest for NASA and blur them by various amounts digitally to simulate telescopic images
- Attempt 3D visualization of local regions
- Design software for a hardware system to be built in Phase II

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# Ultra-High Resolution X-ray Astronomy using Steerable Occulting Satellites


**Glenn Starkman**
**Case Western Reserve University**


- Occultation of an X-ray telescope by a steerable satellite may allow binary point source resolution better than milli-arcsecond with little or no re-design of X-ray telescopes.

- Model reconstructive capabilities of the technique and adjust satellite shape so as to maximize those capabilities.

- Evaluate possible scientific payback from implementing this approach in conjunction with planned facilities, such as Constellation-X.

- Occulter design considerations to be investigated.
  - Thickness
  - Size
  - Steerability
  - Binary point source resolution
  - Compound source resolution
  - Target sources

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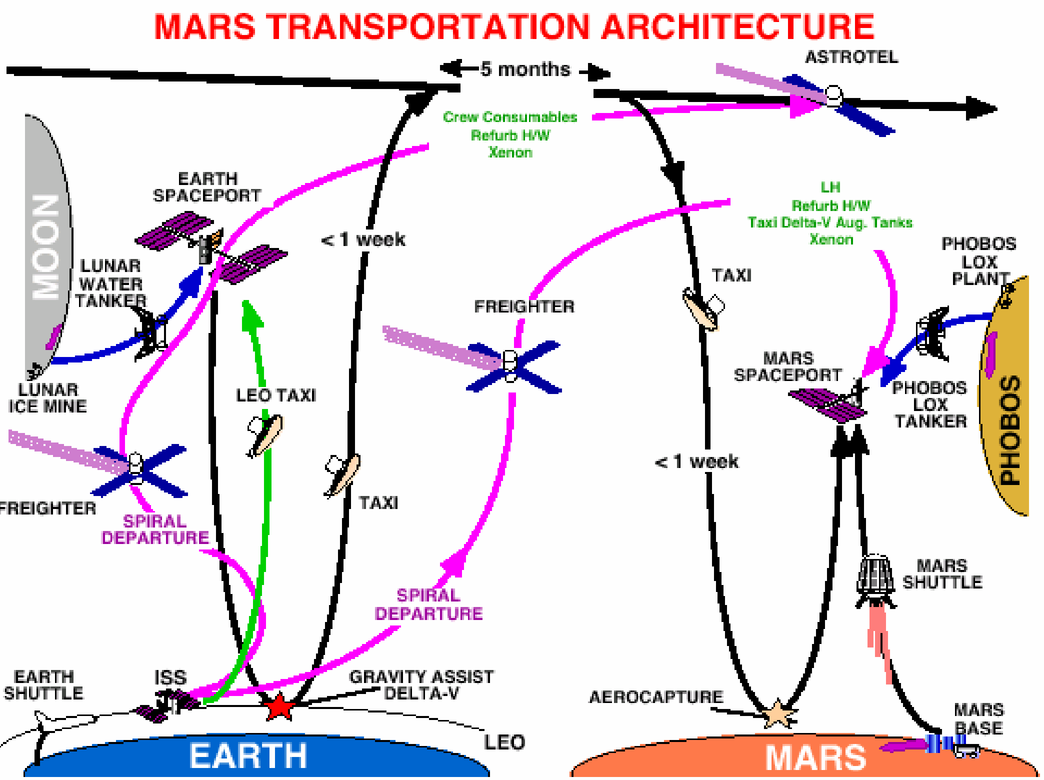
# Phase II Awards

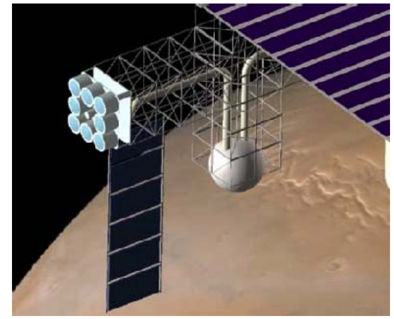
Calls for Proposals: CP 99-01, CP 99-02, CP 00-02

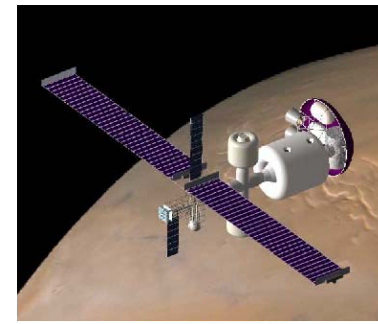
# *Cyclical Visits to Mars via Astronaut Hotels*

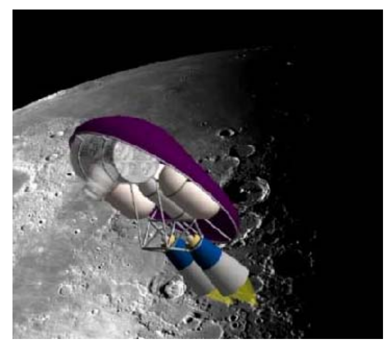
Kerry Nock, Global Aerospace Corporation

