**20.3 Mission Focus Areas**

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**Focus Area: Low C-SWaP EO/IR ISR Sensor Technology**

Description: The goal of this topic is to develop low cost, size, weight, and power (C-SWaP) Electro-Optical Infra-Red (EO/IR) sensor technology to support distributed intelligence, surveillance and reconnaissance (ISR) in contested environments (CEs). Future engagements may necessitate operations in CEs, putting high-value platforms and associated sensors at risk. As such, future missions may utilize lower cost, attributable platforms to support operations in CEs. Associated ISR sensor technology is required for such platforms where C-SWaP constraints are more significant than for traditional platforms. Technology advancement is required in many sensor modalities, including, but not limited to broadband EO/IR, multispectral, hyperspectral, polarimetric, and LIDAR. Research and development can include full system-level designs or advancement of component technology, such as detector materials, telescopes, transmitters, receivers, real-time data processing hardware, etc.

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**Focus Area: Rapid Sustainment**

The Rapid Sustainment Office mission is to leverage mature, new, and emerging technology to reduce sustainment costs and improve readiness. Six lines of effort have been established to focus the office, simplified to five here: 1. Automation & Robotics, 2. Advanced Manufacturing (AM), 3. Condition Based Maintenance Plus (CBM+), 4. Digital, Rapid, Austere, and 5. Augmented/Virtual Reality (AR/VR) for Geo-Separated Expert & Trainer One. There are eight technical focus areas that cross-cut the six lines of effort: 1. Artificial Intelligence/Machine Learning, 2. Advanced Manufacturing, 3. AR/VR/Extended Reality, 4. Automation and Robotics, 5. Data & Digital Environments, 6. Low Observable Maintenance, 7. Rapid/Austere, and 8. Sustainment Modernization. More detailed descriptions of each can be found at [afrso.com](http://afrso.com/). Pain points have been identified from users and used as examples of areas of interest, but are not limited to the following:

* Automation/Robotics:
  + Smart Tool Boxes
  + Vision systems (enabling the robot to detect, orient to and execute work)
  + Mobile automation for depot and Flightline sustainment (Move the system to the platform for sustainment activities)
* Advanced Manufacturing (AM):
  + Automated reverse engineering tool with minimal required user interface
  + Part printing method for easily damaged composite components during the facilitation of other maintenance (FOM) (i.e., blade seals and bullnoses)
* CBM+ Tech Insertion:
  + Ideal Work Unit Code (WUC) Tool—reads narrative and useful fields (i.e., HMC, P/N, etc.), compares WUC selected with available WUC from technical manuals, and suggests idealized WUC for use during maintenance forms (i.e., AFTO Form 781A) Quality Control process. Needs to be able to be run in the AWS enclave (open source-ideal, Python-current utilization).
* Digital & Rapid/Austere:
  + Disposable containers for harsh or temporary environments to support Low Observable and composite repair, corrosion control, and AM
  + Rapidly constructed maintenance structures
  + Predictive Analytics/Algorithm Development (PAD), speech to text for various career fields
  + Components that reduce the need for large logistics tail
  + Parts-supportable high reach capability
  + Multi-platform Test Equipment
* AR/VR:
  + Method to track job status as they are performed
  + Augmented/Extended Reality for maintenance accomplishment
  + Content development enterprise (creation, testing, and life-cycle support)
  + Quick, cost-effective process to convert to S1000D format to leverage into a common operating picture for Technical Order viewing at weapon system while performing maintenance.
  + Geo-separated expert access while performing tasks

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any Rapid Sustainment effort that may impact future Air Force missions.

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**Focus Area: Orb/eVTOL/UAM (Electric Vertical Takeoff and Landing/Urban Air Mobility)**

The objective of this topic is to explore potential commercial products being developed in the emerging eVTOL/UAM market for possible disaster response, humanitarian aid, and logistics missions. This subtopic is intended survey a vast scope of technologies to include: autonomy; advanced aircraft materials and manufacturing; novel acoustics techniques; subsystem, aircraft, and portfolio design and analysis tools; rapid mission planning for dense air environments and logistics efficiencies; command and control of air vehicles; robotic landing gear; large flotation devices; modular payload designs; air vehicle data networks and RF waveforms; sense and avoid architectures, algorithms, and sensors; electrical power storage, generation, charging; distributed electric propulsion control techniques.

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**Focus Area: Digital Curation for Design and Analysis of Aerospace Systems**

A critical aspect of the digital transformation of the U.S. Air Force is developing best practices and tools that accelerate technology transition and capability development for the Warfighter. The U. S. Air Force Research Laboratory (AFRL) and its Aerospace Systems Directorate (RQ) are seeking proposals for research that transition products that identify and curate aerospace system design & analysis artifacts generated by predictive modeling and simulation, ground testing, and flight testing activities. This list is not all-inclusive, and innovative solutions not listed below are encouraged to apply.

Examples of areas of interest to explore system performance and military utility include the following topics:

* Technology-oriented modeling and simulation workflows
* Capability-oriented modeling and simulation workflows
* Technology-oriented ground testing workflows
* Capability-oriented ground testing workflows
* Technology-oriented flight testing workflows
* Capability-oriented flight testing workflows
* Automated identification and selection of disruptive technologies
* Automated identification and selection of disruptive capabilities
* Progressive digital engineering workflows
* Data-driven workflows that identify and prioritize high-value modeling and simulation activities
* Data-driven workflows that automate the curation of completed modeling and simulation activities
* Data-driven workflows that identify and prioritize high-value ground testing activities
* Data-driven workflows that automate the curation of completed ground test activities
* Data-driven workflows that identify and prioritize high-value flight testing activities
* Data-driven workflows that automate the curation of completed flight testing activities
* Static and dynamic visualization tools to communicate the value of research activities

The topics listed above intended to be descriptive in nature, and innovative ideation and automated solutions are of interest to accelerate digital transformation, digital engineering, and digital curation best practices.

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**Focus Area: Advanced Power Technology**

This focus area seeks innovative energy and power related technologies that can improve mission capability, energy resilience and efficiency, reliability, affordability, and sustainability across all domains in which the U.S. Air Force operates. This includes ensuring the agility and survivability of support capabilities to Air Force operations.  Technology Readiness Level (TRL) 6 is preferred; or, a demonstrable path to TRL 7 within 18-24 months. Of prime interest are technologies that:

* Aircraft: Reduce petroleum-based fuel consumption, reduce maintenance and expand/enhance mission capabilities via potential approaches not limited to: lightweight modern materials, drag reduction, electrical and/or lighting modifications, software enhancements, liquid natural gas-capable aerospace systems, etc.  Priorities include:
  + Improving the capabilities of fuel intensive legacy aircraft
  + Alternative and non-petroleum technologies (e.g., tires-to-jet fuel; fuel agnostic combustion; etc.)
* Expeditionary Environment: Improve warfighter self-sufficiency in resource poor, inhospitable, austere world-wide operations by reducing energy, water, logistical and operational footprints and risk. Priorities include:
  + Sustainable energy resources (e.g., wind, solar, etc.)
  + Water reuse
  + Agile, mobile, survivable fuels logistics capabilities (containerized and mobile bulk fuel; multi-spectral fuels concealment for bladders and other fuels equipment; lighter/leaner refueling, e.g. 350 gallons per minute or more; etc.) and expeditionary base energy (e.g., generators powered by fuel agnostic turbine engines)
* Installations: Provide assured and resilient energy. Optimize energy used in processes common to air base operations, maintenance depots, research laboratories and test centers.
* Flight line Equipment & Vehicles: Improve energy efficiency, autonomy, combat agility during CONUS / OCONUS operations, and operator health and safety conditions. Enable electrification of the flight line and associated equipment with full-electric or diesel-electric hybrid solutions.
* Science & Technology Base: Improve energy, power and thermal derived capabilities such as, but not limited to, improved range, duration, resilience, assurance, loiter, sustainment, size, weight and cost.

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**Focus Area: AFWERX Energy Challenge**

The Air Force is looking to improve energy security and sustainability, reduce energy dependence, remain adaptable to climate change impacts, and reduce energy demand. The Department of Defense is the single largest user of energy globally. It consumes energy in two ways: operationally (i.e. training, moving, and sustaining our armed forces) and for powering its installations with electricity, heating, and cooling. In order to improve energy security and sustainability, reduce energy dependence, and remain adaptable to climate change impacts, the DoD has a strategic goal to reduce energy demand. The Air Force is looking for assistance in:

1. Defining the key issues, problems, challenges, and/or inefficiencies with the current energy infrastructure/enterprise
2. Defining the components of a new energy infrastructure/enterprise via exploration of a broad spectrum of energy solutions that are under development and/or in use in commercial applications
3. Uncovering the most critical areas of value that a new energy infrastructure/enterprise can offer
4. Building a consensus in the community of industry, academia, military, and government agency personnel regarding the specifics for this AFWERX Challenge
5. Finding answers to specific problem areas that a new energy infrastructure/enterprise must address, develop a set of solution components that will contribute to the design of a new energy infrastructure/enterprise, and plan for solution evaluation.

Contact: https://afwerxchallenge.com/energy

**Focus Area: AFWERX Space Challenge**

<https://afwerxchallenge.com/spacechallenge>

The Space Challenge initiative is made up of four technology areas targeted at creating integrated space operations leveraging the best in technology while maintaining security, being resilient and increasing agility. The four technology areas are:

* Fortifying Intelligence, Surveillance & Reconnaissance efforts in advance of the future’s approaching threats
* Ensuring our space assets can​ survive and thrive in their unique environment and against enemy danger for years to come
* Reimagining delivery systems and discover what is possible with space transport
* Magnifying the capabilities of the DoD​ by expanding and strengthening its commercial portfolio

1. **Fortifying Intelligence, Surveillance & Reconnaissance efforts in advance of the future’s approaching threats.**  The development and integration of persistent ISR-enabling capabilities into a highly proliferated, hybrid space architecture is one critical element of employing the enterprise for all-domain tactical operations. The Air Force is looking for, space and Ground-based Sensor Technologies for sensing systems to detect and track low-observable threats, utilizing next-generation communications and network technologies, fusing data from disparate systems in order to paint a unified operating picture, protecting against cyber threats that target our data, identifying how to leverage machine learning technology to reduce risks and make better-informed decisions quickly, and protecting against physical threats to our space-based assets.
2. **Ensuring our space assets can​ survive and thrive in their unique environment and against enemy danger for years to come.** Space assets must be protected against all threats to ensure their long-term reliability, functionality, and service. We're calling on critical thinkers and creative problem-solvers to join us and help us improve the resilience of assets in space. The Air Force is looking for, defensive countermeasures, mobility options to our space assets, repairing or reconstructing disabled assets, defining data and security standards to increase interoperability, establishing redundant and resilient communications, and training tools, methods, and practices to train and upskill our space operators.
3. **Reimagining delivery systems and discover what is possible with space transport.** The Air Force is looking to develop a space resupply and delivery system that can quickly and accurately deploy packages, supplies, and equipment to any location on earth. Specifically, we need technologies that, support human life in harsh environments, On-Orbit Maneuvering that will provide mobility options to our space assets, reusable launch vehicles, supply containment for packing and preserving supplies in harsh environments, precision landing capabilities, protection against cyberattacks that target the United State’s data and establishing redundant capabilities, and training tools, methods, and practices to train and upskill space operators.
4. **Magnifying the capabilities of the DoD​ by expanding and strengthening its commercial portfolio.** Solutions are needed to help us to identify cutting-edge commercial satellite technology and uncover new payload ideas, designs, and prototypes to expand the DoD's capabilities. These solutions include contracting and financing opportunities to attract public and private partnerships, collaboration and transparency between government and industry, launch vehicle options, Space payload standards, and communication systems, in-space activities, and transformational opportunities.

Contact: https://afwerxchallenge.com/spacechallenge

**Focus Area: USSF Space Pitch Day**

**\*The AFWERX Open Topic does not directly apply to the Space Pitch Day. If you would like to apply to the Space Pitch Day topic, AF203-CSO2, please read about it here** [**https://www.dodsbirsttr.mil/topics-app/**](https://www.dodsbirsttr.mil/topics-app/)

The Space and Missile Systems Center, a subordinate unit of U.S. Space Force, is the center of technical excellence for developing, acquiring, fielding and sustaining military space systems. SMC's mission is to deliver resilient and affordable space capabilities. The center is responsible for on-orbit check-out, testing, sustainment and maintenance of military satellite constellations and other Department of Defense space systems.

A Phase I award will be completed over three months with a maximum award of $50K. The Space Force is seeking commercial solutions to improve our portfolio of military space systems. These include, but are not limited to:

* Battle Management Command and Control (BMC2): Ability to observe, control, and assess the space domain on tactically relevant timelines to support joint, multi-domain operations. Secure interoperability and networking of multiple proliferated military and commercial 100+ satellite constellations
* Data Analytics: Ability to quickly convert data, stored in various locations and levels, to actionable information for Space Domain Awareness (SDA), Intelligence and Warning (I&W), Battle Management Command and Control (BMC2), anomaly detection and predictive analysis, etc. Distributed on-orbit automated processing of sensor data to reduce downlink requirements. Capture lessons learned, best practices, and repeated errors to inform operator training and battle plans.
* Combat Cloud: Secure communication options to create path diversity between operations center and satellite for Telemetry, Tracking, and Commanding (TT&C) and mission data. Ubiquitous satellite communication to include crosslinks, multi-purpose ground antennas, and automated data routing creating a robust data transport layer.
* Theater Delivery/Integration: Collect, process, exploit, and disseminate data to support warfighter Intelligence, surveillance, and reconnaissance (ISR), missile warning, Positioning, Navigation, and Timing (PNT), Space Domain Awareness (SDA), weather, and Satellite Communication (SATCOM) requirements.
* Warfare Center: Enhanced, end-to-end combined architectures, infrastructure and tools that enable enterprise scheduling, testing, training, and Tactics, Techniques, and Procedures (TTP) development against realistic, representative threats. Virtual environment enabling rapid architectural design studies and change analysis enabling data-driven decision making.
* Advanced Production/Scalability of Capability: Options such as non-traditional weather sensors, launch, data exploitation, and use of allied and commercial capabilities. Affordable employment of on-orbit servicing, hosted payloads, proliferation, diversification, and production on demand (both ground and on-orbit). Rapid/innovative production technologies such as additive manufacturing and enabling factors such as standardized interfaces and common components. Machine learning to accelerate analysis of SV payload/sensor integration using 3-D digital models.
* Space Logistics: Opportunities to provide mission capabilities in non-traditional orbits, including sub-orbital, very low LEO, beyond GEO, and cis-lunar space. Enable resiliency through maneuverability by opening up trade spaces for high delta-v propulsion systems and on-orbit refueling/servicing
* Space Domain Awareness: Knowledge of space objects, status, activities, threats and environments to enable courses of action.
* Space Cyber: Capabilities to enhance space system mission assurance across all segments and across highly cyber-contested system lifecycles, including cyber-secure processing architectures, and tailorable assurance modules. Interest in machine learning and Artificial Intelligence for increased system efficiency, network security monitoring, autonomy, and resilience (AIC2, etc.).
* Commercial Cyber Threat Intelligence: Capability/Options to gather and provide commercial intelligence for current and advance persistent threat (APT) on cyber vulnerabilities. Capability to provide threat agent's Tactics, Techniques and Procedures (TTPs) for use in weapons system cyber risk determination.
* Adopting Commercial Technologies and Practices by the DoD: Opportunities for the DoD to leverage best commercial practices while meeting strict mission requirements and system certifications. Enable incorporation of cutting edge technologies and practices into solutions that will be accepted by United States Space Force (USSF). Leverage cradle-to-grave Digital Engineering practices to achieve greater performance and affordability in space programs and space enterprise (from requirements development, through system design, V&V, operation, and disposal.)
* Space hardware/software test: Enhancing and accelerate test data reviews through continuous aggregation of component, subsystem, and system levels test results, utilizing data analytics (AI/ML) to identify and/or predict defects, bad trends, triage test results.
* Interactions between on-orbit AI and the production environment: Integrating the results of on-orbit AI experiences and learning with the production floor to accelerate the transfer of real-world experience to responsive changes/updates to the product.
* Confidence in AI/ML: How to gain confidence that a non-deterministic, self-directed, learning system operates as intended. As AI/ML become more prevalent, how to gain incremental confidence prior to fielding.
* Weather Monitoring: Technologies to enhance existing space and terrestrial monitoring capabilities to contribute towards a future DoD proliferated weather architecture:
* Terrestrial:
* Enhanced scatterometer technology (terrestrial monitoring for high-resolution boundary layer ocean winds)
* Enhanced Microbolometer technology to contribute to future Electro-Optical Infrared (EO/IR) weather mission
* Terrestrial Weather using Space Based Infrared System (SBIRS): Use SBIR/OPIR Data Records to forecast low atmospheric turbulence in order to enhance mission operations for UAVs and aircraft.
* Space Weather:
* Enhanced Far Ultra-Violet technologies (day/night ionospheric LIMB profiles) for space environment monitoring
* Position Navigation & Timing (PNT): Devise and deliver technologies, systems, and techniques to improve PNT accuracy and availability, especially in contested environments. Specific areas of interest include
* Resilient and rapid signal acquisition and signal tracking in adverse conditions (spoofing, jamming, urban canyons, etc.)
* Ability for deployed receivers to use non-core GPS signals
* Reduced SWAP-C for resilient military PNT receiver systems
* Information assurance for use of non-GPS GNSS signals
* Advanced high-speed (100+ MSPS), high-accuracy (14 ENOB) A/D converters for GPS receivers
* Innovative multi-GNSS solutions for assured PNT applications that are resilient to jamming, spoofing, and other emerging threats, employ software defined security features, have low size, weight, and power characteristics.
* Real time signal analysis, playback, and simulation reference systems are needed to support GPS program activities.
* Satellite Communications (SATCOM): Devise and deliver technologies, systems, and techniques to improve SATCOM link resilience, throughput, and reduce user equipment.
* Missile Warning: Devise and deliver technologies, systems, and techniques to improve MW detection and tracking in contested environments.
* Operator Training: Training capabilities that enhance operator's understanding of satellite structure, terminology, fuel usage, orbital elements, command and control, etc that could be accessed and edited anywhere by multi-modal means.
* Miscellaneous: Other missions and focus areas not listed above may be the breakthrough that the Space Force needs to maintain its competitive edge - but doesn't yet realize (e.g. Advanced Telemetry, Tracking, & Commanding (TT&C) Communication, range management and logistics, etc.)

