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NASA Innovative Advanced Concepts

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The NASA Innovative Advanced Concepts (NIAC) Program nurtures visionary ideas that could transform future NASA missions with the creation of breakthroughs — radically better or entirely new aerospace concepts — while engaging America's innovators and entrepreneurs as partners in the journey. NIAC projects study innovative, technically credible, advanced concepts that could one day "Change the Possible" in aerospace. NIAC supports innovative research through two phases of study, both competitively awarded. The Phase I studies are for nine-month efforts to explore the overall viability of visionary concepts. Phase II studies further develop the most promising Phase I concepts for up to two years, and explore potential infusion options within NASA and beyond. Since 2011, NIAC has funded 70 studies (60 Phase I and 10 Phase II). It is anticipated that five to seven new Phase II studies will be selected in August. This paper discusses NIAC's history and current role, and provides summary statistics about the recent selections.

Nomenclature

NASA	=	*National Aeronautics and Space Administration*
NIAC	=	*NASA Innovative Advanced Concepts (starting in 2011)*
NIAC	=	*NASA Institute for Advanced Concepts (prior to 2011)*
USRA	=	*Universities Space Research Association*
NEC	=	*NIAC External Council*
SSO	=	*Source Selection Officer*
STP	=	*Space Technology Program*
STMD	=	*Space Technology Mission Directorate*

I. Introduction

NIAC is unique! It is a program that values both technical acumen and imagination, inspired by curiosity and the quest for knowledge. We encourage innovators to be creative and attempt great leaps forward in aerospace endeavors. (NASA has other programs for "next-step" research.) NIAC calls for visionary concepts that may be expansive in scope, may inspire new classes of enabling technologies, and may feature disciplines outside of the mainstream aerospace fields. A good NIAC concept seeks to "Change the Possible" or offer revolutionary improvement.

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II. NIAC Goals and Objectives

NIAC supports innovative research through two phases of study. The Phase I awards are nine-month efforts to explore the overall feasibility and viability of visionary concepts. The follow-on Phase II awards further develop the most promising Phase I concepts for up to two years, and explore potential infusion options within NASA and beyond.

NIAC concepts must satisfy all of the following attributes:

- **An Aerospace Architecture, System, or Mission Concept**
    - Proposed with at least one clear application that contributes to NASA strategic goals and/or proposed with clear application(s) to the national space or aeronautics enterprise with potentially wider benefits
- **Exciting**
    - Enables an entirely new kind of mission, or great leap in capabilities
    - Worth studying now, even if far-term or high risk
- **Unexplored**
    - Concept is sufficiently new or different that the appropriate developmental step is initial definition and feasibility/benefit analysis
    - Study breaks new ground, changing the conversation about future possibilities or significantly contributing to science/understanding
- **Credible**
    - Technically sound – based on solid scientific/engineering principles
    - Plausibly implementable – should the proposed study demonstrate sufficient merit, there is at least one reasonable path for further development and eventual implementation (i.e., not requiring any extremely unlikely changes to NASA or U.S. budget, priorities, etc.)

A key feature of NIAC studies is they assess the concept in a space or aeronautics mission context — the main focus is determining feasibility and comparing properties/performance with those of current missions/concepts. This is more important than detailed analysis of the underlying phenomena or technology. Concepts that may support multiple missions must feature detailed analysis of at least one candidate mission application.

NIAC Phase I studies (approximately nine months and $100K) are for preliminary concept investigation. Toward that end, Phase I studies must:

- Develop the concept — the constituent technology/systems and operations should be identified, defined, or refined. Key properties should be investigated. Potential applications and paths for further advancement (of the overall concept and key elements) should be considered.
- Assess the concept in a space or aeronautics mission context — determining feasibility and comparing properties/performance with those of current missions/concepts should be the main focus. (This is more important than detailed analysis of the underlying phenomena or technology.) Concepts that may support multiple missions should discuss the range, but must feature detailed analysis of at least one candidate mission application.

NIAC Phase II awards (approximately two years and $500K) continue the exploration and development of revolutionary advanced concepts that have been initiated through a NIAC Phase I award. The primary goal of the Phase II effort is to study major feasibility issues associated with cost, performance, development time and key technologies. These results are aimed at providing a sound basis for NASA to consider the concept for further development and a future mission, substantiated with a description of applicable scientific and technical disciplines necessary for development.

Toward that end, Phase II studies are expected to:

- Continue to develop the concept studied in the Phase I award — refinements or advances identified in the Phase I effort are expected to be incorporated in the Phase II concept, but it must be essentially based on the Phase I award concept.
- Continue to assess the concept in a mission context — the main focus should be determining feasibility and comparing properties/performance with those of current missions/concepts. Concepts that may support multiple missions should discuss the range, but must feature detailed analysis for at least one candidate mission.
- Assess the programmatic benefits and cost versus performance of the proposed concept — show the relationship between the concept's complexity and its benefits, cost, and performance.

- Develop a pathway for development of a technology roadmap and identify the key enabling technologies

Since Phase II studies are nominally two years long, there is a Midterm Review ("Site Visit") at the end of the first year. Continued funding for the second year is contingent on successful demonstration of progress at the Midterm Review. To aid in the future infusion of the concept into NASA, technical representatives from possible target organizations (within and outside of NASA) are invited to the Site Visit.

