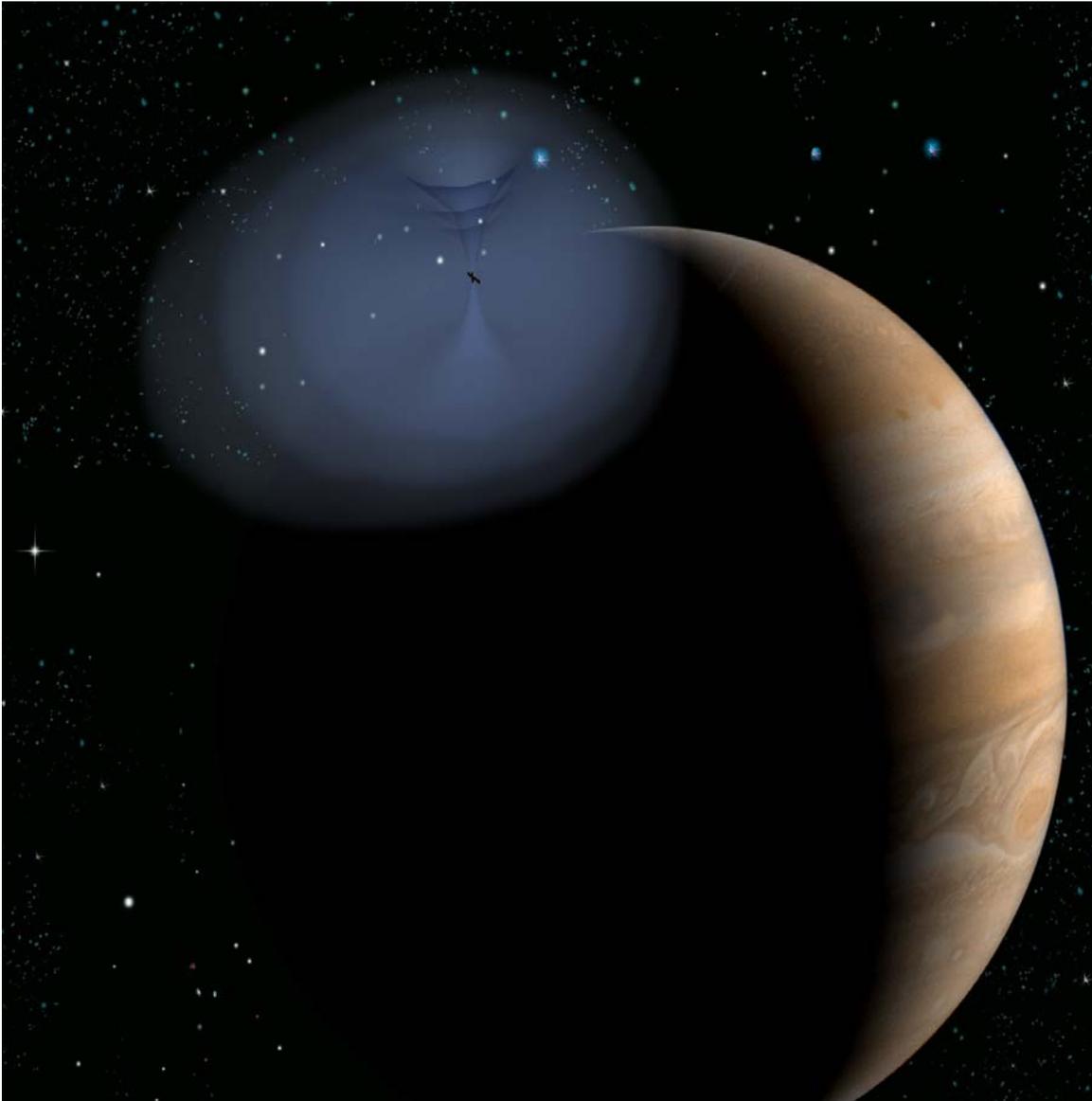


Annual Report



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NASA Institute for Advanced Concepts

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

An Institute of the

Universities Space Research Association

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
ACCOMPLISHMENTS	2
<i>Summary</i>	2
<i>Call for Proposals CP 00-01 (Phase II)</i>	2
<i>Call for Proposals CP 00-02 (Phase I)</i>	3
<i>Call for Proposals CP 01-01 (Phase II)</i>	4
<i>Call for Proposals CP 01-02 (Phase I)</i>	4
<i>Phase II Site Visits</i>	4
<i>Infusion of Advanced Concepts into NASA</i>	5
<i>Coordination with NASA</i>	6
<i>Outreach to Innovators in the Science & Engineering Community</i>	7
<i>NIAC Third Annual Meeting</i>	8
<i>NIAC Fellows Meeting and Workshop</i>	8
<i>Meetings of the NIAC Science, Exploration and Technology (NSET) Council</i>	9
<i>Participation in Technical Society Meetings and Workshops</i>	9
<i>Public Relations</i>	9
<i>Inputs to NASA Technology Inventory Database</i>	10
<i>Financial Performance</i>	10
DESCRIPTION OF NIAC	11
<i>Mission</i>	11
<i>Organization</i>	12
<i>Facilities</i>	13
<i>Virtual Institute</i>	13
ADVANCED CONCEPT SELECTION PROCESS	15
<i>Publicity</i>	15
<i>Solicitation</i>	15
<i>Proposals</i>	16
<i>Peer Review</i>	16
<i>NASA Concurrence</i>	17
<i>Awards</i>	17
PLANS FOR THE FIFTH YEAR AND BEYOND	18
<i>Advanced Concept Solicitation, Selection and Award</i>	18
<i>Management of Awards</i>	19
<i>NIAC Fourth Annual Meeting</i>	19
<i>NIAC Science, Exploration and Technology Council (NSET)</i>	19
<i>Outreach to the Research Community</i>	19
<i>Coordination with NASA and Other Federal Agencies</i>	20
<i>Oversight by USRA Management</i>	20

APPENDIX – Description of Awards During the Fourth Year of Operation	21
<i>Call for Proposals CP 00-01 Phase II Awards - Abstracts and Graphics</i>	22
Anthony Colozza	23
Brad Edwards	24
Andy Keith	25
George Maise	26
Kerry Nock	27
<i>Call for Proposals CP 00-02 Phase I Awards - Abstracts and Graphics</i>	28
David Bacon	29
John Caulfield	30
George Cybenko	31
Edward Hodgson	32
Ross Hoffman	33
Terry Kammash	34
Jordin Kare	35
Lyon King	36
Michael LaPointe	37
Terri Lomax	38
Carlo Montemagno	39
Dava Newman	40
Nick Omid	41
John Paniagua	42
Larry Paxton	43
John Rose	44
Glenn Starkman	45
Guoqing Zhou	46

LIST OF TABLES

Cover	<i>Illustration of the Mini-Magnetospheric Propulsion System Near Jupiter</i>	
Table 1.	<i>Phase I and Phase II Awards Performance Periods</i>	2
Table 2.	<i>Summary of CP 00-01 Responding Organizations</i>	2
Table 3.	<i>CP 00-01 Phase II Award Winners</i>	2
Table 4.	<i>Summary of CP 00-02 Responding Organizations</i>	3
Table 5.	<i>CP 00-02 Phase I Award Winners</i>	3
Table 6.	<i>Summary of CP 01-01 Responding Organizations</i>	4
Table 7.	<i>Phase II Site Visits</i>	4
Table 8.	<i>Status of Infusion of Concepts into NASA</i>	5
Table 9.	<i>NASA NIAC Support Team</i>	7
Table 10.	<i>NASA and OMB Visits</i>	7
Table 11.	<i>Outreach Contacts</i>	8
Table 12.	<i>NIAC Participation in Technical Meetings</i>	9

LIST OF FIGURES

Figure 1.	<i>NIAC Mission</i>	11
Figure 2.	<i>NIAC Organization</i>	12
Figure 3.	<i>Site Map of the NIAC Website</i>	14
Figure 4.	<i>NIAC Proposal Evaluation Criteria</i>	16
Figure 5.	<i>Key Activities during the Fourth Contract Year</i>	18

EXECUTIVE SUMMARY

The NASA Institute for Advanced Concepts (NIAC) has completed its fourth full year of operation and has successfully expanded the technical breadth of funded advanced concepts and begun the process of infusing promising concepts into NASA. Based on the first 48 months of NIAC operation, USRA has consistently received an “excellent” rating from NASA in all categories of contract performance.

NIAC has consistently met financial goals for funds allocated to advanced concept development and for maintaining an efficient and cost-effective operational structure. During this fourth contract year, NIAC awarded 5 Phase II contracts totaling \$2.4M and 18 Phase I grants totaling \$1.2M. Since the beginning of the contract, NIAC has received a total of 509 proposals and has awarded 64 Phase I grants and 16 Phase II contracts for a total value of \$12.3M. These awards to universities, small businesses, small disadvantaged businesses and large businesses were for the development of revolutionary advanced concepts that may have a significant impact on future aeronautics and space missions.

Many of the activities of NIAC are conceived and orchestrated to provide focused encouragement to a broad technical community of potential proposal authors. Methods of encouragement and inspiration include the NIAC annual meetings, NIAC Fellows meetings, workshops focused on emerging technical areas, visible participation by NIAC staff in national technical conferences, NIAC representation on technical committees and boards and presentation of seminars at universities and other organizations. These activities not only afford opportunities for NIAC to distribute notices of upcoming Calls for Proposals and to provide awareness of NIAC-funded advanced concepts, but also serve to catalyze new aerospace concepts built on new generations of emerging technologies.

NIAC continued to reinforce a very productive atmosphere of open communication and feedback from the science and engineering community at large and from NASA researchers and managers at the Centers and Headquarters. This process is accomplished through the virtual operation of NIAC over the Internet, by hosting an annual meeting to showcase the concepts being funded by NIAC, by conducting a workshop to inspire response from a broad cross-section of the research community, visible participation by NIAC in national technical conferences, NIAC representation on technical committees and boards and presentation of seminars at universities and other organizations. In addition, the NIAC Science, Engineering and Technology Council provides focused oversight and dedicated involvement that is especially supportive of the NIAC operation and future activities.

NIAC conducted Phase II site visits this year with two sets of contractors who have completed their first year of Phase II development, and has successfully begun the process of infusing NIAC-funded concepts into NASA programs for continuation funding.

During the next year of the NASA contract, NIAC will continue to use the Phase I/Phase II selection strategy to competitively select advanced concepts with the greatest potential for significant impact. The technical themes chosen for annual meetings and workshops will give special emphasis to scientific discoveries and emerging technologies that could be the basis for inspiring interdisciplinary approaches to major challenges of aeronautics and space. Keynote speakers who are imminently accomplished in their fields of specialty will be selected to reinforce the technical themes in the meetings and to inspire a new class of advanced concepts.

ACCOMPLISHMENTS

Summary

During the fourth year of operation, NIAC continued the processes that it successfully established to inspire, select, fund and nurture revolutionary advanced concepts for aeronautics and space. Table 1 summarizes the performance periods for completed and currently planned awards. The following sections describe the Calls that were awarded or initiated during the year's operation.

	CY98	CY99	CY00	CY01	CY02	CY03
	JUL-DEC	JAN-DEC	JAN-DEC	JAN-DEC	JAN-DEC	JAN-JUN
CP 98-01 Phase I Grants		9801				
CP 98-02 Phase I Grants		9802				
CP 99-01 Phase II Contracts			9901			
CP 99-02 Phase II Contracts			9902			
CP 99-03 Phase I Grants			9903			
CP 00-01 Phase II Contracts				0001		
CP 00-02 Phase I Grants				0002		
CP 01-01 Phase II Contracts					0101	
CP 01-02 Phase I Grants					0102	

Table 1. Phase I and Phase II Awards Performance Periods

Call for Proposals CP 00-01 (Phase II)

CP 00-01 was a Phase II Call for Proposals that was released June 19, 2000, to each of the Phase I grantees that had not previously received a Phase II contract. Nineteen proposals were received and their respective business category is summarized in the following Table 2.

BUSINESS CATEGORY	CP 00-01 PROPOSALS
Universities	1
Historic Black Colleges & Universities and Minority Institutions	0
Small Disadvantaged Businesses	1
Small Businesses	16
National Labs	0
Large Businesses	1
TOTAL PROPOSALS RECEIVED FOR CP 00-01	19

Table 2. Summary of CP 00-01 Responding Organizations

Peer review of these nineteen proposals began in December 2000. Selection and final award of five contracts were made in April 2001. Table 3 summarizes the winning proposals selected for CP 00-01. Detailed descriptions of these concepts are available on the NIAC website and in the Appendix.

PI NAME AND ORGANIZATION	ADVANCED CONCEPT PROPOSAL TITLE
ANTHONY COLOZZA OHIO AEROSPACE INSTITUTE	Planetary Exploration Using Biomimetrics
BRADLEY CARL EDWARDS EUREKA SCIENTIFIC	The Space Elevator
ANDREW KEITH SIKORSKY AIRCRAFT CORPORATION	Methodology for Study of Autonomous VTOL Scalable Logistics Architecture
GEORGE MAISE PLUS ULTRA TECHNOLOGIES, INC.	Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer
KERRY T. NOCK GLOBAL AEROSPACE CORPORATION	Cyclical Visits to Mars via Astronaut Hotels

Table 3. CP 00-01 Phase II Award Winners

Call for Proposals CP 00-02 (Phase I)

NIAC CP 00-02 was released on September 22, 2000, and one hundred seventy-two Phase I proposals were received by the February 18, 2001 due date. Table 4 summarizes the business category distribution of these proposals.

BUSINESS CATEGORY	CP 00-02 PROPOSALS
Universities	62
Historic Black Colleges & Universities and Minority Institutions	2
Small Disadvantaged Businesses	3
Small Businesses	87
National Labs	10
Large Businesses	8
TOTAL PROPOSALS RECEIVED FOR CP 00-02	172

Table 4. Summary of CP 00-02 Responding Organizations

Peer review began shortly after receipt of the proposals. Grants were subsequently made to eighteen proposers in June 2001. Table 5 summarizes the winning proposals selected for CP 00-02. Detailed descriptions of these concepts are available on the NIAC website.

PI NAME AND ORGANIZATION	ADVANCED CONCEPT PROPOSAL TITLE
DAVID P. BACON SAIC	<i>Adaptive Observation Strategies for Advanced Weather Prediction</i>
H. JOHN CAULFIELD FISK UNIVERSITY	<i>3D Viewing of Images on the Basis of 2D Images</i>
GEORGE CYBENKO DARTMOUTH COLLEGE	<i>A Novel Information Management Architecture for Maintaining Long-Duration Space Crews</i>
EDWARD HODGSON HAMILTON SUNSTRAND SPACE SYSTEMS INTERNATIONAL, INC.	<i>A Chameleon Suit to Liberate Human Exploration of Space Environments</i>
ROSS N. HOFFMAN ATMOSPHERIC & ENVIRONMENTAL RESEARCH, INC.	<i>Controlling the Global Weather</i>
TERRY KAMMASH UNIVERSITY OF MICHIGAN	<i>Ultra-fast Laser-Driven Plasma for Space Propulsion</i>
JORDIN T. KARE KARE TECHNICAL CONSULTING	<i>High-Acceleration Micro-Scale Laser Sails for Interstellar Propulsion</i>
LYON BRAD KING MICHIGAN TECHNOLOGICAL UNIVERSITY	<i>Propellantless Control of Spacecraft Swarms using Coulomb Forces</i>
MICHAEL R. LAPOINTE HORIZON TECHNOLOGIES DEVELOPMENT GROUP	<i>Formation Flying with Shepherd Satellites</i>
TERRI L. LOMAX OREGON STATE UNIVERSITY	<i>A Flexible Architecture for Plant Functional Genomics in Space Environments</i>
CARLO D. MONTEMAGNO CORNELL UNIVERSITY	<i>Directed Application of Nanobiotechnology for the Development of Autonomous Biobots</i>
DAVA J. NEWMAN MASSACHUSETTS INSTITUTE OF TECHNOLOGY	<i>Astronaut Bio-Suit System for Exploration Class Missions</i>
NICK OMIDI SCIBERNET, INC.	<i>High Speed Interplanetary Tug/Cocoon Vehicles (HITVs)</i>
JOHN PANIAGUA PLUS ULTRA TECHNOLOGIES, INC.	<i>Europa Sample Return Mission Utilizing High Specific Impulse Refueled with Indigenous Resources</i>
LARRY J. PAXTON THE JOHNS HOPKINS UNIVERSITY	<i>Global Observations and Alerts from Lagrange-Point, Pole-Sitter, and Geosynchronous Orbits (GOAL&GO)</i>
JOHN R. ROSE UNIVERSITY OF SOUTH CAROLINA	<i>Achieving Comprehensive Mission Robustness</i>
GLENN D. STARKMAN CASE WESTERN RESERVE UNIVERSITY	<i>Ultrahigh Resolution X-Ray Astronomy Using Steerable Occulting Satellites</i>
GUOQING ZHOU OLD DOMINION UNIVERSITY	<i>Architecture of Intelligent Earth Observation Satellite for Common Users in 2010-2050</i>

Table 5. CP 00-02 Phase I Award Winners

Call for Proposals CP 01-01 (Phase II)

Release of Phase II CP 01-01 on July 13, 2001 resulted in eighteen proposals received by January 7, 2002. Table 6 summarizes the business category distribution of these proposals.

BUSINESS CATEGORY	CP 01-01 PROPOSALS
Universities	9
Historic Black Colleges & Universities and Minority Institutions	0
Small Disadvantaged Businesses	1
Small Businesses	6
National Labs	0
Large Businesses	2
TOTAL PROPOSALS RECEIVED FOR CP 01-01	18

Table 6. Summary of CP 01-01 Responding Organizations

Peer review began immediately upon NIAC receipt of the proposals and is still ongoing as of the due date for this report.

Call for Proposals 01-02 (Phase I)

This Phase I solicitation was released on October 1, 2001, with a proposal due date of February 11, 2002. The results of this Call were not available in time for inclusion in this report.

