NASA Institute for Advanced Concepts

Annual Report

February 10, 1999

NASA Institute for Advanced Concepts

555-A 14th Street, NW, Atlanta, GA 30318

An Institute of the

Universities Space Research Association

USRA

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Stretch your imagination decades into the future

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EXECUTIVE SUMMARY

The contract for the operation of the NASA Institute for Advanced Concepts (NIAC) began on February 10, 1998 with the awarding of a contract to the Universities Space Research Association. The NIAC office in Atlanta was established shortly thereafter, full time staff were hired, computing resources and other office equipment were purchased and installed. Membership of the NIAC Science, Exploration and Technology Council (NSETC) was confirmed.

The NIAC "Grand Challenges" workshop was conducted on May 21-22, 1998 in Columbia, Maryland. Brainstorming sessions were structured to complement the NASA Enterprises areas, and thirty-two invited participants contributed to the creation of a broad list of challenges in aeronautics and space. These "Grand Challenges" became the essence of the technical scope for the first Phase I Call for Proposals which was released on June 19, 1998 with a due date of July 31, 1998.

The first Phase I Call for Proposals attracted 119 proposals. After a thorough peer review, prioritization by NIAC and technical concurrence by NASA, sixteen subgrants were awarded. The second Phase I Call for Proposals was released on November 23, 1998 with a due date of January 31, 1999. Sixty-three (63) proposals were received in response to this Call. On December 2-3, 1998, the NSETC met to review the progress and future plans of the NIAC. The next NSETC meeting is scheduled for August 5-6, 1999. The first Phase II Call for Proposals was released to the current Phase I grantees on February 3,1999 with a due date of May 31, 1999.

Plans for the second year of the contract include a continuation of the sequence of Phase I and Phase II Calls for Proposals and hosting the first NIAC Annual Meeting and USRA/NIAC Technical Symposium in NASA HQ.

DESCRIPTION OF THE NIAC

Purpose

The NIAC has been formed for the explicit purpose of being an independent source of revolutionary aeronautical and space concepts that could dramatically impact how NASA develops and conducts its mission. The Institute is to provide highly visible, recognized and high-level entry point for outside thinkers and researchers. The Institute functions as a **virtual** institute and uses the resources of the internet whenever productive and efficient for communication with grant recipients, NASA and the science and engineering community.

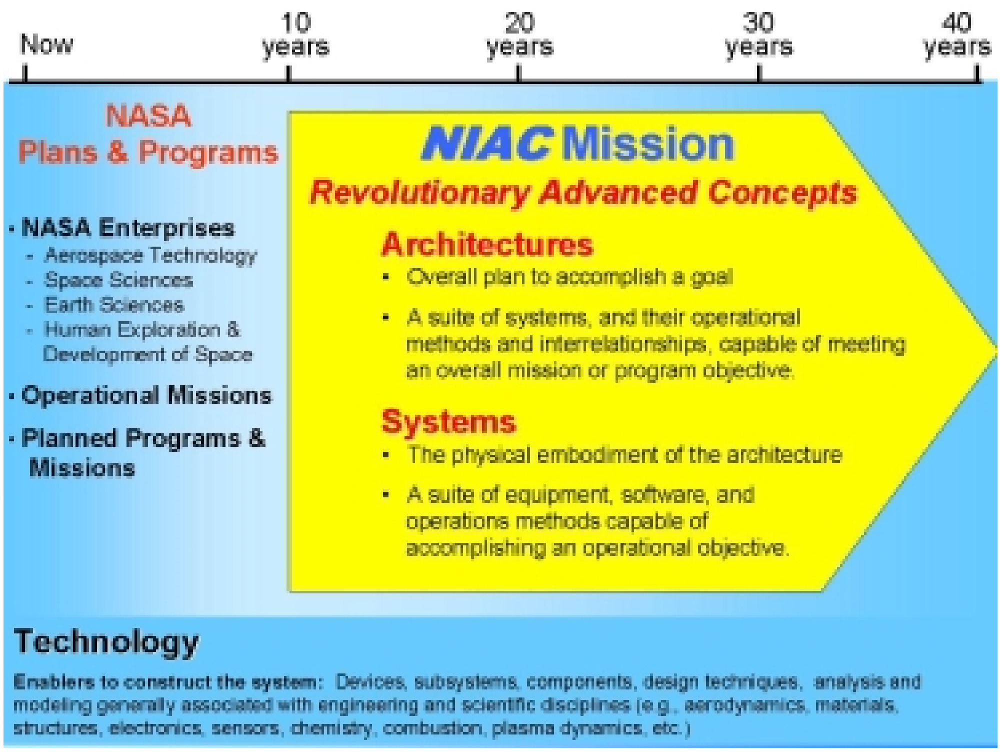


Figure 1. NIAC Advanced Concepts Mission

Figure 1 illustrates the mission of the NIAC relative to the NASA Plans and Programs and the ongoing technology development efforts. The purpose of the NIAC is to provide an independent, open forum for the external analysis and definition of space and aeronautics advanced concepts to complement the advanced concepts activities conducted within the NASA Enterprises. The NIAC has advanced concepts as its sole focus. It focuses on revolutionary concepts - specifically systems and architectures - that can have a major impact on missions of the NASA Enterprises in the time frame of 10 to 40 years in the future. It generates ideas for how the current NASA Agenda can be done better; it expands our vision of future possibilities. The scope of the NIAC is based on the National Space Policy, the NASA Strategic Plan, the NASA Enterprise Strategic Plans and future mission plans of the NASA Enterprises, but it is bounded only by the horizons of human imagination.

Normal development of the NIAC advanced concepts is carried out through issuance of research subgrants or subcontracts in a two-phased approach. Phase I awards of approximately $50K-$75K are for 6 months to validate the viability of the proposed concept and definition of major feasibility issues. Phase II award(s) of from $350K-$500K for a period of 18-24 months study the major feasibility issues associated with cost, performance, development time and key technology issues. Both Phase I and Phase II awards are competitively selected by the NIAC based on an independent peer review. Principal investigators (PIs) receiving NIAC subgrants are designated as NIAC Fellows.

Contract Status and Financial Information

The contract for operation of the NIAC, NAS5-98051, began February 10, 1998. The contract is for three years plus a two-year optional performance period. The total value of the contract for the first three years of operation is $10,990,106. NASA has the option to extend the contract an additional two years which would add $9,161,332 to the value.

NIAC Organization, Personnel and Team Members

The organization of the NIAC is illustrated (below) in Figure 2. As an institute of the Universities Space Research Association, the NIAC reports to the President of USRA.

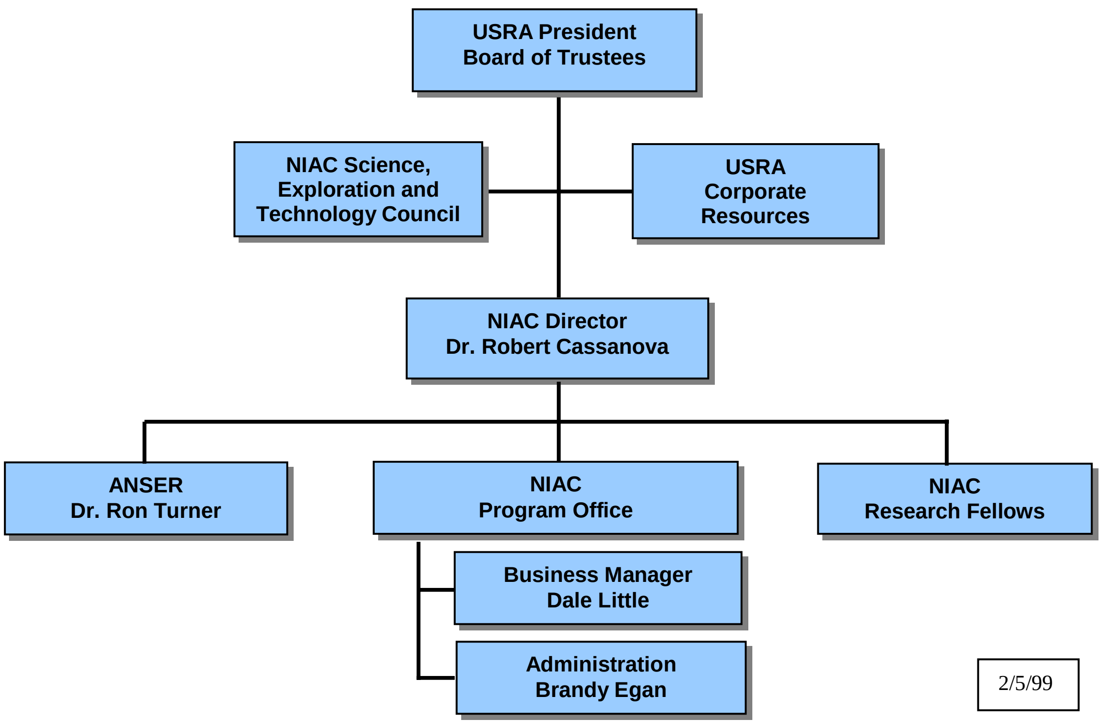


Figure 2. Organization of the NIAC

The permanent staff is located at the NIAC office in Atlanta, Georgia, and consists of the Director, Business Manager and Administrative Assistant. Co-op students perform technology searches and provide computer support. An additional staff member will be added early in CY99 to provide full-time computer network and software application support.

ANSER, through a subcontract from the USRA/NIAC, provides program support, technical support and information technology support for NIAC operation. Activities include maintaining the NIAC website (http://www.niac.usra.edu), performing technology database searches to support proposal peer review and evaluation and general technical support of meetings, conferences, briefings and peer reviews.

As a corporate expense, USRA formed the **NIAC Science, Exploration and Technology Council (NSETC)** to oversee the operation of the NIAC on behalf of the relevant scientific and engineering community. The Council is composed of a diverse group of thinkers, eminent in their respective fields and representing a broad cross-section of technologies related to the NASA Charter. The Council will have a rotating membership, with each member serving a three year term. Council members are appointed by the USRA Board of Trustees.

The current membership of the NIAC Science, Exploration and Technology Council is as follows:

Dr. Burton Edelson, George Washington University (*Convener*)
Dr. David Black, Lunar and Planetary Institute
Mr. Peter Bracken, ACS Government Solutions Group, Inc.
Professor Aaron Cohen, Texas A&M University
Dr. Jerry Grey, Aerospace Consultant
Mr. Gentry Lee, Aerospace Consultant and Author
Dr. Lynn Margulis, University of Massachusetts
Professor John H. McElroy, University of Texas at Arlington
Professor Roald Sagdeev, University of Maryland
Dr. Taylor Wang, Vanderbilt University
Dr. Wesley T. Huntress, Carnegie Institute of Washington
Dr. Robert E. Whitehead, Aerospace Consultant
Dr. Robert A. Cassanova, NASA Institute for Advanced Concepts (*ex officio*)

