Aeronautics Research Mission Directorate Seedling Fund 2011 Overview and Annual Report

January - December 2011

The Aeronautics Research Mission Directorate (ARMD) Seedling Fund, established in 2011, systematically invests in early-stage innovative ideas for aeronautics from within the NASA civil servant workforce.

2011 AT A GLANCE

By The Numbers

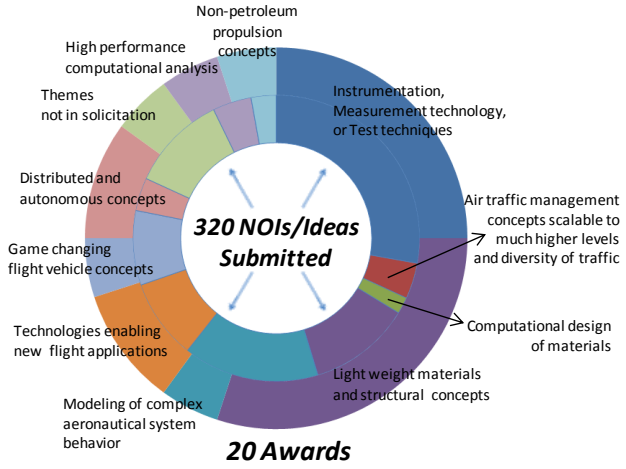
320	Innovative ideas submitted/NOIs
239	Civil servants submitted ideas
52	Proposals developed from innovative ideas
20	Awards made
10	Solicitation themes
8	NASA Centers participated
0.6	Percent of ARMD budget

Milestones

As of December 31, 2011

April 4, 2011	Call for Proposals released
April 18, 2011	Notice of Intent submissions closed
May 9, 2011	Notice of Intents selected to continue to the Proposal phase announced
May 23, 2011	Proposal submissions closed
June 22, 2011	2011 ARMD Seedling awards announced
July 1, 2011	Start of 2011 Seedling tasks

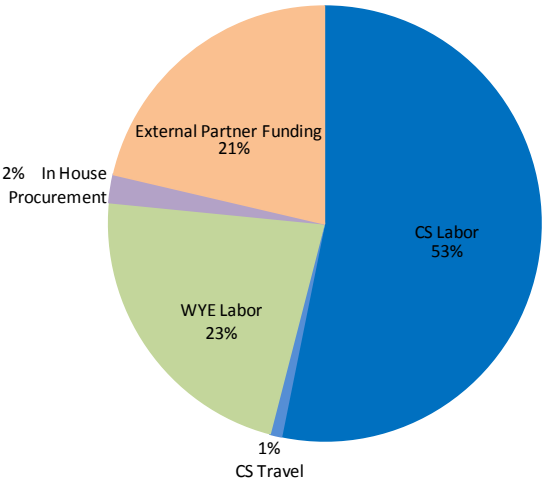
By Solicitation Theme



Inner circle shows the distribution of the 320 Ideas Submitted (or NOIs) and the outer circle is the distribution of the final 20 awards by solicitation theme.

2011 Spending Plan

The operating budget of $3 million was split equally between the 20 proposals. The PIs requested the following split among team members.



SEEDLING AWARD PROCESS

The objective of ARMD Seedling Fund is to explore novel concepts, new processes, and game-changing technologies with potential to either mature into the fundamental ARMD research programs or to launch new avenues of aeronautics research. This is accomplished by funding annual, NASA–internal solicitations of short-duration studies that are typically less than $150,000.

In Fiscal Year 2011 (FY11), the first ever ARMD Seedling solicitation was held. The solicitation was publicized at all NASA Centers. The complete solicitation was accomplished via the secure website https://armd-seedling.arc.nasa.gov. The documents associated with the solicitation continue to be located on the website:

- Seedling Fund Call Letter for FY11
- Seedling Fund Scope for FY11
- Seedling Fund Overview
- ARMD Program and Project Overview
- National Aeronautics Research and Development Plan-2010

The Oversight Committee had developed the following 10 themes (solicitation high interest areas) for the 2011 solicitation.

