NASA SBIR 2015 Phase I Solicitation

A1 Air Vehicle Technology

Lead Center: HQ

The Air Vehicle Technology topic solicits cutting-edge research in aeronautics to overcome technology barriers and challenges in developing safe, new vehicles that will fly faster, cleaner, and quieter, and use fuel far more efficiently. The primary objective is the development of knowledge, technologies, tools, innovative concepts and capabilities needed as the Nation continues to experience growth in both domestic and international air transportation while needing to protect and preserve the environment.

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This topic solicits tools, technologies and capabilities to facilitate assessment of new vehicle designs and their potential performance characteristics. These tools, technologies and capabilities will enable:Â

- The best design solutions to meet performance and environmental requirements and challenges.
- Technology innovations of future air vehicles.

It also solicits research in revolutionary aircraft concepts; lightweight high strength structures and materials; more efficient propulsion systems; low emissions propulsion concepts; measurement techniques, and advanced concepts for high lift and low drag aircraft that meet the performance, efficiency and environmental requirements of future aircraft, and the goals of the NextGen.

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This topic covers aircraft technologies covered by the former Fundamental Aeronautics Program as well as ground test technologies formerly covered by the Ground and Flight Test Techniques and Measurement topic under the Aeronautics Test Program, which are now under the Advanced Air Vehicles Program (AAVP). The re-structuring will emphasize development of tools, technologies, test techniques, and knowledge to meet metrics derived from a definitive set of Technical Challenges responsive to the goals of the National Aeronautics Research and Development (R&D) Policy and Plan, the National Aeronautics R&D Test and Evaluation (T&E) Infrastructure Plan (2011), and the NASA Aeronautics Strategic Implementation Plan (2013). AAVP consists of five projects, three that target a specific vehicle class/type, and two crosscutting projects focused on commonly encountered challenges associated with composite materials and capabilities necessary to enable advanced technology development:Â

- Advanced Air Transport Technologies (AATT) Project explores and develops technologies and concepts for improved energy efficiency and environmental compatibility of fixed wing, subsonic transports.
- Revolutionary Vertical Lift Technologies (RVLT) Project develops and validates tools, technologies, and concepts to overcome key barriers for rotary wing vehicles.
- Commercial Supersonics Technology (CST) Project enables tools and technologies and validation

capabilities necessary to overcome environmental and performance barriers to practical civil supersonic airliners and sustains NASA competence in hypersonic air-breathing propulsion necessary to support the nearer-term Department of Defense (DoD) hypersonic mission.

- Advanced Composites (AC) Project focuses on reducing the timeline for development and certification of innovative composite materials and structures.
- Aeronautics Evaluation & Test Capabilities (AETC) Project sustains and enhances those specific research and test capabilities necessary to address and achieve the future air vehicles and operations as described above.Â

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Subtopics

A1.01 Structural Efficiency-Hybrid Nanocomposites

Lead Center: LaRC

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Two of the primary goals of the Advanced Air Vehicles program are safety and efficiency, which can be achieved simultaneously through designer materials tailored for future aircraft structures. The SOA for lightweight structures are carbon fiber reinforced polymeric composites which make up approximately 50% of the weight of Boeing's 787. Adoption of all-carbon nanotube (CNT) composites to exploit their potential for enhancing structural efficiency is viewed as too far term, given the current state of CNT technology maturation. A more attainable approach is to take advantage of the multifunctionality offered by CNTs through the use of hybrid composites where CNTs are integrated into conventional carbon fiber reinforced composite structures. Hybrid composites enable improved mechanical properties such as interlaminar strength, while simultaneously increasing electrical and thermal conductivity to enable features such as lightning strike protection, embedded sensing, etc. The targeted outcome is reduced weight and enhanced safety performance for future hybrid composite aircraft structures. For this subtopic, the plan is to start phase 1 with a systems analysis approach to identify the benefits and target areas for hybrid composite utility and to provide some direction and benefit analysis for applying hybrid composites in aircraft structures. Then the intention of the Phase II would be to tailor, build and test the materials to demonstrate the property enhancements identified in Phase I.

