AIR FORCE SBIR 17.3 Topic Index

AIR FORCE SBIR 17.3 Topic Descriptions

AF173-001 TITLE: Occupancy assessment and control of smart buildings and resilient infrastructure

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: An autonomous system to assess inputs from sensors and allocate energy to functions in a facility to optimize usage for assets present, and to sense, report and respond to an event, track personnel, and sustain personnel and sensitive equipment.

DESCRIPTION: Occupancy sensing technology has burgeoned for a decade, outpacing methods to apply sensed data to improve efficiency of energy usage. Technology is sought that autonomously gathers and processes information from various sensors to assess occupancy (personnel and materiel) of a facility, maintain inventory and tracking of these assets, and adjust environmental conditions to support them while minimizing energy usage. During an event, technology will reallocate power to respond to the emergency and minimize impact of that reallocation to assets present.

Relevant state-of-the-art sensing technology ranges from complex IR systems (often cost-prohibitive for large scale networked implementation) to various simple motion detectors (low cost, but can present reliability limitations). All of these approaches require the deployment of new hardware, and vary in accuracy; motion detectors are qualitative, rather than quantitative, and exit/entry monitoring requires readers to be placed at all entrances. As a result, a variety of approaches have been evaluated but with scattered, inconsistent results. Occupancy assessment, however, does not necessarily require a designated suite of installed sensors, but can instead be assessed by analysis of knowledge-based inputs; i.e. computer usage, lighting levels, door key-card entry, telephone usage etc. Many of these metrics are monitored, but not integrated to a system that combines the inputs to generate occupancy profiles.

Using contractor-selected sources of information, software solutions are sought that provide universal compatibility with sensors and affected assets and a useable management tool. A successful solution will have immediate applications in "smart" buildings that adjust to environmental conditions (lighting and temperature) to suit occupancy energy load demand. In addition to energy efficiency for fixed military installation applications there are significant opportunities to apply solutions to facility security and inventory management and control. The technology transition may extend from human occupancy for environmental conditioning, for example, to "machine" occupancy for remote inventory of equipment, security, and monitoring. The technology solution must be versatile enough to integrate information inputs in a rapid, real-time, and cost-effective marketable product. The focus of this effort is not an occupancy sensor, but a technical solution that derives situational awareness information (e.g., lighting and power drain (equipment on/off)) that can be used to detect and act upon occupancy/energy use/energy need/mission needs.

PHASE I: Use small-scale testing and evaluation with selected sensors in four or more categories to demonstrate efficiency and to evaluate reliability of a program using sensor outputs to manage energy use by a set of military-relevant tasks and to sense and report faults in sensors and interacting utility service/components in functional structure to be selected IAW AFCEC guidance.

PHASE II: Assemble a prototype system for field demonstration in a multifunctional facility operating in a relevant operating environment selected with AFCEC input. After the demo deliver the system to the Government for end-user evaluation. The prototype must control an HVAC system, allow user access to evaluate user-specific scenarios under adjustable assumptions, sense and report "errors," e.g., loss of electrical service, open breakers, smoke/fire, and respond as needed (e.g., failsafe door locks).

PHASE III DUAL USE APPLICATIONS: Final product has market in energy-intensive industries--convention centers, office buildings, R&D labs. T/RH/IAQ control & depot inventory are routine; goal is one system to match energy use to changing environmental and materiel needs, monitor & report on infrastructure, secure site in blackout.

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1. Virtual occupancy sensors for real-time occupancy information in buildings. Building and Environment, 93 (2), 2015, 9-20

2. Virtual occupancy sensors for real-time occupancy information in buildings. Building and Environment, 93 (2), 2015, 9-20

3. Occupancy measurement in commercial office buildings for demand-driven control applications—A survey and detection system evaluation. Energy and Buildings, 93, 2015, 303-314

KEYWORDS: energy management, integrated, software, interior environment, sensor integration, sensors, emergency response

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AF173-002 TITLE: Endpoint Protection for Zero Day Prevention

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: Endpoint/host protection based on automated, signature-less (i.e. artificial intelligence based), malware detection algorithms run locally on hosts.

DESCRIPTION: A solution is desired to autonomously detect and prevent zero-day and other exploits of Air Force hosts in real time with a passive, self-learning system from different sources (mail servers, boundary devices and other hosts). It should also be able to contain any found exploitation with the capability to remove and quarantine malicious code. The solutions should be based on self-learning, artificial intelligence algorithms, and not primarily on signatures. It must be capable of analyzing all static non-executables or interpreted documents and scripts in a minimum of Microsoft Office products, PDFs, bash scripts, powershell scripts, etc.

The solution must be able to interact and report findings to existing SIEM (ArcSight) systems within 45 minutes. When malicious activity is detected, the solution must notify any existing SIEM systems and host-based agents of the attempted activity. The solution must be able to integrate with current AF enterprise Host Intrusion Protection Systems/Host Based Security Systems. The solution should be capable of running in an autonomous fashion if connectivity to a server is interrupted. It should have a high degree of fault tolerance and reliability during abnormal host events and/or disconnection, and if failure occurs it fails into a known safe state.

The solution should be able to perform a Static Analysis of malware executables while minimizing the degradation of the host performance. The solution should provide the capability to inject customized instruction checks and perform Behavior Analysis on web requests and network traffic. The solution shall notify all other host-based agents of newly discovered malware threats. The solution must have the capability to detect malicious activity that have not been previously detected regardless of network connectivity. The solution must be able to protect itself if there is unauthorized manipulation/control of the host. Capability must support an out-of-band connection, with support that includes, but is not limited to bi-directional authentication, authorization and accounting that is secured via an encrypted command, control and data channel, and virtual LANs. Capability must be interoperable with virtualized environments.

PHASE I: Provide a design for a laboratory scale version to demonstrate its proof of concept. Determine a method for verifying the capabilities of the design to detect and block malicious activity and demonstrate the results.

PHASE II: Continuation of Phase I. Adapt the laboratory version to a full version which can be installed and run on actual or simulated hardware. Verify that this can be trained to detect and potentially block malicious activity with the goal of a false alarm rate less than 10%. This solution may only interface with a subset of existing AF SIEM products.

PHASE III DUAL USE APPLICATIONS: Create a final version which can run autonomously on actual AF hardware and will detect and block malicious activity with the goal of a false alarm rate less than 2%. This must interface with any existing AF SIEM products.

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1) Tamar Shafler. “Protecting the Endpoint Against Advanced Malware and Zero-Day Threats” IBM. March 10, 2015.https://securityintelligence.com/protecting-the-endpoint-against-advanced-malware-and-zero-day-threats/

2) George Tubin. “Blocking zero-day application exploits: A new approach for APT prevention” HelpNetSecurity. April 3, 2013.https://www.helpnetsecurity.com/2013/04/03/blocking-zero-day-application-exploits-a-new-approach-for-apt-prevention/

KEYWORDS: Zero Day, Endpoint, Malware, Detection, Malicious

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AF173-003 TITLE: Smart Modules/Antennas to Enable Multiple Simultaneous TCDLs

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: Develop cost-effective smart modules and/or smart antennas that can be bolt-on or added to TCDL transceivers on multiple platforms to enable simultaneous TCDL links at the same band.

DESCRIPTION: Tactical Common Data Link (TCDL) supports omni-directional antennas. Omni directional antennas are lightweight and provide connectivity in all bearings. However, employing multiple frequency-separated omni-directional TCDL links in a congested and contested area results in waste of vital spectrum. Furthermore, those airborne assets carrying TCDL have an undesired vulnerability to unintended and intended interference. Due to advances in multiple-input-multiple-output (MIMO) radio [1], airborne line of sight MIMO [2], blind MIMO channel estimation [3,4], and blind interference mitigation [5], it is anticipated that a smart low-cost bolt-on module or a smart add-on antenna could increase spectral efficiency and reduce vulnerability to interference.