- Air traffic management concepts and technologies that are scalable to much higher levels and diversity of traffic
- Computational design of materials to meet specified application requirements and/or reduce the need for testing to characterize material properties
- Distributed and autonomous concepts for aviation systems
- Game-changing flight vehicle concepts
- High performance computational analysis concepts applied to aeronautics. Specific applications that would allow real-time interaction between simulated results and physical experiments.
- Instrumentation/measurement technology/test techniques for aeronautics
- Light weight materials and structural concepts
- Modeling of complex aeronautical system behavior and interactions
- Propulsion concepts based on non-petroleum energy sources
- Technologies that would enable new applications of flight

The scope allowed for proposals that address other high-interest ARMD areas or included innovative and visionary aeronautical concepts not addressed in the solicitations 10 identified themes.

Evaluation and selection was a two step process with a one-page Notice of Intent (NOI) followed by a three-page proposal for the selected NOIs. 320 complete NOIs were received from 8 NASA Centers. Each Center's NOIs were evaluated by the Center's Point of Contact (POC). The Center POCs prioritized them within their Center using their own processes and the evaluation criteria provided in the Overview document. All Center POCs provided a list of their top twenty ranked NOIs. The ARMD Senior Technical Advisor (STA) reviewed all NOIs and their Center rankings to select the top 53 NOIs. This step allowed the STA, who has a wider ARMD perspective, to select proposals that may not be a high priority from a Center's perspective but may be from an ARMD perspective.

The proposers of these 53 NOIs were asked to develop full proposals for submittal. One of them chose not to submit because of International Traffic in Arms Regulations (ITAR) issues. The 52 proposals were evaluated, using the evaluation criteria of the Overview document, by 14 reviewers from four ARMD Centers. The Review Panel chose to forward the list of proposals in average rank order, i.e., the average of all the ranks provided by reviewers who had no conflict of interest with that specific proposal.

The Oversight Committee then gave further guidance and asked the STA and Seedling Fund Manager to go over the top 36 proposals and re-rank them based on the guidance factors. The proposals were re-ranked and three pairs of cases were identified where the technical content of the pair of proposals was quite similar. Given this information, the Oversight Committee chose to accept the re-ranked top 20 proposals. In three cases where a pair of proposals was very similar, the Committee decided to accept only the highest ranked proposal among the pair in order to maximize the diversity of Seedling awards.

AND THE AWARDS GO TO …

Twenty NASA civil servants received awards of $150,000 for research efforts lasting 12 months. The Seedling Principal Investigators are responsible for actively managing their task work and the required deliverables. Each of the Centers will provide the requisite management over the Principal Investigators to ensure successful task performance.

Principal Investigator	NASA Center	Seedling Title	Discipline Area	Where Idea Could Be Applied	Objective
Glen S. Bigelow	GRC	Single Crystal High-Temperature Shape Memory Alloys	Materials	Shape memory alloy based actuator	Establish the feasibility of growing single crystal shape memory alloys that will provide greater shape memory and superelastic capability compared to the polycrystalline shape memory alloys. This will allow actuation of large aircraft primary control structures with the benefit of significantly reducing weight and increasing performance.
Jay M. Brandon	LaRC	Nonlinear Aerodynamics Modeling using Fuzzy Logic	Aerodynamics	Model the flight envelope	Develop system identification approach without a priori specification of model structure for highly non-linear and multi-variable aerodynamic response of aircraft in flight to enable efficient, autonomous wind tunnel and flight testing of future vehicles.
Martin J. Brenner	DFRC	Controller Performance Evaluation of Fly-by-Feel Technology	Aerodynamics	Unmanned aircraft systems autonomous sensing and control	Provide technical basis for determining the extent of performance improvement of the Fly-by-Feel approach under operational flight conditions in comparison to conventional flight control. Fly-by-Feel will maximize aircraft stability and performance across a wide range of conditions wherein the aircraft autonomously and intelligently senses the aerodynamic environment and efficiently adapts the aircraft structure and control surfaces to suit the mission objectives.
John W. Connell	LaRC	Novel Bonding Methodologies Toward the Attainment of Primary Bonded Aircraft Structure	Materials and Structures	Titanium bonded structures	Develop an environmentally friendly, reliable, and reproducible surface treatment for Titanium adhesive bonding methodologies that will lead to reduced weight and complexity in aircraft manufacturing.
Paul M. Danehy	LaRC	Fluorescence-Doped Particles for Simultaneous Temperature and Velocity Imaging	Measurement Technology	Non-toxic wind-tunnel testing	Develop and test environmentally friendly particles for laser Doppler velocimetry and particle image velocimetry that will allow simultaneous temperature and velocity measurement, measurements closer to the wall than with non-fluorescent particles, and will provide streakline information during wind tunnel testing.
James A. DiCarlo	GRC	Ultra High Temperature Silicon Carbide Fiber	Materials	Hypersonic leading edges, turbine vanes and blades	Develop and demonstrate a cost-effective production of Ultra High Temperature Silicon Carbide fiber with high structural capability up to 3000^{0}F that will lead to minimally-cooled or un-cooled gas turbine engine components and re-usable hypersonic leading edges.