A1.02 Aerodynamic Efficiency Drag Reduction Technology

Lead Center: LaRC

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The challenge of energy-efficient flight has at its foundation aerodynamic efficiency, and at the foundation of aerodynamic efficiency is low drag. Drag can be broadly decomposed into four components: viscous or skin friction drag, lift-induced drag, wave or compressibility drag, and excrescence drag due to various protruding items such as antennae, wipers, lights, etc. The relative impact of these four forces depends upon the targeted flight regime and vehicle-specific design requirements. The first force, however, viscous skin friction, stands out as particularly significant across most classes of flight vehicles and effective measures for its control would have a major impact of flight efficiency. In particular, supersonic, low-boom flight and new generations of energy-efficient subsonic transport airplanes including high L/D strut-braced designs, the blended wing body (BWB), so called â€œdouble-bubbleâ€ designs and other concepts with large expanses of surface area would benefit from effective viscous drag control.

Viscous skin friction can be classified as either laminar or turbulent. While the laminar case and its attendant laminar flow control (LFC) techniques remain important scientific and technological disciplines, the goal of high Reynolds number flight efficiency requires that the turbulent case receive renewed attention. In place of the first-principles-derived theoretical framework of the laminar flow stability problem, in the turbulence case we have a wide collection of experimental observations, data correlations, various CFD approaches requiring turbulence closure models and, at low Reynolds numbers, full direct numerical simulation of the Navier-Stokes equations (DNS). While such experimental and CFD-derived knowledge, has greatly increased our understanding of turbulent boundary layer physics over the past decades, key relationships between wall layer and outer layer dynamics essential to a full understanding remain to be identified and verified.

Inadequacies in our understanding of boundary layer turbulence increase reliance upon a more qualitative, physics-guided approach to discovery. For example, the experimental observation of reduced skin friction in the corners of triangular cross-section pipes lead to the discovery of drag-reducing V-groove riblets (subsequently also associated with the skin of certain shark species). The quasi-periodic, low-speed streak structures observed in the near-wall layer of turbulent boundary layers lead to the implementation of mechanically controlled spanwise waves or lateral oscillations of the wall to disrupt the processes associated with low speed streak bursting. Similar observations have either been made or suggested with respect to the stabilizing influence of convex and in-plane curvature; long length-to-diameter ratio particulates; passive, active and reactive wall motion; manipulation of the wall layer by various geometrical devices (e.g., vortex generators (VG) and large eddy breakup devices (LEBU)), and various weakly ionized gas (WIG) and magnetohydrodynamic/electrohydrodynamic (MHD/EHD) concepts. This solicitation is offered in this spirit of innovation based on experimental or computational observations guided by a basic, though not necessarily complete, physical understanding of the turbulent processes.Â

In order to stimulate innovation in the area of turbulent viscous drag reduction, proposals are sought subject to the following guidelines:

- Proposals shall address passive, active or reactive concepts for external, attached, fully developed, turbulent boundary layer viscous drag reduction in air.
- Experimental, hardwareâ€“based proposals and theoretical/computational proposals based on realizable hardware are preferred.
- All practical physical concepts are acceptable including but not limited to: mechanical/electro-mechanical actuators, weakly-ionized-gas (WIG) concepts, laser/microwave energy deposition, MHD/EHD devices, surface microstructure/geometry, embedded mechanical devices (VGâ€™s, LEBUâ€™s), wall mass transpiration, heat transfer, wall motion, wall curvature effects and pressure gradient (vehicle shaping).
- Significant enhancements or refinements of existing concepts and technologies are acceptable.
- First order assessment or technically plausible discussion of any net system energy saving claims shall be provided.
- Proof-of-concept experimental demonstrations are encouraged for Phase I where applicable but are not required.
- Target conditions are flight-relevant Reynolds numbers at either high subsonic (0.7 < M < 0.9) or low supersonic (M<~ 3) speeds. Proposals at lower Mach and Reynolds numbers shall provide discussion of a developmental path towards flight-relevant conditions but not necessarily inclusive of actual flight.

