NASA/TM—2016-219397

An Overview of Air-Breathing Propulsion Efforts for 2015 SBIR Phase I

Hung D. Nguyen and Gynelle C. Steele
Glenn Research Center, Cleveland, Ohio

October 2016

NASA STI Program . . . in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program plays a key part in helping NASA maintain this important role.

The NASA STI Program operates under the auspices of the Agency Chief Information Officer. It collects, organizes, provides for archiving, and disseminates NASA's STI. The NASA STI Program provides access to the NASA Technical Report Server—Registered (NTRS Reg) and NASA Technical Report Server—Public (NTRS) thus providing one of the largest collections of aeronautical and space science STI in the world. Results are published in both non-NASA channels and by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counter-part of peer-reviewed formal professional papers, but has less stringent limitations on manuscript length and extent of graphic presentations.

- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., "quick-release" reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.

- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.

- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

For more information about the NASA STI program, see the following:

- Access the NASA STI program home page at http://www.sti.nasa.gov

- E-mail your question to help@sti.nasa.gov

- Fax your question to the NASA STI Information Desk at 757-864-6500

- Telephone the NASA STI Information Desk at 757-864-9658

- Write to:
  NASA STI Program
  Mail Stop 148
  NASA Langley Research Center
  Hampton, VA 23681-2199

NASA/TM—2016-219397

An Overview of Air-Breathing Propulsion Efforts for 2015 SBIR Phase I

Hung D. Nguyen and Gynelle C. Steele
Glenn Research Center, Cleveland, Ohio

National Aeronautics and
Space Administration

Glenn Research Center
Cleveland, Ohio 44135

October 2016

Level of Review: This material has been technically reviewed by technical management.

Available from

NASA STI Program
Mail Stop 148
NASA Langley Research Center
Hampton, VA 23681-2199

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
703-605-6000

This report is available in electronic form at http://www.sti.nasa.gov/ and http://ntrs.nasa.gov/

Contents

An Overview of Air-Breathing Propulsion Efforts for 2015 SBIR Phase I

Hung D. Nguyen and Gynelle C. Steele
National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio 44135

Abstract

NASA's Small Business Innovation Research (SBIR) program focuses on technological innovation by investing in development of innovative concepts and technologies to help NASA mission directorates address critical research needs for Agency programs.

This report highlights 24 of the innovative SBIR 2015 Phase I projects that emphasize one of NASA Glenn Research Center's six core competencies—Air-Breathing Propulsion. The technologies cover a wide spectrum of applications such as hybrid nanocomposites for efficient aerospace structures; plasma flow control for drag reduction; physics-based aeroanalysis methods for open rotor conceptual designs; vertical lift by series hybrid power; fast pressure-sensitive paint systems for production wind tunnel testing; rugged, compact, and inexpensive airborne fiber sensor interrogators based on monolithic tunable lasers; and high sensitivity semiconductor sensor skins for multi-axis surface pressure characterization. Each featured technology describes an innovation and technical objective and highlights NASA commercial and industrial applications.

This report provides an opportunity for NASA engineers, researchers, and program managers to learn how NASA SBIR technologies could help their programs and projects, and lead to collaborations and partnerships between the small SBIR companies and NASA that would benefit both.

Hybrid Nanocomposites for Efficient Aerospace Structures

Cornerstone Research Group, Inc.

NASA seeks to address the primary goals of the Advanced Air Vehicles program, improving safety and efficiency, through exploration of the value for hybrid composites to guide the direction for development and insertion of the materials into industry. Cornerstone Research Group Inc. (CRG) formed a team of experts in the aerospace composites industry to perform a systems-level value assessment for hybrid composites into target aircraft application areas, and to demonstrate actual material properties through a preliminary hybrid composite formulation, fabrication, and characterization activity during this Phase I project. The Phase I project successfully demonstrated composite property enhancements for hybrid nanocomposites over a baseline toughened epoxy prepreg. The successful material approach has potential to reduce aircraft costs and emissions. In Phase II and beyond, this team provides the necessary skills and capabilities—industry insight, materials formulation, nanomaterials dispersion, composites design, aerospace structures design, and composites manufacturing—to drive the technology into commercial application.

Applications

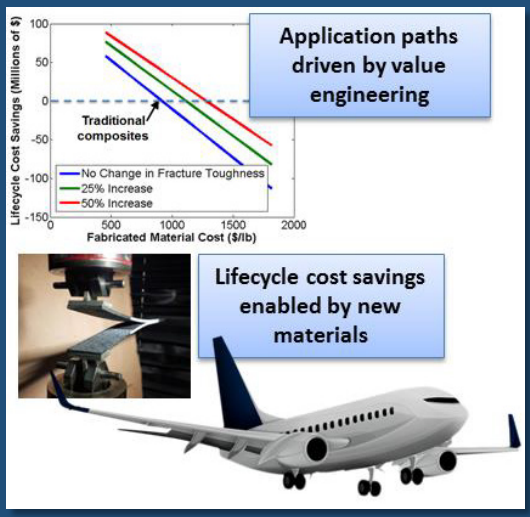
NASA

Supporting several NASA Aeronautics Research Mission Directorate projects and the Advanced Composites Project, this project's technologies directly address requirements for acceleration of development and certification procedures for composite materials. The project results provide an objective, value-driven roadmap for the development and integration of hybrid composite materials, leveraging scalable, certifiable design and manufacturing practices. Hybrid nanocomposites could be used by NASA to design, build, and test future aerospace research vehicles.

Commercial

Hybrid nanocomposite technology has high potential for application in public and private sector commercial aircraft systems. Providing structural property enhancements with affordable manufacturing approaches, hybrid nanocomposites developed by CRG and its team have the potential to buy their way onto both single aisle and double aisle commercial aircraft.

Hybrid composites: reducing aircraft cost and emissions



Firm Contact

Bryan Pelley
pelleybm@crgrp.com
2750 Indian Ripple Road
Dayton, OH 45440-3638
(937) 320-1877

Proposal number: 15-1 A1.01-9678

Plasma Flow Control for Drag Reduction

Innovative Technology Applications Company, LLC

Fuel costs have historically been the largest single cost associated with aircraft operations. Improved efficiency therefore translates directly to the bottom line. The worldwide aviation industry is a significant emitter of carbon dioxide and other greenhouse gases; the International Civil Aviation Organization puts it at 2% of the global anthropogenic total. The impact of these emissions is amplified even more, however, because they go directly into the upper troposphere. We propose an efficient plasma-based method for drag reduction which, when fully developed will directly translate to reduced fuel consumption and reduced emissions. The Phase I effort involved a combined experimental and numerical investigation for proof-of-concept implementation of the plasma-based drag-reducing technology. In follow-on Phase II work, the ITAC team will work to expand the flight envelope over which the plasma-based method can be applied.

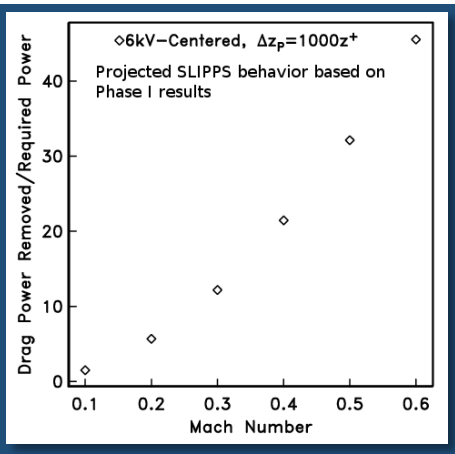
Applications

NASA

When fully developed, the proposed plasma-based drag reduction technology would be widely applicable within NASA. Any system with significant contributions to drag from attached turbulent boundary layers has the potential to benefit from this approach. This includes not only flight vehicles, but also test facilities, which can take advantage of the reduced power required to maintain test conditions.

Commercial

Since fuel costs have historically been the largest single cost of airline operations, any technology which offers significant drag reduction (and thus fuel savings) is of great interest to aircraft manufacturers. Other potential areas of application include high speed rail (and also normal passenger rail). Operators of ground test facilities outside of NASA (whether DoD or privately held) might also be interested in this technology.



Firm Contact

Dr. Alan Cain
abcain1@gmail.com
P.O. Box 6971
Chesterfield, MO 63006-6971
(314) 373-3311, Extension: 1

Proposal number: 15-1 A1.02-9373

Cryogenic and Non-Cryogenic Hybrid Electric Distributed Propulsion with Integration of Airframe and Thermal Systems to Analyze Technology Influence

Empirical Systems Aerospace, Inc

A design iteration of ESAero's ECO-150 split wing turboelectric distributed propulsion (TeDP) concept is proposed to incorporate recent lessons learned in synergistic configuration opportunities, propulsion and thermal management system research and tool development, and aeropropulsive benefits reported by Lockheed Martin. Non-cryogenic and cryogenic/superconducting components will be included in three separate propulsion system architectures: one cooled via conventional "warm" coolant, one cryogenically cooled with a cryocooler system, and one cryogenically cooled with a liquid hydrogen blow-down system. The effort will begin with an interagency collaborative "Brainernet" brainstorming session to identify and assess technology and concept drivers and opportunities. Detailed configuration, aerodynamics, performance, and mission analysis will complement the effort, culminating in three flagship TeDP or hybrid electric distributed propulsion (HEDP) concepts which embody the propulsion-airframe-thermal integration (PATI) paradigm.