Frederick W. Dynys	GRC	Nano-rod Piezoelectrics for Icephobic Surfaces	Materials, Safety	Icing mitigation	Demonstrate feasibility of using piezoelectric nano-rods in conjunction with super hydrophobic surface technology to eliminate ice formation on solid surfaces. This will improve safety by reducing risk associated with atmospheric icing and reduce or eliminate de-icing costs and time.
Jeffrey I. Eldridge	GRC	Luminescence-Based Temperature Mapping at Turbine Engine Temperatures Using Breakthrough Cr-Doped GdAlO3	Measurement Technology	Engine temperature measurement	Develop a capability to make temperature measurements using Cr-doped GdAlO3 broadband luminescence decay and demonstrate the exceptional suitability of this approach for turbine engine probing gas temperature measurement and for producing dynamic 2D temperature measurements of turbine component surfaces.
Chad R. Frost	ARC	Autonomous Optical Collision Detection to Enable Unmanned Aircraft Systems in the National Airspace System	Air Traffic Management	Unmanned aircraft systems collision detection	Show the feasibility of a small form factor camera system to capture video of sufficient quality for computer vision techniques to identify other aircraft. Then develop and test algorithms to identify and track airborne objects against cluttered, dynamic backgrounds that can eventually support unmanned aircraft systems collision detection.
Edward H. Glaessgen	LaRC	Deformation and Damage in Structurally Graded Nano-Crystalline Aluminum Alloys	Materials, Safety	Lightweight structures	Design and evaluate structurally graded nano-crystalline aluminum materials that will lead to the development of lightweight metallic materials with previously unachievable combinations of strength, ductility and toughness.
Corey Ippolito	ARC	Integration and Control of Morphing Wing Structures for Fuel Efficiency/Performance	Control, Aircraft Dynamics	Morphing wing structures	Build, analyze, simulate, and perform flight test experiments with a Distributed Morphing Wing Control system and a prototype Pressure Adaptive Wing System so as to overcome several outstanding issues and realize significant gains in performance and efficiency in flight testing at a relevant scale.
David A. Jacqmin	GRC	Computations of Multicomponent Fuel Jet Atomization and Evaporation, and Effects of Evaporation in Producing Drops of Different Compositions	Combustion	Extend combustion knowledge to new/bio-fuels	Show the feasibility of computing and tracking the chemical composition of drops atomized from jets of multicomponent (mixture of many chemical species) liquid fuel that will lead to discerning the intricacies of biofuel ignition, flame stability or pollutant formation, all of which are crucial in determining biofuel practicalities and usefulness.
Dean A. Kontinos	ARC	Combined Electric Aircraft and Airspace Management Design for Metro-Regional Public Transportation	Air Traffic Management	Electric aircraft and airspace management systems	Develop an integrated system simulation that will incorporate models of compatibly designed aircraft, stations, and airspace to determine the feasibility of using electric, short or vertical takeoff and landing vehicles to serve a metro-regional transportation system.
Sunil L. Kukreja	DFRC	Sensor-Only System Identification for Structural Health Monitoring of Advanced Aircraft	Prognostics	Structural health monitoring	Develop and demonstrate Sensor-Only System Identification as a viable technology for passive aircraft Structural Health Monitoring that will provide significant cost and time savings for aircraft health monitoring.