III. NIAC History

A. Background

NASA was created on the premise of "doing those things, not because they are easy, but because they are hard."[1] It has since inception, and generally by necessity, sought out innovative ways to push the boundaries of technology and exploration. NASA believes that development of advanced aerospace technologies is crucial for the future exploration of the Earth, our solar system, and the universe. Innovative research increases both human knowledge and capabilities, and these can be applied to future questions and requirements. Additionally, new capabilities stimulate innovation, enabling more creative solutions to issues that are difficult to solve due to budget and schedule. Finally, investment in futuristic, innovative research has historically benefitted the nation as a whole on a far-reaching basis – up to and including generating entire new industries.

A broad, long-term approach to developing advanced space concepts and technologies will have many positive outcomes. One of the most immediate is that the citizens of the United States will have a more exciting science and exploration future, and a more robust capability for aerospace activities that can improve our competitiveness in international marketplaces, enable new industries, and contribute to economic growth. NASA advanced concepts efforts also serve as a spark to innovation that will ignite the technology-based economy, and stimulate increased science and mathematics literacy. NASA's research will provide a suite of revolutionary discoveries that could include major breakthroughs in energy generation, health, transportation, manufacturing, and environmental protection. Finally, NASA's achievements are recognized the world over as a symbol of our country's scientific innovation, engineering creativity, and technological skill.

B. The Institute

But how did the first NIAC get started? There was an Advanced Concepts office in NASA Headquarters in the mid 1990's, organized within the Office of Aerospace Technology (Code R) which reported on progress to NASA's administrator (Dan Goldin). Mr. Goldin decided that he wanted to reach out to creative people who perhaps were not directly in involved in NASA efforts, but still had good ideas about what could be done. NASA set out to create what became the original NIAC, established outside of NASA to reach outside of the "NASA culture." The NASA Institute of Advanced Concepts (known widely as "NIAC" but referred to herein as "the Institute" to avoid confusion with the current program), was led by Dr. Robert Cassanova and started in 1998 under a contract to Universities Space Research Association. NIAC was initially managed within NASA's Code R, supporting all the NASA directorates. As NASA reorganized, management oversight was transferred, until finally it was in the Exploration Systems Mission Directorate. The Institute continued until its termination in August 2007. Throughout its nine years, Sharon Garrison was the Institute's Contracting Office Technical Representative (COTR). She managed the interface of the Institute with the NASA directorates.

It was run as a virtual institute, which, befitting its name was an innovative operational construct at the time. All calls for proposal were done through email and internet postings, and all proposals were received and evaluated electronically (though a face-to-face panel was formed to integrate and discuss the evaluations, and to advise Dr. Cassanova on the selection of awards.) The Institute had two tiers of studies, loosely modeled after the Small Business Innovative Research Program. Award winners were designated "NIAC Fellows" to foster a sense of community and collaboration. Phase I studies were six months, approximately \$50K, and Phase II studies were two years and approximately \$400K. During its nine years of operation, the Institute received 1309 proposals and awarded 126 Phase I studies and 42 Phase II studies.[2]

The Institute was virtual in more sense than just the evaluation process. Its small leadership team was distributed around the country (Atlanta, Georgia; Arlington, Virginia; Boston, Massachusetts; Chicago, Illinois). Its Fellows were also distributed around the country. To maintain a sense of community and to foster interaction between Fellows and with the public, the Institute hosted two Symposia each year. A Fall Symposium was aimed at the newly selected Phase I Fellows, and was generally held in the Atlanta area. A Spring Symposium was the "flagship" conference, held at various venues around the country. It featured the Phase II Fellows and generally included keynote talks from distinguished speakers.

From its inception, the Institute also hosted a website, providing easy access to ongoing activities, status of solicitations, and links to presentations and final reports of its funded studies (which were required to be publicly releasable, with some allowance for small private attachments for proprietary content, as long as the publicly releasable version was clear and informative). Details of the Institute, the studies it funded, and the activities it supported can still be found on the USRA-supported website: http://www.niac.usra.edu/.

Finally, in 2005 and 2006 the Institute managed a small but vibrant Student Fellow program, created by its Deputy Director, Dr. Diana Jennings. Undergraduate students competed for a nine thousand dollar fellowship to pursue studies of advanced concepts. The students were invited to attend NIAC Symposia to present a poster session and a briefing on their findings. In all ten students were awarded Fellowships.

The Institute's legacy may well be summed up by its signature quote, attributed to Dr. Robert Cassanova and Sharon Garrison: "Don't let your preoccupation with reality stifle your imagination." In its nine years of operation, the Institute fostered an energetic and enthusiastic community of inspirational thinkers and innovative concepts. Selection as a NIAC Fellow became a mark of distinction, and their exciting concepts received significant publicity. Together, these features helped the Institute have an impact far beyond the size of its budget.

C. NRC Review

The Institute's 2007 termination occurred in a period when NASA was strongly focused on planning for a return to the Moon. In 2008, Congress directed NASA to commission a National Research Council (NRC) study to evaluate the Institute's performance and to make recommendations concerning whether the Institute should be reinstated. If so, the NRC was also asked to suggest changes that could increase its effectiveness.