A system that supports multiple TCDL links on the same frequency will need to have a simple applique on the TCDL transmit terminal and have a simple receive array to support spatial multiplexing. The TCDL links will need to maintain performance in when multiplex, thus, tight constraint should be imposed on the TCDL smart modules/antennas performance (e.g. 0.5 dB RF loss). Combining commercial-off-the-shelf (COTS) mixed signal devices, analog and digital signal processing techniques, and advanced antennas can provide attractive cost (<$10K) per module/antenna while enhancing operational spectral efficiency and interference resistance levels.

PHASE I: Phase I will study candidate designs for smart modules/antennas and their performance and anticipated SWAP-C for different con-ops. Phase I results should quantify the benefits of different approaches for varying link distances, interference levels, and scintillation environments using analysis and/or simulations, accounting for practical implementation constraints. Work with the government to identify the requirements for a Phase II demonstration.

PHASE II: Implement the selected technology in hardware and demonstrate the gains at an AFRL test range. Present a path toward optimizing SWAP-C. Show compatibility among demonstrator systems and legacy (in-use systems) radios.

PHASE III DUAL USE APPLICATIONS: Develop and deliver flight-qualified units with a complete RF system for transition to appropriate platforms. The product could be used in a variety of homeland security areas, such as border patrol and the Coast Guard.

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1. M. J. Gans, “Aircraft free-space MIMO communications,” in Proc. 43rd Asilomar Conf. on Signals, Systems and Computers, pp.663–666, Pacific Grove, CA, Nov. 1–4, 2009.

2. W. Su, J. D. Matyjas, M. J. Gans and S. Batalama, "Maximum Achievable Capacity in Airborne MIMO Communications with Arbitrary Alignments of Linear Transceiver Antenna Arrays," in IEEE Transactions on Wireless Communications, vol. 12, no. 11, pp. 5584-5593, November 2013.

3. E. Serpedin, A. Chevreuil, G. B. Giannakis and P. Loubaton, "Blind channel and carrier frequency offset estimation using periodic modulation precoders," in IEEE Transactions on Signal Processing, vol. 48, no. 8, pp. 2389-2405, Aug 2000.

4. A. K. Jagannatham and B. D. Rao, "Whitening-rotation-based semi-blind MIMO channel estimation," in IEEE Transactions on Signal Processing, vol. 54, no. 3, pp. 861-869, March 2006.

5. G. Okamoto and C. W. Chen, "Minimal complexity blind interference mitigation via Non-Eigen Decomposition beamforming," MILCOM 2008 - 2008 IEEE Military Communications Conference, San Diego, CA, 2008, pp. 1-7.

KEYWORDS: MIMO, Blind channel estimation, Spectral efficiency.

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AF173-004 TITLE: Turbine Exhaust Gas Temperature Sensing using Fiber Optics Technologies

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop non-intrusive technologies for gas turbine exhaust temperature measurement that will enable future high performance engines.

DESCRIPTION: The control and health management of modern turbine engines depends on sensing a wide variety of quantities throughout the engine, including temperatures, pressures, and vibration with different redundancy, reliability, and accuracy requirements. Exhaust gas temperature (EGT) is a critical parameter for gas turbine engine control and health management. EGT and other turbine temperature sensors are susceptible to degradation due to high temperature oxidation, erosion and contaminant intrusion into probes and wiring harnesses. Thermocouples acting as sensing elements provide microvolt signals that are easily affected by noise or other environmental factors. Military/commercial field experience indicates that gas path thermocouple removals affect aircraft availability and add maintenance time. Also, the adaptive engine of the future is driving the control system to outperform legacy design, and driving higher temperatures. “Best” entitlement for accuracy at higher than experience range 15-20F (20 deg temp margin ~1% thrust margin) allotment in redline stack is required. Additionally, calculated EGT entitlement is insufficient for future engine needs. Multicolor Pyrometers are not mature, complex, emissivity dependent, and expensive. With alternate technologies that use fiber optic technology to measure exhaust gas effects, measurement of significantly higher temperature should be possible. High temperature measurement requires innovation to survive the harsh environment while maintaining reliability, accuracy, ruggedness, and minimum size/weight/power.
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EGT sensors for military /commercial engines are located downstream from the highest temperature sections of the engine and can be used to infer the state/condition of the turbine blades/disks. As aircraft turbine engines continue to push the envelope on material capabilities, it is important to be able to sense how close to the material limits the system is operating. The new technology should be able to survive for the expected life of the engine between overhauls and measure temperatures in excess of 1600 degrees C (Life: 2000 EFH (immersive), 4000 Engine Flight Hours (EFH)) (non-immersive). It is desired for the accuracy of the sensing systems to be 0.5% of full scale and stable over the life of the engine. Air temperature measurements in the exhaust gases must be taken outside of the wall boundary layer.

Existing approaches for measuring EGT typically implement high temperature capability with thermocouples but extension to even higher temperatures is questionable. Other technologies that have been investigated include thin film thermocouples, pyrometers, spectroscopy, and radioactive isotope-based sensors. They are not mature, accurate or cost/effective for engine implementation. It is important that new technologies be ruggedized for installation in production aircraft.

The high temperature measurement technology within the scope of this program should initially be developed for test cell demonstration and application. After successful technology demonstration and application in the test cell environment, other opportunities for Prognostics, Health management and controls may be considered.

It is appropriate to design and fabricate a prototype EGT probe and interconnect system that is capable of passive testing in a turbine test rig on the ground. Bench testing the EGT probe in an environment that simulates engine operation should be accomplished. Demonstration of flight weight components and ruggedness of the system in Phase III will be critical for transition to insertion in a future program of record. It is recommended that that an engine or controls OEM be involved in the program to ensure future technology transition is facilitated.

PHASE I: Work with at least one engine OEM to establish requirements for exhaust gas temperature measurement. Develop a new concept or adapt existing concepts for measuring exhaust gas temperature that meets the objectives of the system. Prove the feasibility of the concept through analysis and laboratory testing of representative devices.

PHASE II: Based on the Phase I results, build and test a complete laboratory based EGT system that subjects the EGT sensors to realistic environments. Characterize the sensors with respect to accuracy and long term stability.

PHASE III DUAL USE APPLICATIONS: Based on the Phase II & III (results & SOW), work with a sensor OEM to design and fabricate a prototype EGT probe (ground testing) in a turbine test rig. Bench test the EGT probe in an engine environment. Demonstration of flight weight components.

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2. "Durable, Fiber-Optic Sensor for Gas Temperature Measurement in the Hot Section of Turbine Engines," Tregay, G., Calabrese, P., Finney, M., Stukey, K. Proc. SPIE 2295, Fly-by-Light, 156 (October 4, 1994).

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5. "Sapphire Fiber Bragg Grating Sensor made using Femosecond Laser Radiation for Ultrahigh Temperature Applications," D. Grobnic, S. J. Mihailov, C.W. Smelser, and H. Ding. IEEE Photonics Technology Letters, Vol 16, No. 11, pp. 2505-2507, 2004.

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KEYWORDS: EGT, fiber optics sensing, turbine engine control, PHM, exhaust gas temperature

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AF173-005 TITLE: Lithium Metal or Lithium-ion (Li-ion) Battery using Nonflammable, Room-Temperature Ionic Liquid or Solid Electrolyte(s)

TECHNOLOGY AREA(S): Nuclear Technology

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: Develop an ionic liquid or solid based electrolyte for lithium metal or lithium-ion batteries that is nonflammable, has a high ionic conductivity over a wide temperature range, and is electrochemically stable to ensure long battery lifetimes.