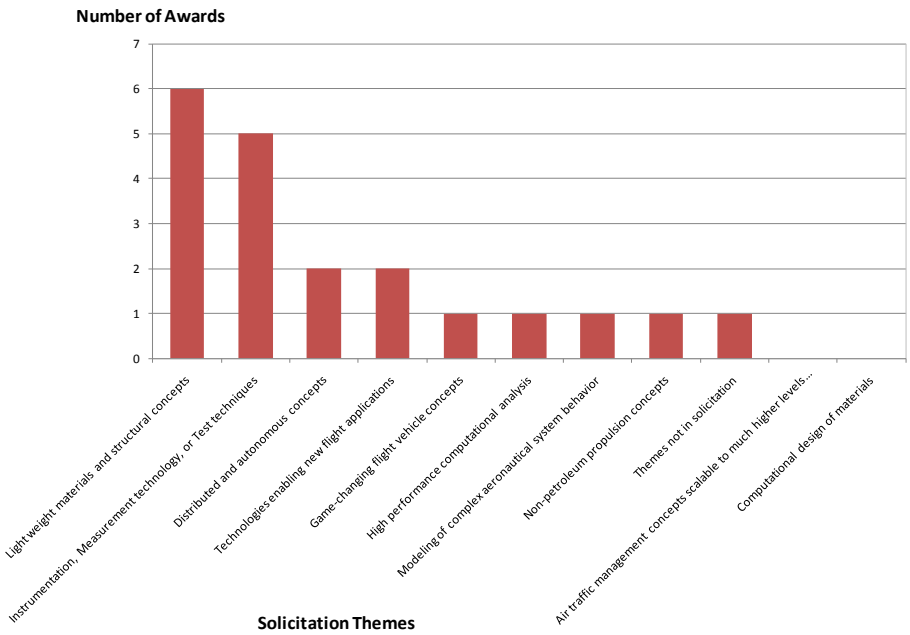
Mary Ann Meador	GRC	Design and Development of Aerogel-Based Antennas for Aerospace Applications	Materials	Lightweight antenna	Develop aerogel antennas with properties tailored to enable performance characteristics (wide bandwidth and high directivity) and material properties (low density, environmental stability, and robustness) superior to the state of practice to address the challenges of reduction of mass and number of antenna systems in aircraft.
Michael V. Nathal	GRC	Three Dimensional Cellular Structures Enhanced By Shape Memory Alloys	Materials and Structures	Lightweight structures	Demonstrate shape memory behavior in both lattice and auxetic structures and compare the results with a more conventional aerospace titanium alloy as a baseline. The combination of strength and flexibility of these structures will lead to lightweight aircraft and engine structures.
Sai V. Raj	GRC	High Temperature Lightweight Self-Healing Ceramic Composites for Aircraft Engine Applications	Materials	Engine structures	Show the feasibility of a new class of high temperature, lightweight, self-healing, Silicon Carbide fiber-reinforced ceramic composites that can be used in hot sections of the aircraft engine to minimize cooling and reduce engine weight.
Diana Santiago-deJesus	GRC	Hybrid Boron Nitride Nanotubes – Carbon Nanostructures Supercapacitor with High Energy Density	Materials	Energy storage device	Establish the feasibility of solid state supercapacitors with insulating boron nitride nanotubes as the dielectric layer and high conductivity carbon nanostructures as the electrode material that will offer simultaneous capability of high power density and high energy density.
Emilie J. Siochi	LaRC	Enhanced Dielectric-Barrier-Discharge Body-Force Generation using Nanofoam Materials with Infused Catalytic Layer	Materials	High-performance plasma actuators for flow controls	Quantify the performance of various nanofoam and aerogel dielectric materials, with and without an infused catalytic layer, as they relate to increasing the body-force-generating ability of Dielectric-Barrier-Discharge actuators. This will enable a wider Reynolds number range of potential flow control applications, from increased airfoil stall angles to improved jet engine turbine blade performance.
Ashok N. Srivastava	ARC	Reducing the Environmental Impact of Aviation: A Data Mining Approach to Instantaneous Estimation of Fuel Consumption	Data Mining, Air Traffic Management	Estimators for instantaneous fuel consumption	Develop, build, and validate Virtual Sensors using a corpus of at least 100,000 flights to predict the instantaneous fuel consumption as a function of other Flight Operational Quality Assurance parameters. This will provide comprehensive anomaly detection to help detect overconsumption of fuel in aircraft.