Phase II Site Visits

As part of normal contract management activity, NIAC conducts site visits with all of the Phase II contractors near the end of the first year to review the technical and management performance of their Phase II contract before exercising the contract option on the remainder of the Phase II activity. In addition to the attendance of the NIAC Director, other persons attending may include Ms. Sharon Garrison (NIAC COTR), NIAC technical consultants and representatives from NASA HQ and the Centers. The agenda for the site visits includes a review of the status and plans for development of the advanced concepts and discussions exploring the possibility of follow-on funding after the Phase II contract. Site visits were conducted with the following Phase II contractors. NIAC and ANSER staff, NIAC consultants and NASA representatives are noted in Table 7:

SITE VISIT	PI NAME	DATES	ATTENDEES IN ADDITION TO THE PI'S TEAM
The Boeing Co.	John Grant	2/7/01	<ul style="list-style-type: none"> Bob Cassanova, Lewis Peach (USRA), Kirk Sorensen (MSFC)
Global Aerospace Corporation	Kerry Nock	2/8/01	<ul style="list-style-type: none"> Bob Cassanova, Lewis Peach (USRA), Dennis Andrucyk (GSFC), Jim Margitan (JPL)
University of Colorado	Webster Cash	2/17/01	<ul style="list-style-type: none"> Bob Cassanova, Keith Gendreau (GSFC), Steve O'Dell (MSFC), Jeff Antol (LaRC)
ORBITEC	Eric Rice	3/8/01	<ul style="list-style-type: none"> Bob Cassanova, Jeff Antol (LaRC)
Plus Ultra Technologies	George Maise	12/14/01	<ul style="list-style-type: none"> Bob Cassanova, Ron Turner (ANSER), Bob Whitehead (NIAC consultant), Rob Adams (MSFC), Stan Borowsky (GRC)
Ohio Aerospace Institute	Anthony Colozza	1/30/02	<ul style="list-style-type: none"> Bob Cassanova, Bob Whitehead (NIAC consultant), Ron Turner (ANSER), Dave Raney (LaRC)
Eureka Scientific	Bradley Edwards	1/31/02	<ul style="list-style-type: none"> Bob Cassanova, Bob Whitehead and Jerome Pearson (NIAC consultants), Ron Turner (ANSER), Kirk Sorensen, David Smitherman and Preston Magill (MSFC)
Sikorsky Aircraft Corporation	Andrew Keith	2/1/02	<ul style="list-style-type: none"> Bob Cassanova, Bob Whitehead (NIAC consultant), Ron Turner (ANSER), Mark Moore (LaRC)
Global Aerospace Corporation	Kerry Nock	2/7/02	<ul style="list-style-type: none"> Bob Cassanova, Pat Russell (USRA), Robert Easter and Jason Andringa (JPL), Mel Ferebee (LaRC)

Table 7. Phase II Site Visits

Infusion of Advanced Concepts into NASA

The primary purpose of NIAC is to provide leadership to inspire advanced concepts, solicit, select, fund and nurture advanced concepts that may have significant impact on future NASA missions and programs. After a concept has been developed and matured through the NIAC process, it is NASA's intent that the most promising concepts will be transitioned into NASA's program for additional study and follow-on funding. NIAC has taken a proactive approach to this infusion process. In addition to the routine activities to maintain public awareness and visibility for all of the NIAC advanced concepts, NIAC orchestrates the following activities:

- Conducts status and visibility briefings with NASA researchers and managers
- Invites NASA leaders to Phase II site visits to participate in status and planning discussions
- Provides names of key NASA contacts to NIAC Fellows
- Encourages NIAC Fellows to publish their work in technical society meetings and technical journals

By the end of this contract year, a number of concepts have successfully begun the process of transitioning back to NASA and some have obtained funding from other sources. Table 8 reports the status of those concepts that have begun the transition process.

PHASE I		
PI Name	Concept Title	Director Comments
Ivan Bekey Bekey Designs	An Extremely Large Yet Ultralight Space Telescope and Array	<ul style="list-style-type: none"> • Similar concept study by Ivan Bekey funded by NRO after completion of Phase I grant
Robert Gold Johns Hopkins University	A Comprehensive Earth-Protection System Array	<ul style="list-style-type: none"> • System analysis of concept is underway at LaRC under the RASC program • RASC contacted PI to explore collaboration
Alex Ignatiev University of Texas Houston	New Architecture for Space Solar Power Systems: Fabrication of Silicon Solar Cells using In Situ Resources	<ul style="list-style-type: none"> • Awarded Cross-Enterprise contract for related technology
PHASE II		
PI Name	Concept Title	Director Comments
Andrew Keith Sikorsky Aircraft Corp.	Methodology for Study of Autonomous VTOL Scalable Logistics Architecture	System analysis of concept is underway at LaRC under the RASC program that, while not exactly the same vehicle and architecture, is exploring an architecture to perform a similar function.
Bradley Edwards Eureka Scientific	The Space Elevator	<ul style="list-style-type: none"> • Pursuing additional funding through NRAs and SBIR • Received inquiries from private investment organizations • Based on site visit attended by MSFC personnel, MSFC may be considering inclusion as a 4th generation concept
Robert P. Hoyt Tethers Unlimited, Inc. and John Grant Boeing Company	Moon and Mars Orbiting Spinning Tether Transport (MMOSTT) Hypersonic Airplane Space Tether Orbital Launch (HASTOL)	<ul style="list-style-type: none"> • Strong collaboration with MSFC • MSFC has performed system analysis • Funding for momentum exchange tethers in MSFC planned for FY03 • Awarded Cross-Enterprise subcontract for related technology
Robert M. Winglee University of Washington	The Mini-Magnetospheric Plasma Propulsion System, M ² P ²	<ul style="list-style-type: none"> • Received funding from MSFC for experiments and system analysis support • Awaiting decision for additional funding from OSS • Ranked as high priority concept for both in-space propulsion and radiation shielding • Reported to be included in the NASA Decadel Plan

(Table 8 continues on the following page.)

PHASE II <i>(continued...)</i>		
PI Name	Concept Title	Director Comments
Neville J. Woolf University of Arizona Steward Observatory	Very Large Optics for the Study of Extrasolar Terrestrial Planets	<ul style="list-style-type: none"> • Directly connected with Life Finder concept that is mentioned in the NASA OSS Strategic Plan • Reported to be included in the NASA Decadel Plan
Kerry T. Nock Global Aerospace Corporation	Global Constellation of Stratospheric Scientific Platforms	<ul style="list-style-type: none"> • The Earth Science Technology Office (ESTO) Platform people located at JPL has funded GAC to perform a \$50K study to help determine technology requirements for stratospheric Earth Science balloons for the ESTO platform technology initiative for 2003 • Significant interest by GSFC for further development • Near-term possibilities for significant DARPA sponsorship • Recent significant interest in ultra-long-duration-balloon (ULDB) constellations by Earth Science Vision team • Key sub-system, the trajectory control system, has been funded by SBIR program and has received expressions of interest for further development
George Maise Plus Ultra Technologies	Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer	<ul style="list-style-type: none"> • Based on comments of the NASA attendees at the Phase II site visit in December 2001, there may be significant interest in future follow-on studies
Ralph L. McNutt, Jr. The Johns Hopkins University Applied Physics Lab	A Realistic Interstellar Explorer	<ul style="list-style-type: none"> • Would be a follow-on to a less ambitious interstellar mission being considered by JPL • McNutt is a member of interstellar mission working group at JPL • Awarded Cross-Enterprise contract for related work
Webster Cash University of Colorado	X-ray Interferometry – Ultimate Astronomical Imaging	<ul style="list-style-type: none"> • Strong collaboration with GSFC • Directly connected with MAXIM program mentioned in OSS Strategic Plan. MAXIM is in the Cosmic Journeys Initiative, to be funded next year. X-ray Interferometry is explicitly called out for \$60,000,000 in funding over the next 10 years by the National Academy Decadel Survey of astronomy • Reported to be included in the NASA Decadel Plan • New funding from NASA SR&T for Interferometry from GSFC • Cross-Enterprise funded a study on formation flying drive that was a sub-system explored by the University of Colorado team

Table 8 (continued): *Status of Infusion of Concepts into NASA*

Coordination with NASA

Sharon M. Garrison is the NASA Coordinator for the NIAC in the Aerospace Technology Office (ATO) of the NASA Technology Integration Division (NTID) at GSFC. She is the primary point of contact between 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. Table 9 is a listing of these representatives. Throughout the process of managing NIAC, these representatives have been kept informed via Ms. Garrison of the status of the Institute and have been appropriately involved in decisions and feedback. The NIAC provides monthly contract status reports and an Annual Report to the NASA Coordinator who forwards the reports to the Support Team and others within NASA.

NASA COTR	NASA Office of the Chief Technologist	NASA Enterprises	Centers
Sharon Garrison, GSFC	Murray Hirschbein, R	John Mankins, M Karl Loutinsky, R Glenn Mucklow, S Alex Pline, U Gordon Johnston, Y	Larry Lasher, ARC Steve Whitmore, DFRC Daniel Glover, GRC Dennis Andrucyk, GSFC Art Murphy, JPL Ken Cox, JSC Dave Bartine, KSC Dennis Bushnell, LaRC John Cole, MSFC Bill St. Cyr, SSC

Table 9. NASA NIAC Support Team

Throughout the first four years of the NIAC contract, the NIAC Director briefed the Associate Administrators and other senior technical staff at NASA HQ and Directors of NASA Centers. The purpose of these briefings is to facilitate the eventual transition of NIAC advanced concepts into mainstream NASA funding, to inform them about the plans for NIAC and to seek their active support and feedback. Each of the NASA Enterprises was requested to provide visionary, grand challenges that may be used in future NIAC Calls for Proposals. In addition, NASA technical staff presented overviews of related NASA advanced concept activities to the NIAC Director. This year's activities also included an invited briefing to the Office of Management and Budget that was coordinated with NASA. Visits with NASA managers and technical leaders and the Office of Management and Budget during the fourth year are listed in Table 10.

NASA Organization	Dates of Visits	Purpose of Visits
Office of Management and Budget (OMB)	April 24, 2001	Director presented an invited overview of NIAC activities to staff of OMB and Office of Science and Technology Policy.
HQ	April 25, 2001	Director met with Bettie White, Director of MURAD, to explore additional methods for encouraging proposals from HBCUs and MIs.
HQ	April 26-27, 2001	Director attended the meeting of the Space Science Technology Management and Operations Working Group and assisted in the preparation of the Space Sciences Technology Implementation Strategy.
LaRC	July 10, 2001	Dr. Mukhopadhyay briefed the NIAC Director on "Innovative approach to Blended-Wing-Body (BWB) pressurized non-cylindrical fuselage design and optimization."
HQ	September 11-13, 2001	Overview briefings were planned with the Associate Administrators of the Offices of Space Sciences, Earth Sciences, Human Exploration and Development of Space, Aerospace Technology and Biology & Physical Research. Unfortunately, the events of September 11 th caused the briefings to be postponed until Spring 2002.
LaRC	November 8, 2001	Director gave briefing to the RASC program staff and coordinated with their efforts to perform system analysis on advanced concepts.
KSC	November 28-29, 2001	Director gave NIAC overview briefing to the Center Director and his senior staff and met with advanced concepts research staff.

Table 10. NASA and OMB Visits

In addition to the periodic coordination visits to NASA Headquarters and the Centers, the NIAC Director has been invited to participate in a number of planning and oversight groups organized by NASA. Currently, the NIAC Director is a member of the Space Science Technology Management and Operations Working Group (SSTMOWG) that meets approximately every three months.

Outreach to Innovators in the Science & Engineering Community

The activities shown in Table 11 were conceived and orchestrated to provide focused encouragement to a broad technical community of potential proposal authors. Methods of encouragement and inspiration include the NIAC annual meetings, NIAC Fellows meetings, workshops focused on emerging technical areas, visible participation by NIAC staff in national technical conferences, NIAC representation on technical committees and boards, and presentation of seminars at universities and other organizations. These activities not only afford opportunities for NIAC to distribute notices of upcoming Calls for Proposals and to provide awareness of NIAC-funded advanced concepts, but also serve to catalyze new aerospace concepts built on new generations of emerging technologies. NIAC has also actively sought the advice of leaders in a number of fields in a continuing effort to access the potential of scientific communities.

Group/Individual	Date of Visit	Purpose/Subject
National Institute for Standards and Technology (NIST) Boulder Colorado	February 13, 2001	Bob Cassanova met with Drs. Dave Wineland, Jim Berquist and Mark Lee Boulder for technical discussions on entangled pairs.
Laboratory for Atmospheric and Space Physics (LASP) University of Colorado	February 15, 2001	Bob Cassanova gave a seminar, presented an overview of NIAC and answered questions about potential NIAC areas of interest. It was attended by about 70 faculty, staff and students.
American Assn. for the Advancement of Science Annual Meeting-San Francisco	February 15-18, 2001	Distributed brochure and Pat Russell answered questions.
Dr. Don Johnson University of Michigan	March 7, 2001	Discussed Global atmospheric modeling.
ARO Physics Program Review	May 16, 2001	Collaboration between NIAC and ARO funded research.
Leanne Cole Haverford College	July 9, 2001	Phone discussion about outreach to minorities.
Dennis Kirk Toffler Associates	July 25, 2001	Bob Cassanova was interviewed on the subject of "science and technology investment and its importance to our future."
Dr. Lynn Margulis University of Massachusetts-Amherst and faculty of the University of Georgia	November 19, 2001	Bob Cassanova attended the seminar by Dr. Margulis on "The Face of Gaia: Earth's Microcosm" and a dinner with the faculty of the University of Georgia.

Table 11. Outreach Contacts

NIAC Third Annual Meeting

Over one hundred people attended NIAC's third annual meeting held at NASA Ames Research Center, June 5-6. The CP 00-02 Phase I NIAC Fellows who recently received Phase I grants were introduced. All sixteen of the currently funded Phase II NIAC Fellows gave forty-minute summaries of their concepts and responded to questions from the audience. In addition, two keynote speakers gave inspiring presentations on subjects that address two key challenges of aerospace research:

Dr. Bruce M. Jakosky
University of Colorado
What is Astrobiology and Why Do We Care?

Dr. Eric Barron
Pennsylvania State University
National and International Objectives in Environmental Sciences

The agenda and all presentations are available on the NIAC website.

NIAC Fellows Meeting and Workshop

The Meeting and Workshop was hosted at NIAC Headquarters on October 30-31, 2001 and was attended by seventy people including all of the current NIAC Phase I Fellows and representatives from universities, industry and NASA. All currently funded Phase I Fellows gave overviews of their concepts. Keynote speakers provided special insights in two areas of research that lead to critical breakthroughs for the space program:

Dr. Ron White
National Space Biomedical Research Institute
The Digital Human

Dr. Henry Everitt
U.S. Army Research Office
Nanoscience and Quantum Information Science in the Army

The agenda and all presentations area available on the NIAC website.

Meetings of the NIAC Science, Exploration and Technology (NSET) Council

The NSET Council is organized and funded by the USRA for the purpose of providing executive oversight and feedback to the Director of NIAC and to USRA management. Meetings of the NSET Council were conducted immediately following the NIAC Fourth Annual Meeting on June 7, 2001 and following the NIAC Fellows Workshop on November 1, 2001. These meetings were attended by a quorum of the Council members, NASA representatives, USRA management representatives and the NIAC staff.

Participation in Technical Society Meetings and Workshops

The Director of NIAC and other members of the USRA and ANSER technical staff actively participated in a number of meetings and workshops sponsored by NASA and other government agencies and technical societies.

MEETINGS	DATES	SPONSORS	NIAC FUNCTIONS
12 th Annual Advanced Space Propulsion Workshop	April 3-5, 2001	NASA JPL MSFC AIAA	Bob Cassanova presented an overview of NIAC and several NIAC Fellows presented technical papers on their concepts.
38 th Space Congress 2001	May 1-4, 2001	AIAA National Academic of Sciences	Ron Turner presented a paper.
Symposium on Futuristic Space Technologies	May 2002 (Rescheduled from Oct 2001)	Italian Space Agency	Bob Cassanova participated on the organizing committee and will present keynote address in the May 2002 symposium.
Turning Goals Into Reality	May 15-17, 2001	NASA	Ron Turner and Pat Russell attended.
AIAA Technical Committee on Space Colonization	June 26-27, 2001	AIAA and ORBITEC	Bob Cassanova participated in the planning of future committee activities.
Radiation Investigators' Workshop	June 27-29, 2001	DOE and NASA	Ron Turner participated.
Human/Robotic Exploration of the Solar System	Nov 6-7, 2001	NASA LaRC RASC Program	Bob Cassanova participated in the workshop planning, management of the RFI and presented an overview of RFI results. Ron Turner served as rapporteur in two technical sessions.
American Society for Gravitational and Space Biology (ASGSB) Annual Meeting	Nov 7-11, 2001	ASGSB	Pat Russell serves on the Executive Board and participated in the meeting.
European Space Agency (ESA), European Space Technology & Engineering Center	December 3, 2001	ESA	At ESA's expense, Pat Russell traveled to Noordwijk, The Netherlands, to give an overview of NIAC.
Quantum Communications	December 19, 2001	National Reconnaissance Office	Attended by Ron Turner.
40 th AIAA Aerospace Sciences Meeting	January 14-17, 2002	AIAA	Bob Cassanova presented an overview of NIAC and a summary of the Human-Robotics workshop and attended Colonization TC.

Table 12. NIAC Participation in Technical Meetings

Public Relations

In addition to the ongoing publicity through the NIAC website, NIAC activities have been the subject of articles in publications serving the general public and the technical community.

Georgia Tech's *Research Horizons* Fall 2001 issue published an article on Anthony Colozza's Phase II concept for "Planetary Exploration Using Biomimetics." The article is entitled "Flying on Mars: Nature's Flight System could be the key to exploring the newest frontier." A hard or electronic copy of this press article can be downloaded at www.gtresearchnews.gatech.edu. NIAC was informed by Harley Thronson in NASA HQ OSS that the article would be forwarded to the White House Office of Management and Budget.

During October 2001, Swedish Public TV broadcast a program on the subject of Mars exploration and included interviews with NIAC Fellows Rob Hoyt, Bob Forward and Kerry Nock and showed brief segments of the animated simulations of the rotating momentum exchange tether and the HASTOL concepts. A copy of the video tape was received by NIAC in December. NIAC was not mentioned prominently, but the NIAC website was shown. Chris McKay and Natalie Cabrol from NASA Ames were also interviewed.

On October 31st, **Space.com** published an interview with Kerry Nock on the Phase II Astrotel concept that can be viewed at: http://www.space.com/business/technology/astrotel_mars_011031-1.html.