**Focus Area: Cis-Lunar Space Domain Awareness (SDA)**

Cis-Lunar space domain awareness (SDA), orbit estimation, and refinement has recently become a pressing issue within the national security and civilian space domain of the United States government. All of the existing state-of-the-art orbit determination/custody capabilities are geared only towards those satellites at or below Geosynchronous Earth Orbit (GEO) where the Earth is considered to be the lone attracting body. This mindset has been in place since the 1950’s. Today, the U.S. Air Force is seeking a new capability to track, compute, and predict the orbits of spacecraft in the regions between GEO and the Moon, and beyond. If the United States is to remain engaged as a leader in the future of space domain awareness, we must meet the challenges of this new frontier of space.

Last week, in my Hinga Orbit Simulator, I demonstrated that Cis-Lunar orbit determination is mathematically possible. Using measurements from an orbiting observer in the Circular Restricted 3-Body Problem (CR3BP) rotating reference frame, I was able to compute the orbit of an Asteroid as viewed from an APOLLO spacecraft flying to the Moon. By repeating this experiment using simulated measurements from a ground telescope (i.e. in Albuquerque, NM), my next step is to estimate the Cis-Lunar orbit of the APOLLO spacecraft. I anticipate simulated proof of this concept of terrestrial-based SDA of Cis-Lunar space objects in the next few months. However, I will need actual (real-world) telescope measurements (optical-angles – line of sight unit vectors to target) of perceived Cis-Lunar objects flying between GEO and the Moon to validate my simulated results. (In addition, if feasible, light curve analyses of detected objects will be attempted.)

Eventually, I will endeavor to introduce Cis-Lunar SDA standards and techniques of orbit determination/custody that can be adopted as official procedures for the U.S. Air Force network of ground based telescopes. At this stage, my objective is to find a small company which has the expertise and hardware that can deliver the Cis-Lunar data I need so we can begin to address this extremely large gap in our SDA.

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**Focus Area: Artificial Intelligence-Enhanced Atmospheric Optics Sensing for in-situ Turbulence and Refractivity Forecasting & Predictive Modeling**

Although adaptive optics has proven useful for both imaging and propagation of light through the atmosphere, the dependence of optical wave characteristics on a diverse set of atmospheric phenomena represents one of the most serious technical challenges for various military electro-optics, HEL DE and remote sensing platforms. The existing understanding and knowledge necessary to enable accurate prediction of the impact of atmospheric effects on laser beam and image propagation is either insufficient or even absent. This has been clearly indicated by strong mismatch between theoretical predictions and measurement results obtained in several recently performed laser beam propagation experiments and simulations especially in deep turbulence conditions and long-range distances.

The recently emerged artificial intelligence-based data processing framework provides opportunity for in-situ fusion and processing of multiple data streams coming from various sensors (e.g. meteorological sensors, scintillometers, sonic anemometer, wavefront sensing and differential image motion systems, etc.) to facilitate on-board information processing, data fusion, reduction, mining, interpolation and extraction. The solicitation is focused on technologies and concepts for:

* Integration of atmospheric sensors for in-situ measurements of atmosphere turbulence
* Deep learning-enhanced analysis of atmospheric optics effects
* Validated AI based processing approach
* Demonstrations of concepts in laser beam propagation experiments or imaging experiments
* Applications of these techniques DoD HEL weapon, remote sensing, free space communication and surveillance systems.

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**Focus Area: Sensor Fusion for Autonomous UAVs**

The rate of development for deep learning-based software architectures towards real-time problem-solving increases at a rate faster than product development and deployment capabilities are able to match. Therefore, there is a constant need to re-evaluate the state of the art methods in machine learning for sensor fusion. New techniques are needed to automatically detect and identify targets with airborne data. Methods are needed, which allow the sensor fusion-based approaches to overcome the limitations of specific sensors. For example, radar, lidar, microphones, and optical cameras all have different operating conditions and produce different types of data. Individual sensors are very good at identifying specific targets within a constrained set of conditions, but a combination of sensors allows for the detection of targets under a wider scope of conditions. On a foggy day, optical cameras cannot view a target through a fog, but a radar system would be able to. Therefore, sensor fusion-based approaches in deep learning would increase the robustness for target identification under real-world conditions. A method is needed to detect targets and partially obscured targets at multiple distances and resolutions. The method should transform raw sensor data into regions of interest, which are then loaded into neural networks whose output leads to actionable information such as target identification, friend or foe identification, obstacle avoidance, or accomplishment of mission objectives. The performance of the fusion-based methods should be evaluated by the probability of detection versus probability of false alarm. A significant portion of the effort should involve selecting and or creating relevant benchmark datasets for comparison against other state of the art approaches and methods. There are many applications for deep learning-based neural networks for single sensor systems, but far less documented literature for deep learning-based sensor fusion methods for airborne data. The new deep learning-based sensor fusion methods will ultimately promote robustness towards the deployment of both autonomous UAV/UASs and UAV/UAS swarm technology.

The Phase I effort should leverage industrial and academic advances in sensor fusion-based approaches to achieving target detection and recognition in aerial imagery and or full-motion video at various image resolution and signal to noise levels. The aim of the work is to present a sensor fusion deep learning-based method that can be deployed with both autonomous UAV/UASs and UAV/UAS swarm technology. The method should be demonstrated on a variety of targets and landmarks from UAV aerial data. Phase I should demonstrate Basic Principles, TRL 1.

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**Focus Area: Solutions in multi-sensor data fusion to provide accurate, robust, and continuous situational awareness of the battlespace**

The Air Force is seeking innovative solutions in multi-sensor data fusion to provide accurate, robust, and continuous situational awareness of the battlespace. Although decision-level fusion has been state-of-the-art, the Air Force is currently focused on developing methods for data fusion at the feature-level and signal-level. The mix of sensing phenomenologies being fused could vary temporally as well as spatially. The objects of interest are geography, static objects, and dynamic/moving objects.

Of particular interest are the following data fusion scenarios:

* Multiple sensors, single platform
* Single sensor-type, multiple platforms
* Multiple sensors, multiple platforms

Solutions supporting the following areas are of interest:

* Cueing one sensor from another sensor to focus on an area of interest
* Detecting data across sensors and phenomenologies
* Registering data across sensors and phenomenologies
* Adaptively fusing data over time as the mix of sensors changes.
  + May include adapting the fusion methodology (decision, feature, signal)
  + May need to have a mix of data fusion methodologies.
* Keeping custody of objects of interest over short (tracking) and/or long (Pattern of Life) periods of time
* Identifying objects across phenomenologies
* Optimizing the location of sensors and the sensor mix to maximize information extraction (e.g., target identification)

The sensing phenomenologies addressed should include one or more of the following:

* Radio Frequency (Range profile, SAR, GMTI, etc.)
* Electro-Optical
* Infrared
* LADAR/LIDAR
* HSI
* Publicly Accessible Information (PAI)
* Other

Proposals that address one or more of the problems mentioned above will be considered for this topic focus area.

There are a number of commercial applications for this technology. Crop analysis is one possible application where multi-sensor data would be used to determine the types and health of crops. Another application would be in self-driving vehicles to more robustly identify obstructions to help choose courses of action. It's conceivable that the robustness that comes with multi-sensor systems could be used to compensate for graffiti or other degradations in road signs. Another possibility might be a robust non-GPS navigation system for vehicles using information about the surroundings to determine location.

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**Focus Area: Resilient Global Navigation Satellite System (GNSS) -based Positioning Navigation and Timekeeping (PNT) Technology**

Develop a wide-band adaptive antenna array to enable reception of Global Navigation Satellite Systems (GNSS) signals and electronic protection (EP) and electronic support (EP) against jamming and interference. It is anticipated that military users will benefit from the capability to receive signals from multiple GNSS including GPS (L1, L2, and L5), Galileo (E1, E5, and E6), and other existing, emerging and future constellations including Space-Based Augmentation Systems (SBAS), and those inspired by Navigation Technology Satellite 3 (NTS-3.) The goal is to enable resilient Positioning, Navigation and Timekeeping (PNT) in electronically contested, Navigation Warfare (NAVWAR) mission scenarios or where signals are otherwise unavailable, blocked or degraded. The advantages of multi-band GNSS reception include spectral, signal, spatial, and system diversity. This project will research, develop and test a wideband GNSS controlled reception pattern antenna (CRPA) array that can operate with a compatible antenna electronics (AE) to provide a front line of EP/ES against GNSS jammers, interferers, and spoofers. CRPA arrays have been utilized for NAVWAR EP of the GPS L1 and L2 bands. This project will expand CRPA array frequency coverage to enable reception for availability, accuracy, integrity, multipath rejection, minimal dilution of precision (DOP) and enhanced EP/ES for the above GNSS signals operating across current and anticipated wide portions of the L-Band.

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**Focus Area: Novel Optical and Photonic Components**

The objective is to provide the Air Force with a new class of enabling optical and photonic components capable of enhancing EO/IR Sensors with novel form factors, functionality, and performance.  The ongoing development of new mid- and low- altitude UAVs will require existing sensors to be redesigned to fit stringent size, weight, and power requirements.  Components can be for both passive and active EO/IR sensing which may include but are not limited to, additive manufacturing techniques for lenses and optics, non-mechanical beam steering, free-space optical switches and communications, free form telescopes, foldable optics, distributed sensing, fiber laser components, and high-sensitivity detectors.  An emphasis will be placed on components that allow multispectral integration of active/passive sensing across multiple wavebands. Many technologies that use optical components can benefit from ways to make them cheaper and easier, while also adding functionality like dynamic tunability and lower SWaP. Industries outside the DoD that will benefit include the space satellite industry for commercial imagery generation, NASA, solar energy companies, AR/VR displays, UAVs and drone companies, and even Facebook and Google with their plans to explore aerial free-space optical communications networks, to name a few.

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**Focus Area: Crafting a Fog Computing Analytics Platform for IoT**

The objective is to create a fog computing analysis platform that can operate on any computing node (including edge nodes) within an extended network to support critical functions like battery optimization, sensor command, and control, sensor configuration or sensor optimization in order to maximize the utility of a deployed sensor network. The ability to employ fog computing means that analysis can be performed at any computing node, enhancing overall network resilience as well as reducing the data latency challenges and network bottlenecks that plague many Internet of Things (IoT) sensor networks. The key goal of this effort will be to develop processes for both analysis and synchronization that enable the network nodes to work together harmoniously in support of the user’s operational requirements.

Traditional networks, which feed data from devices to a central storage hub, can easily become overwhelmed when many sensors are trying to send massive amounts of data to the hub at the same time. This central hub or “data warehouse” model tends to create significant challenges in data latency and response time that both frustrate users and create confusion as to what is actually happening in the network. Although cloud computing concepts offered a potential solution to this problem, sending data directly from a network to the cloud poses its own challenges. Communication nodes become potential data bottlenecks, and one can encounter serious issues if one is trying to send large amounts of data (say multiple streaming data feeds) through the same communications node at the same time. Both of these solutions have potential shortfalls that can be overcome if one is able to distribute the important computational tasks so that the use of these services can be optimized.

For our approach, we are seeking to leverage recent advancements in computation and mathematics so that we can support these intensive computational requirements on traditional computer hardware. Our aim will be to craft these advancements into a lightweight set of synchronized analytical platforms that can perform the critical optimization and communications tasks required to support data transmission rates that cannot currently be supported through the use of traditional systems architectures.

If we are successful, this capability should allow data collected from multiple streaming sensors to be collected, processed and transmitted through the use of synchronized edge nodes designed to send the information to the cloud so that it arrives in a way that it can be coherently analyzed and processed to support user needs. Ultimately, our approach will be able to provide enough configurable computing capacity to effectively and efficiently support the maximum sensing capacity of any distributed network of sensors.

This technology would also be applicable in the public sector as it will enable end-users or customers with little technical experience to easily and rapidly deploy IoT sensors for their custom solutions from an everyday consumer putting smart sensors in their home to physical security to monitoring production lines. These sensor networks can rapidly adapt to the changing environment, such as security for a different venue or different items on the production line.

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**Focus Area: On the Fly Tasking, Configuration, and Control of IoT Networks**

Our objective is to develop an on-the-fly tasking method for Internet of Things (IoT) sensors. In short, we seek to develop a system whereby users can employ “no-code” programming techniques to enable the creation, adaptation, or command and control of ad-hoc IoT sensor nets from a mobile device. Ideally, the technology developed should facilitate sensor monitoring across the entire IoT network and should enable the data to be collected, stored and monitored in the field or directly forwarded through the device to a designated monitoring service. Although the initial capability will be human-driven, the system design is intended to facilitate the integration of a machine learning-based tasking system that helps the user to configure the IoT network so that it can optimally support the user’s requirements.

At present, control, configuration, and monitoring of IoT sensors is done through a variety of proprietary, open standard, and open-source software tools that generally need to be configured by people with some expertise in programming. Although these coding processes are not particularly difficult, these systems are not generally designed for remote configuration or reconfiguration of deployed sensors for supporting dynamic (rapidly shifting) mission requirements. Beyond this, these sensing systems generally need to be integrated with other tools to facilitate security, analytical, or other support requirements. These secondary and tertiary integrations add significant time and effort to employing these sensors in operationally useful ways.

Our approach leverages the latest advancements in graphical programming techniques to facilitate the rapid integration of COTS and GOTS IoT devices. We have demonstrated the potential utility of this programming approach through the development of our programming tool for Android Mobile Devices called AGILE BADGER. For this effort, we would build upon our existing expertise to craft a compatible programming platform that could be used for crafting software designed to operate or integrate stand-alone sensors and other headless (no display) computing devices.

If we are successful, this capability will allow the rapid systems integration, configuration, and mission-driven reconfiguration of IoT devices using a mobile device. Although we see this initially being done by hand, the long-term objective of this effort would be to build a reconfiguration process that would be driven by the actual activity seen within the network. By performing this kind of dynamic integration, it might be possible to enhance the utility of the network by enabling the sensors to respond or rest dynamically – based upon conditions that the sensors experience in the actual environment. Done correctly, this type of responsiveness could save critical network resources such as battery life, network bandwidth, and speed of data transmission.