ANALYSIS OF AWARDS

It is difficult to firmly establish whether certain areas were better received by the Review Panels. From a statistical perspective:

- Awards in the two theme areas of “Lightweight materials and structural concepts” and “Instrumentation, Measurement technology, or Test techniques” accounted for 11 of the 20 awards.
- Awards in “Materials” discipline received half the awards.
- Review Panels were open to all ideas since at least one of the awards was not associated with any of the broad solicitation themes.

Since the awards are in fairly diverse categories there is not much synergy between the tasks. With a lot of work in the materials area, there exists information sharing opportunities, especially where a couple of tasks involve working with Aerogel and another two working with Silicon Carbide composites.



A fundamental aspect of the Seedling NOI selection process was a two-step assessment, one performed at the Center and the other at the ARMD level. The following table shows Center ranked NOIs did well in terms of the final award selection process. Almost three-quarters of the awarded tasks were ranked in the top ten by their Center POCs. Interestingly, the data also shows that a quarter of the selected NOIs were outside the top twenty as ranked within their Centers. The latter data supports the benefit of including an ARMD perspective in the selection process.

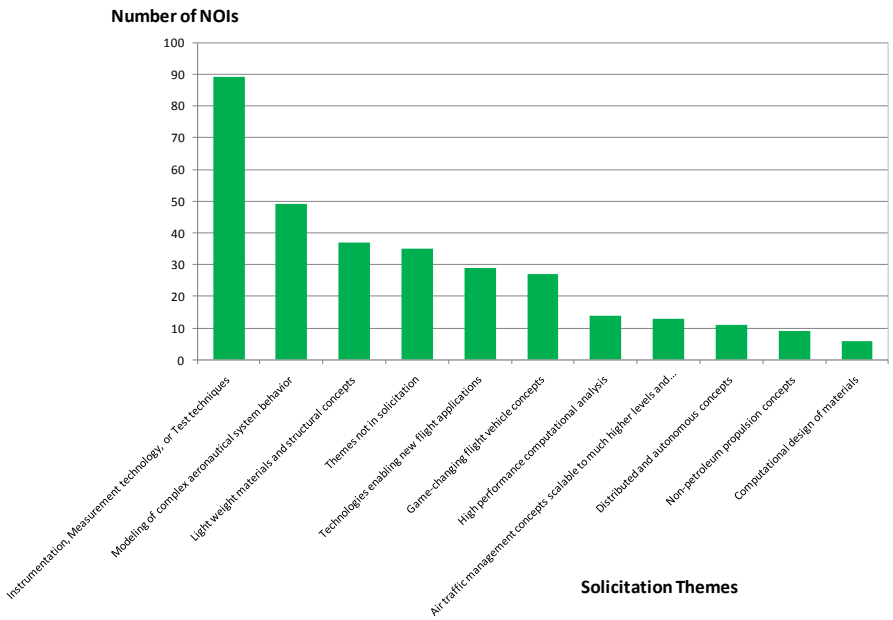
Center Ranking of NOIs	Number of NOIs Selected for Seedling Awards
1 to 5	11
6 to 10	3
10 to 20	0
Ranked lower than 20	6

All the FY11 awarded concepts are at very low Technology Readiness Levels — as intended by the Seedling Fund. It is too early to do a systems analysis of potential benefits for these concepts. As the concepts mature some of them may develop far enough so as to deserve a benefits analysis. At that time, the Seedling Fund will identify these concepts to the ARMD Director for Strategy, Architecture and Analysis.