NIAC Facilities

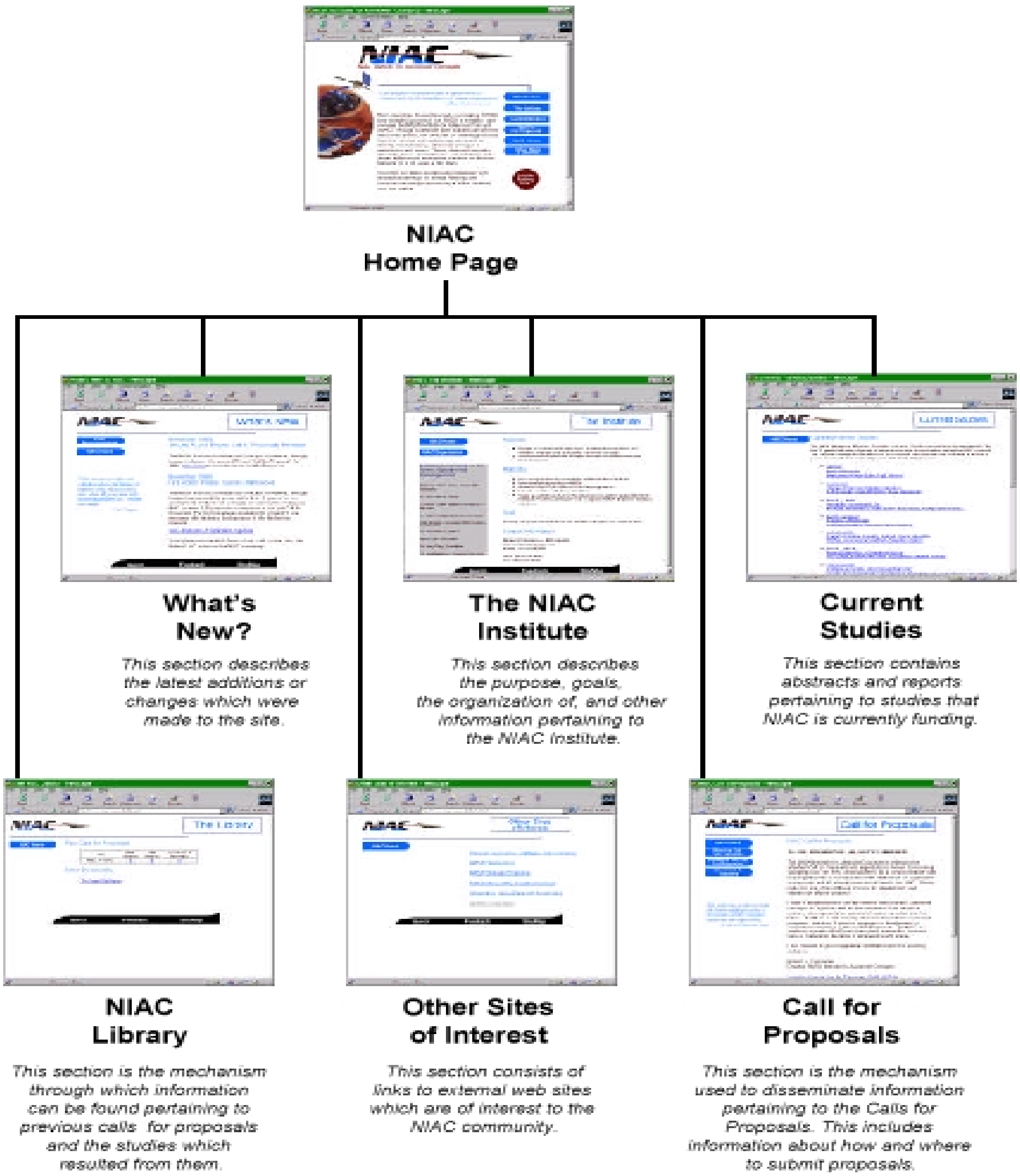
The NIAC is centrally located in Atlanta, Georgia, and occupies 2000 square feet of professional office space. Additional conference facilities with a 75-seat auditorium and two conference rooms are also available on-site as needed. The staff is linked via a Windows NT based Local Area Network (LAN) consisting of 5 Pentium II PCs, one Macintosh G3 and one Unix server. Internet access is provided via a fiber-optic link through the Georgia Tech network. Other equipment includes a flat-bed scanner, an HP Color LaserJet 5 printer, an HP LaserJet 4000TN printer, an HP LaserJet 3100 Fax and a Canon NP6050 copier.

Virtual Institute

The NIAC envisions the progressive use of the internet as a key element in a cost-effective, paperless interconnection between the geographically dispersed elements of the NIAC operation. The internet is the primary vehicle to link the NIAC office with grantees, NASA points of contact, and other members of the science and engineering community. The internet will be the primary communication link for publicizing the NIAC, announcing the availability of Calls for Proposals, receiving proposals and reporting on technical and financial status. All proposals submitted to the NIAC must be in electronic format. All monthly reports from the grantees to the NIAC and from the NIAC to NASA are submitted electronically. The peer review of proposals is also conducted electronically whenever the peer reviewer has the necessary internet connectivity and application software.

ANSER created and maintains the NIAC website at http://www.niac.usra.edu, which serves as the focal point of the NIAC to the outside world. The website can be accessed to retrieve and submit NIAC information and proposals. The NIAC website is also linked from the NASA Technology Planning & Integration Office (NTPIO) website at http://ntpio.nasa.gov. Figure 3 is the site map of the NIAC website.

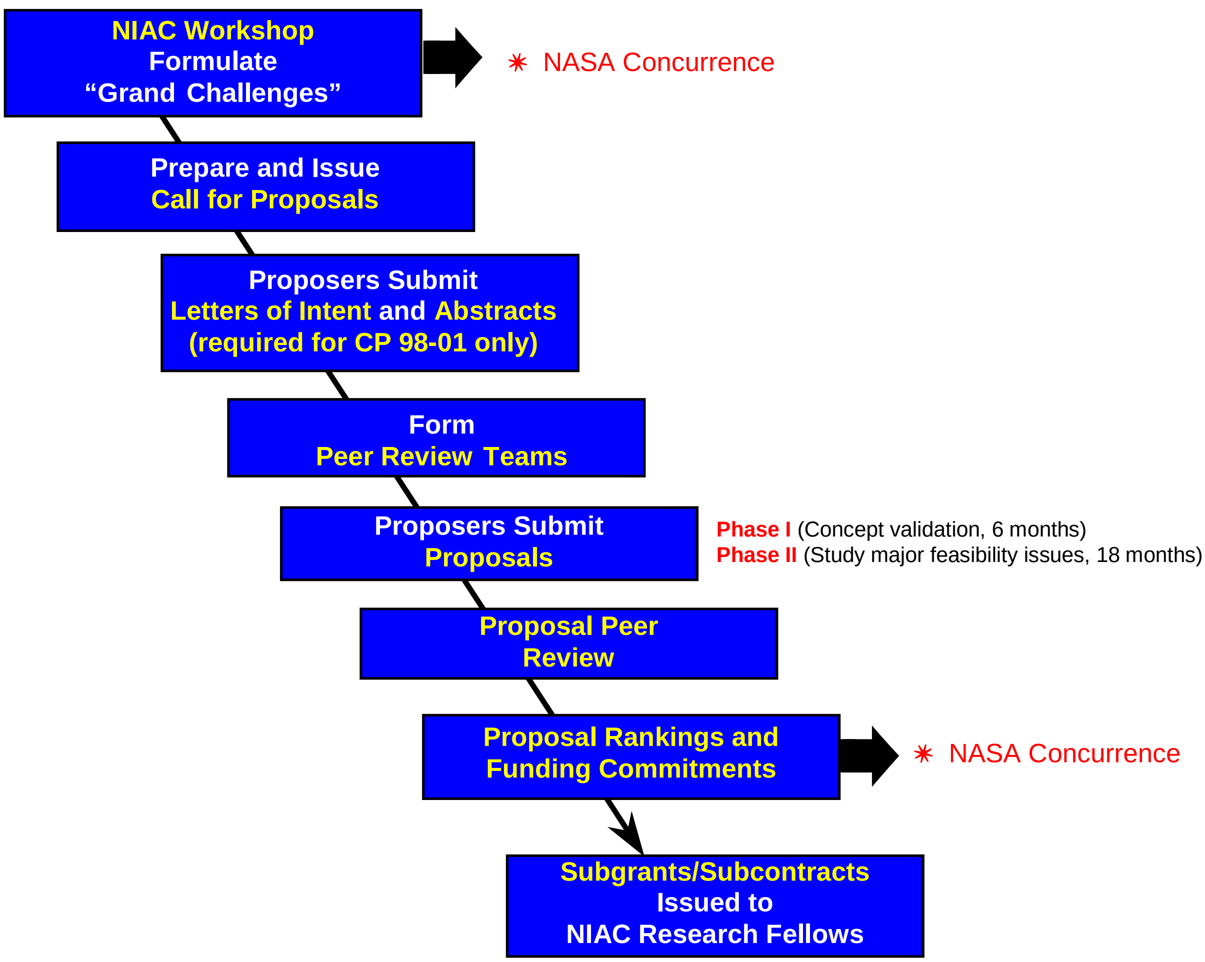
Figure 3. Site Map of the NIAC Website, http://www.niac.usra.edu



OPERATION OF THE NIAC

The NIAC is operated in a manner to encourage an atmosphere of open participation by the science and engineering community and to provide active feedback and concurrence from the NASA Office of the Chief Technologist and the NASA Enterprises. Figure 4 illustrates the process that was used to establish the technical and programmatic thrusts of the NIAC and to initiate the proposal solicitation process. Refinements to the solicitation have occurred with subsequent Calls; for example, refinement of the Technical Scope and deletion of the requirement for a letter-of-intent for Phase I.

Figure 4. Proposal Solicitation Process for CP 98-01



Grand Challenges Workshop

The Grand Challenges Workshop was conducted on May 21-22, 1998 at the Columbia Inn in Columbia, Maryland. The workshop generated a list of 41 "challenges" which served as the starting point for refining to a consolidated list to be used in the Call for Proposals. The "challenges" list was sent to selected staff at USRA, ANSER and NASA for comment. The final version of the "Grand Challenges" was included in the NIAC Call for Proposals, CP98-01. Attendees and their affiliations at the Workshop included:

Dr. Robert Cassanova	NIAC (Director)
Dale Little	NIAC (Business Manager)
Dr. Paul Coleman	USRA (President)
Al Diaz	NASA-GSFC
Sam Venneri	NASA-HQ
Sharon Garrison	NASA-GSFC
Murray Hirschbein	NASA-HQ
Alan Ladwig	NASA-HQ
Guy Miller	NASA-GSFC
Gen. (Ret.) James Abrahamson	Consultant
Freeman Dyson	Institute for Advanced Study
Dr. Robert Forward	Tethers Unlimited Incorporated
Dr. Bill McDonald	University of Alabama, Birmingham
Dr. Nick Matwiyoff	SpaceHab
Bob Pattishall	NRO
Thomas Rogers	Space Transportation Association
Jerry Rising	Lockheed Martin Skunk Works
Charlie Stancil	Georgia Tech Research Institute
Joe Sciabica	AF Research Lab
Dr. David Black	USRA/LPI
Professor Roald Sagdeev	University of Maryland
Dr. Taylor Wang	Vanderbilt University
Peter Bracken	Computer Data Systems Incorporated
Dr. Burt Edelson	USRA/George Washington University
Gentry Lee	Consultant
Dr. Jerry Grey	Consultant
Jim Finnegan	USRA
Dr. William Howard	USRA
David Holdridge	USRA
Stan Sadin	USRA
Jack Sevier	USRA
Dr. Ron Turner	ANSER

Figure 5 (on the following page) is a photograph of workshop participants.

Figure 5. NIAC Grand Challenges Workshop Participants

left to right, front to back: David Black, Jack Sevier, Robert Cassanova, Joe Sciabica, Burt Edelson, Ron Turner, Freeman Dyson, Nick Matwiyoff, David Holdridge, Stan Sadin, Taylor Wang, Charles Stancil, William Howard, Roald Sagdeev, Carl Beaudry, Gentry Lee, Dale Little, Bill McDonald, Thomas Rogers, Jerry Grey, Bob Pattishall, Robert Forward, James Abrahamson, Jim Finnegan, Peter Bracken (not shown: Paul Coleman, Jerry Rising, Alan Ladwig, Al Diaz, Murray Hirschbein, Sharon Garrison, Guy Miller, Bill Davis, Sam Venneri). Photo by Glogau Studios.