A1.03 Low Emissions Propulsion and Power

Lead Center: GRC

Participating Center(s): AFRC, ARC, LaRC

Proposals are sought which support electric propulsion of transport aircraft, including turboelectric propulsion (turbine prime mover with electric distribution of power to propulsors) and various hybrid electric concepts, such as gas turbine engine and battery combinations.

Turboelectric propulsion for transport aircraft applications will require components with high specific power (hp/lb or kW/kg) and high efficiency, and cryogenic and superconducting components will likely be required. The cryogenic components of interest include fully superconducting generators and motors (i.e., superconducting stators as well as rotors), cryogenic inverters and active rectifiers, and cryocoolers. Proposals related to the superconducting machines may include aspects of the machines themselves and their subcomponents, as well as low AC loss superconducting materials for the stator windings. Generators with at least 10 MW capacity and motors of 2 to 4 MW capacity are of interest. Technology is sought that can contribute to superconducting machines with specific power more than 10 hp/lb.

Hybrid propulsion with non-cryogenic components will likely require new materials and configurations to reach required high specific power and efficiency. Hence ideas are sought for achieving 2-3X increase in specific power at high efficiency for non-cryogenic motors through a multidisciplinary approach utilizing advanced motor designs, better materials, and new structural concepts.

New approaches to achieving conductors with lower electrical resistivity than copper are particularly sought, e.g., conductors based on carbon nanotubes. However, such approaches must be backed by plausible reasons why a resistivity lower than that of copper can be expected to be achieved, in contrast to the best reported resistivity values for carbon nanotube fibers, which are nearly an order of magnitude higher.

Ideas are also sought to address challenges related to high voltage power transmission in future hybrid electric aircraft.

New modeling and simulation tools for hybrid electric aircraft propulsion systems are also of interest.

Some studies of turboelectric distributed propulsion components and systems can be found in the following and referenced therein:Â

- â€œStability, Transient Response, Control, and Safety of a High-Power Electric Grid for Turboelectric Propulsion of Aircraftâ€, Michael Armstrong, Christine Ross, Danny Phillips, and Mark Blackwelder, NASA/CRâ€”2013-217865, 2013
- â€œTurboelectric Distributed Propulsion in a Hybrid Wing Body Aircraftâ€, J. Felder, G. Brown, H. Kim, J. Chu, 20th ISABE Conference, GÃ¶tenberg, Sweden, 12-16 Sept., 2011
- â€œWeights and Efficiencies of Electric Components of a Turboelectric Aircraft Propulsion Systemâ€, G. V. Brown, 49th AIAA Aerospace Sciences Meeting, Orlando FL, January 4-7, 2011
- â€œTurboelectric Distributed Propulsion Engine Cycle Analysis for Hybrid-Wing-Body Aircraftâ€, J. L. Felder, H. D. Kim, G. V. Brown, 47th AIAA Aerospace Sciences Meeting, Orlando FL, January 5-8, 2009

A1.04 Quiet Performance

Lead Center: LaRC

Participating Center(s): GRC

Innovative technologies and methods are necessary for the design and development of efficient, environmentally acceptable aircraft. In support of the Advanced Air Vehicles, Integrated Aviation Systems and Transformative Aero Concepts Programs, improvements in noise prediction, acoustic and relevant flow field measurement methods, noise propagation and noise control are needed for subsonic, transonic and supersonic vehicles targeted specifically at airframe noise sources and the noise sources due to the aerodynamic and acoustic interaction of airframe and engines. Innovations in the following specific areas are solicited:Â