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





*Astrotel IPS*



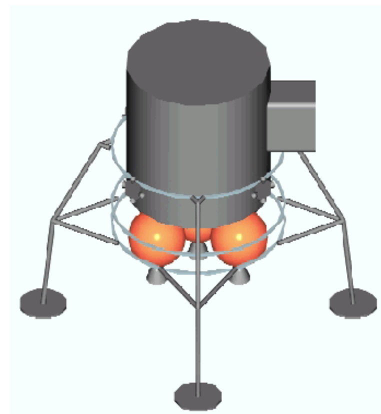

*Taxi departing*

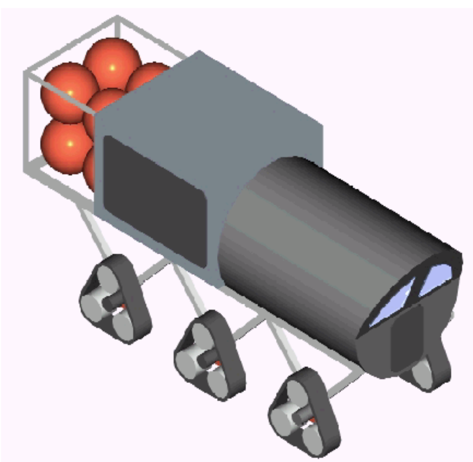

*Taxi during Mars Aerocapture*

# 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**

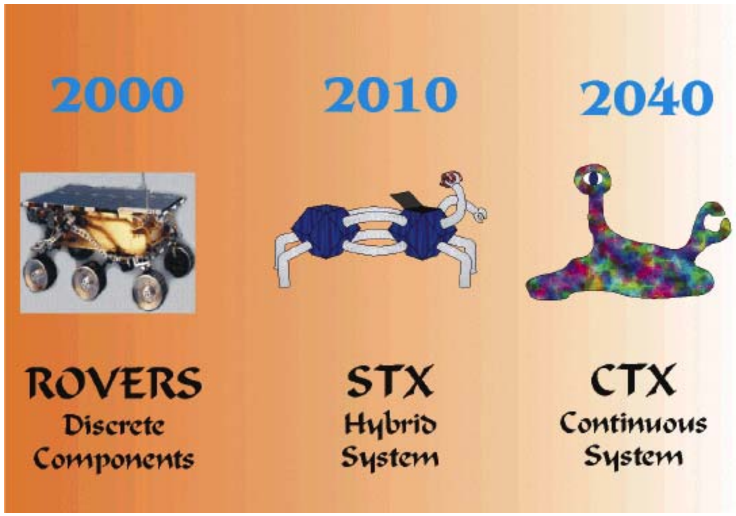


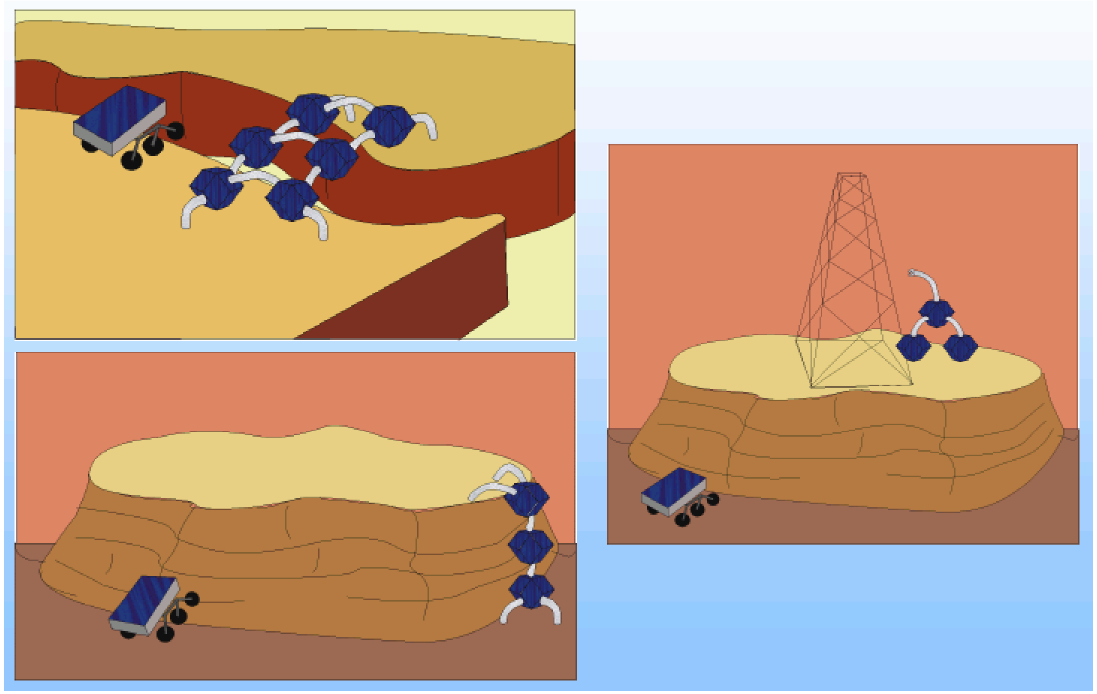


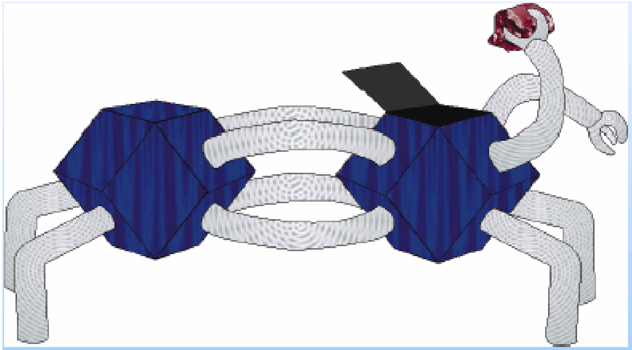
## *Self-Transforming Robotic Planetary Explorers*