The Canadian National Public Radio affiliate produced a radio show on the Phase II *Space Elevator* concept that included an interview with Brad Edwards. It was aired November 3, 2001, in Canada on the weekly *Quirks and Quarks* program. The broadcast can be heard by downloading the program from the web at <http://www.cbc.ca/quirks>. Click on "Archive" and search for "Space Elevator." The program also included interviews with Jerome Pearson, David Smitherman (NASA MSFC) and Nobel-Prize winner, Richard Smalley.

The December 2nd issue of *SpaceRef.Com* included an article about the Phase II concept being investigated by the Ohio Aerospace Institute and the Georgia Tech Research Institute, "Planetary Exploration Using Biomimetics." The article can be viewed at <http://www.spaceref.com/news/viewpr.html?pid+6761>.

The December 2001 issue of the AIAA publication *Aerospace America* contains highlights of aerospace research and development. A number of NIAC-sponsored concepts were included in the review, including:

- Mini-Magnetospheric Plasma Propulsion System
- Exploration of the Jovian Atmosphere using Nuclear Ramjet Flyer
- Europa Sample Return Mission Utilizing High Specific Impulse Propulsion Refueled with Indigenous Resources
- A Realistic Interstellar Explorer
- High-Acceleration Micro-Scale Laser Sails for Interstellar Propulsion
- Advanced System Concept for Total ISRU-Based Propulsion & Power Systems for Unmanned and Manned Mars Exploration

Mark Pendergrast who is a science author preparing a book on mirrors for astronomical observatories with an anticipated publication in 2002, interviewed Bob Cassanova. Mr. Pendergrast intends to contact several NIAC Fellows who are experts on the subject.

Inputs to NASA Technology Inventory Database

NIAC provides input to the NASA Technology Inventory Database immediately after awards for Phase I or Phase II concepts are announced. The public version of this database, which is maintained by NASA GSFC, is available at <http://technology.gsfc.nasa.gov/technology/>.

Financial Performance

NIAC strives to minimize its operational expenses in order to devote maximum funds to viable advanced concepts. For the fourth straight year, this objective has been met. Calendar year four actual results indicate 79.4% of NIAC's total budget was devoted to advanced concept research.

DESCRIPTION OF THE NIAC

Mission

The NASA Institute for Advanced Concepts (NIAC) was 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 a highly visible, recognized and high-level entry point for outside thinkers and researchers. The ultimate goal of NIAC is to infuse NIAC funded advanced concepts into future NASA plans and programs. The Institute functions as a **virtual** institute and uses resources of the Internet whenever productive and efficient for communication with grant recipients, NASA, and the science and engineering community.

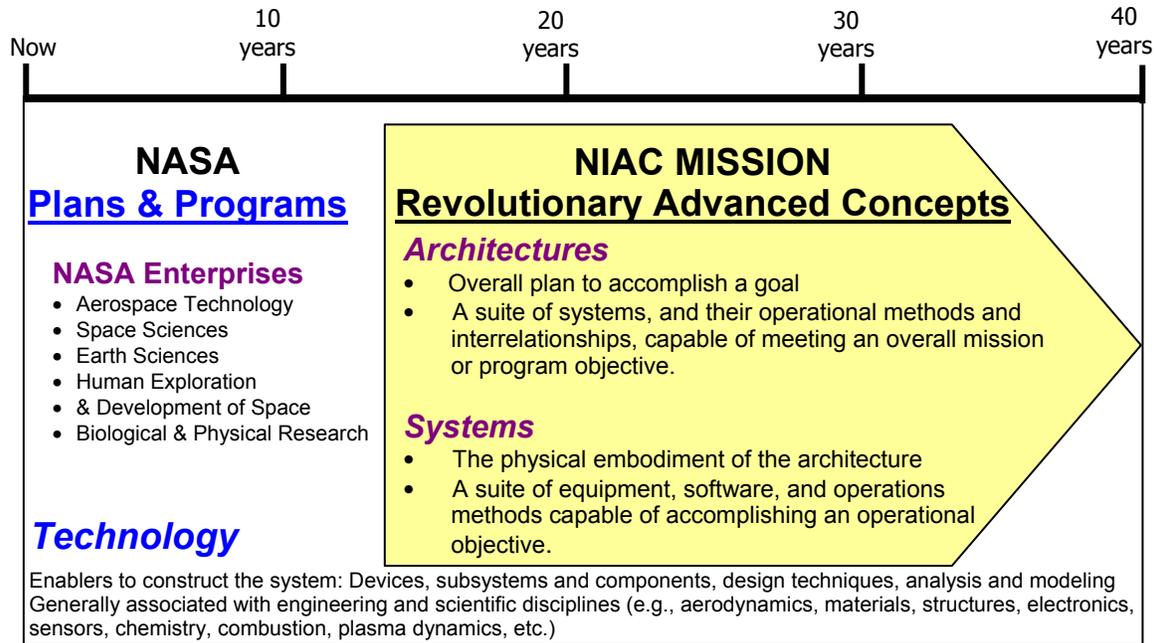


Figure 1. NIAC Mission

Figure 1 illustrates the mission of NIAC relative to the NASA plans and programs and the ongoing technology development efforts. The purpose of 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.

Organization

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

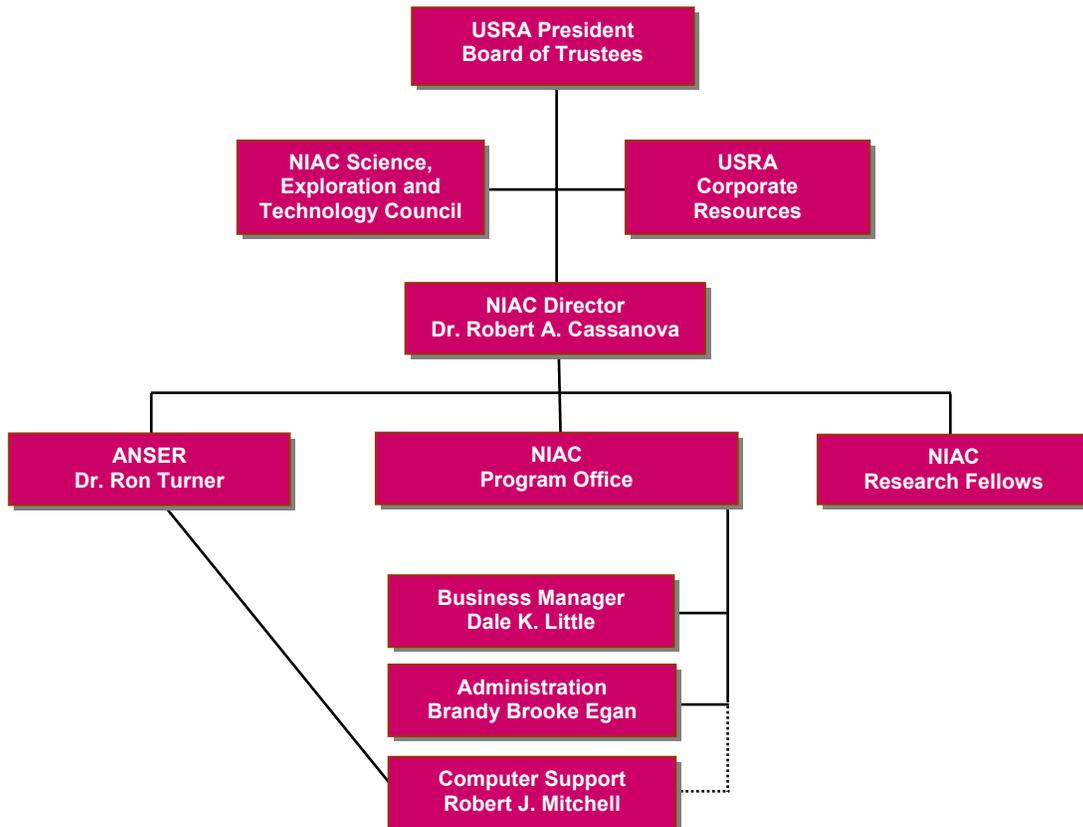


Figure 2. NIAC Organization

The NIAC staff is located at the NIAC HQ office in Atlanta, Georgia, and consists of its director, business manager and administrative assistant. An additional staff member was added by ANSER in March 1999 to provide full-time computer network and software application support at NIAC HQ.

Recipients of NIAC grant or contract awards are designated as “NIAC Fellows.”

ANSER, through a subcontract from the USRA/NIAC, provides program support, technical support and information technology support for NIAC’s operation. ANSER actively participated in NIAC program reviews and planning sessions, proposal peer reviews, source selection activities, and concurrence meetings. ANSER is responsible for maintaining an understanding of ongoing funded studies and the relationship of these studies to other work underway or previously considered by the aerospace community. To meet this challenge, ANSER reviews aerospace technology databases, conducts on-line data searches, and completes short assessments as needed to identify the status of technologies related to proposed and ongoing studies. This information is used in direct support of the peer review and selection processes as well as the management function of conducting site visits. To help maintain understanding the relevance of potential studies to current and potential NASA Enterprises and Missions, ANSER attends NIAC meetings with NASA Associate Administrators. ANSER periodically reviews the NIAC website technical content. The periodic review of the website ensures the integrity and timeliness of the posted data and provides an opportunity to add interesting links to related sites maintained by NASA and the aerospace community.

As a corporate expense, USRA formed the NIAC Science, Exploration and Technology Council to oversee the operation of 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 has a rotating membership with each member serving a three-year term. The USRA Board of Trustees appoints council members.

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

Dr. Robert E. Whitehead, Aerospace Consultant, Chairperson
Dr. Jerry Grey, Aerospace Consultant
Dr. Mark Abbott, Oregon State University
Dr. Taylor Wang, Vanderbilt University
Dr. John V. Evans, COMSAT Corporation
Dr. Dava J. Newman, Massachusetts Institute of Technology
Mr. Parker S. Stafford, Aerospace Consultant
Dr. Robert A. Cassanova, NASA Institute for Advanced Concepts (*ex officio*)

Five additional members will be named in 2002.

On June 6, 2002, NIAC lost a pioneering member of the NSET Council with the death of Dr. Burt Edelson. His wisdom and leadership at George Washington University most recently, at NASA in the past and in all that he touched will always be remembered.

Facilities

NIAC Headquarters is centrally located in midtown Atlanta, Georgia. It occupies 2,000 square feet of professional office space, with access to two conference rooms onsite as well as a 75-seat auditorium. The staff is linked via a Windows NT based Local Area Network (LAN) consisting of 5 Pentium II PCs, one Macintosh G3 and two UNIX servers. 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 facsimile machine and a Sharp AR405 copier.

The servers use RedHat Linux for their operating systems, Apache for the web server, Sendmail for the email server, Sybase SQL Server for the database, and OpenSSL for web and email security. The workstations use Windows 2000E for their operating systems, Microsoft Office 2000 Professional for office applications, Netscape Communicator for email access, and Adobe Acrobat for distributed documents.

Virtual Institute

NIAC envisions progressive use of the Internet as a key element in its 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 is the primary communication link for publicizing NIAC, announcing the availability of Calls for Proposals, receiving proposals and reporting on technical status. All proposals submitted to NIAC must be in electronic format. All monthly reports from the grantees to NIAC and from 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 NIAC to the outside world. The website can be accessed to retrieve and submit NIAC information and proposals. The NIAC website is linked from the NASA Technology Integration Division (NTID) website at <http://ntpio.nasa.gov> as well as the NASA Research Opportunities website at <http://www.nasa.gov/research.html>, the Office of Earth Science Research Opportunities at <http://www.earth.nasa.gov/nra/current/index.html> and the Small Business Innovative Research program, <http://sbir.nasa.gov>. Numerous other links to the NIAC website are now established from NASA Centers and science and engineering websites. The visibility of NIAC has improved to the point that their website has been receiving almost 90 hits per day. Since February 4, 2000, the NIAC website has logged 68,143 connections. Figure 3 depicts the site map of the NIAC website.



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

[NIAC Home Page](#)

[What's New](#)

[What's New](#) contains news about NIAC. There is also a link to the latest [Commerce Business Daily](#) release pertaining to NIAC.

[The Institute](#)

[The Institute](#) contains information about NIAC including a list of the NIAC Science, Exploration and Technology Council members, Purpose, Method, Goal, and Contact information. There is also a link to an [organizational chart](#) of NIAC.

[Funded Studies](#)

[Funded Studies](#) provides information about each Principal Investigator and project that NIAC has funded. There are links to various documents including an abstract of each of the proposals, presentations and Final Reports.

[Call for Proposals](#)

[Call for Proposals](#) is a link to the current Call for Proposals. There is a link to the [Questions & Answers](#) section provided also.

[Library](#)

The [library](#) contains an archive of previous Calls for Proposals, NIAC Annual Reports and other miscellaneous documents. There are links to view the proceedings of [Fellows meetings](#) and various [workshops](#) in this section as well.

[Links](#)

[Links](#) to other sites are provided in this section.

[Mailing List](#)

NIAC provides a [mailing list](#) where people can receive the latest Call for Proposals via Email. An individual is allowed the capability to add, edit and/or delete his/her own entry in this section.

[Feedback](#)

[Feedback](#) provides users the opportunity to ask questions about NIAC. [Questions](#) and [answers](#) pertaining to the current Call for Proposals may be viewed in this section.

The NIAC web page has undergone a marked change since last year's annual report. The implementation of Java Server Pages has allowed the dynamic production of certain web pages. This is most evident in the *Funded Studies* section and the *Mailing List* section."

The number of hits by Internet users has increased to approximately ninety per day, confirming that NIAC has continued to grow in popularity.

ADVANCED CONCEPT SELECTION PROCESS

Publicity

Publicity regarding the availability of a NIAC Phase I Call for Proposals is provided to the community through:

- Publication of an announcement in the *Commerce Business Daily*
- 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
- NASA GSFC News Release
- Web links from NASA Enterprise web pages
- Web link from the NASA Coordinator's web page
- Announcements to a distribution list for Historically Black Colleges & Universities, Minority Institutions and Small Disadvantaged Businesses provided by NASA
- Distribution of announcements to an Earth Sciences list provided by NASA GSFC
- Announcements distributed at technical society meetings

Since Phase II awards are based on a down select from Phase I winners, all Phase II Call for Proposals are emailed directly to past Phase I winners who have not previously received a Phase II contract.

Solicitation

The actual solicitation for advanced concepts is assembled and published by the NIAC staff. Since the technical scope of the solicitation is as broad as the NASA Mission, the solicitation wording emphasizes the desire for revolutionary advanced concepts that address all elements of the NASA Mission. This is particularly true for Phase I solicitations.

The scope of work is written to inspire proposals in all NASA Mission areas and contains brief descriptions of NASA Enterprise areas of emphases. In general, proposed advanced concepts should be:

- Revolutionary, new and not duplicative of previously studied concepts
- An architecture or system
- Described in a mission context
- Adequately substantiated with a description of the scientific principles that form the basis for the concept
- Largely independent of existing technology or unique combination of systems and technologies

The Phase I Call for Proposals that was released October 1, 2001, expressed a special interest in receiving proposals for innovative and visionary concepts from disciplines that are normally focused on non-aerospace endeavors and may have the potential for innovative application in the aerospace sector. These concepts may be emerging at the interface of traditional disciplines where innovation often springs forth in non-aerospace fields.

Based on an analysis of Phase I proposals submitted in response to previous Calls, CP 01-02 also included an explanation of the basic requirements for concepts submitted to NIAC as expressed in the following statement:

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

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

The evaluation criteria for Phase I and Phase II concepts are structured to convey what is being sought and are summarized in Figure 4.

PHASE I 6 months \$50 - \$75K	PHASE II Up to 24 months Up to \$500K
<ul style="list-style-type: none"> • Is the concept revolutionary rather than evolutionary? To what extent does the proposed activity suggest and explore creative and original concepts? • Is the concept for an architecture or system, and have the benefits been qualified in the context of a future NASA mission? • Is the concept substantiated with a description of applicable scientific and technical disciplines necessary for development? 	<ul style="list-style-type: none"> • Does the proposal continue the development of a revolutionary architecture or system in the context of a future NASA mission? Is the proposed work likely to provide a sound basis for NASA to consider the concept for a future mission or program? • Is the concept substantiated with a description of applicable scientific and technical disciplines necessary for development? • Have enabling technologies been identified, and has a pathway for development of a technology roadmap been adequately described? • Has the pathway for development of a cost of the concept been adequately described, and are costing assumptions realistic? Have potential performance and cost benefits been quantified?

Figure 4. NIAC Proposal Evaluation Criteria

A NIAC Call for Proposal is distributed in electronic form only. Under a typical schedule for NIAC operation, a solicitation for one Phase I and one Phase II is prepared and released every calendar year. These releases occur generally in the latter half of the calendar year.

Proposals

All proposals must be submitted electronically to the NIAC in **.pdf** format in order to be considered for award. Technical proposals in response to Phase I Call for Proposals are limited to 12 pages. Phase II technical proposals are limited to 25 pages. Cost proposals have no page limit.

Phase II proposals are only accepted from authors who have previously received a Phase I award and have not previously received a Phase II follow-on contract. The due date is the same for the Phase II proposal and associated Phase I final report. Phase I Fellows may submit a Phase II proposal at any time after completion of their Phase I grant, but it must be received by NIAC by the designated due date in order to be considered in a particular review cycle.

Peer Review

NIAC peer reviewers represent 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.

Each reviewer is required to sign a non-disclosure and no-conflict-of-interest agreement prior to their involvement. A small monetary compensation is offered to each reviewer. The technical proposals and all required forms are transmitted to the reviewer over the Internet, by diskette or by paper copy, depending on the electronic capabilities of each reviewer. Reviewers are given approximately thirty days to review the technical proposals and return their completed evaluation forms.

Each proposal receives at least three independent peer reviews. Each reviewer evaluates a proposal according to the criterion stated in the Call for Proposals. Templates/forms are created to help guide the reviewer through the process of assigning a numerical ranking and providing written comments. Only NIAC and USRA staff analyze cost proposals.

The ANSER Corporation provided valuable assistance to the peer review process through a search of its archives, knowledge databases 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. To help assure that a proposed concept is not duplicating previous studied concepts, NIAC accesses the NASA Technology Inventory Database and searches for related NASA funded projects.