This technology would also be applicable in the public sector as it enables end-users or customers with little technical experience to easily and rapidly deploy IoT sensors for their custom solutions from an everyday consumer putting smart sensors in their home to physical security to monitoring production lines. These sensor networks can rapidly adapt to the changing environment, such as security for a different venue or different items on the production line.

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**Focus Area: Air Force Agency for Modeling and Simulation**

Geospatial AI, also referred to as GeoAI, geospatial analytics, and geospatial intelligence (GEOINT), is the application of artificial intelligence and Machine Learning (AI/ML)to geographic/GIS (geographic information systems). Geographic information systems (GIS) are widely used to provide a view of our world based on geographic and geospatial data. In asset-intensive industries, such as defense, the ability to visualize and identify objects of interest on maps is critical to improving efficiency and decision-making. With the implementation of advanced AI and ML, some GIS has transitioned into fully-automated or semi-automated systems, dramatically decreasing data processing speed and improving the quality of results. Major disruptive advancements in the field of Geospatial AI are currently being developed, promising to expand the utility of Geospatial information and revolutionize industries and government agencies ranging from healthcare, agriculture, weather forecasting, defense, transportation, and insurance. These advancements are being driven by open availability of extensive geospatial data, advancements in deep learning methodologies, and increased accessibility of high-performance computing resources.

**RESEARCH TOPICS:** In partnership with National Geospatial-Intelligence Agency (NGA); Open Innovation Campus (OIC) at Rome, NY; and Griffiss Institute at Rome, NY; our program is seeking non-profit research institutions and small businesses to research and develop novel GeoAI methodologies with high potential to deploy in operational environments.

While we are interested in all innovations in the field of GeoAI, we have identified the following sub-topics as being of particular interest as potentially high-risk, high-reward research areas.

**1) Novel Methods for Applying Computer Vision to Geospatial AI:** Deep learning has revolutionized computer vision. Given that satellite and aerial imagery is produced at a rate that is impossible for human analysts to keep pace, deep learning for GIS is of particular interest. Methods for rapidly and automatically deriving insight on a constant stream of GIS data are needed.

A key facet of computer vision is object detection - finding objects and their specific location or boundaries within an image. By applying object detection to GIS, satellite and aerial imagery can be automatically analyzed for infrastructure mapping, anomaly detection, and feature extraction. Advances in detecting difficult to identify objects are of particular interest.

In addition, insight into the meaning of GIS observations could be greatly enhanced by incorporating AI models of the environment and common-sense knowledge. Novel approaches to fusing computer vision with semantic models are needed.

Examples of this subtopic include Recognition/Detection of Objects comprised primarily of Linear Shapes; and Computer Vision with Semantic Reasoning for Geospatial AI.

**2) Techniques for Reasoning across Multiple Data Domains:** Explosive growth in geospatial, temporal, and social media data paired with the development of new AI and visualization technologies have provided an opportunity to fuse disparate data sources into an unparalleled situational awareness platform. Social media outlets increasingly include geolocated evidence in connection with individual activity and correspondence. Innovative techniques for reasoning across social networks within the context of GIS will allow us to model and predict human behavior within complex geographic landscapes.

Examples of this subtopic includes Automation of Socio-temporal-geo Correlation to Drive Predictive Modeling.

**3) Advances in Synthetic Data Generation:** While there is an abundance of available GIS data, fully aligned and annotated ground truth data for training and testing is difficult to acquire. Methods for rapidly generating realistic geospatial landscapes with known features (infrastructure, anomalies, etc.) and automatically translating such landscapes into realistic satellite and aerial collection simulations are needed.

Examples of this subtopic include Automated Generation of Aligned Data Sets Across Multiple Phenomenologies (Electrooptical, Synthetic Aperture RADAR, etc..)

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**Focus Area: Pilot Training Transformation**

The 19th Air Force trains more than 30,000 U.S. and allied students annually in specialties including pilots,  aircrew members, remotely piloted aircraft crews, air battle managers, weapons directors, Air Force Academy airmanship programs, and survival, escape, resistance and evasion specialists.

We are building next-generation aircrew training systems for both crewed and remotely operated platforms.  To this end, we are developing an open architecture platform for low-cost flight simulation using commercially available hardware and software.  The platform relies on gaming-class simulation engines, Commercial off the shelf (COTS) hardware, and technologies such as augmented reality and virtual reality (AR/VR).

In addition, we are defining a data architecture to collect detailed, real-time aircrew performance information.  The data will be made available through a government-furnished application programming interface (API) to any approved device or service which can make use of it.

19th Air Force wants to eventually field low-cost flight simulation devices at prices that make high quantities (750-2,000+) affordable.  There are large prices and, capability gaps between consumer and professional devices we believe can be narrowed with proper outside investment.

We want commercial solutions that address the following problem areas:

* User portal, learning management systems (LMS), and/or learning record stores (LRS) applications that offer end-user accessible customization, dashboarding and related services.  Our developmental LMS relies on Moodle and xAPI.
* Content production and/or delivery platforms optimized for 360 video, AR/VR, or other media types to facilitate fast and simple end-user content creation. (eg. An instructor can access existing content, modify it themselves for a student they will teach tomorrow, then repost the content for other instructors to use or modify.)
* Extensions to COTS flight simulation engines.  Many gaming-class flight simulation platforms offer the option to create custom scenarios, scenery, or aircraft models.  We’re looking for technologies and/or providers to reduce the cost and friction of creating these models. We are particularly interested in tools that allow instructors or students to easily create custom scenarios.
* Technologies to reduce the cost of mid or high fidelity simulated flight controls.  Controls must accurately duplicate the control forces of a given aircraft.  These flight controls could include joysticks, yokes, throttles, collectives, or rudder pedals.
* Technologies to increase the speed and accuracy of a student pilot’s interaction with cockpit controls in a VR environment.  We will consider mixed reality or ultra-low-cost physical cockpit implementations.
* The government will consider haptic glove applications if truly novel but does not generally believe they will adequately solve the problem.
* Technologies to significantly reduce the burden on instructors and administrators and/or facilitate greatly accelerated learning.  Examples include adaptive syllabus technologies, automated scheduling tools, or automated grading of student maneuvers.
* Technologies to simplify training systems and personnel management.  Examples include:
  + Manage student flow into, through, and from one course to another.
  + Applications which align existing or readily available data in new or novel ways
* Any other technologies for training in an aerospace environment

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**Focus Area: RQ-05-1909: Use of Artificial Intelligence: To Accelerate Development of New Energetic Materials**

The Air Force Space Command seeks to develop technological capabilities in Multi-Mode Propulsion with Common Propellant using artificial intelligence (AI), machine learning (ML) and/or deep learning (DL) approaches to accelerate the discovery/design of new energetic in-space materials via accurate assessments of their physicochemical properties from available databases. Space superiority refers, in general, to a space asset’s ability to outperform other, potentially adversarial assets with particular emphasis on space situational awareness and space control. New energetic materials provide the opportunity to increase the operational capability of space-borne assets. Data-driven approaches, which include intelligent predictive capabilities, provide new opportunities to accelerate the discovery of such energetic materials. Artificial neural networks and/or deep learning (DL) are examples of potential methods that can provide this acceleration. These methods take advantage of data that resides in current databases to greatly accelerate the discovery of new energetic molecules since it greatly reduces the amount of computationally intensive brute force calculations used to calculate molecular properties from first principles or correlative techniques.

Traditionally, the development of an energetic material has primarily been based on a test-driven approach, and as such, the continued application of this methodology may not be cost-effective, sustainable, or sufficiently responsive to today’s warfighter needs. Over the past few decades, chemists have synthesized a large number of energetic materials and generated their corresponding physio-chemical data sets. In many cases, the actual materials have not been considered beyond their laboratory characterization, and systematic efforts of using their data sets to learn and accelerate new material discoveries have not been undertaken within the energetic material community. Techniques such as artificial intelligence (AI), machine learning (ML), and deep learning (DL) are promising approaches for utilizing available energetic material data sets/bases, and for providing design rules for better and faster property predictions. While this state-of-the-art (SOTA) techniques have been reported in the literature, and widely used in other commercial areas, such as in image processing, target recognition, social networking, and health and financial sectors, they have not been used for energetic materials for space propulsion or space access applications. These SOTA approaches are to be specifically adapted and enhanced here for the design of AF energetic in-space materials and related aspects.

* Artificial Intelligence
* Machine Learning
* Deep Learning & Artificial Neural Networks
* Energetic Materials & In-Space Materials
* Data Mining
* Accelerated Discovery
* Increased Operational Capability

The main scope of this Focus Area is to undertake a systematic effort to collect data sets/bases (as well as further generate new databases) and use them in conjunction with the mining techniques of AI, ML and DL to accelerate the development of new energetic materials and formulations with desired properties. It is to be noted that in the past, modeling and simulation (M & S) efforts have mainly played a supportive role, rather than a leading role in the discovery/design of new energetic materials. Herein, this effort shall change this M & S paradigm, and all relevant aspects of energetic material design and application are to be considered. This effort seeks to combine demonstrated expertise in AI software development and physio-chemical material’s property development (either theoretical or experimental). The offeror may form effective teams towards this end, which is encouraged, but not required. The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any approaches to AI, ML, and DL technologies that may impact future Air Force Space Command missions.

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**Focus Area: Nuclear Weapons Center**

\*This document is being used for the Dec 2020/Jan/Feb 2021 Air Force CSO 20.3 SBIR proposal call and is applicable to both AF20.2-CSO1 Phase I SBIR Open Innovation in Dual Use Technology topic, AF20.A- CSO1 Phase I STTR Open Innovation in Dual Use Technology topic and AF20.1-DCSO1 Direct to Phase II Open Innovation in Dual Use Technology topic. The first 10 focus areas are tied to upcoming Air Force Pitch Day events focusing on the transition of Phase I companies to Phase II. This means that if awarded a Phase I under the Open Innovation Dual Use Technology topic companies will go through the Phase I as managed by AFWERX and the Pitch Day event will focus on the transition from Phase I to Phase II. Please note which focus area you are applying for on the first page of your pitch deck presentation and technical proposal. Please check back on this document throughout the proposal period as changes may be made.

The Air Force Nuclear Weapons Center (AFNWC), is the nuclear-focused center within Air Force Materiel Command (AFMC) synchronizing all aspects of nuclear materiel management on behalf of the AFMC commander in direct support of Air Force Global Strike Command (AFGSC). AFNWC consists of four major execution directorates: Air Delivered Capabilities; Ground Based Strategic Deterrent Systems (GBSD); Minuteman III Systems; Nuclear Command, Control, and Communications (NC3) Integration; and Nuclear Technology and Integration. It also has several functional directorates and its commander is dual-hatted as the Air Force Program Executive Officer (PEO) for Strategic Systems.

# **DIGITIAL TRANSFORMATION**

## **Digital Engineering**

Digital Engineering is an integrated approach that uses authoritative sources of system data and models as a continuum across disciplines to support lifecycle activities from concept through their disposal. Digital Twins are virtual representations of physical objects that share data throughout the systems lifecycle. In order to maintain our strategic deterrent, we must be able to effectively manage data.

## **Data Science & Management Solutions**

***Objective***

AFNWC is looking for solutions to develop enterprise-wide capabilities that enables the understanding, development and execution of Digital Engineering practices. This requires the need to develop interconnected solutions that are able to gather significant amounts of data and communicate information across weapon platforms and information systems.

***Approach***

Develop solutions that integrate data, enables data visualization, provides data analytic functions and the ability to communicate information among systems (both government and contractor owned plus individuals among different organizations and agencies).

Some examples may include:

* Digital tools that integrate infrastructure data for supply and maintenance (focused towards the authorization orders and the warfighter) such as Supply Chain Risk Management Solutions
* Develop digital clones, 3-D visualization/dashboards and data distillation/aggregation, providing system-level cognizance

## **Digitization and Management of Authoritative Resources**

***Objective***

There are many documents developed during the procurement of Air Force systems. They provide technical and operational instructions/policies that evolve throughout time. In some cases, it is difficult to determine which document is the authoritative resource (the most current policy/guide). Authoritative resources are a significant factor in the success of developing and integrating tools and infrastructure to facilitate the adoption of Digital Engineering.

***Approach***

We are seeking alternatives to establish digitization of such tools and practices. These efforts require resource models and a general way to provide precise descriptions of how to manage such resources. Digitization also requires that the notion of a document and its elements can be distributed, but still be authoritative. The theme may include published reports, patents and lessons-learned materials. The mechanisms, including distributed versioning and tagging and security levels, need to be specified and be part of the resource model. Tooling should allow business rules to be defined around the resource model to establish required and best practices during and maintaining the resource lifecycle.

Some examples may include:

* Solutions that update information across multiple systems/domains
* Validity check process on the analytical information to verify consistency with authoritative truth
* Automated data crawler (machine learning) such as DAEMON
* Query data can be inserted in the new program from source information with source identified
* Graphical User Interface (GUI) of system-of-systems with multiple overlays for levels from warfighter, System Program Office (SPO) engineers to leadership
* Automating source of truth update across multiple systems and across distinct and multiple domains
* Innovative solutions that can adopt modern human factors concepts with a modular design that can integrate them to the Air Force’s existing digital infrastructure and future developments

## **Code Inspection/Checks for Software**

***Objective***

In transitioning to a digital enterprise and developing the digital engineering infrastructure, there has been a strong dependency on automation and software. As the GBSD enterprise develops a higher dependency on software, there is a need for a structured and rigid, yet efficient process to verify and authenticate coding.

***Approach***

With the increase and complexity of modern coding, AFNWC is searching for more effective ways to conduct code inspection and check software than to have 100% code check by a person. As a result, we are seeking solutions that provide a hybrid model of code inspection and software check with the combination of automation and targeted human interference.

## **Program Management/Business Practices**

***Objective***

In the Air Force, systems are managed by Program Managers with the focus on cost, schedule (timeline and milestones of the project) and performance (technical baseline – is what we are developing/purchasing meet our needs, being developed based on current needs). One of the most important aspects of Air Force acquisition/sustainment is the ability to effectively manage programs and systems using accurate information in a timely manner integrating analytical information beyond financial portfolio management.

***Approach***

Some of the current systems used are stand alone and do not have the capability of communicating with each other and/or exporting data. We are seeking solutions that enhance and improve business functions and processes for program managers.

Some examples may include:

* Integrated Portfolio Management solutions that are able to analyze data and distribute information in a tailored manner depending on the role and/or function of the analysis. These may include program risk (cost, schedule & performance) management compatible with current Air Force Systems and Platforms (Microsoft Suite, Program Management Resource Tools [PMRT], etc.)
* With a transition to a digital environment, communication across the Air Force has evolved with different means of virtual exchange through chat, voice calls and video capabilities. In seeking a way to enhance and improve and simplify communication strategies and options for individuals, we are interested in Customer Relationship Management solutions for enhanced communication capabilities that comply with Air Force regulations and systems.

## **Engineering Analysis**

***Objective***

Migrating to a digital environment will enabled the GBSD community to be able to develop engineering capabilities in a virtual realm that allows for enhanced weapon system design and sustainment analysis. Virtual modeling and simulation will facilitate analysis without having a physical prototype reducing alteration costs and schedule risk.

***Approach***

Develop solutions that enable end-to-end weapon system performance modeling/simulation capabilities with the ability to conduct evaluations such as performance data analysis among others.

## **Unified Certification Activities Including Cyber Security and Nuclear Surety**

***Objective***

In order to ensure the U.S. strategic deterrent is effective, systems must meet the highest standards to guarantee they are safe, secure and reliable. Cyber security and nuclear surety are similar but more complex than the normal industrial quality assurance processes and policies. Different requirements exist depending whether it is a digital product (software/coding), a physical product (rocket/control center) or a hybrid (software embedded hardware).

***Approach***

Seeking solutions to develop data visualization tools such as dashboards and workflows that facilitate timely and accurate completion of cyber security and nuclear surety activities.

# **DATA SYNCHRONIZATION**

Processing Model Based System Engineering (MBSE) in multiple security domains drives the need for constant aggregation and synchronization of data environments. With this in mind, maintaining version control is a laborious process which is prone to human error. The need for cross-domain synchronization of data both up and down the hierarchy is one that must be filled without compromising classification integrity.