Steven Dubowsky, Massachusetts Institute of Technology

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



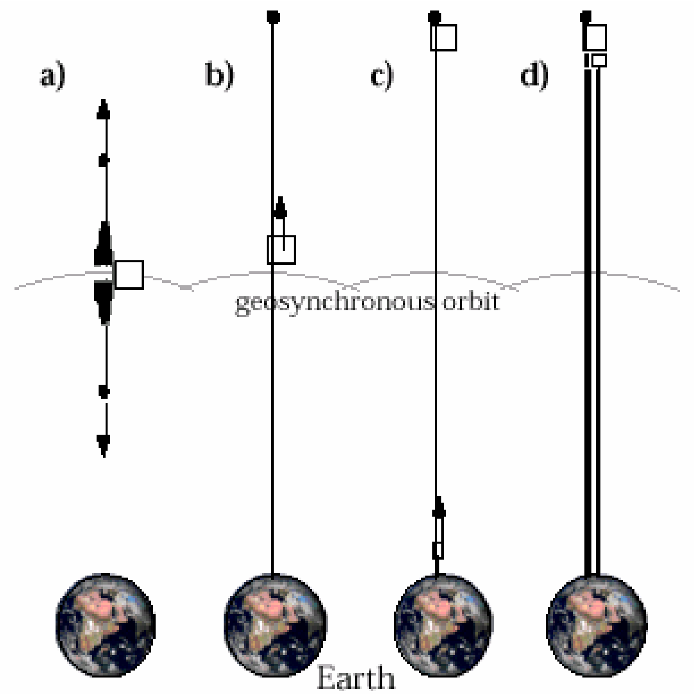


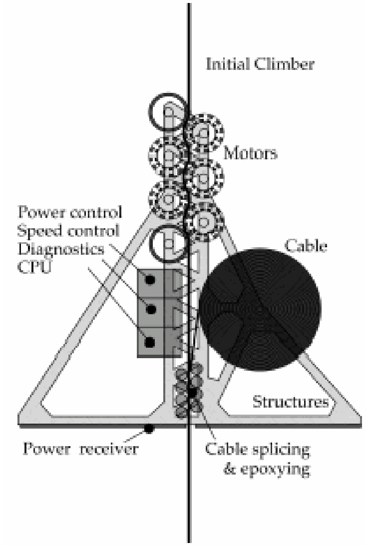
The STX c.2010

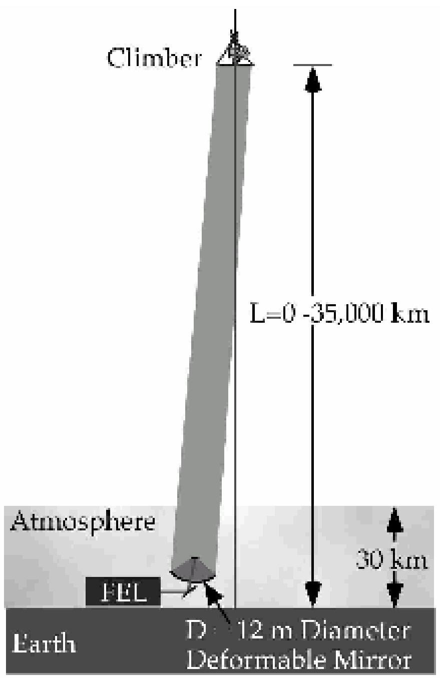
# The Space Elevator

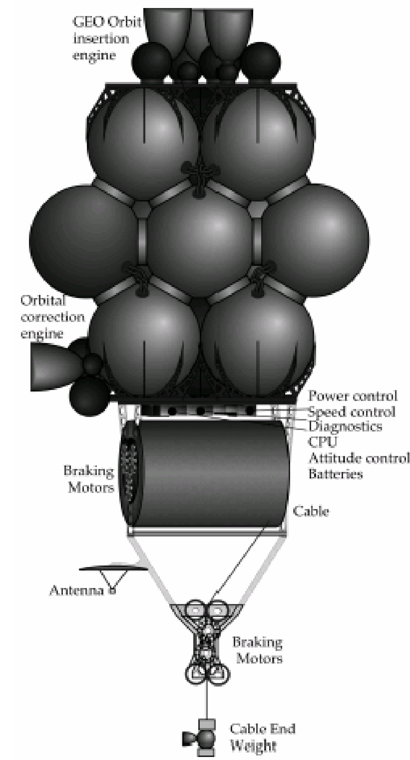
**Bradley Edwards, Eureka Scientific**

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

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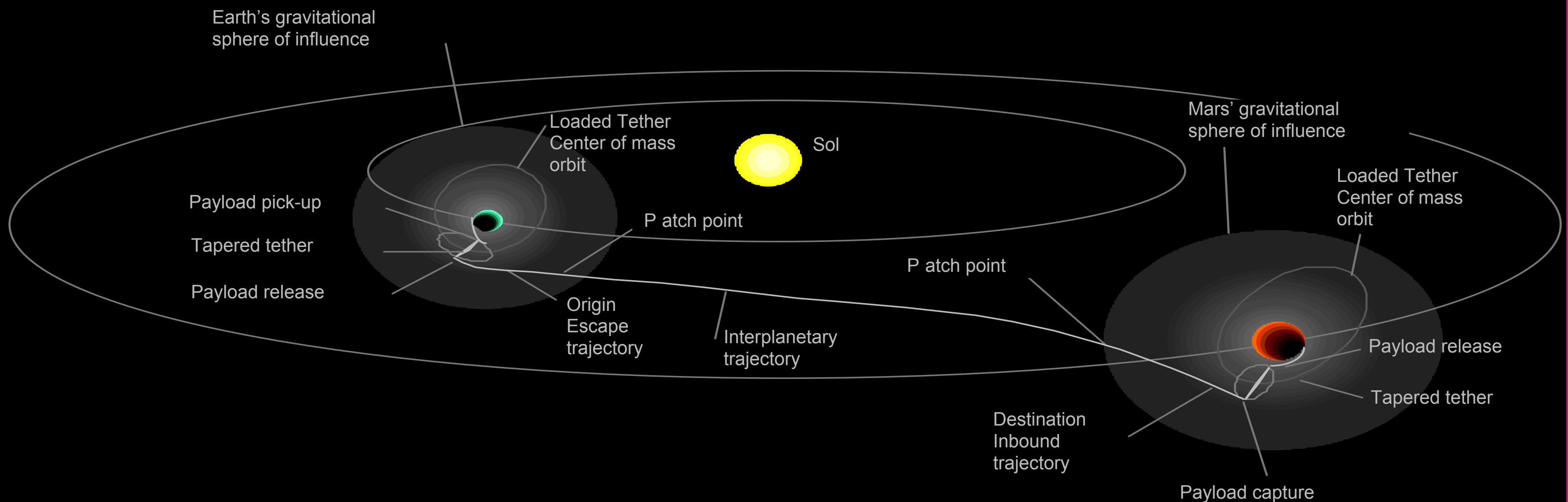
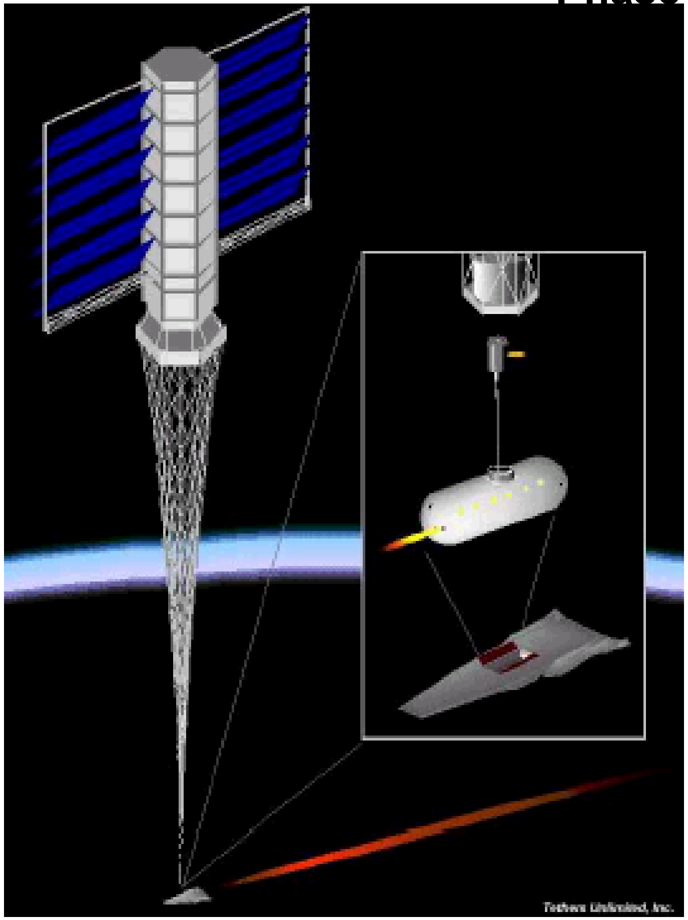
# INTERPLANETARY TRANSPORT USING ROTATING TETHERS