Results of the peer reviews are compiled by NIAC, rank-ordered by a review panel and prepared for presentation to NASA in a concurrence briefing.

NASA Concurrence

The NIAC Director is required to present the apparent research selections to the NASA Chief Technologist and representatives of the NASA Strategic Enterprises before the announcement of awards. Technical concurrence by NASA, required before any subgrants or subcontracts are announced or awarded, is obtained to assure consistency with NASA's Charter and that the concept is not duplicating concepts previously, or currently being, developed by NASA.

Awards

Based on the results of the NIAC peer review, technical concurrence from NASA's Office of the Chief Technologist and the availability of funding, the award decision is made by the NIAC Director. All proposal authors are notified electronically of the acceptance or rejection of their proposal. If requested, feedback based on the peer review evaluator's comments is provided to the non-selected proposers.

The USRA contracts office then begins processing contractual instruments to each of the winning organizations. Also, the NIAC staff inputs all the pertinent technical information regarding the winning proposals into the NASA Technology Inventory Database, as well as the NIAC website. The "product" of each award is a final report. All final reports are posted on the NIAC website for public viewing.

PLANS FOR THE FIFTH YEAR AND BEYOND

During the fifth year of the NASA contract, NIAC will build on the operational framework established in the first four years to broaden the constituency of innovators responding to NIAC initiatives and to expand the participation of scientists and engineers from outside of the normal aerospace disciplines. NIAC will continue to improve the Phase I/Phase II selection strategy to inspire and competitively select revolutionary advanced concepts with the greatest potential for significant impact. To reinforce an atmosphere of revolutionary and innovative, but technically credible thinking, the technical themes chosen for annual meetings and workshops will give special emphasis to scientific discoveries and emerging technologies that could be the basis for innovative, interdisciplinary architectures and systems aimed at the major challenges of aeronautics and space.

The activities planned for the fifth year will build on NIAC's leadership position to inspire, select, fund and nurture revolutionary advanced concepts and to orchestrate the transition of successful concepts into consideration by NASA for long range development. Figure 5 summaries the major activities to be conducted in the fifth year as well as activities that began in prior years.

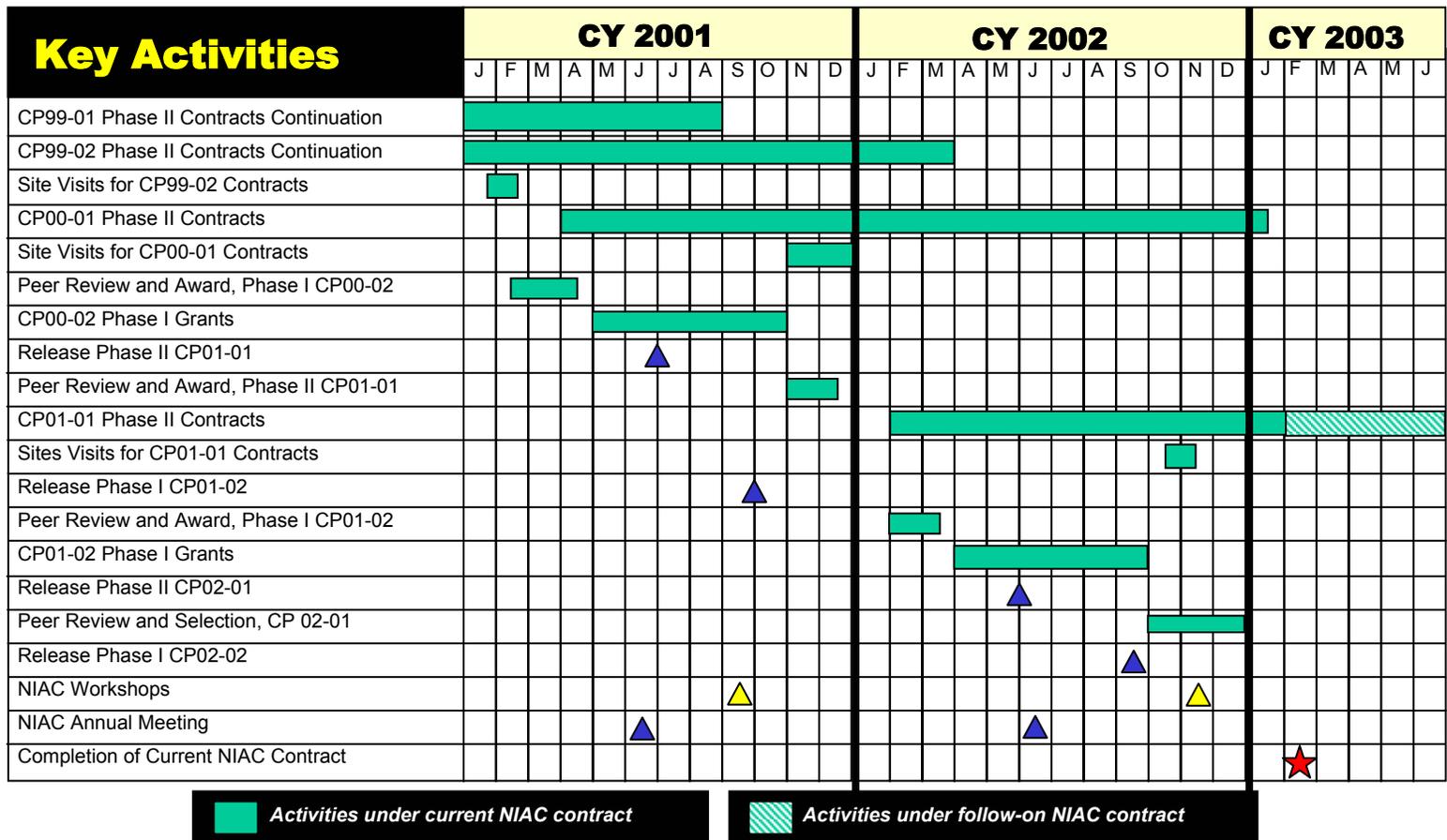


Figure 5. Key Activities during the Fourth Contract Year

Advanced Concept Solicitation, Selection and Award

The peer review, selection, concurrence by NASA and award based on proposals received in response to Phase II Call CP 01-01 and Phase I Call CP 01-02 will be completed in the first quarter of the fifth contract year. Grant and contract start dates are anticipated in March and May 2002, respectively.

The next Phase II Call for Proposals, CP 02-01, will be sent to the PIs selected for CP 01-02 by the third month of their Phase I grant. Phase II proposals received for CP 01-01 will be peer-reviewed and awarded in 2002. The next Phase I Call for Proposals, CP 02-02 will be released Fall 2002. The peer review and award will occur in 2003, if the operation of NIAC by USRA is continued by NASA beyond the current contract expiration date of February 9, 2003. No awards will be made that would extend past the current NIAC contract performance period.

Management of Awards

NIAC will continue to require all grant and contract recipients to submit monthly and final reports. In addition, all Phase II contractors will be required to submit an annual report at the completion of their first year of funded activity.

All Phase II contractors will be required to host a site visit and to submit an interim report before the end of the first half of their contract. Site visits for Phase II awards under CP 01-01 are tentatively scheduled during November and December 2002. Participants in the site visits will include the NIAC Director, invited experts in the technical field of the concept, and NASA representatives who may be able to facilitate the eventual transition to long-range NASA funding.

NIAC Fourth Annual Meeting

The 4th Annual Meeting will be hosted by the Lunar and Planetary Institute (LPI) in Houston, Texas, June 11-12, 2002. The meeting speakers will include all of the currently funded Phase II NIAC Fellows and invited keynote speakers who are prominent in their research fields. The meeting will be webcast with the assistance of staff from LaRC.

NIAC Science, Exploration and Technology Council (NSET)

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

- Dr. Robert E. Whitehead, Aerospace Consultant, Chairperson
- Dr. Jerry Grey, Aerospace Consultant
- Dr. Mark Abbott, Oregon State University
- Dr. Taylor Wang, Vanderbilt University
- Dr. John V. Evans, COMSAT Corporation
- Dr. Dava J. Newman, Massachusetts Institute of Technology
- Mr. Parker S. Stafford, Aerospace Consultant
- Dr. Robert A. Cassanova, NASA Institute for Advanced Concepts (ex officio)

Five additional members will be named in 2002. The next meeting of the NSET is planned for June 13th at LPI after the 4th Annual Meeting.

Outreach to the Research Community

NIAC will continue to actively participate in technical meetings, workshops and symposia throughout the year sponsored by NASA, AIAA, AAS, ASGSB and other organizations. Whenever appropriate, NIAC representatives will participate on governing boards, technical committees and executive planning committees for technical societies. Seminars will be scheduled at universities and other locations to generate exposure for NIAC solicitations and to catalyze innovative solutions to critical challenges of aerospace endeavors.

Coordination with NASA and Other Federal Agencies

All NASA Associate Administrators or their designees selected HQ theme managers, Center Directors, and selected technical staff at the Centers will be briefed annually on the NIAC status and plans. Other Federal agencies, such as the National Reconnaissance Office, Air Force Office of Scientific Research, Office of Naval Research and the Army Research Office will be visited to explore opportunities for collaboration with NIAC and with NIAC Fellows.

Oversight by USRA Management

The NIAC Science, Exploration and Technology Council will meet to receive an overview of the status and plans of NIAC on the day following each of the scheduled annual meetings and the workshops. The Council will issue a report to USRA management and NASA on NIAC's operation and will offer suggestions for future activities.

APPENDIX

Description of Awards During the Fourth Year of Operation

Call for Proposals CP 00-01
Phase II Awards
Abstracts and Graphics



Planetary Exploration Using Biomimetics

ANTHONY COLOZZA

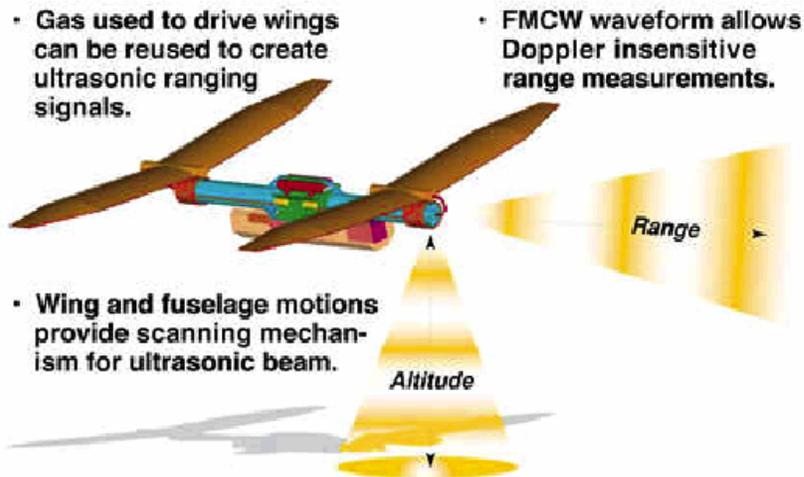
Ohio Aerospace Institute

The Mars environment, particularly the low atmospheric density, makes flight much more difficult than on Earth, requiring an aircraft to fly within a very low Reynolds number/high Mach number regime. A possible solution is the use of an entomopter, a mechanical flying machine utilizing insect flight characteristics. Their similar Reynolds number flight regime indicates air vehicle system potential for future Mars exploration missions.

Insects are able to fly at a significantly higher Coefficient of Lift (C_L) than conventional airplanes ($\sim C_L = 1$), due to their unique lift generation mechanisms. Utilizing these mechanisms as well as flow control over the wings, an entomopter can achieve lift coefficients from 5 to 8 times higher than those theoretically possible from the wing shape itself. This enhanced lifting capability could allow an entomopter to carry up to 15 kg of payload while flying at 30 m/s.

The Phase II program will involve investigation of the aerodynamics, appropriate propulsion methods, Mars compatible propellants, and the potential for fuel synthesis from indigenous materials. Autonomous and self-stabilizing behavior and control will be investigated for flight operations, refueling, communications, and navigation. The existing body of knowledge from terrestrial applications research and patents will be leveraged to enhance the vehicle's capabilities.

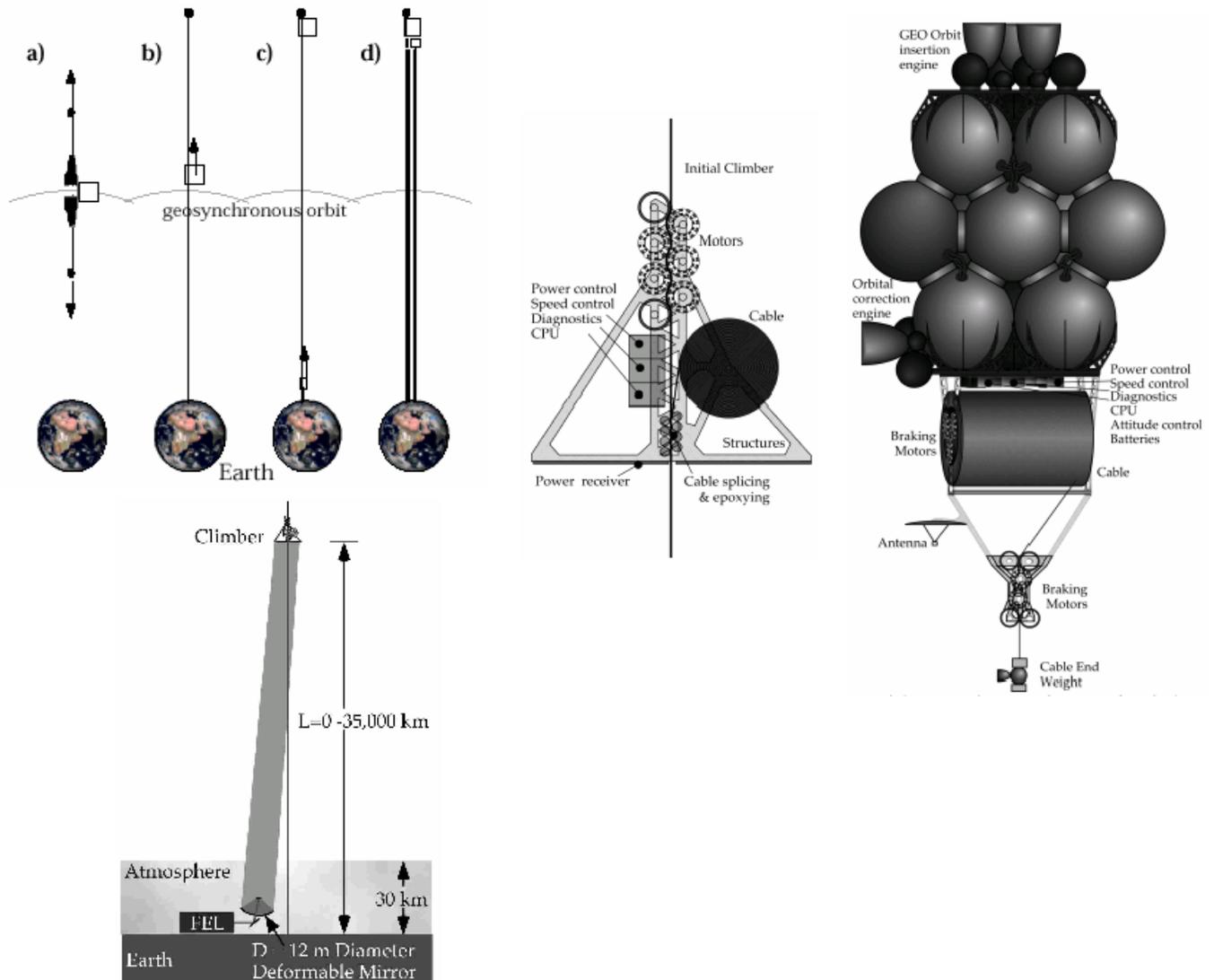
An entomopter based exploration vehicle system with *in situ* generated refueling could provide a flexible system for long duration exploration of the Mars surface. A 1 m. wingspan entomopter may be an elegant and practical architecture to produce a vehicle with the ability to take off, land, return samples, and even hover, providing significant mission capability enhancements over conventional aircraft.



The Space Elevator

BRADLEY CARL EDWARDS
Eureka Scientific

Currently NASA and all space agencies are completely dependent on rockets to get into space. Several advanced propulsion systems are being examined by NASA and others, but few, if any, of these technologies, even if perfected, can provide the high-volume, low-cost transportation system that will be required for the future space activities mankind hopes for. A system that may have the required traits is the one that we examined in our Phase I, the space elevator. The space elevator, a cable that can be ascended from Earth to space, is unlike any other transportation system for getting into space. Our Phase I laid down the technical groundwork examining all aspects of a proposed first elevator, but was unable to test many of the designs and scenarios proposed. The hurdles were found and the technology requirements for the system quantified. Even we, the proposers, were surprised by the apparent feasibility of the space elevator, the availability of almost all of the required technology, and the affordability of the first elevator. Our Phase II effort is the critical next step. It will begin to answer many of the questions that remain, provide direction for future research and be crucial for future funding and programmatic decisions. In Phase II we will construct cable segments from carbon nanotube composites and test their general characteristics as well as their resistance to meteor and atomic oxygen damage. We will examine critical aspects of the space elevator design such as the anchor and power beaming systems, cable production, environmental impact, the budget and the major design trade-offs. Our previous work along with our Phase II results will then be introduced into the NASA mainstream effort through a conference and publication.