The NRC responded with a report in 2009, "Fostering Visions of the Future"[3] that was highly supportive of the Institute, and recommended that NASA reinstate a NIAC-like entity, but suggested a few changes as well. The NRC endorsed the Institute's vision, scope, and selection process. The most substantial change was to open the process to NASA researchers. They also felt that Phase I studies funding should be greater ($100K) and longer (one year) and Phase II funding should be greater ($500 K). The NRC also challenged NASA to enable a better pathway for follow-on support for successful Phase II studies, with a specific recommendation that NIAC award a small number of large "Phase III" studies to demonstrate the concept under investigation.

D. OCT/STMD

With a new administration in 2009, NASA was poised for a change away from a dedicated lunar outpost and toward more emphasis on technology development that would lay the groundwork for future exploration missions. Among the changes implemented was the re-creation of a NASA Chief Technologist, this time with a more substantial supporting Space Technology Program infrastructure. A revived NIAC fit naturally into this, as an entry point for visionary new ideas.

In 2010, the Chief Technologist invited Dr. Jay Falker to NASA HQ to help with Space Technology formulation, and specifically to address the NRC recommendations about NIAC. Dr. Falker proceeded to establish the NASA Innovative Advanced Concepts (NIAC) program, hosted by the Space Technology Program in the Office of the Chief Technologist. The program name was modified slightly to reflect the fact that it would no longer be a purely external institute. But the acronym NIAC was preserved to send a clear signal that the new program would be true to the goals and ideals of the Institute.

NIAC adopted most of the recommendations of the NRC report. It opened funding to NASA employees, and teams with NASA employees. As the entry point in the Space Technology Program, it facilitated transition of NIAC studies to other NASA programs. It retained the same general evaluation process, relying heavily but not exclusively on non-NASA peer reviewers, and it increased Phase I and Phase II funding to the levels recommended by the NRC. As NIAC was now part of NASA's technology development "pipeline", no Phase III study structure was added. Instead, other, programs for further development (such as the Game Changing Technology Program) were stood up alongside NIAC to meet the spirit of the request of the NRC report's desire that NASA enable a better pathway for follow-on support of successful NIAC concepts.

In 2012 NASA more formally separated the Office of the Chief Technologist from the Space Technology Program, and in 2013 it elevated the Space Technology Program to Directorate level: The Space Technology Mission Directorate (STMD). Today, NIAC remains within STMD and continues its role as the entry point for innovative concepts that may someday "change the possible" in the words of its Program Executive, Dr. Jay Falker. Figure 1 is a NIAC organization chart.

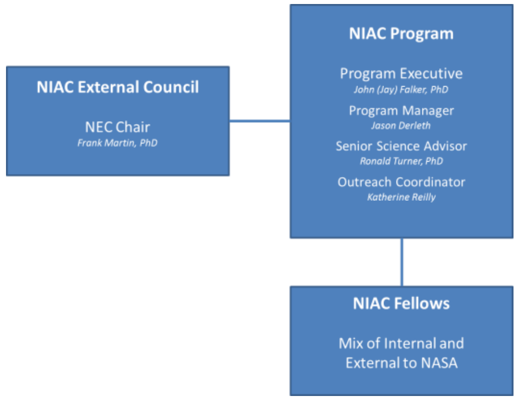

Figure 1. NIAC Organization Chart

Note that NIAC retains a feature of the original Institute, an External Council, consisting of distinguished individuals whose role is to assess how well NIAC is meeting its vision and goals and to make recommendations to the NIAC Program Manager. The NIAC External Council (NEC) attends NIAC's public symposia and meets formally after each symposium to discuss any issues and to provide feedback. Dr. Robert Cassanova was the NEC Chair from 2011 to 2013. The current Chair is Dr. Frank Martin.

IV. NIAC Study Selection Process

A. Phase I Proposal Evaluation Process

NIAC studies are selected by merit as determined by a thorough peer review process. Anyone is eligible to submit a NIAC Phase I proposal (while NASA can fund only US organizations…foreign entities may propose but if selected the study will be conducted on a "no exchange of funds" basis).

The Phase I and Phase II solicitation process are shown in Figure 2.

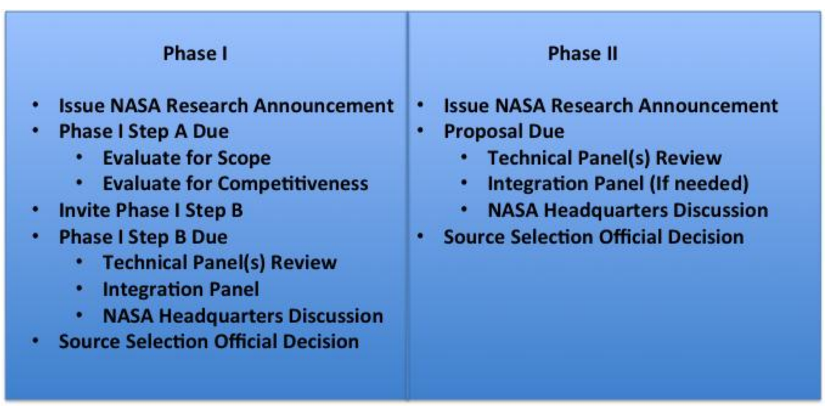

Figure 2. Phase I and Phase II solicitation Process

NIAC Phase I selection begins with the release of a call for proposals through the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) (http://nspires.nasaprs.com). Scope is a tricky subject for NIAC, so we use a two-step process to avoid wasting the proposers, and subsequently the reviewers, time. Step A proposals are very brief descriptions of the concept. The NIAC Program Office reviews the Step A proposals and invites the most promising of the eligible concepts to submit a more thorough Step B proposal.