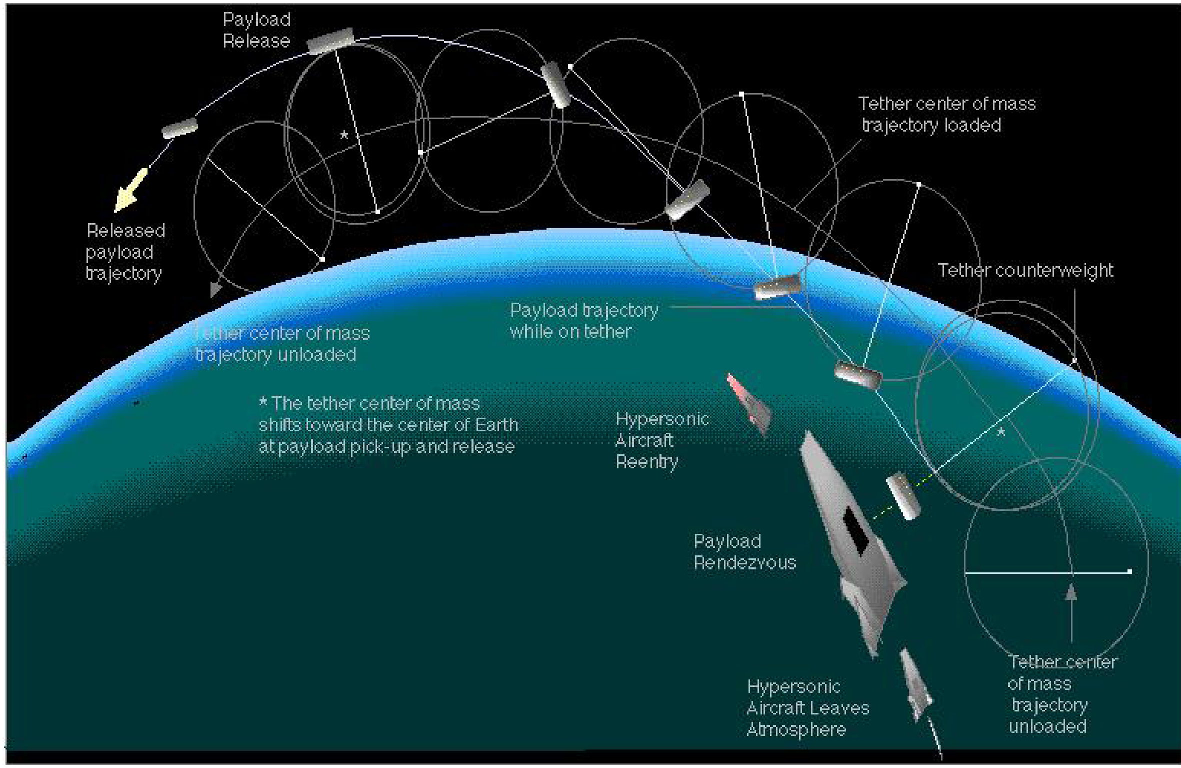


# Hypersonic Airplane Space Tether Orbital Launch – HASTOL

John Grant, The Boeing Company

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



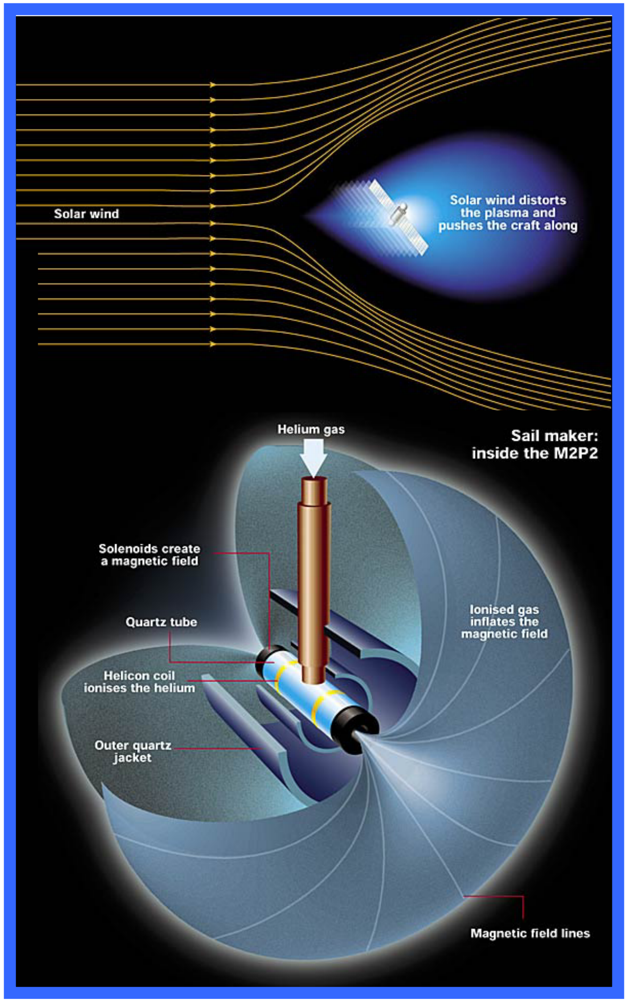



# The Mini-Magnetospheric Plasma Propulsion System, $M^2P^2$

Robert M. Winglee, University of Washington

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

## Concept for interstellar propulsion and radiation shielding

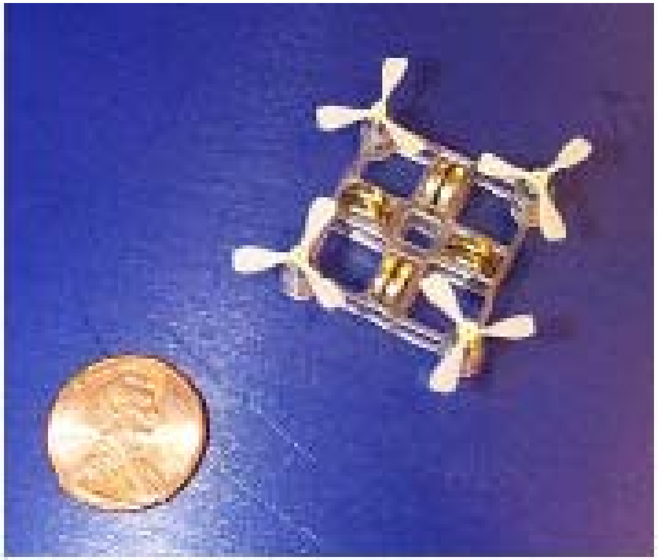


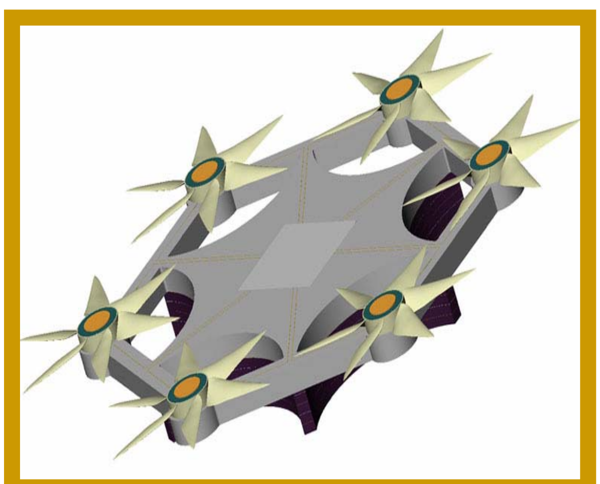