## **Advanced Parts Management System**

***Objective***

Seeking technology to track parts to support inventory optimization for the Defense Logistics Agency (DLA). Including Supply Chain Management (SCM) among others: providing supplies to the military services and supporting their acquisition of weapons, fuel, repair parts, and other materials.

***Approach***

There is a need for methods to predict the future state of a supply chain to optimize the flow of parts while maintaining the inventory. We strongly anticipate this will involve Artificial Intelligence (AI) and Machine Learning (ML) algorithms, looking at historical data and statistics to predict optimal stock levels. AI/ML algorithms are capable of analyzing large, multi-variable, and diverse data sets quickly, improving demand forecasting accuracy. This tool would save time and money and improve efficiency, while ensuring the availability of parts to military programs and operations.

Some examples may include:

* Identify top ten worst parts
* Identify which vendors are out of business (how do we adjust accordingly)
* Identify vendors historical delivery trends

## **Transition to Digital Sustainment for Minuteman III (MMIII)**

***Objective***

The MMIII system was developed during the pre-digital era where most work was conducted on paper and limited electronic capabilities as compared to today. As we are transitioning into a digital environment, there is a lack of infrastructure and integration between modern tools and systems with existing ones. We need to create the ability to visualize the health of the weapon system to include key performance parameter health site by site, future age-out functional capability, future supply asset attrition status, etc.

***Approach***

MMIII is a 50-year-old weapon system that has traditionally been managed using disparate data repositories and workflows across the enterprise. These are information systems that are independent and have limited integration capabilities amongst each application and/or tool. The System Program Office is working to transition to a single data repository and workflow tool in a Product Lifecycle Management (PLM) environment (or similar management analytical tool) and create middleware and scripts necessary to tailor the disparate data sources into a format that can be readily used in PLM.

***Needed Digital Sustainment Capabilities***

* Linked Systems Modeling Language (SysML) and 3D models capturing each Configured Item (CI) element for an authoritative source of sustainment data
* AI learning tool to synthesize mission and system data and help assess/prioritize the biggest “bang for the buck” relative to mission capability
* Visual depiction of health of the fleet (linked to the weapon system key performance parameter capabilities) across all Launch Facilities (LFs), Command and Control (C2), and Air Vehicles (AVE)
* Visual depiction of sustainment data and documentation such as engineering technical assistance requests, request for engineering support, deficiency reports, depot maintenance/engineering requests, and maintenance activity log from the Integrated Maintenance Data System (ETARs, MARs, DRs, 339s, and IMDS) across all CIs
* Visual depiction of the daily operations on-going in the missile complexes
* Product Lifecycle Management (PLM) workflows to manage the technical baseline in a 3D environment both in the supply, depot and field locations
* Efficient translation of acquisition design data to sustainment data in digital and 3D environments

## **HAZMAT References Search**

***Objective***

The development and sustainment activities of ICBMs have been producing hazardous materials (HAZMAT) for decades. In some cases, these materials have been logged in different documents with different formats that range from physical paper to electronic documents (JPEG, Word, PPT, ODF, etc.). We are seeking solutions to identify embedded references to HAZMAT within documents, drawings (e.g. JEDMICS), Bill of Materials (BOMs) and others. These references could be specific materials, variants, part numbers, and/or potential vendors. We will be searching both single files as well as potential large directories that may hold hundreds or thousands of documents/drawings/BOMs.

***Approach***

These materials may be listed in documents such that word-searches can identify them, but many documents have images in which a HAZMAT may be listed and would be missed by a word-search. A method is needed to scan the images to identify any HAZMAT that may be referenced, including partial names and/or partial part numbers that may contain hazardous materials.

Technology has been developed to scan words (optical character recognition, OCR), but to analyze a large volume of documents and images may potentially require applications of AI and ML. The search results would include the document file name, as well as the related programs and subsystems. For example, a computer dashboard will be created. It will identify and integrate hazardous material acquired data across the weapon system, supporting analytical engineers in their design, test, and integration efforts.

# **MODELING AND SIMULATION (M&S)**

With advances in computing capabilities and digital engineering, M&S has become an important tool in system development. Through M&S, we can verify system development performance reducing costs in the development stages while ensuring performance requirements are met. Seeking M&S capabilities that are able to integrate with AFNWC systems and develop innovative approaches and solutions.

## **Needed Modeling & Simulation Capabilities**

* *Stage Separation Analysis Improvements* - develop improved capabilities to characterize the flight environment and predict flight loads related to missile staging. Improvements could include new prototype ground testing methods or improved analytical / computational capabilities relative to fidelity and/or computational time.
* *Rocket Motor Slag Modeling -* develop the capability to analytically predict the accumulation of slag and the resulting moment forces in solid rocket motors, then benchmark analytics with empirical flight data.
* *Aluminum Particle Wall Interaction Modeling* - develop an analytical / computational method that can be integrated into computational fluid dynamics (CFD) codes that more accurately predict the physical interaction between aluminum oxide particles ejected from a solid rocket motor upon impact with solid surfaces such as a silo wall, down stage missile dome, etc. This method should seek to improve accurate position predictions of aluminum oxide particles and energy balance reactions before, during and after interface collision. Significantly improve the fidelity of predicting environments related to silo fly-out, stage separation, pad launching, and shroud separation with an impulse device. Reduce flight test failure risk for GBSD avoiding costly and timely redesign.
* *Aeroacoustics Coupled with CFD* - develop a method to improve computational speed of solving aeroacoustics codes coupled with CFD that includes rocket motor plume interactions. The problem space should have considerations for missile silo launch, pad launch, and shroud separation with an impulse device. Solutions should be focused on improving analytical / computational methods, and not improvement of computer hardware.
* *Missile Base Heating* - develop improved modeling capabilities of base heating effects on launch vehicles that include both convective and radiant heating contributions. Reduces flight test failure risk for GBSD avoiding costly and timely redesign.

## **Stakeholder Concern-Directed Modeling**

***Objective***

Current modeling practice has architects developing models and then showing stakeholders their concerns by back-fitting statically defined viewpoints and views of that model. It is recognized that this static process performed by architects (as current "best practice") does not satisfy the needs of stakeholders. Stakeholders desire to dynamically query models to satisfy their concerns over the system(s) being defined by those models.

***Approach***

This agility in the modeling practice is desired, but at this time is not present. One obstacle to overcome is the development of a naturalistic language that can be used by stakeholders to define such queries. Models that an architect has developed to date, may only be able to answer such queries in part. Such queries should be able to be used to guide architects as to what must be furthered developed in the precise model description to allow a complete answer to a stakeholders’ concern. This will help to remove the extra modeling efforts carried out by architects (with best intentions) but not answering the precise concerns of stakeholders.

# **GBSD TECHNOLOGIES**

Seeking advanced and modular technologies in order to support the GBSD enterprise. Interested in capabilities that are able to integrate with AFNWC systems and develop innovative approaches and solutions.

## **Hybrid Ceramic Throats for High-Temperature Propellants**

***Objective***

Mature and scale-up materiel solutions to non-eroding hybrid ceramic throats for contemporary or disruptive high-temperature (boost, min-smoke, no-smoke) propellants to enhance range, speed, and size, weight, and power (SWAP) efficiency of missile systems. Results of this work would be enhanced designs and an accompanying understanding required to scale non-eroding throats for future missile systems with the option to test delivered configuration to validate proposed designs.

***Approach***

Demonstrate and/or scale existing materials to their next logical size increment. Develop assembly techniques for their integration that mitigate erosion. Conduct modeling of design to optimize throat performance. Deliver throat assemblies for test. Small-scale testing or planning for larger scale testing is encouraged.

## **Precision Dimensional Tolerances in Large Non-Stoichiometric SiC Pre-Ceramic-Polymer Composite Structures**

***Objective***

C/SiC, and SiC/SiC composites derived from polymer infiltration and pyrolysis are high performance, but very expensive. Polysiloxane and polysilizane (SiOC and SiNC matrices) have entered consideration as substitutes because they have the potential to maintain intermediate temperature capability for short- life applications at a cost-point far lower than polymers designed to terminate in stoichiometric SiC. Process models for these materials are needed to improve location-specific properties, optimize quality, minimize part distortion, and ultimately prevent high scrap rates of large components. Results of this work would be an enhancement to affordability and quality of large-scale, high-temperature articles for missile systems. Models and understanding developed could be readily implemented into standard industrial practices.

***Approach***

Develop process models for SiOC and SINC resin systems that incorporate cross-linking and volatile release in the presence of various fiber architectures. Construct component level models that incorporate location-specific affects based on fiber architecture. Anchor these models at the coupon scale, validate them at the sub-element, and ultimately at the component level in a deliverable article (e.g. flow-path, aeroshell, or faring element).

## **Nuclear Protection of Carbon-Carbon Composites**

***Objective***

Enhanced nuclear protection of carbon-carbon aeroshells and motor components is desirable for future systems. The process for manufacturing carbon-carbon is extreme and limits material additions to the material that would enhance its nuclear protection capability. Innovative processing trials and technique developments are necessary to realize this technology. Results of this work will enable system level enhancements in nuclear protection to future missiles.

***Approach***

Develop, adapt or modify existing nuclear hardening techniques and materials for low and intermediate temperature composites to 2D and 3D carbon-carbon processing routes. Characterize and optimize resulting materials and processes. Identify and optimize compatibility with standard industrial carbon- carbon processes. Demonstrate manufacturing at coupon and/or sub-element level.

## **Scale-Up and Testing of Hardened Aeroshells to Thermo-Mechanical Effects**

***Objective***

Technologies for hardened aeroshells will enable system level enhancements to future missiles and subsystems. These technologies need to be scaled to the sub-element and component level to continue maturation and demonstrate feasibility. Results of this work will mature a capability and either demonstrate feasibility or identify risks for future system enhancements in nuclear protection of future missiles and sub-systems.

***Approach***

Hardened aeroshell materials and properties need to be characterized at the sub-element and component level. Thermo-mechanical properties should be characterized. Tests in-flight relevant environments (vibration, aerothermal loading) are desirable. Functional properties relevant to nuclear effects testing should be characterized, but also should be tested at scale in a relevant environment.

## **Advanced Survivable Sensors**

***Objective***

Development of advanced, survivable sensor technologies is crucial for the development of advanced systems. Seeking innovative solutions that support information collection functions as well as integration with other systems for data management. The primary objective is to have the sensors commercially available beginning at the first GBSD test flight.

***Approach***

For an instrumentation sensor package, design, develop, and prototype an instrumentation sensor package with 10X-100X capability over existing instrumentation to gather separation and tip-off velocities and angles as well as dynamic motion and state data of the re-entry vehicle (RV).

For silo fly-out survivable sensors, develop survivable sensors to measure in-silo environments of a GBSD launch such as species concentrations, heat flux values (radiant and convective), temperature, and flow visualization. Sensors must survive the harsh launch environment, have a quick response time, and institute design considerations for aluminum oxide particles impacting the sensor surfaces.

# **COMMUNICATIONS TECHNOLOGY**

## **Low Cost Secure Space Communications (SATCOM) Alternatives**

***Objective***

Create SATCOM communication strategies to improve performance and reduce cost. Study alternative ways to improve anti-scintillation communications performance, to enhance data rates and improve availability in the most stressed combined scintillation, weather, and/or jamming environments.

***Approach***

The objective of this focus area is to support future operations by providing the critical surveillance, tactical edge communications, processing, networking, and battle management command and control capabilities to the joint warfighting force. More specifically, to have intelligence and targeting data transformed into timely and actionable information through trusted networks and intelligent algorithms that enable our warfighters to focus on decisions. In this construct, information is a service rather than a platform and the layers of sensing and communication pathways will provide reliability and assurance in contested environments. This focus area will reach companies that can complete a feasibility study and prototype validated concepts in accelerated Phase I and II timelines. Solutions shall address simple low size message traffic (as opposed to full motion video) and communication nodes will include fixed ground sites as well as aircraft. Solutions shall address all constellation alternatives (LEO, MEO, GEO, and GEO+).

Some examples may include:

* Reliable Air-Space and Air-Ground Communications
* Multi-level secure communication
* Satellite signal and location detection

## **Small Form Factor VLF Tx /Rx Antenna**

***Objective***

These challenges are especially pronounced in the Very Low Frequency (VLF, 3-30 kHz) band, where wavelengths are 10-100 km. Existing VLF transmitters have either extremely short-range, or extremely large size with little bandwidth. Solving this problem would impact several defense and civilian applications, including hemisphere-scale subsea communications, underground sensing and detection, navigation and timing, and even space radiation belt remediation.

***Approach***

Design is intended for large aircraft integration so aircraft integration issues should be addressed. EM waves could be excited by magnetic field manipulation through mechanical actions. This class of antennas is refereed to mechanical antennas and they obey a different set of rules for EM wave propagation relative to electronic antennas. Engineers who design transmitting antennas at long wavelengths have struggled for decades to make antennas compact, efficient, and broadband. Users are demanding improved performance and logistic-friendly antennas to support field-level maintenance. The problem, however, is the inability of antenna designers to shrink size and weight as quickly as integrated circuit designers have been able to shrink circuits. Historically, low frequencies require physically large antennas. Ideally, it is desired to have electrically large antennas that are lighter or compactable in physical size. Currently used UHF/VHF antennas have some undesirable performance attributes.

Some examples may include:

* Reliable Air-Space and Air-Ground Communications
* Multi-level secure communication
* Satellite signal and location detection

## **Multi-Domain Multi-Medium (MDM2) Text Messaging with Receipt**

***Objective***

The Electromagnetic Spectrum (EMS) “…transcends all physical domains and the information environment and extends beyond defined borders and boundaries. Electromagnetic Interference (EMI) is rapidly becoming the “Achilles heel” of military operations. Maneuver within the electromagnetic spectrum is required by most warfighters, from basic radio operators to electronic warfare assets to satellite sensors. The sheer number of electronic devices on the battlefield, which travel through ill- defined and coordinated EMS, may lead to routine blue-on-blue (friendly fire) EMI fratricide. This could only be compounded if our opponents actively attempt to deny access.

***Approach***

Development of a messaging application/format that can be transmitted over any domain, any medium, without the need for conversion or translation. Attributes might include message integrity checking, authentication, and delivery receipt.

Some examples include:

* Open architecture sensor integration capabilities to support rapid integration of sensor data, dynamic discovery, and automated collaborative collection, automated collaborative tasking, and layered sensing
* A command and control sensor web that allows for control of sensors across the battlespace enabling automated cross-cueing and automated tracking
* Instrumentation and tags necessary to enable Internet of Things (IoT)
* Generating course of action responses within a dynamic environment for multi-domain command and control

# **STTR OPEN TOPIC**

Innovation is not a final product, but a by-product of applying sound business practices to great ideas managed by individuals who are empowered to learn and grow coupled with effective use of technology.

***Objective***

Develop the most effective and technologically advanced acquisition workforce. Modern acquisition practices require a symbiotic relationship between the adoption of digital engineering and emerging technologies, and the fusion of traditional and rapid acquisition policies & strategies. The existing state of affairs does not support the need to acquire new capabilities at the rate that the warfighters need. AFNWC is not prepared to facilitate the adoption of modern acquisition practices due to the lack of infrastructure (digital and physical) and the need for cultural growth.

***Approach***

Establish project catalyst to develop the first Modern Acquisition Center of Excellence (MACE). A learning and collaboration environment where government, academia, industry and the local community can shape the future of the world’s most powerful deterrent force. MACE’s mission is to fuse acquisition expertise (“traditional” and rapid-acquisition) with technological superiority (artificial intelligence, digital engineering, additive manufacturing, etc.) in order to cross-pollinate knowledge across functional areas.

***Needed Capabilities for Design and Layout of MACE***

* Open workspace environment
* Commercial internet with NIPR adaptability
* Audio and video conference capabilities
  + Commercial (skype, zoom, etc.)
  + NIPR VTC system
* Move-in ready work-stations
* Conference Rooms
  + Meeting rooms – Larger audience
  + Breakout Rooms – Smaller audience
* Complete laboratory – fully equipped with training curriculum/program for:
  + Artificial Intelligence
  + Additive Manufacturing
  + Digital Engineering
  + Programming/Coding – Basic programming, Internet of things, block chain, etc.

