AMENDMENT No. 3 TO THE NASA RESEARCH ANNOUNCEMENT (NRA) ENTITLED "RESEARCH OPPORTUNITIES IN AERONAUTICS – 2010 (ROA-2010)," NNH10ZEA001N, RELEASED October 12, 2010

Changes are made to the following:

- Updated Table of Contents
- Summary of Solicitation: Table 2
- Summary of Solicitation: Table 3
- Appendix A-2 - Subsonic Fixed Wing Project

TABLE 2. SOLICITED RESEARCH PROGRAMS (IN ORDER OF PROPOSAL DUE DATES)

APPENDIX	PROGRAM	NOI DUE DATE	PROPOSAL DUE DATE
C-2	Dynamic Airspace Concepts (CTD1)	6/21/2010	7/22/2010
D-2	Advanced Vehicle Concepts Study (ERA1)	6/14/2010	7/23/2010
A-2	Subsonic Fixed Wing (SFW1)	10/26/10	11/30/10

Note: It is expected that additional project areas will be added in future amendments.

TABLE 3. SOLICITED RESEARCH PROGRAMS (IN ORDER OF APPENDICES A–D)

APPENDIX	PROGRAM	NOI DUE DATE	PROPOSAL DUE DATE
A-2	Subsonic Fixed Wing (SFW1)	10/26/10	11/30/10
C-2	Dynamic Airspace Concepts (CTD1)	6/21/2010	7/22/2010
D-2	Advanced Vehicle Concepts Study (ERA1)	6/14/10	7/23/10

Note: It is expected that additional project areas will be added in future amendments.

A-2: Subsonic Fixed Wing Project

1. Project Overview

A major focus of the Subsonic Fixed Wing (SFW) project is to develop improved prediction methods and technologies for lower noise, lower emissions, and higher performance for subsonic aircraft. Increased performance requires increased energy efficiency and operability for advanced airframe and engine systems and subsystems. The ten-year strategy includes providing novel test methods and validated prediction tools that can be used to improve system trades for advanced concepts that are capable of meeting long-term noise, emissions, and performance targets. The following objectives address the overall project goals, not all of which are within the scope of this solicitation.

- Improvements in prediction tools and new experimental methods that provide fundamental properties and establish validation data
- Noise prediction and reduction technologies for airframe and propulsion systems
- Emissions reduction technologies, alternative fuels, and particulate measurement methods
- Improved vehicle performance through design and development of lightweight, multifunctional and durable structural components, efficient aerodynamics throughout the flight envelope, and higher bypass ratio engines with efficient power plants

Table 1 summarizes the Project's vehicle technology goals for future generation aircraft and represents the "corners" of the trade space. It is desirable to identify technology and vehicle solutions that simultaneously meet the goals for noise, emissions, and energy usage (fuel burn).

Table 1 – NASA's Technology Goals for Future Subsonic Vehicles

CORNERS OF THE TRADE SPACE	N+1 (2015)*** Technology Benefits Relative to a Single Aisle Reference Configuration	N+2 (2020)*** Technology Benefits Relative to a Large Twin Aisle Reference Configuration	N+3 (2025)*** Technology Benefits
Noise (cum below Stage 4)	- 32 dB	- 42 dB	- 71 dB
LTO NOx Emissions (below CAEP 6)	-60%	-75%	better than -75%
Performance: Aircraft Fuel Burn	-33%**	-50%**	better than -70%
Performance: Field Length	-33%	-50%	exploit metroplex* concepts

*** Technology Readiness Level for key technologies = 4-6
** Additional gains may be possible through operational improvements
* Concepts that enable optimal use of runways at multiple airports within the metropolitan areas

2. Description of Solicited Research

2.1 Geometry Interface Development for Multidisciplinary Design, Analysis and Optimization (MDAO) Open-source Engineering Framework

Objective

The objective of this topic is to enhance NASA's open-source engineering framework (OpenMDAO) through the addition of a geometry capability and the development of a Geometry Application Programming Interface (API). The research will center on creating techniques that will enable users to employ any geometry tool and have the logic within the framework to transfer requisite data for use with other analysis modules. Successful development will enable OpenMDAO to support coupling to higher-order aerodynamic and structures tools which rely heavily on the existence of a common geometry.

Approach

Approaches to be taken should be developed in a manner consistent with what can be implemented in the physics-based OpenMDAO framework. OpenMDAO is the new, open-source MDAO engineering architecture being developed by NASA in collaboration with other organizations within the MDAO community. The OpenMDAO framework and relevant documentation is available at http://openmdao.org. Background information on expectations for the geometry API is provided at http://openmdao.org/docs/arch-doc/geometry.html. This material should be viewed as a starting point for research and is not intended to be a complete description of a final geometry API.

A critical aspect to this work is the capability to create multiple geometry representations that are suitable for a wide range of disciplines in an intelligent way while minimizing labor requirements. The creation of these geometric representations would be done using a specified interface that could be applied to a multitude of different geometry modeling tools. This would allow the same processes for the creation of specific geometric representations to be applied to any geometry software package which provides the specified interface. This conversion often includes operations such as meshing to meet specific needs, the creation of a watertight geometry or feature removal.
Being able to utilize geometry more quickly and with less manpower would provide timely access to more sophisticated tools. This could enable the designers to consider much higher levels of fidelity during early stages of vehicle design. This capability is necessary when considering the design of unconventional configurations.

Expected Outcome

The research effort will result in the creation of a Geometry API and an implementation process for that API for a specific geometry modeler within an MDAO framework. If the geometry modeler implementation is based on open source software, the product will be considered for integration with an OpenMDAO software release. The product would then serve as the default geometry engine in the OpenMDAO framework.