Applications

NASA

The ECO-150R configurations, with all the solicited NASA, Industry, and AFRL involvement, will have high visibility. This has unquantifiable benefits to commercialization, exposure, and business growth. ESAero's objective is to create a "poster child" for tube and wing TeDP/HEDP for themselves, but it is possible that this vehicle could be adopted by NASA. By updating the ECO-150 to the level of other concepts such as the N3-X, which has fostered immense research and development from all sides of the industry, ESAero will secure itself as a vital partner for follow-on research. Many aspects of the synergistic concept still wait to be investigated and introduced to the conceptual design process, including performance requirement relaxation opportunities and propulsion-aided control algorithms (PACA).

Commercial

ESAero will leverage the resulting configurations and the applied design process and tools to support conceptual design groups in their research and development of HEDP aircraft. This effort will demonstrate the utility of ESAero's latest tool development endeavors, which contribute to a more efficient conceptual design process with consideration of PATI factors. The tools and design process can guide aerospace primes and AFRL toward the identification of feasible HEDP configurations and support component manufacturers interested in how their technology would affect the leading edge in HEDP design and performance.

Firm Contact

Andrew Gibson
andrew.gibson@esaero.com
P.O. Box 595
Pismo Beach, CA 93448-9665
(805) 275-1053

Proposal number: 15-1 A1.03-9122

A New Cryocooler for MgB_2 Superconducting Systems in Turboelectric Aircraft

Creare, LLC

Turboelectric aircraft with gas turbines driving electric generators connected to electric propulsion motors have the potential to transform the aircraft design space by decoupling power generation from propulsion. Creare has previously developed a Cryoflight turbo-Brayton cryocooler concept that exceeds the mass and performance targets identified by NASA for superconducting aircraft with high-temperature superconducting (HTS) materials requiring cooling to 50 K. Here, we propose to extend the temperature range of our cryocooler with an innovative new cycle concept to provide cooling to 20 K for MgB_2 superconductors, which offer price and performance advantages for certain superconducting machines. In Phase I of this project, we evaluated the performance advantages of our concept through modeling and preliminary component designs. In Phase II, we will fabricate and test the highest-risk component to bring the overall TRL to 4. In Phase III, we will build and test a complete cryocooler to support extended performance testing with MgB_2 systems. This development effort will provide an enabling technology for the superconducting systems needed to make turboelectric aircraft feasible.

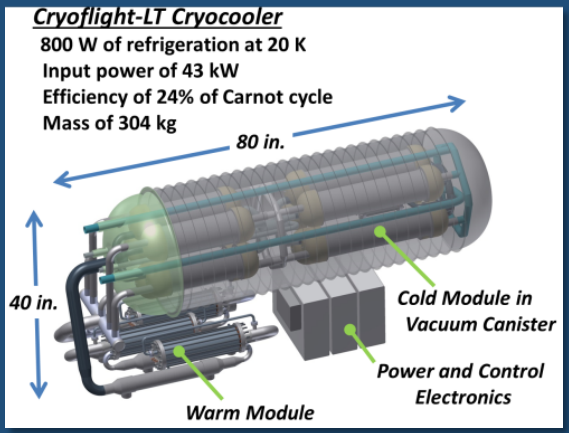
Applications

NASA

Our proposed cryocooler development effort will support NASA's long-term goal to increase aircraft efficiency and reduce aircraft emissions and noise. The results of this SBIR project will support continuing NASA design trade studies, system demonstrations, and eventual superconducting aircraft demonstrations. Other NASA applications include space applications such as hydrogen cryogenic liquefaction and storage for planetary and extraterrestrial exploration missions, CEVs, extended-life orbital transfer vehicles, in-space propellant depots, and extraterrestrial bases. Terrestrial NASA applications include cooling for spaceport cryogen storage and transportation systems. The highly reliable and space-proven turbo-Brayton cryocooler is ideal for these applications.

Commercial

Superconducting materials have the potential to revolutionize the way we generate, transmit, and consume power. Transformational initiatives that rely on superconducting technologies include power conditioning and power transmission systems, large-scale offshore wind turbines, high efficiency data centers, Navy ship systems, and turboelectric aircraft. While the latter is the target application for the proposed cryocooler, the other applications represent potential near-term markets for the technology. The 20 K operating temperature of these systems makes the cryocooler a critical component of any solution. There is also a large potential market beyond superconducting applications, including cooling for laboratory and industrial-scale gas separation, liquefaction, cryogen storage and cryogen transportation systems, liquid hydrogen fuel cell storage for the automotive industry, and commercial orbital transfer vehicles and satellites.



Firm Contact

Robert J Kline-Schoder
contractsmgr@creare.com
16 Great Hollow Road
Hanover, NH 03755-3116
(603) 643-3800, Extension: 2487

Proposal number: 15-1 A1.03-9346

Interferometric Correlator for Acoustic Radiation & Underlying Structural Vibration (ICARUSV)

Advanced Systems & Technologies, Inc.

Current methods for identification of aircraft noise sources, such as near-field acoustical holography and beam forming techniques, involve the use of pressure probes or microphone arrays to measure the radiated sound field. However, those techniques are intrusive, bandwidth limited, time consuming to implement, require extensive data processing and the resulting data may ultimately generate false results in the form of pseudo (noise) sources. Advanced Systems & Technologies Inc. proposes an optical non-contact sensor fusion concept which, for the first time, enables direct capture and observation of full-field non-stationary dynamic structural intensity (DSI) and unsteady radiated sound fields or transient flow fields around the structure of interest. In addition to being non-intrusive the measurements are fast, can be made at operationally relevant bandwidths, which extend to the ultrasonic domain, and provide deeper insight into the complex structural dynamics which are the root cause of noise emission.

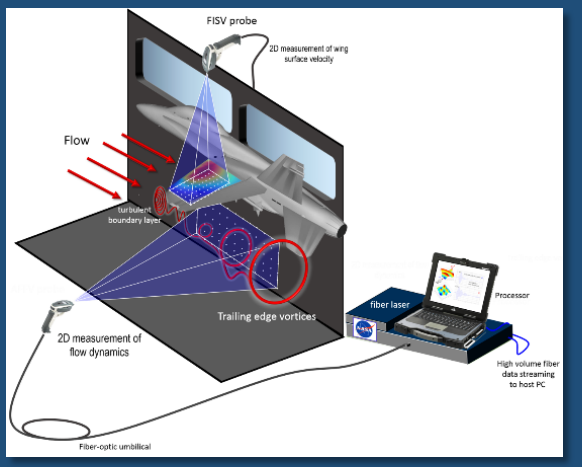
Applications

NASA

The ICARUSV contributes towards current and future noise reduction goals by providing a diagnostic tool for evaluation of a wide range of aircraft structures designed to effect noise reduction. Examples applications include testing of continuous mould line wing structures, drooped leading edge, active flow control, adaptive and flexible wing structures, smart chevrons, and toboggan fairings. Related applications include evaluation of engine noise reduction systems such as Ultra High Bypass engines, distortion-tolerant fans and variable fan nozzles. ICARUSV also offers a new tool for identification of vehicle specific aero-elastic instabilities and for fundamental aeronautic studies related to ground testing, wind tunnel tests, and flight experiments.

Commercial

The parallel sensor architecture of the ICARUSV overcomes limitations in existing technology, introducing, for the first time, a true imaging modality to the laser Doppler vibrometer (LDV). The ICARUSV concept and related instruments is thus anticipated to appeal to a broad spectrum of applications and industries where existing commercial single beam LDV's are currently employed. In addition to performing routine vibration measurements much more efficiently (orders of magnitude faster than LDV) the imaging modality of the ICARUSV is anticipated to find new diagnostic capability beyond those of traditional LDV, including aerospace, automotive, electronics and industrial plants applications. Numerous industries (automotive, aerospace, medical and computer electronics) employ LDV for modal vibration analyses.



Firm Contact

Dr. Vladimir Markov
vmarkov@asatechinc.com
12 Mauchly Building H
Irvine, CA 92618-2330
(949) 733-3355, Extension: 26

Proposal number: 15-1 A1.04-9214

Physics-Based Aeroanalysis Methods for Open Rotor Conceptual Design

Continuum Dynamics, Inc.

Operating costs and fossil fuel consumption of civil transports can be reduced through use of efficient counter rotating open rotor (CROR) propulsion systems, thereby addressing both key industry needs and long-term NASA technical goals. To develop such next-generation systems, multiple design variables must be assessed and optimized efficiently within a conceptual design software environment. A blend of physics-based, low- and mid-fidelity tools featuring rapid turnaround time and ease of setup can provide this capability; implementation represents a serious technical challenge, though, and there is a high premium on developing tools that are both sufficiently accurate to capture current technology performance metrics while permitting the rapid re-calculations necessary for design trades. The proposed approach centers on a blend of enhanced features and novel departures for two complementary aeroanalysis methods: an evolved version of an established subsonic lifting surface free wake model for propellers, denoted CHARM, as a fast, 'low-fidelity' tool; and a more computationally intensive, fully compressible Cartesian Grid Euler (CGE) model as a 'mid-fidelity' tool. The projected Phase I will implement and test key modeling and formulation improvements for these methods to enable them to support the design of multi-stage open rotor configurations to meet current and projected performance targets.