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**Focus Area: Miniaturized Portable Power Source for Powering of Munitions**

Focus area is to independently power (Mil STD 1760 and non-Mil STD 1760) munitions for built in test and data transmission during pre-flight and maintenance operations. Miniaturized power source should be 5 lbs or less, capable of providing 25 amps, 28V, 400 Hz, 115 VAC.  Must work in austere locations and in or near explosive environments. Technology would enable significant size reduction of next generation munition tester.

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**Focus Area: User Authentication Utilizing Tokens while Maintaining Usability of Non-Networked Test Equipment**

Focus area is to provide the ability to authenticate users of automatic test systems in a disconnected environment to meet cyber security challenges. The USAF is not currently able to effectively utilize DoD Public Key Infrastructure in the disconnected environment in which these automatic test systems operate.

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**Focus Area: Expeditionary Fluid Analysis Capability**

Focus area is to advance the analysis of engine oils to identify a greater range of particle sizes, elements, alloys and alien fluids present within an oil sample. Solutions and technologies shall detect, identify, and quantify wear metal particles and debris in engine oil from at least 4-1000 micrometers in size. The solution shall also quantify oil viscosity, water content, and Total Acid Number (TAN). Data from testing shall be transferable to the existing USAF OAP-EX database. The unit must be self-correlating, requiring no contact with a remote laboratory to ensure accuracy to industry standard. The solution shall be deployable to austere environments, require no more than a two-man carry to move while in its transit configuration, and require no more than one person to set up and operate.

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**Focus Area: Next Generation Jammer/Smart Munitions Loading Systems**

Focus area is for the development of a smart/automated munitions loading system for the purpose of uploading/downloading munitions onto fighter and bomber aircraft. While full autonomy is not expected, the developed system should be capable of precision placement of a munition up to (or removal from) aircraft attachment points with minimal inputs from load crews. The system will be required to safely move and handle munitions based on each munition’s technical characteristics (CG, attach points, pressure/load-sensitive areas, etc.), maneuver around interferences on or around the aircraft, and properly position the munition for load crew action. The system is expected to have a suite of intelligent sensors and an onboard processor in order to achieve the desired performance.

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**Focus Area: Chemical Biological Radioactive Nuclear (CBRN) Simulants**

Focus area is to determine proper simulants for the testing of CBRN ensembles and sensors. The Government requires simulants that are correlated to chemical warfare agents for ensemble swatch testing, ensemble system testing, chemical sensor low-level agent determination and correct reporting of chemical vapor presence. Simulants that are human exposure safe and non-exposure safe simulants are both acceptable. Deliverables will be both simulant choice, recommendations for the tests these may be used for, and correlation modeling to the specific chemical warfare agents they are meant to represent.

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410-417-3265

**Focus Area: Research and Modeling of Chemical Biological Radioactive Nuclear (CBRN) Protection Analysis**

Focus area is to research how challenge level of chemical warfare agents and simulants impact the results of chemical protective ensemble materials testing. Also desired is research to show the impact of different challenge levels of agent and simulant on the reported results of chemical sensor agent concentration levels. The Government needs to know if CBRN protection or sensing has a linear or non-linear basis compared to the challenge level changes. Required deliverables will be models showing correlation results for the appropriate chemical agent testing or the same for simulant testing plus the correlation between simulant results and agent results.

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**Focus Area: Fuel Cell Electrical Power Plant**

The Focus area is to provide a common electrical power system to support multiple weapon systems that require 115/200 VAC, 400 Hz, and 270 VDC, as well as 28 VDC per Mil-STD-704 power requirements. Equipment shall be very low audible noise level (50 dB and below), multi-fuel fuel cell Flightline power generation that can be operating 24/7 in austere locations without required facility charging sources. Design shall be scalable to support larger/high demand weapon systems and safe in a threat environment. Technology would enable a significant size reduction/small footprint and be air transportable.

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**Focus Area: Simulators Focus Areas**

The Air Force Lifecycle Management Center, Simulators Program Office (AFLCMC/WNS) is seeking proposals to drive innovative concepts and technology into the operational training enterprise. While the primary focus is on flight simulators, WNS is interested in simulation and training innovation that span the aircrew and maintainer training spectrum. Projects may address one or more listed focus areas, and if applicable, reference all that apply in your response. Key foundational concepts that should be considered include modular open systems architecture, DevSecOps concepts, and flexibility with commercial upgrade cycles. This list is not meant to be all-inclusive, and innovative solutions to improve the state of the art in the simulator and training enterprise that are not listed below are encouraged for submission.

**Focus Areas**

1. Virtual reality, augmented reality, mixed reality, extended reality gaming tools applied to aircrew simulation and training. The objective is to build lightweight, commodity hardware-based training devices for use alongside the existing spectrum of aircrew training systems. This includes providing novel capabilities and/or solutions to deficiencies in current technologies or implementations. An additional objective is the generation of high-quality 3D models, available for reuse on future projects.
2. Gaming technologies and gamification concepts applied to simulation and training. The objective is to utilize gaming industry engagement concepts, immersion, skill development, and user performance data capture and analysis to enhance experience and training outcomes. An additional objective is to create a portable, internet-enabled, training capability that can be used either in or outside of a classroom environment, enabling students to participate in a controlled and secure gaming/training sessions anytime, anywhere.
3. Artificial intelligence, machine learning, and data analytics applied to simulation training. The objective is to enhance training outcomes by improving performance, user and instructor feedback, and leveraging data to expand and transform the training experience. These growth areas may also yield improvements in training efficiency and accelerate individual performance through adaptive learning tailored specifically for the individual. An additional objective is the collection and analysis of data in large, networked training exercises with disparate users and devices.
4. High-fidelity, visual, and physics-based effects within the training simulator. The objective is to provide realistic user experience in the simulation of the effects of weather, atmosphere, and electromagnetic spectrum on the visual and mechanical simulation of aircraft and all associated systems.
5. Cloud computing applied to the development, deployment, and operation of simulation training. The objective is to exploit and capture advancements in using cloud-based compute and storage power, as well as DevSecOps type development and delivery practices. An additional objective is to evaluate standardized toolsets and delivery models such as PlatformOne in the context of the training simulation.
6. Secure remote training and instruction. The objective is to develop a secure and robust remote instructor capability that connects an instructor(s) to an individual simulator, set of simulators, or a classroom environment located at a government training site. The instructor or multiple instructors and training sites are geographically separated from each other. The system should consider voice, visual, and data exchange capabilities to provide feedback during simulator training events across multiple students.
7. Multi-player, multi-aircraft, multi-role networked training simulation environment. The objective is to provide a simulation environment where multiple trainees in different simulations across a variety of simulated aircraft can interact in a shared environment. This environment may include instructors, related user fields (ex. air traffic control), other simulation environments, and is inherently flexible to expand or incorporate other DoD training environments (ground, sea, space cyber, etc.). Demonstrate the capability to account for latency, a high number of entities, and users—ability to segregate information accessible to users by role or approved credentials.
8. Advanced computer-generated entities within training simulation and synthetic environments. The objective is to simplify operation and enhance the performance of automated agents (non-playable characters) in simulation to provide more effective training, particularly in multi-player networked simulations. Constructive agents are required to deliver a dynamic, robust, and challenging training environment representative of real-world operations.
9. Securing commodity hardware and software for military training needs. Objective is to evaluate, assess and develop cybersecurity approvable concepts, processes, and status of commodity training systems (ex. head-mounted displays, gaming engines) in order to rapidly deploy and update such assets into, or removal from, secured environments. An additional objective is to develop device security and manufacturing requirements to allow manufacturers to build compliant devices that are authorized for use in secured environments. This includes identifying security-related devices or system deficiencies in existing commodity devices that prevent their use in secure facilities.
10. Data analytics applied to the collection and synthesis of design criteria data for simulator development and concurrency modifications. The current simulator design process is highly dependent on the availability of platform design and performance data, which may be prohibitively expensive or nonexistent, resulting in data voids which can affect the fidelity and realism of the simulation. Analytical methods may provide some of this information by extracting data from other sources not typically used for simulators, such as instrumentation data from flying ranges. This includes identifying current data deficiencies and exploring alternative sources of information to improve simulator systems.

**Focus Area: Computational Fluid Dynamics for Rotational Detonation Rocket Engines**

The Air Force Research Laboratory Aerospace Systems Directorate seeks to develop high-fidelity computational fluid dynamics (CFD) methodologies for application to Air Force rotating detonation rocket engines (RDREs) in order to increase understanding of the critical physics, provide guidance for future diagnostic techniques, and support practical engineering design. While the use of combustion and turbulence models is expected, the development of new models is not the intended goal; instead, this effort will enhance the overall investigation of the non-idealized detonation processes present within real-world RDREs. These complex physical behaviors may include, but not limited to, injector/plenum coupling, shock interactions with throat geometries, liquid-propellant shock interactions, and unsteady nozzle expansion. Ultimately, the goal of this effort is to produce a model-driven design paradigm, whereby RDRE development is enhanced and accelerated with CFD-derived predictions of performance using verified tools.

At present, a thorough physical picture of the complex dynamics within an RDRE is lacking. The first technical objective of this effort seeks to remedy this by means of high-fidelity computations. Achieving the goal above necessitates simulation of the complete domain. Post-processing these large datasets will require efficient extraction of relevant flow features in order to rigorously build an understanding of the evolution of the chaotic fields and highlight connections between seemingly unrelated characteristics. Additionally, this should quantify the effects of mixing, kinetics, and geometric scaling on measured thrust performance. The current dearth of knowledge regarding the combustion chamber dynamics stems largely from the difficulty of optical and instrumental access. Large temperature and pressure fluctuations occurring at high frequencies for relatively long periods extend beyond the ability of most existing diagnostic techniques presently employed for detonation research. Thus the second technical objective of this effort will be for the models to guide diagnostic development, identifying regions of particular interest and helping to infer broader engine behaviors from isolated experimental datum. The final third technical objective of this effort will be to develop/integrate a set of multi-fidelity modeling tools that will enable rapid and efficient design iteration using a combination of verified high fidelity computational tools coupled to less computationally expensive lower fidelity tools for rapid design optimization.

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**Focus Area: Data Science and Digital Environmental Situational Awareness**

An important part of the ACC/A29 mission is understanding the status of the environment globally and how that can be leveraged for I&W. A feasibility study is desired to understand and determine the range of available sensors and the nature of the data that can be derived from such cyber-physical systems (CPS). A focus on traditional and non-traditional CPS devices should be included in the overall assessment with an emphasis on data transferred that does not require physical proximity to the data source. More specifically, research should be conducted to address the following areas:

● Identify available sensors that are able to provide information about the environment

● Identify the data sources available to support environment assessments

● How is this data accessible and who can access it?

● How does the availability of this data vary around the world?

● What are key passive systems techniques?

● Characterize types of data and associated uncertainties that might be used to derive information pertaining to environmental conditions; and

● Assess the ability to fuse data derived from CPS systems to complement conventional information collection systems to advance situational awareness for a relevant scenario(s)

The technical areas highlighted above are not meant to be exhaustive, but to provide a basis for building an architecture and system to collect, fuse, and analyze data collected from these sources in order to provide accurate situational awareness, and I&W of the environmental conditions in a region of interest.

**Focus Area: Space Logistics Technology**

The largest impact on the longevity of a satellite is the availability of fuel. After accounting for the necessary Delta-v (ΔV) to obtain a desired operational orbit and end-of-life operations, such as moving into a graveyard orbit or de-orbiting into the atmosphere, the fuel reserved for actual operations are limited. This is especially true considering the required orbital maintenance required due to equipment malfunction or space debris impacts. On-orbit servicing, such as refueling, orbital tug, component upgrade, robotic manipulation, and other services, can support and extend the life of a satellite. By enabling such services, not only will the life of a satellite increase, but the capabilities of the satellite can be increased. On-orbit assembly and upgrade may also simplify and streamline the current practice of integration testing of a whole satellite system to be resilient to launch loads. As the use of space logistics-enabling technology becomes more prevalent, a new paradigm of on-orbit services opens up to include assembly and manufacturing. When a system can be assembled or manufactured in space, unrestricted by the constraints of launch, the capabilities of such assets that the US Air Force can place around the globe will increase exponentially. Space logistics is the field of study and implementation that enables the aforementioned capabilities. As such, proposals for the following technical areas relevant to space logistics, or on-orbit servicing, assembly, and manufacturing (OSAM), are sought:

* Modular components, interfaces, and subsystems
* In-space assembly of large structures
* Coordinated robotic manipulation of servicer satellites on one or multiple servicers
* Propulsive satellite bus capable of interfacing with robotic payload
* Standard fuels for all modes of space vehicle operations
* On-board autonomous operations in all relevant orbital regimes
* On-orbit additive manufacturing and related technologies
* Mass/Inertia property determination and control of large flexible structures
* Modular software to provide safe, autonomous real-time operations
* Technologies for controlling non-cooperative objects/client satellites
* Local and relevant communication and information sharing
* Verification and Validation testing of developed software

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any high-performance small satellite component, software, bus, or payload technologies enabling ease of space logistics that may impact future Air Force space missions.

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**Focus Area: Space Domain Awareness**

The 2018 National Defense Strategy dictates that the Air Force must prioritize investments in resilience to assure our space capabilities. Autonomy is a key enabling technology in order to improve space asset resiliency. When autonomy is implemented on a multi-agent system, a number of unique missions become possible through collaboration across the swath of space operating domains such as Space Domain Awareness (SDA), environmental monitoring, and on-orbit servicing and manufacturing. Multi-agent collaboration in space is a largely unexplored topic and is a prime candidate for the application of autonomous collaboration technologies that have been developed in other domains. Due to the unique demands of the space operating environment, the implementation of multi-agent systems on orbit requires a number of novel, currently under-developed technologies. This topic area seeks to push the US space enterprise into a paradigm of more agile and cost-efficient products. Some of these areas of interest include the following:

* Application of existing multi-agent collaboration to new and existing space operating domains
* Development of vehicle/domain-agnostic software framework for algorithm application & testing
* Software for training and familiarization of space operators with multi-agent assets
* Methods for formal verification and validation (V&V), testing, and simulation of cooperative autonomous systems
* Local awareness sensors, heterogeneous data fusion, and sensor management
* Communication algorithms considering problems unique to space-based, multi-agent systems such as network consensus, high latency/low data rate links, and mesh networks
* Distributed, cyber-secure processing, communications, and resource sharing
* Small, space-rated, high-performance computing and software-defined radios
* Unique methods of guidance, navigation, and control for multi-agent systems
* Methods for maintaining multi-agent collaboration in contested/denied environments

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any technology which enables the application of space-based, multi-agent collaboration in future US Space Force.

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**Focus Area: Persistent Space-based Intelligence, Surveillance, and Reconnaissance (ISR)**

With the rise of commercial space, decreased cost to orbit, and increasingly capable small satellites, the traditional model of large, costly space-based sensors flown on a small constellation of large satellites in a dedicated layer will likely be supplemented by a second model based on very large constellations of smaller satellites carrying smaller, lower-cost sensors. The development and integration of persistent ISR-enabling capabilities into a highly proliferated, hybrid space architecture is one critical element of employing the enterprise for all-domain tactical operations.

These capabilities are fundamental to ensuring the warfighter has timely and decision-quality information for tactical threats in a denied or degraded environment. This approach will allow mission capabilities to move beyond traditional space-based strategic missile warning and air-based ISR missions and into new mission capabilities including multi-mission platforms with the capability for autonomous integrated ISR in tactical-to-strategic environments. Areas of interest for this topic include the following:

* Novel space-based electro-optical, inferred, and radio frequency (EO, IR, and RF) sensors with lower cost, enhanced performance, or improved protection and rad-tolerance; multi-modal sensing concepts are also of interest.
* Wide area motion-imaging concepts for moving target indication is also of interest.
* Fast-response, biologically inspired neuromorphic, or event-based sensors (EBS), in visible and infrared including hybrid EBS/conventional imagers
* Combination of electromagnetic metamaterials, two-dimensional and topological optical and semimetals materials for hybridized detection and transport
* Low cost, in-lab cryogen generation, recovery, and recycling for focal plane array(FPA) characterization
* Novel instrumentation and test methodologies for in situ resiliency/damage studies on detectors/readout integrated circuits (ROICs,) such as Capacitance Voltage (CV), Deep Level Transient Spectroscopy (DLTS), laser-based particle acceleration
* Cryogenic optical fiber data-links for space-based read-out integrated circuits (ROICs)
* Autonomous tactical ISR sensors and networked payloads/satellites
* Sensor signal and imaging processing analytics onboard satellites and cloud platforms
* Integrated data analytics for agile/adaptive space-based sensing
* Cloud-based ISR data fusion and predictive data analytics for enhanced decision making
* Autonomous computing and machine learning methods for generating data and information across distributed elements of an integrated ISR enterprise
* Tactical edge computing concepts with limited and or intermittent command and control

The technical areas identified above are examples of technologies for which innovative ideas and concepts would have a significant impact on the USAF and USSF ISR mission. Additional technical areas and technologies that may enhance space-based ISR and other space missions may also be applicable since this focus area is designed as an open topic.