2.2 Robust Aircraft Conceptual Design Geometric Modeling

Objective

The objective of this topic is to enhance the ability to employ higher-order, physics-based analysis during conceptual design through robust, easy to create geometry models. The research goal is to automate the rigorous steps required for intelligent conversion of a conceptual level parametric geometry model into the detailed representation necessary for higher-order analysis. Conceptual design is the starting point for a new engine or aircraft development. A successful design is highly dependent on accurate geometric representations, since they are used throughout the computational engineering process. Over the past several decades computational capability has drastically improved as has the understanding of human-computer interfaces. These advances have enabled less experienced users to perform far more sophisticated tasks without the requirement of extensive training time. More accurate geometry representations will advance the state-of-art in conceptual design by enabling more routine use of higher-order analysis tools.

Approach

A key need of conceptual design is the ability to quickly articulate ideas and engineering concepts into a digital 3-D database. While this can be accomplished through building a CAD (computer aided design) model of the geometry, it would be valuable to have the ability to parameterize the geometry's characteristics. Parametric overlays to CAD programs can be performed, but there can be negative implications to this approach. For instance, it requires users to obtain often expensive software, and there can be inherent limitations with a given CAD package. Therefore, a prerequisite of any valuable conceptual design geometry solution is that it be parametric-input based and use aircraft design terminology to communicate effectively with the user (e.g., span, aspect ratio, chord). Currently, there are no accepted standards for parametric-based geometry representations to facilitate sharing of geometry. There is a need to create a generalized standard for parametric geometry and an approach to transfer geometry models in that standard to CAD-based models. These new approaches to streamline the conversion of conceptual geometry to the geometry representation needs of more detailed analysis, however, should not diminish the ability to rapidly explore the conceptual design space using a parametric geometry tool.

NASA has made prior investments in the development of a parametric geometry tool for conceptual design [i.e., Vehicle Sketch Pad (VSP)]. There is a need, however, to create better coupling between higher-order engineering analysis codes and geometry tools like VSP. The developed geometry methods should be flexible in nature and must be compatible with, and support, NASA's existing ModelCenter-based systems analysis and conceptual design process. An overview of the tools used in a ModelCenter environment is available in the "Other Documents" section at: http://nspires.nasaprs.com/external/solicitations.

Expected Outcome

The new capability shall provide parametric-based geometry modeling and analysis methodologies that enable conceptual designers to accomplish analyses in a faster, easier manner. In addition, the geometric representation will enable transferring of key geometry for use with higher-order aerodynamics, structural, mass properties, propulsion, control, aeroelastic, aeroacoustic, and aeropropulsive tools. However, developing an export capability/linkage to another tool is not sufficient. The goal is to embed in the tools the rigorous steps required for intelligent conversion of the geometric database into the necessary information for the higher-order analysis. This typically involves modification of the geometry through meshing to meet specific needs. Currently these intermediate steps are very time consuming – and transitioning between tools loses necessary parametric definitions that could provide valuable sensitivity analyses. Being able to accomplish these steps in more intelligent ways, with less labor would provide timely access to more sophisticated tools. Such capability is not merely about attaching geometry interfaces to the most powerful CFD (computational fluid dynamics) or FEA (finite element analysis) tools– it is about bringing all levels of analysis capability to the designer in an easier and more rapid fashion, with less data loss from geometric translations.

2.3 Modeling of Multifunctional Materials for Aircraft Structures and Engines

Objective

The ultimate goal of the Structures, Aeroelasticity and Materials discipline in Subsonic Fixed Wing is to improve aircraft performance and reduce weight through innovative integration of new materials and structural designs. The objective of this topic is to develop physics-based computational tools to improve understanding of advanced aircraft materials and accelerate the development and implementation of these materials into aircraft structural applications. The optimization of materials and structures to carry loads, provide greater flexibility in control surfaces, enable higher temperatures in engines, provide reduced acoustic transmission or enable aeroelastic tailoring are key to the success of the SFW project.

Computational materials modeling tools can be used to exploit the tremendous physical and mechanical properties of new materials by understanding materials at atomic, molecular, and supramolecular levels. Multi-scale analysis methods provide connections between the length and time scales that span from the nano to the micro to the continuum and can be used to guide and accelerate material development and their integration of materials into structural configurations. Computational methods may also be applied to materials processing to assess the impact of processing variables and predict optimized conditions required to achieve desired material properties, geometries, and structural characteristics such as residual stress and geometry. Some degree of materials synthesis, processing, and testing are also required to validate the models to ensure the physics are being adequately modeled across the length and time scales.

Approach

Development of computational materials analysis methods and tools is desired that is directed to understand basic physics of materials for airframe structures and engine components. Specific applications of interest include developing computational models that support (1) nanostructured materials for lightweight aircraft structures, (2) adaptive materials for actuation devices for reshaping wing flaps, turbine nozzles, and fan or compressor blades for controlling engine blades vibrations, acoustics and flow for reduced fuel burn, and (3) advanced processing and materials development for structurally-tailored aircraft structures and high-temperature turbine blades, disks and combustor components.

Validation of models is also important to reduce uncertainty and verify computation results with experimental data. This validation may be made by comparing modeling results to existing data in the literature, conducting validation experiments as part of the modeling activity, or collaborating with NASA to leverage experimental in-house research. The specific validation approach proposed to support the computational model development should be described.

Expected Outcome

- Validated computational models to help understand material behavior, guide material and process development, and integrate multifunctional/adaptive materials into active aircraft structures.