The full scope of NIAC Phase I concepts was described earlier. Other programs at NASA have the responsibility to explore and develop new technologies, materials, or subsystems. A continuing challenge in the NIAC Program is to articulate the unique niche that NIAC fills: the opportunity to explore bold new ideas that may fundamentally change the way NASA embarks on future missions, by looking at concepts at the mission or system level. In line with the approach used by the Institute, to further clarify what NIAC is looking for in a study, NIAC solicitations also note what the program is *not* looking for. Table 1 is the list as published in the 2013 NIAC Call for Proposals. Out of scope examples, which are not considered for award, include narrowly focused technology studies, proposals for scientific studies, and broad literature reviews of advanced technology or approaches.

- **Are not an Aerospace concept. A proposal must address NASA goals or wider benefits with space or aeronautics applications.**
- **Are unclear about the concept being proposed or its potential mission application. A NIAC proposal must identify the specific aerospace concept, and how it might one day be used to enable or radically improve at least one candidate mission. It is not sufficient to identify only a relevant problem and/or a tool, process, or approach to find a solution or determine further steps.**
- **Revisit concepts that, while not implemented, have been studied in detail in the past, without proposing an essentially new factor that substantially differentiates the proposal from prior efforts.**
- **Are incremental. There are many other programs that foster continuing research, evolutionary technology development, or "next-generation" systems with modest improvements. NIAC seeks breakthrough concepts that could redefine the future possibilities for NASA.**
- **Are not technically credible. NIAC deliberately seeks unorthodox, high risk, and revolutionary concepts, but proposals that appear to be in conflict with the known laws of physics or basic engineering principles must offer a sufficiently credible defense or will be dismissed as unworthy of serious consideration.**
- **Are not programmatically credible. NIAC deliberately seeks unorthodox, high risk, and revolutionary concepts, but proposals that appear to have no practical implementation path (apparently insurmountable cost or other barriers) must offer a sufficiently credible defense or they will be dismissed as unworthy of serious consideration.**
- **Are narrowly focused on technology, subsystems, or investigations of smaller scope (e.g., components, instruments, materials). While some degree of focused analysis may be necessary to establish the credibility of the underlying innovation, it should not be to such a degree that it interferes with a study goal to establishing the concept feasibility in an appropriate mission context.**
- **Primarily perform experiments, analysis, or theoretical derivations; Characterization of material properties, studies of advanced artificial intelligence algorithms, or tests of physical theories, any of which may lead to breakthroughs, are of value, but not within the NIAC scope. NIAC studies must focus on mission concepts.**
- **Primarily develop tools or processes to improve design, development, decisions, etc. These might one day lead to great concepts, but the focus of NIAC is development and assessment of the concepts themselves.**

Table 1. In line with the NIAC goal to foster truly revolutionary concepts, calls for proposals identify types of studies that are outside NIAC's scope. Proposals that fit into these categories are not considered for award.

There is great enthusiasm within the aerospace community for exploring revolutionary ideas. As a result, there is a tremendous response to NIAC's calls for studies. Since NIAC can only fund a fraction of the hundreds of proposed concepts, the first step in the evaluation process is a determination by the Program Office of whether each proposal meets NIAC's scope, as explained in the solicitations. Proposals that fail are assigned a primary, and in some cases also a secondary, reason why it was determined to be out of scope. In the FY 2013 Call for Step A Proposals, 404 out of 514 proposals were deemed Out of Scope. Table 2 shows the percentage of times each of the out of scope criteria was invoked as a Primary or Secondary reason for screening out a proposal. Over one third of the Step A proposals (37 percent) were narrowly focused on technology without putting the application of the technology in a mission or system context. For the proposals that had a secondary reason for screening out, nearly one third were proposing incremental increases in capability. (Largest counts shown in bold for emphasis.)

FY 2013 Step A Proposals	Percent of Instances		
Out of Scope Reason	Primary	Secondary	Combined
Narrowly focused technology	**36.9**	10.4	**28.7**
Incremental	14.4	**31.3**	19.6
Unclear concept	13.4	14.3	13.7
Experiment or research	11.4	14.3	12.3
Previously studied	11.1	13.7	11.9
Not technically credible	5.4	6.0	5.6
Tool or process	3.7	2.7	3.4
Not programmatically credible	2.2	6.6	3.6
Not aerospace	1.5	0.5	1.2

Table 2 There were 404 Step A Proposals deemed out of scope. This table shows the percentage of times out of the 404, that each of the out of scope criteria was invoked as a Primary or Secondary reason for screening out a proposal. Of the 404, 182 also had an assigned secondary reason. The last column combines all the Primary and Secondary reasons into one list of 586 reasons.

A further screening of the remaining Step A proposals looks at the potential competitiveness of the concept, which is based on the proposed concept's potential impact if fully successful and the clarity with which the proposal describes the essential elements of the concept and addresses the concept's plausibility and feasibility. Principal Investigators of the highest rated eligible proposals are invited to submit a more complete Step B proposal. In FY 2013, 75 out of the 109 eligible Step A submissions were invited to Step B and 73 responded with proposals.