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**Focus Area: Responsive, Resilient SatNav**

A critical part of the US Space Force vision for space-based Positioning, Navigation, and Timing (PNT) is to have the capability to respond quickly to the user’s situation, ideally in less than one minute. This means the user’s situation must be sensed, analyzed, and reported; courses of action developed, evaluated, and decided; decisions communicated to all three segments of the PNT architecture, and these segments reconfigured to provide the user with the needed PNT for their situation. The control segment will distribute the needed information and provide the monitoring services; the spacecraft (GPS, hosted payloads, non-traditional transmitters, etc.) will reconfigure to deliver the needed signals; and the user equipment will be reprogrammed to receive and process the new signal. This topic area seeks technologies to make responsive, resilient space-based PNT services possible. Example areas of interest include, but are not limited to the following:

* Smart, learning technologies capable of generating various options (complete with effectiveness metrics) of possible reconfigurations of the traditional and non-traditional PNT architecture based on information received on a user’s PNT situation.
* Automated PNT signal development compatible with transmitter/receiver hardware using inputs from PNT situational awareness and other constraints
* Advanced encryption and spreading code concepts for waveform exclusivity and authentication
* Incorporation of non-traditional Satellite Navigation (SatNav) transmitters into a SatNav architecture
* Advanced SatNav waveform transmitters that can be flexibly changed to meet transient operational needs
* Control Segment technology capable of closing the active feedback loop quickly and distributing the needed information to the space and user segments
* Integration of responsive PNT operational capabilities

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any responsive Space-based PNT component technology that may impact future US Space Force missions.

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**Focus Area: STTR Agile Manufacturing for Space Systems**

Space is rapidly becoming more congested and contested as the number of countries, commercial entities, and non-traditional space users increases. There is also a growing need for persistent global delivery of space-based services such as timing, communications, and missile warning. The challenges have driven DoD to pursue new and novel hybrid space architectures with the primary approach to achieve both global persistence and architecture resiliency through proliferated Low Earth Orbit ( LEO) and proliferated Low Earth Orbit (pLEO) constellations using small satellites. For this focus area, small satellites are defined as CubeSats through ESPA-Grande class satellites. While there are many advantages to a pLEO constellation, one of the biggest challenges is delivering the number of diverse spacecraft capabilities required by the DoD at a reasonable cost and schedule point.

The specific topics of interest for this STTR focus area are design tools, manufacturing, assembly, integration, and testing approaches that dramatically reduce the cost and schedule to produce space hardware. We are especially interested in leveraging new and emerging techniques from non-traditional space technology areas, including 3D printing, intelligent robotic assembly, virtual and augmented reality concepts, and DevSecOps flight software concepts. Systems that are modular and leverage open source architectures for both hardware and software integration are also of interest.

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**Focus Area: Air Force Identification of Potential Inspection Topics**

The Air Force Inspection Agency seeks innovative approaches for the development and implementation of techniques to leverage existing reports or data relevant to Air Force missions or programs in order to recommend specific topics or trends for inspection.

Directed Inspections are high-priority, time-sensitive inspections conducted by Air Force Inspectors General (IGs) which generate deficiencies and recommendations of significant interest to the Air Force, the Department of Defense, Congress, and/or the general public. Responding on short notice to direction from DoD or Congress requires re-organization of existing inspection schedules, shifts in inspection priorities, and unplanned travel costs in order to address an “emerging” topic of importance. Often, research conducted by non-IG entities (Government Accountability Office, Congressional Research Service, RAND Project Air Force) contains identified shortcomings within Air Force programs. Additionally, social media is a growing repository for sources of dialogue and discussion among military professionals, their families, and interested citizens regarding issues that can impact morale, discipline, and readiness of military forces.

The absence of aggregated or compiled text results obscures insight into the pervasiveness of the shortcoming(s) and the scale of the potential impact to the Air Force. Timely recognition of potential problem areas would allow the Air Force to schedule inspections to pro-actively validate deficiencies and to implement solutions rather than responding on short notice to a Directed Inspection. The Analysis Division within the Air Force Inspection Agency is interested in exploring how existing data sources can be leveraged to achieve a more robust understanding of potential programmatic shortcomings and to make recommendations to perform pre-emptive investigations.

Natural Language Processing Tools and Machine Learning techniques may provide the means by which masses of text files are assessed to identify topics/themes which show promise for further investigation and subsequent recommendation for selection as an inspection subject.

Operational constraints include 1) Selection of a set of data sources from which topics/themes could be most likely derived, 2) Ability to update data content on a routine, e.g., quarterly, basis as does data not need to be collected in real-time, and 3) Solutions that could be applied to data in unclassified and classified domains. These constraints are not all-inclusive, and the solutions generated for this focus area could apply to other Air Force functional organizations with responsibility for the execution of inspections, audits, investigations, inquiries, or analyses.

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**Focus Area: AFLCMC Cryptologic and Cyber Systems Division**

AFLCMC/HNC is the Cryptologic and Cyber Systems Division. AFLCMC/HNC provides long-term system development and support to fulfill 16 Air Force cyber requirements.

We partner with acquisition, operational, and test communities to develop and field solutions to meet operational needs. These can be found within the Defensive Cyber Operations (DCO) and Distributed Cyber Warfare Operations (DCWO), Joint Cyber Command and Control (JCC2), and Unified Platform (UP) portfolios.

We operate at every stage of the acquisition life cycle from development planning through sustainment.

MISSION - Deter, defend, and defeat the threats of today and tomorrow by providing lethal cryptologic and cyber capabilities to the Joint Warfighter

GOALS – Provide complete lifecycle development and sustained Cryptologic and Cyber solutions

VISION – Supporting Secure Communications

**Problem Statements**

1. How might we enable operators to ***effectively process the Observe, Orient, Decide, Act (OODA) loop when evaluating networks?*** Specifically, what ways are there to map networks quickly and accurately with minimal impact on network performance?
2. How might we ***enhance Radio Frequency signal identification and decoding?***
3. How might we enable automated testing to match the speed of development? Specifically, we need a capability that allows us to **generate and manage radio frequency waveforms that allows for varying environmental conditions and simulation of real-world environments.**
4. How might we enable automated software security testing to match the speed of Agile development? Specifically, as part of a software development pipeline, we need a capability that will rapidly allow software developers to identify and focus efforts on fixing vulnerabilities in compiled software before it enters production.

**Technologies of Interest**

* **Communication:**
* Secure Multi-band Antenna
* RF signal demodulation and location detection
* Adaptive radio frequency waveforms
* **Cyber:**
* Cyber Configuration Management
* Firmware and Software
* AI-based network behavior detection and analysis
* Analytic decision tools, including ingesting existing and untapped data resident on/in weapon systems to better understand and predict network traffic
* Software vulnerability research tools
* **Interfaces & Protocols:**
* Standards for secure interfaces/instantiation
* Securing open protocols and encryption
* Software-defined radio interfaces

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**Focus Area: Online Learning of Semantic and Syntactical Representational Structures**

The objective of this effort is to explore various approaches that may automate the process of generating new knowledge, significantly modifying existing knowledge structures, and even deriving new ontologies or other representational structures for knowledge.

When it comes to cognitive modeling there are three major paradigms that are currently recognized: symbolic (or cognitivist) systems, connectionism (or emergent) systems, and dynamism. Symbolic approaches have been around for 40 years, while connectionism has been growing in popularity over the last ten years. Theoretical and practical developments in dynamism tends to involve a very small camp. In recent years people have begun to loosely integrate pieces from the Cognitivist and Emergent camps. Symbolic Approaches (Ex ACT-R, SOAR) are older but most prominent, while newer Connectionism and hybrid Symbolic-Connectionism approaches are becoming more popular. Symbolic representations are often the logical choice for representing structured knowledge (Ex semantic graphs like WordNet).

Interest in connectionist models for higher-level processing has been growing because of recognized limitations in symbolic rule-based systems. These include brittleness, inflexibility, scaling problems, difficulty in experiential learning, poor generalization, and knowledge domain limitations due to specificity. More recently, research has been developing connectionist models with valuable properties like good generalization, graceful degradation, robustness, fast processing, context-sensitivity, learning from experience, and scalability. In the past, most connectionist models have not had all of the aforementioned properties and were certainly challenged to perform higher-level reasoning tasks. This was because temporary data structures required for higher-level reasoning are often complex and cannot be represented in common connectionist models.

Symbolic models for more complex structured knowledge representations are known to suffer from brittleness and ambiguity in meaning. Additionally, their syntax and ontologies are almost always hand-built. On the other hand, most sub-symbolic or connectionist representations via artificial (or spiking) neural networks are well suited for various forms of machine learning but often don’t represent knowledge in a way that is suitable for cognitive reasoning. Exceptions to this are compressed representations implemented as high dimensional data pointers as found in holographic reduced representations (HRR), the vector symbolic architecture (VSA), and the combination of the aforementioned in the symbolic pointer architecture (SPA). These approaches show promise in taking advantage of the strengths of symbolic and connectionist approaches while avoiding several of their limitations.

Potential Applicability #1

* Command and Control (C2) Systems
  + Radar C2 system providing modern Integrated Air Defense Systems (IADS) effects versus a threat-representative system
  + Integrated Displays to track threats across all Air Warning (AW) and Missile Warning (MW) domains for seamless event tracking
  + Integration of high-fidelity data from non-traditional sources
  + Characterization of threats without ambiguity or delay
  + Rapid searching for massive data sources for valuable information presentation
  + Identification of threatened areas and targets for assessment reporting
  + Left of launch intelligence threat situational awareness
  + Data pool analysis, consolidation, and assessment for emerging threats
  + Integration of multiple and cross-classified data sources
  + Rapid, adaptive, and integrated system as auto-router decision aid

Potential Applicability #2

The Air Force, specifically the Command Control Communications Intelligence & Networks, Special Programs Division (AFLCMC/HNJ) is looking for solutions to enable completely integrated all-domain operations, specific components of an integrated platform, or an integration layer that will create the basis for all-domain operations designed for:

* Real-time data collection, validation, and analytics
* Communication and battle management network enhancements
* Integration, fusion, and analysis of advanced sensors, sensor data, and software
* Advanced sensor modes
* Artificial Intelligence(AI)-based and Machine Learning-based decision making
* Data security, identity, and trusted access
* Multi-level security-enabling technologies and cryptography
* AI Unmanned Aerial Vehicle control
* Low-cost Radio Frequency (RF) antennas
* Low-cost RF sensors
* Additive manufacturing

This technology has broad applicability for various commercial (and government) applications where AI systems need to learn online and/or handle new situations. Some example applications include but are not limited to the following: 1) Industrial inspection drones or robots with improved inspection and/or navigation capabilities; 2) Service robots that can learn new behaviors online in changing environments; 3) Online artificial intelligence (AI) services that deepen their knowledge as they accumulate new events; 4) Improved conversational and explainable AI agents/robots that learn from experience; 5) Improved cybersecurity AI that understand new situations via analogical learning.

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**Focus Area: Responding to sustainment needs quicker and more affordably**

Traditionally sustainment costs account for about 70% of the lifecycle costs of military systems. The Air Force has also been reluctant to fund new projects solely on the basis of rising sustainment costs within the Supply Chain (SC). At times sustainment projects are funded only when projects reach a crisis level. At that point, the acquisition system cannot respond fast enough to meet the growing need. As we are using military systems well beyond their design life, sustainment costs are rising. Further complicating the situation, since 1995 the professional acquisition workforce has been reduced by 47% while program execution dollars have increased by 50%. Remaining workers must get more efficient and more creative. The acquisition system needs to be more responsive to sustainment needs. The sustainment community needs to be able to justify projects based on trends in support cost, rather than waiting until a crisis arises. We need to be able to partner sustainment with development to retire costly, low performing systems with current technology without the constraint of Form, Fit, Function, Interface (F3I) only replacement. Examples of areas of interest include the following:

* Mary software re-design (such as FACE) with hardware upgrade to legacy mission computers while achieving Diminishing Sources and Manufacturing Suppliers
* Better strategies to deal with obsolescence by approving specific upgrades as SC & Acquisition partners
* Cost-Effective Sustainment and Growth by Automated Software Optimization
* Means to move aircraft without a tow vehicle and without using aircraft engines
* Agile Intelligence, Surveillance and Reconnaissance (ISR) Pod Low Power Synthetic Aperture Radar (SAR) Integration with Long Term ISR Sensor Growth
* Application of open systems architecture at the subsystem level and below
* Tools (including augmented reality and enterprise-level systems deployment across the entire life-cycle enterprise) that increase the efficiency of the sustainment and acquisition workforce

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for lower sustainment cost, greater workforce efficiency, and quicker acquisition response time.

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**Focus Area: Electric Braking System for Fighter Aircraft**

A critical part of the AF requirement for extending the deployment footprint of fighter-type aircraft requires austere airfield operations. This drives the need for better takeoff and landing performance (shorter runways); provides on-ground maneuver in tight turn conditions without tugs; reduced maintenance requirements for turning sorties; and reduced supply chain requirements to establish effective forward operating locations. Upgrading legacy friction brakes and wheel assemblies to electric brakes offers significant opportunities in all these areas.

* Provide an A-10 proof of concept production-ready electric brake system achieving all the opportunities listed above
* Provide flight test support to certify an electric brake system
* Provide both braking as well as electric taxi
* Provide full wheel and tire system upgrade to enhance the full electric brake system integration and improve retrofit on existing aircraft.
* Provide model-based systems engineering (MBSE) of braking system with Failure Mode Effects and Criticality Analysis (FMECA) adaptable to all fighter-type aircraft

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for lower sustainment cost, greater workforce efficiency, and quicker acquisition response time.

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**Focus Area: Classified Data at Rest (CDAR) System of Systems**

A critical part of the AF requirement for CDAR is to extend the basic function of recording and sending pre-recorded files. Using the encrypted files for system-level requirements vastly enhances the value of CDAR. One of the keys is to use systems engineering to advance an architecture that achieves the high security inherent in CDAR while providing functions previously allocated to other non-secure processors. Examples of areas of interest include the following:

* Provide Crash Survivable Flight Data Recording (CSFDR) as an encrypted output from the CDAR core system
* Provide flight management system functionality, using recorded CDAR data, to integrate with navigation system
* Provide Ground Collision Avoidance System (GCAS) integration using the encrypted mapping data loaded onto the removable storage device
* Provide Model-Based Systems Engineering (MBSE) assessment of extended CDAR system of systems to integrate with platform MBSE datasets
* Provide cybersecurity roadmap for enhanced cyber resilience of a CDAR system of systems

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for lower sustainment cost, greater workforce efficiency, and quicker acquisition response time.

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**Focus Area: DevOps Process for COTS PLM based Configuration Management**

The Air Force seeks to establish the technical and operational feasibility of a DevOps process that can release incremental enhancements to a configured and customized Commercial Off the Shelf (COTS) Product Lifecycle Management (PLM) solution. This process is a hybrid (outside and inside the .mil network) environment to release multiple enhancements to the Air Force Distributed Common Ground System (DCGS) configuration management (CM) application.

This technology (new process and supporting toolchain) that can enable the planned release of incremental enhancements to a configured and customized COTS PLM solution without deprecating legacy functionality, as well as integrity of operational data. The new DevOps process is unique in that it would be practiced in two distinct environments. All of the development and quality assurance (QA) would be practiced on a commercial cloud outside of the .mil network followed by deployment and post-deployment QA on the .mil network.