Graphics by permission of *New Scientist*

# Meso-Scale Flight Vehicle for Atmospheric Sensing

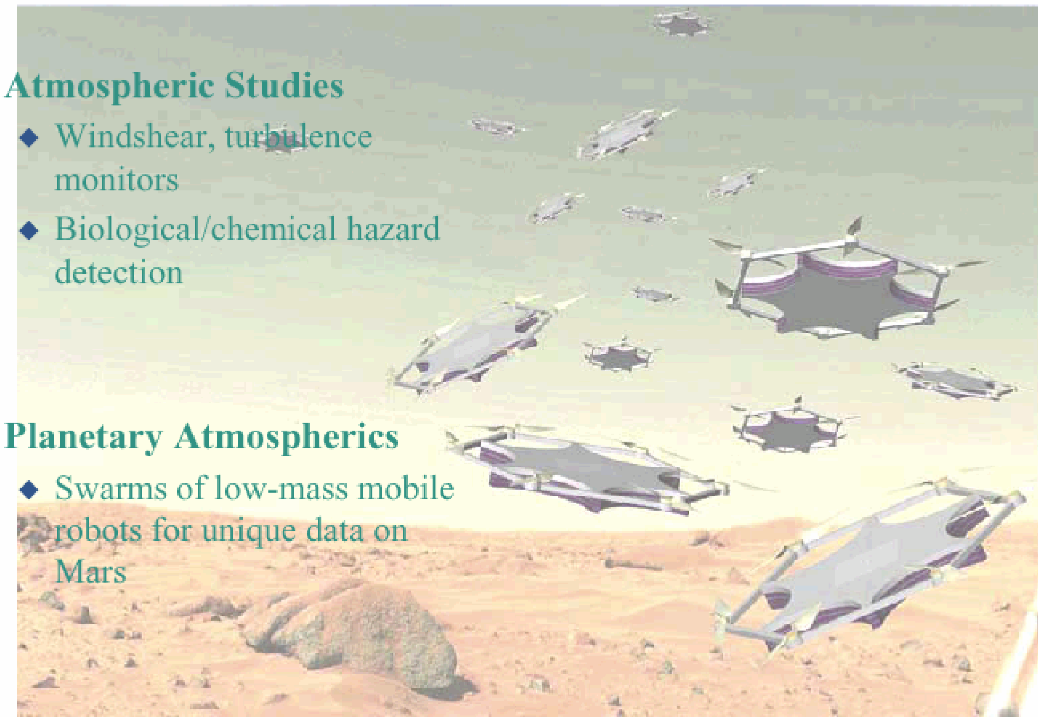
Ilan Kroo, Stanford University

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





## The Concept: Applications

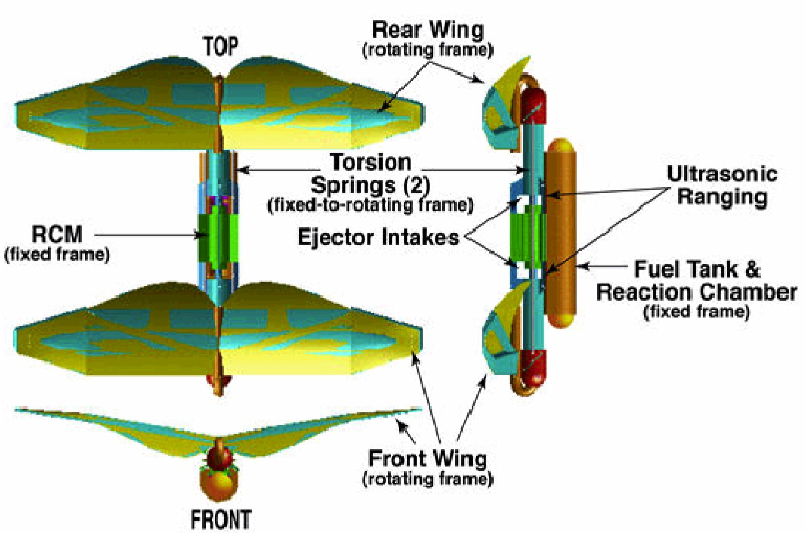


- **Atmospheric Studies**
  - Windshear, turbulence monitors
  - Biological/chemical hazard detection
- **Planetary Atmospherics**
  - Swarms of low-mass mobile robots for unique data on Mars

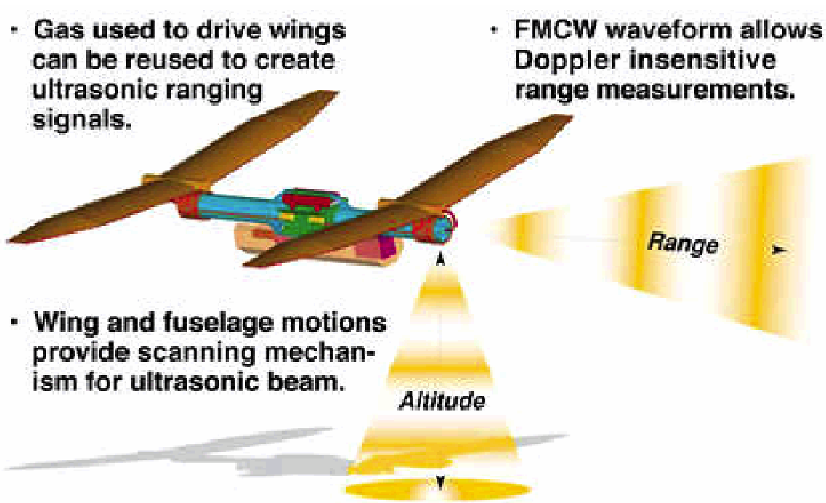
# *Planetary Exploration Using Biomimetrics*