DESCRIPTION: Rechargeable Lithium and Li-ion batteries can fail violently when subjected to an internal electrical short, are overheated, crushed, or when they are overcharged/overdischarged. Recent events such as the grounding of a commercial aircraft due to Li-ion battery fires demonstrate that the safety of Li-ion batteries is of major concern. Of particular interest are improvements in safety for Lithium and Li-ion batteries with the use of electrolytes based on nonflammable, room temperature ionic liquids or solids. These new batteries will demonstrate improved safety under various abuse/extreme conditions while also increasing the battery performance at military relevant operating temperatures (-40 to +75 degrees C), storage temperatures (-55 to +85 degrees C), and at high charge/discharge rates (capable of charging/discharging at greater than a 20C rate). These innovative solutions should also place an emphasis on reducing the acquisition costs of these alternative batteries to levels that will make them cost competitive with existing Li-ion, lead-acid, nickel-cadmium, and Lithium Thermal military batteries in terms of acquisition and life cycle.

During Phase II, the offeror will produce a prototype battery for a chosen Air Force (AF)/ICBM application that involves on-demand power using the advanced electrolytes. The offeror will also compare the performance to the baseline battery system. The Phase II prototype should be delivered to the AF for additional testing and evaluation. At the end of the contract, the offeror should also demonstrate the prototype to outbrief technology advancements.

PHASE I: Propose an innovative nonflammable electrolyte based on room temp ionic liquids or solids for rechargeable Lithium or Li-ion batteries. Lithium or Li-ion batteries will have equivalent or better energy & power density capability in relation to current high-rate Li-ion technology. Present experimental & other data to demonstrate feasibility of innovative solution. Prepare initial transition plan.

PHASE II: Produce an alternative safer Li-ion battery using the developed nonflammable electrolytes for use in an Air Force/ICBM on-demand power application (TBD during Phase I). The prototype battery or module size will also be determined during Phase I. Provide cost projection data to substantiate the design, performance, operational range, acquisition, and life cycle costs. Refine transition plan and business case analysis.

PHASE III DUAL USE APPLICATIONS: The military applications include aircraft emergency and pulse power, electric tracked vehicles, unmanned systems, hybrid military vehicles, and unmanned underwater vehicles (UUVs). Commercial applications include hybrid and electric vehicles, portable electric drills, etc.

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2. Balducci, A., et al., "Development of safe, green and high performance ionic liquids-based batteries (ILLIBATT project)," J. Power Sources, Vol. 196 (2011) pp. 9719-9730.

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KEYWORDS: lithium, lithium-ion, batteries, non-flammable, ionic liquid, electrolyte, safety

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AF173-006 TITLE: Ultra-Compact Heat Exchangers

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Demonstrate a 30kW refrigerant-air condenser design with 50 percent improvement in volumetric heat transfer capacity and no more than 10 percent increase in pressure drop per kW of heat exchanged compared to state-of-the- art compact condensers.

DESCRIPTION: Advances in manufacturing techniques and heat transfer enhancement schemes have enabled realization of heat exchanger designs with high thermal load capacity in small volumetric footprints. Emerging heat exchanger technologies such as advanced channel geometries, surface modifications (e.g., split dimples [1]), active flow manipulation (e.g., synthetic jets [2] or oscillating surfaces [3]) and conformal structurally integrated core architectures [4, 5] can be combined to obtain significant improvements in heat exchanger energy density. When combined with computational fluid dynamics (CFD) and heat transfer tools, novel heat transfer enhancement approaches, channel configurations, and packaging can be customized to suit specific applications, constraints, and operating conditions. The possibility also exists to incorporate heat exchangers in irregular and/or confined spaces, thereby providing maximum utilization of volume real estate. Additionally, passive flow manipulation geometries and channel designs can be optimized for heat transfer and pressure losses, which can reduce or even eliminate the efficiency and capacity penalties associated with flow devices contained in highly confined volume envelopes.

The incorporation of game-changing, high capacity vapor cycle systems (VCS) onboard both future and current aircraft hinges on the ability to occupy the smallest volume possible, and acquire, transport, and reject waste heat from electronics, crew, and weapon systems. However, increasing air vehicle loads require evaporators and condensers (especially if air-cooled) that occupy prohibitively large volumes, which decreases the available space for mission systems, fuel, and weapons. This represents a serious capability shortfall in which the thermal management system (TMS) is unable to scale to meet new, more severe mission demands.

The intent of this program is to both improve capacity and reduce integration risks associated with VCS in future or current aircraft by significantly reducing the volume footprint of two-phase heat exchangers. There are two approaches that can be combined to attain this objective:

1. Enhanced energy density (compared to conventional plate-fin designs); this could be achieved by leveraging advanced manufacturing techniques and flow regime-tailored heat transfer intensification schemes

2. Conformal geometry permitting the UCHX to be designed around available space in the equipment bay; this will likely require advanced manufacturing techniques - such as additive manufacturing - to realize irregular, non-rectilinear shapes.

The viability of this technology will be demonstrated by development of a subscale, air-cooled condenser prototype with 30 kW capacity, and having an enhanced volumetric energy density of no less than 50 percent, and increased pressure drop (per kW capacity) of no greater than 10 percent, as compared to currently employed state-of-the-art aerospace air condenser designs (typically plate-fin cross-flow) at a variety of representative operating conditions.

Because utilizing air as a sink requires considerable volume, the technical concepts, fabrication methodologies and design practices developed in this program will open multiple transition paths to high-capacity TMS onboard future air vehicle architectures without requiring additional volume real estate. This technology could also be applied to improve the energy density of other HX types, including evaporators, cold plates, air-air HXs, and air-liquid HXs.

Coordination and/or partnership with an original equipment manufacturer (OEM), first tier subsystem company and/or weapons system company (WSC) in order to gain insight into realistic operational requirements is highly encouraged.

PHASE I: Design viable UCHX design solutions for a notional aerospace air-R134a condenser. The deliverables are:
1. Fabrication protocol for HX; demonstrate manufacturing capability to produce heat exchanger channels and integrated heat transfer enhancement structures
2. Candidate UCHX design to be compared against baseline air-R134a condenser.

PHASE II: Produce full-scale prototype of selected UCHX design to compare to current baseline. Prototype testing will demonstrate satisfaction of heat exchanger performance targets and compliance with the volume and integration restrictions in a representative HX equipment bay environment. Deliverables include final report, technical documentation for UCHX prototype, prototype testing results, and fabricated UCHX prototype.

PHASE III DUAL USE APPLICATIONS: This is an enabling technology for upgrading heat sink capacity, while reducing cost and schedule risks associated with insertion of new equipment in the airframe due to reduced volume requirements. These same benefits extend to most weapon systems where heat exchangers are critical to operation.

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KEYWORDS: heat exchangers, air-air, thermal management

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AF173-007 TITLE: Automated Parametric Discretization Tool for High-Fidelity Hypersonic Design Analysis

TECHNOLOGY AREA(S): Air Platform

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer,

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OBJECTIVE: Take recent mathematical advances in use by the movie animation industry for creating subdivision surfaces and extend to three dimensions for use in CFD and CSM solvers to enable high-fidelity hypersonic vehicle design.