Proposal Solicitation Process

The process for solicitation of proposals is illustrated in Figure 4 based on the Call for Proposals, CP 98-01. Major milestones regarding Calls for Proposals issued to-date are as follows:

Call Number	Type of Call	Release Date	Due Date	Award Date
CP 98-01	Phase I	June 19, 1998	July 31, 1998	Nov. 1, 1998
CP 98-02	Phase I	Nov. 23, 1998	Jan. 31, 1999	May 1, 1999 (estimated)
CP 99-01	Phase II	Feb. 3, 1999	May 31, 1999	Aug. 1, 1999 (estimated)

Notice of the availability of the CP 98-01 was provided through:

- publication of an announcement in the *Commerce Business Daily*,
- publication of a special edition of the *USRA Researcher* which was mailed to more than 12,000 names on an USRA distribution list,
- notices sent to a NIAC email distribution list generated from responses by persons who signed up on the NIAC website to receive the Call,
- announcements on professional society websites or newsletters (American Institute for Aeronautics and Astronautics, American Astronautical Society and the American Astronomical Society),
- announcements on the USRA and NIAC websites,
- an article published in *Space News,*
- an article published on the ABCNews.com website.
- NASA GSFC News Release,

In addition to the above announcement vehicles, CP 98-02 was announced in:

- web links from NASA Enterprise web pages,
- web link from the NASA Coordinator's web page,
- announcements to an HBCU/SDB distribution list provided by NASA,
- distribution of announcements to an Earth Sciences list provided by NASA GSFC
- distribution of announcements at the annual meeting of the American Astronautical Society in Houston, Texas, November, 1998.

CP 98-01 Statistics

As of the due date of midnight, July 31, 1998, 162 letters-of-intent and 119 proposals had been received in correct .pdf format. The types of organizations submitting proposals were, including multiple submissions by several organizations:

Large business = 7 (8 proposals)
Small business = 38 (50 proposals)
Individuals = 4 (4 proposals)
University = 29 (57 proposals)

There were very few proposals in Earth Sciences (one) and Aviation Safety (one), and a large number of proposals in space propulsion and astronomy. Proposals were received in the following technical areas:

Air Breathing Propulsion	Habitat Construction
Long Duration A/C	Space Platforms & Vehicles
Ground Based Propulsion	Astronomy
Solar Sails	Deep Space Probes
Nuclear and Plasma Propulsion	Robotics
Power Generation	Planetary Explorers
Orbital Mechanics	Gravity, Dark Matter in Universe
Earth Science	Intelligent Controls
Asteroid Protection	Computing
NEO Mining	Power Transmission
Biomedical/Bioengineering	Laser Communication
	Planetary Resource Utilization

CP 98-02 Statistics

Sixty-three (63) proposals were received by the due date of January 31, 1999 in response to CP98-02. All proposals were received electronically in .pdf format. The types of organizations submitting proposals were, including multiple submissions by several organizations:

Large business = 3 (3 proposals)
Small business (USA) = 22 (34 proposals)
Small business (Foreign) = 5 (5 proposals)
Small Disadvantaged Business = 5 (5 proposals)
Historic Black College/University = 1 (1 proposal)
University = 12 (14 proposals)
National Lab = 1 (1 proposal)

Proposals were received in the following technical areas:

- Long Duration A/C
- Ground Based Propulsion
- Solar & Magnetic Sails
- Space Propulsion & Transportation
- Power Generation
- Biomedical/Bioengineering
- Habitat Construction
- Space Platforms & Vehicles
- Astronomy
- Large Transport Aircraft
- Hypersonic Aircraft
- Robotics
- Planetary Explorers
- Computing
- Power Transmission
- Space Communication & Navigation
- Planetary Resource Utilization
- Space Environment
- Earth Environmental Monitoring

Peer Review and Prioritization Process

A group of forty-four reviewers took part in the peer review of the 119 proposals submitted in response to CP98-01. These peer reviewers represented a cross-section of senior research executives in private industry, senior research faculty in universities, specialized researchers in both industry and universities, and aerospace consultants. Peer reviewers for CP98-02 were drawn from a similar community of scientists and engineers.

For CP98-01 each proposal received at least three peer reviews. Each reviewer was asked to evaluate the proposal according to the criteria stated in the Call-for-Proposals. Forms were created to help guide the reviewer through the process of assigning a numerical ranking and providing written comments.

Each reviewer was required to sign a non-disclosure and no-conflict-of-interest agreement. A small monetary compensation was offered to each reviewer. Depending on the capabilities of each reviewer, the proposals and all required forms were transmitted to the reviewer over the internet, by diskette or by paper copy. Each reviewer was given approximately thirty days to review the proposals and return the completed evaluation forms.

The ANSER Corporation provided valuable assistance to the peer review process through a search of its archives, knowledge bases and additional resources. These information databases were used to provide additional background on prior and ongoing advanced concept research efforts sponsored by NASA and non-NASA sources.

NASA Concurrence

The NIAC contract requires the receipt of NASA concurrence on the "Grand Challenges" generated at the NIAC Workshop on May 21-22, 1998 and "challenges" lists generated in future workshops. The NIAC Director is required to present the research subgrant/subcontract selections to the NASA Chief Technologist and representatives of the NASA Strategic Enterprises before any awards are announced. Technical concurrence by NASA to assure consistency with NASA's Charter, strategy and budget limits is required before any subgrants or subcontracts are announced or issued.

The NASA technical concurrence meeting for the CP 98-01 subgrants was held on October 21, 1998. Attendees included:

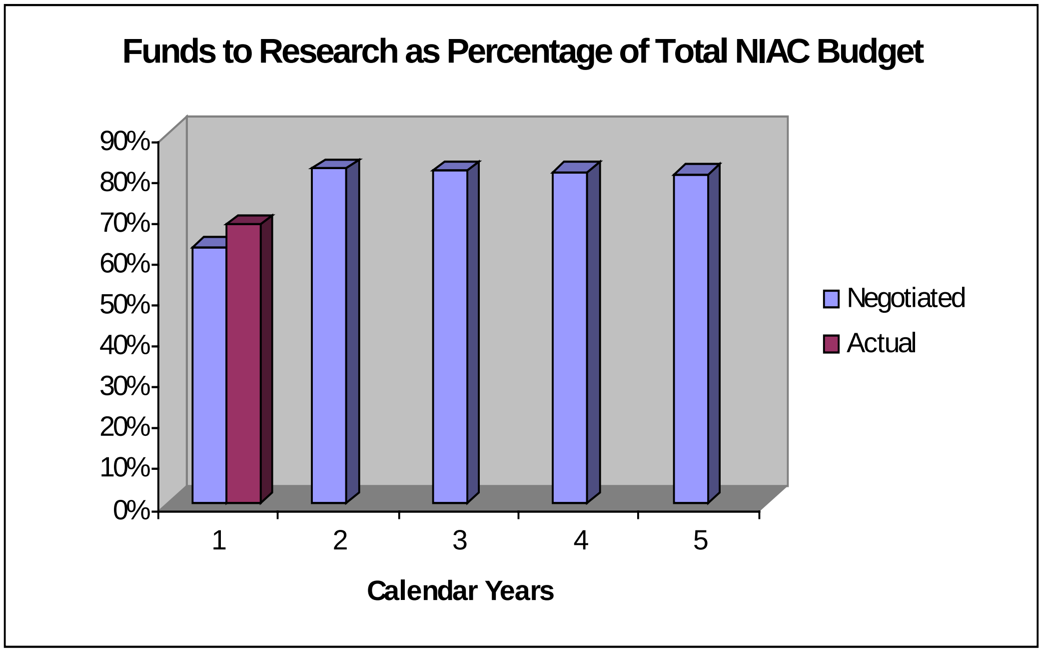
Robert A. Cassanova, NIAC Director
Dale Little, NIAC Business Manager
Ron Turner, ANSER
Sam Venneri, NASA Chief Technologist
Murray Hirschbein, NASA
Greg Reck, NASA
Glenn Mucklow, NASA
Sharon Garrison, NASA Coordinator for NIAC
Robert Norwood, NASA
Peter Ahlf, NASA
John Mankins, NASA
Carl Wagenfurer, NASA
Gary Martin, NASA
Gran Paules, NASA
Joe Hale, NASA

Based on the results of the NIAC peer review, technical concurrence from NASA's Office of the Chief Technologist and the availability of funding, a decision was made to fund 16 Phase I subgrants. All proposal authors were notified electronically of the acceptance or rejection of their proposal. The USRA contracts office began processing subgrants with appropriate NASA GSFC contracts office concurrence to each of the winning organizations with starting dates of November 1, 1998.

NIAC Financial Performance

The NIAC makes extensive use of internet connectivity for all appropriate functions and operates with a small staff to maximize the funding being used for development of advanced concepts. During the first year of operation, the NIAC exceeded the negotiated percentage of funding transferred to subgrants, as shown in Figure 6.

Figure 6. Funds to Research as Percentage of Total NIAC Budget



STATUS OF FUNDED INVESTIGATIONS

Phase I Awards, November 1, 1998

The following awards were funded with a performance period of November 1, 1998 through April 30, 1999. An abstract of each subgrant is available in Appendix A.

1. Ilan Kroo, Stanford University
   "Mesicopter: A Meso-Scale Flight Vehicle"
   $70,000

2. Charles M. Stancil, Georgia Tech Research Institute
   "Electric Toroid Rotor Technology Development"
   $74,872

3. Robert P. Hoyt, Tethers Unlimited, Inc.
   "Cislunar Tether Transport System"
   $75,000

4. Steven D. Howe, Synergistic Technologies, Inc.
   "Enabling Exploration of Deep Space: High Density Storage of Antimatter"
   $74,480

5. Clark W. Hawk, University of Alabama-Huntsville, Propulsion Research Center
   "Pulsed Plasma Power Generation"
   $51,632

6. Clint Seward, Electron Power Systems, Inc.
   "Low-Cost Space Transportation Using Electron Spiral Toroid (EST) Propulsion"
   $74,941

7. Robert M. Winglee, University of Washington
   "The Mini-Magnetospheric Plasma Propulsion, M^2P^2"
   $74,721

8. Geoffrey A. Landis, Ohio Aerospace Institute
   "Advanced Solar- and Laser-Pushed Lightsail Concepts"
   $73,122

9. Ron Jacobs, Intelligent Inference Systems Corporation
   "A Biologically Inspired Robot for Space Operations"
   $74,789

10. Robert E. Gold, The Johns Hopkins University, Applied Physics Laboratory
    "SHIELD: A Comprehensive Earth Protection System"
    $73,903

11. Steven Dubowsky, MIT
"Self-Transforming Robotic Planetary Explorers"
$74,880

12. Ralph L. McNutt, Jr., The Johns Hopkins University, Applied Physics Laboratory
"A Realistic Interstellar Explorer"
$73,903

13. Mark E. Campbell, University of Washington
"Intelligent Satellite Teams for Space Systems"
$61,951

14. Neville J. Woolf, Steward Observatory, University of Arizona
"Very Large Optics for the Study of Extrasolar Terrestrial Planets"
$74,932

15. Paul Gorenstein, Smithsonian Institute, Astrophysical Observatory
"An Ultra-High Throughput X-Ray Astronomy Observatory with a New Mission Architecture"
$73,844

16. Ivan Bekey, Bekey Designs
"A Structureless Extremely Large Yet Very Lightweight Swarm Array Space Telescope"
$69,025

NIAC COMMUNICATION WITH NASA AND THE SCIENCE AND ENGINEERING COMMUNITY

In addition to the continuous, open communication provided through the NIAC website, the NIAC provides monthly status reports submitted electronically to NASA which are subsequently distributed through the NASA Coordinator to her NASA/NIAC support team (representatives from the NASA Enterprises and Centers, GSFC procurement, financial and legal offices, NASA Office of the Chief Technologist, Enterprises and Centers). The NIAC will also be providing regular updates as needed to appropriate technical contacts in NASA and JPL. NIAC will also sponsor annual meetings to showcase the current Phase I and Phase II concept development efforts to an audience of NASA Enterprise and Center representatives and members of the science and engineering community.

Coordination with NASA Office of the Chief Technologist, Enterprises and Centers

Ms. Sharon Garrison is the NASA Coordinator for the NIAC in the NASA Technology and Planning and Integration Office (NTPIO) at GSFC. She is the primary point of contact between the NIAC and NASA. Ms. Garrison actively communicates throughout NASA to a review team comprised of representatives from the Enterprises, Centers and Office of the Chief Technologist. Figure 7 is a listing of these representatives. Throughout the process of managing the NIAC, these representatives, via Ms. Garrison, have been kept informed of the status of the Institute and have been appropriately involved in decisions and feedback. The NIAC provides monthly contract status reports to the NASA Coordinator which are forwarded to these and other points of contact within NASA.