Methodology for the Study of Autonomous VTOL Scalable Logistics

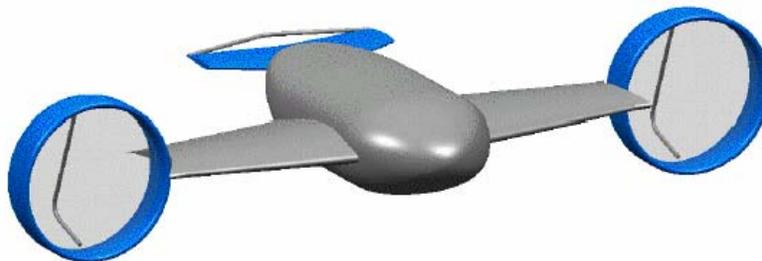
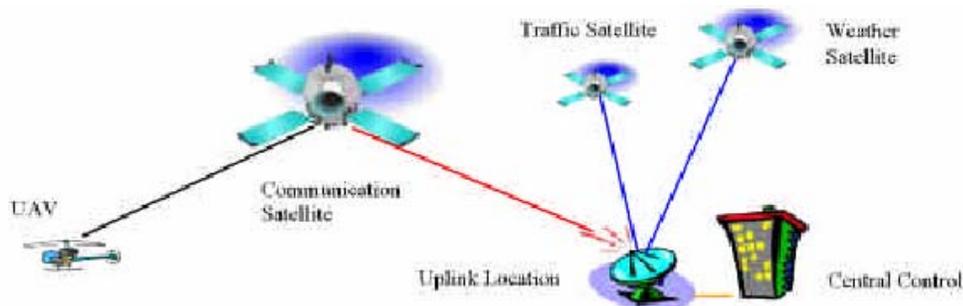
ANDREW KEITH

Sikorsky Aircraft Corporation

Substantial and promising results have been obtained by Sikorsky Aircraft during a NIAC Phase I study of an Autonomous VTOL Scalable Logistics Architecture (AVSLA). AVSLA is envisioned to be a future cargo delivery "system-of-systems" that provides cheaper, more efficient, and more effective service to the nation's consumers. Related VTOL vehicles for military heavy-lift purposes are also likely to benefit from AVSLA technology. The stated goal of the NIAC Phase II program is to provide a sound basis for NASA to use in considering advanced concepts for future missions. Thus, this Phase II proposal focuses on specific, critical research areas identified for AVSLA. The overall technical objective is to develop a system-of-systems model of the AVSLA design space, complete with supporting analyses in key areas that, when combined with advanced feasibility/viability determination methods, can establish a solid basis for a full-scale research program at NASA. In addition, a successful research program could be leveraged by Sikorsky Aircraft to obtain other funding in support of the development of an AVSLA.

Several areas critical to transforming AVSLA from an idea to reality were identified in Phase I. These technology areas include on-board vehicle computing functions (including communication, navigation, and safety), reliable autonomous control, air traffic management (ATM) system integration, and transportation architecture scalability. The Phase II effort proposed here provides the framework and steps for examining feasibility and viability of alternative AVSLA concepts and identification and assessment of the necessary new technologies in these areas. Research of these technology areas requires much more effort than possible in the NIAC Phase II. Thus, with the likely benefits of a deployable, efficient AVSLA established, these areas could form the basis of NASA research programs aimed at support for future systems. Missions enabled by AVSLA, including efficient, cost-effective package delivery and unique military tasks, are extremely important to the nation from economic, environmental, and national security points-of-view.

The Sikorsky-led Phase II team (a pairing of Sikorsky with the Georgia Institute of Technology) brings unique scientific and technical capabilities required to properly characterize the AVSLA system-of-systems design space. These unique capabilities lie in three critical areas: 1) system design methodologies, focused on future concept development and the probabilistic evaluation of new technologies and overall affordability, 2) systems dynamics and VTOL vehicle modeling, and 3) access to key expertise across the relevant disciplines and domains.

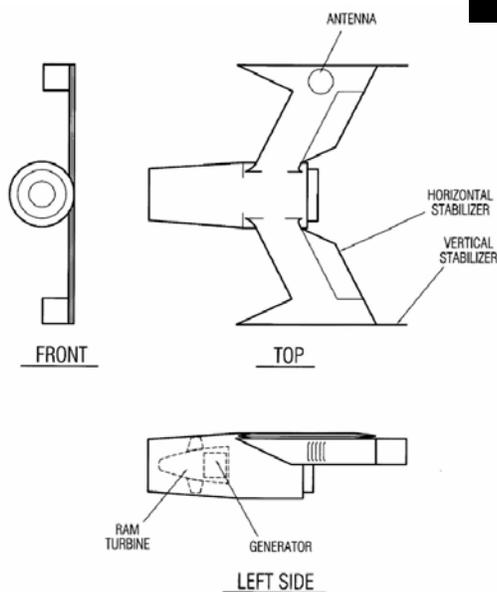
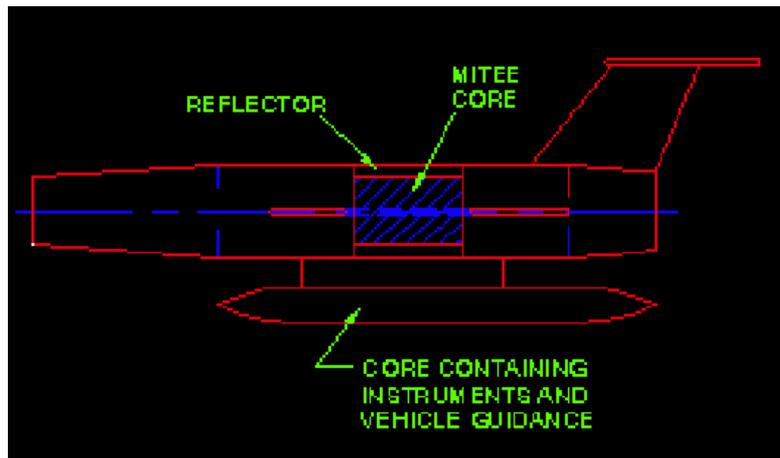


Exploration of Jovian Atmosphere Using Nuclear Ramjet Flyer

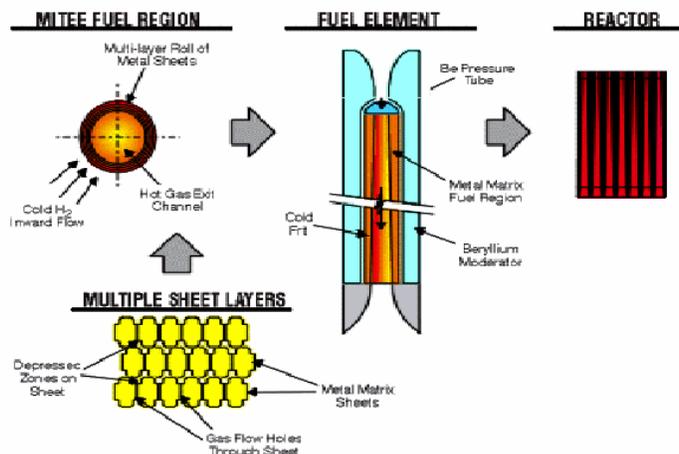
GEORGE MAISE

Plus Ultra Technologies, Inc.

We propose continued investigation of the design, operation, and data gathering possibilities of a nuclear-powered ramjet flyer in the Jovian atmosphere. The MITEE nuclear rocket engine can be modified to operate as a ramjet in planetary atmospheres. (Note: MITEE is a compact, ultra-light-weight thermal nuclear rocket which uses hydrogen as the propellant.) To operate as a ramjet, MITEE requires a suitable inlet and diffuser to substitute for the propellant that is pumped from the supply tanks in a nuclear rocket engine. Such a ramjet would fly in the upper Jovian atmosphere, mapping in detail temperatures, pressures, compositions, lightning activity, and wind speeds. The nuclear ramjet could operate for months because: 1) the Jovian atmosphere has unlimited propellant, 2) the MITEE nuclear reactor is a (nearly) unlimited power source, and 3) with few moving parts, mechanical wear should be minimal. During Phase I of this project, we developed a conceptual design of a ramjet flyer and its nuclear engine. The flyer incorporates a swept-wing design with instruments located in the twin wing-tip pods (away from the radiation source and readily shielded). The vehicle is 2 meters long with a 2 meter wingspan. Its mass is 220 kg, and its nominal flight Mach number is 1.5. Based on combined neutronic and thermal/hydraulic analyses, we calculated that the ambient pressure range over which the flyer can operate to be from about 0.04 to 4 (terrestrial) atmospheres. This altitude range encompasses the three uppermost cloud layers in the Jovian atmosphere: 1) the entire uppermost visible NH_3 ice cloud layer [where lightning has been observed], 2) the entire NH_4HS ice cloud layer, and 3) the upper portion of the H_2O ice cloud layer. To continue the validation of the ramjet flyer concept, additional work is required in several areas. These include a detailed study of radiation effects on instruments, flight stability of the vehicle in the highly turbulent Jovian atmosphere, data storage and transmission.



MITEE Nuclear Engine



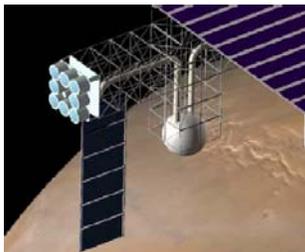
Cyclical Visits to Mars via Astronaut Hotels

KERRY T. NOCK

Global Aerospace Corporation

Global Aerospace Corporation is developing a revolutionary concept for an overall interplanetary rapid transit system architecture for human transportation between Earth and Mars which supports a sustained Mars base of 20 people circa 2035. This innovative design architecture relies upon the use of small, highly autonomous, solar-electric-propelled space ships, we dub *Astrotels* for **astronaut hotels** and hyperbolic rendezvous between them and planetary transport hubs using even smaller, fast-transfer, aeroassist vehicles we call Taxis. Astrotels operating in cyclic orbits between Earth, Mars and the Moon and Taxis operating on rendezvous trajectories between Astrotels and transport hubs or Spaceports will enable low-cost, low-energy, frequent and short duration trips between these bodies. This proposed effort provides a vision of a far off future which establishes a context for near-term technology advance, systems studies, robotic Mars missions and human spaceflight. In this fashion Global Aerospace Corporation assists the NASA Enterprise for Human Exploration and Development of Space (HEDS) in all four of its goals, namely (1) preparing to conduct human missions of exploration to planetary and other bodies in the solar system, (2) expanding scientific knowledge, (3) providing safe and affordable access to space, and (4) establishing a human presence in space. Key elements of this innovative, new concept are the use of:

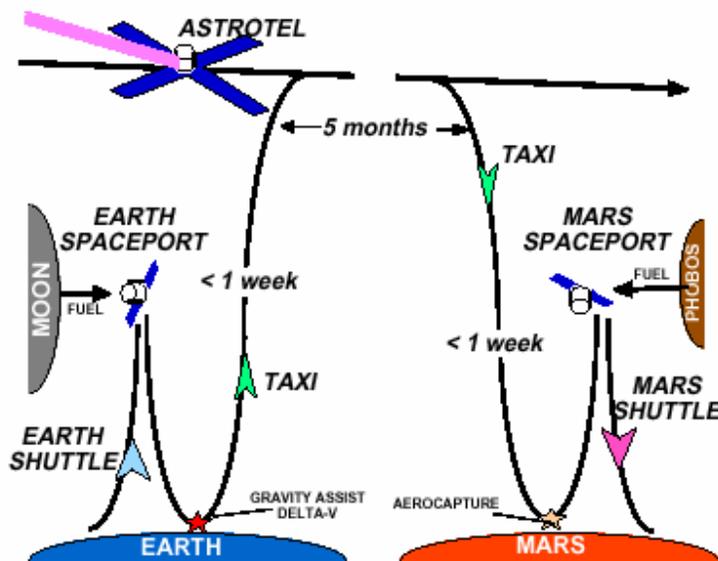
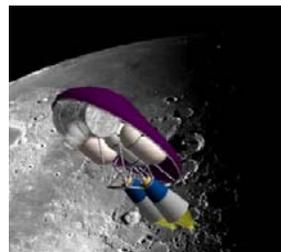
1. Five month human flights between Earth and Mars on cyclic orbits,
2. Small, highly autonomous human transport vehicles or Astrotels,
 - In cyclic orbits between Earth and Mars
 - Solar Electric Propulsion for orbit corrections
 - Untended for more than 20 out of 26 months
 - No artificial gravity
3. Fast-transfer, aeroassist vehicles, or Taxis, between Spaceports and the cycling Astrotels,
4. Low energy, long flight-time orbits and unmanned vehicles for the transport of cargo
5. in situ resources for propulsion and life support
6. Environmentally safe, propulsion/power technology



Astrotel IPS

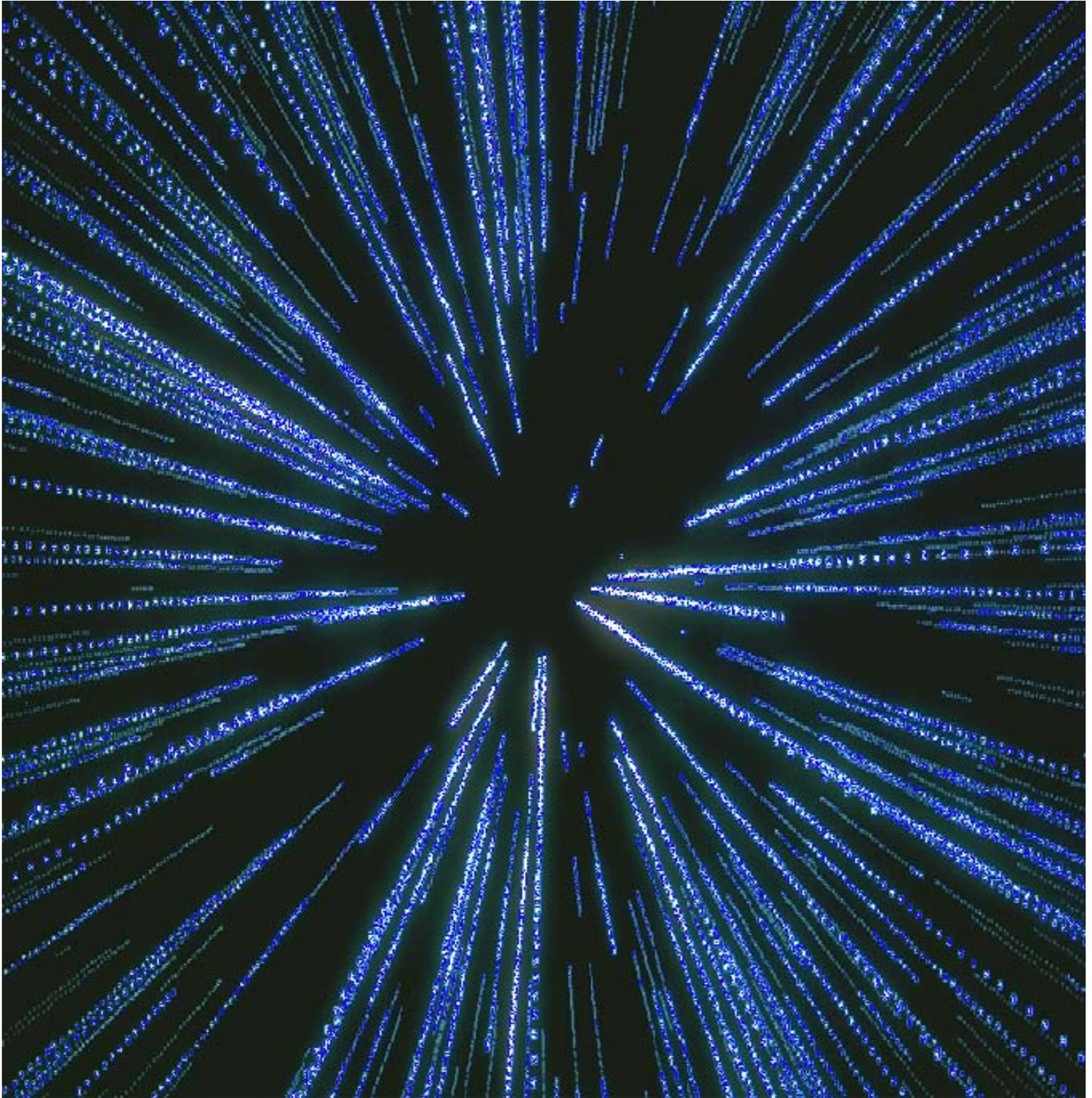


Taxi during Mars Aerocapture



Illustrates a schematic of the overall concept for regular human visits to Mars via an Astrotel concept that uses cyclic interplanetary orbits.

Call for Proposals CP 00-02
Phase I Awards
Abstracts and Graphics



Adaptive Observation Strategies for Advanced Weather Prediction

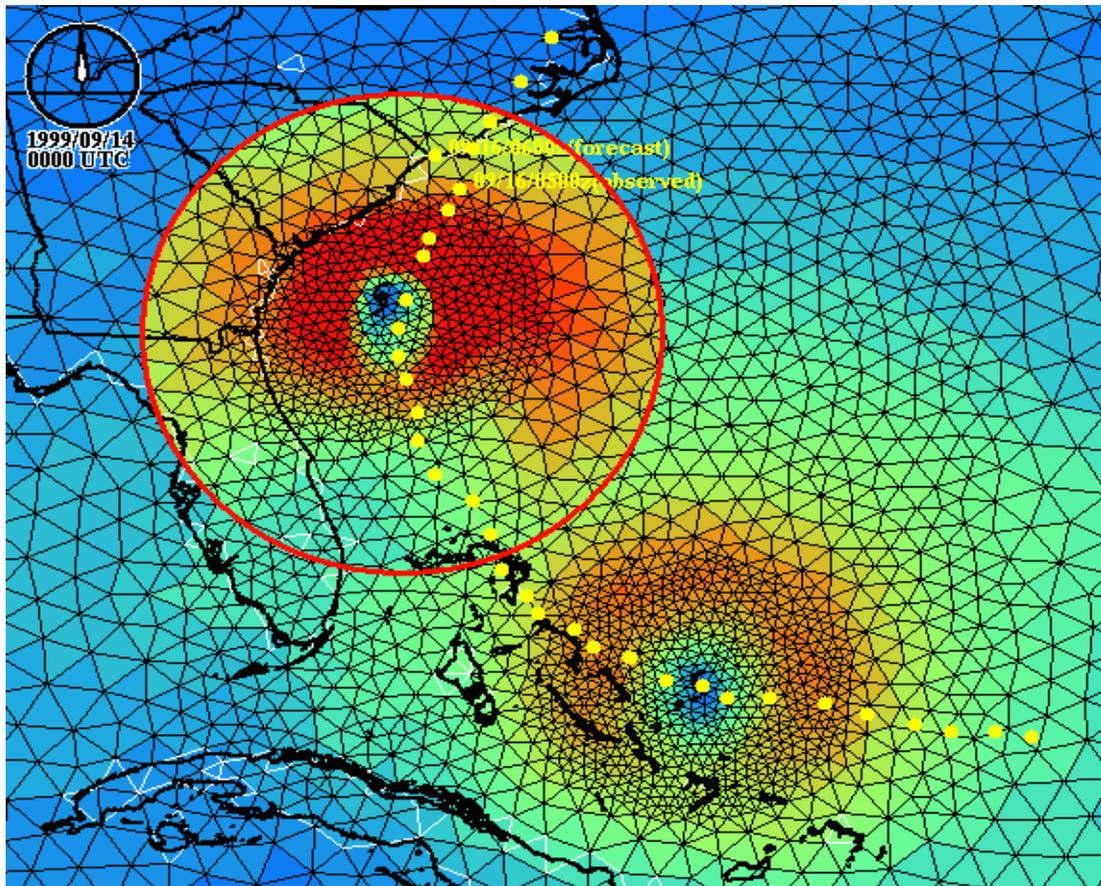
DAVID P. BACON

Science Applications International Corporation (SAIC)

Over the past 40 years, there have been significant improvements in weather forecasting. These improvements are primarily due to (1) improved model physics and increased numerical grid resolution made possible by ever-increasing computational power, and (2) improved model initialization made possible by the use of satellite-derived remotely sensed data. In spite of these improvements, however, we are still not able to consistently and accurately forecast some of the most complex nonlinear diabatic mesoscale phenomena – particularly out beyond 3 days. These phenomena include: propagating mesoscale convective complexes, tropical cyclones, and intense extratropical squall lines and rainbands (i.e., phenomena which develop over very fine spatial scales of motion and temporal periods and are dependent on convection for their existence). Poor observations of convection, boundary layer dynamics, and the larger scale pre-convective environment are often the cause of these substandard simulations, and thus require improved observational data density and numerical forecast grid resolution.