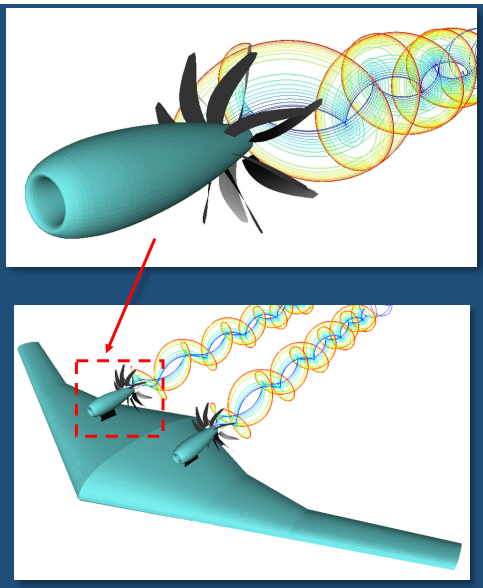
Applications

NASA

The proposed effort directly responds to NASA's SBIR solicitation goal of investigating the potential of advanced, innovative propulsion concepts to improve fuel efficiency and reduce the environmental footprint of future commercial transports. Propulsion systems such as open rotors can help meet aggressive, long range emission reduction targets in support of initiatives such as the Environmentally Responsible Aviation (ERA) project. The proposed effort will also enhance analysis and conceptual design tools that can support assessment of novel air vehicle designs using CROR propulsion.

Commercial

The enhanced fast-turnaround, physics-based analysis and design tools will also be of great use to both civil aircraft manufacturers and DoD. The US Air Force is actively seeking more efficient future transport aircraft designs, and the proposed models can support those initiatives. Airframers and private industry can also utilize these tools in designing more efficient fixed wing aircraft. In addition, spinoffs to support design of propulsion systems for compound rotorcraft and UAVs are also possible.



CHARM model of a generic CROR propulsion system (top) installed on a notional Blended Wing Body air vehicle (bottom)

Firm Contact

Dr. Todd R. Quackenbush
todd@continuum-dynamics.com
34 Lexington Avenue
Ewing, NJ 08618-2302
(609) 538-0444, Extension: 110

Proposal number: 15-1 A1.05-9104

Vertical Lift by Series Hybrid Power

Aurora Flight Sciences Corporation

Multi-rotors (e.g., quad-copters) typically have direct electric drive, where the electric motor shaft is directly coupled to the propeller shaft. The benefit of this configuration is simple and high fidelity control. But electric drive for vertical lift typically relies on lithium polymer batteries for energy storage, and battery specific energy is extremely low compared to internal combustion fuels; Gasoline has about a 15X advantage over rechargeable batteries and diesel has about an 18X advantage. Aurora proposes to develop a reformulated Miller Cycle engine in Series Hybrid Architecture for use in small unmanned vertical lift aircraft to combine the benefits of both direct electric drive and internal combustion engine technology. The reformulated Miller Cycle will also confront the fuel mixing issues associated with sUAS sized small engines.

Applications

NASA

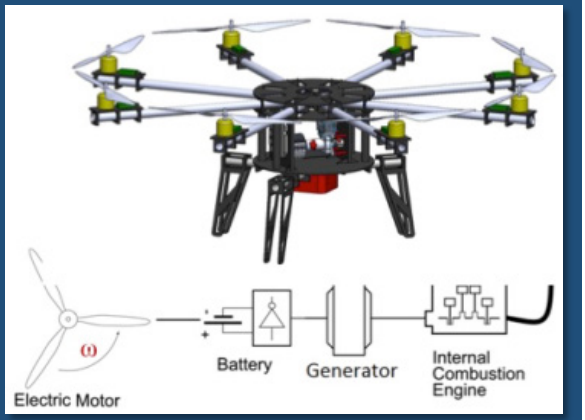
In this proposal, a reformulated Miller cycle is presented as a method for both increasing the endurance of small unmanned vertical lift aircraft and overcoming fuel mixing issues associated sUAS sized engines. With greater endurance and payload it is expected that a multi-rotor observatory platform would be suitable for many earth science missions:

- Volcanic Plume research
- Wildfire Tracking
- Highly localized emission in urban environments

Commercial

The Passive Miller Cycle in a Series Hybrid Architecture could be integrated into a number of Tier 1 (<50 lb) UAV's and used to substantially increase the endurance and payload. Current unmanned multi-rotor aircraft do not have the endurance or payload capability to act in place of manned observatory platforms, but with a Passive Miller Cycle Series Hybrid, endurance and payload could meet the requirements that manned systems do today. The unmanned multi-rotor has many advantages over manned helicopter systems:

- Takeoff and landing
- Buy-in cost
- Operating cost



Firm Contact

Mr. Jeremy Hollman
hollman.jeremy@aurora.aero
90 Broadway, 11th Floor
Cambridge, MA 02142-1050
(617) 500-4830

Proposal number: 15-1 A1.06-9851

High Temperature "Smart" P3 Sensors and Electronics for Distributed Engine Control

Sporian Microsystems, Inc.

Current engine control architectures impose limitations on the insertion of new control capabilities due to federated certification of control systems. NASA in collaboration with Air Force Research Lab (AFRL) has been conducting research in developing technologies to enable Distributed Engine Control (DEC) architectures. The long-term objective of the proposed effort is to advance high-temperature P3 sensor technology for DEC applications through working with OEM partners and industry working groups to: (1) iterate the current technology toward DEC formats/functions, (2) advance the digital electronics design/firmware and high-temperature electronics, and (3) present the viability (technical and business case) of the proposed sensor through demonstration and stakeholder collaboration.

Applications

NASA

The proposed sensor directly supports NASA Aeronautics Research Mission Directorate (ARMD) research thrusts including vehicle safety, efficiency and carbon emission reduction. The sensor is also directly applicable to a planetary exploration mission to Venus since a high temperature sensor that does not require cooling will significantly reduce payload weight, volume, and complexity. Space propulsion systems, including chemical rockets, nuclear thermal propulsion, launch and station keeping, all exhibit high temperatures and would benefit from the proposed technology. Energy generation systems such as Stirling engines and fuel cells also have high operational temperatures that could be monitored by the proposed sensor.

Commercial

Aero propulsion turbine engines, communally used in commercial and military jets, would benefit significantly by having a non-invasive, small mass, on-engine component sensor allowing for visibility of the conditions in the turbine engine. Commercial applications abound for the successful results of this proposal in commercial and military turbine engine industries, which are made up of companies such as GE, Pratt & Whitney and Rolls-Royce. Additional potential market areas include: marine propulsion, land based power generation, turbine-powered land vehicles, rail locomotives, automotive, oil and gas refining, government and academic laboratories.

(Front View)

(Back View)

Firm Contact

Dr. Michael Usrey
musrey@sporian.com
515 Courtney Way, Suite B
Lafayette, CO 80026-8821
(303) 516-9075 Extension: 19

Proposal number: 15-1 A1.07-9387

Miniaturized Dynamic Pressure Sensor Arrays with Sub-Millimeter (mm) Spacing for Cross-Flow Transition Measurements

Interdisciplinary Consulting Corporation

The Interdisciplinary Consulting Corporation (IC2) and in partnership with the University of Florida (UF) are developing a micro-fabricated, dynamic piezoelectric pressure sensor array with sub-mm spacing to enable high temporal and spatial resolution measurements of cross-flow transition in swept-wing, supersonic aircraft research. The innovation is a highly miniaturized, dynamic piezoelectric pressure sensor array with sub-mm spacing for high bandwidth, high spatial resolution measurements of cross-flow transition. High-spatial resolution pressure sensors with sub-mm spacing provide a much-needed capability that does not currently exist among state-of-the-art offerings, enabling dynamic wall pressure measurement and identification of traveling and standing cross-flow modes. The concept extends the basic design to high bandwidth, high-spatial resolution, dynamic pressure sensing via reduction in sensor geometry and integration of multiple sensors arrayed on a single chip. The end result is a miniaturized, highly-compact array of dynamic pressure sensors with backside contacts to enable a truly flush-mounted, smooth interface for flow measurement applications.

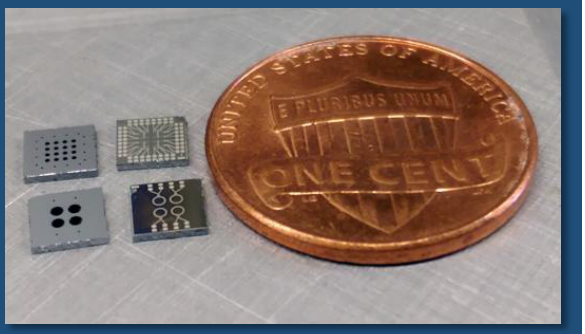
Applications

NASA

IC2's dynamic pressure sensor array instrumentation technology has the potential to be transportable across multiple NASA facility classes as well as implemented across government-owned, industry and academic institution test facilities. The target market is the research-grade instrumentation and measurement shear stress sensors market for the aerospace research and development industry. The target application for entry into NASA Aeronautics Test Program is as ground test wind-tunnel instrumentation for turbulent skin friction measurements and separation detection and control, specifically for cross-flow boundary layer transition measurements for swept wing models, such as is performed at NASA Langley.

