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”
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.

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
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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- Search for life in the universe and understand cosmological phenomena.
- 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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- 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
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 forces flown 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 off. It is custom fitted to each astronaut using a laser scanning/electrospinning process (Lafick Soldier Center). Remaining suit elements are simple, functional, interchangeable, and easy to maintain and repair.

Electrospinning 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\textsubscript{2} and H\textsubscript{2}O
- 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

<table>
<thead>
<tr>
<th>2010</th>
<th>2040</th>
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<tbody>
<tr>
<td><strong>Concept Evolution</strong></td>
<td><strong>Enabling Technologies</strong></td>
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</tbody>
</table>
| No-Expendables Heat Rejection | Smart Polymers
MEMS Wearable Electronics |
| Self-Fitting Pressure Suit | Polymeric Thermo-Electrics
Microturbines / Micro-channel HX |
| Integrated CO\textsubscript{2} & H\textsubscript{2}O Management | High Force Active Polymer
Advanced Joint Designs
Chemical Transport Smart Polymers - Selective Membranes |
| Energy Generation & Capture | 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 |
| **Research Needs & Directions** | 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 |
| **Research Needs & Directions** | 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

- Payload pick-up
- Tapered tether
- Payload release
- Origin
- Escape trajectory
- Interplanetary trajectory
- Patch point
- Loaded Tether Center of mass orbit
- Earth’s gravitational sphere of influence
- Mars’ gravitational sphere of influence
- Payload capture
- Payload release
- Loaded Tether Center of mass orbit
- Destination
- Inbound trajectory
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 $\geq 10^{18}$ 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.
Cyclical Visits to Mars via Astronaut Hotels
Kerry Nock, Global Aerospace Corporation
Phase II Performance Period: March 1, 2001 to January 31, 2003
The Space Elevator
Bradley Edwards, Eureka Scientific
Phase II Performance Period: March 1, 2001 to January 31, 2003
Concept for interstellar propulsion and radiation shielding
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
**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**
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.

Developing a Plant Genetic Assessment and Control System for Space Environments

Terry Lomax, Oregon State University

Arabidopsis will be used as the model plant.
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 Biomimetics
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

MITEE FUEL REGION

FUEL ELEMENT

REACTOR

MULTIPLE SHEET LAYERS

Cold Fuel Flow

Hot Gas Exit Channel

Cold Fuel Flow

Depressurization Zones on Sheet

Gas Flow Holes Through Sheet

Multilayer Roll of Metal Sheets

Fuel Element

Be Pressure Tab

Metal Matrix Fuel Region

Spent Fuel Moderators

Metal Matrix Sheets
A Realistic Interstellar Explorer

Ralph McNutt, Jr., Johns Hopkins Applied Physics Lab
Phase II Performance Period: April 1, 2000 to March 31, 2002
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

Super-pressure Balloon
~40-50 m diameter

Gondola

Balloon Trajectory Control System

35-45 km Flight Altitude
Rel. Wind 0.3-2.0 m/s
Possible Science Sensors

Rel. Wind 5-10 m/s

10-15 km

~10-15 km
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

Controlling the Global Weather

Ross Hoffman, Atmospheric and Environmental Research
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