Figure 7. NASA NIAC Support Team

NASA COTR
Sharon Garrison, GSFC

NASA Office of Chief Technologist
Murray Hirschbein, AF

NASA Enterprises
John Mankins, M
David Stone, R
Karl Loutinsky, R
Glenn Mucklow, S
Minoo Dastoor, U
Richard Monson, Y

Centers
Art Murphy, JPL
Gale Allen, KSC
Olga Gonzalez-Sanabria, LeRC
John Cole, MSFC
Ronald Kahl, JSC
Dennis Bushnell, LaRC
Bill St. Cyr, SSC
Steve Whitmore, DFRC
Larry Lasher, ARC
Wayne Hudson, GSFC

Very early in the start-up process of the Institute, Dr. Cassanova and Ms. Garrison visited Associate Administrators and Enterprise representatives to brief them on the plans for the NIAC and to seek their active support and feedback.

Dr. Cassanova and Ms. Garrison visited LaRC, GSFC, LeRC, JPL, DFRC, ARC and MSFC to present an overview of the NIAC and to establish management and technical contact with NASA groups developing advanced concepts. Similar coordination visits are planned with JSC, SSC and KSC.

Annual Meeting and Technical Symposium

The first NIAC Annual Meeting and Technical Symposium is planned for March 25-26, 1999 in the NASA HQ Auditorium in Washington, D.C. On March 25th, all sixteen of the Phase I Fellows will brief the status of their work at the Annual Meeting. The agenda for the annual meeting is included in Appendix B.

The Technical Symposium scheduled for the morning of March 26th has as its theme "Grand Visions of Aerospace – The Next 30 Years", and will include presentations by recognized leaders in aeronautics and space. Speakers will include:

Mr. Sam Venneri, NASA Chief Technologist
Dr. Wes Huntress, Carnegie Institute of Washington
Dr. Mark Abbott, Oregon State University
Dr. Laurence Young, MIT
Dr. George Donohue, George Mason University
Dr. Jerry Grey, Aerospace Consultant
Dr. Peter Denning, George Mason University

The agenda for the symposium and biosketches of the speakers are included in Appendix C.

PLANS FOR THE SECOND YEAR OF THE CONTRACT

During the first year of the NIAC contract, the vision of the Institute was established and an operational framework was constructed. The involvement of the science and engineering community in advisory activities was established through the "Grand Challenges Workshop" and the NIAC Science, Exploration and Technology Council. The first Phase I Call for proposals attracted a large number of technically diverse proposals and the first 16 subgrants were awarded. The exposure and recognition of the Institute's activities continued to grow through contact and collaboration with NASA Enterprises and Centers, attendance at technical society meetings, publicity generated through news releases and trade publications, and the NIAC website.

The second year's activities will continue to build on the first year's framework. Figure 8 illustrates the major activities which occurred during the first year and are scheduled for the second year.

The second Phase I Call for Proposals, CP 98-02, was released on November 23, 1998 with a due date of January 31, 1999. During the month of February and early March, 1999, these proposals will be in the peer review evaluation process. Based on the results of the peer reviews, a funding plan and prioritized list will be presented to the Office of the Chief Technologist for technical concurrence in late March or early April, 1999. Awards will be announced shortly thereafter.

The first NIAC Annual Meeting will be held on March 25, 1999 in NASA HQ Auditorium, and each of the first 16 Phase I grantees will brief the status of their concept development activities. The second NIAC Annual Meeting is scheduled for March, 2000. On March 26, 1999, NIAC is co-hosting a Technical Symposium with USRA in the NASA HQ Auditorium on the subject of "Grand Visions of Aerospace – The Next Thirty Years".

The Phase II Call for Proposals, CP 99-01, was released on February 3, 1999 to the Phase I grantees with a due date of May 31, 1999. Peer review of these proposals will take place during June and early July, 1999. The NIAC Director and selected technical experts may conduct site visits before presenting the technical concurrence briefing to the Office of the Chief Technologist and making Phase II awards. Technical concurrence and announcement of awards will occur in July/August, 1999.

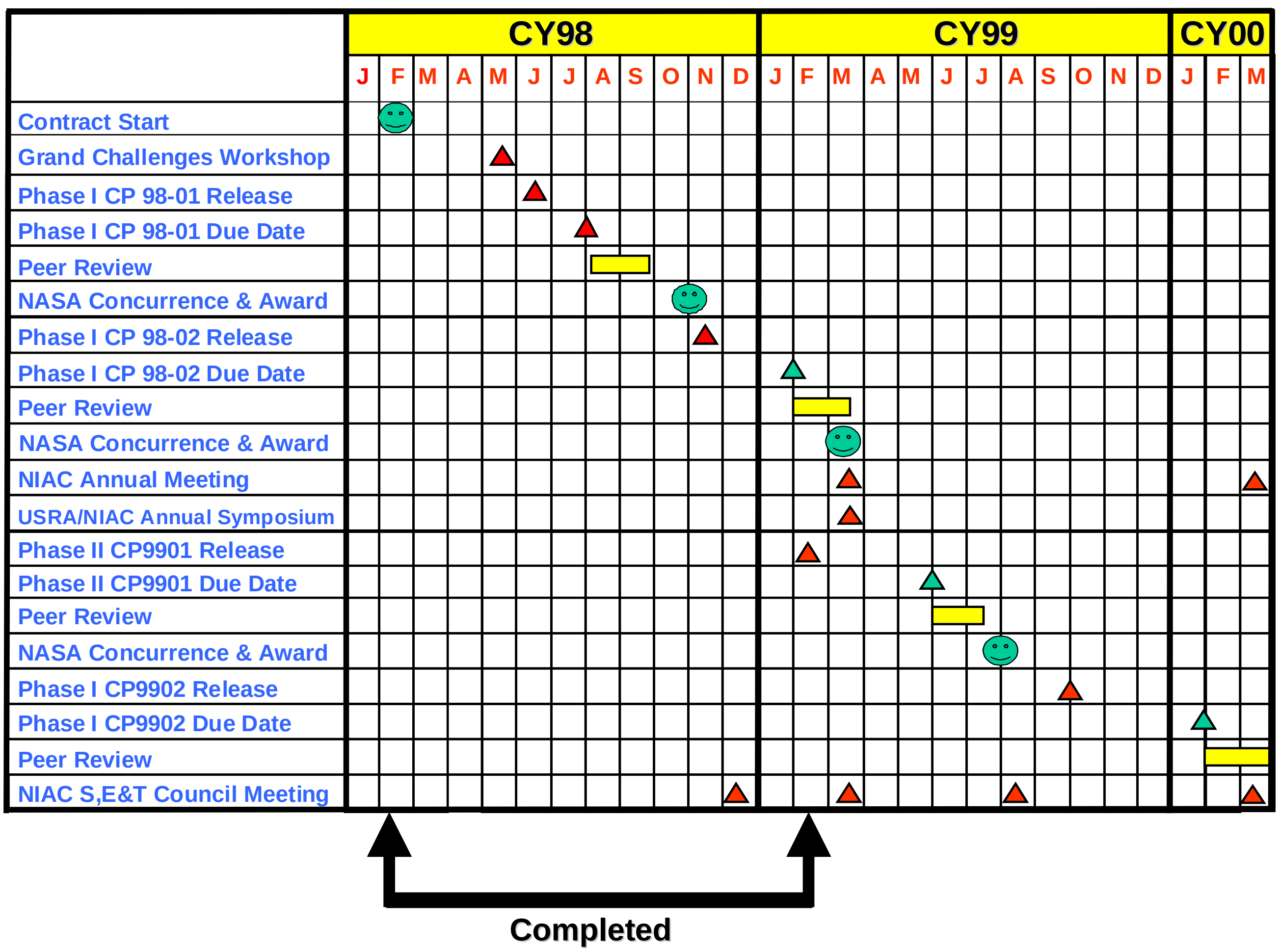
The next Phase I Call for Proposals, CP99-02, will be released in October, 1999 with a due date of January 31, 2000. The peer review evaluation will occur in January and February, 2000.

The NIAC Science, Exploration and Technology Council met for their first meeting on December 3, 1998. Meetings of the Council will occur biannually with meetings scheduled in August, 1999 and March, 2000.

The NIAC will continue to pursue a balance of awards across all NASA Enterprise areas and to encourage the participation of Historic Black Colleges and Universities and small, disadvantaged businesses. In anticipation of the timely infusion of NIAC advanced concepts into NASA, the NIAC Director will maintain close contact with high level managers and technical representatives at NASA HQ, NASA Centers and JPL to assure the technical relevance and quality of NIAC activities and advanced concept awards. Visits to each of the Associate Administrators, Enterprise representatives, HQ theme managers and NASA Centers will be scheduled annually or more frequently as needed to assure continuous communication and appropriate interaction. The NIAC Director will also attend and participate in workshops and technical meetings sponsored by technical societies, NASA Centers and JPL in order to be kept informed about ongoing and planned NASA research.

The NIAC will aggressively pursue relationships with other agencies, such as the National Reconnaissance Office, Federal Aviation Administration, Department of Energy and various DoD agencies, in support of the development of revolutionary advanced concepts for aeronautics and space.

Figure 8. Summary of First and Second Years of NIAC Contract



APPENDIX A

Abstracts of CP 98-01 Awards

CP 98-01 PHASE I ABSTRACTS

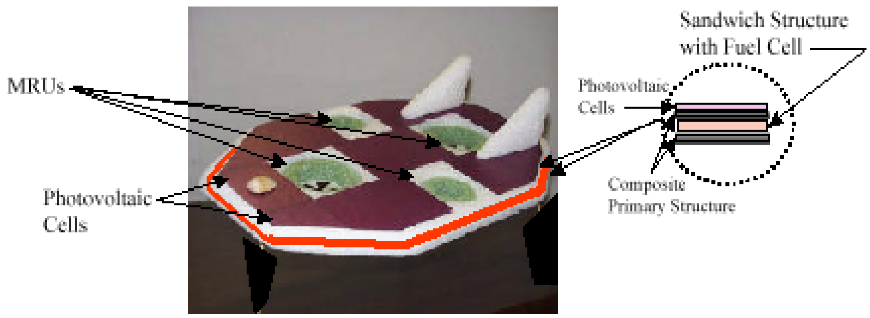
1. **Ilan Kroo, Stanford University**
   "Mesicopter: A Meso-Scale Flight Vehicle"

A team of researchers from Stanford University, SRI, and M-DOT Corporation propose to build the 'mesicopter', a centimeter-size electric helicopter, designed to stay airborne while carrying its own power supply. This device represents a revolutionary class of flight vehicles at an unprecedented size, and suggests a range of potential uses. The proposed work focuses on the development of mesicopters for atmospheric science, permitting in-situ measurements of meteorological phenomena such as downbursts and wind shear, and with unique capabilities for planetary atmosphere studies. Swarms of mesicopters could provide atmospheric scientists with information not obtainable using current techniques and could aid in the understanding of phenomena that play a critical role in aviation safety.

Better characterization of atmospheric phenomena on Mars and other simple sensing tasks may be feasible with these very low mass and low cost aerial micro-robots. The mesicopter will pioneer the application of new aerodynamic design concepts and novel fabrication techniques, including solid free-form fabrication and VLSI processing steps. These techniques may ultimately allow the mesicopter to be scaled down to millimeter dimensions. Significant challenges are anticipated in the areas of materials, battery technology, aerodynamics, control and testing. This proposal describes work for the first phase of the program in which initial designs and fabrication tests are used to evaluate the concept's feasibility. An outline of subsequent phases is also provided.