Commercial

External customers for dynamic pressure measurements include universities and industry aircraft manufacturers such as the Boeing Company. Particularly, those customers seeking or currently designing next generation, civilian or defense supersonic aircraft have an identical unmet measurement need as NASA Langley. Furthermore, in-flight flow-control (a rapidly growing area of research and development) requires compact accurate measurements of key fluid dynamic parameters such as wall shear stress and dynamic wall pressure. This is a potentially larger volume market with relatively high ASP but will require more development time to meet the tighter space constraints, tougher operating conditions and unique target specifications that such an application entails.



Photograph of several prototype pressure sensor arrays (4-16 sensors per chip)

Firm Contact

Mr. Leonard Kubik
IC2.lkubik@gmail.com
5745 SW 75th, 364
Gainesville, FL 32608-5504
(256) 960-9520

Proposal number: 15-1 A1.08-8885

Pressure-Sensitive Paint System for Production Wind Tunnel Testing

Innovative Scientific Solutions, Inc.

The cost to acquire data in ground-based test facilities can be significantly reduced by implementing measurement systems featuring high data capture per test while requiring limited instrumentation of models. Fast PSP offers a means of acquiring unsteady pressure data at millions of locations on a model surface with no change to the model geometry. Data at an individual pixel can be extracted and processed as traditional pressure tap data to identify mean, RMS, and spectral content. Full data sets can be decomposed spectrally to present the amplitude of the pressure fluctuations spatially at a series of frequencies. Acquisition of the data is only one portion of an effective fast PSP system. Fast PSP systems generate thousands of images in seconds, and each of these images represents a sample of up to one million fast pressure sensors. During this program, the productivity of fast PSP is being increased by improving the speed with which the data is collected, processed, and analyzed. Techniques that speed data processing with no requirement to change the fundamental analysis code have been identified. Simultaneous acquisition of unsteady and mean pressure data was demonstrated during a SLS buffet test. Data mining tools and algorithms are being developed to identify key flow features in near real-time.

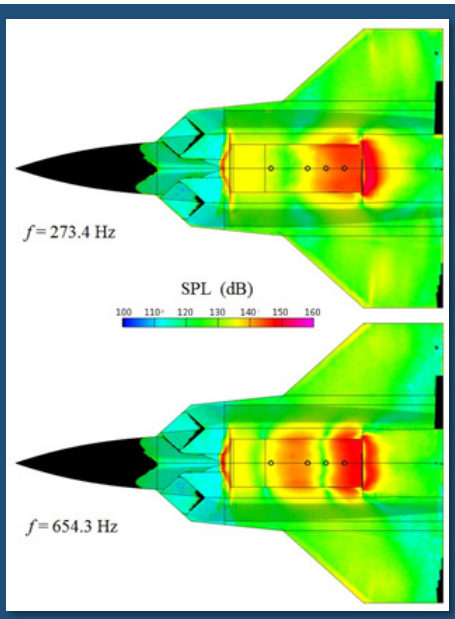
Applications

NASA

There is considerable interest in measurements of unsteady pressure for the evaluation of computational models and the study of flow physics on hypersonic inlets, compressors, aeroelasticity, and rotorcraft aerodynamics. This program is optimizing the fast PSP system for use in NASA tunnels by providing: 1) simultaneous collection of mean and unsteady pressure data, 2) near real-time identification of key flow features to enable within-test protocol adjustments, and 3) data mining tools for rapid exploration of the large data sets produced. The fast PSP technology could be deployed at Ames, Glenn, and Langley for applications including aircraft acoustics, flow control, supersonic inlets, and launch vehicles.

Commercial

ISSI is deploying commercial systems for shock/boundary layer flows, supersonic inlets, aeroelasticity, cavity acoustics, rotorcraft aerodynamics, and propeller acoustics for customers in North and South America, Europe, and Asia. Their applications include traditional aerodynamic models, rotorcraft models, bridge aerodynamics, and automotive aerodynamics. ISSI is the commercial source of PSP technology world-wide. Several customers have expressed interest in a fast PSP capability and export has been approved for commercial applications. ISSI is in discussions with several commercial aircraft manufacturers regarding the potential of a fast PSP system for flight testing. This represents a high value application that will produce flight Reynolds number experimental data.



Fast PSP results from AEDC 16T test showing the amplitude of the pressure fluctuations at the first two Rossiter frequencies in a fuselage cavity

Firm Contact

Larry P Goss
gosslp@innssi.com
7610 McEwen Road
Dayton, OH 45459-3908
(937) 630-3012

Proposal number: 15-1 A1.08-9052

Rugged, Compact, and Inexpensive Airborne Fiber Sensor Interrogator Based on a Monolithic Tunable Laser

Freedom Photonics, LLC

In this program, Freedom Photonics will develop and build a robust, low C-SWaP laser source with improved performance over current technology, to enable advanced Fiber Optic Sensing (FOS) interrogator systems. The laser will be wavelength tunable over 40nm around C-band (1550 nm), with fast sweep rate (1000 nm/s). Optional availability at 1590 nm and 1510 nm center wavelengths for 120 nm combined tuning range. The laser interrogator module to be developed will be based on our advanced monolithic, fast-tunable laser and receiver technology, leading to a smaller FOS laser interrogator module, 25 cm^3 (1.5 in^3) in volume, two orders of magnitude smaller than existing technology, and interrogator mass of less than 100 grams. The configuration will be rugged, compatible with fuel, fuel vapor, high shock and vibration.

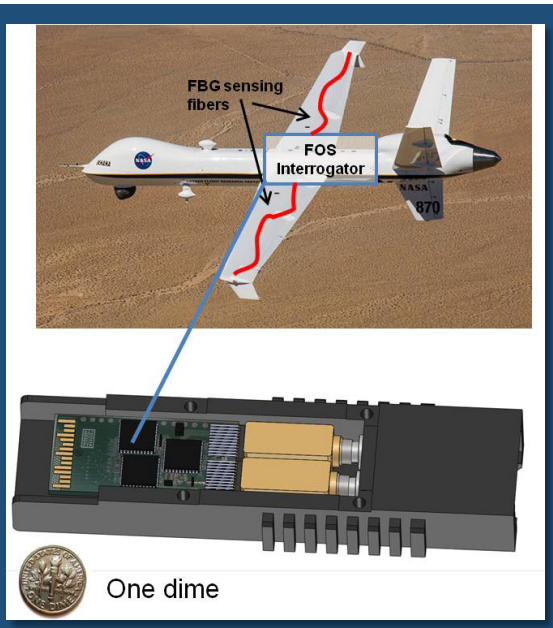
Applications

NASA

- 3D Shape Sensing: Antenna deflection, solar array deployment, space station snake robots
- 2D Shape/Deflection Sensing: Wing deflection, morphing wings, engine nozzle shape, rocket shape - trajectory corrections
- Strain Measurements: Distributed load monitoring, COPV failure prediction, failure precursor detection, composite material embedment, full-scale testing, structural dynamics
- Temperature Measurements: Cryogenic liquid level (rocket fuel), re-entry ablative material monitoring

Commercial

- Oil & Gas: Drill/tool shape and head position, well movement, ROV tether, flexible riser shape, Platform movement, Well health monitoring, well equipment integrity, Storage tank liquid level, liquid composition, distributed well temperature
- Medical: Catheters, robotic surgery, Mattress deflection, body contour sensing, bone impact deflection
- Swallow strength - detection, prosthetic limb design and test, sport equipment safety, Inflammation, Heat Therapy, Cancer Treatment
- Energy (other): Nuclear facility snake robots, nuclear tube deformation, Wind turbine blade and shaft deflection-Wind turbine blade embedment - health monitoring, blade design and testing, Gas turbine temperature distribution



Firm Contact

Dr. Milan Mashanovitch
info@freedomphotonics.com
41 Aero Camino
Santa Barbara, CA 93117-3104
(805) 967-4900, Extension: 7003

Proposal number: 15-1 A2.01-8787

High Sensitivity Semiconductor Sensor Skins for Multi-Axis Surface Pressure Characterization

Nanosonic, Inc.

This NASA Phase I SBIR program would fabricate high sensitivity semiconductor nanomembrane 'sensor skins' capable of multi-axis surface pressure characterization on flight test vehicles, wind tunnel models as well as operational aerospace vehicles, using SOI (Silicon on Insulator) NM techniques in combination with our pioneering HybridSil® ceramic nanocomposite materials. Such low-modulus, conformal nanomembrane sensor skins with integrated interconnect elements and electronic devices can be applied to new or existing wind tunnel models for multi-axis surface pressure analysis, or to lightweight UAVs as part of active flutter control systems. NanoSonic has demonstrated the feasibility of NM transducer materials in such sensor skins for the measurement of dynamic shear stress and normal pressure. Sensors may be connected to external support instrumentation either through thin film and ribbon cable interconnects, or potentially wirelessly using RF communication directly from electronic networks incorporated into the sensor skin material.