The problem with uniform increases in both observational data density and numerical forecast grid resolution is that, quite often, great volumes of the atmosphere are relatively uniform; hence, the increased density results in a great deal of redundant data. For example, numerous samples of the bulk of the same air mass are not as valuable as the same number of observations accurately describing the location of the front between air masses. This proposal explores dynamic data assimilation strategies that identify *critical* data necessary to improve forecast accuracy, and hence reserves as much computational power as possible for model physics.

This proposal looks at data assimilation strategies that focus on critical, rather than typical, data. We will use a weather forecasting system based on a dynamically adapting grid to create a synthetic/optimally sampled data set and then look at the forecast accuracy of simulations performed with critical data inclusion / denial.



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

H. JOHN CAULFIELD

Fisk University

We show that it is impossible for a 2D image to contain the needed information to reconstruct the 3D scene from which it was derived. We then show how the human visual processing system overcomes that impossibility and how we can.

The criteria for judgment are listed below and commented upon with respect to our proposal.

- a. **Is the concept revolutionary rather than evolutionary? To what extent does the proposed activity suggest creative and original concepts?** We suspect that no one else has dared attempt this, because it is provable that the 2D image cannot contain enough information to allow a 3D view of it to be derived. Our solution is revolutionary and very old. We strongly suspect we have discovered how nature allows you to see a 3E image using only one eye at a hyperfocal distance from your eye. Is that creative? Only the reader can judge. Is it original? If others could do what we assert we can, they surely would have. We think originality is provable in that way.
- b. **Is the concept for an architecture or system and have the benefits been qualified in the concept of a future NASA mission?** Certainly, it is for a system that can (in Phase II) become an architecture for online conversion of 2D images into 3D images. It applies to all future (*and past!*) NASA missions that involve images. That is, most of them.
- c. **Is the concept substantiated with a description of applicable scientific and technical disciplines necessary for development?** We have already accomplished this task for small, close-up objects. That suggests that the necessary disciplines are already in use. The proposal will furnish as much detail as is consistent with the page limitations.

A Novel Information Management Architecture for Maintaining Long Duration Space Crews

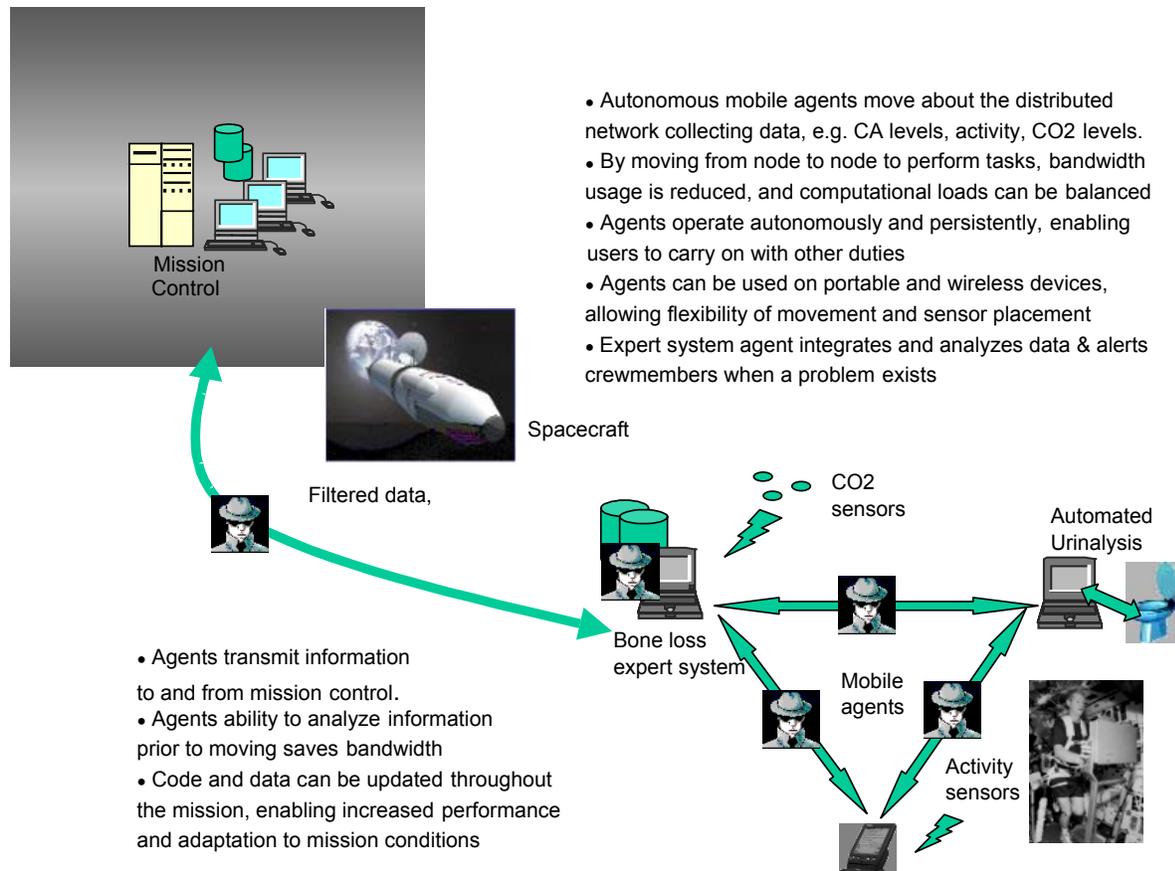
GEORGE CYBENKO

Thayer School of Engineering, Dartmouth College

A key factor limiting long-duration space flight is the inability to maintain the crew effectively in weightlessness. Current approaches to crew preservation involve discrete experiments to measure physiologic adaptation and post flight evaluations to assess the effectiveness of countermeasures. As the length and complexity of missions increase, these approaches will be inadequate. A revolutionary new approach is needed, where crewmembers have automated, continuous, unobtrusive, and accurate monitoring of their physiology so they can maintain themselves in space. Suitable future crew maintenance systems will require complex, automated information retrieval, monitoring, and analysis. These systems will also need to be robust and flexible enough to operate in the distributed, information intensive, bandwidth limited environment characteristic of space flight. Creating such systems will be a major challenge for the National Aeronautics and Space Administration (NASA).

We propose a revolutionary approach to automating onboard information management that could be used for many applications during future long-duration space flights. We outline a feasibility study where mobile agents, an emerging software technology, would be used to demonstrate this new architecture for onboard and spacecraft-to-Earth-based information processing, monitoring and analysis applications. The study will focus on design and implementation requirements related to crew maintenance systems for long duration space flights. The problem of bone loss will be the test case for the Phase I study, although the approach is generally applicable to other critical issues such as radiation exposure, psychosocial adaptation and medical care.

To execute the proposed research, we have assembled a multidisciplinary team with extensive and unique experience in mobile agent systems research and development and space flight. Dartmouth College has developed a mobile agent system that is used internationally for multi-language mobile agent system development. Co-Investigator Jay Buckley, Jr. M.D., a former Payload Specialist Astronaut, will provide critical insight into the domain and life science requirements of long-duration space flight.

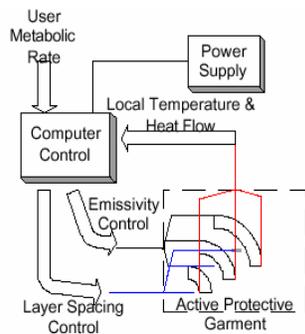
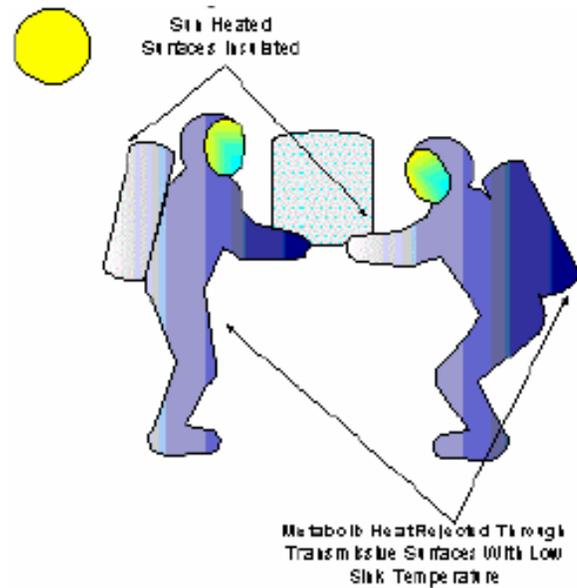
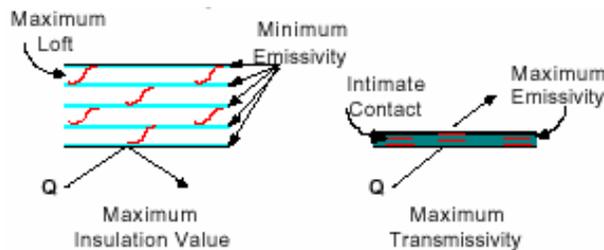


A Chameleon Suit to Liberate Human Exploration of Space Environments

EDWARD HODGSON

Hamilton Sunstrand Space Systems International, Inc.

The direct operation of humans in space environments must become commonplace if the goals of the HEDS Enterprise are to be achieved. This transition from rare and expensive Extra-Vehicular Activity (EVA) to normal and expected “going outside” can be enabled by a system concept in which the walls of the protective clothing work with the space environment to provide required thermal control functions. This will liberate future space workers and explorers from reliance on cumbersome mechanisms and consumable resources currently used for thermal control. It will be achieved by providing the ability to tune the heat transmission characteristics of the outer garment from highly insulating as in present spacesuit designs to highly transmissive. This will allow heat flow from the body to be modulated to match varying metabolic activity levels in any environment and permit selective control on different garment surfaces to take advantage of the most advantageous thermal conditions at any work site. This study is proposed to evaluate the implications of the “Chameleon Suit” system concept that integrates emerging technologies for varying conductance/convection insulation with controllable radiation emissivity surfaces. We will assess concepts for its implementation and required technology development beyond currently emerging and projected technologies to make it a success.



Controlling the Global Weather

ROSS N. HOFFMAN

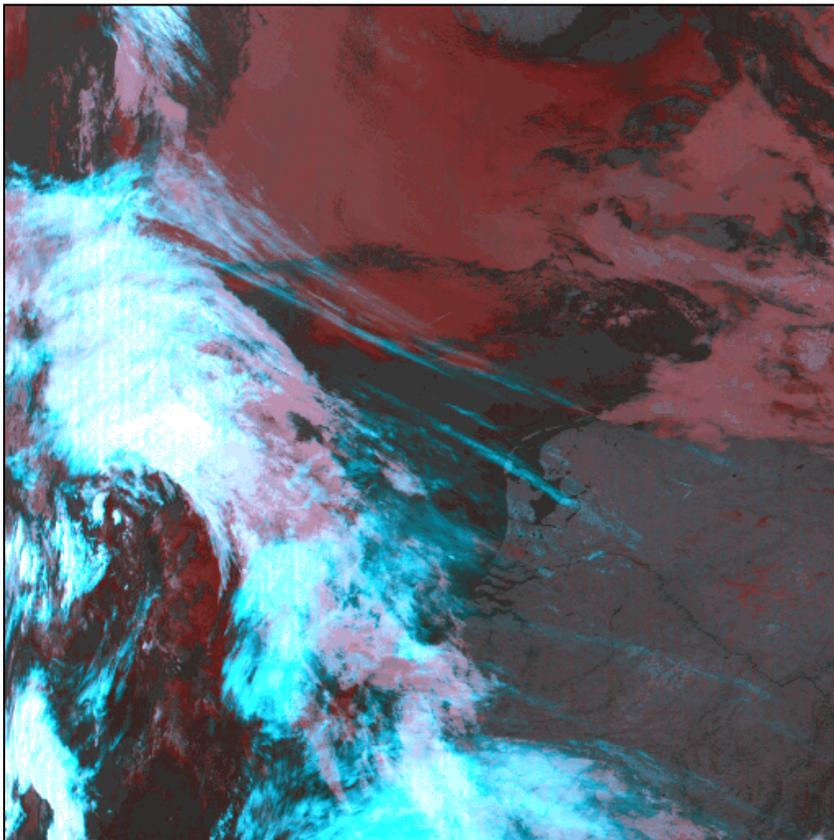
Atmospheric & Environmental Research Inc.

The key factor enabling control of the weather is that the atmosphere is sensitive to small perturbations. That is, it is the very instability of the atmosphere's dynamics that makes global weather control a possibility. The Earth's atmosphere may be chaotic, and very likely is very sensitive to small perturbations. Certainly very simple nonlinear dynamical models of the atmosphere are chaotic, and the most realistic numerical weather prediction models are very sensitive to initial conditions. Extreme sensitivity to initial conditions implies that small perturbations to the atmosphere can effectively control the evolution of the atmosphere, if the atmosphere is observed and modeled sufficiently well.

We describe the architecture of a feedback control system to control the global atmosphere, and the components of such a system. Although the weather controller is extremely complex, the existence of the required technology is plausible at the time range of 30-50 years.

While the concept of controlling the weather has often appeared in science fiction literature, our statement of the problem provides a scientific basis and system architecture to actually implement global weather control. The nation that controls its own weather will perforce control the weather of other nations. Weather "wars" are conceivable. An international treaty may be required to ensure that weather control technology be used for the good of all.

In addition to being directly relevant to the call for revolutionary concepts, which expand our vision of the future, many of the technologies involved in our proposed system are areas of interest to NASA that will be developed for other reasons. These include atmospheric science, remote sensing, aviation systems, fleets of low-cost satellites, solar power satellites, advanced computational systems, mega-systems engineering, and more.

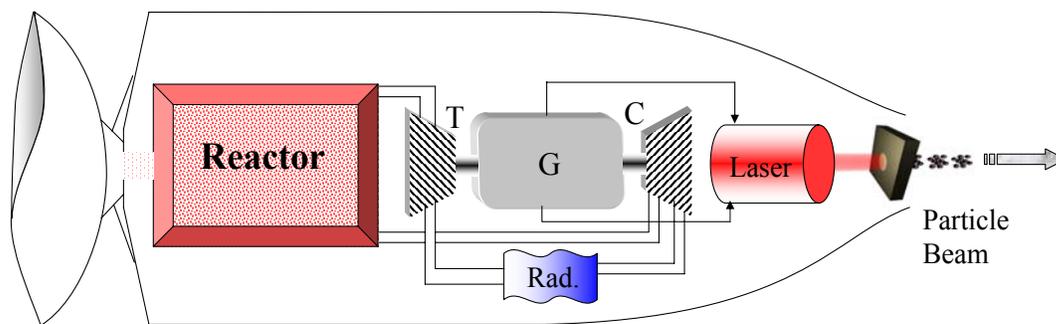


Ultrafast Laser-Driven Plasma for Space Propulsion

TERRY KAMMASH

University of Michigan

Recently conducted experiments at the University of Michigan and elsewhere have shown that ultra short pulse (ultrafast) lasers could accelerate charged particles to relativistic speeds. Current achievable laser peak power of about 10^{15} Watts has been utilized in the study of relativistic nonlinear optics in plasmas, and it is expected that laser power values will be reached in the near future that will accelerate protons to energies equal to their rest mass energy. That readily means that if such particles are ejected from a propulsion system at 0.866 (the speed of light), they will produce a specific impulse of 26 million seconds. Present day experiments have also demonstrated that a beam of MeV protons containing more than 10^{10} particles at 100 MeV energy will indeed be achieved in the not too distant future. Propulsion systems based on such concepts will indeed make distant planets in the solar system, and some interstellar missions, achievable in relatively short times.



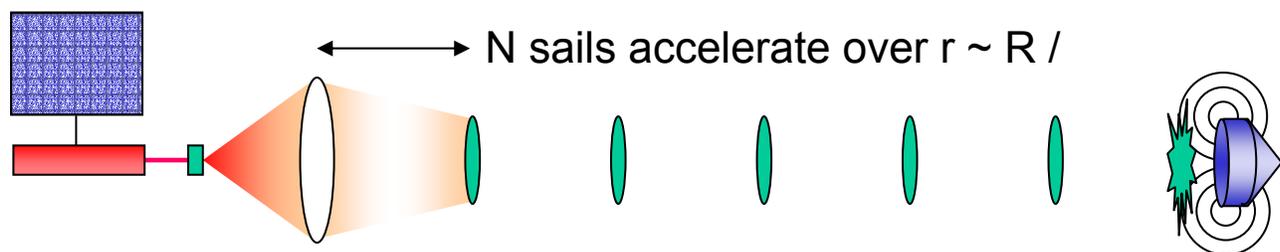
Laser-Accelerated Plasma Propulsion System (LAPPS)

High-Acceleration Micro-Scale Laser Sails for Interstellar Propulsion

JORDIN T. KARE

Kare Technical Consulting

We proposed to develop a conceptual system architecture and to evaluate physical and technical limitations for a revolutionary relativistic propulsion concept which may enable interstellar probe missions to be launched at 1/10 light speed or more within 40 years. This propulsion concept is based on an innovative combination of the well-established concepts of laser-pushed light sails and particle-beam propulsion. The key innovation is the realization that a series of N small light sails can be accelerated more easily than a single large sail of the same total mass; in particular, the transmitter optical aperture area can be a factor of N smaller than for the single sail. Transparent dielectric sails (as opposed to metal-film sails) can withstand very high fluxes, which allows N to be large, potentially 10^6 or greater. A larger vehicle, sufficient to carry high performance sensor and communications payloads, can be accelerated over a long period – months or years – by a comparatively modest laser, using momentum transferred from a “beam” of sequentially-launched microsails. Under NIAC Phase I, we will review laser-dielectric interaction models and data to determine approximate limits on microsail flux, and attempt to identify, analyze, and quantify other system limitations such as mechanical stresses on sails. These results will be used to develop a preliminary architecture and define a development program. A particularly interesting feature of microsails is that they can be tested in the laboratory using existing lasers. If Phase I results are promising, significant experimental work on interstellar propulsion may be possible within the scope of a NIAC Phase II effort.