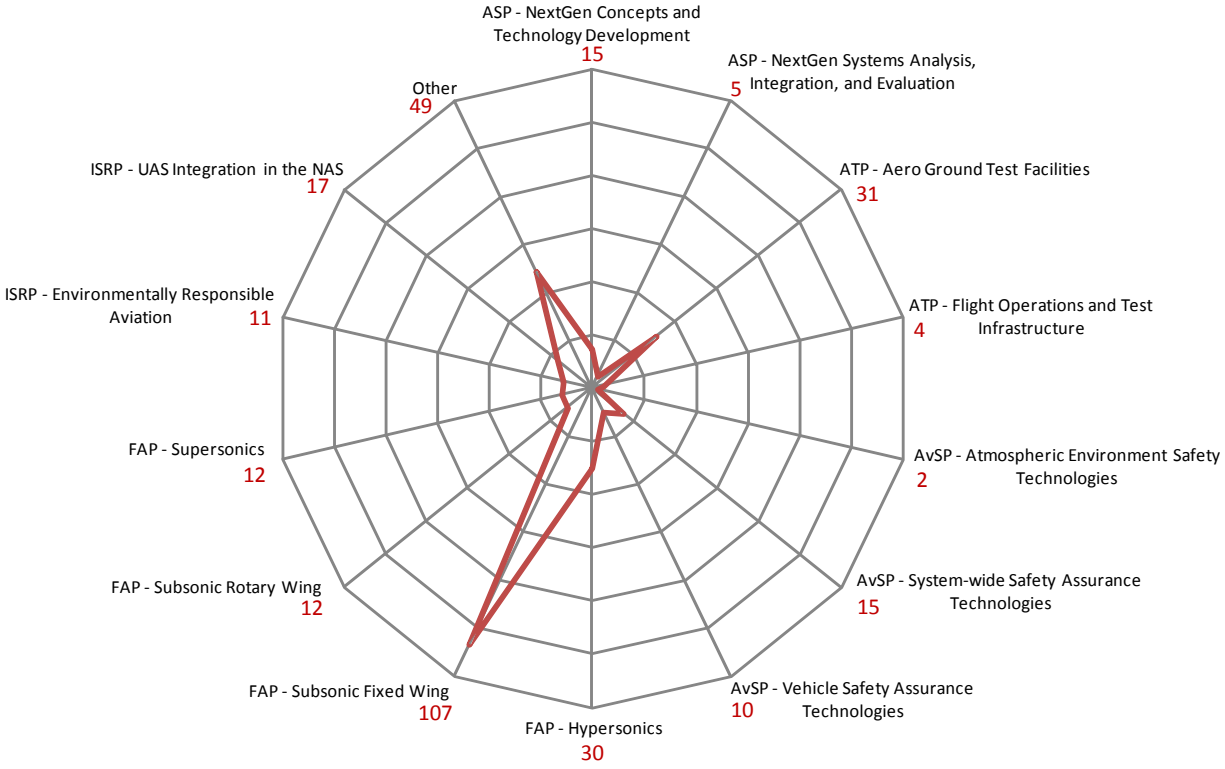
GETTING A FEEL FOR THE TYPES OF INNOVATIVE IDEAS

All the innovative ideas, including the ones not selected, continue to be the Intellectual Property of the proposers. So none of the proposal specifics are discussed, instead the NOIs were categorized to provide insight into the types of ideas generated by this Seedling call. Some NOIs are aligned with multiple themes, for these NOIs only the first theme listed by the authors was chosen for categorization. Project infusion potential, when not mentioned in the NOI, was inferred. If a concept could be transferred into any of the projects in the Fundamental Aeronautics Program, the default was the Subsonic Fixed Wing project. The primary aeronautics Discipline, Application Area, and Problem Area were inferred from the NOIs.