Anthony Colozza, Ohio Aerospace Institute

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



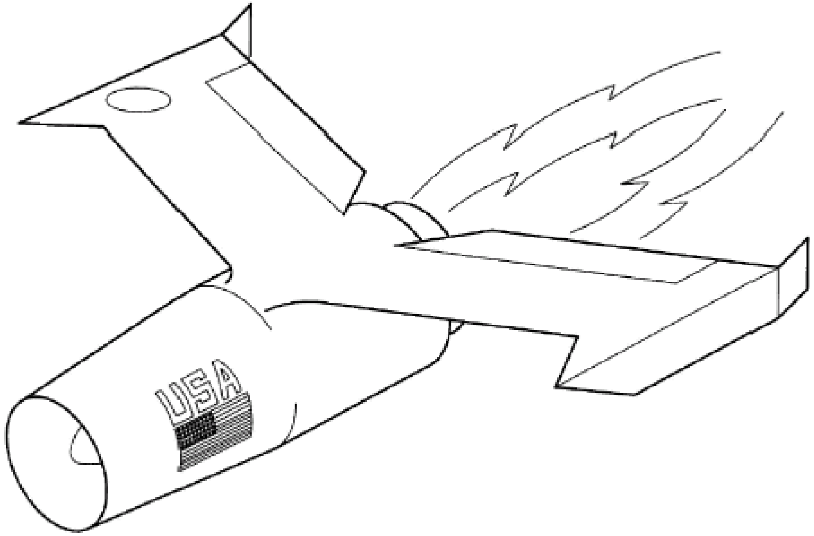

Click for movie



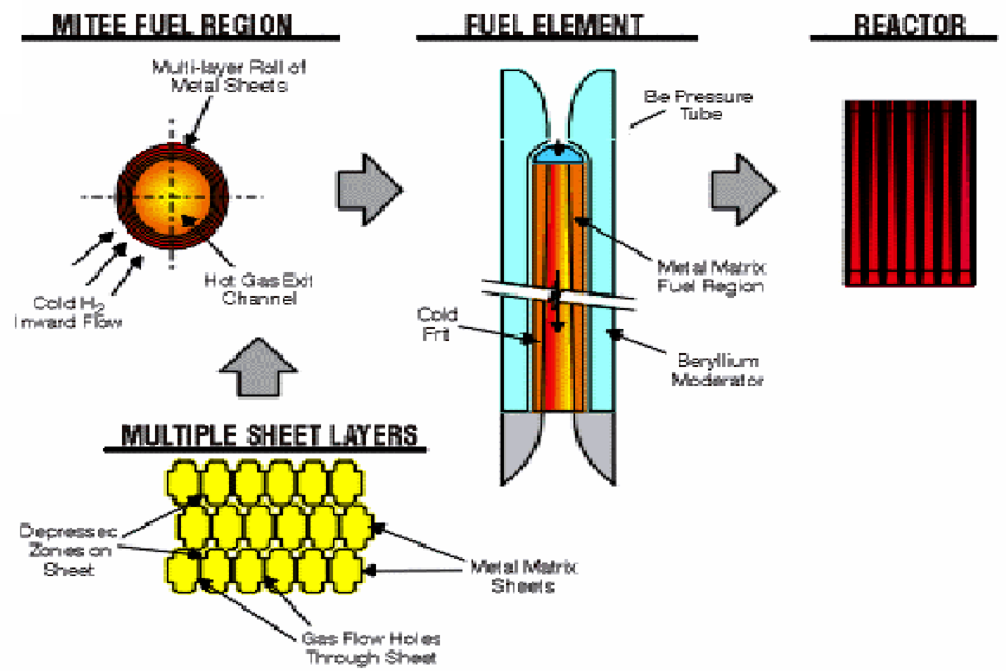
# Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer

George Maise, Plus Ultra Technologies, Inc.

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



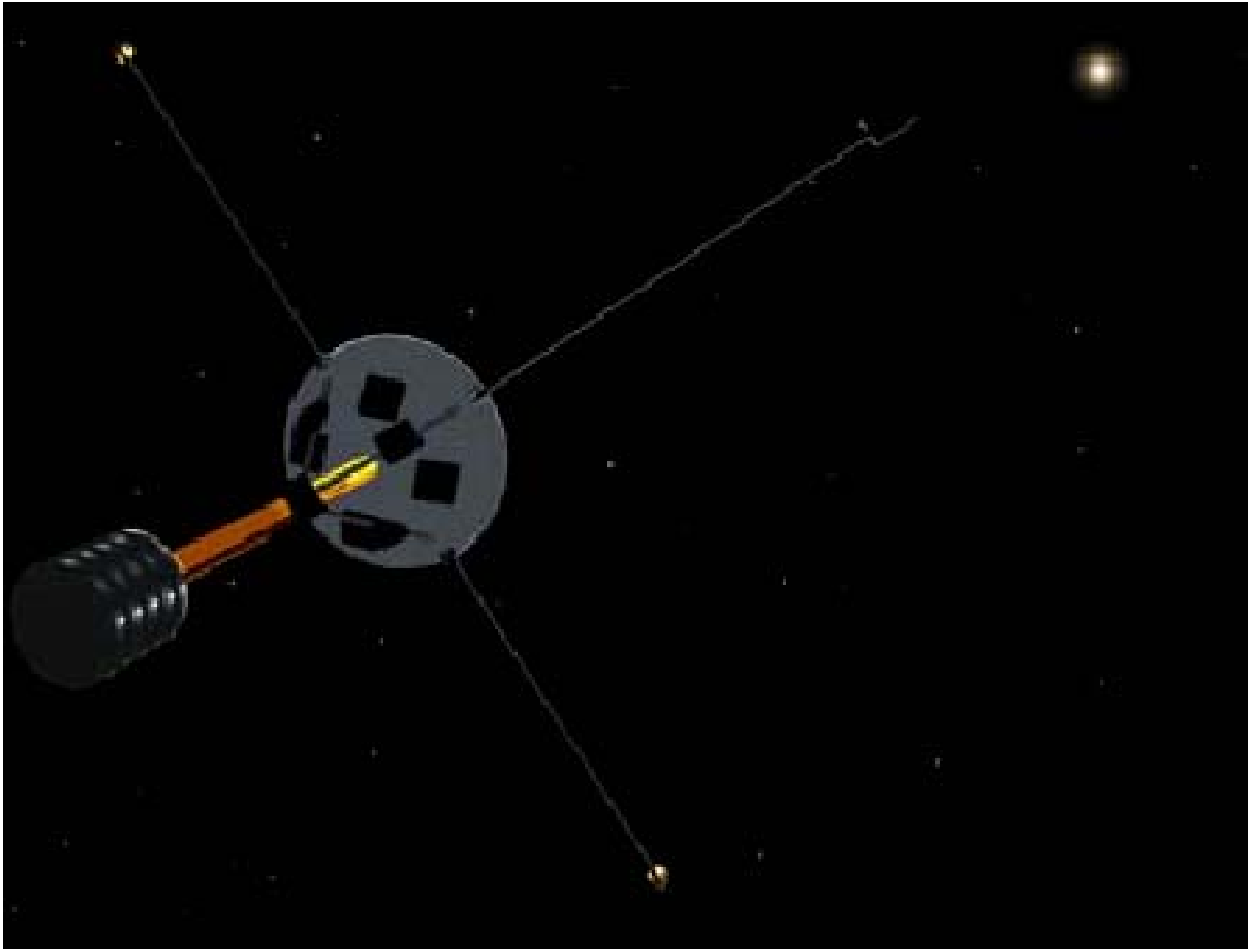

## MITEE Nuclear Engine



*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

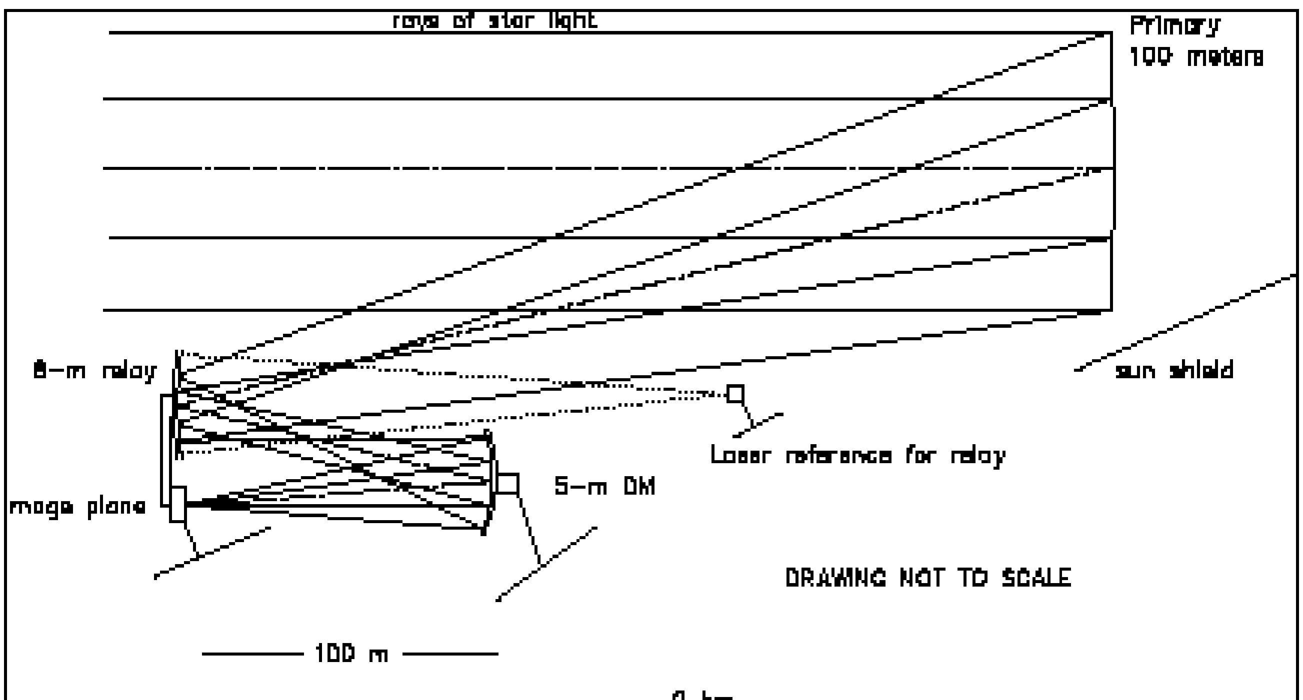
Phase II Performance Period: August 1, 1999 to July 31, 2001