Propellantless Control of Spacecraft Swarms using Coulomb Forces

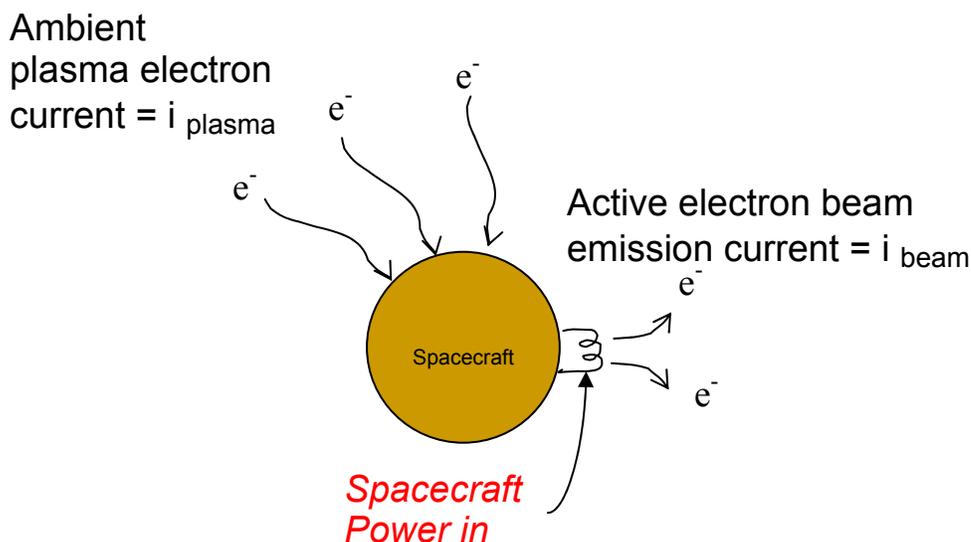
LYON BRAD KING

Michigan Technological University

NASA has demonstrated a need to begin research on the next generation of very small, capable satellites employed in collaborative formations for various space missions. Of the many technologies that must be developed to enable deployment of microsatellite swarms, perhaps spacecraft propulsion and collaborative control issues are the most challenging. Fine positioning and formation-flying of swarms of microsatellites will require very controllable thrust on the order of micro-Newtons. Apart from the difficulty in engineering such thrusters, issues of concern are controllability of thrust, finite fuel supply, and inter-spacecraft contamination during close proximity operations due to exhausted propellant from neighboring craft.

The goal of this proposal is to develop the technologies required to enable propellantless control of swarm satellite formations using Coulomb forces generated between spacecraft. By either harvesting ambient space-plasma electrons or actively emitting electrons, the net spacecraft charge can be controlled. In this innovative concept, it is feasible to generate tens of micro-Newtons of attraction and repulsion between spacecraft separated by tens of meters, with the possibility for hundreds of μN hinted at through flight data. Sufficient Coulomb forces can be generated with only a few Watts of power. The mutually interacting Coulomb spacecraft will orient themselves in stable minimum-energy structures that can be reconfigured using active control. Although ambitious, the proposed concept is supported by flight heritage from the SCATHA spacecraft. In this 1979 experiment, electron emission was successfully used to control the potential of the spacecraft over many kilo-volts. The demonstrated SCATHA control was sufficient to generate the inter-satellite forces proposed here.

Results of the proposed investigation are expected to (1) circumvent the need for micro thrusters in close proximity operations of satellite swarms, (2) increase formation mission lifetimes by harvesting in-space resources, (3) greatly improve fine position-keeping within a swarm through active feedback, (4) facilitate a wider range of satellite formation of flying orbits, (5) provide the ability to reject external disturbances to the formation, and (6) increase swarm robustness through fault-detection and reconfiguration.



Formation Flying with Shepherd Satellites

MICHAEL R. LaPOINTE

Horizon Technologies Development Group

Formation-flying an array of specialized micro satellites in place of a single, multi-instrumented spacecraft offers several advantages for earth and space science applications. However, the formation and control of a distributed array of several small, power-limited satellites is a tremendous challenge for current guidance, control and propulsion technologies. A new concept is proposed in which a limited number of special service satellites are used to form and maintain a large number of micro satellites in a precise formation. The proposed “shepherd satellite” concept removes the considerable difficulty associated with the positioning and control of individual micro satellites within a formation-flying array, and places that burden on a small number of shepherd satellites that can more easily be controlled through autonomous programming or ground commands. Active maneuvering of the array and the positioning of distributed elements within the array are performed through the shepherd satellites, which allows the individual micro satellites to devote their limited mass and power resources to instrumentation and observation.



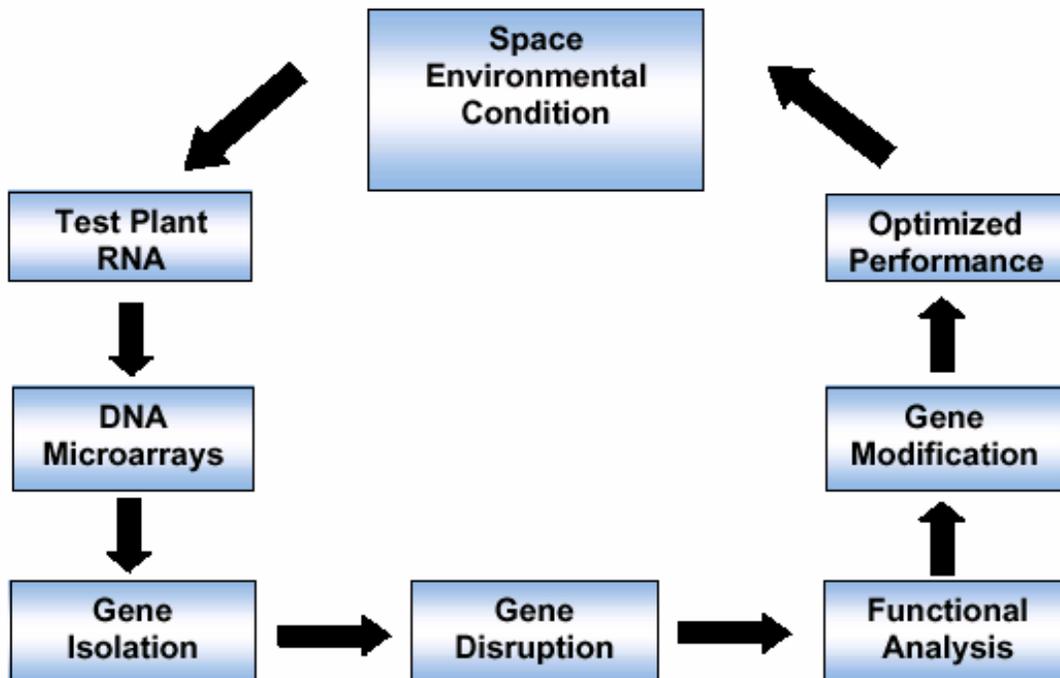
A Flexible Architecture for Plant Functional Geonomics in Space Environments

TERRI L. LOMAX

Oregon State University

Plants will play an essential role in providing life support for any long-term space exploration or habitation. This proposal describes a revolutionary concept for a flexible architecture for measuring the response of plants to any unique space condition and then determining the function of genes that can be used to optimize plant performance under those conditions. The proposed architecture is based on combining the recent and forthcoming rapid advances in the field of plant genomics with the power of homologous recombination to determine gene function via gene alterations or knockouts. Discoveries made in this manner can be used to allow the engineering or selection of plants optimized to thrive in specific space environments.

Testing the feasibility of the proposed plant functional genomics architecture for space has only recently become possible with the availability of the first complete genome sequence for a plant (*Arabidopsis*), the development of micro array technology for measuring gene expression, and the demonstration of efficient homologous recombination in a model green land plant, a moss (*Physcomitrella*). The novel combination of these three technologies will allow us to validate the viability of the proposed concept and define the major feasibility issues during Phase I. Eventually, as more plant genomes are sequenced and homologous recombination techniques are expanded to other species, it should become possible to use this architecture to optimize the performance of any plant in any space environment. Future additions to the architecture will include the technical advances necessary for remote collection and evaluation of data. The proposed concept will advance NASA's mission of human exploration, use, and development of space, both in the near- to mid-term on the International Space Station and in the far-term and beyond for longer duration missions (i.e. to Mars) and eventual space habitation.



Directed Application of Nanobiotechnology for the Development of Autonomous Biobots

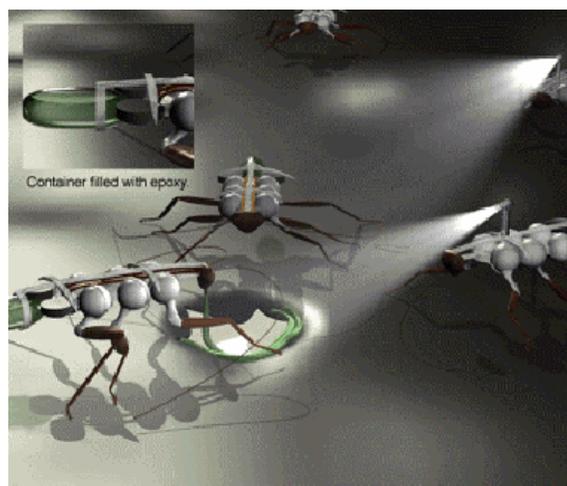
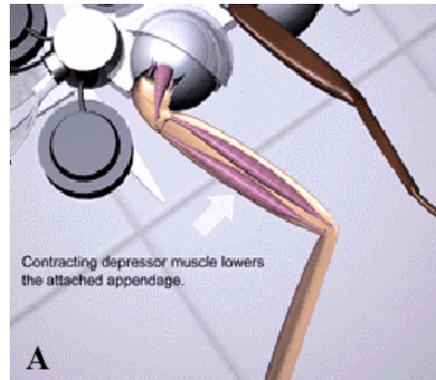
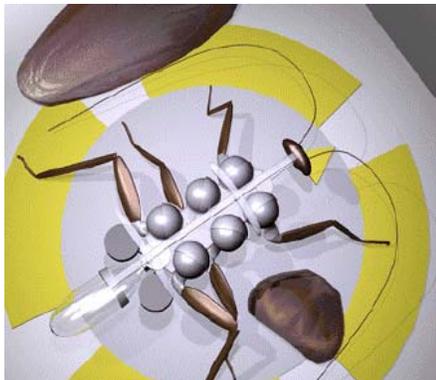
CARLO D. MONTEMAGNO

Cornell University

Through preliminary experimental investigation, this proposal seeks to demonstrate the potential of producing self-assembled, hybrid living/non-living, autonomous insect-sized robots. Through the application of "Swarm" intelligence, groups of Biobots could be used to support a myriad of needs associated with both current and future NASA space missions. Biobots could be used to facilitate the repair and inspection of both the inside and outside of spacecraft, thus eliminating or reducing the number needed EVAs and providing rapid inspection access to areas of the spacecraft not normally assessable to the crew. Collections of Biobots could also be used to explore and provide intelligence over large areas with minimal resource cost.

Because over 90% of the power budget of robots are associated with generating motion, intrinsic limitations in the power densities of currently available sources of power make it all but impossible to produce long-lived functional devices with any significant mobility. Use of controlled individual striated muscle myoblasts integrated with a nanofabricated skeleton framework offers a very real solution to this engineering challenge. In addition, because the power density of muscle fibers is very high, they also open the potential of engineering both terrestrial and aerial Biobots. Corollary potential benefits of this technology are that fully assembled devices could be stored indefinitely at -70°C or be assembled off Earth onto specialized robotic frameworks suitable for the current need with very modest facility requirements.

Using a combination of MEMS, nanobiotechnology, and tissue engineering during the Phase I study, we will seek to demonstrate the potential of this innovative concept by: 1) demonstrating the actuation and control of millimeter scale (ca. $\sim 1.5\text{mm}$) levers using single muscle fibrils thus eliminating the concept of Muscle MEMS as a source of locomotive power for Biobots, and 2) providing evidence of our ability to self-assemble muscle myoblasts with engineered nano and micro structures to produce functional mechanical devices. Achievement of these two goals will clearly establish the exceptional potential of this concept.

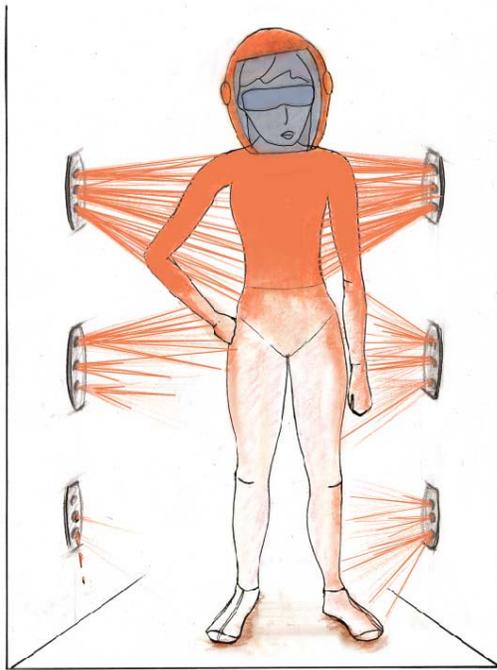


Astronaut Bio-Suit System for Exploration Class Missions

DAVA J. NEWMAN

Massachusetts Institute of Technology

The proposed *Bio-Suit System* could revolutionize human space exploration by providing enhanced astronaut extravehicular activity (EVA) locomotion and life support based on the concept of providing a “second skin” capability for astronaut performance. The novel design concept is realized through symbiotic relationships in the areas of biomimetics; wearable technologies; information systems and evolutionary space systems design; and medical breakthroughs in skin replacement and materials. By working at the intersection of engineering; design; medicine; and operations, new emergent capabilities could be achieved. The *Bio-Suit System* would provide life support through mechanical counter-pressure where pressure is applied to the entire body through a tight-fitting suit with a helmet for the head. Wearable technologies will be embedded in the *Bio-Suit* layers and the outer layer might be recyclable. Hence, images of “spraying on” or “shrink wrapping” the outer layer of the *Bio-Suit System* emerge, which offers design advantages for extreme, dusty planetary environments. Flexible space system design methods are proposed to enable adaptation of *Bio-Suit* hardware and software elements in the context of changing mission requirements. Reliability can be assured through dependence of *Bio-Suit* layers acting on local needs and conditions through self-repair at localized sites while preserving overall system integrity. The proposed *Bio-Suit System* contributes to four under-represented NIAC areas, specifically, human space flight, life sciences, information systems and software, and biology. The *Bio-Suit System* is relevant to NASA’s strategic plan and stated visionary challenges in the Human Exploration and Development of Space, AeroSpace Technology, and Space Science enterprises.

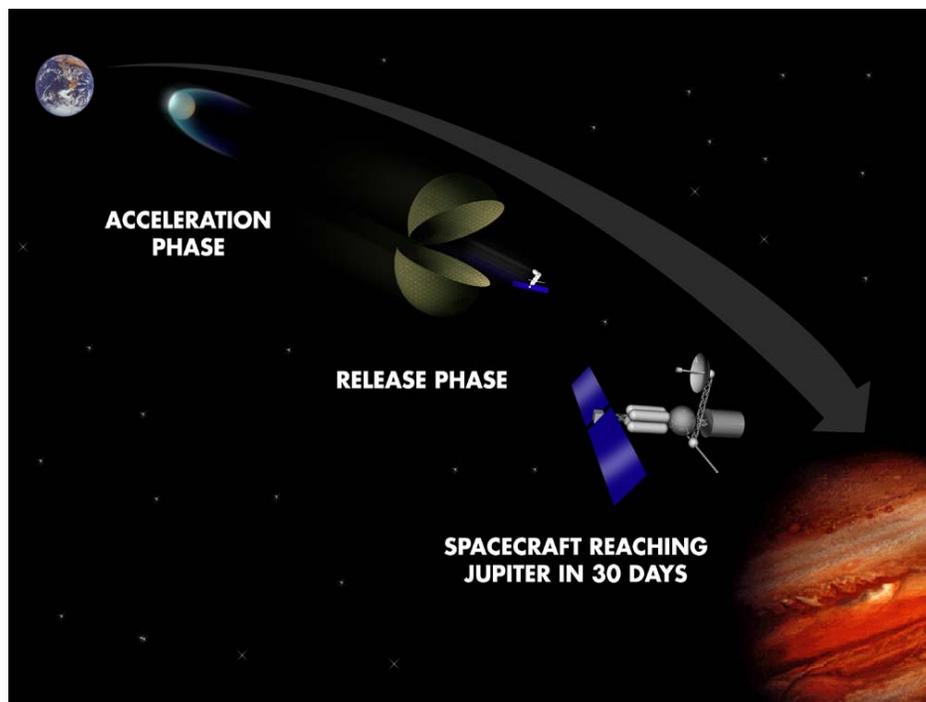


High Speed Interplanetary Tug/Cocoon Vehicles (HITVs)

NICK OMIDI

SciberNet, Inc.