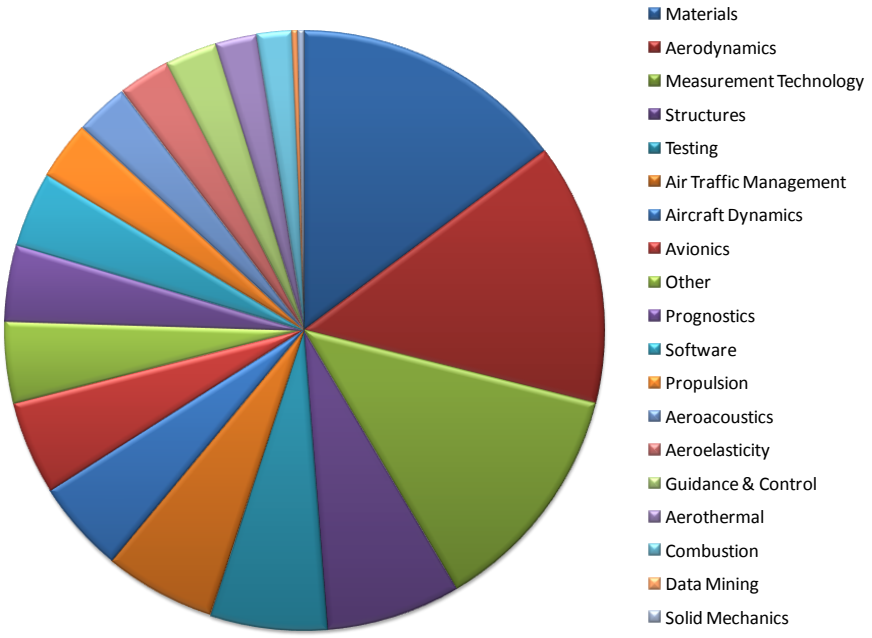
By Seedling Theme



By ARMD Project Infusion Potential (if concept is successfully developed)



By Aeronautical Discipline



By Aeronautics Application Area

More than a 100 ideas out of 144 were towards a unique aeronautics application area, the top 5 areas are listed below.

Aircraft Design	33
Aircraft Engine	21
Entry Descent Landing Vehicles	16
Structural Health Monitoring	13
Wind Tunnel	11

By Aeronautics Problem Area

Most of the ideas addressed a unique aeronautical problem or issue within an application area. However, a few ideas did address similar problems — the top 5 are listed below. The small numbers on this list show that most NOIs addressed unique problem areas.

Energy harvesting	8
Drag reduction	4
Real time health monitoring	4
Aircraft noise	3
Fan blade vibration	3

LESSONS LEARNED

Seedling solicitation process and communication worked well

- The coordination to announce the Call was fair to all Centers — all personnel were informed at the same time and presented with the solicitation documentation and instructions.
- Communication between Seedling Fund and the POCs worked well.
  - The POCs received prompt responses to questions from STA and the Fund Manager.
  - Multiple follow-ups in communication helped avert failure in the process steps.
  - The idea of sending an Excel file to each Center with name of the proposer, proposal's titles, and name of the files was excellent. The file facilitated the process of checking for printing and accounting for all NOIs.
- Allowing the POCs to establish the review process that works for their Center worked out well.
- Adapting and being flexible to situations helped reduce potential complaints. For example, MSFC was given an extra week in their schedule because their POC was initially unavailable to disseminate the solicitation documents.
- The timing of the release, although out of NASA control due to Continuing Resolution of the NASA budget, could be improved. This resulted in rushing to meet some of the Centers' internal reviews and setting up the internal processes. The Seedling Fund Manager will:
  - Provide as early as possible communication to all the Centers so that they can establish their internal processes.
  - Actively seek feedback from the Centers regarding the solicitation schedule.
- The two-step NOI and Proposal process reduced work load for the Proposal review panel.
- The current process does not allow ITAR restricted work within Seedling. This restriction will be assessed annually by the Oversight Committee to ensure that it continues to match ARMD vision.

Solicitation documents can be improved

- In future solicitations, links to current ARMD program content will be provided to help proposers and reviewers.
- By design, the solicitation themes were provided at a high level. Some NOI reviewers interpreted this as being extremely vague. For example they would have preferred a definition of what is complex in "Modeling of complex aeronautical system behavior." Questions arose among reviewers, like is a single discipline high fidelity model complex? Another issue with vagueness was whether a specific technology like shape changing actuator that can be used to implement a vehicle concept be considered part of the "Game-changing flight vehicle concepts" theme?
  It is understandable that reviewers would prefer more guidance, but the Seedling Fund intent is for reviewers to use their best judgment during evaluations. Seedling Fund will continue with high level solicitation themes when appropriate.
- A one page NOI is very restrictive in terms of its content and may not appropriately satisfy all the evaluation criteria for all reviewers. Seedling Fund continues to believe that NOIs should not be scored solely on the basis of information provided in them. Reviewers, based on their knowledge of ARMD programs and the National Aeronautics R&D Plan, may infer from the NOI content potential value and impact of the proposed concepts.
- Concepts that do not align with the solicitation themes are allowed but may not score well under several evaluation criteria. Seedling solicitation is expected to be an annual activity with potentially different themes each year. This helps Seedling Fund align with ARMD plans. As a result there is no plan to change the evaluation criteria. And, despite these limitations, one award was made to a proposal that did not align with any of the ten solicitation themes. This shows that innovative concepts in other areas can make it through the existing selection process.