- Fundamental and applied computational fluid dynamics techniques for aeroacoustic analysis, which can be adapted for design purposes.
- Prediction of aerodynamic noise sources including those from the airframe and those that arise from significant interactions between airframe and propulsion systems including those relating to sonic boom.
- Prediction of sound propagation from the aircraft through a complex atmosphere to the ground. This should include interaction between noise sources and the airframe and its flow field.
- Propagation of sonic boom through realistic atmospheres, especially turbulence effects.
- Innovative source identification techniques for airframe (e.g., landing gear, high lift systems) noise sources, including turbulence details related to flow-induced noise typical of separated flow regions, vortices, shear layers, etc.
- Concepts for active and passive control of aeroacoustic noise sources for conventional and advanced aircraft configurations, including adaptive flow control technologies, and noise control technology and methods that are enabled by advanced aircraft configurations, including integrated airframe-propulsion control methodologies. Innovative acoustic liner and porous surface concepts for the reduction of airframe

noise sources and/or propulsion/airframe interaction are solicited but engine nacelle liner applications are specifically excluded.

- Development of synthesis and auditory display technologies for subjective assessments of aircraft community noise, including sonic boom.

A1.05 Physics-Based Conceptual Aeronautics Design Tools

Lead Center: GRC

Participating Center(s): LaRC

NASA continues to investigate the potential of advanced, innovative propulsion and aircraft concepts to improve fuel efficiency and reduce the environmental footprint of future generations of commercial transports across the breadth of the flight speed regimes. Propulsion systems, such as open rotors and hybrid-electric propulsion, are viewed as potential options for helping meet aggressive, long range (i.e., 'N+3' timeframe) emission reduction targets. Accurate representation of the propulsion system is critical in confidently assessing the potential of a concept. Conceptual design and analysis of unconventional propulsion concepts and technologies is used for technology portfolio investment planning, development of advanced concepts to provide technology pull and independent technical assessment of new concepts. The agency's systems analysts need to have the best conceptual design/analysis tools possible to support these efforts. Substantial progress has been made recently in incorporating more physics-based analysis tools in the conceptual design process, and NASA has developed a capability that integrates several analysis tools and models in engineering frameworks, such as ModelCenter and OpenMDAO. However, modeling gaps still remain in many disciplines.

Historically, empirical and semi-empirical weight estimation methods have been utilized during the conceptual design phase. These techniques work well for the conceptual design of conventional propulsion systems with parameters that reside within the historical databases used to develop the methodologies. However, these methods are not well suited for unconventional propulsion concepts, or even conventional concepts which reside outside of the database. Developing higher order, more accurate tools suitable for conceptual design is a difficult challenge. The first issue is analysis turnaround time. To perform the configuration trades and optimization typical of conceptual design, runtimes measured in seconds or minutes, instead of hours or days, are required. However, rapid analysis turnaround time alone is insufficient. To be suitable for conceptual design, tools and methods are needed which accurately predict the 'as-built' characteristics. Because it is not possible to model every detail of the design and account for all the underlying physics in the problem formulation, it is difficult to predict the 'as-built' characteristics with physics-based methods alone. What is usually required is a combination of these methods with some semi-empirical corrections. A final challenge in conceptual design is a lack of detailed design information. Lower order, empirical-based methods often require only gross design parameters as inputs. The gap between the analysis capability and the maturity of the design being analyzed currently limits the usefulness of high order analysis in conceptual design. Physics-based tools for conceptual design are needed which are consistent with the amount of design knowledge that is available at the conceptual design stage.

NASA has a well-established propulsion systems analysis tool suite that is based on the Numerical Propulsion System Simulation (NPSS) and the Weight Analysis of Turbine Engines (WATE) codes. Ideally, new capabilities that arise from this solicitation should be compatible with NPSS and/or WATE or offer significantly increased capability beyond/outside of these state-of-the-art tools.