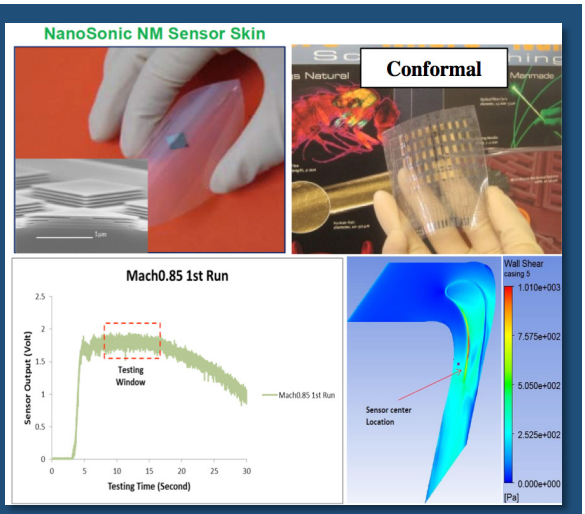
Applications

NASA

The anticipated initial market of the NM sensor skin arrays is for flight testing and wind tunnel testing of flow models for NASA flight research centers. An appreciation of the instrumentation issues obtained by working with such centers would allow improvements in sensor materials, electronics and packaging, and potentially allow the transition of related products to operational vehicles. The commercialization potential of the NM technology developed through this NASA SBIR program lies in four areas, namely 1) NM sensor skin arrays for the measurement of multi-axis surface pressure, 2) Broader sensor skin arrays for the measurement of pressure, 3) Single-element air or water flow sensors, and 4) NM material itself.

Commercial

Primary customers would be universities, government laboratory and aerospace industry researchers. Small, unmanned air vehicles large enough to carry the extra load associated with electronics and power, and operationally sophisticated enough to require air data sensors would be a likely first military platform use. Distributed pressure mapping on air vehicles as well as in biomedical devices and other systems may have merit. Further, the thin film shear sensor elements may be used as air flow or water flow devices in systems where either the low weight, low surface profile, lack of need for space below the flow surface, or high sensitivity at a low cost are needed.



Firm Contact

Melissa Campbell
mcampbell@nanosonic.com
158 Wheatland Drive
Pembroke, VA 24136-3645
(540) 626-6266

Proposal number: 15-1 A2.01-8865

CloudTurbine: Streaming Data via Cloud File Sharing

Cycronix

We propose a novel technology to leverage rapidly evolving cloud based infrastructure to improve time constrained situational awareness for real-time decision making. Our "CloudTurbine" innovation eliminates the distinction between files and streams to distribute live streaming sensor and video data over cloud file sharing services.

Building upon a functional prototype, we propose to characterize, evaluate, refine and adapt CloudTurbine technology to NASA and commercial applications. CloudTurbine is a streaming data interface to and from standard file sharing cloud services. It delegates much of the data transmittal, security, and server resources to the cloud service provider. It provides robust continuous streaming for high data and frame rates while trading off manageable amounts of delivery latency (on the order of seconds). In so doing, it eliminates the distinction between files and streams, and enables a simple, cost effective new paradigm for streaming data middleware.

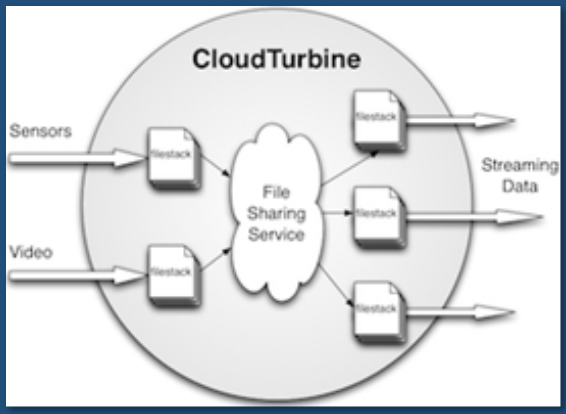
Applications

NASA

CloudTurbine significantly enhances the NASA "Virtual Presence" technology for flight research, wind tunnel testing, and other forms of collaborative data monitoring. It provides secure video distribution using existing cloud and web infrastructure. It brings the power and advantages of modern cloud computing to streaming data for flight operations. It is synergistic and compatible with both DataTurbine and WebScan systems, and leverages the investment and utility of these legacy technologies.

Commercial

Potential non-NASA applications include scientific sensor applications such as environmental and Earth observation systems, a DataTurbine compatible enhancement for scientific researchers at http://dataturbine.org, smartphone photo/video sharing, and a new paradigm for streaming data content delivery networks. CloudTurbine addresses many significant needs of the expanding "Internet of Things" market, such as secure cost effective home appliance, utility and energy use monitoring.



Firm Contact

Matthew J. Miller
matt@cycronix.com
21 Surrey Lane
Laconia, NH 03246-6010

Proposal Number: 15-1 A2.01-9858

Collision-Avoidance Radar for Small UAS

UAVradars, LLC

This SBIR focuses on the commercialization development of a miniaturized collision avoidance radar system capable of being mounted onboard a small unmanned aircraft system (sUAS) providing the sUAS with robust, airborne, sense-and-avoid detection capability. The benefits of utilizing radar for airborne collision avoidance detection is its ability to sense both cooperative and non-cooperative hazards, day or night, and in all weather conditions. Furthermore, the patent pending radar technology at UAVradars LLC allows the radar system to provide coverage up to 800 m in range, 360° in azimuth and ±15° in elevation without any moving parts; and in a size, weight, and power (SWaP) form factor that has never been achieved before for this level of capability. Target information includes range, Doppler, azimuth and elevation angles relative to the sUAS carrying the radar. The Phase I SBIR work focused on transferring the radar's operation controller (previously a user laptop) into a portable unit compatible with NASA's ground stations, migrating the radar operation frequency into the ISM band to reduce FCC complications, and encode each radar's transmit to reduce radar cross-jamming. The miniature collision-avoidance radar system is expected to become a significant disruptive technological breakthrough towards the integration of sUAS into the national airspace system (NAS) for the commercial and government sectors.

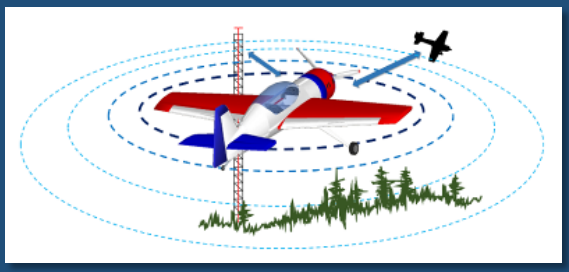
Applications

NASA

NASA currently has multiple UAS applications/technology development programs which could benefit from the proposed collision-avoidance radar system. The radar system supports NASA's goals for assisting the integration of UAS into the NAS which is currently limited primarily due to collision safety concerns. The radar system meets NASA's need for UAS technology that would allow humans to safely operate multiple UAS with minimal oversight and provide the foundation for UAS automation and multi-vehicle cooperation. Such capabilities would allow NASA to implement sUAS for various dangerous missions, mitigating human risk, while providing capabilities that did not previously exist such as long endurance scientific surveying. Since radar systems are capable of functioning in outer space, the miniature radar with its reduced SWaP could also assist future space missions as well.

Commercial

Multiple sources including the FAA have identified numerous commercial uses for sUAS which include agriculture, communications, package delivery, and assisting first responders. The Association for Unmanned Vehicle Systems International (AUVSI) has predicted a multibillion dollar U.S. economic impact caused by the commercial UAS industry within ten years of fully integrating sUAS into the NAS. However, to achieve this possibility, UAS operation must first be made safe. It is likely that a sensor suite will ultimately be needed to meet the UAS in the NAS safety threshold but such a suite will certainly include a radar system as its primary sensor due to its all weather, stand-alone, detection and location capability of non-cooperative hazards (i.e., other aircraft without transponder technology, cellphone towers, balloons, etc.).



Firm Contact

Lei Shi
shi@uavradars.com
3120 Mesa Way, Suite B
Lawrence, KS 66049-4203
(316) 461-1181
www.uavradars.com

Proposal number: 15-1 A2.02-9059

Development and Flight Testing of an Autonomous Upset Recovery System

Barron Associates, Inc.

UAS have the potential to offer great economic and operational advantages, but realizing this potential will require greater operational flexibility for UAS in the National Airspace. Autonomous upset recovery technology will reduce reliance on a human operator to mitigate hazards posed by Loss of Control (LOC) due to upset, leading to greater operational freedom. LOC of an UAS operated at low altitude poses a hazard to people and property on the ground and is a barrier to relaxing operational restrictions. The Phase I research has developed a recovery system that replaces the perception, cognition, and decision making of a skilled operator with a two-stage automated recovery architecture and an innovative upset detection system. The decision about when to activate each stage of a recovery is difficult to make at design-time, so the upset detection system employs a novel statistical testing framework that combines at run-time numerous pieces of data including vehicle attitude, rotational rate, and controller performance to answer the question: Has an upset occurred? During Phase I, the recovery system was evaluated in a high quality simulation of a small fixed-wing vehicle. All hardware needed for flight testing was obtained, and systems integration work was performed. The Phase II effort, currently underway, will focus on flight testing of the recovery system.