2. **Charles M. Stancil, Georgia Tech, Georgia Tech Research Institute**
   "Electric Toroid Rotor Technology Development"

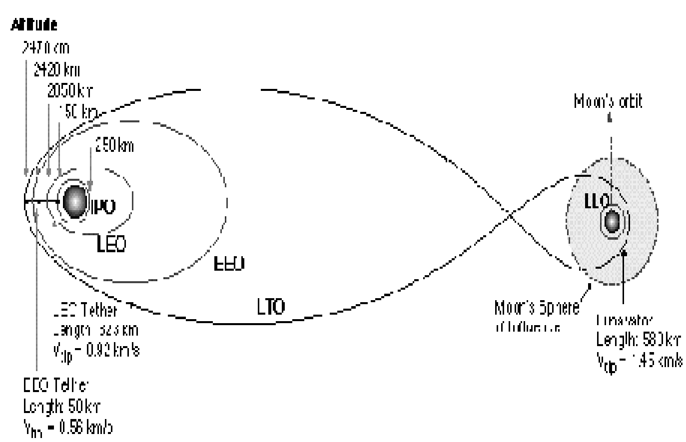
Development of a revolutionary air vehicle technology is proposed. It involves research in the following areas: Toroid Rotor Aerodynamics, Toroid Electric Motor Technology, Fuel Cell and Photovoltaic Systems, Storage Battery and Pulse-Wave-Form Recharge Techniques and Advanced Composite Sandwich Structures. The proposed feasibility study will provide scientific assessment of an electric vehicle system that makes use of toroid motor-rotor units (MRU) to hover and fly. Key to understanding the utility of the toroid rotor concept is understanding its efficiency in providing lift. Conventional rotor theory is inadequate to accurately predict toroid rotor performance. A powered wind tunnel model test is proposed in Phase II to gather appropriate technical data to support a valid scientific assessment.



A successful “rim-drive” (toroid) electric motor has been built for submersible propulsion and control. This hardware can be used to power a wind tunnel model. Unique, non-dimensional parameters may be obtained for MRU performance assessment. Upper surface of a vehicle will have photovoltaic (PV) cells as part of a propulsion system supplying electrical energy to the MRUs. Storage batteries can be charged using advanced pulse charging algorithm for periods without sunlight. An ultimate, fully integrated vehicle will have fuel cells imbedded in the primary structure of the aircraft. The fuel cells will function on the products of electrolysis of H_2O (water). Products from the fuel cell (heat, electricity, water) will be captured for heating electrical components sensitive to low temperatures; the electricity consumed by the electric motors or battery re-charge, and the water recovered for electrolysis reprocessing—starting the cycle all over again. A “perpetual-motion-machine” is not advocated here. Energy losses will occur limiting mission time. However, a 30% efficiency improvement from the MRU coupled with a 30% energy storage to structural weight improvement point to the viability of the concept.

3. Robert P. Hoyt, Tethers Unlimited, Inc.
"Cislunar Tether Transport System"

Systems composed of several rotating tethers in orbit can provide a means of transporting payloads and personnel between Low-Earth-Orbit and the lunar surface with little or no propellant required. The underlying concept is to build a reusable transport system that utilizes rotating tethers to throw payloads to the moon and to catch return payloads sent from the moon. By balancing the flow of mass to and from the moon, the total energy of the system can be conserved, eliminating the need for the large quantities of propellant required by rocket systems. Previous studies have shown the potential of tether systems for making LEO to GEO and LEO to Lunar travel affordable by greatly reducing the amount of propellant that must be launched into orbit.

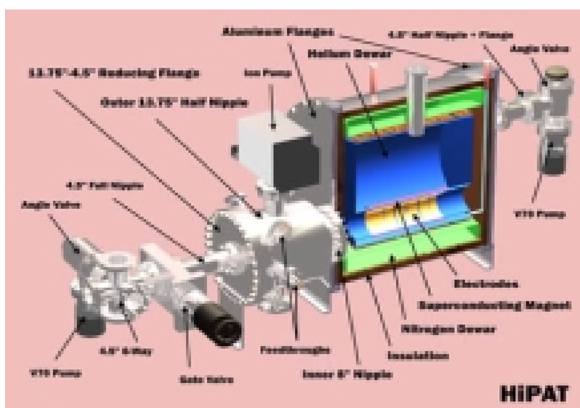


These studies, however, utilized a number of simplifying assumptions that limit the credibility of their designs. The proposed effort will develop a design for a Cislunar Tether Transport System that is both technically feasible and economically viable by addressing three key aspects of the system.

First, the effort will develop a realistic scenario for repeatedly transferring payloads from LEO to the lunar surface that takes into account the full complexities of the orbital mechanics of the Earth-Moon system, including non-spherical gravitational potentials, inclined orbit dynamics, and luni-solar perturbations. Second, it will develop a design for the system that can be built incrementally, with early stages earning revenue to pay for the development of later stages by serving as boost facilities for MEO and GEO traffic. Third, the effort will develop a design for the first stage of the system, a LEO "rotating electrodynamic force tether" that combines the technology of electrodynamic tethers with the principles of rotating momentum-transfer tethers to enable multiple payloads to be boosted from LEO to higher orbits with no propellant needed.

4. Steven D. Howe, Synergistic Technologies, Inc.
"Enabling Exploration of Deep Space: High Density Storage of Antimatter"

Space is big. Over the next few decades, humanity will strive to send probes farther and farther into space to establish long baselines for interferometry, to visit the Kuiper Belt, to identify the heliopause, or to map the Oort cloud. In order to solve many of the mysteries of the universe or to explore the solar system and beyond, one single technology must be developed – high performance propulsion.



In essence, future missions to deep space will require specific impulses between 50,000 and 200,000 seconds in order to accomplish the mission within the career lifetime of an individual, 40 years. Only two technologies available to mankind offer such performance --fusion and antimatter. Fusion has proven unattainable despite forty years of research and billions of dollars. Antimatter, alternatively, reacts 100% of the time in a well-described manner. Antimatter is produced currently in the world at levels above the storage capacity of state-of-the-art Penning Traps. The single key technology that is required to enable the revolutionary concept of antimatter propulsion is safe, reliable, high-density storage. Development of a system capable of storing megajoules per gram will allow highly instrumented platforms to make fast missions to great distances. Such a development will open the universe to humanity. We propose to develop such a system.

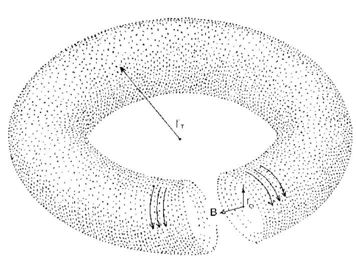
5. Clark W. Hawk, University of Alabama-Huntsville, Propulsion Research Center
"Pulsed Plasma Power Generation"

This Phase I proposal will address the long-term development of a pulsed power generator and integrated propulsion system based on the compression of a magnetic field between an expanding detonation driven plasma and a Meissner surface formed from a high temperature superconductor (HTSC). An expanding hot plasma ball driven by chemical or micro-fusion detonations will be highly conductive and will exclude the magnetic field from its interior. When this detonation is initiated in a solenoid magnet surrounded by a cylindrical superconducting shell, the magnetic field will be swept outwardly and compressed against the superconducting surface which repel the magnetic flux due to the Meissner effect. The kinetic energy of the plasma is stored in the magnetic field, and when the plasma collapses, electrical power may be extracted from the time varying magnetic flux using induction coils. In this concept, an understanding of pulsed magnetic fields on bulk superconductive materials will lead to higher compressed magnetic fields and increased energy conversion efficiency.

This proposed concept holds promise for achieving very high power densities with long-term potential for a highly integrated generator/propulsion device for interplanetary spacecraft.

6. Clint Seward, Electron Power Systems, Inc.
"Low-Cost Space Transportation Using Electron Spiral Toroid (EST) Propulsion"

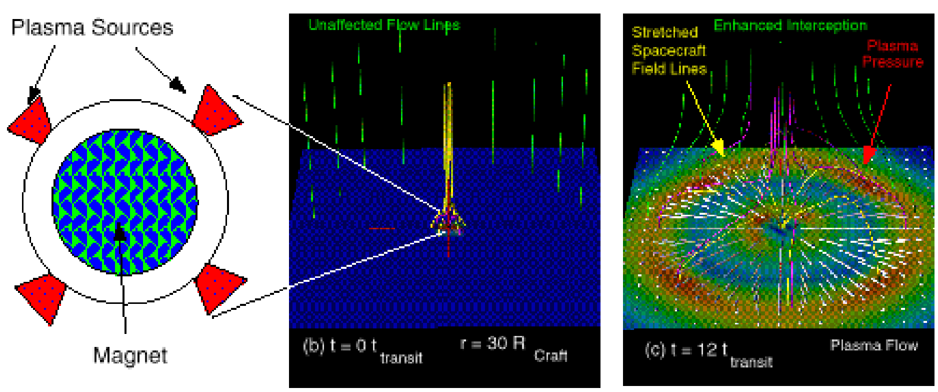
A revolutionary method has been discovered to store large amounts of energy as magnetic field energy with virtually no mass, using the newly patented Electron Spiral Toroid (EST). On a BMDO contract in February 1998, a research scientist at the MIT Plasma Science and Fusion Center independently confirmed that some ESTs will be stable without the need of an external magnetic field; just a small electric field.



The EST has large total energy and low mass, potentially resulting in revolutionary advances in space propulsion. An EST is calculated to store 10 12 joules of magnetic field energy in a containment of 235 kg, replacing a Titan rocket's 700,000 kg of fuel with 32 kg of thruster gas. The potential is for a space transportation vehicle with a cost of $100K vs. $89M for a Titan, reducing the cost of all NASA missions. The EST is a hollow toroid of electrons, all spiraling in parallel paths in a thin outer surface. The EST is charge neutral, being surrounded by ions which provide the small electric field. This makes the EST force free. The parallel paths are current loops, which create a very large internal magnetic field. Microwave energy may be added to raise electrons to 10,000 eV. Propulsion would heat ions without combustion through collisions with the EST surface, ejecting them for thrust. Specific impulse: 143,000 seconds vs. 500 for chemical rockets. The ions are contained by electric fields until ejected; thus protecting mechanical parts. The thrust can be shut off when required. Proof-of-concept tests have shown EST energy loss rates to be small. This project will develop a concept design of a low cost EST based space propulsion system, and will continue the study of the EST equilibrium and stability.

7. Robert M. Winglee, University of Washington
"The Mini-Magnetospheric Plasma Propulsion, M^2P^2"

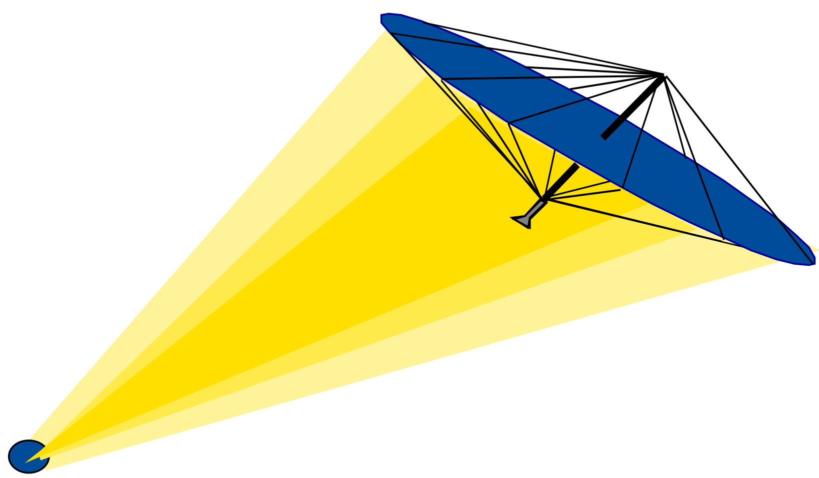
The Mini-Magnetospheric Plasma Propulsion, M^2P^2, system provides a revolutionary means for spacecraft propulsion that can efficiently utilize the energy from the space plasmas to accelerate payloads to much higher speeds than can be attained by present chemical oxidizing propulsion systems. The system utilizes an innovative configuration of existing technology based on well established principles of plasma physics. It has the potential of feasibly providing cheap, fast propulsion that could power Interstellar Probe, as well as powering payloads that would be required for a manned mission to Mars. As such, the proposed work is for missions out of the solar system and between the planets.