NIAC Phase I Step B proposals are assigned to Technical Panels for review. The number of panels is determined by the number and technical mix of the proposals: in FY 12, there were five technical panels, in FY 13 there were three. The technical panels are charged to evaluate the proposals against the review criteria. In FY 13 these criteria, as published in the NASA Research Announcement, were:

- **Potential of the Concept**
    - Is the proposed aerospace concept exciting, unexplored, and credible? Does the proposal include at least one mission application that addresses NASA's goals or the needs of wider space or aeronautics enterprise? Does the concept enable an entirely new mission or great leap in capabilities (often high risk or far term, but worth studying now)? Are the concept's feasibility or properties not known, not readily determined, nor adequately addressed in prior studies? Is the concept technically sound with at least one plausible implementation path? Does the proposal include a justification (at the "back of the envelope" level) to support the concept's credibility and feasibility?
- **Strength of the Approach**
    - Does the proposal present a sound technical approach to accomplish the proposed research objectives? Does the proposal demonstrate an understanding of the major issues? Does the study approach identify and address any significant obstacles or objections to the concept? Is the proposed team qualified to complete the proposed Phase I study? Is the proposed study effort feasible within the proposed cost and planned with an appropriate schedule?
- **Benefits of the Study**
    - To what extent is the proposed study likely to significantly advance our understanding of the feasibility and benefit of the concept? (This is particularly important if related concepts have been studied before.) Is the study likely to have any wider benefits? (Some examples include engaging the public, making a contribution to the national economy, or producing potential non-aerospace spin-offs.) Are there likely intermediate contributions from the study, offering immediate scientific or engineering benefit, regardless of the success of the underlying concept? Is this inspiring or pioneering – a truly new approach, an early attempt to apply approaches from other domains to aerospace, or otherwise different thinking that might lead to new opportunities?

The third criterion deserves some elaboration, as it is unique to the NIAC process. In keeping with NIAC's goal to "change the possible" it is important that the outcome of the study itself have value, before the concept would have time to be implemented. This has both positive and negative aspects. Positive influences would include significantly changing the dialogue about a proposed concept…would the study focus attention on the idea, would it lead others to consider the approach more critically? Other positive impacts may include leading to the start of immediate spinoffs, perhaps outside of the aerospace community. On the negative side, a proposal would be downgraded if it were judged that the study would not contribute substantially to a body of existing studies of closely related concepts. If an idea is innovative in the sense that it has promise yet has not been implemented, but a large body of work has been done to explore that concept, then further study would have less benefit.

The technical panels consider the proposals and submit a technical evaluation against the criteria resulting in an overall technical score. They then submit a final overall recommendation to NASA: how strongly would they recommend funding the proposed study? This advice is guided by the technical scores, but need not be constrained by them. While rare, a panel may issue a recommendation that is higher or lower than the technical scores would suggest, provided with an accompanying justification.

The final Technical Panel evaluation forms the basis of all further deliberation and discussion, and also provides the formal evaluation feedback to the proposers (in most cases exactly as received; in rare cases subsequent discussion adds a further notable comment). No subsequent step ever changes any technical review. However, there are additional steps in the selection process, to include:

- **An Integration Panel** — needed when NIAC has multiple Technical Review Panels, in Phase I. This looks across the evaluations from each, and if needed recommends shifts in the final recommendations only. This is needed if some proposals appear to be out of family in terms of merit or quality from the Technical Review, compared to the others that received similar ratings. The Integration Panel also takes the first look at the final list as a portfolio, and votes to recommend funding order of the highest rated proposals.

- **HQ Discussion/Selection** — first, NIAC checks with other NASA programs for potential duplication or synergy. NIAC seeks comments only, not further technical review, scoring, or sorting. These inputs may or may not affect the final recommendation order sent to the Source Selection Officer (for NIAC this is the STMD Associate Administrator, or his Deputy if designated), but all Technical Panel scores are presented, unchanged. The Selection Officer also considers political factors and overall STMD portfolio balance, and makes the final selection. Technically, all of NIAC's review inputs are merely advisory — but to date NASA has demonstrated confidence in and respect for the NIAC review process, and implemented very few changes in final awards.

B. Phase II Proposal Evaluation Process

NIAC Phase II selection also begins with the release of a call for proposals through NSPIRES. However, the eligibility is substantially different. Only Fellows who have completed a Phase I study may submit a Phase II proposal, and the study must be substantially based on the Phase I study results. Because of its termination, Fellows of the Institute may also submit Phase II proposals if the concept was not selected for Phase II or if it was selected but the Phase II study was cancelled before it could be completed. Again, the concept must be substantially based on the prior Phase I study.

The proposed studies are submitted to one or more technical panels for review. Since these concepts have already been selected against the NIAC scope criteria, and since the studies are aimed at providing a sound basis for NASA to consider the concept for further development and a future mission, the evaluation criteria are different from that of the Phase I studies. As posted in the FY 13 Phase II NASA Research Announcement, the evaluation criteria are:

- **Potential Impact (Value)**
  - To what extent are the benefits of the proposed concept adequately described and understood?
  - How significant is the impact of the proposed future concept on the aerospace development community?
  - Based on the results of the Phase I study, how well 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 a future mission or program?
- **Technical Merit**
  - How well is the concept substantiated with a description of applicable scientific and technical disciplines necessary for development? Has the Phase I work shown that the concept is technically viable?
  - How well does the proposed study explore the relationship between the concept's cost, risks, performance, development time, and relevant key technologies?
  - Has a pathway for development of a technology roadmap been adequately described? Is there a mechanism for identifying the enabling technologies?
- **Suitability of Work Plan, Team, Schedule, and Budget**
  - To what extent does the proposed work plan complete, reasonable, and appropriately balanced?
  - To what extent does the proposed study team have sufficient technical knowledge and capabilities for completion of this project?
  - Is the proposed schedule sufficient to carry out the effort?
  - Is the proposed budget sufficient to carry out the effort?