DESCRIPTION: The current state of hypersonic computational fluid dynamic solvers being used by the Air Force, other DOD members, and NASA require structured order numerical methods to accurately predict aerodynamic performance and heat transfer for flight and reentry greater than Mach 6. This results in the requirement for generating structured meshes for computational fluid dynamics (CFD) and computational structure mechanics (CSM) solvers to capture the sharp gradients found in their solution. These types of grids allow for the required C1 (continuous in the first spatial derivatives) and C2 (continuous in the second spatial derivatives) continuity required by hypersonic CFD solvers. Tetrahedral mesh geometries although easy to create automatically have great difficulty in ensuring the C1 and C2 continuity throughout the entire solution domain. Making this one of the major causes of tetrahedral grid generation not working well for current industry CFD solvers used for hypersonic flow calculations. Current state of the art technology for structured mesh generation requires significant man hours that now take longer than the time CFD solvers use to compute hypersonic flows with the full Navier-Stokes equations. This significantly limits the capability of the high-fidelity analysis tools to impact the design cycle of hypersonic systems. Automation of the process to allow for seamless adaption to changes in the CAD (Computer Aided Design) definition of the hypersonic system are a requirement to close this gap. The animation industry has closed this gap in regards to model generation of movie characters and the actors controlling the motions of said characters. One example is the Pixar Opensubdiv library that automatically creates subdivision surfaces as the structured discretization domain for image rendering based off of parameterized character models. This surface rendering technology along with recent mathematical advances in creating a union between Non-Uniform Rational Basis Splines (NURBS) and sub-division geometry can finally allow for fully coupled definition between CAD software definitions and discretized definitions required by CFD solvers. The work to be conducted in this SBIR would be to fold these technologies into a grid generation software tool that is completely driven by parametric representation such as found in modern CAD software that will allow for easy exchange between the CAD and CFD/CSM environment. The tool should employ a smoothing strategy that guarantees C1 and C2 even for multi-point mesh singularities. The mesh should then be defined as parametric system. In addition, an external library with open source licensing is to be developed to allow automated creation of discretized domains for current CFD and CSM solvers from this parametric definition. This library must also create the grid in a partitioned distributed memory format compatible with CFD solvers that are utilized on large scale cluster systems. The CFD solver must then be allowed to communicate back discretization requirements that then the library will use to refine the solution domain and send it back to the CFD solver. This should also allow for user defined perturbations (control surface deflections or optimization corrections) to the underling parametric definition and automatically discretize the domain to this new requirement.

PHASE I: Develop strategy for implementation of automated discretization process and survey CFD/CSM solvers to identify types of data memory formats required by CFD solvers to ensure compatibility. Outline initial math for representation of parametric volumes, surfaces and curves. Demonstrate discretization and smoothing methodology on curve and surface geometries.

PHASE II: Extend methodologies developed in Phase I to volume geometries. Take government reference hypersonic vehicle CAD geometries defined by NURBS, generate parametric grid volume definition, and create distributed structured discretized domain holding C1 and C2 continuity. Demonstrate capability for grid refinement and perturbations to parametric definition of underlying CAD definition of hypersonic geometry. Develop external library for coupling to Navier-Stokes CFD solver. Demonstrate automated grid creation and execution of CFD solver.

PHASE III DUAL USE APPLICATIONS: Commercialization of software and release of open source library for beta testing to small working group demonstrating capability on multiple hypersonic geometries.

REFERENCES:

1. http://graphics.pixar.com/opensubdiv/docs/intro.html.

2. McDonnell, K.T., et al. "Subdivision Volume Splatting," Eurographics/IEEE-VGTC Symposium on Visualization, 2007.

3. Cashman T.J., "NURBS-compatible subdivision surfaces," University of Cambridge, Technical Report UCAM-CL-TR-733 (2010).

4. Bajaj, C., et al. " A subdivision scheme for hexahedral meshes," The Visual Computer, 18, 343-356 (2002).

KEYWORDS: computer aided design (CAD), computational fluid dynamics (CFD), computational fluid mechanics (CFM), hypersonic, vehicle design, computational grids

TPOC-1: Dr. Ryan Gosse
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AF173-008 TITLE: Enhanced SiC Matrix for Launch Vehicle Carbon / Carbon Composites

TECHNOLOGY AREA(S): Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: Develop affordable, high-temperature Carbon / Carbon composite materials that will reduce the manufacturing cost of critical launch vehicle components.

DESCRIPTION: Two high-payoff areas for space launch applications in terms of performance are lowering the design weight and improving the high-temperature capabilities of advanced materials. Composites have become the material of choice for many applications because of their significant weight savings compared to conventional metallic structures. Improving the high temperature capability of composites while maintaining affordability has been more difficult to achieve and still remains a key objective.

In solid rocket motors, structural components for which affordable, lighter-weight, high-temperature composites would provide the greatest payoff are cases, nozzles, and insulation. In liquid rocket motors, improved high-temperature capability offers the greatest payoff for thrust chambers, nozzles, and nozzle extensions.

Carbon fiber /Carbon matrix composite materials are already in use on launch vehicles (e.g., RL10 nozzle extensions); however, the material and/or components are mostly procured from foreign suppliers. Initiatives are underway to develop high temperature Carbon / Carbon materials in the U.S. that can compete with foreign suppliers; however key technical and affordability challenges need to be overcome. One of these challenges is oxidation protection. Carbon / Carbon materials are vulnerable to oxidation at high temperatures and the current state-of-the-art SiC conversion coating process is a significant cost driver. This solicitation seeks to develop an enhanced SiC matrix that does not require high temperature furnaces or specialized coating retort tooling to make Carbon / Carbon materials oxidation resistant. If successful, this technology could enable affordable domestic production of Carbon / Carbon solid and liquid rocket engine components.

Technology Need Date: 2023 (EELV Phase III)

PHASE I: IA. Identify current / future launch vehicle components that could benefit from enhanced SiC matrix technology together with projected savings in lifecycle cost.

IB. Develop manufacturing process plan, beginning with raw material procurement to end item production, including intermediate steps for material property validation, inspection, and quality control.

PHASE II: IIA. Demonstrate manufacturing process for selected prototype structure, evaluate process scalability, and refine production cost estimates.

IIB. Qualify process using building block approach, including generation of material allowables per CMH-17 for critical failure modes and analysis/testing to validate capability under flight environments (e.g., oxidation resistance).

PHASE III DUAL USE APPLICATIONS: IIIA. Conduct full-scale,hot-fire test of prototype structure on representative rocket engine or motor.

IIIB. Assess scalability for other aerospace or commercial applications.

REFERENCES:
1. Composites Materials Handbook-17 (CMH-17) Revision G.

2. Thompson, J., “High Melt Carbon-Carbon Coating for Nozzle Extensions,” NASA NTRS Technical Report 20160005370, 1 August 2015.

3. "Mechanical Properties and Performance of Engineering Ceramics and Composites: A Collection of Papers Presented at the 29th International Conference on Advanced Ceramics and Composites, Jan 23-28, 2005, Cocoa Beach, FL, Ceramic Engineering and Science Proceedings, Vol 26, Issue 2.

4. Wachtman Jr., John B., et al., “Chapter 30. Oxidation Kinetics of Enhanced SiC/SiC,” Proceedings of the 19th Annual Conference on Composites, Advanced Ceramics, Materials, and Structures – B: Ceramic Engineering and Science Proceedings, Vol 16, Issue 5, 26 Mar 2008.

KEYWORDS: launch vehicle, liquid rocket engine, solid rocket motor, nozzle, skirt, carbon-carbon, silicon-carbide, composites, coatings, high temperature environments, thermal protection, durability, materials selection

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AF173-009 TITLE: Identifying and Predicting Influential Factors Across the Materiel and Non-Materiel Solution Spectrum for Complex, Multi-Domain USAF Challenges

TECHNOLOGY AREA(S): Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: Develop an analytical capability to overcome challenges inherent in predicting potential influencing factors, performance, and mission effectiveness within complex, multi-domain challenges that the future USAF will face.