The benefits to U.S Air Force (USAF) include:

* + Authoritative current configurations of AF DCGS assets
  + USAF approved COTS PLM instead of Government Off the Shelf (GOTS) software
  + Reduced total cost of ownership (TC) of the CM function
  + Incremental insertion of data model upgrades, workflow-based change management, as well as very low footprint reporting and analytics on the web

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**Focus Area: Develop avalanche photodiode (APD) detectors**

The goal of this focus area is to develop avalanche photodiode (APD) detectors operating at wavelengths of 2 um or longer, based on GeSn or SiGeSn absorber materials. Specific elements of interest in this focus area include, but are not limited to:

* Demonstrations of single-element APDs or APD arrays, either linear or Geiger-mode;
* Enabling fabrication processes such as ion implantation, diffusion doping, or laser annealing;
* Enabling heteroepitaxial deposition techniques such as alternative substrates (e.g. silicon, InP, GaSb) or patterned deposition;
* Wafer-scale deposition onto CMOS without using indium bump hybridization;
* Device designs in either the vertical or lateral direction, including SAM structures (i.e. separate absorption and multiplication), waveguide photodiodes, or novel designs.

For applications using linear-mode APD operation, requirements including gain (>20), unity gain external quantum efficiency (>30%), low dark current density (<10 µA/cm2), and thermoelectrically cooled operation (>200 K) are desirable.

For applications using Geiger-mode APD operation, requirements including dark count rate (<10 MHz), excess bias (<5 V), afterpulsing probability (<1% at 1 millisecond), jitter (<1 nanosecond), single-photon detection efficiency (>10%), and thermoelectrically cooled operation (>200 K) are desirable.

For applications using waveguide structures, integration with high-speed CMOS circuitry and with photonic integrated circuits is desirable. The automobile industry needs low-cost, eye-safe LIDAR systems to enable fully autonomous driving. The current state of the art uses either silicon or InGaAs sensors, which allow either low-cost or eye-safe operation, respectively, but not both. GeSn meets both criteria. It can be used for not only for imaging but also for remote sensing using integrated photonics. These applications include infrared phenomena beyond the current state of the art wavelengths, including biological and chemical sensing in the extended SWIR and MWIR. In short, GeSn sensor development could impact the automobile, medical device, and gas exploration industries.

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**Focus Area: Attack Inferencing and Response for Resilient Avionics Software and Firmware**

The Air Force is seeking innovative approaches to mitigate supply chain attacks on avionics and mission system software and firmware. In particular, the goal of this topic is to develop a capability to instrument untrusted binary executables and perform attack inferencing and response to mitigate the attacks. The technology should allow the insertion of cyber sensors and actuators/responders into binary executables for the purposes of detecting and responding to malicious behavior (e.g., from a malicious implant). The inserted sensors would provide telemetry data to the attack inferencing engine that runs outside the target binary executable. The responders would be strategically inserted into the binary so they can be directed to take action by the attack inferencing engine, e.g., to disrupt the malware triggering mechanism or prevent malicious actions. Decompilation and decomposition of the software or firmware may be required in order to determine where to best place the sensors and responders. The insertion of the sensors and responders should be done in such a manner as to minimize the changes to the original binary. Leveraging of commercial or government developed reverse engineering tools (e.g., decompilers) for the purpose of binary insertion is encouraged. Finally, while the focus of this topic is primarily to enhance the cyber resiliency of Air Force weapon system software and firmware, the underlying binary insertion technology should be designed to accommodate other use-case scenarios (e.g., the insertion of adapters into the executables to enable Open Mission System (OMS) compliance of legacy software) and this flexibility built into the tool design. Commercial applications span numerous technology areas and broad interest is expected from private corporations concerned with supply chain compromises from third party vendors, including the cellular communications industry (e.g., google, Samsung), banking and finance industry (e.g., J.P. Morgan Chase, Bank of America), and the personal computer industry (e.g., Samsung, HP, Microsoft). Other non-DoD government agencies, such as the Department of Homeland Security (DHS), with its focus on Supervisory Control and Data Acquisition (SCADA) and Industrial Control Systems (ICS), would also benefit from this topic.

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**Focus Area: Development of Small Unmanned Aircraft System for Civil Engineering**

The Air Force Civil Engineer Center is seeking a multipurpose drone to perform inspections of infrastructure and other areas, including post-attack and Explosive Ordinance Disposal (EOD) missions. Must be compliant with Reference 1, (FY 2020 NDAA *Section 848*).

1. **Description:** The civil engineer has a unique mix of missions that would benefit from the Small Unmanned Aircraft System (SUAS) operations. A new SUAS will meet a mix of the following capabilities:

* Small Utility/Base Support SUAS: Man-transportable SUAS to support typical Civil Engineer (CE) base support missions.
* Survey Grade SUAS: Vehicle transportable SUAS to support base surveys and precision georeferenced imagery collection.
* EOD/1st Responder SUAS with manipulation capability: Vehicle transportable SUAS to support critical EOD and 1st responder mission requiring manipulation.
* Ground mobility SUAS: Vehicle transportable SUAS to support base utility and infrastructure inspection missions where ground mobility is also required.

1. **Ideal Configuration:**
   1. Small Utility/Base Support SUAS system components (SUAS, controller, radios, batteries, & sensors) will be transportable in an individual backpack or small travel case. System will be used for missions such as infrastructure inspections, construction monitoring, environmental surveys, 1st responder support, base recovery from weather events, etc. The system should have a minimum of 20 minutes operating time, include a 2.7K or greater color E/O camera, a thermal IR camera, GPS waypoint navigation. The system should be operable in light rain and light to medium winds (~20mph).
   2. Survey Grade SUAS system components (SUAS, controller, radios, batteries, & sensors) will be transportable in no more than 2 travel cases. System will be used for precision survey missions to update base maps and infrastructure for the GeoBase program, site planning for military construction (MILCON) and minor construction projects, and any other mission requiring precision georeferenced imagery/data. The system should have a minimum of 20 minutes operating time, include a 20 megapixel (MP) or greater color E/O camera and differential GPS waypoint navigation. The system should be operable in light rain and light to medium winds (~20mph).
   3. EOD/1st Responder SUAS system components (SUAS, controller, radios, batteries, & sensors) will be transportable in no more than 3 travel cases. System will be used for EOD and 1st responder missions that require “light” manipulation of ground objects up to 5lbs potentially including placement of counter-charges or neutralization devices. The system should have a minimum of 30 minutes flying time and 30 minutes of ground operation times, include a 20 MP or greater color E/O camera, a high-resolution thermal IR camera, GPS waypoint navigation, and ideally have obstacle avoidance and swappable payloads. The system should be operable in heavy rain and high winds (~40+ mph).
   4. Ground mobility SUAS: All system components (SUAS, controller, radios, batteries, & sensors) will be transportable in no more than 2 travel cases. The system will be used for base utility and infrastructure inspection missions in confined spaces where ground mobility is required such as culvert and tank inspection. The system should have a minimum of 30 minutes flying time and 30 minutes of ground operation times, include a 20 MP or greater color E/O camera with illumination, a high-resolution thermal IR camera, GPS waypoint, and GPS denied navigation and ideally have obstacle avoidance and swappable payloads. The system should be operable in light rain, light to medium winds (~20mph), and be submersible to a depth of 6 inches.
2. The system should be designed with open architecture considerations, or at a minimum should be designed with interoperability profiles to allow third party software and payloads to be quickly configured and added. Provide at least three references to similar work or technology or needs. See attached table for additional threshold and objective requirements.

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**Focus Area: High Power Electromagnetics**

High Power Electromagnetics offer innovative opportunities in the Air Force’s pursuit of game-changing technologies. In particular, the HPEM addresses the Air Force’s mission for precision counter-electronic attack. Radio Frequency (RF) or High Power Microwave (HPM) weapons are devices designed to disrupt, degrade, or destroy targets by radiating electromagnetic energy in the RF spectrum, typically between 10 MHz and 100 GHz. A typical HPEM system consists of the following subsystems prime power, power conditioning, the RF generating source and an antenna. Trade offs between the size and weight of these different subsystems are key to producing militarily useful HPEM weapons. The prime power is the source for powering the HPEM system such as a turbo-generator, motor or battery. The power conditioning takes the input from the prime power and modifies it to provide power to the source at the energy, current, pulse shape, rise time & width and repetition rate so that source can efficiently produce high power electromagnetic radiation. The antenna increases the gain and radiates the HPEM power toward the target. Examples of power conditioning are combinations of power converters, Marx generators, Telsa transformers and pulse forming networks. There are a number of electron beam drive HPM sources as described in the references below. Other types of HPEM sources include ultrawide band sources, solid state sources and RF munitions. Technologies that can increase the effectiveness of HPEM systems for various non-lethal, low collateral damage counter-electronic applications are vital to enabling HPEM weapons. In addition the ability to improve the size, weight and power (SWaP) of the HEPM systems increases the manner in which systems could be employed. This area seeks to push the envelope of existing HPEM components as well as developing new and innovative approaches for HPEM generation. Examples of areas of interest include but are not limited to the following:

* Low aspect ratio, high gain mesoband antennas
* High current density, composite HPM cathode technology
* Low-outgassing, bakeable field emission cathodes
* Novel fabrication techniques including additive manufacturing for HPEM vacuum electronic sources
* Sealed tube HPEM source enabling technologies
* S- to Low K-Band HPEM Sources
* Disruptive Concepts for compact, Broadband HPM Amplifiers
* High pulse repetition rate, compact pulsed power
* High gain, conformal broad bandwidth antennas

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**Focus Area: Potable Water Generation**

An adequate supply of potable water is an absolute necessity for any installation or deployment. The logistics of supplying bottled water is formidable in the best of conditions, consumes fuel, and generates a voluminous waste stream. Reverse Osmosis Water Purification Unit (ROWPU) is the traditional response to this problem but they are scaled for large applications and make relatively inefficient use of water in their brine streams. Energy-efficient systems to supply potable water meeting regulatory standards are sought for two operating environments: 1. A system scaled to sustain the deployment of 150 personnel in an area with access to a non-potable water supply and 2. A 5000 gallon per minute closed-cycle system for long-term operation in an area with insufficient or no external access to water.

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**Focus Area: Runway Maintenance**

The standards for retro-reflectivity of beaded runway markings recommended by FAA and used by the AF are based on a highway instrument that measures intensity returned at a 1.05° angle to the horizon. Flight approach angle is 3°. This is a call for an instrument that measures retro reflectance at 3° to the horizon.

Operable by a single airman or autonomous

Battery life NLT 4 hours

Assessment of color fidelity and fractional coverage both pluses

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**Focus Area: Advanced Detection and Characterization of Low Probability of Intercept (LPI) Signals**

Develop new digital signal processing (DSP) methods for reliably detecting and characterizing advanced LPI signals in contested and congested environments. New time-frequency (TF) analysis techniques, coupled with non-Fourier techniques, such as the reassignment method, the discrete-time, discrete-frequency reassignment method, and the Hough transform, and potentially deep-learning networks, will be required to meet the challenges posed by these next-generation waveforms.

The global proliferation of advanced solid-state and digital radio frequency (RF) technologies has facilitated the development and deployment of next-generation LPI waveforms that are not easily detected or analyzed using traditional techniques. Instantaneous signal energy can be well below the receiver noise floor due to extreme spreading in time and frequency, rendering traditional Fourier-based methods as non-optimal. Moreover, cognitive radars and electronic warfare (EW) systems can introduce a degree of unpredictability and diversity that further exacerbates these problems. Recently, TF techniques (spectrogram, scalogram, Wigner-Ville distribution, Choi-Williams distribution) have been shown to offer an improvement over traditional Fourier-based methods, and the more so when these TF techniques are combined with other non-Fourier methods, such as the reassignment method and the Hough transform, with the newly patented discrete-time, discrete-frequency reassignment method holding promise as well. Deep learning networks is yet another emerging technology that shows great potential when combined with the above.

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**Focus Area: Laser Weapon Systems Beam control for laser weapon systems**

Laser weapon systems, in practice, offer speed of light delivery, unparalleled precision, and deep magazines. Thus, the Air Force’s pursuit of this game-changing technology is steadfast. One critical subsystem of the total laser weapon system is the beam-control system. Such a subsystem enables the light from a high-energy laser (HEL) to make it from point A, the HEL source, to point B, the distant target, and establish a focused beam. Disturbances found along the propagation path often hinder one’s ability to establish a focused beam on distant targets. For example, these disturbances can come in the form of base-motion jitter, aero-mechanical jitter, aero-optical turbulence, atmospheric turbulence, atmospheric extinction, etc. (to name a few). Moving forward we need to precisely characterize and replicate these disturbances so that we can engineer robust beam-control solutions that overcome their detrimental effects. Examples of areas of interest include but are not limited to the following:

* User-friendly MATLAB toolboxes for beam-control component and system-level development
* Inertial reference units for line-of-sight stabilization
* Precision shaker tables for replicating harsh and mitigated jitter environments
* Integrated sensing solutions that perform both combat-ID and beam-control functions
* Novel beam-control solutions that handle the deep-turbulence problem
* Novel beam-control solutions that handle the aero-mechanical problem
* High-average-power pulsed Short Wave Infrared (SWIR) illuminators
* Fast-framing SWIR cameras with low noise
* Novel diagnostics for subsonic and supersonic wind tunnels to characterize aero effects
* Novel diagnostics for test ranges to characterize atmospheric effects
* Novel diagnostics for test ranges to characterize laser weapon system performance
* Dynamic target simulators for test ranges with a limited field of regard

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**Focus Area:** Multi-Use Flexible Conforming Robotic Tooling

Develop a multi-purpose end of arm tooling technology to support the spectrum of aircraft

sustainment operations utilizing Commercial Off the Shelf (COTS) industrial robotic arms, across a variety of depot applications.

Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with reverse engineering and low-rate reproductions. Potential beneficiaries in aircraft industries alone include but are not limited to DoD components, FAA, and private (domestic) airline maintainers. As the technology broadens in scope, it will apply to other complex system assemblies, such as ship works and space vehicles.

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**Focus Area:** Collection management across PAI sources

The Air Force is seeking an algorithmic approach and software framework for automated collection management across PAI sources, with the ability to generate requests for information (RFIs) for ISR sources, enabling improved relevance and accuracy in event discovery and threat forecasting.

Publicly Available Information (PAI) data sources are growing in volume and velocity and can provide critical and timely information about important events, such as changes in an adversary’s threat posture. However, these datasets include significant irrelevant, incorrect, or incomplete information. Prioritization, verification, and supplementation are therefore essential to identify and analyze critical events, and given the volume of data, much of this work must be automated. Previous research in “hard-soft fusion”, combining PAI with traditional Intelligence, Surveillance, and Reconnaissance (ISR) sources, has shown promising strides toward identifying and verifying relevant events based on evidence spanning these disparate sources. Recent research in the intelligence community has also shown the potential to exploit disparate data sources to predict future threats in specific categories. However, a key enabler for such event discovery and threat forecasting capabilities is the ability to manage the collection of data to ensure detected events and threats are relevant to Air Force analysts and warfighters. While significant work in collection planning has been performed in single domains or for single intelligence (INT) sources such as satellite imagery, managing collection jointly across disparate PAI sources with coordinated cueing of more constrained ISR sources remains a challenging, unsolved problem.

The objective of this STTR is to design and develop an algorithmic approach and software framework for automated collection management spanning disparate PAI sources and modalities, with support for cueing of traditional ISR or other non-PAI sources via Requests for Information (RFI) messaging. The framework should address the following specific challenges:

1. Prioritizing and optimizing PAI collection based on analysts’ interests, to improve the relevance of discovered events. A machine representation of analyst interests is an important aspect of this problem.
2. Prioritizing and cueing follow-up collection to gather additional information on discovered events, to improve characterization and understanding of the discovered events. This may include evidence from alternative PAI sources or modalities, as well as traditional ISR or non-PAI sources and modalities. As an example, a PAI Mission-critical defense and security operations (MOVINT) indication of troops massing at a border can be corroborated by satellite IMINT, providing both higher confidence and more actionable information about the event.
3. An additional challenge is that of prioritizing and organizing what is reported to analysts based on what is found by the automated collection and downstream event discovery and threat forecasting systems, to improve the relevance of reported events. Addressing this challenge can leverage existing algorithms in these areas, simplified software that approximates such algorithms, human judgment, or a combination of these methods.

For Phase I and II, developed software and data should be unclassified. The generation of unclassified RFIs is sufficient for ISR sources and domains where the collected data itself is typically classified.