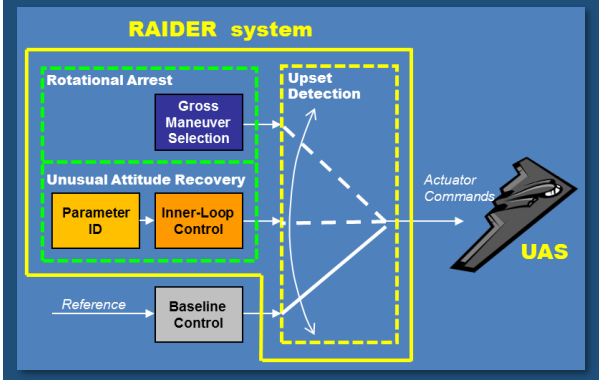
Applications

NASA

This research program aligns closely with several NASA programs. The system directly addresses the Integrated Aviation Systems Program (IASP) focus areas of "perception, cognition, and decision making" and "operation of multiple UAS with minimal human oversight." The overall goal of the IASP is to "demonstrate integrated technologies to a maturity level that is sufficient to reduce the risk of implementation for stakeholders in the aviation community." To meet this goal, the Phase I effort has been used to lay the groundwork for a series of flight-test experiments in Phase II that will advance the recovery system to TRL 7. The Unmanned Aircraft System Traffic Management (UTM) project is researching prototype technologies "to enable and safely manage the widespread use of low-altitude airspace and UAS operations." Upset recovery technology will help meet the autonomicity goals of this program, enabling UAS to maintain control when faced with the large range of precipitating factors that lead to LOC.

Commercial

The research program is structured to raise the maturity of the recovery system to a level that enables product commercialization onboard commercial inspection UAS. The Phase II flight-test partner is actively conducting inspection flights for utility companies under a Section 333 exemption from the FAA. Inspection operations are conducted at low altitude and in close proximity to infrastructure to provide the highest quality imagery. The recovery system will help to mitigate the ground hazard, a very real concern considering a significant amount of utility infrastructure exists in densely populated areas. As continued use allows stakeholders to gain confidence in the system, the recovery system will enable flight beyond visual line of sight, operation of multiple UAS by a single operator, and larger mission envelopes.



Firm Contact

Ms. Connie Hoover
barron@bainet.com
1410 Sachem Place, Suite 202
Charlottesville, VA 22901-2559
(434) 973-1215

Proposal number: 15-1 A2.02-9086

Fully-Automated, Agricultural Application Using Unmanned Aircraft

Continuum Dynamics, Inc./Dragonfly Pictures, Inc.

Interest in Unmanned Aircraft Systems (UAS) for civilian use has increased greatly in recent years and is expected to grow significantly in the future. NASA is involved in research that would greatly benefit from advancing the ability of UAS to make autonomous real-time decisions based on sensor data. This SBIR effort will provide this capability, developing and demonstrating an intelligent controller for a UAS that can autonomously perform agricultural chemical spraying following EPA and NASA guidelines for spray drift and airworthiness. Phase I demonstrated the required onboard sensing and communication between a UAS and flight controller, effectively executing a flight path/spraying strategy autonomously. Phase II will see the design, development and implementation of a fully-autonomous, prototype system that can perform high-level decision-making during flight utilizing spray drift management software within the autonomous flight control system.

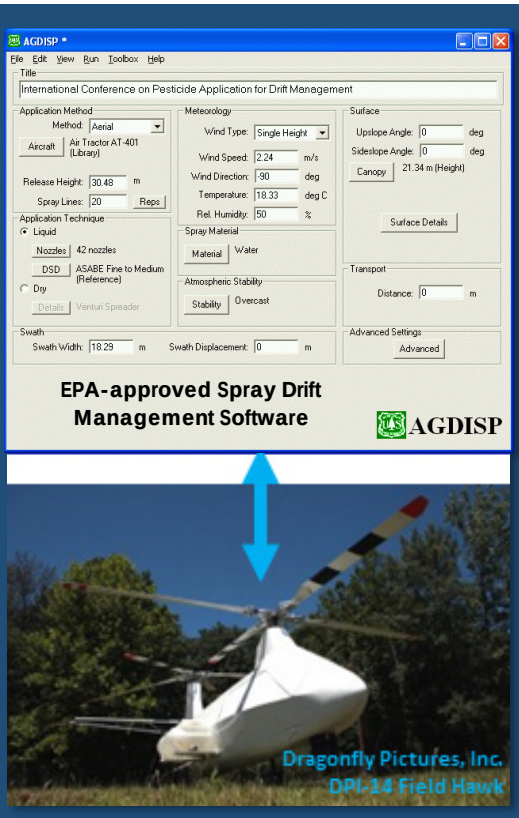
Applications

NASA

The proposed effort directly addresses NASA program goals to develop technologies that provide the ability of UAS to extract information in-flight and utilize this information in decision making. This SBIR effort also directly supports current NASA/industry initiatives to establish airworthiness standards for FAA-certification that will provide a roadmap for future application of UAS in commercial applications within the United States. Specifically, this SBIR effort dovetails with a NASA initiative to study airworthiness certification for use of UAS in the national airspace. The proposed project addresses two key elements that must be demonstrated before UAS can be applied in commercial missions within the U.S; a need for technical advancement related to autonomous control and decision-making and a need to develop airworthiness FAA-certification requirements for UAS operations.

Commercial

Private industry will benefit greatly from this effort. First, this SBIR will provide advancements in fully-autonomous, application-specific, UAS platforms. Autonomous control is critical to the expansion of the customer base for UAS beyond those with piloting skills. Thus, this area of research supports an enormous leap in commercialization potential. Second, the proposed effort has a component addressing FAA-certification requirements for autonomously-controlled UAS. This is currently a critical barrier to the commercial use of UAS in the U.S.



Firm Contact

Ms. Barbara Agans
barbara@continuum-dynamics.com
34 Lexington Avenue
Ewing, NJ 08618-2302
(609) 538-0444, Extension: 106

Proposal number: 15-1 A2.02-9479

Flight Testing of Resource allocation for Multi-Agent Planning (ReMAP) System for Unmanned Vehicles

Area-I

The ReMAP system, whose core function is to significantly reduce operator workload by providing mission-driven autonomy to unmanned aircraft in single and multi-agent scenarios, has undergone extensive hardware-in-the-loop simulation-based and actual flight-based evaluations. Core capabilities provided by the ReMAP system include: 1) A small, lightweight, inexpensive avionics package that provides real-time mission-driven guidance capabilities to unmanned air vehicles. 2) A system architecture that is platform and autopilot agnostic and can therefore be utilized by a wide array of aircraft with varying performance levels. 3) A multi-agent planning and control algorithm to allow multiple aircraft to coordinate and thereby maximize mission capabilities and results. 4) Aircraft and obstacle avoidance capabilities, including ADS-B In integration, providing autonomous avoidance maneuvers or operator warnings. 5) A mission planning toolbox to provide situational awareness and mission management to operators, usable as a stand-alone system or integrated with existing mission planning tools.

Ongoing work aims to further mature the ReMAP system for improved performance and scalability to result in a technology demonstration using an actual use-case during multi-agent flight.

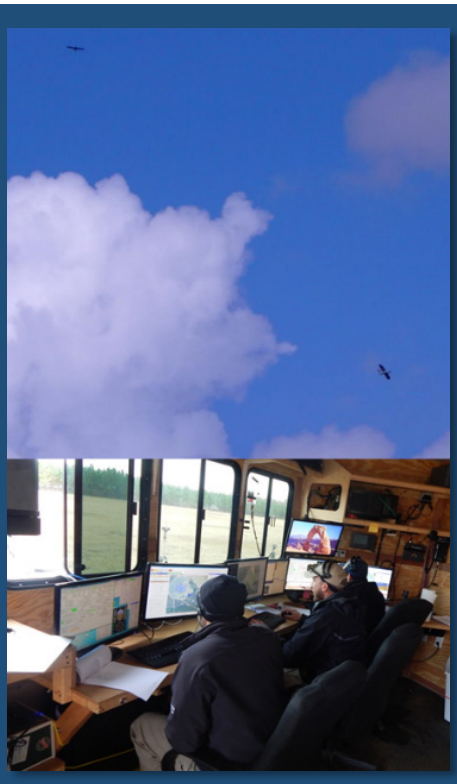
Applications

NASA

The ReMAP system provides a unique ability to enhance two of NASA's mission directorates: the Aeronautics Research Mission Directorate (ARMD) and the Science Mission Directorate (SMD). The system improves the goals of the ARMD through the development of a system that promotes the safe integration of unmanned aircraft systems into the National Airspace System (NAS) and is in line with the goals of the NextGen system. The majority of others' work performed in multi-agent systems has been largely academic and often solves very specific or theoretical problems. The goal of the ReMAP development, however, has been to provide a successful and operationally relevant product that may be used in a wide variety of applications. The result is a system that has a significant potential impact on the SMD to support a variety of missions, both present and future.