- Rapid analysis tools that allow the designer to make accurate trade-offs between performance and weight using fundamental material properties that can be controlled during material synthesis. Through the use of this tool or set of tools, the time and cost associated with material scale-up can be reduced from the current state-of-the-art.
- Multi-scale analysis methods (including computational chemistry tools) that provide a linkage between engineering properties at the structural level and fundamental changes in materials and material design that can be used to design, analyze, and optimize new tailored, multifunctional materials concepts. The outcome should include validation of the tools and methods at each critical development stage. It is expected that the methods would be flexible enough to be applicable to novel material types and systems as they are developed.

2.4 Turbulence Model Development and Assessment for Complex Aerodynamic Flows - High-Fidelity Numerical Simulations

The ability to accurately predict the flow around an aircraft impacts all of NASA's key goals of reduced fuel burn, reduced noise, reduced emissions, and reduced field length. Confidence in CFD predictions permits more aggressive designs, resulting in reduced drag and/or weight, with concomitant reductions in fuel consumption and emissions. Accurate prediction of turbulence structure permits the use of higher fidelity noise prediction algorithms that facilitate designing for reduced noise. Reliable predictions of flow fields associated with active and passive flow control technologies enable design of aircraft for optimum performance throughout the flight envelope.

<u>Objective</u>
Develop more accurate turbulence models that enable reliable and accurate predictions of complex turbulent flows of aerodynamic interest.

<u>Approach</u>
The Subsonic Fixed Wing (SFW) Aerodynamics team has identified the ability to predict 3D high-Reynolds-number flow separation onset and progression as critical to advances in future aircraft. For the past several years, emphasis has been placed on generating high-quality experimental and computational databases of separated flows that can serve as validation cases for new turbulence models geared toward the prediction of such flows (e.g. Fundamental Aerodynamic Investigation of the Hill (FAITH) experiment, 2-D flow control hump experiment, Trap Wing experiment, experimental and computational assessment of the Englar circulation control airfoil. An overview of these experiments is available in the "Other Documents" section at: http://nspires.nasaprs.com/external/solicitations/). Using the above well-documented flow fields, shortcomings of existing turbulence models can be identified and ideas for improvements can be generated. Newly developed or improved models can then be further validated against recently gathered experimental data obtained for state-of-the-art aircraft and other advanced complex aerodynamic configurations.

Consideration will be given to Reynolds-Averaged Navier-Stokes (RANS) turbulence models, Large-Eddy Simulation (LES) models, and Detached Eddy Simulation (DES) or other hybrid modeling approaches, as long as these are designed for the prediction of relevant aerodynamic flows of interest to SFW. The focus should be on the prediction of separated flows, such as those at wing-body junctions, over airfoils at high angles of attack, over multi-component or circulation control airfoils used for high lift, or in the context of airframe noise sources and in propulsion airframe interaction aeroacoustics. Internal flows with separation, such as those occurring in turbomachinery applications, are also of interest. The generation of high-fidelity numerical databases by Direct Numerical Simulation (DNS) or LES for the purpose of guiding turbulence model development, particularly for the validation experiments noted above, is also encouraged.

The proposed task must be well defined and the task description must include details on how the new model will be tested, including the codes being used.

Expected Outcome

- Assessment of traditional and recently developed turbulence models, on a broad spectrum of complex aerodynamic flows to assess their utility. Reports of newly developed turbulence models are available in the "Other Documents" section at: http://nspires.nasaprs.com/external/solicitations.
- Generation of high-fidelity numerical databases of separated flows to guide turbulence model development
- Utilization of experimental and computational validation databases to foster new turbulence modeling ideas
- Delivery of improved turbulence prediction capability for complex aerodynamic flow fields that include separation

2.5 Understanding and Mitigating Tip Leakage and End Wall Losses in High Pressure Ratio Cores

Objective

The aerodynamic performance of core compressors and turbines is influenced strongly by end wall and tip clearance flows and the attendant losses. In addition to impacting pressure rise and efficiency, end wall and tip clearance flows also impact compressor stability and turbine durability. Turbomachinery clearance-to-span ratios are expected to increase in the future with engine designs incorporating higher overall pressure ratios, higher stage loadings, and smaller cores resulting in higher losses. This will place a premium on the ability to understand and reduce tip leakage aerodynamic losses and other detrimental effects. The objective of this topic is to improve the performance of highly-loaded turbomachinery in high pressure ratio cores through the development of advanced concepts for mitigating tip leakage and end wall losses, as well as databases, numerical tools, and models that provide improved understanding of these loss mechanisms in turbines and compressors.

Approach

Advanced concepts for mitigating tip leakage and end wall losses are sought along with experimental data, high-fidelity flow simulations, and/or modeling techniques for turbomachinery clearance and end wall flows for use in computational model validation and/or advanced concept evaluation. Improvements, such as three-dimensional blade and end wall design, blade lean and sweep, new tip clearance geometries and casing treatments, will be required to achieve higher turbomachinery aerodynamic efficiencies and address other relevant issues for highly-loaded blade rows with large clearance-to-span ratio. Assessments of the blade row aerodynamic performance benefit and determinations of the potential benefit to the engine specific fuel consumption are desired. Experimental data should include detailed flow field measurements as well as overall parameters. Consideration must be given to the ability of the datasets to be used for CFD validation, including boundary condition and geometry specification. High-fidelity flow simulations may include RANS, LES, DES, or DNS methods. Modeling techniques may include validated simplified methods for predicting loss and other relevant issues.

Expected Outcome

Experimental results and/or numerical simulations of the relevant physics described in the approach. Geometries and flow conditions are expected to be broadly available to the turbomachinery research community. The topic objective is to achieve a better understanding of the physical phenomena and mechanisms of turbomachinery tip clearance and end wall flows for high pressure ratio cores through improved experimental data, computational simulations and models, and demonstration of advanced concepts to reduce the loss in aerodynamic performance and stability associated with tip clearances and enwalls.