We propose to conduct a preliminary study of a new class of space vehicles, which utilize the motional electric field in the solar wind to accelerate robotic spacecraft to velocities of a few hundred km/s. The premise behind these Tug or Cocoon type vehicles is based on a number of facts. One, is that any charged object embedded in the solar wind will be accelerated to velocities comparable to its flow speed (~400 km/s) with the magnitude of acceleration varying from tens of thousands of Gs to less than 1 G depending on its mass and total charge. Second, for typical masses of robotic spacecraft (tens of kg) the required charge on the spacecraft is very large and could disrupt its electronics circuits. However, specially designed Tug or Cocoon type vehicles could be charged to the required levels without exposing the robotic spacecraft to any charging hazards. We refer to these as High Speed Interplanetary Tug/Cocoon Vehicle (HITV). Once accelerated to the desired speeds, HITV can proceed to discharge and release the robotic spacecraft towards its destination. We envision HITV to have an expandable spheroid structure with radius of 1-10km, when fully deployed. An onboard charging mechanism controls the electric charge density on HITV and the surface material/structure can withstand large (10⁶-10⁹ V/m) electric fields. If used as a Tug vehicle, the robotic spacecraft is attached to HITV with a long enough tether to avoid the hazardous electromagnetic environment in the vicinity of HITV. If used as a Cocoon, the robotic spacecraft is placed within HITV where again it will be protected from large electromagnetic fields. The proposed feasibility study will address a number of outstanding issues. The highly nonlinear interaction between the solar wind and HITV will be investigated by using Particle-in-Cell (PIC) electromagnetic simulations. These simulations will allow us to better understand the nature of the resulting electromagnetic environment around HITV, and determine its acceleration under a variety of mass and charge states, as well as solar wind conditions. The onboard charging mechanism and its power requirements, as well as surface properties of HITV will also be investigated. Issues related to attitude control, reusability of HITVs and Tug vs. Cocoon designs would be addressed as well. The utilization of solar wind energy for acceleration of spacecraft to high velocities has been proposed in the past (e.g., magnetic sails, Mini-Magnetosphere Plasma Propulsion). HITV is another exciting and novel approach to the use of solar wind power to drastically reduce trip times to other bodies in the solar system. In particular, HITVs may be especially suitable for Class I and II micro spacecraft.



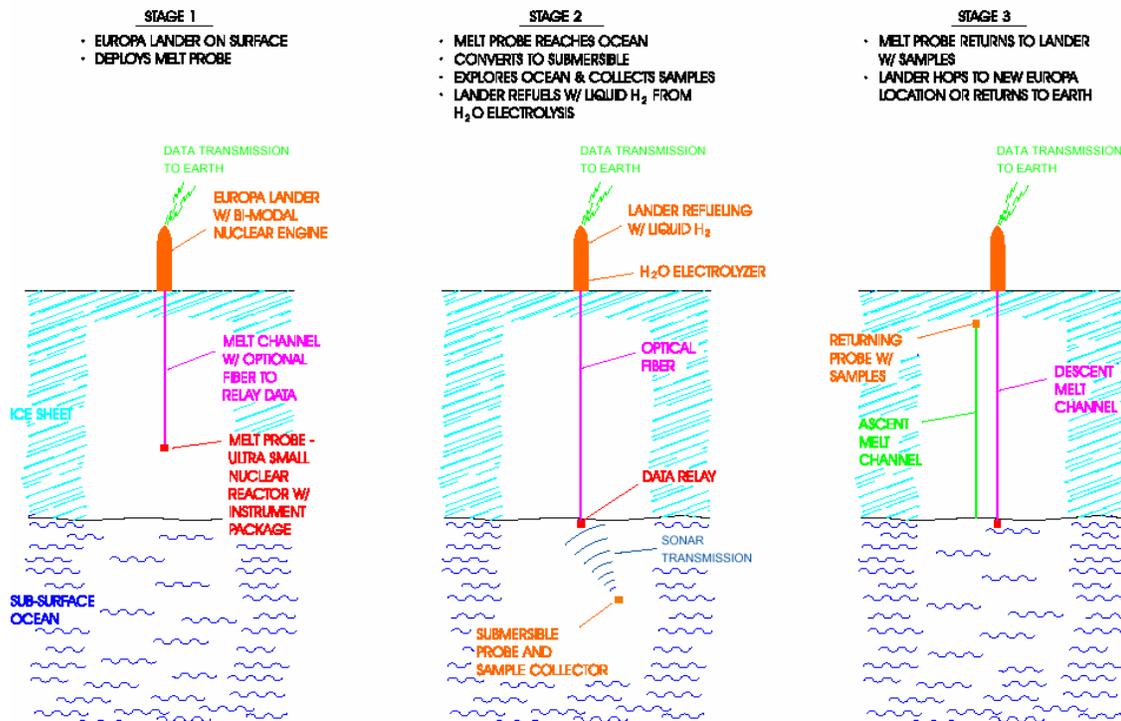
Europa Sample Return Mission Utilizing High Specific Impulse Refueled with Indigenous Resources

JOHN PANIAGUA

Plus Ultra Technologies, Inc.

We are proposing to conduct studies of a revolutionary new concept for conducting a Europa Sample Return Mission. Robotic spacecraft exploration of the Solar System has been severely constrained by the large energy requirements of interplanetary trajectories and the inherent delta V limitations of chemical rockets. Current missions use gravitational assists from intermediate planets to achieve these high-energy trajectories restricting payload size and increasing flight times. We propose a five-year Europa Sample Return Mission with very modest launch requirements enabled by MITEE. A new nuclear thermal propulsion engine design, termed MITEE (Miniature reactor Engine), has over twice the delta V capability of H₂/O₂ rockets (and much greater when refueled with H₂ propellant from indigenous extraterrestrial resources) enabling unique missions that are not feasible with chemical propulsion. The MITEE engine is a compact, ultra-lightweight, thermal nuclear rocket that uses hydrogen as the propellant. MITEE, with its small size (50 cm O.D.), low mass (200 kg), and high specific impulse (~1000 sec), can provide a quantum leap in the capability for space science and exploration missions. The Europa Sample Return Vehicle (ESRV) spacecraft has a two-year outbound direct trajectory and lands on the satellite surface for an approximate 150 day stay. During this time, the vehicle is refueled with H₂ propellant derived from Europa ice by the Autonomous Propellant Producer (APP), while collecting samples and searching for life. A small nuclear-heated submarine probe, the Autonomous Submarine Vehicle (ASV), based on MITEE technology, would melt through the ice and explore the undersea realm. The spacecraft has a two and one-half year return to Earth after departure from Europa with samples onboard. Spacecraft payload is 300 kg at the start of the mission and can be launched with a single, conventional medium-sized Delta III booster. The spacecraft can bring back 300 kg of samples from Europa.

EUROPA EXPLORATION AND SAMPLE RETURN MISSION

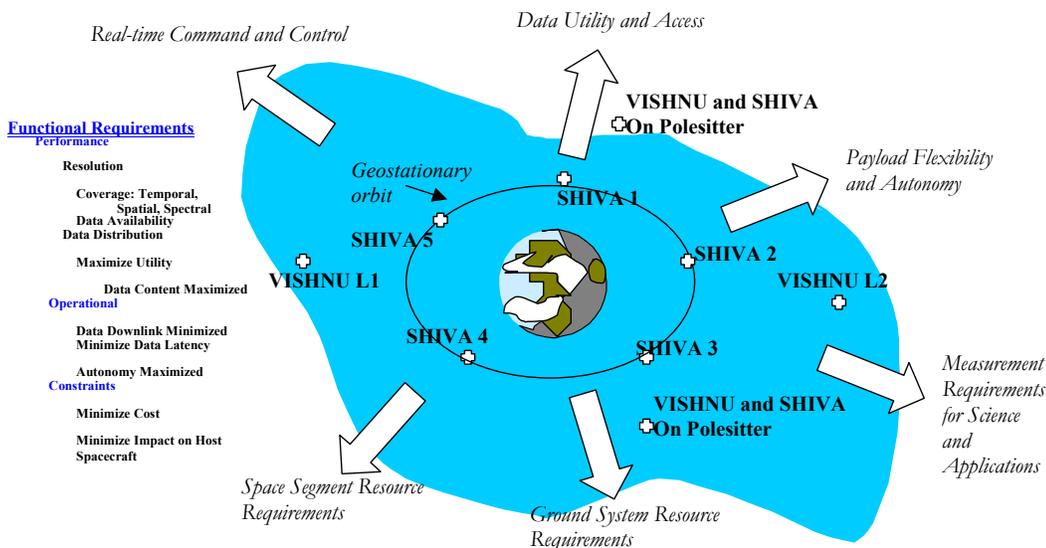
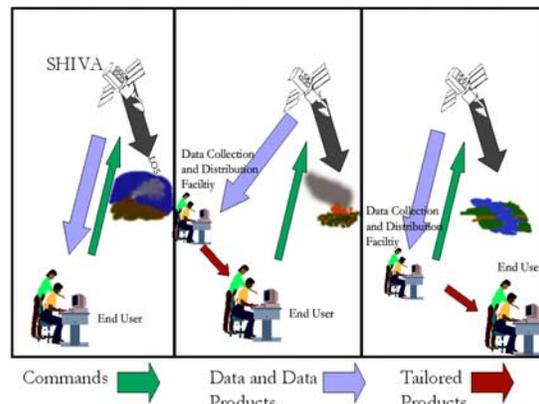


Global Observations and Alerts from Lagrange-Point, Pole-Sitter, and Geosynchronous Orbits (GOAL&GO)

LARRY J. PAXTON

The Johns Hopkins University

The Global Observations and Alerts from Lagrange-point, Pole-sitter, and Geosynchronous Orbits (GOAL&GO) mission is a revolutionary measurement concept that will enable the deployment, maintenance, and seamless integration of diverse and distributed measurement capabilities that provide a new capability for humankind to monitor the Earth as it responds to anthropogenically-induced global climate change. GOAL&GO will form a smart, adaptable sensor web for disaster management and science data collection. GOAL&GO incorporates current technology thrusts and accounts for roadmap technologies to posit a system of sensors in geosynchronous, L1, L2, and pole-sitter orbits. These sensors can operate autonomously or under the control of remotely located users. Geolocated data GOAL&GO consists of two types of sensors: the Visible/IR/UV Imaging System Hardware for New Uses (VISHNU), a “science” sensor, and the Supporting High-resolution IR Visible Applications (SHIVA), a disaster management sensor. VISHNU provides full disk imagery from the poles, L1, and L2 to monitor ozone depletion, tropospheric weather patterns in support of weather prediction initiatives, biomass burning, urbanization, and aerosol and cloud distributions, heights, and transport. VISHNU data are obtained with a 1 km resolution from the poles and 5 km from L1 and L2. VISHNU also incorporates an organic capability to command SHIVA sensors to examine particular areas in the VISHNU field of view. SHIVA is a compact multi-spectral imaging system with 250 m resolution capable of being pointed anywhere within the visible portion of the Earth. The unique feature of SHIVA is that it is designed to be commanded from remote, simple, inexpensive and portable ground sites, and to downlink data and data products directly to users. This system would require relatively little investment on the part of the end users.

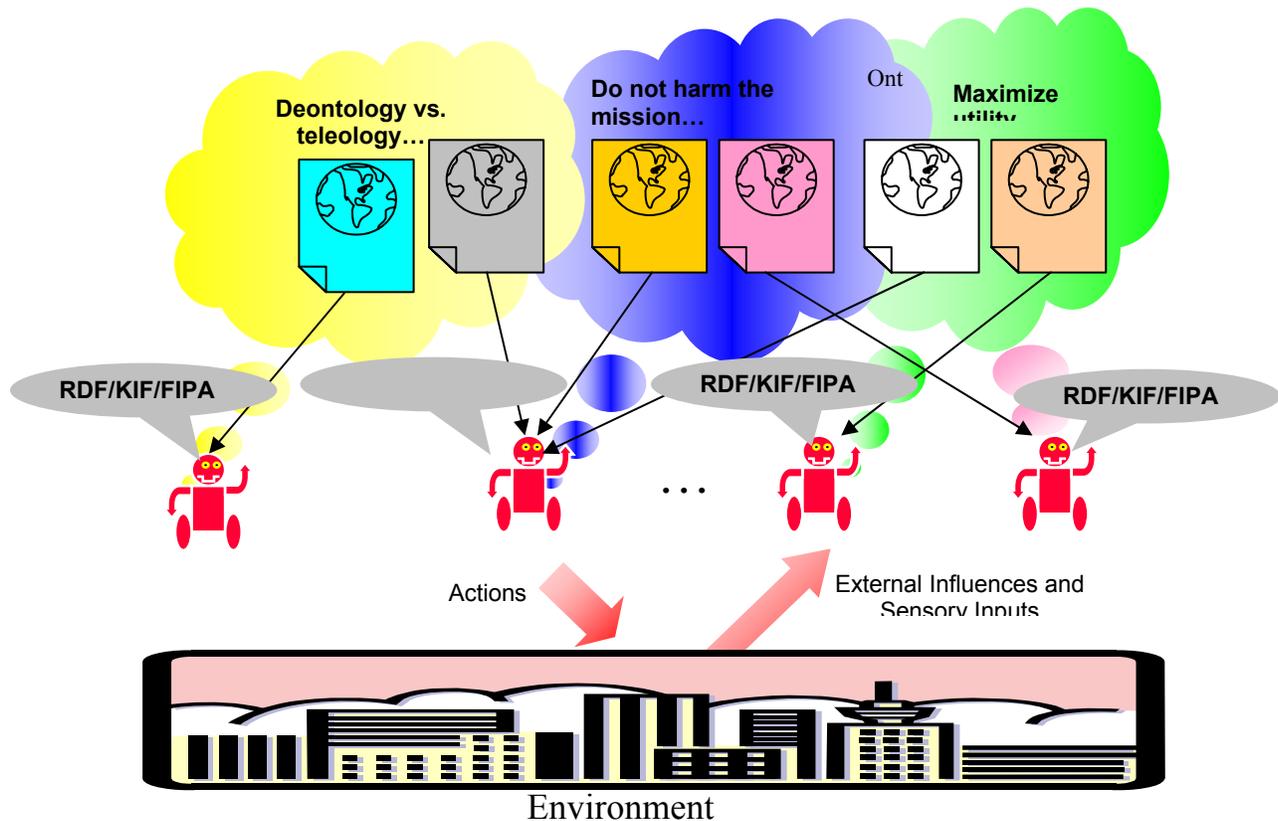


Achieving Comprehensive Mission Robustness

JOHN R. ROSE

University of South Carolina

An architecture for achieving robust autonomous decision making and task execution is proposed. A key feature of the proposed architecture is that robustness is achieved through massive decentralization and redundancy in planning and execution. This revolutionary approach to achieving mission goals relies on interaction as a fundamental construct. Competing proposals for satisfying tasks or sets of tasks are developed by fluid collaborating groups of software agents vying for resources so that the failure of one approach does not jeopardize overall mission goals. Competing proposals can be acted on in parallel when they do not interfere significantly with each other, but are pruned as necessary to conserve resources. This approach to agent behavior will be constrained by sets of agent societal laws similar to Asimov's laws of robotics. In accordance with embedded philosophical principles, agents will use decision theory in their negotiations to evaluate the expected utility of proposed actions and use of resources. This will result in planning and task execution that is dynamic, rational, massively distributed, occurs at multiple levels of granularity, and can be trusted. The proposed architecture is a revolutionary departure, both from current monolithic approaches to planning and from distributed approaches to task execution. It takes advantage of the differences in local perspective that exist in a massively distributed environment to formulate and execute plans that, while not perfect, will not have identical flaws, producing robustness through redundancy and diversity of approach. The benefit of this architecture to future NASA planetary and deep space missions is fourfold: (1) it will support missions of much greater complexity than are possible under the current model of earth-based control, (2) it will reduce costs by minimizing the amount of earth-based support required for missions, (3) it will essentially eliminate communication time lag as a significant factor in local task execution, providing the ability to react to and take advantage of serendipitous events, and (4) it will significantly enhance mission robustness. The development of the proposed architecture builds on developments in decision theory, agent societies, trusted systems, and ubiquitous computing.



Ultra-high Resolution X-Ray Astronomy using Steerable Occulting Satellites

GLENN D. STARKMAN

Case Western Reserve University

The diffraction limit for a 1m X-ray telescope is about 3 milli-arcseconds at 1keV, yet current X-ray telescopes achieve about 0.5 arcseconds, and future planned telescopes will do less well in order to collect more X-rays. Only X-ray interferometry has been presented as a possibility for higher resolution. We suspect that by transiting an occulting satellite across the field of view of an ordinary X-ray telescope, such as an envisaged Constellation-X unit, one could achieve unprecedented angular resolution, at or near the diffraction limit, for X-rays below approximately 100keV. This resolution would be limited only by photon flux and source stability. This improvement in resolution would be equivalent to moving from a 10cm optical telescope to the 10m Keck telescope. In the history of astronomy, such improvements have always heralded revolutions in understanding. We also believe that the technological challenges are not insurmountable. We therefore propose to determine whether using image reconstruction techniques, the theoretical angular resolution such a system would afford, would be sufficient to investigate reasonable models of known and expected X-ray sources, given their expected stability, and to make a preliminary determination of the technological hurdles to be overcome for the occulter. We anticipate this effort to require approximately six person-months of effort by a senior postdoctoral researcher, with the timely assistance of one undergraduate with experience in code development.

Architecture of Intelligent Earth Observation Satellite for Common Users in 2010-2020

GUOQING ZHOU

Old Dominion University

This proposal presents a revolutionary and advanced aeronautical and space concept that could dramatically impact how NASA develops and conducts missions within NASA Enterprises in the next 20 to 40 years. It will generate ideas for how the current NASA Agenda can be done better.

The proposed "intelligent" satellite system is a space-based architecture for the dynamic and comprehensive onboard integration of Earth observing sensors, data processors and communication systems to enable simultaneous, global measurement and timely analysis of the Earth's environment for real-time, mobile and common users in the remote sensing, photogrammetry and GIS communities. In the short run, this proposal only provides a highly visible, recognized and high-level entry point, specifically systems and architectures of "intelligent" earth observation satellites. In the long run, we will research how to implement the "intelligent" satellite, including technical problems, development phases, costs, and the steps of implementation. The proposed architectures and implementation strategies are a seamless integration of diverse components into a smart, adaptable, and robust Earth observation satellite system.

This proposal is based on a decade of teaching and research experiences in remote sensing, GPS, photogrammetry, GIS, and natural resources management.