The project is interdisciplinary involving space science, plasma engineering and aeronautics and space transportation, which are key components of NIAC's program. The M^2P^2 system utilizes low energy plasma to transport or inflate a magnetic field beyond the typical scale lengths that can be supported by a standard solenoid magnetic field coil. In space, the inflated magnetic field can be used to reflect high-speed (400 – 1000 km/s) solar wind particles and attain unprecedented acceleration for a power input of only a few kW which can be easily achieved by solar electric units. Our initial estimates for a minimum system can provide a typical thrust of about 3 Newton continuous (0.6 MW continuous power), with a specific impulse of 10^4 to 10^5s) to produce an increase in speed of about 30 km/s in a period of 3 months. Proposed optimization could allow the development of system that increase the acceleration with less expenditure of fuel so that a mission could leave the solar system could become a reality.

8. Geoffrey A. Landis, Ohio Aerospace Institute
"Advanced Solar- and Laser-Pushed Lightsail Concepts"

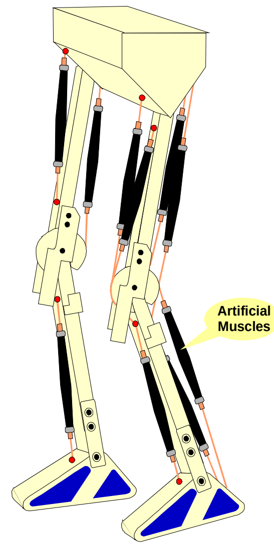
Solar sails allow the possibility of fuel-free propulsion in space. Typical concepts for solar and laser sails use reflective sails, but recently there has been some analysis suggesting that dielectric films could, in some missions, provide superior performance. The project will analyze the potential use of dielectric thin films for solar and laser sails. The advantages are extremely light weight and good high temperature properties, which are necessary for both for solar-sail missions inward toward the sun, for solar sail missions outward from the sun that use a close perihelion pass to build speed, and for high velocity laser-pushed missions for the outer solar system and for interstellar probes.



9. Ron Jacobs, Intelligent Inference Systems Corporation
"A Biologically Inspired Robot for Space Operations"

There is a strong need for legged systems that can travel and operate in difficult terrain, where existing wheeled vehicles cannot go. This is especially true for future missions to MARS (for example), where the planet surface is rugged and uneven. In the near future, we foresee that revolutionary legged robots will be used as part of a community of multi-intelligent agents on MARS.

Each individual legged robot will be able to execute tasks that are requested by lower and higher levels in the community. In designing such a revolutionary MARS Walker, we have used our extensive experience in a variety of different disciplines, such as computational intelligence, soft computing, robotics, biomechanics and neural control of human movements. Our experience is integrated towards a unique and new biologically-inspired approach in developing these legged robots. Smart artificial muscle-like actuators (currently under development at IIS Corp.) will drive the movements. We anticipate outfitting the MARS Walker with the abilities that are necessary for its role as a future intelligent agent in space. The MARS Walker will be able to adapt to different walking speeds and terrain with various degrees of ruggedness.



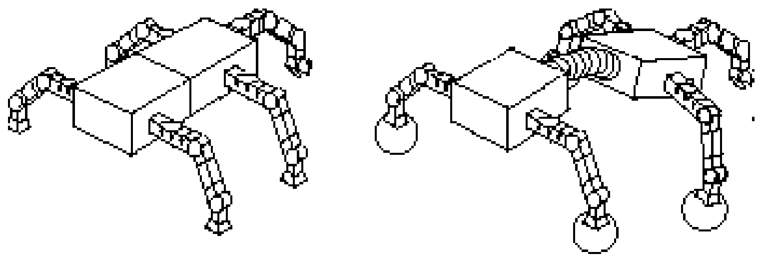
Legged robot design using anatomical and physiological data from humans

10. Robert E. Gold, The Johns Hopkins University, Applied Physics Laboratory
"SHIELD: A Comprehensive Earth Protection System"

Although the probability of a small body impact with Earth is low, the greatest natural threat to the long-term survivability of civilization is an asteroid or comet impact. To-date, the existence and orbits of a only few hundred near-Earth asteroids and comets are known -- many more are yet to be discovered. In addition, limited resources are dedicated to expanding this catalog. To protect the Earth against a collision, the asteroid must first be discovered, then deflected or fragmented into pieces that will miss the Earth or vaporize in Earth's atmosphere. The problem involves both detection and elimination. Many studies have examined particular portions of the problem of detecting and protecting the Earth from approaching comets and asteroids. However, there has been very little examination of the complete Earth-protection problem. This proposal will study the architecture of SHIELD, a comprehensive Earth-protection system, with special emphasis on a non-nuclear method of small-body deflection. This proposal will show that a non-nuclear system for smaller threats can almost be built today, and that with projected advancements in technology, a complete system for the important range of impactor sizes will be practical in a 40 year interval.

11. Steven Dubowsky, MIT
"Self-Transforming Robotic Planetary Explorers"

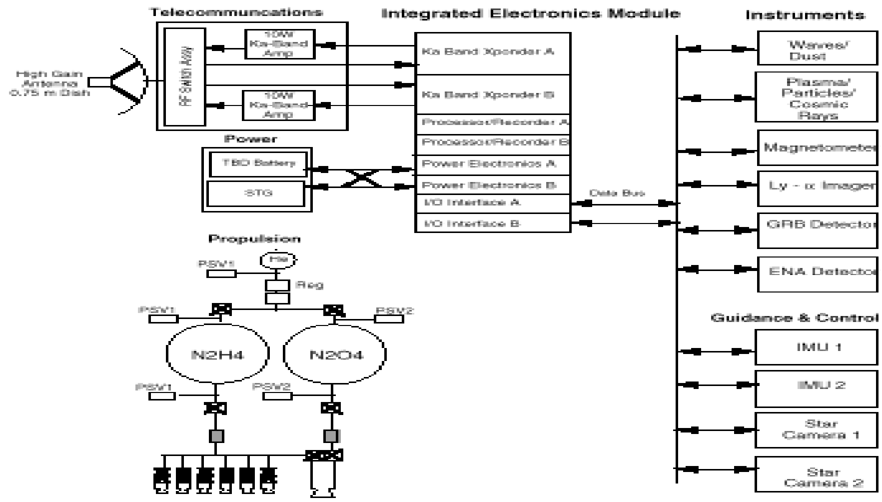
While the 1997 Sojourner mission was an outstanding technical feat, future robotic exploration systems will need to be far more capable. They will need to explore challenging planetary terrain, such as on Mars, with very limited human direction. To achieve this capability, major revolutionary breakthroughs in planetary robotic technology will be required. Here a new and potentially very important concept for robotic explorers is proposed. These are self-transforming planetary explorers -- systems that are able to autonomously change their physical and software structure to meet the challenges of its environment and task. Such systems could dramatically enhance the ability of planetary explorers to survive and to successfully complete their mission objectives. In the concept, the robotic systems would be constructed with re-configurable elements, or modules. Based on sensor information and on-board models and analysis, the system would autonomously transform itself into the “best” configuration to meet the local challenges.



System configurations that could be self-constructed from the original basic system are called cognates. Realizing effective and practical self-transforming systems is difficult for a number of reasons. During this Phase I program, the feasibility of the concept will be studied. While the challenges associated with this study are substantial, so are the potential benefits. If the self-transformation concept can be practically applied, it could significantly impact future planetary exploration missions in the year 2010 and beyond.

12. Ralph L. McNutt, Jr., Johns Hopkins Applied Physics Laboratory
"A Realistic Interstellar Explorer"

For more than 20 years, an “Interstellar Precursor Mission” has been discussed in scientific circles as a high priority for our understanding (1) the interstellar medium and its implications for the origin and evolution of matter in the Galaxy, (2) the structure of the heliosphere and its interaction with the interstellar environment, and (3) fundamental astrophysical processes that can be sampled in-situ. The chief difficulty with actually carrying out such a mission is the need for reaching significant penetration into the interstellar medium (~1000 AU) within the working lifetime of the initiators (< 50 years). Significant solar-system escape speeds can be obtained by “dropping” a probe into the Sun and then executing a DV maneuver at perihelion. This idea has been mentioned but never studied in detail in a spacecraft-systems-and-implementation sense. In particular, to fully realize the potential of this scenario, the required DV maneuver of ~10 to 15 km/s in the thermal environment of ~3 R S remains challenging. Two possible techniques for achieving high thrust levels near the Sun are: (1) using solar heating of gas propellant, and (2) using a scaled-down Orion (nuclear external combustion) approach. We investigate architectures that, combined with miniaturized avionics and miniaturized instruments, will enable such a mission to be launched on a vehicle with characteristics not exceeding those of a Delta III. We will also explore architectures and redundancies that will extend the probe lifetime to well over a century. Such a long-lived probe could be queried at random over decades of otherwise hands-off operations.

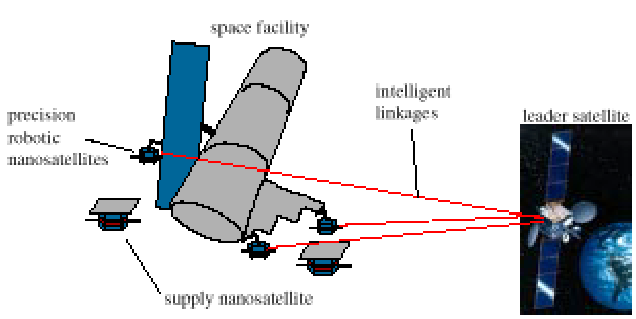


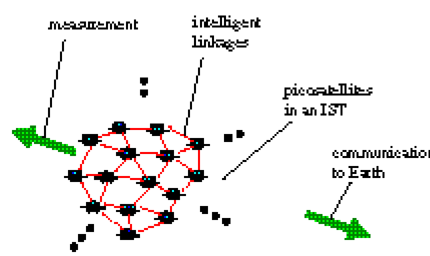
This systems approach for such an Interstellar Explorer has not been previously used to address all of these relevant engineering questions and will also lead to (1) a probe concept that can be implemented following a successful Solar Probe mission (concluding around 2010), and (2) system components and approaches for impact on exploration and sample-return missions from the outer planets and Kuiper objects in our own solar system. By assaying the near-interstellar medium, a better understanding of the challenges of eventually crossing the interstellar gulf (e.g., with a Bussard ram jet) will also be realized.

13. Mark E. Campbell, University of Washington

"Intelligent Satellite Teams for Space Systems"

The proposed study will examine the far-reaching plan of developing Intelligent Satellite Teams (ISTs) for complex space missions. An IST is an organized system of many nano/picosatellites enabled by (envisioned) revolutionary advances in microtechnology and intelligent control. Candidate missions for ISTs include construction or servicing of space facilities such as space laboratories or telescopes, and the measurement of an asteroid's gravitational field, followed by reconfiguration of the IST for communication back to Earth. IST development is a synergy of many technologies, including mission analysis, intelligent control, and microtechnology.

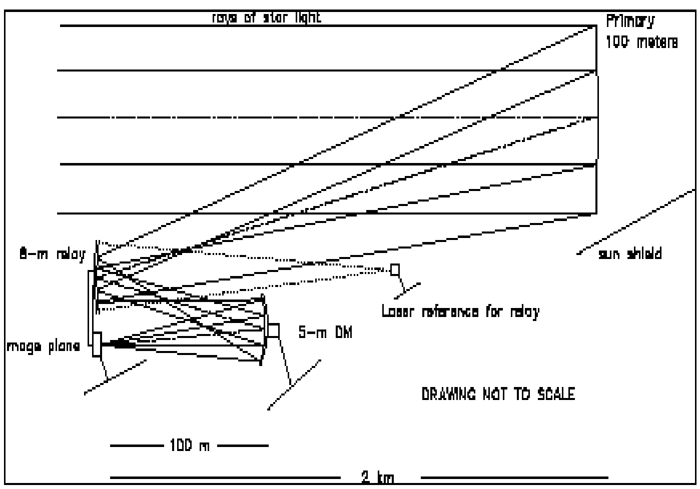




Currently, strides are being made in each of these areas such that a visionary, system-level study of ISTs and potential applications can be accomplished. The proposed study is clearly in line with NIAC's goals of fostering revolutionary ideas in systems and architectures that potentially have a major impact on how future NASA missions are accomplished.