2.6 Novel Control Effectors

Overview

Traditional design techniques for Next Generation aircraft continue to push airframe and propulsion technologies towards energy efficient and environmentally compatible solutions. Recent concept studies have revealed advanced designs that achieve these goals through reduced drag, lower weight and decreased noise levels as compared to state-of-the-art aircraft. Still, opportunities exist to further optimize Next Generation aircraft designs by exploring novel methods of satisfying stability and control requirements.

Objective

This subtopic seeks novel and comprehensive control effector concepts that will fully or partially satisfy the stability and control requirements for Next Generation aircraft while leading to a system-level reduction in weight, drag, noise, and power consumption. The traditional stability and control requirement of control effectors is to provide the control authority needed for a variety of purposes. Those purposes include maintaining stability, trimming for optimum steady-state performance, arresting undesired characteristics or disturbances and maneuvering during all phases of the flight envelope.

The application of control effectors to Next Generation aircraft may also impose additional requirements, especially when considering Next Generation aircraft with lightweight, aeroelastic structures or reduced static stability, or Next Generation aircraft that are meant to exhibit extensive laminar flow, be robust to wake vortices or reduce trailing edge vortices. The objective of this topic is to make considerable advances in aircraft energy efficiency and environmental compatibility by researching novel solutions to traditional stability and control requirements and Next Generation requirements.

Approach

Successful development of a comprehensive control effector design sought in this solicitation relies on an analysis of the Next Generation system integration and system performance.

The system integration will require a candidate Next Generation aircraft concept with suitable novel control effectors, a set of requirements selected for the control effector concept and a detailed definition of the control effector design. To assess improvements to the energy efficiency and environmental compatibility of the advanced-concept system, a quantitative analysis of the system weight, drag, noise and power consumption should be conducted in parallel with an analysis of a similar system with state-of-the-art control effectors.

The system performance is a function of the control effectors ability to affect the dynamics of the Next Generation aircraft and the requirements to control the system. Physics-based modeling or a hardware test of the control effectors will be required to assess the control effectiveness, as defined by the static and/or dynamic stability and control derivatives, over the range of the proposed flight phases. Characteristics of the control effectiveness, such as the conditions for maximum or minimum control effectiveness, shape of the control effectors response to control input and trends in control effectiveness with flight condition, are also of interest. Since the physical design attributes of a control effector, such as maximum and minimum control input, maximum and minimum rate limit, bandwidth and time delay, may limit the utility of the effector, these physical attributes and their effects on the control effector performance should also be defined and analyzed. Finally, to demonstrate the ability of the control effector concept to meet the control objectives specified for Next Generation aircraft, a simulation or system prototype is desired.

Expected Outcome

- Comprehensive study of a control effector concept for Next Generation aircraft.
- Quantitative analysis of the system impact on weight, drag, noise and power consumption.
- Definition of the control authority provided by the control effectors, including properties of the control effectiveness and physical design attributes.

2.7 Decentralized Engine Control

Future engine system improvements will be increasingly reliant on the incorporation of more and increasingly sophisticated control technologies. The current state-of-the-art engine designs present a physically challenging environment in which engine control systems must operate. These physical constraints are increasingly restricting the ability to maintain a cool environment for electronics, thereby threatening to make the control system a limiting factor in future engine performance.

A decentralized or distributed engine control system architecture alleviates the impact of these environmental constraints through the use of more flexible design criteria. This architecture minimizes the exposure of the most sensitive electronic microprocessor components, the control system's most powerful asset, and introduces more robust high temperature electronics for use in the most hostile portions of the environment. In effect, the complexity of the hardware system is reduced because much of the functionality is redistributed in a multitude of smaller, less complex pieces. However, in doing so the complexity of the control system integration becomes greater. These integration challenges are best addressed through the use of common interface standards.

The redistribution of control functionality in distributed systems introduces significant advantages for engine systems in terms of flexibility and weight reduction while introducing a long term growth path for system performance enhancement and cost reduction. However, all of these capabilities are dependent on the efficiency of control system integration technology. The development of a common platform for engine control system design, development, test and integration is critical for achieving the maximum capability of new decentralized engine control technologies.

Objective

Develop an integrated environment for the design/development and verification/validation of future aircraft engine control systems and control components. There is specific interest in methodologies which are modular in functionality and scalable in both system complexity and temporal fidelity to enable crosscutting research and collaboration in the areas of control system hardware design and engine system performance, adaptability, and safety.

Approach

Modular and scalable Hardware-in-the-Loop (HIL) technology is a possible focal point for present and future collaboration in engine control system development. A flexible HIL platform should have the capability to integrate a broad range of control system activities within a common environment to promote the sharing of ideas and assist in the development of common standards.

Ideally, the HIL technology should be capable of integrating an unlimited variety of real and simulated engine control components in a modular fashion. This will allow the scope of a test effort to range from an examination of a single control component to a full system evaluation within a common platform. Implementing modularity with the use of common interface standards facilitates the flow of information between modules without the need for revealing the origin of that information. The usefulness of this approach is that it allows any collaborator to participate in a given test effort at little or no cost, while minimizing the risk of loss of intellectual property.

The study of control system dynamics is becoming increasingly important in optimizing engine system performance. HIL technology should be extended to incorporate these capabilities which are often developed separately as pure simulations running in faster-than-real-time. In this vision of a modular environment, control equipment providers would be encouraged to develop such capabilities within their existing HIL component models, further consolidating collaboration in the control system environment.

Finally, the complexity and cost of verification and validation of control systems is a major concern for developers. The common HIL technology framework could be extended to function as a preliminary verification and validation tool to be used within industry. The capability of such a tool could even incorporate the replication of environmental factors like the temperature and vibration profiles of the relevant equipment mounting location in specific engine environments.