Commercial

The ReMAP system has a large number of end-use applications, including multiple aircraft platforms and mission types. Our strong industry support shows the significant impact the ReMAP system may have on UAS applications and provides a clear path to commercialization. The system may be commercialized as a stand-alone system, or coupled as an add-on to COTS autopilot systems. Area-I may also commercialize turn-key, ReMAP enabled aircraft as well as multi-agent mission support. Current efforts include developing ReMAP as a stand-alone plug-in for Insitu's ICOMC2 ground station interface.



Firm Contact

Hilary Beeston
1590 N Roberts Rd. Ste. 102
Kennesaw, GA 30144-3636

Proposal number: 15-1 A2.02-9634

A Modular Swarm Optimization Framework Enabling Multi-Vehicle Coordinated Path Planning

Heron Systems, Inc.

Heron Systems proposes the Multi-Agent Cooperative Engagement (MACE) framework that enables collaborative resource allocation, task allocation, and path planning for unmanned systems operating in dynamic environments subject to diverse communication conditions. This Phase I work will focus on the path planning portion of MACE, as path planning is an integral part of collaborative efforts in nearly every real world application. The path planning architecture will define key modules to plan paths to a global objective, assess potential obstacles, and avoid collisions while maintaining progress towards the global objective. The framework will be constructed in a modular fashion to allow a plug-and-play capability for the resource/task allocation as well as the various components of the path planning pipeline, giving end users the flexibility to explore other methods for UAS collaboration.

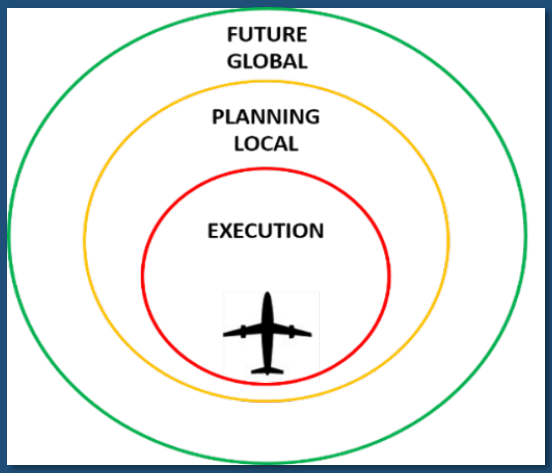
Applications

NASA

Heron Systems identifies the UAS National Air Space (NAS) integration project as the principle NASA mission to benefit from MACE. Collaborative UAS capabilities can support several ongoing initiatives either directly or by offering capabilities that empower further opportunities. MACE is well suited to benefit the ongoing effort to integrate UAS into the NAS. Methods for determining suitable paths in the presence of both cooperating and non-cooperating aircraft are vital for safe integration.

Commercial

Commercially, MACE promises to dramatically improve the efficiency of operations of many envisioned UAS applications. Of particular interest are those in the areas of precision agriculture and pipeline/electrical grid inspection. Heron Systems will build a service delivery model tailored for precision agriculture supporting rapid surveying of fields and follow-on tasking based on real-time findings. Similarly, a second product line will tailor to the needs of long distance pipeline and electrical grid operators, supporting inspection requirements. Heron Systems is principally targeting the commercial market.



Firm Contact

Mr. Brett Darcey
brett.darcey@heronsystems.com
2121 Eisenhower Ave., Ste. 401
Alexandria, VA 22314-4688
(571) 257-8403

Proposal number: 15-1 A2.02-9727

Command and Control Software for Single-Operator Multiple UAS Missions

Opto-Knowledge Systems, Inc. (OKSI)

Existing command and control (C2) paradigms for UAS platforms are extremely limited and cumbersome, requiring at least a single operator per UAS, if not more than one operator for each UAS (as is the case with many scientific and commercial UAS platforms). Opto-Knowledge Systems Inc (OKSI) and Analytical Graphics Inc. (AGI) are joining forces to design, demonstrate, and deliver a robust multiple Unmanned Aerial System (UAS) semi-autonomous command and control tool that will enable a single human operator to manage multiple UAS platforms concurrently. Though there has been significant research into the single-operator multiple UAS control paradigm, there are currently no existing commercially available tools for this application. This work is aimed at shoring up this gap by creating the Single-Operator Multiple Autonomous Vehicle (SOMAV) command and control tool that will be integrated with AGI's Systems Tool Kit (STK) software and sold commercially at the end of the Phase-II program.

Applications

NASA

NAS Integration and Air Traffic Control (NASA NextGen Program): For the past decade, NASA has been working to develop NextGen Air Traffic Control (ATC) Management capabilities that will provide increased efficiency and throughput of the National Air Space (NAS) to meet growing system demands. The SOMAV STK module for multiple-UAS command and control directly promotes these efforts in several ways. First, it provides a high-fidelity simulation environment for testing potential ATC routing algorithms, particularly those for systems of UAS platforms. Second, our tool reduces human operator workload by pushing much of the low-level control onto the UAV platforms themselves and having the routing/coordination performed autonomously.

Commercial

UAS Communication Networks: Recent advancements (e.g., Aerial Communications Node platforms) have resulted in UAS-based aerial communications platforms that are able to provide up to 10 times more coverage than traditional ground-based communications towers, and that are able to dynamically move to address changing customer needs. There has recently been a great deal of talk about bringing these capabilities to the civilian communications sector. SOMAV will provide high fidelity simulation and modeling of the entire UAS fleet and the RF communications links between the ground-based users and the UAS communications nodes including effects due to radio and antenna characteristics, weather, terrain, and communication protocol.

Firm Contact

Dr. Nahum Gat
nahum@oksi.com
19805 Hamilton Avenue
Torrance, CA 90502-1341
(310) 756-0520, Extension 237

Proposal Number: 15-1 A2.02-9786

Airport Gate Activity Monitoring Tool Suite for Improved Turnaround Prediction

Optimal Synthesis, Inc.

The goal of this research is to create a suite of tools for monitoring airport gate activities with the objective of improving aircraft turnaround. Airport ramp areas are the most crowded and cluttered spaces in the entire National Airspace System (NAS). Activities related to turnaround of the aircraft from the gate represent a significant source of delay and therefore impact the predictability of NAS operations. Optimal Synthesis Inc., seeks to leverage its expertise in monitoring aircraft in the ramp areas using video surveillance data and advanced computer vision algorithms towards building an advanced gate activity monitoring that will in turn enable a gate turnaround prediction tool. The tool suite will specifically identify the various stages of turnaround such as refueling, luggage unloading/loading, catering, and deicing. It will further create a probabilistic model of the times associated with each of these events, that will be used for predicting the future sequence of events and their predicted times of completion.

Phase I research will demonstrate the core ideas of gate activity recognition using state-of-the-art computer vision and machine learning algorithms. Phase II research will elevate the technology readiness level of this tool suite to work with real-time video surveillance streams.

Applications

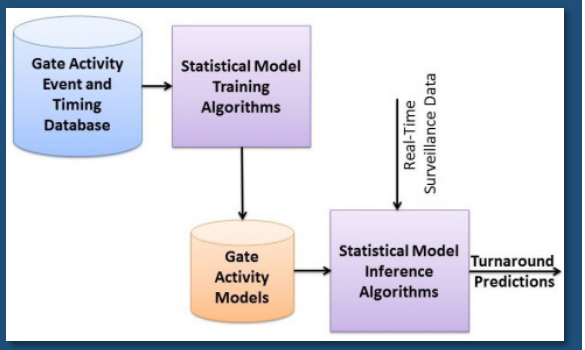
NASA

The proposed gate activity monitoring tool suite can be used in the following NASA applications:

- The gate monitoring tool suite directly benefits surface operation scheduling tools such as NASA's Spot and Runway Departure Advisor (SARDA).
- The gate monitoring tool suite directly caters to objectives of the Networked ATM sub-project under the SMART NAS project. It increases gate operations predictability and reduce total cost of National Airspace System operations.
- Development of TBO concepts and enabling technology solutions that leverage revolutionary capabilities and that enable capacity, throughput, and efficiency gains within the various phases of gate-to-gate operations.
- The proposed suite of tools can enable autonomy/autonomous technologies and concepts for trajectory management and efficient/safe traffic flows.

Commercial

Low cost airport activity monitoring techniques are of considerable interest to FAA and airports in general. Moreover, computer-vision-based activity monitoring techniques are of significant interest in several areas such as warehouses, commercial office buildings, train stations, and bus stations.



Firm Contact

Dr. Victor H. L. Cheng
vcheng@optisyn.com
95 First Street, Suite 240
Los Altos, CA 94022-2777
(650) 559-8585

Proposal Number: 15-1 A3.01-8953

Networked ATM for Efficient Routing

Robust Analytics

Our concept proposes a more capable architecture that can take full advantage of emerging communications technologies to integrate airline operations center (AOC) and flight deck capabilities. This approach offers a more robust, extensible architecture that can be tailored to an individual airline's operational model while simultaneously offering an upgrade path for adding more capability over time. Our solution aims to combine the best features of Dynamic Weather Routing (DWR) and Traffic Aware Strategic Aircrew Requests (TASAR) and adds more capability via enhanced data communications. Our solution fully integrates with the AOC but retains full access to the superior information from the flight deck. This enables our architecture to use the best available data, allocate data processing and analytical functions to where they can be performed most efficiently, and allows the airline to choose where it wants decision making to occur.