14. Neville J. Woolf, Steward Observatory, University of Arizona
"Very Large Optics for the Study of Extrasolar Terrestrial Planets"

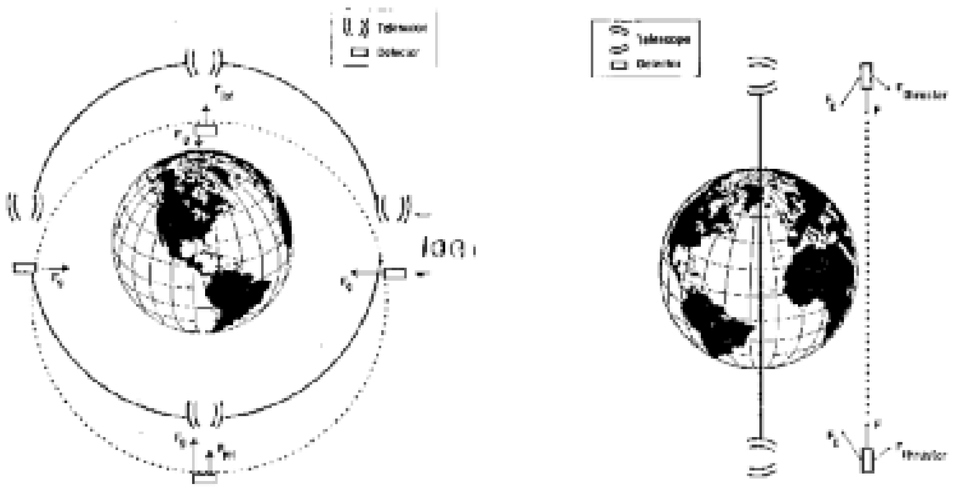
To evaluate habitability and to search for primitive life on Earth-like planets of other stars, telescopes in space with collecting areas of 10 m 2 to 1,000,000 m 2 are needed. We propose to study revolutionary solutions for reflecting telescopes in this size range, going beyond technologies we are developing for adaptive secondary mirrors and for ultra lightweight panels for the NGST. Ways will be explored to build very large lightweight mirrors and to correct their surface errors. As a specific example, we will study a 100 m reflector with a concave NGST-size secondary relay that images the primary onto an 5-m deformable tertiary. The primary, free-flying 2 km from the secondary would be assembled from 5-m flat segments made as reflecting membranes stretched across triangular frames. A 1/20 scale (5 m) image of the primary is formed on the deformable mirror, itself segmented, where panel deformation would be corrected. Scalloping of the segments would compensate the missing curvature of primary segments.



A second example for study will be a 30 m telescope made up from accurately figured 4 m segments. This would represent the limit of emerging technology being developed for NGST. The panel density would be 5 kg/m 2, light enough to launch in a single vehicle all the rigid, 10 cm thick panels needed for the 30-m aperture. The six-month proposal is for analysis and evaluation of different mirror technologies in the broad context of studying exo-planets in the space environment. The 2-year continuing study would follow up on one or two most promising technologies.

15. Paul Gorenstein, Smithsonian Institute, Astrophysical Observatory
"An Ultra-High Throughput X-Ray Astronomy Observatory with a New Mission Architecture"

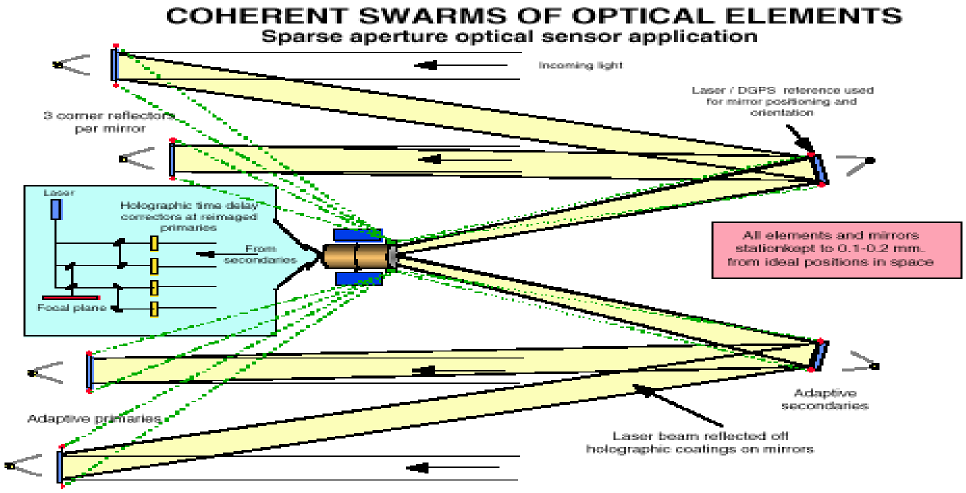
We propose a study of a new mission architecture for an ultra high throughput X-ray astronomy observatory containing a 10 m aperture telescope and a set of detectors. It has potentially much better ratios of effective area to weight and cost than current approaches for the 1 m class AXAF and XMM and “next generation" 3 m class observatories. Instead of a single spacecraft that contains the telescope, the optical bench, and a fixed limited set of detectors in the new architecture, the telescope and an unlimited number of detectors are all on separate spacecraft. Their trajectories are in the same vicinity either in high Earth orbit or the L2 point. Usually, only one of the detectors is active. The active detector places and maintains itself at the telescope's focus by station-keeping. Its distance and aspect sensors provide signals that drive electric propulsion engines on the detector spacecraft which regulate its distance from the telescope to be precisely equal to the focal length.



Unlike current systems, detectors can be replaced and new ones added by launching a small spacecraft that will rendezvous with the others. To reduce its mass, the telescope has a segmented architecture and the segments are actively aligned. The study will identify the nature and magnitude of problems that need to be solved in order to develop a 10 m class X-ray astronomy observatory with these new architectures. The study will involve both analysis and laboratory measurements. The mission architecture is applicable to other observatories.

16. Ivan Bekey, Bekey Designs
"A Structureless Extremely Large Yet Very Lightweight Swarm Array Space Telescope"

A new and original concept is described for a revolutionary space telescope. It implements a continuously corrected adaptive membrane for the primary reflector element, a holographically driven liquid crystal second stage of correction and a complete absence of any truss or other structure with all elements being station-kept with respect to each other. The combination of these techniques will create an optical telescope of 20-30 meters diameter, yet weigh 125 times less than the Hubble Space Telescope or 50 times less than the NGST.



A number of these adaptive primary elements can be coherently combined when employed in a loosely station-kept "swarm," creating coherent sparse optical arrays that can be hundreds of meters or kilometers across. The resolution and light gathering power of the resulting instruments is such that images of Earth-sized planets around other stars can feature 10,000 pixels of resolution, or detect objects at the edge of the universe and at the beginning of time. Conventional or even NGST-level technology telescopes to perform these missions would weigh up to millions of Kg., as well as be impossible to launch. No planned programs even come close. Though there is little question that this concept can work in principle, the proposed task structure will allow systematic assessment of the ability of the key techniques to function as a system, and will assess its likely performance. The preferred architecture of the concept will be explored, and its utility to NASA's future assessed via one or more Design Reference Missions, chosen from the Grand Challenges or NASA's Strategic and Enterprise plan goals. Lastly, the technologies and risks will be assessed and an overall feasibility of the concept addressed.

APPENDIX B

Agenda for NIAC Annual Meeting

NASA Institute for Advanced Concepts

Annual Meeting Agenda
Thursday, March 25, 1999
NASA HQ Auditorium

8:00am - 8:30am **Registration**

8:30am - 9:00am **Welcome and Opening Remarks**
Dr. Robert A. Cassanova, Director of NIAC
Mr. Sam Venneri, NASA Chief Technologist

9:00am - 10:20am **NIAC Grant Status Reports** *(20 minutes each)*

- Dr. Ilan Kroo, Stanford University
  Mesicopter: A Meso-Scale Vehicle
- Mr. Charles Stancil, Georgia Tech Research Institute
  Electric Toroid Rotor Technology Development
- Dr. Robert P. Hoyt, Tethers Unlimited, Inc.
  Cislunar Tether Transport System
- Dr. Steven D. Howe, Synergistic Technologies, Inc.
  Enabling Exploration of Deep Space: High Density Storage of Antimatter

10:20am - 10:40am **Break**

10:40am - 12:00pm **NIAC Grant Status Reports** *(20 minutes each)*

- Dr. Clark W. Hawk, University of Alabama-Huntsville
  Pulsed Plasma Power Generation
- Mr. Clint Seward, Electron Power Systems, Inc.
  Low-Cost Space Transportation Using Electron Spiral Toroid Propulsion
- Dr. Robert M. Winglee, University of Washington
  The Mini-Magnetospheric Plasma Propulsion, M^2P^2
- Dr. Geoffrey A. Landis, Ohio Aerospace Institute
  Advanced Solar- and Laser- Pushed Lightsail Concepts

12:00pm – 12:20pm **Discussion of Status Reports**

12:20pm – 1:30pm **Lunch** *(on your own)*

Annual Meeting *(continued)*
Thursday, March 25, 1999
NASA HQ Auditorium

1:30pm - 2:50pm	**NIAC Grant Status Reports**

- Dr. Ron Jacobs, Intelligent Inference Systems Corp.
  A Biologically Inspired Robot for Space Operations
- Dr. Robert E. Gold, Johns Hopkins Applied Physics Laboratory
  SHIELD: A Comprehensive Earth Protection System
- Dr. Steven Dubowsky, MIT
  Self-Transforming Robotic Planetary Explorers
- Dr. Ralph L. McNutt, Johns Hopkins Applied Physics Lab
  A Realistic Interstellar Explorer

2:50pm - 3:10pm	**Break**
3:10pm - 4:30pm	**NIAC Grant Status Reports**

- Dr. Mark E. Campbell, University of Washington
  Intelligent Satellite Teams for Space Systems
- Dr. Neville J. Woolf, Steward Observatory, University of Arizona
  Very Large Optics for the Study of Extrasolar Terrestrial Planets
- Dr. Paul Gorenstein, Smithsonian Institute, Astrophysical Observatory
  An Ultra-High Throughput X-Ray Astronomy Observatory with a New Mission Architecture
- Mr. Ivan Bekey, Bekey Designs
  A Structureless Extremely Large Yet Very Lightweight Swarm Array Space Telescope

4:30pm - 5:00pm	**Concluding Discussions**

APPENDIX C

Agenda and Biosketches of Speakers for the USRA/NIAC Technical Symposium

USRA

NIAC
NASA Institute for Advanced Concepts

UNIVERSITIES SPACE RESEARCH ASSOCIATION
and the
NASA INSTITUTE FOR ADVANCED CONCEPTS

Technical Symposium:
"Grand Visions of Aerospace – The Next Thirty Years"

March 26, 1999 8:30am - 12:30pm
NASA HQ Auditorium

The Universities Space Research Association and the NASA Institute for Advanced Concepts are sponsoring a technical symposium which will explore "Grand Visions for Aerospace – The Next Thirty Years". The invited speakers will examine the challenges and possibilities for revolutionary advances that may impact the direction of aeronautical and space development over the next 30 years. These presentations are aimed at stretching our imagination decades into the future.