It is likely that the Phase I evaluation criterion on the Benefits of the Study will be incorporated into future Phase II evaluation criteria.

The Phase II Technical Panel(s) products are similar to those of Phase I Technical Panels: detailed evaluations and advice on funding priority. If there is more than one Technical Panel, then an Integration Panel is formed, with the same charge as the Phase I Integration Panel. In FY 13 there was only one Technical Panel to review 27 proposals, so there was no need for an Integration Panel.

The Phase II Technical/Integration Panels are followed by steps similar to the Phase I process.

V. Overview of Funded Projects

Since 2011, NIAC has funded 70 studies (60 Phase I and 10 Phase II). It is anticipated that five to seven new Phase II studies will be selected in August 2013. Table 3 shows the number of awards by Fiscal Year and by Phase

(I or II). Note that the decrease in the number of Phase I studies is largely a result of the increased number of Phase II studies (which last two years), and is not a reflection of a decrease in over-all NIAC funding. It is anticipated that the number of Phase I and Phase II studies will reach a generally steady state close to that selected in FY 13.

	New Phase I	New Phase II	Continuing Phase II
FY 2011	30	-	-
FY 2012	18	10	-
FY 2013	12	5-7 (anticipated)	10 (anticipated)

Table 3. Number of NIAC Phase I and Phase II awards by fiscal year.

Figure 3 shows the breakdown of total NIAC awards (Phase I and Phase II) through mid-August 2013. The chart on the left shows the total number of awards, while the chart on the right shows the approximate dollar total awarded (at \$100K for each Phase I and \$500K for each Phase II). They are grouped by the Principal Investigator's (the Fellow's) organization, so the dollar distribution does not reflect funds that may have been subcontracted or otherwise allocated to other organizations. The category "NASA" includes all NASA Centers, including the Jet Propulsion Laboratory. The category "Industry/Other" includes a variety of organization types, including large and small businesses, not-for-profit and research institutes, etc. Table 4 is a further breakdown of Phase I and Phase II awards by organization and Fiscal Year.

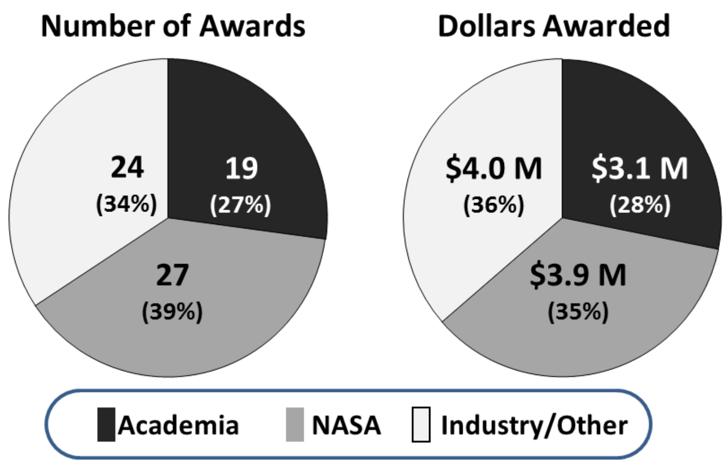

Figure 3. A breakdown of total NIAC awards (see text for additional details).

	Phase I			Phase II		
Awarded	Academia	NASA	Industry/Other	Academia	NASA	Industry/Other
FY11	10	11	9			
FY12	3	8	7	3	3	4
FY13	3	5	4	(Pending; anticipate 5-7)		
Total	16	24	20	3	3	4

Table 4. A breakdown of Phase I and Phase II awards by organization and Fiscal Year

NIAC awards have been distributed throughout the United States: 19 states are home to one or more NIAC Fellows. Figure 4 shows where they are located (as of August 2013).