Applications

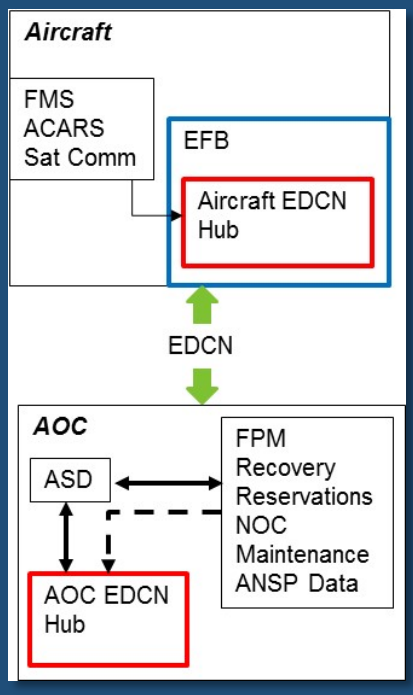
NASA

Our concept offers NASA two applications with significant value both near term and in the ATM+2 environment. In the near term, our architecture will identify improvements to existing NASA technologies such as DWR and TASAR. Our concept shows how to add benefits with the potential for improved communications technologies and increased cockpit access to low cost, reliable wireless. Strategically, our concept offers an early success for the Networked ATM subproject under the SMART NAS project. By developing an architecture that includes AOCs, our team offers NASA an alternate pathway to deployment of its ATM technology, without the delays and constraints of the FAA's Acquisition Management System and associated institutional barriers.

Commercial

Our concept has immediate application to airlines that want to improve operating efficiency and reduce costs and fuel consumption. A recent benefit study of DWR estimated that a lower bound estimate of benefits from DWR alone would be at least $800 per aircraft, or over $3 million annually. Our concept offers the potential for greater benefits by identifying more opportunities and increases the probability of successfully executing the improved route.

Our approach also increases the number of airlines that would be interested as it offers a flexible solution that can be tailored to the airline preferred operating mode. Our concept provides a convenient mechanism for deploying the solution in the AOC using existing software services provided by our Sabre partner, or another provider of similar services. For some airlines, an EFB solution might be preferred and our concept supports that implementation at low cost.



Firm Contact

Dr. Peter Kostiuk
peter.kostiuk@robust-analytics.com
2053 Liza Way
Gambrills, MD 21054-2007
(410) 980-3667

Proposal Number: 15-1 A3.01-9499

Generic FMS Platform for Evaluation of Autonomous Trajectory-Based Operation Concepts

Optimal Synthesis Inc.

The objective of this research project is to create a generic advanced Flight Management System (FMS) platform that could be used for evaluation of autonomous trajectory-based operations (TBO) concepts. The research addresses the following deficiencies: most FMS have limited advanced features; are specific to a single aircraft type; expensive and protected by FMS manufacturers. The proposed FMS platform will enable users to deploy a wide array of autonomy enabling FMS features with the click of a button. Some of the proposed features include: (i) air-ground & inter-aircraft trajectory negotiation, (ii) 4D Trajectory-Based Operations (4DTBO), (iii) high-fidelity wind modeling for improved predictability, (iv) trajectory planning options based on environmental and efficiency considerations, and (v) advanced guidance modes such as Required Time of Arrival (RTA) and 4DFMS. A key feature of the proposed research is the integration of this platform and its features with NASA's Multi-Aircraft Control System (MACS) platform.

Applications

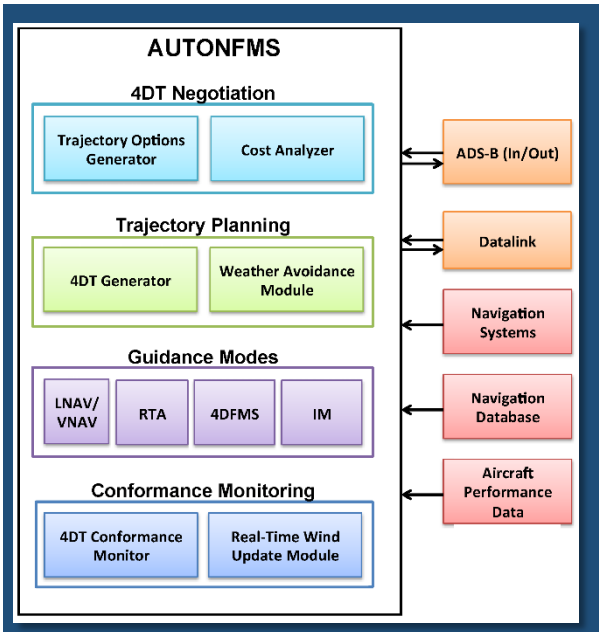
NASA

The proposed FMS platform can be used in the following NASA applications:

- Networked cockpit management
- Autonomicity (or self-management) -based architectures for the entirety or portions of airspace operations
- Verification and validation tools for increasingly autonomous operations
- Autonomy/autonomous technologies and concepts for trajectory management and efficient/safe traffic flows
- FMS features such as Interval Management (IM) which enable self-separation and contribute towards autonomous National Airspace System

Commercial

The proposed FMS platform is ideal for experimental FMS testbed. As such it could be of interest to universities, research labs, and other small businesses pursuing research in air-traffic management. It could also be of interest to Unmanned Aerial System (UAS) operators for simulating the interactions of UAS with other aircraft in the National Airspace System. Trajectory-Based Operations realized by autonomous cars could be the answer to congested city traffic. The concepts, architectures, and evaluation tools developed under this research would be very much applicable to futuristic road traffic management system.



Firm Contact

Dr. Victor H. L. Cheng
vcheng@optisyn.com
95 First Street, Suite 240
Los Altos, CA 94022-2777
(650) 559-8585

Proposal Number: 15-1 A3.02-8950

Verification & Validation of Complex Autonomy Concepts Using the Cloud

Crown Consulting, Inc.

Crown Consulting, Inc. (CCI) has developed a new method of concept verification and validation for autonomous operations and identifying emergent behaviors. This method integrates several Internet technologies to enable massively parallel execution of National Airspace System (NAS) simulations in a cloud environment, vastly increasing the number of Monte Carlo simulation runs that can be executed in a given time, thus enabling broad assessments of safety, performance, and workload across thousands of scenarios representing wide ranges of conditions. The Phase I project established the feasibility by demonstrating greatly reduced run time by allowing for the running of thousands of simulation cases at a time; automated system performance and safety evaluation; and capabilities for rapid analysis of safety, performance, and workload related to NAS operations as well as for simulations of almost any complex system.

Applications

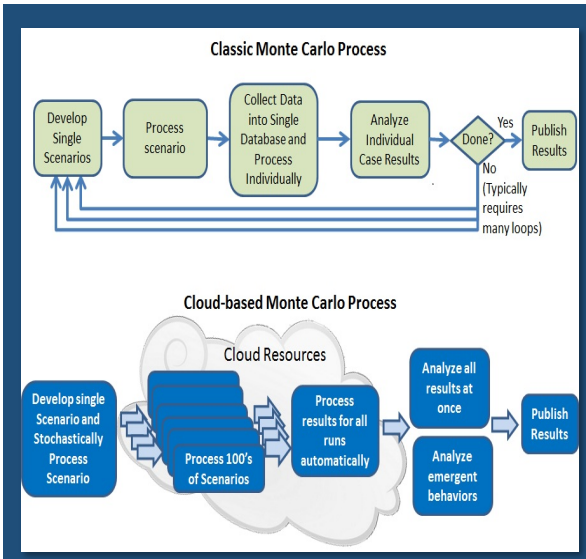
NASA

Potential NASA Commercial applications include licensing the results of the research and leveraging them in Space Act Agreements for the following:

- Developing UTM and other concepts for UAS operations: Monte Carlo and deterministic simulations to explore Rules of the Road under wide ranges of conditions and to support air traffic management (ATM) concept development.
- Prognostic safety assessments and concepts: Monte Carlo and deterministic simulations to support validation and certification of new concepts for prognostic safety assessments and system-wide prognostic safety assurance system development.
- Real-time evaluation of traffic flow management (TFM) strategies: Use of extremely fast parallel simulations for real-time evaluation of TFM strategies, enabling adaptability to unforeseen conditions or events.

Commercial

Potential customers include researchers in government, industry, and academia exploring UAS uses, new system concepts, safety assurance methods, and autonomy; FAA offices, industry, and operators involved in certification of new systems or procedures; government agencies involved in operation of UAS or other new system concepts; entities concerned with development of complex systems and uses of autonomy (e.g., autonomous ground vehicles); and UAS civil operators such as precision agriculture, commercial package delivery, energy, survey, real estate, and similar applications.



Firm Contact

Mr. Paul Cobb
Senior Software Engineering Manager
pcobb@crownci.com
1400 Key Boulevard, Suite 1100
Arlington, VA 22209-1577
(650) 533-8727

Proposal Number: 15-1 A3.02-9153