Matlab/Simulink is commonly accepted in a broad spectrum of control system development applications and would be the preferred tool for implementing this Hardware-in-the-Loop capability. Matlab/Simulink has been used in the development of gas turbine engine models such as the NASA-developed Commercial, Modular Aero-Propulsion Simulation System (C-MAPSS).

Expected Outcome

- Assessment and recommendations for industry-wide collaboration on distributed engine control architecture.
- Design of proposed modular and scalable control system HIL architecture which is compatible with new decentralized control systems.
- Development and definition of a HIL user interface.
- Development and definition of modular interfaces between a “standardized” engine simulation module and the real or simulated engine control system to encourage the development of a library of engine simulation modules.

- Development and definition of modular interfaces between real or simulated control components within the HIL environment.
- Development of HIL interface extensions for environmental stress testing.

2.8 Acoustic Prediction Tools and Noise Reduction Technologies for N+3 Generation Subsonic Aircraft

Fundamental understanding of the physics of noise generation by aircraft and validated aircraft noise prediction tools are two essential elements for enabling designers to perform accurate tradeoffs of noise against other performance factors (e.g., fuel burn, emissions) in the development of low-noise aircraft configurations. Fundamental experiments are necessary to provide insight into underlying mechanisms of noise generation and help guide the development of low-noise aircraft and noise mitigation strategies. Robust, efficient and more accurate noise prediction tools are needed to perform aircraft system noise studies in a multidisciplinary framework for aircraft design.

To meet the challenging noise target set by NASA for the N+3 generation subsonic aircraft (i.e., Stage 4 minus 71 EPNdB cumulative); there is a critical need for the development of reliable tools and robust technologies. These include higher-fidelity noise prediction tools for highly integrated ultra high bypass ratio and open rotor propulsion systems and unconventional aircraft configurations as well as advanced noise reduction technologies. In this solicitation, a number of key technical areas are targeted. These include:

1. Acoustic databases for low-emission combustors and high-power-density cores
2. Liner aeroacoustics tools
3. Cabin noise modeling
4. Noise prediction tools [e.g., for use in NASA's Aircraft Noise Prediction Program (ANOPP). The NASA Technical Memorandum 83199, Aircraft Noise Prediction Program Theoretical Manual is available in the "Other Documents" section at: http://nspires.nasaprs.com/external/solicitations]

Objective

Proposals are sought in these areas to augment NASA capabilities for addressing the noise goals for the N+3 generation aircraft. The principal objectives are to:

1. Reassess and gain a better understanding of physics of core noise sources and to generate a detailed and carefully documented experimental database for code validation;
2. Improve the capability to assess aerodynamic and acoustic characteristics of liners;
3. Develop and improve cabin noise prediction tools that handle both metallic and composite structures such that they are better integrated into the early design cycle; and
4. Develop efficient acoustic scattering prediction methods for propulsion/airframe interaction configurations and airframe component noise predictions for high lift device and landing gear noise reduction concepts.

Approach

The core noise effort would be experimental, in which time histories of unsteady temperature and pressure fluctuations at elevated temperature and pressure would be acquired at multiple locations in modern combustor rigs, turbine rigs or a full-engine setting. This effort should include documentation of (i) the circumferential acoustic modes and their axial propagation of unsteady temperature and pressure fluctuations, (ii) multistage aerodynamic interactions responsible for turbine and compressor tone noise, (iii) turbine entropic noise sources, and (iv) the spectra and Root Mean Square (RMS) levels of the temperature and pressure fluctuations at the combustor exit plane.

Advanced acoustic liners, installed in the engine nacelle or on the aircraft surface, are needed for increased noise reduction, but limited research has been conducted to measure their skin friction drag and self-noise. Improved diagnostic tools are needed to provide efficient, detailed measurements of skin friction drag and self-noise due to acoustic liners, whether installed on an aircraft or in laboratory flow duct.

Cabin noise prediction tools with increased efficiency and accuracy are needed for mid-frequency modeling. For mid- and high-frequency modeling, improved integration with finite element or computer aided design (CAD) models, including novel methods, is needed to integrate with multi-objective (i.e. noise, weight, strength) optimization and improved experimental methods for estimating parameters relevant for vibro-acoustic models.

Noise prediction tools are needed to assess acoustic scattering associated with propulsion (e.g. turbofans, open rotors)/airframe integration configurations. Also, high-fidelity airframe component and interaction noise prediction methods are needed that couple the acoustic analogy with steady Reynolds-Averaged Navier-Stokes (RANS) computations that characterize key flow features (e.g., shear layers, vortices, and separated flows). Proposals in this area must address the prediction accuracy and efficiency.

<u>Expected Outcome</u>
Proposals are sought that address one or more of the following:

- Diagnostic tools, instrumentation designs, and layouts with improved frequency response for unsteady temperature measurements at high temperatures; an improved understanding of the relative importance of noise sources in emerging core designs; and a detailed database for code validation. The outcome will enable improved design rules for low-noise, low-emission, and high-power-density cores.
- Sensors and other diagnostic technologies for quick, reliable determination of acoustic liner skin friction drag and self-noise in the presence of realistic aeroacoustic environments, to enable noise and performance trade-off studies.
- For cabin noise modeling: Improved tools with respect to speed and accuracy; improved integration with other tools and methods; improved parameter extraction methods; and integration with optimization techniques at various levels of fidelity.
- An improved capability for quick (approximately 1 week design cycle) assessment of noise from conventional and unconventional aircraft (with turbofans and open rotor propulsion systems), with sufficient fidelity to account for details such as geometric changes, flow control, and the addition of noise reduction devices.