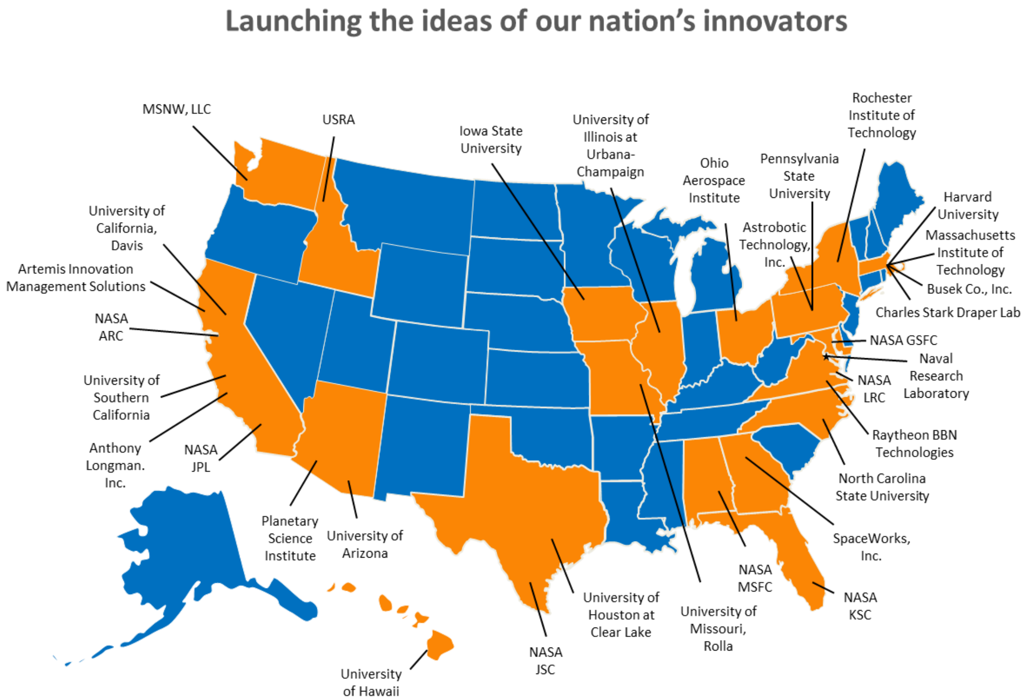

Figure 4. Locations of NIAC Fellows.

A full list of NIAC funded studies, along with links to final reports and symposium presentations, is available on the NIAC website: http://www.nasa.gov/directorates/spacetech/niac/NIAC_funded_studies.html

VI. Outreach

The NASA Innovative Advanced Concepts program has a long history of exciting a diverse audience across the U.S. and abroad. NIAC engages audiences from the technical and scientific communities, independent researchers and government institutions, industry, academia, and the general public, covering concepts from numerous scientific disciplines via a wide range of media outlets. NIAC communications, outreach, and media also engage students (from middle school through graduate school) – with educational outreach that inspires a new, younger audience to consider Science, Technology, Engineering, and Mathematics (STEM) careers as they learn of NIAC Fellows' creative solutions to technical problems, breakthroughs and their new technologies.

NIAC followers have learned that being creative and taking risks is what defines this unique program, and that NIAC innovations could potentially fuel economic growth, the creation of new industries, companies, jobs, products and services, and the global competitiveness of U.S. industries.

NIAC's media efforts include television, radio, national events, online media programs, and public outreach resources. These efforts are designed to introduce millions to the most exciting advanced aerospace concepts and technologies. Those in turn are enabling new approaches toward NASA's current and future missions, many that today we can't even imagine.

A. NIAC Website

NIAC's website (www.nasa.gov/niac) is the primary method of communicating program information to the public. Thousands of followers use it to stay current on NIAC upcoming events, funded studies, solicitations, presentations, press releases, external media, videos, podcasts, and an image gallery of Fellows' concepts. Each NIAC Phase I and Phase II Fellow is given a web page devoted to their study. Each page includes a brief abstract, Symposia presentations, graphics and related visual media, and the final report. Past NIAC Symposia have also been archived to the site via LiveStream. NIAC staff and External Council biographies are available there as well, and links to other NASA Space Technology programs are also conveniently accessible.

B. Radio Programming

To date, sixteen NIAC broadcasts have aired on *Innovation Now Radio* (http://www.innovationnow.us/) through the National Institute of Aerospace. Each broadcast gives listeners a front row seat to hear compelling stories of revolutionary ideas, emerging technologies, and the people behind the concepts that are shaping our future. The program airs each weekday as new 90-second episodes explore how these innovations benefit our lives and impact our world.

Numerous NIAC Fellows have also been interviewed and aired on *Planetary Radio* (http://www.planetary.org/multimedia/planetary-radio/), supported by The Planetary Society. Each week, Planetary Radio visits with a scientist, engineer, project manager, astronaut, or writer who provides a unique and exciting perspective on the exploration of our solar system and beyond.

C. NIAC in the News

NIAC and its Fellows are privileged to receive extensive press coverage. Hundreds of media articles have appeared detailing NIAC Fellows' concepts, and NIAC's media footprint continues to grow each year. A small sampling of publications that routinely report on NIAC studies are: NBC News, Popular Science, The New York Times, The Washington Post, Space.com, AIAA Daily Launch, Aviation Week, MSNBC, Discovery News, Universe Today and hundreds more at major universities, and newspapers throughout the U.S. and abroad.

D. NIAC Social Media

Further extending NIAC's visibility to the general public, NIAC concepts have been placed on NASA's social media sites which have a large audience of followers and subscribers.

Social Media Site	URL	Audience: August, 2013
Facebook	http://www.facebook.com/NASATechnology	7245 likes
Twitter	http://twitter.com/NASA_Technology	133,310 Followers
YouTube	http://www.youtube.com/NASATelevision	320,283 subscribers

Table 5. NIAC Social Media Participation

E. NIAC Patent Applications

NIAC tracks patent applications and patents produced by its Fellows during their funded studies. Table 6 shows the Fellows who have submitted patent applications.