DESCRIPTION: Development Planning efforts across the Air Force include gap analysis, emerging technology assessments, war-gaming, experimentation, performance analysis, operational analysis, requirement development, acquisition strategies, and investment strategies. In general, these efforts aim to inform investment decisions by estimating the cost and mission capability of potential alternatives. Despite these efforts, the Air Force has had mixed results in identifying multi-domain problem elements which have the largest impacts on mission success. One reason for the mixed results is that the Air Force needs to evaluate a vast number of cross-domain solutions and strategies in order to have confidence in its understanding of the trade-space. During Development Planning, the vast number of potential solutions are often difficult, if not impossible, to evaluate using sophisticate methods, like simulations, due to resource and computation limitation. An alternative to more sophisticate methods could include Bayesian networks.

Bayesian networks have long been utilized to understand the probabilistic relationship between a set of variables and the relationship that may or may not exist between them. They can be a powerful tool for identifying the key interactions in complex systems and for evaluating alternative approaches to achieving an end goal. An important, poorly understood, limitation of current applications of Bayesian networks is the implied assumption that the conditional probabilities embedded in the network all have approximately similar uncertainty.

Efforts here will seek to develop a toolset across the materiel and non-materiel spectrum that will extend approaches like the Bayesian networks to include the uncertainty in the conditional probabilities enabling a more precise understanding of those larger system elements that have the greatest overall influence on success or failure. For example, current Analysis of Alternatives tools do not include selected technology readiness level impacts on the solution. Further work will develop a toolset that provides straightforward inclusion of confidence/uncertainty levels into the Bayesian network analysis approach to predicting performance of complex systems. This would have a wide range of applications to include areas as diverse as: Improved health diagnostic tools, Analysis of Alternatives tools, performance analysis of complex systems, and multi-domain mission effectiveness analysis.

PHASE I: Develop and demonstrate a methodology to extend Bayesian networks (or another innovative approach) by including uncertainty in conditional probabilities. Provide general descriptions of how such a methodology could be applied to the Air Force's development planning process and an example of how it could be used to estimate the effectiveness of alternatives.

PHASE II: Implement a Bayesian network (or another innovative approach) into a delivered tool to evaluate, understand, and predict key influential technology areas within a multi-domain, Air Force centric, future challenge. Demonstrate and validate the utility of such a tool to predict emerging concepts along the materiel and non-materiel spectrum that are most influential to the successful of a campaign and thus deserving of further investigation and/or maturation. Ideally this tool should run on a high-performance windows operating system laptop or desktop; however, a LINUX based operating system is also acceptable.

PHASE III DUAL USE APPLICATIONS: The technology developed in Phase I and demonstrated in Phase II will have application throughout government and industry.

REFERENCES:
1. Glenny, V., "A Framework for the Statistical Analysis of Probability of Mission Success Based on Bayesian Theory." (2014). Defense Technical Information Center (DTIC) report number ADA610732.

http://www.dtic.mil/docs/citations/ADA610732

2. Uusitalo, L., "Advantages and Challenges of Bayesian Networks in Environmental Modelling." Ecological Modelling, 203(3), 312-318. (2007).

3. Chan, H., and Darwiche, A., "When do numbers really matter?" Proceedings of the Seventeenth Conference on Uncertainty in Artificial Intelligence (pps. 65-74), Morgan Kaufmann Publishers Inc. (August 2001).

KEYWORDS: measures of effectiveness, system(s)-of-systems, bayesian nets, probabilistic-based methods

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AF173-010 TITLE: Lifecycle Cost Modeling Tools for Elements of a Digital Engineering Ecosystem

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Develop methodologies for modeling the lifecycle cost of different Digital Engineering ecosystem configuration options, including IT/network infrastructure, software tools, data warehousing, data management, user interfaces, and associated CONOPS.

DESCRIPTION: Digital Engineering (DE), Digital Systems Model (DSM), Digital Thread (DT), and Digital Twin (DTw) are emerging concepts within the U.S. Department of Defense (DoD) and the U.S. Air Force (USAF) to improve the acquisition, management, and engineering of defense systems throughout their lifecycles. These four concepts are interrelated and involve an emphasis on the use of digital data and models. Bringing these concepts to fruition requires an ecosystem linking analysis tools, data, and personnel through the use of IT/network infrastructure; document, data, and model management; and digital workflows. Many different USAF organizations will be involved in providing elements of the ecosystem and exercising elements of DE. Furthermore, there are many options for building the ecosystem and providing DE capability. While specific stakeholders have the ability to estimate costs for certain pieces of the ecosystem, there is no capability to assess costs at an enterprise level or to assess costs for different ecosystem configuration and CONOPS options. Therefore, the goal of this project is to create a capability to estimate costs of specific ecosystem configurations and CONOPS on a stakeholder-by-stakeholder basis and to compare and contrast options for strategic cross-organization discussions.

One example of an element of the DE ecosystem is Product Lifecycle Management (PLM) capability for managing product lifecycle information. There are a number of options for providing PLM capability to a given System Program Office (SPO), and each SPO will have different requirements for PLM based on lifecycle strategy, current lifecycle stage, and availability of PLM data. A methodology to identify the options for meeting each SPO's requirement and comparing the cost and capability implications of each option for the SPO and enterprise stakeholders is desired.

The solution developed will result in tangible delivery of a computer-based tool to develop estimates of lifecycle cost for each of the stakeholders involved in providing Digital Engineering capability to the USAF based upon presumed configurations/CONOPS. The tool may consist of any of several types of computer-based tools, including an executable windows-based software package, a web-browser-based tool, or a plug-in or module that runs inside a widely available commercial software package.

PHASE I: Identify existing DoD IT capabilities which may contribute to the desired DE capability; identify associated stakeholders/cost centers. Identify capability gaps and options to deliver desired capability tailored by SPO. Define specific use cases to appropriately scope the effort in Phase I and demonstrate the ability to integrate disparate DE ecosystem elements into a tailored cost model.

PHASE II: Develop, prototype, validate and demonstrate the proposed DE ecosystem lifecycle cost modeling tool. Demonstrate the system using a predetermined list of DE capability gaps and SPOs from Phase I.

PHASE III DUAL USE APPLICATIONS: As Digital Engineering becomes more widespread, the technology developed in Phase I and demonstrated in Phase II will be used by government and industry to determine their respective cost effective Digital Engineering ecosystems.

REFERENCES:
1. "An Element of Digital Engineering Practice in Systems Acquisition," Robert A. Gold, 19th Annual NDIA Systems Engineering Conference, Springfield, VA, Oct 26, 2016.

2. http://www.acq.osd.mil/se/initiatives/init_de.html - Digital Engineering Initiative Homepage, Office of the Deputy Assistant Secretary of Defense for Systems Engineering (accessed on Feb 13, 2017).

3. "Digital Thread and Twin for Systems Engineering: Requirements to Design." Zweber, J. V., Kolonay, R. M., Kobryn, P., and Tuegel, E. J., 55th AIAA Aerospace Sciences Meeting (p. 0875) (2017).

4. "Digital Thread and Twin for Systems Engineering: Design to Retirement." Tuegel, E. J., Kobryn, P., Zweber, J. V., and Kolonay, R. M., 55th AIAA Aerospace Sciences Meeting (p. 0876) (2017).

KEYWORDS: digital engineering, digital thread, lifecycle cost, product lifecycle information

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AF173-011 TITLE: COLLECTIVE/COOPERATIVE NAVIGATION

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: To develop multi-source navigation algorithms to ensure weapons grade navigation capability for weapons systems in Anti-Access/Area Denial (A2AD) environments. This will address the need for Global Positioning System (GPS)-denied, A2AD over-land and/or over-water cooperative navigation capability applicable to low cost munitions.