For FY 2015, the focus is on addressing remaining capability gaps. Examples of desired capability improvements include the following:Â

- Physics-based methodologies and sizing of hybrid-electric propulsion components.
    - Weight/volumetric estimates for major components (e.g., batteries, fuel cells, motors, generators, cryocoolers, transformers, inverters, rectifiers).
- Heat exchanger performance and weight/volume estimation modeling tools.
- Computational counter-rotating open rotor performance tools.
    - Low/Medium-fidelity modeling approaches for predicting open rotor performance based on key blade characteristics.
- Multi-fidelity environmental analysis tools.
    - Combustion emission indices generation consistent with advanced combustor architectures.

- Advanced acoustic-modeling addressing propulsion/airframe shielding, Fan/turbomachinery noise and/or jet noise.
- Multi-fidelity Propulsion-Airframe Integration (PAI) performance analysis tools.
    - Propulsion installation analysis methods (inlet/nacelle/nozzle analysis in the presence of an airframe).
    - Advanced mission-analysis methods incorporating multiple degrees of freedom and including expansive/adaptable propulsion operability capability.
- Macro Systems Analysis tools addressing propulsion-related impacts.
    - Reduced-order atmospheric chemistry/global mixing tools.
    - Safety/reliability analysis tools consistent with conceptual-level design/analysis.
    - Global airport throughput network and commerce models.

A1.06 Vertical Lift

Lead Center: ARC

Participating Center(s): GRC, LaRC

The Vertical Lift subtopic is primarily interested in the following two areas:Â

- The use of small vertical lift UAVs has increased in recent times with many civilian missions being proposed, including autonomous surveillance, mapping, etc. Much of the current research associated with these vehicles has been in the areas of electric propulsion, batteries, small sensors and autonomous control laws, while very little attention has been paid to their acoustic signature. The generation and propagation of noise associated with this small class of vertical lift UAVs are not well understood and validated prediction tools do not currently exist. The objective of a proposed effort would be to develop tools for the modeling and prediction of the high frequency acoustics for small vertical lift UAVs, such as quad-copters, coaxials, ducted fan rotors, etc.
- A transition to low-carbon propulsion has the promise of dramatically reducing the emissions from full-scale rotorcraft, as well as reducing overall fuel consumption and operating cost. All electric and hybrid propulsion systems could be beneficial to rotorcraft due to high power requirements of hover and integrated motor-drive systems designs that could be realized. The objective of a proposed effort would be to develop and demonstrate hybrid/electric technologies for full-scale rotorcraft drive and propulsions systems that show benefits in-terms of weight, efficiency, emissions and fuel consumption. Validated modeling and analysis tools for all-electric and hybrid propulsions systems are also sought in this solicitation.

Proposals on other rotorcraft technologies will also be considered but the primary emphasis of the solicitation will be on the above two identified technical areas.Â

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A1.07 Efficient Propulsion and Power

Lead Center: GRC

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For 2014, this sub-topic will focus on propulsion controls and dynamics. Propulsion controls and dynamics research is being done under various projects in the Fundamental Aeronautics Program (FAP) and Aviation Safety Program (ASP). For turbine engines, work on Distributed Engine Control (DEC) and Active Combustion Control (ACC) is currently being done under the Aeronautics Sciences (AS) project, and is expected to transition to the new Transformative Tools and Technologies (TTT) project in FY15. Aero-Propulso-Servo-Elasticity (APSE) research will continue under the High Speed project. Model-Based Engine Control research is currently being conducted under the Vehicle System Safety Technologies project, and is expected to transition to the TTT project in FY15. Propulsion controls and dynamics technologies that help achieve the goals of the following NASA ARMD strategic thrusts: Innovation in Commercial Supersonic Aircraft; Ultra-Efficient Commercial Vehicles; and Assured Autonomy for Aviation Transformation, will be given preference. Following technologies are of specific interest:*Â*