Principal Investigator & NIAC Award	Institution	Patent or Patent Application	Future Work or Spin-Off Technology
Kevin Duda Ph I & Ph II 2011-2012	The Charles Stark Draper Lab & MIT	U.S. Patent Application "Exoskeleton Suit for Adaptive Resistance to Movement" (Nov. 30, 2011)	Test at JSC Summer, 2013, Possible collaboration with Mayo Clinic, rehabilitation, future test on ISS?
Sheila Thibeault Ph I 2011	NASA Langley Research Center	Sauti, Godfrey; Park, Cheol; Kang, Jin Ho; Kim, Jae-Woo; Harrison, Joycelyn S.; Smith, Michael W.; Jordan, Kevin C.; Lowther, Sharon E.; Lillehei, Peter T.; and Thibeault, Sheila A.: Boron Nitride Materials and Boron Nitride Nanotube Materials for Radiation Shielding. Disclosure of Invention, LAR-17902-1. Patent Application, 13/068,329, filed on May 9, 2011.	TBD
Sheila Thibeault Ph I 2011	NASA Langley Research Center	Thibeault, Sheila A.; Fay, Catharine C.; Sauti, Godfrey; Kang, Jin Ho; and Park, Cheol: Radiation Shielding Materials Containing Hydrogen, Boron, and Nitrogen. Disclosure of Invention, LAR-18134-1. Provisional Patent Application, filed on November 16, 2011.	TBD
Wendy Boss & Amy Grunden Ph I & Ph II 2004-2007	North Carolina State University	Provisional patent 'Grunden AM, Sederoff HI, Boss WF. 2012. Transformed Plants Expressing Archaea Superoxide Reductase (provisional patent # 5051-813PR)'	Based on the technology developed from our Phase I and II NIAC studies and have interest from several agriculture biotechnology companies for licensing this technology.

Table 6. NIAC Patent Applications.

F. NASA Technology Day on the Hill

Each year, hundreds of researchers across NASA are nominated to attend NASA's Technology Day on the Hill, to showcase a few examples of NASA space technology development for Congress. This year, NIAC was honored to have two representatives: 2012 Phase II Fellows William Whittaker and Behrokh Khoshnevis. They presented their concepts and designs to over 500 people who attended the full day event. Among the attendees were U.S. Senators, Representatives, and the NASA Administrator.

G. Annual NIAC Symposium

Each year, NIAC holds a public Symposium at different locations throughout the United States. The purpose of this event is for the Phase I and Phase II Fellows to introduce their concepts, to present current research findings, report on progress, and discuss their future plans. Additional time is built into this required meeting to allow the Fellows to collaborate with each other to build a multidisciplinary community. The collaborations that have occurred at past Symposia between Fellows from differing scientific backgrounds have even developed into partnerships that use a blend of different technologies.

The meeting receives approximately 150 live attendees, plus roughly 4000 virtual participants via LiveStream. NIAC Symposia are archived for 2012 and 2013 Symposia can be viewed via LiveStream at: http://www.livestream.com/niac2012 and http://www.livestream.com/niac2013.

H. Innovative Partnerships & Collaborations: STEM Education at Science & Technology Museums

A unique collaboration has developed between the NASA Innovative Advanced Concepts (NIAC) program and the Chicago Museum of Science and Industry. It has produced an educational lecture series, "From Science Fiction To Science Fact" that has successfully introduced NIAC Fellows' research to youth, underrepresented students, and the general public to STEM-related innovations that inspire.

On March 16, 2013 two award-winning scientists, NIAC Fellows Dr. Gregory Scott and Michael V. Paul, presented their work to a large audience of teachers, students and families. Dr. Scott is with the United States Naval Research Laboratory and has a Ph.D. in space robotics. His research focuses on mini-bots powered by bacteria. Michael Paul is a space systems engineer with experience on systems flown in Earth's orbit, in to Mercury, and out to the farther reaches of our solar system. Michael is leading the Pennsylvania State University's Applied Research Laboratory efforts toward space mission leadership in the emerging private space exploration industry. Both researchers received Phase I funding from the NASA Innovative Advanced Concepts program.

NIAC Fellows also engaged with MSI's *Science Minors and Science Achievers Youth Program*. The Museum of Science and Industry's *Science Minors and Science Achievers* youth development programs provide out of school time STEM learning experiences for high school aged youth from across the Chicago area. These programs exemplify the Museum's commitment to serving high needs communities and providing access and support for youth from backgrounds traditionally underrepresented in STEM fields. The Science Minors and Achievers programs are designed to engage youth participants in science and engineering content, support them in communicating what they are learning to the Museum's public audiences, and prepare them for college and to consider STEM careers. Through NIAC's partnership with MSI, the youth have gained the opportunity to interact with the researchers selected as NIAC Fellows. These interactions have included discussions with the Fellows about their areas of expertise, as well as their individual careers paths. In addition, the youth have had the unique experience of presenting their projects to the Fellows, getting direct feedback from NASA science and engineering professionals.

NIAC looks forward to continuing this partnership to inspire the next generation of explorers and innovators. A lecture with two additional NIAC Fellows is in development for Spring, 2014. Additionally, due to the success of this outreach event, NIAC will be expanding the program to connect NIAC Fellows' research to their local science and technology centers throughout the United States.

VII. Conclusion

There have been many aerospace research and technology programs, inside NASA and around the nation, but NIAC truly is unique. While scientists and engineers are usually constrained to careful, incremental steps, this program invites researchers to be bold and imaginative. NIAC is helping to change aerospace conversations, expand NASA's vision, excite the general public, and inspire the next generation to dream and dare ever further.

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