DESCRIPTION: When access to GPS is denied, weapons can share relevant measurements and make inter-weapon measurements to provide improved mid-course navigation accuracy compared to single weapon inertial navigation system (INS) performance. Recent hardware advancements allow for accurate inter-agent range measurements; there is also potential for range rate, bearing, and bearing rate measurements. We seek a general decentralized navigation software framework capable of leveraging these and other measurements. The proposed solution should provide both an accurate local frame navigation solution (i.e. each agents' position relative to its peers) and a reduction in global position uncertainty for the cooperating agents when compared to the single agent case. The cooperative navigation algorithm shall be implemented in a decentralized manner in the sense that it should not be expected that all sensor measurements are available to all agents at all times or even at a single centralized processor. If GPS or other georeferenced sources become available to any agents, the navigation algorithm should incorporate this information without requiring these sources to maintain a functional navigation solution. Preference will be given to proposals that are theoretically sound and approaches that are applicable to a wide range of vehicle and sensor types and performance characteristics. Approaches with more limited application will be considered but these limitations must be clearly defined. However, approaches that support heterogeneous groups of weapons are encouraged. Flexible estimation systems, ones that could be leveraged on a number of different platforms (with minimal modification), will be viewed favorably. Additionally, the estimation framework should also support graceful degradation of the cooperative INS solution to the single INS case. This effort should focus on navigation algorithm software development instead of hardware development. For proof-of-concept development and testing, inter-agent measurements that are computed from GPS and telemetry data may be used in place of actual measurements. However, any inter-agent measurements should be justified as feasible with additional hardware development. Communication data rates, robustness to intermittent or permanent loss of communication to one or more agents, and specific network connectivity requirements will also be taken into account.

Proposals shall provide a representative concept of operations (CONOPS) appropriate for their proposed method along with the underlying system assumptions including sensors to be used and associated sensor qualities, frequency of any geo-registered data (i.e. GPS or registration of known features), number and trajectory of vehicles, and communication bandwidth required. The CONOPS and proposed technical work detailed in the proposal should be commensurate and the proposal shall provide anticipated navigation accuracy in both the global frame and relative frame (i.e. position of vehicles with respect to each other) for the associated CONOPS.

For systems anticipating geo-referenced measurement inputs, the anticipated root-mean squared (RMS) global position error and 95th percentile error is appropriate (alternatively, the one and three sigma positioning uncertainty values). For systems with no geo-referenced feedback, or long time periods between geo-referenced feedback, the proposal should provide anticipated RMS (or one and three sigma) for positioning error as a function of time, or distance traveled, since last geo-update. Additionally, the anticipated RMS position error and 95th percentile error (or one and three sigma) for relative frame accuracy should also be included.

The anticipated accuracies should be framed in terms of goal accuracies (what the program would aim to achieve) and required accuracies (accuracies which need to be met in order to claim program success) for the proposed CONOPS. It is understood that there are many trades within this research space, the proposal should be viewed as an opportunity to explain at least one CONOPS where the proposed solution is relevant and the expected performance this program would provide within that relevant environment.
Finally, if the proposed development has anticipated non-military use cases, these should also be stated in the proposal.

PHASE I: Phase I should focus on navigation algorithm development with implementation in simulation. Software in-the-loop (SIL)/ hardware in-the-loop (HIL) or proof-of-concept hardware results are encouraged, but not required. The effort should clearly identify the effectiveness of the system, minimum sensor quality requirements (e.g. noise, resolution, etc.), communication requirements, and system limitations. No Gov't materials, equipment data, or facilities will be used.

PHASE II: Phase II should focus on improvements to the navigation algorithm and real-time proof-of-concept hardware demonstrations and SIL/HIL testing as necessary. Plans for future partnering or internal development of inter-agent measurement hardware/software should be addressed, supporting transition potential for Phase III (planning done in Phase II).

PHASE III DUAL USE APPLICATIONS: The technology developed for this effort shall be demonstrated on weapons systems or appropriate surrogate systems (TRL 6/7) using sensor hardware capable of making the required inter-agent measurements or partner with a company that has an existing solution toward transitioning the technology to appropriate cooperative munition program(s).

REFERENCES:

1. Rajnikant Sharma and Clark Taylor. "Vision Based Distributed Cooperative Navigation for MAVs in GPS denied areas", AIAAInfotech@Aerospace Conference,Infotech@Aerospace Conferences, 2009. doi:10.2514/6.2009-1932.

2. V. Indelman, P. Gurfil, E. Rivlin and H. Rotstein, "Graph-based cooperative navigation using three-view constraints: Method validation," Position Location and Navigation Symposium (PLANS), 2012 IEEE/ION, Myrtle Beach, SC, 2012, pp. 769-776. doi: 10.1109/P

3. B. Kim et al., "Multiple relative pose graphs for robust cooperative mapping," Robotics and Automation (ICRA), 2010 IEEE International Conference on, Anchorage, AK, 2010, pp. 3185-3192. doi: 10.1109/ROBOT.2010.5509154.

4. J. Pentzer and E. Wolbrecht, "Improving autonomous underwater vehicle navigation using inter-vehicle ranging," Oceans, 2012, Hampton Roads, VA, 2012, pp. 1-8. doi: 10.1109/OCEANS.2012.6404994.

KEYWORDS: multi-source navigation algorithms

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AF173-012 TITLE: Dual-mode Energetics

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: Develop energetic formulations that can function as a propellant and an explosive yet satisfy insensitive munition requirements.

DESCRIPTION: Next generation munitions addressing technology gaps, particularly for Air Superiority, are anticipated to generate higher lethality from smaller systems likely requiring advanced technology and potentially alternative approaches. One approach would be to develop an energetic formulation that is capable of serving as a common energy source which can be exploited as a fuel for propulsion to get the system to the target with the remainder used to provide the target defeat mechanism. This approach has the potential to alter the paradigm of missile/munition design since it increases system flexibility by allowing additional thrust control in the terminal encounter and/or utilizing the larger surface area of a case to mimic a larger warhead for either blast or fragment distribution near a target. While the energetic crystals within propellants and explosives are often similar indicating dual-mode potential, the formulations are different and optimized for their respective application. [1,2,3] Propellants are optimized to have certain burn rates and mechanical properties over a broad range of temperatures [-65°F to 165°F] in order to produce desired thrust in a controlled manner. For example, propellant formulations seek to avoid cracking that may occur with thermal-cyclic loading because a crack will result in a catastrophic failure since the propellant burn-rate will accelerate out of control and potentially detonate prematurely. The focus of this effort is on developing formulations that are capable of producing the desired thrust over a broad range of temperatures and yet can be easily detonated upon command when needed. The formulations will also need to consider requirements for passing insensitive munition requirements. [4]

PHASE I: Identify potential formulations that are capable of functioning as both a propellant and an explosive. Ideally, formulations will have a controlled burn rate, sensitive to pressure or some other throttling mechanism, yet can be detonated with the minimal initiation train. Initial characterization of the burn-rate and mechanical properties.

PHASE II: Detailed validation and systematic parametric sensitivity of formulations through mechanical property and burn-rate characterization over a broad range of temperatures and pressures. Assess the feasibility of passing IM requirements. Demonstration of dual-mode energetic material within a representative configuration. Demonstration would consist of burning the material with a motor, extinguishing burn, and detonating residual energetic material.