2.9 Fischer-Tropsch Alternative Fuels

<u>Objective</u>
The objective of this topic is to promote the understanding of F-T synthesis kinetics and seek novel catalysts and supports to increase reaction yields, reduce deactivation, and minimize physical breakdown of the catalyst for the production of aviation fuel.

Approach

Fischer-Tropsch (F-T) synthesis uses non-petroleum feed stocks such as coal, natural gas, and bio-mass to produce high-value chemicals and commercial fuels such as gasoline, jet fuel, and diesel. F-T jet-fuel is a cleaner burning fuel that generates very low sulfur emissions, and reduced particulate emissions. The versatility of the F-T synthesis provides the opportunity to produce a new jet fuel, possibly a drastically different composition with minimum aromatics and an optimum blend of olefins/paraffins while achieving high combustion efficiency and minimizing pollutant emissions. F-T synthesis is primarily aimed at producing diesel fuel rather than aviation fuel due to economic factors. In order to improve aviation fuel yield, a fundamental understanding of reaction kinetics as well as improved catalyst formulation will lead to improved reactor design, enhanced reaction yields and product distribution, with specific application to aviation fuel. F-T reaction yield and selectivity should be developed for optimum results and efficiency. Increasing the selectivity will reduce the energy input and the methane production and increase the yield of aviation fuel components.

Catalysts currently used in the F-T synthesis reactors are divided into two basic groups – cobalt (Co-based) and iron (Fe-based). Co-based catalysts are typically used with natural-gas feeds and iron-based catalyst are more suitable for complex hydrocarbon feeds such as coal due to its lower cost and ability to operate with lower H2:CO ratio in the syn-gas feeds. Cobalt-based F-T catalysts are supported catalysts with alumina, silica, and other transitional metal oxides. Recent studies of cobalt F-T catalysts identified key parameters affecting catalyst activities such as: metal loading, active metal cluster sizes, interaction of active cobalt metals with catalyst support, catalyst support pore size, and the catalyst calicination procedure (reports on these studies are available in the "Other Documents" section at: http://nspires.nasaprs.com/external/solicitations/). However, the Co-based catalyst with high activity tends to degrade rapidly. Further work is required to improve catalyst life performance.

Iron-based F-T catalysts are not typically supported and are also prone to physical breakdown in the reactor. Iron-based F-T catalysts also induce the water-gas-shift (WGS) reaction which provides additional H2 for F-T synthesis. The interaction of WGS and F-T synthesis is of interest because of the effect on reactor design and feed stock choice. Innovative catalyst substrates for the iron typecatalyst could improve durability by minimizing physical breakdown of catalyst particles while maintaining high activity. Emphasis on iron catalysts will provide a means for the use of abundant coal resources in the United States. In studying coal specific Fe-based F-T fuels, it would also be of interest to introduce contaminants to the feed gases and study kinetic model differences. In studying iron catalyst in F-T applications, the application of promoters can be useful.

NASA is also developing advanced catalysts in-house and is interested in having a complete characterization performed on at least two NASA produced F-T catalysts. A summary of this work is available in the "Other Documents" section at: http://nspires.nasaprs.com/external/solicitations.

The approach is to perform F-T kinetics studies and catalyst characterization with the proposed catalysts to obtain a better fundamental understanding of F-T catalysis. Correlations of desirable catalyst physical attributes leading to durable and active catalysts will provide new insights for future catalyst compositions. Improving catalyst life performance by optimizing catalyst treatment during calcinations, activations and operations is also required. Performing screening tests of novel hydro-cracking catalysts will also improve conversion of F-T synthesis products to high quality jet fuel.

Expected Outcome

- Kinetic and degradation studies and models of Fischer-Tropsch synthesis with improved cobalt-based catalysts and supports.
- Kinetic and degradation studies and models of Fischer-Tropsch synthesis with improved/promoted iron-based catalysts.
- Complete catalyst characterization on at least two NASA produced F-T catalysts.
- Provide a minimum of three new cobalt-based F-T catalysts: 100 grams each for use in the NASA GRC Alternative Fuels Laboratory. Kinetic data and results will be interpreted by both the NRA recipient and NASA for joint publication.
- Provide wax accumulation pore studies for at least two Cobalt catalysts. Provide at least four new iron-based F-T catalysts: 100 grams each for use in NASA GRC Alternative Fuels Laboratory. Kinetic data and results will be interpreted by both NRA recipient and NASA for joint publication.
- Catalyst life testing of at least 2 catalysts for the best catalysts identified during the first two years of this study.

2.10 Combustion Instability Modeling and Experiments

Objective

The objective is to develop physics-based modeling tools to improve the predictive capability for combustion dynamics. Improved physics-based modeling tools and validation experiments are desired that will enable the prediction of combustion dynamics of low emissions combustion concepts operated on conventional and alternative fuels.

Approach

The performance and operability of low-emissions combustors for gas turbines are frequently impacted by acoustically coupled instabilities commonly referred to as “combustor dynamics.” These instabilities are difficult to mitigate or predict due to a lack of understanding of the root-cause physical mechanisms that couple the combustor’s acoustics with its unsteady heat release rate. The development of advanced low emissions combustor concepts to meet increasingly stringent NOx emissions goals is expected to increase the probability of encountering combustion dynamics. The use of alternative fuels may also have an effect on combustion dynamics. Efforts are solicited that utilize the latest developments in modeling and experimentation in an integrated fashion. Using these integrated tools to assess the susceptibility of various fuel injection and flame stabilization schemes found in low emission combustors to combustor dynamics is of particular interest.

Expected Outcome

- Validated physics-based combustor dynamics models that can be used to assess the stability of low emission combustor concepts.