- Some NOI reviewers would prefer that the Seedling Fund define a grading scale to clarify the evaluation criteria for both the proposers and the reviewers. The use of an easily understood grading scale would improve the consistency of reviews. The Seedling Fund will use the Langley Research Center grading scale as a starting point for discussions with the Oversight Committee.

Centers reported the NOIs being very valuable

- The brief one-page NOI was the right length for both proposers and evaluators and enabled a speedy process.
- A template for the NOIs could be developed to facilitate the reviewer's evaluation process. Given the large number of NOIs generated at some Centers a standardized format would aid the review process.
  Standardization is a proposer vs. reviewer benefits issue. The intent of Seedling Fund was to make it as easy as possible for proposers to submit NOIs. NOIs were obtained in many different forms and styles, including document types like Microsoft Word, Adobe Portable Document Format, and Microsoft PowerPoint presentations. The number of NOIs submitted and the variety of format showed that the intent of Seedling, to encourage the largest number of idea submissions, was met by the 2011 call.
  The Oversight Committee will discuss this issue and provide guidance to Seedling Fund.

Proposals were the right size

- Due to the low cost nature of the Seedling Fund, the proposal size was appropriate and does not over burden the proposers with lengthy proposals. Seedling process was compared favorably against the NASA Innovative Advanced Concepts (NIAC) solicitation.

Suggested review panel improvements

- In 2011 the STA reviewed all NOIs to determine which proposers would be invited to submit a full proposal. Seedling Fund is considering using a team of ARMD Project Scientists as the NOI review panel to provide a more detailed view of the ARMD perspective while assessing NOIs. There are benefits in utilizing the ARMD perspective from more than one person and the Oversight Committee will provide final guidance.
- In the 2011 selection process, review panels at the Center or the ARMD level were staffed by experienced, senior level personnel. Senior personnel also received many of the awards. This gives the appearance of bias and suggestions to either have blind reviews or including younger researchers in the review panels would remove the perceived bias.
  Seedling Fund understands this perception of seniority bias and would like to discuss this with the Oversight Committee for future guidance on review panel compositions.
- Every proposal was reviewed and ranked by all 14 members of the review panel. The proposal evaluation was a very competitive process and all proposals were ranked by at least one reviewer among their top 10. On the one hand this showed that there were a lot of great ideas submitted, on the other hand the panel was not able to establish a consensus. Seedling Fund will discuss with the Oversight Committee whether it would be preferable to instead have subcommittees consisting of experts in a specific discipline reviewing only proposals within their field of expertise.

Seedling website worked well with no bugs or crashes

- Compared to the data required by NSPIRES (NASA Solicitation and Proposal Integrated Review and Evaluation System), the Seedling solicitation was light on overhead, easy to use, and useful to the proposers.
- Having a Seedling Fund specific website to post information and gather solicitations standardized it across Centers. Proposers reported that it was easier to use than NSPIRES.
- Seedling Fund will pursue the following website improvements:

- A function that allows the Center POC to download all NOIs at once. This will save time and eliminate missing NOIs from the current manual downloading approach.
- An automatic confirmation by email to the proposers to validate a correct upload of the NOI or Proposal.
- Within constraints of the NASA Information Technology security, allow the website to be accessible from home or temporary duty outside the Center.

2011 BUDGET DISTRIBUTION

	Dollars (in thousands)	Percentage of Total
NASA Civil Servant Labor	1,595	53
NASA Civil Servant Travel	26.5	1
NASA Contractor Labor	674.5	23
NASA In-House Procurement	63	2
External Partner Funding	641	21
Total	3,000	100

The solicitation stated that “Multidisciplinary teaming within NASA and in partnership with industry and academia is encouraged.” Every award went to a PI team that included either Contractor Labor or an External Partner. The external partners are:

- American Isostatic Presses
- Case Western Reserve University
- George Mason University
- MLB Company
- National Institute of Aerospace
- National Test Pilot School
- Stanford University
- SV Star - flight testing
- Tao of Systems Integration
- Texas A&M University
- University of Kansas
- University of Michigan
- Virginia Tech