PHASE III DUAL USE APPLICATIONS: Within a Phase III effort it is anticipated that the small business would partner with a prime contractor to form a team that includes pertinent government representatives for guidance. Multiple near-term munition concepts may benefit from a dual-mode energetic and the team would tailor the energetic to the promising concepts. This process would involve assessments of how current designs (geometry, initiation, etc.) could be modified to exploit the dual-mode material as well as envision new designs based on performance. Additionally, the material would be evaluated to determine the feasibility of the energetic material to boost efficiency of secondary reactions within cases. Advanced demonstrations conducted by prime or sub-prime contractors in partnership with the small business and in coordination with the government would reveal advantages of the dual-mode energetic and create a commercialization path.

REFERENCES:

1. Goedert, Z., Sieg, G., Scale-up Of Cl-20 Propellant Formulations. Desensitization Of Cl-20, Accession Number: CPIAC-2009-0031CD, April 2009

2. Mason, M., et. al., Performance and Fragment Impact Testing of PBXC-135, an Insensitive CL-20 Based Plastic-Bonded Explosive, Accession Number: ADB403398, August 2014

3. Mason, M., et. al., Pbxc-135: A Reduced-sensitivity, High-performance, Plastic-bonded Explosive Based On Cl-20, Accession Number: CPIAC-2008-0006AH, May 2008

4. MIL-STD-2105D Hazard Assessment Tests for Non-nuclear Munitions

KEYWORDS: Dual-mode energetics, multi-mode energetics, multi-purpose energetics, dual-purpose energetics, CL-20, HMX, RDX, dual-mode munitions, multi-use explosives, advanced propellants

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AF173-013 TITLE: BIO-INSPIRED OPTICAL SOURCE EXCLUSION (BIOSE)

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: To improve sensor survivability and operations by developing blocking technologies that protect detectors from damaging/blinding spikes in signal intensity.

DESCRIPTION: Many insects have very wide field-of-view (FOV) compound eyes that can see almost everywhere at once enabling them to maintain situational awareness, disambiguate optical flow, etc. This feature has a potential drawback, however, since the sun (or moon) is often going to be in their FOV, which can damage photosensitive cells and/or significantly reduce sensitivity in that region of their vision. As is common, however, such animals have evolved a clever mechanism for dealing with this problem: they have blocking pigments that move in response to bright sources, optically reducing or blocking the bright signal in the affected region of their FOV while maintaining sensitive vision in unaffected regions. New multi-aperture optical systems are leading to novel weapon seeker concepts that have very wide FOVs and therefore may have to deal with bright sources such as the sun that can damage focal plane arrays and cause significant undesirable effects such as blooming. This topic solicits innovative approaches to addressing this issue for wide FOV multi-aperture optical systems. The system must be able to quickly respond to bright sources by blocking or reducing the energy in that region of the FOV while maintaining sensitive imaging capability elsewhere. Such a system may also present the opportunity to establish an optical communication channel with another object in the FOV, which is of interest.

Current state of the art for the visible band implements an approximate 1010 reduction in intensity in a ±3º exclusion zone within a ±45º field of view. The Air Force will prioritize novel concepts that at least double this field of view while maintaining similar optical performance. Response time for switching the optical exclusion zone of < 100µs is desired. The Air Force anticipates that no government furnished property will be required for the effort and that all development will take place at the contractor facilities.

PHASE I: Develop the concept and preliminary design. Build a breadboard system to test and demonstrate the concept. The preliminary design should be consistent with an optical sensor for a small unmanned vehicle with total volume < 70 in3 excluding any needed power source.

PHASE II: Further develop the Phase I system and create a prototype design. Build the prototype system and test. Demonstrate the capability and deliver the prototype.

PHASE III DUAL USE APPLICATIONS: Partner with industry partner to develop the Phase II prototype into a commercial product and market it. Commercial applications may include automotive and non-military aerospace sectors.

REFERENCES:

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2. Ribi, Willi A. "Ultrastructure and migration of screening pigments in the retina of Pieris rapae L.(Lepidoptera, Pieridae)." Cell and tissue research 191.1 (1978): 57-73.

KEYWORDS: sensor survivability, optical communication channel

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AF173-014 TITLE: Metallic Glass

TECHNOLOGY AREA(S): Space Platforms

OBJECTIVE: Develop materials with greater strength and resilience for spacecraft structures and mechanisms.

DESCRIPTION: Metallic Glass is a relatively new class of materials that can have the rare combination of strength, resilience and toughness. It is a metal alloy that formed by a particular schedule of rapid heating and cooling that results in a disorganized, partially crystalized structure verses the organized crystalline structure of typical metals and alloys. The Defense Threat Reduction Agency funded research in this area with a grant to a collaboration of USC, Cal Tech and the Jacobs School of Engineering (grant HDTRA1-11-1-0067). They showed that certain formulations have an elastic limit that exceeds stainless steel by a factor of nearly 100 and silicon carbide by a factor of two.

Such a material may have additional space application in booster, adapter, and engine structures where high elastic limit is critical, and satellites for impact shielding as well as certain structural purposes.

This topic would survey, characterize, and devise applications for metallic glass. Assess the effects of space environment on the materials and determine properties over long periods of space flight and assess the thermal properties of the material. Determine the cost-benefit of replacing classic metal alloys and/or composites in space applications where a high elastic limit is key.

PHASE I: Survey recent advancements in metallic glass. Characterize properties for applications to structures and mechanisms for spacecraft. Assess best options for product development and insertion into spacecraft design. Provide plan to make the first metal glass component(s). Indicate cost-benefit of using metallic glass. Raise TRL to 2+.

PHASE II: Using output of Phase I, produce a space component of the chosen metallic glass. Test component response to relevant spacecraft environment: Vacuum, radiation, thermal response. Test component functionality and compare to existing technology. Raise TRL to 3+.

PHASE III DUAL USE APPLICATIONS: Devise transition plans, strategy to disperse product to larger market: commercialize spacecraft solar arrays, bulkheads, actuators, reaction wheels, aircraft, manned/unmanned, wing roots, flaps, slats, speed brakes, helicopter rotors and blades, shielding and body armor. Identify ancillary markets and applications where metallic glass can replace existing materials.

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KEYWORDS: Metallic Glass, crystalline structure, space environment, spacecraft design

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AF173-015 TITLE: Model Based Systems Engineering Big Data Analytics

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Develop and demonstrate ability to discover, aggregate and analyze disparate data types and formats to enhance the decision making process during weapon system design and development.

DESCRIPTION: In performing design trades, Analysis of Alternatives (AoA), statistical inference, and requirements development the engineer must be able to utilize an aggregation of Model based Systems Engineering (MBSE) data and models to mature the design into a system which has sound systems engineering qualities. As every process requires a starting point, MBSE would be tremendously enhanced by seeding the process with existing weapon system data. The starting point of a new design should include not only the warfighter requirements found in the Joint Capabilities Integration and Development System (JCIDS), Capabilities-Based Assessments (CBA) and Initial and Capability Development Documents (ICD/CDD), but any available historical data for the given class of weapon system or subsystem at hand. Lessons learned (good and bad) from all previous endeavors should be taken into account in a new design.

Therefore, the goal of this project is to create a capability to employ traditional techniques from “Big Data” research to seed design, capability development, and system integration with substantial prior knowledge from the vast collection of technical development documentation provided to the Government through years of system acquisition and sustainment. This new capability would be developed in the form of a software toolchain which provides a design environment to reason over historical information such as material, subsystem, or system performance, production experience, test results, and sustaining engineering analyses. This environment would provide substantial acceleration of solution development resulting in reduced time to deliver critical technology to the warfighter.

The ability to capture multiple types of historical engineering reports and technical documents into a digitized shared reasoning environment which allows engineers to link desired design artifacts together will provide systems engineers with the opportunity to make cross-domain trades. Also, this capability will offer engineers the capability to use available existing weapon system and subsystem data in the design of new innovative weapon systems and subsystems that by nature are resilient and possess greater OSS&E qualities based on years of lessons learned.