Hubble Space Telescope (operational)

Next Generation Space Telescope (technology development)

Terrestrial Planet Finder (concept development)

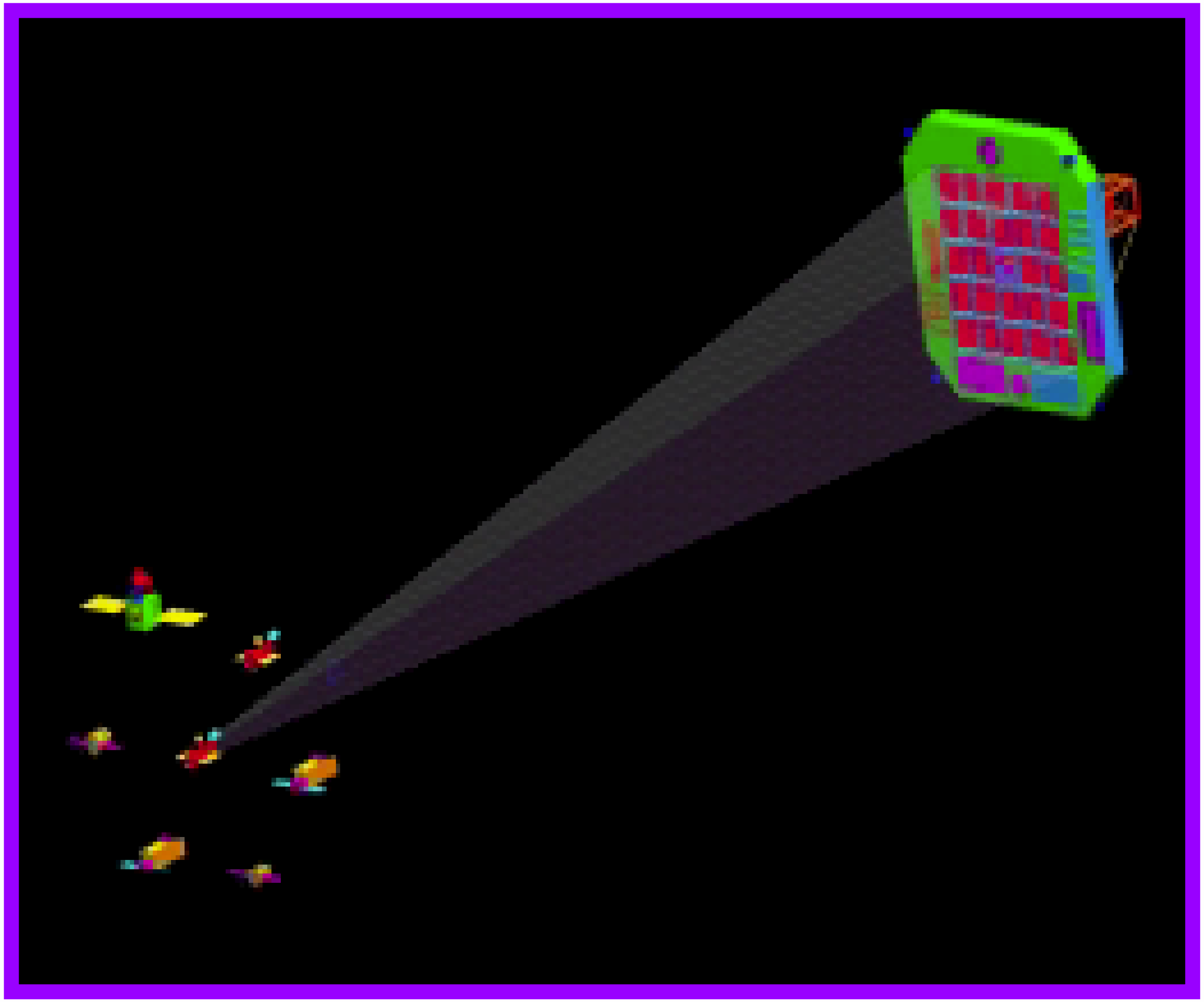
# Life Finder



# An Ultra-High Throughput X-Ray Astronomy Observatory with A New Mission Architecture

Paul Gorenstein, Smithsonian Institute, Astrophysical Observatory

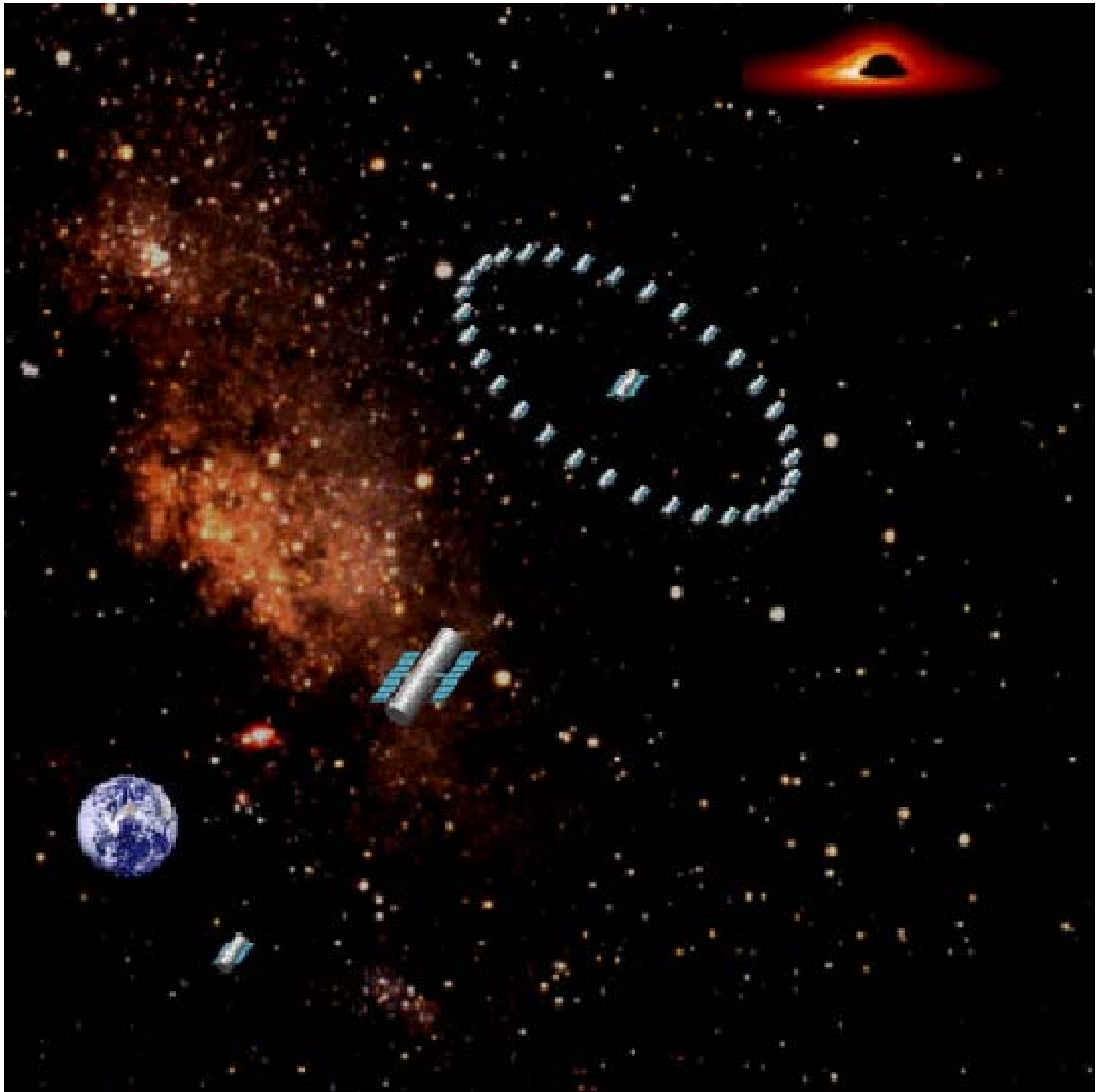
Phase II Performance Period: August 1. 1999 to July 31, 2001