- *High Efficiency Robust Engine Control* - Typical current operating engine control logic is designed using SISO (Single Input Single Output) PI (Proportional+Integral) control. The control logic is designed to provide minimum guaranteed performance while maintaining adequate safety margins throughout the engine operating life. Additionally, the control logic indirectly provides control of variables of interest such as Thrust, Stall Margin, etc. since these variables cannot be measured or are not measured in flight because of restrictions on sensor cost/placement/reliability, etc. All this results in highly conservative control design with resulting loss in efficiency. NASA is currently conducting research in Model-Based Engine Control (MBEC) where-in an on-board real-time engine model, tuned to reflect current engine condition, is used to generate estimate of quantities of interest that are to be regulated or limited and these estimates are used to provide direct control of Thrust, etc. Alternate methods such as Model Predictive Control, Adaptive Control, direct non-linear control, etc. are of interest. However, the alternative methods must achieve the same objectives as the current MBEC approach by providing practical application of the control logic in terms of operation with sensor noise, operation across varying atmospheric conditions, operation across varying engine health condition over the operating life, and real-time operation within engine control hardware limits. The emphasis is on practical application of existing control methods rather than theoretical derivation of totally new concepts. Control design approaches that can accommodate small to medium engine component faults and can still provide desired performance with safe operation are of special interest. The pre-requisite for proposals for engine control design methods is that the NASA C-MAPSS40k (Commercial Modular Aero-Propulsion System Simulation for 40,000 lb class thrust engine) be used for control design and evaluation. This simulation can only be used by U.S. citizens since it is subject to export control laws. Methods for real-time engine parameter identification using flight data are also of interest by themselves.
- *Distributed Engine Control* - Current engine control architectures impose limitations on the insertion of new control capabilities primarily due to weight penalties and reliability issues related to complex wiring harnesses. Obsolescence management is also a primary concern in these systems because of the unscheduled cost impact and recertification issues over the engine life cycle. NASA in collaboration with AFRL (Air Force Research Lab) has been conducting research in developing technologies to enable Distributed Engine Control (DEC) architectures. Modularity is an inherent feature of distributed engine control architecture. Modularity enables the rapid integration of the individual functions of control into a cohesive system by virtue of common digital interfaces and the well-defined flow of data. This interface structure can persist regardless if the control function exists in hardware or simulation. At the engine system level, distributed architecture enables scalability and reuse of control functional elements across engine platforms, but it also simplifies the insertion of new control technologies within the smart devices. NASA is interested in the development and simulation of these distributed control functions for high temperature embedded application on the engine core. NASA is particularly interested in the design and development of these applications for assessing the benefit they bring to the engine system.
- *Active Combustion Control* - The overall objective is to develop all aspects of control systems to enable safe operation of low emissions combustors throughout the engine operating envelope. Low emission combustors are prone to thermo-acoustic instabilities. So far NASA research in this area has focused on modulating the main or pilot fuel flow to suppress such instability. Advanced, ultra-low emissions combustors utilize multi-point (multi-location) injection to achieve a homogeneous, lean fuel/air mixture. There is new interest in using precise control of fuel flow in such a manner as to suppress or avoid thermo-acoustic instabilities. Miniature fuel metering devices (and possibly also fuel flow measurement devices) are needed that can be physically distributed to be close to the multi-point fuel injector in order to enable the control system to accurately place a given proportion of the overall fuel flow to each of the fuel injection locations.
- *Aero-Propulso-Servo-Elasticity (APSE)* - The objective of NASA research effort in APSE is to develop a comprehensive variable cycle engine (VCE) type dynamic propulsion system model that can be utilized for thrust dynamics and integrated APSE vehicle controls and performance studies, like vehicle ride quality and vehicle stability under typical flight operations, vehicle maneuvering and atmospheric disturbances, for supersonic vehicles. Innovative approaches to dynamic modeling that are of interest include supersonic external compression inlets; multi flow paths convergent-divergent type nozzles with a spike; parallel flow path modeling of propulsion components upstream of the combustor to accurately model the distortion effects, maneuvering and atmospheric disturbances; and integration of dynamic propulsion models with aircraft simulations incorporating flexible vehicle structural modes.