PHASE I: Define solution to store data, import common engineering documents, link design artifacts to represent correlation, and conduct cross-domain trades. Solution must specify data storage and computational requirements. Solution will identify existing DoD capabilities which may contribute to the desired end-state capability, identify capability gaps and establish a methodology to deliver needed capability.

PHASE II: Develop, prototype, validate and demonstrate the proposed data analytic capability leveraging as much existing DoD infrastructure as possible. Demonstrate the system using a predetermined list of databases and MBSE tools from Phase I.

PHASE III DUAL USE APPLICATIONS: The technology developed in Phase I and demonstrated in Phase II will have application throughout government and industry.

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KEYWORDS: Model based Systems Engineering (MBSE), Analysis of Alternatives (AoA), statistical inference, requirements development, Joint Capabilities Integration and Development System (JCIDS), Capabilities-Based Assessments (CBA), Initial Development Documents, Ca

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AF173-016 TITLE: Space Debris Engagement and De-Orbiting Device

TECHNOLOGY AREA(S): Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct ITAR specific questions to the AF SBIR/STTR Contracting Officer, Ms. Gail Nyikon, gail.nyikon@us.af.mil.

OBJECTIVE: Develop a self-contained device that can be deployed from a host satellite in proximity to an orbiting defunct rocket body, attach to or capture the rocket body, and cause sufficient increase in drag, using no power after deployment, to remove the rocket body from orbit.

DESCRIPTION: Rocket bodies from decades of launch of satellites into Earth orbit are the largest component of space debris by mass, and they may pose a significant present and future threat to operation of space systems in certain orbits. Most of these objects will remain in place for several more decades before they re-enter the Earth's atmosphere and eventually burn up.

Recognizing the broader challenges of space debris, multiple organizations have created concepts for mitigating that debris and de-orbiting space junk. The concepts include attaching propulsion modules, electrodynamic tethers, and drag enhancement devices including sails and balloons.

The Air Force is interested in long term reduction in the number of large rocket bodies in low earth orbits, especially near-polar and sun synchronous orbits to help preserve and extend the effective use of space. A specific interest in this solicitation is in clearing critical orbits and accelerated de-orbiting through drag augmentation, and methods to attach such augmentation devices to resident space objects. A useful system would cause a rocket body to de-orbit at least ten times faster than the body would de-orbit without drag augmentation.

As other space infrastructure matures, including rideshare launches, small satellites and space vehicle propulsion systems, the feasibility and affordability of such an approach to debris mitigation has increased. This research will focus on the final engagement with rocket bodies, and the attachment and deployment of drag-enhancing devices. The research can assume the existence of a satellite host vehicle, with sufficient propulsion and attitude control capability to enter and maintain a co-orbital trajectory with the target debris and an orientation that enables a precise release of the debris mitigation payload in the proximity of the target debris. The payload is assumed to passively rendezvous with the target debris, for example a rocket body, which may be tumbling. The payload must attach to or capture the rocket body and deploy a device of sufficient area and stiffness to enhance the drag of the coupled system, increasing the decay rate to accelerate re-entry of the system. The system must not create more debris, and must consider the potential fragility of target debris that have been exposed to the space environment for decades.

A broader service may contain multiple copies of the debris mitigation payload carried by a delivery vehicle, and the design and concept of operation of this payload should allow several engagements with different rocket bodies as the maneuverable satellite host delivers a separate device to each of the bodies in turn.

PHASE I: Identify representative rocket bodies and determine their orbits, mass, volume, shape and rotation rates. Develop a satellite payload with low size, weight, and power that separates from a co-orbital satellite host at close proximity to the body, then attaches to or captures the body with low risk to the host and low probability of creating additional debris. Increase drag of the rocket body to alter its trajectory, causing it to de-orbit at >10X natural rates. The device must maintain structural integrity and minimize the creation of additional debris during the expected duration of the de-orbit.

PHASE II: Based on the Phase I effort, design and build a debris mitigation payload that can be integrated in a satellite host. Perform simulations to demonstrate the engagement with and capture of the candidate rocket body, deployment or engagement of the drag enhancement device, and the subsequent decrease in orbital lifetime of the rocket body. Perform a ground based hardware demonstration that supports feasibility of the design concept.

PHASE III DUAL USE APPLICATIONS: A number of commercial space ventures are exploring the use of massive (100s or 1000s of satellite) constellations in LEO to provide imaging and communications services. The availability of unpopulated orbits, with reduced probability of collision with resident rocket bodies and other debris, could make commercial debris mitigation services viable. Furthermore, these existing rocket bodies pose a potential for creating more debris in these orbits, which could make them unusable for government or commercial purposes, and the government may step in to help mitigate this danger with public-private partnership funding to clean up specific orbits. The device developed under this effort could be the key element of such a debris mitigation system, either commercial or government operated.

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KEYWORDS: space debris, debris mitigation, grapple mechanism, attachment mechanism, passive de-orbit, orbital drag

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AF173-017 TITLE: Air Force Declassification Office Knowledge Capture and Process Optimization

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: The Air Force Declassification Office (AFDO) seeks to document and analyze business processes for classified document review and define industry best practices and new technologies to increase efficiencies and promote cost savings. This project would assist AFDO in order to adhere to the presidential mandate Executive Order 13526, “Classified National Security Information,” Promotion of New Technologies to Support Declassification that was issued on 29 December 2009. It outlines how classified information should be handled and established the principle that no records may remain classified indefinitely. It also provides enforceable deadlines for declassifying documents, generally between 10 to 25 years from the time of classification.

DESCRIPTION: Currently, AFDO has 12000+ Boxes of physical records to review, ahead of a large number of incoming digitally born records. In order to adhere to the Executive Order 13526, a process must be in place to speed up the rate of review using a machine-assisted tool. This will not be possible with physical records, as only digital records can be ingested into a review tool. Physical records must be scanned, digitized and processed using an OCR tool. In addition, digitizing records will remove the responsibility and cost of storing physical records at the Washington National Records Center (WNRC) in Suitland and the logistics of transferring records from WNRC to AFDO, and then from AFDO to NARA.

AFDO is saddled with extensive logistics work and the process is very labor intensive. AFDO Reviewers currently reserve vehicles, coordinate with Suitland and NARA, and physically move the boxes onto the trucks. This costs AFDO $101,003 per year and takes reviewers away from their core activities, preventing 207,301 pages from being reviewed per year.

In addition, the process that AFDO reviewers use in reviewing these documents is human-centered

PHASE I: Phase I of this project will: (1) conduct user analysis that leverages Cognitive Task Analysis (CTA) interview and observation methods to capture the AFDO process to include knowledge elicitation, process analysis, and process representation; (2) investigate potential digitization tools, scanning, and Optical Character Recognition (OCR) applications, and (3) process automation tools to support intelligent decision support in the AFDO process.

PHASE II: Phase II of the project will design and develop a system including human-machine teaming to optimize the AFDO mission process. This will include: (1) exploring the proof of concepts developed in Phase I, (2) building/integrating protoypes for demonstration, and (3) detailing a production level system for implementation into the AFDO.

PHASE III DUAL USE APPLICATIONS: AF/A6 has planned funding (Phase III) for the effort assuming that any process with digitization/automation tools selected will be approved for Certification and Accreditation and that NARA will accept digital files in place of originals. Enough of the physical documents will result in OCR accuracy suitable for a review tool, which will gain AFDO time and cost efficiencies. There will be an insignificant volume of documents that cannot be batch scanned or will result in poor OCR quality. These documents will still require manual review.

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3. US Environmental Protection Agency Information Standards - CIO2155-S-01.0

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