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.
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”
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.
• 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. Cassanová
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

Seward
Artificial
muscles
Jacobs Hoyt
Gold
Howard
Hawk
Campbell
Dubowsky
Gorenstein
Gold
Seward
Stancil
Howe
Hawk
LaForge
Rice
Zubrin
Slough
Speith
Howard
Hoskins
Cash
Bekey
Maclay
Edwards
Molnar
Bacon
Cybenko
Newman
Hoffman
Colozza
Brown
Boston
Maise
Montemagno
Paniagua
Omidi
Paxton
Van Buiten
O’Handley
Palisoc
England
Tyll
Kammash
Kammash
Kare
Zhou
N sails accelerate over r ~ R / N
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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- 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.
Proposals Received and Awards
(through May 18, 2001)

TOTAL PROPOSALS RECEIVED (509)

- UNIVERSITY (189)
- HBCU (5)
- SDB (23)
- SMALL BUSINESS (252)
- NATIONAL LABS (13)
- LARGE BUSINESS (27)

AS OF 5/18/01

TOTAL NUMBER OF AWARDS (80)

- UNIVERSITY (34)
- HBCU (2)
- SDB (2)
- SMALL BUSINESS (35)
- NATIONAL LABS (0)
- LARGE BUSINESS (7)

AS OF 5/18/01
September 2001
Release of Next Phase I Call for Proposals with a due date of early February 2002

October 30-31, 2001
NIAC Phase I Fellows Meeting and Workshop
NIAC HQ, Atlanta, Georgia

November 6-7, 2001
Workshop on Revolutionary Aerospace Systems Concepts for Human/Robotic Exploration of the Solar System
NASA LaRC

June 4-5, 2002
NIAC 4th Annual Meeting
Lunar and Planetary Institute, Houston, Texas
Phase I Awards

Call for Proposals: CP 00-02
Performance Period: June 1 – November 30, 2001
NIAC CP 00-02 Technical Areas

- Terrestrial Power (1)
- Space Transportation (28)
- Space Power (8)
- Space Comm & Nav (5)
- Satellite/Spacecraft Tech (2)
- Satellite Constellations (5)
- Sails (6)
- Planetary & Space Sci (8)
- Physics (25)
- Life Sciences & Biology (13)
- ISRU/Colonies/Habitats (14)
- Information Technology (11)
- Exploration and Robotics (10)
- Earth to Orbit (12)
- Earth Science (36)
- Astronomy & Cosmology (5)
- Aeronautics and ATC (19)

Total Proposals = 172
Some are double counted in multiple technical areas
An astronaut on Mars donning the comfortable elastic bio-suit layer (1). The hard torso shell (4) is donned next and sealed 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 flexibly 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 (Natick 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 this 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
A Flexible Architecture for Plant Functional Genomics in Space Environments

Terri Lomax
Oregon State University
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

Directed Assembly of μ-Scale Biobots

Directed attachment of muscle fibers to specified areas of adhesion controlled by nanotechnology and chemistry

Engineered biobot "skeletons"

Non-differentiated muscle cells

Muscle fibers

Montemagno Research Group, 2001

Container filled with epoxy

Converting depressor muscle towards the attached appendage.
Achieving Comprehensive Mission Robustness

John Rose
University of South Carolina

Deontology vs. teleology...

Do not harm the mission...

Maximize utility...

Actions

External Influences and Sensory Inputs

Environment

RDF/KIF/FIPA

RDF/KIF/FIPA

RDF/KIF/FIPA

RDF/KIF/FIPA
Ultra-Fast Laser-Driven Plasma for Space Propulsion

Terry Kammash
University of Michigan

Laser-Accelerated Plasma Propulsion System (LAPPS)
High Acceleration Micro-Scale Laser Sails for Interstellar Propulsion

Jordin Kare
Kare Technical Consulting

N sails accelerate over $r \sim R / N$
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-Newton 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

**Stage 1**
- Europa lander on surface
- Deploys melt probe

**Stage 2**
- Melt probe reaches ocean
- Converts to submersible
- Explores ocean & collects samples
- Lander refuels w/ liquid H₂ from H₂O electrolyzer

**Stage 3**
- Melt probe returns to lander w/ samples
- Lander hops to new Europa location or returns to Earth
Adaptive Observation Strategies for Advanced Weather Prediction

David Bacon
SAIC, Center for Atmospheric Physics

Michael Kaplan
North Carolina State University
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
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.
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
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
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
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

2000
ROVERS
Discrete Components

2010
STX
Hybrid System

2040
CTX
Continuous System

The STX c.2010
The Space Elevator
Bradley Edwards, Eureka Scientific
Phase II Performance Period: March 1, 2001 to January 31, 2003

[Diagram of the space elevator with labeled parts and dimensions]
Moon and Mars Orbiting Spinning Tether Transport (MMOSTT)

Robert P. Hoyt, Tethers Unlimited, Inc.
Phase II Performance Period: August 1, 1999 to July 31, 2001

INTERPLANETARY TRANSPORT USING ROTATING TETHERS

Earth’s gravitational sphere of influence

Payload pick-up
Tapered tether
Payload release

Loaded Tether Center of mass orbit
Origin Escape trajectory
Interplanetary trajectory
Patch point

Mars’ gravitational sphere of influence

Loaded Tether Center of mass orbit
Interplanetary trajectory
Destination Inbound trajectory
Payload capture
Tapered tether
Payload release
Hypersonic Airplane Space Tether Orbital Launch – HASTOL

John Grant, The Boeing Company

Phase II Performance Period: April 1, 2000 to September 30, 2001
Concept for interstellar propulsion and radiation shielding
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

- 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.

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

MITEE FUEL REGION
- Multi-layer Roll of Metal Sheets
- Hot Gas Exit Channel
- Cold Flow Mixed Flow

FUEL ELEMENT
- Be Pressure Tabs
- Moderators

REACTOR
- Multiple Sheet Layers
- Decrease "Zones on Sheet"
- Gas Flow Holes Through Sheet
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

Super-pressure Balloon
~40-50 m diameter
35-45 km Flight Altitude
Rel. Wind 0.3-2.0 m/s

Gondola

10-15 km
Possible Science Sensors

Balloon Trajectory Control System

Rel. Wind 5-10 m/s
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
New task
Funded from the LaRC RASC activity through the USRA ICASE contract. Led by ICASE with NIAC involvement in the RFI and Workshop

Human & Robotics Exploration Mission Objective:
Identify key revolutionary technologies for Human and Robotics systems which have the potential, when synergistically combined, to reduce the time, distance and safety barriers associated with scientific exploration beyond Low Earth Orbit (LEO)

Activities:
1. Orchestrate a collaborative effort of industrial, government and academic experts.
   - Determining the appropriate mix of autonomous systems, and crewed systems necessary to yield the greatest scientific benefits from the destination at which the systems will be deployed.
2. Global survey of both the human and robotic exploration activities in NASA, and elsewhere, to determine how this mix might evolve with the incorporation of revolutionary advanced systems concepts to achieve a maximum of scientific return.
3. Conduct a NIAC-Style Request for Information (RFI), due September 24, 2001
4. Organize and lead a workshop, November 6-8, 2001 at NASA LaRC
5. Identify key technologies that should be pursued.