A1.08 Ground Testing and Measurement Technologies

Lead Center: LaRC

Participating Center(s): GRC

This subtopic supports the experimental modeling and simulation requirements of NASA's Aeronautics Research Mission Directorate, as well as the testing requirements of other government and commercial entities. The subject facilities are managed by the Aeronautics Evaluation and Test Capability (AETC) Project within the NASA Advanced Air Vehicles Program. The primary objective of this subtopic is to develop innovative tools and technologies that enhance testing and measurement capabilities, improve ground test resource utilization and efficiency, and provide capability sustainment. Where possible, the tools and technologies should be applicable for the broad national scope of government, commercial, and university capabilities.

Wind tunnel vehicle design databases have traditionally included the foundational measurements of forces and discrete surface pressures and temperatures. However, designing and testing future vehicles with non-traditional aerodynamic geometries, possibly including highly integrated and distributed propulsion and flow control systems, will require enhanced, remotely sensed global surface measurements that cover a wide range of operational conditions. Enhanced optical systems are required to visualize the flow interactions both on and off the surface. Non-intrusive measurement systems offering multi-component velocities, density, and pressure in the tunnel stream are required to routinely quantify and baseline the test environment and to establish boundary conditions for advanced computational simulations. Non-intrusive measurements of off-body and near-body flow parameters both at a point and globally (i.e., planar or volumetric) are necessary to examine fluid-fluid and fluid-structure interactions for computational solution validation. The development of diagnostics for simultaneous volumetric measurements are particularly desired and will require a concentrated research effort in the development of enhanced laser and imaging techniques (including light field imaging), the development of new optical configurations, and the development of near real-time to real-time acquisition and processing architectures. In particular, development of techniques that significantly increase data capture per test point are needed, including the ability to simultaneously measure multiple flow parameters at high acquisition rates to capture rapidly evolving or oscillatory flow phenomena. Maturation of current particle-based, molecular, and/or surface diagnostics and unification of compatible instruments are desired. In all cases, significant measurement accuracy enhancements are required. Measurement systems must be robust and user-friendly for practical and routine application.

Proposals for clean seeding methods that do not contaminate wind tunnel walls or anti-turbulence screens are solicited. Seedless methods for velocity measurements near a model surface are particularly desired for adverse test environments where seeding contaminants are prohibited, may alter the model surface flow, or possibly damage gas reclamation systems. Two such environments occur at NASA Langley for -250Â°F cryogenic testing at the National Transonic Facility and heavy-gas testing using R134a at the Transonic Dynamics Tunnel.

Proposals are also solicited for shear stress sensors that are applicable to high-temperature/high-flow-rate environments such as those encountered in engine and high-speed testing where surface heating is important.

Small models and/or packaging constraints for large models can make model attitude measurements difficult. Testing in the non-gravity direction precludes use of traditional angle sensors. Many test configurations require multiple angle of attack systems, including redundant systems to guard against in-test failure. Maintaining calibration currency and accuracy of multiple systems significantly increases test costs and complexity. Proposals are solicited for accurate, real-time, optical, non-intrusive techniques for determining model attitude.

The impact of icing on vehicle performance for flight certification is increasingly important. Currently, the NASA Glenn Icing Research Tunnel cannot reproduce the full range of test conditions defined in the FAA Appendix O Supercooled Droplet Icing Conditions. Simulation of Appendix O conditions for freezing rain and drizzle scenarios requires a bimodal droplet distribution with much larger size droplets. These large droplets have an extended cooling period before entering the test section; and, they dont follow the flow, falling toward the test section floor. Innovative ideas and technology advancements are solicited to create and control Appendix O conditions in current facilities.

Many NASA wind tunnel facilities conduct tests at elevated temperatures (400Â°F to 700Â°F) or at extremely low temperatures (-250). Displacement measurement components in actuator systems for the setting of hydraulic cylinder positions and other hardware that is used in test article support and positioning systems must operate routinely in these environments. Innovative designs and hardware solutions are desired to provide accurate and reliable performance at these extreme conditions.

Additional information about the mission and facility capabilities may be obtained at (http://www.aeronautics.nasa.gov/atp/index.html).

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