2.11 Fully Superconducting Electric Machine Modeling, Design and Fabrication

NASA is evaluating turboelectric aircraft propulsion to meet N +3 Goals. In this concept turboshaft engines drive high-power-density generators that produce electric power for high-power-density motors that drive the aircraft propulsion fans. The most critical technology development needed is high-power-density motors and generators. Prior NASA feasibility studies have assumed these machines to be superconducting machines with superconducting windings on both rotors and stators. The feasibility studies have been based on preliminary sizing models, but higher fidelity mathematical models are needed to predict machine mass and performance and to guide further technology development. Component and subscale machine demonstrations are required to validate the models.

Objectives
The objectives are to develop higher fidelity models for the mass and efficiency of high-power, fully-superconducting electric machines, including all major subcomponents, and to conduct component and subscale machine demonstrations to validate those models and to discover unknowns.

NASA internal evaluations suggest that only wound rotor synchronous machines with superconducting windings on both rotors and stators will be able to produce the specific power required for turboelectric flight propulsion, though credible alternatives may be proposed. The aircraft propulsion application is anticipated to require electric machines within a power range of 4 MW to 40MW with electrical frequencies between 200 and 500 Hz and shaft speeds in the range of 4000 rpm to 8000 rpm. The lower power machines will operate as motors and the higher power ones as generators. By 2025 to 2030 the machines must have specific power greater than 20 hp/lb (33 kW/kg), including the cryocooler, and efficiency above 99%, including the cryocooler power.

Approach

NASA has preliminary superconducting motor sizing models (based on ideal current sheet models as presented in Hughes and Miller, "Analysis of Fields and Inductances in Air-Cored and Iron-Cored Synchronous Machines", Proc. IEE, 124, 1977, and Luongo, et al, IEEE Trans. on Appl. Superconductivity, Vol. 19, No. 3, June 2009, pg 1055, “Next Generation More-Electric Aircraft: A Potential Application for HTS Superconductors”) and superconductor AC loss models from current literature.. Models based on physically-realizable windings and machine structural elements are required to make realistic mass and efficiency estimates. The proposer should develop more detailed preliminary designs for fully superconducting machines (or credible alternatives). Mass estimates (as functions of machine power) of all the components listed below should be provided. Loss estimates should be provided for each component as well as loss mechanisms, including armature AC loss, rotor electrical loss and heat leak, windage (if appropriate) and ferromagnetic losses (if appropriate, e.g. in an external magnetic shield). The following components should be included in the modeling:

- Electromagnetic components (rotor and stator windings plus external, room-temperature shielding iron or FeCo)
- Formers for rotor conductor and structures to support rotor centrifugal loads, torque transfer, and internal winding compressive loads
- Formers and structure to support stator windings and transfer stator loads to aircraft structure
- Exciters with on-shaft electronics (no slip rings)
- Room temperature bearings and associated “torque tubes”
- Vacuum jacketing and insulation

- Cold gas cooling passages to remove the minor rotor heat load and the significant stator AC-loss heat load
- Other components deemed needed by proposer

AC loss models should be developed for the type of superconductor (or credible alternative) to be used in the stator.

The proposer should develop and report the electrical, structural and thermal designs, analytical evidence of their sufficiency and the mass models (mass as a function of machine power over the 4 MW to 40 MW power range). Designs should minimize the combined electric machine and cryocooler mass, which will influence the choice of operating temperature and superconductor, especially for the stator. Cryocooler mass may be assumed to be 3 kg per kW of cooler input power and cryocooler efficiency may be assumed to be 30% of Carnot. AC stator losses can be based on superconducting filaments of 10 micron diameter for superconductors that may reasonably be expected to be produced in filamentary form by the 2025 to 2030 time frame. Assume that power input and output leads are superconducting, so they contribute no heat load. Electric busses are not considered part of the system to be analyzed. Appropriate placement of the machine first bending mode should be considered. Note that substituting low resistivity normal (i.e. non-superconducting) cryogenically cooled conductors (e.g. Cu or Al, possibly in composite form) for superconductors is permissible <u>if</u> the proposer can show that the electric machine plus the cryocooler can meet the stated performance goals. To show that the required specific power and efficiency can be reached, technology and materials projections to the 2025 to 2030 timeframe are permissible and encouraged, if supported by convincing reasoning.

The proposer should fabricate and test complete machines, components or subcomponents, any or all of which may be sub-scale, but sufficient to validate the models and designs.

<u>Expected Outcome</u>
The mass and efficiency models and the general design of the machine should be non-proprietary, delivered to NASA and usable in component optimization procedures and in complete aircraft system studies. Test results on components and on subscale machines should be shown to validate the models and should be delivered to NASA along with the test components and test machines.

3. Programmatic Considerations

The Subsonic Fixed Wing project plans to invest $4-6M per year in the solicited topics over the next 3 years, starting fiscal year 2011 (FY11). We anticipate 20-30 awards in the range of $150-300K per year per award - depend on proposed scope of work and number of topics covered in the proposal. The actual number and value of the awards will depend on the quality of the proposals received. Multi-year awards are subject to funding availability in subsequent fiscal years. In some cases, a subset(s) of a proposal may be selected for a partial award.

The following checklist describes the minimum information expected in the science-technical management section of the proposal. It must clearly describe:

- Specific topic(s) in this solicitation the proposal is addressing
- Statement of relevance to the Subsonic Fixed Wing (SFW) project goals
- Background and objectives of the proposed research
- Technical approaches
- Level of effort to be employed
- Targeted/anticipated results
- Specific quantifiable metrics to be used to judge progress
- Detailed work plan - includes a schedule with milestones and measurable metrics; as well as the qualifications, capabilities, and experience of the lead organization and team members.
- Contribution of the proposed work to subsonic aeronautics technology
- Statement of what intellectual property is expected to be publicly available at the conclusion of the work (note that it is our intent to share knowledge developed under this solicitation, thus, any restrictions to the objective may impact the evaluation of the proposal)
- Plans for oral presentations, interim reports, and final report. A travel budget to support these reviews should be included in the proposal

The science-technical-management section must not exceed 20 pages. Supporting information such as budget, resumes, and commitment letters will not be counted toward the 20 page limit. Please refer to NASA ROA-2010 section IV, “Proposal and Submission Information”, for requirements on proposal content, format, budget details, and submission procedures. Bidders should propose an appropriate level of effort (cost and duration). The estimated level of effort provided with the topic description is for general guidance.