AGENDA:

8:00am - 8:30am	**Registration**
8:30am - 9:00am	**Welcome and Opening Remarks** (Dr. Robert A. Cassanova and Dr. Paul Coleman) **NASA Vision for the Next 30 Years** (Mr. Sam Venneri) **Introduction of Speakers** (Dr. Robert Cassanova)
9:00am - 9:30am	**Space Sciences** (Dr. Wes Huntress)
9:30am - 10:00am	**Remote Sensing and Earth Science in 2030:** ***Trends in Technology & Science and the Sources of Innovation*** (Dr. Mark Abbott)
10:00am - 10:30am	**Human Exploration and Artificial Gravity** (Dr. Larry Young)
10:30am - 10:45am	**Break**
10:45am - 11:15am	**Aeronautics/Aviation Capacity** (Dr. George Donohue)
11:15am - 11:45am	**Space Propulsion** (Dr. Jerry Grey)
11:45am - 12:15pm	**The Next Thirty Years of Computing** (Dr. Peter Denning)

BIOSKETCHES OF SPEAKERS

Dr. Wesley T. Huntress, Jr.

Dr. Huntress is currently the director of the Geophysical Laboratory of the Carnegie Institute of Washington, and is also serving as president of the American Astronautical Society. He came to Carnegie after ten years at NASA Headquarters in Washington, DC. From 1990 to 1992, he was the director of the Solar System Exploration division; and from 1993 to 1998, he served as the associate administrator for Space Science where he was a key architect of the "smaller, faster, cheaper" Space Science mission model and of NASA's new Origins program. Dr. Huntress came to NASA after a successful 20-year career as a scientist at the Jet Propulsion Laboratory (JPL) in Pasadena, California. Trained in chemical physics at Brown University (BS, 1964) and Stanford University (PhD, 1968), his scientific career at JPL involved studies in astrochemistry. He participated in several missions, as a co-investigator on the Giotto Halley's Comet mission, coma scientist for the Comet Rendezvous Asteroid Flyby mission, as study scientist for the Cassini mission, and a number of line and program management assignments. At JPL, Dr. Huntress and his research group gained international recognition for their pioneering studies of chemical evolution in interstellar clouds, comets and planetary atmospheres. Dr. Huntress spent his last year at JPL in 1987-1988 as a visiting professor of cosmochemistry in the Department of Planetary Science and Geophysics at CalTech.

Dr. Mark R. Abbott

Dr. Abbott is a professor in the College of Oceanic and Atmospheric Sciences at Oregon State University. He received his BS in Conservation of Natural Resources from the University of California-Berkeley in 1974 and his PhD in Ecology from the University of California-Davis in 1978. He has been at OSU since 1988. His research focuses on the interaction of biological and physical processes in the upper ocean and relies on both remote sensing and field observations. Dr. Abbott is currently a member of the MODIS and SeaWiFS Science Teams, and he chairs the Committee on Earth Studies for the National Academy of Sciences. He also heads a NASA Earth Observing System interdisciplinary science team. His field research includes the first deployment of an array of bio-optical moorings in the Southern Ocean as part of the U.S. Joint Global Ocean Flux Study.

Dr. Laurence R. Young

Dr. Young, Apollo Program Professor of Astronautics at the Massachusetts Institute of Technology (MIT), is Director of the National Space Biomedical Research Institute. He co-founded the MIT Man-Vehicle laboratory in 1962, and has been recognized for contributions in this field by the Paul Hansen Award of the Aerospace Human Factors Association, the Dryden Lectureship in Research, the Jeffries Medical Research Award of the AIAA, the Franklin Taylor Award of the IEEE, and most recently the Koetser Foundation Prize for his contributions to the aerospace medical field. A member of the National Academy of Engineering, the Institute of Medicine and the International Academy of Astronautics, Dr. Young is the author of over 250 journal articles largely in the areas of space physiology and human factors, including the review chapters in Fundamentals of Aerospace Medicine and the Handbook of Physiology. He has served on the NRC Committee on Human Factors and many NRC and NASA space and aviation boards and panels, most recently those on the NRC's Space Station, on Human Factors in Air Traffic Control panel, and on NASA's Life Science Advisory Subcommittee. He has been PI on five Spacelab experiments, and was the alternate Payload Specialist for the Spacelab Life Science II mission. His involvement with expert systems dates to 1988 when he began research at Stanford and at NASA Ames Research Center on the PI-in-a-Box Project which has flown on three space missions.

DR. GEORGE L. DONOHUE

DR. GEORGE L. DONOHUE IS CURRENTLY THE FAA VISITING PROFESSOR FOR AIR TRANSPORTATION TECHNOLOGY AND POLICY AT GEORGE MASON UNIVERSITY. HE BECAME THE FEDERAL AVIATION ADMINISTRATION'S ASSOCIATE ADMINISTRATOR FOR RESEARCH AND ACQUISITIONS IN AUGUST 1994. IN THIS CAPACITY, DONOHUE WAS RESPONSIBLE FOR A 2000 MEMBER ORGANIZATION CHARGED WITH DESIGNING AND UPGRADING THE INFRASTRUCTURE OF THE NATIONAL AIRSPACE SYSTEM (NAS) TO KEEP PACE WITH NEW TECHNOLOGY AND INCREASING CUSTOMER DEMANDS. IN EARLY 1995, HE INITIATED THE DEVELOPMENT OF THE NAS ARCHITECTURE, WHICH HAS BECOME THE WORLD'S BENCHMARK FOR INTERNATIONAL TECHNOLOGY INVESTMENT. IN 1998, HE WAS THE HEAD OF THE U.S. DELEGATION TO THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) MEETING IN RIO DE JANEIRO, BRAZIL ON MODERNIZATION OF THE WORLD'S AIR TRANSPORTATION INFRASTRUCTURE. BEFORE JOINING THE FAA, DONOHUE HAD SERVED AS VICE PRESIDENT OF THE RAND CORPORATION IN SANTA MONICA, CALIFORNIA SINCE 1989. CONCURRENTLY FROM 1988-1989, HE SERVED AS DIRECTOR OF THE AEROSPACE AND STRATEGIC TECHNOLOGY OFFICE FOR THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) IN WASHINGTON, D.C. IN THAT POSITION, HE PROVIDED FISCAL AND MANAGEMENT OVERSIGHT OF A WIDE RANGE OF PROGRAMS INCLUDING THE LOW COST GPS/FIBER-OPTIC-GYRO NAVIGATION SYSTEM, THE X-31 EXPERIMENTAL FIGHTER AIRCRAFT AND THE PEGASUS SPACE LAUNCHED VEHICLE PROGRAM. FROM 1979-1984, HE WAS VICE PRESIDENT OF DYNAMICS TECHNOLOGY, INC. OF TORRANCE, CALIFORNIA, A SMALL, HIGH-TECHNOLOGY RESEARCH AND VENTURE CAPITAL FIRM. HE IS A MEMBER OF NUMEROUS PROFESSIONAL ORGANIZATIONS, INCLUDING A FELLOW OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS. FROM 1995 TO 1997, HE SERVED AS A MEMBER OF THE BOARD OF DIRECTORS FOR RTCA. IN 1972, DR. DONOHUE EARNED HIS PHD IN MECHANICAL AND AEROSPACE ENGINEERING AT OKLAHOMA STATE UNIVERSITY, WHERE IN 1968 HE RECEIVED HIS MASTERS DEGREE IN THE SAME FIELD, AND IS A 1967 GRADUATE OF THE UNIVERSITY OF HOUSTON WITH A BS IN MECHANICAL ENGINEERING.

DR. JERRY GREY

DR. GREY RECEIVED HIS BACHELOR'S DEGREE IN MECHANICAL ENGINEERING AND HIS MASTER'S IN ENGINEERING PHYSICS FROM CORNELL UNIVERSITY; HIS PHD IN AERONAUTICS AND MATHEMATICS FROM THE CALIFORNIA INSTITUTE OF TECHNOLOGY. HE WAS AN INSTRUCTOR IN THERMODYNAMICS AT CORNELL, ENGINE DEVELOPMENT ENGINEER AT FAIRCHILD, SENIOR ENGINEER AT MARQUARDT, AND HYPERSONIC AERODYNAMICIST AT THE GALCIT 5-INCH HYPERSONIC WIND TUNNEL. HE WAS A PROFESSOR IN PRINCETON UNIVERSITY'S DEPARTMENT OF AEROSPACE AND MECHANICAL SCIENCES FOR 17 YEARS, WHERE HE TAUGHT COURSES IN FLUID DYNAMICS, JET AND ROCKET PROPULSION, AND NUCLEAR POWER PLANTS AND SERVED AS THE DIRECTOR OF THE NUCLEAR PROPULSION RESEARCH LABORATORY. DR. GREY WAS THE PRESIDENT OF THE GREYRAD CORPORATION FROM 1959 TO 1971, ADJUNCT PROFESSOR OF ENVIRONMENTAL SCIENCE AT LONG ISLAND UNIVERSITY FROM 1976 TO 1982, AND PUBLISHER OF AEROSPACE AMERICA FROM 1982 TO 1987. HE IS NOW THE DIRECTOR OF AEROSPACE AND SCIENCE POLICY FOR THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, CONSULTANT TO A NUMBER OF GOVERNMENT AND COMMERCIAL ORGANIZATIONS, AND VISITING PROFESSOR OF MECHANICAL AND AEROSPACE ENGINEERING AT PRINCETON, WHERE HE TEACHES "SPACE SCIENCE AND TECHNOLOGY" TO STUDENTS IN THE HUMANITIES. DR. GREY IS THE AUTHOR OF 20 BOOKS AND OVER 300 TECHNICAL PAPERS IN THE FIELDS OF SPACE TECHNOLOGY, SPACE TRANSPORTATION, FLUID DYNAMICS, AEROSPACE POLICY, SOLAR AND NUCLEAR ENERGY, SPACECRAFT AND AIRCRAFT PROPULSION, POWER GENERATION AND CONVERSION, PLASMA DIAGNOSTICS, INSTRUMENTATION AND THE APPLICATIONS OF TECHNOLOGY. HE HAS SERVED AS CONSULTANT TO THE U.S. CONGRESS (AS CHAIRMAN OF THE OFFICE OF TECHNOLOGY ASSESSMENT'S SOLAR ADVISORY PANEL AND SEVERAL SPACE ADVISORY PANELS), THE UNITED NATIONS (AS DEPUTY SECRETARY-GENERAL OF THE SECOND UN CONFERENCE ON THE EXPLORATION AND PEACEFUL USES OF OUTER SPACE IN 1982), NASA (AS A MEMBER OF THE NASA ADVISORY COUNCIL), THE DEPARTMENT OF TRANSPORTATION (AS VICE-CHAIRMAN OF THE COMMERCIAL SPACE TRANSPORTATION ADVISORY COMMITTEE), THE DEPARTMENT OF ENERGY (AS A MEMBER OF THE SECRETARY OF ENERGY ADVISORY BOARD), AND THE U.S. AIR FORCE, AS WELL AS OVER THIRTY INDUSTRIAL ORGANIZATIONS AND LABORATORIES.

Dr. Peter J. Denning

Dr. Denning is a professor of computer science and the university coordinator for Process Reengineering at George Mason University. He previously served as vice provost for Continuing Professional Education, associate dean for Computing, and chair of the Computer Science department in the School of Information Technology and Engineering. He is founding director Emeritus of the Hyperlearning Center (known formerly as the Center for the New Engineer) founded in 1993. He was formerly the founding director of the Research Institute for Advanced Computer Science at the NASA Ames Research Center, was co-founder of CSNET, and was head of the Computer Science department at Purdue. Dr. Denning received a PhD from MIT and BEE from Manhattan College. He was president of the Association for Computing Machinery 1980-82, chair of the ACM publications board 1992-98 where he led the development of the ACM digital library, and is now chair of the ACM Education Board. He has published 4 books and 260 articles on computers, networks and their operating systems, and is working on two more books. He holds two honorary degrees, three professional society fellowships, two best-paper awards, two Distinguished Service awards, the ACM Outstanding Contribution award, the ACM SIGCSE Outstanding CS Educator award, and the prestigious ACM Karl Karlstrom Outstanding Educator award.