*X-ray Interferometry - Ultimate Astronomical Imaging*

Webster Cash, University of Colorado

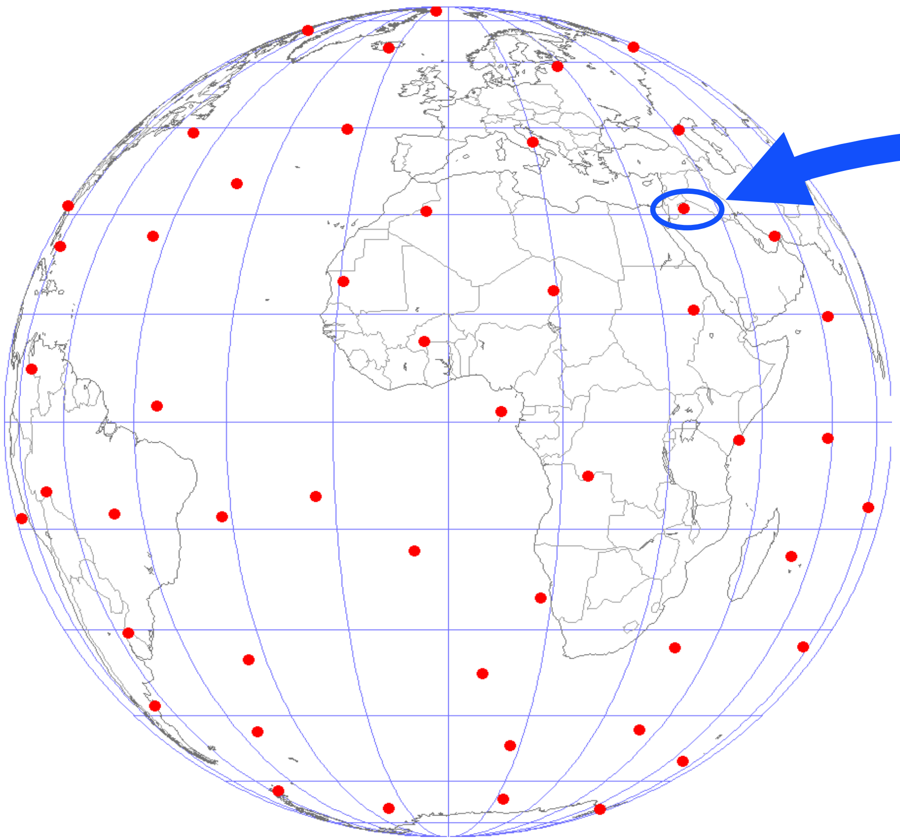
Phase II Performance Period: April 1, 2000 to March 31, 2002

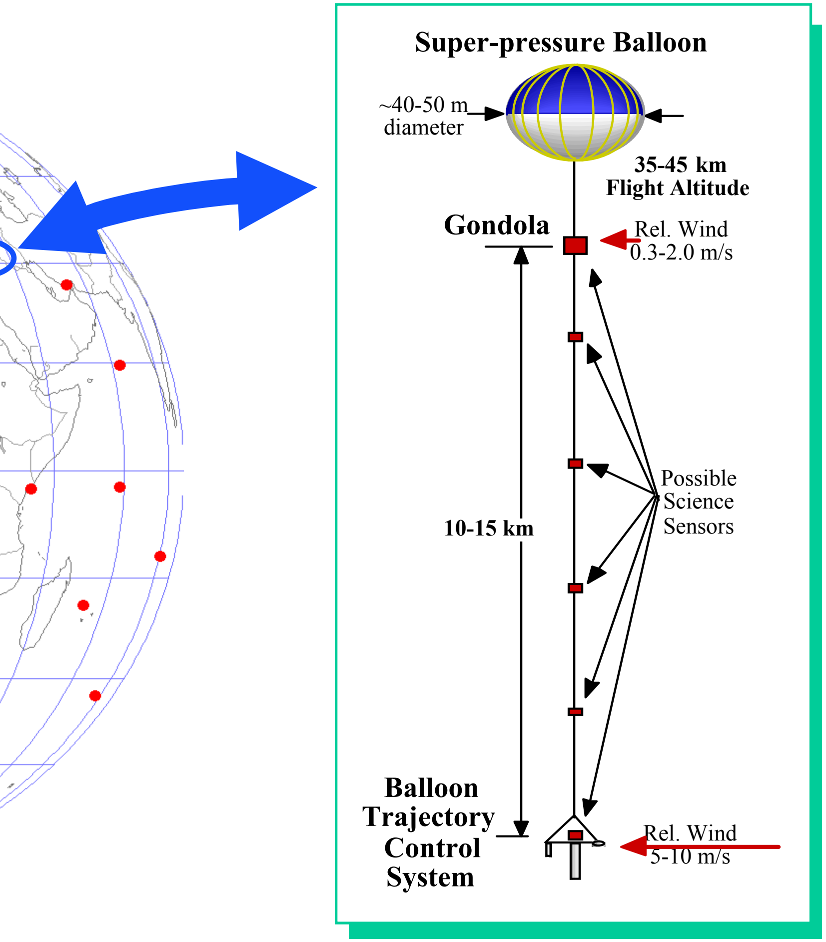


# Global Constellation of Stratospheric Scientific Platforms

Kerry Nock, Global Aerospace Corporation

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





# Methodology for Study of Autonomous VTOL Scalable Logistics Architecture

Andrew Keith, Sikorsky Aircraft Corporation

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