Milestones with measurable metrics toward achieving the proposed goal must be provided. Annual and final oral presentations to be made as part of an open technical exchange meeting for purposes of technology transfer and knowledge dissemination will be expected. There will be a kick-off meeting at the beginning of the award period, annual reviews and a final review. These meetings will be held at/near one of the NASA centers, and must be attended by at least the principal investigator for the award. Quarterly reports are expected; the information in these reports will be one of the factors used to determine whether adequate progress has been made. Complete documentation of approach and results in the form of a written final report is required at the end of the complete effort.

The intent of the NRA process is to foster strategic partnerships between NASA and the awarded institutions for collaborative research and development of innovative concepts, ideas, technologies and approaches. Therefore substantial interaction with NASA researchers may be anticipated while performing work under these awards. Bidders may include as part of the proposal visits of appropriate length to a NASA Center for the purpose of coordinating the proposed work with corresponding efforts by NASA researchers.

4. Evaluation Criteria and Basis for Award

The principal elements considered in evaluating a proposal are its relevance to NASA's objectives, technical merit, and effectiveness of the proposed work plan (including cost and team qualifications). Failure of a proposal to be highly rated in any one of the following elements is sufficient cause for the proposal to not be selected.

1. Relevance (weight 30%):
- Evaluation of a proposal's relevance to NASA's objectives includes the consideration of the potential contribution of the effort to the specific objectives and goals given in the solicitation to which the proposal is submitted.
- The evaluation process will also consider the importance of the work to the primary project objectives of advancing knowledge and understanding of the fundamental principles of flight unique to subsonic flight.

2. Technical Merit (weight 50%):
- Overall scientific or technical merit of the proposal, including unique and innovative methods, approaches, or concepts.
- Evaluation will also include: credibility of technical approach, including a clear assessment of primary risks and a means to address them; proposer's capabilities, related experience, facilities, techniques, or unique combination of these which are integral factors for achieving the proposal's objective.
- The selection process will also assess the proposal against the state-of-the-art.

3. Effectiveness of the Proposed Work Plan (weight, 20%):
- Comprehensiveness of work plan, effective use of resources, management approach, and proposed schedule for meeting the objectives.
- Proposed team qualifications.
- Proposed cost realism and reasonableness.
- Objectives with measurable metrics toward achieving the proposer's goal must be provided, with a minimum of one metric per year.
- Documentation of approach and results in the form of final written technical reports is required.
- A clear statement of what intellectual property is expected to be publicly available at the conclusion of the work. It is NASA's intent that all deliverables under the contract be provided to NASA with unrestricted/unlimited rights; thus, any restrictions must demonstrate a significant net benefit to NASA and may cause a lower score.
- Collaboration with NASA researchers (including joint use of facilities, sharing of materials, development of computer code modules compatible with NASA's software, and synergistic research goals) is desirable, with the objective of enhancing knowledge transfer and the long-term value of the proposed work.

5. References

5.1 NASA Facilities

The following websites provide information on NASA aeronautics facilities capabilities, testing, and contact information. If use of NASA facilities is proposed, the facility costs associated with testing will be covered outside of the funding for this NRA. The costs of fabricating test articles, fixtures, and instrumentation required for the testing shall be incurred by the proposer and included in the proposed cost. The proposal will need to specify the test article size, requirements, facility, and approximate testing time. Specific details such as timeframe and duration of testing will be negotiated upon selection of a proposal. A non-NASA facility may be proposed, in which case the costs must be included in the proposed cost. Information on NASA test facilities can be found at the following websites.

NASA Center	URL
Ames Research Center, ARC	http://windtunnels.arc.nasa.gov/ http://ffc.arc.nasa.gov/ (simulations facilities)
Dryden Flight Research Center, DFRC	http://www.nasa.gov/centers/dryden/capabilities/index.html
Glenn Research Center, GRC	http://facilities.grc.nasa.gov/explore/explore_aero.html
Langley Research Center, LaRC	http://wte.larc.nasa.gov/

6. Summary of Key Information

Expected annual program budget for new awards	~ $4-6M per year
Number of new awards pending adequate proposals of merit	~ 20-30 awards
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	10/26/10
Due date for proposals	11/30/10
NASA objective(s) which proposals must state and demonstrate relevance to	Every proposal must address the specified topic objective(s) and outcome(s) in the solicitation of this NRA.
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NRA Proposers Guidebook – 2010* at: http://www.hq.nasa.gov/office/procurement/nraguidebook/proposer2010.pdf
Page limit for the central Science-Technical-Management section of proposal	20 pages; see also Chapter 2 of the *NRA Proposers Guidebook.*
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the Summary of Solicitation of this NRA and Chapter 3 of the *NRA Proposers Guidebook.*
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Expected award type	Contracts or Cooperative Agreements
Funding opportunity number for downloading an application package from Grants.gov	NNH10ZEA001N-SFW1
NASA points of contact (POC)	Email questions to: Subsonicfixedwing@grc.nasa.gov Written responses will be posted on the solicitation website. Principal Investigator: Ruben Delrosario Project Scientist: Rich Wahls NRA Manager: Kim Pham Procurement POC: Melissa Merrill, melissa.a.merrill@nasa.gov