The resulting algorithmic framework will help “get the right decision quality data to the right decision-maker at the speed of relevance. It will also provide a useful foundation for the transition into emerging hard-soft fusion analytics toolchains for military Joint All Domain Command and Control (JADC2) decision-makers, with strong potential for applications in the commercial sector.

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**Focus Area: Large Area Quick Scanning**

The Air Force is seeking a solution for quickly creating mesh models (.stl, .obj. etc.) for large and small off-air frame assets. Several elements of technology may be involved to demonstrate automated data collection and processing with a much lighter footprint and substantially lower cost than traditional approaches. This solution must be an automated process for collecting photogrammetry data using a scanner or several stationary cameras with a simultaneous single shot from each camera.  This should be an automated process for collecting photogrammetry data and overlaying that to a new higher accuracy mesh model with existing robotic hardware. Also, to develop an automated process for collecting photogrammetry and structured light data using two or more high-resolution cameras and a structured light scanner. This data may be collected with multiple “shots”. This will be an automated process for transforming that data into the Texture Mapped Model of the part.

This system must be capable of quickly producing meshes will tremendously increase the efficiency, functionality, and productivity of our robotic systems by:

* + Providing a mesh that matches the unique geometry of each part.
  + Reducing the flow time and man-hours required to obtain meshes.
  + Increasing ease of use of scanning and modeling operations.fluid an
  + Significantly reduce human error associated with model/mesh creation.

Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with reverse engineering and low-rate reproductions. Potential beneficiaries in aircraft industries alone include but are not limited to DoD components, FAA, and private (domestic) airline maintainers. As the technology broadens in scope, it will apply to other complex system assemblies, such as ship works and space vehicles.

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**Focus Area: Remote Monitoring of Fluid and Air Pressure Settings in Aircraft Paint Systems**

This Air Force is seeking a technology that allows aircraft maintainers to remotely monitor aircraft paint carts for correct fluid and pressure settings from a range of minimally 500 feet. This system will provide an alert to supervisor/work leads on whether the settings for paint carts are within the setting ranges established by the United States Environmental Protection Agency (USEPA), Georgia Environmental Protection Division (GAEPD), US Air Force, and DoD regulations There is potential for this technology to positively impact environmental controls by being in compliance with environmental regulations and guidelines.

A Remote Monitoring of Fluid and Air Pressure Settings in Aircraft Paint Systems would compliment and enhance the Air Force maintenance process tremendously by:

* + minimizing costly reworks associated with painting and de-painting
  + saving a great amount of cost associated with Environmental fines and citations for being non-compliant with Title V GAEPD Air permit regulatory requirements.
  + Better control the fluid flow, fluid, and air pressure on the paint carts
  + Being able to more consistently stay in compliance with Title V GAEPD Air permit regulatory requirements

Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with aircraft maintenance, particularly in the aircraft painting process. Potential beneficiaries in aircraft industries alone include but are not limited to DoD components and private (domestic) airline maintainers.

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**Focus Area: Intelligent Robotic Painting of Large Aircraft**

The 402nd Air Force Maintenance Group (AMXG) requires the ability to implement an intelligent robotic painting system capable of painting an entire large frame aircraft with extreme accuracy. The use of an adaptable intelligent robotic painting system that can effectively and efficiently paint an entire large-framed aircraft would reduce exposure to hazardous chemicals and increase aircraft throughput. The system would need to be rapidly reconfigurable for various aircraft sizes, of which should include C-130, C-17, and C-5, at minimum, and utilize a simple path planning method that requires minimal training to operate. This intelligent robotic painter must include an advanced collision avoidance system to prevent damage to aircraft and ensure safe operation. The system will be able to apply multiple coats at different thicknesses while eliminating the need for reiteration.

The benefits for USAF are numerous, the chief benefits are:

- Increased A/C throughput

- More flexibility with constrained resources

- Reduces the need for materials and reduces exposure to hazardous chemicals

- Higher quality coatings and reduced rework

- Additional capacity for future workload

Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with aircraft maintenance, particularly in the aircraft painting process. Potential beneficiaries in aircraft industries alone include but are not limited to DoD components and private (domestic) airline maintainers.

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**Focus Area: Smart Manufacturing**

The Air Force seeks to improve depot-level manufacturing (components, machines, controls, software) for Air Logistics Complex (ALC) processes. Smart Manufacturing is an evolution from traditional manufacturing with the goal of optimizing concept generation, production, and product transaction. While manufacturing can be defined as the multi-phase process of creating a product out of raw materials, smart manufacturing is a subset that employs computer control enhanced by high levels of adaptability, sensing and data mining, intelligent technologies for Condition Based Maintenance (CBM) and advanced diagnostic, prognostic and reconfigurable control technologies. The term "smart" encompasses enterprises that create and use data and information throughout the product life cycle with the goal of creating flexible manufacturing processes that respond rapidly to changes in demand at low cost to the organization without damage to the environment. Typically, the concept necessitates a life-cycle view, where products are designed for efficient production and recyclability. Implementation issues are addressed via a digital twin framework supported for lifecycle considerations by a Model-Based Systems Engineering (MBSE) approach. For the Sustainment Enterprise, this holistic, life-cycle approach was not considered for legacy aircraft. Therefore Smart Manufacturing approaches must foundationally consider 1 piece lot sizes, outdated processes and materials, and random supportability problems such as last-minute requirements and late material deliveries. Smart Manufacturing enables all information about the manufacturing process to be available when it is needed, where it is needed, and in the form that it is needed across entire manufacturing supply chains, complete product lifecycles, multiple ALCs.

### Technology Areas of Interest

1. Instrumentation – Data is the essential underpinning of new and “smart” technology insertion to the manufacturing floor. Complex industrial processes are controlled by PLCs or computer control apparatus and are instrumented with sensors dedicated to the control activities. We take advantage of these sensors and complemented with devices specifically designed to monitor faults of failure modes (for example, accelerometers measuring vibration signals). The latter are necessary with their design and implementation (location in process) determined from knowledge of failure modes and FMECA++ studies. Additional sensing modalities increase the cost of the process operation, but they are necessary if we are building a “smart” manufacturing process.
2. Smart Data Mining Technologies—Converting Data into Actionable Intelligence: Many Condition Based Maintenance (CBM) technologies have failed to provide optimum maintenance strategies because of inadequate and poor choices for extracted features or Condition Indicators (CIs). Emerging Deep Learning and other AI-based techniques are exploited to derive “good” features that reduce the data dimensionality while sustaining the core sensor information. Pre-processing (improving the signal to noise ratio) and processing of raw sensor data set the stage for accurate and rigorous diagnostic and prognostic algorithms.
3. Fault Diagnosis – an incipient failure or fault must be detected expeditiously with specified accuracy (say 95% accuracy) and given false alarm rate (say 5%). The state of the art in fault detection has progressed significantly over the past years yet a rigorous approach with prescribed performance metrics is lacking capable of providing an early indication of a fault allowing for enough time to execute a prognostic routine.
4. Prognosis has been called the Achilles’ heel of CBM and related technologies (predictive maintenance) due to the inherent uncertainty entailed in prognostic algorithms. We differentiate between “health-based” and “usage-based” prognosis with the first applied in real-time when a fault condition is detected and the second used for reliability and lifecycle management purposes. We distinguish between prognosis and trending with the second associated with tracking a single variable (say temperature) until it reaches a specified threshold. Prognosis requires streaming data, a model of the fault progression, and an estimation method (Kalman filtering, particle filtering). Rigorous prognostic approaches are seeing the light in the published literature with fewer in actual application domains.
5. Digital Twin – Major industrial companies in the aerospace and other domains are experimenting with Digital Twin technologies seeking to reduce the design cycle and optimize system operation and maintenance. These emerging technologies are relatively new and success stories are needed to endow them with a degree of credibility. The fundamental prerequisites are at hand, i.e. the sensing and system modeling modalities, as well as the appropriate computing and communications facilities. It is anticipated that the future will witness a surge of Digital Twin technologies as management makes the right decisions to realize “smart” technologies in manufacturing and industrial application domains.
6. Model-Based Systems Engineering – MBSE is typically used in combination with the Digital Twin framework seeking long-term design, analysis, and optimization of a given complex system/process. Major aerospace companies are designing, and testing protocols based on MBSE. Like Digital Twin, these emerging technologies will require success stories to assign a degree of credibility to them.
7. Predictive Maintenance – We view predictive maintenance as the epitome of those technologies that will enable a smart manufacturing facility. The challenges here relate to the previous technology gaps identified above with the major one being prognosis.

### Technology Solution Options

* Smart technologies from data mining, fault detection, and failure prognosis that contributes to new methods for predictive maintenance implemented as a digital twin in Model-Based Systems Engineering framework
* Smart Predictive Maintenance-Intelligent Machine Health Management with sensored machining centers that predict failures before they occur and advise of maintenance solutions
* Live Asset Visibility to address known audit material weakness for assets on the shop floor, and reduce the effort and cost to track production progress and productivity
* Radio Frequency Identification (RFID) or similar technology that improves accountability and tracks and can report on the precise location of equipment and high-value commodities
* Artificial Intelligence and Machine Learning tools to optimize task performance and identify issues for the intervention (‘humans on the loop”)
* Smart reasoning paradigms are complementing the decision-making process and digital-twin development for improved operations and maintenance of manufacturing lines. The digital twin framework is an enabler of smart and effective design and inspection processes
* Industrial ‘Internet of Things’ to address current issues with unplanned and lengthy equipment outages, inability to optimize energy and equipment utilization, inability to identify anomalies in facilities access and breakdowns in perimeter and access controls, and the health and safety of facilities
* Real-time process monitoring –in situ part measurement - for repair operations coupled with model-based systems engineering to stop production at the point where the part repair is no longer acceptable thereby saving production time
* Augmented Reality and Virtual Reality to address productivity, capacity, and quality issues related to lack of skilled technicians, training burdens, and length of time to optimize production flow and facilities
* Digital Engineering and Manufacturing (model-based engineering and manufacturing) tools and systems to improve the integration between engineering, production, quality, and customers. Digital documentation, cloud-based industrial services, automated replenishment, individual component tracking, and data-driven quality control
* Cybersecurity and cyber resiliency for the manufacturing facility’s digital environment

Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with maintenance or production of complex end-items or systems. Potential beneficiaries include DoD and other governmental aircraft and other system maintainers, private manufacturers, and other professional services. Commercialization would increasingly extend to all sectors requiring highly adaptable, reconfigurable modes of industrial operation.

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**Focus Area: Real-time In-Situ Analysis of Chemical Bath Coating Systems for Aircraft Component Repair and Manufacture**

The 402nd Air Force Maintenance Group (AMXG) is seeking to develop a real-time in-situ analysis of chemical bath coating systems for aircraft component repair and manufacture. The sought after technology would perform automated sampling and self-clean operations, communicate with a data collection system, provide alarms when out of spec conditions arise, withstand harsh environmental conditions of plating process lines, and analyze more than 75% of process tank operations in Air Force commodities maintenance processes.

An In-situ testing technology will complement and enhance the present testing approach by providing significantly more data points and instantaneous feedback, around the clock, each and every day of the year. Automated Fourier Transform Infrared (FTIR) technologies may deliver a beneficial testing solution in this situation, provided water in solutions, and do not mask chemical concentrations. Automated Liquid Chromatography may be another beneficial technological approach to address this need. Ultraviolet, micro-fluidics, or chip-type designs may be worthy of consideration, additionally.

In-situ testing technology would compliment and enhance the Air Force maintenance laboratories’ present testing approach by:

* + carrying out continuous monitoring of solution chemistry and health
  + minimizing downtime of process tanks
  + acquiring significantly more data to more accurately predict out of service conditions
  + providing instant feedback and alarms when out of spec conditions occur

Furthermore, non-destructive inspection process lines could potentially benefit from this technology, which should additionally be considered when developing solutions and prototypes. Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with maintenance and repair of aircraft commodities or other commodities and sub-systems similarly situated within complicated mechanical and electro-mechanical systems. Potential beneficiaries in aircraft industries alone include but are not limited to DoD components and private (domestic) airline maintainers. To the extent that this system would substantially reduce the use of hazardous chemicals, beneficiaries would additionally include EPA, state-level environmental agencies, and other organizations dedicated to environmental regulation and improvement.

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**Focus Area: Wearable Heads-Up Nondestructive Inspection Instrument Display**

This Air Force is seeking a viable solution that will enable Nondestructive Inspection Instrument (NDI) performers to effectively interpret NDI instrument readings by being able to simultaneously see probe location and instrument readings. There are existing technologies for heads-up displays. However, there is not a heads-up display designed for non-destructive inspection performers and their maintenance procedures.

Currently, when NDI inspections are taking place, one has to shift their field of vision from where they are manually placing NDI sensors to inspection instrument displays. This process of continuously shifting field of vision creates limitations such as Inefficiencies and potential for missing defects (lowered probability of inspection {POI}), decreasing probability of detection {POD}, prolonged maintenance times, and reduced availability of aircraft, and decreases the probability for catastrophic failure.

The benefits of developing this technology are numerous, including:

* Decreases maintenance times and increases the availability of aircraft
* Creates efficiency for the NDI inspectors and reduces workload
* Increases POI and POD
* Significantly reduces the potential for catastrophic failure.

Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with aircraft maintenance or virtually any other activities involving assessment of structures or mechanisms requiring regular non-destructive inspections. Potential beneficiaries in aircraft industries alone include but are not limited to DoD components, FAA, and private (domestic) airline maintainers.

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**Focus Area: Ozone-Based Aircraft Sterilization**

Sterilize an aircraft in less than an hour with minimal support personnel or expertise, providing sterilization of non-line-of-sight locations within the aircraft without the need for personnel to move equipment, seatbelts, or open compartments. Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with aircraft operations. Applications of ozone-based sterilization could eventually extend to envelopes other than aircraft, such as other vehicles and buildings.

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**Focus Area** Geospatial Intelligence/3D Imaging

This Air Force is seeking a technology that will eliminate the use of outdated 3D glasses that are not ergonomically efficient for forward processing exploitation and dissemination (FPED) analysts. The 3D monitors would provide the capability to view emerging data formats that could allow our analysts to exploit information into a virtual reality or mixed-reality context. There is the potential to help maintain the life span of existing workflows while opening up new opportunities in imagery exploitation for Intelligence Analysts.

A Geospatial Intelligence/3D Imaging system will tremendously increase the efficiency, functionality, and productivity of our intelligence analysts by:

* + Providing the integration of virtual reality and/or mixed and augmented reality technologies for our Analysts.
  + Eliminating the cost of cumbersome and uncomfortable headgear that is currently being used for mission support.
  + Increasing ease of use of exploitation technology
  + Significantly reduce any chances of stress and fatigue within the average 4 to 8 hours of analysts work schedule.

Commercial applications span numerous industries and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with analysis, interpretation, and intelligence renderings of three-dimensional imaging for operational reconnaissance and planning; similar interest would extend to users in the fields of climate science, meteorology, and mineral resource research.

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**Focus Area: Development of Sulfur Hexafluoride Alternatives in Avionics Operations and Maintenance**

The Air Force seeks to develop an alternative to Sulfur Hexafluoride (SF6) in various applications on weapon systems operations and maintenance. The principal use of SF6 in military weapon systems is as a waveguide pressurization agent and coolant in radar systems, which also take advantage of the electrical insulating properties of SF6.  In addition, depot maintenance processes have historically used Sulfur Hexafluoride for arc quenching or electrical insulation in processes such as Avionics and Instrument Maintenance, Surveillance Radar Maintenance, High Voltage Assembly leak test, Radar software maintenance testing, and Testing electronic equipment/motors.

In the 3-year period from 2017-2019, Air Force (AF) depots reported using a total of 6.4k pounds of Sulfur Hexafluoride, which is considered an Emerging Contaminant and on the Environmental Protection Agency (EPA) Action List. Shop usage includes Avionics Testing, Surveillance Radar maintenance as well as consumption and detection of SF6 for E-3 Airborne Warning And Control System (AWACS). The majority of usage is at Tinker AFB, with approximately 5.5k pounds used during the same time period. A replacement dielectric fluid could be used across these maintenance processes to significantly reduce the release of greenhouse gases and contribute to global warming potential.

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**Focus Area: Detecting and Analyzing non-conformances on composite structures**

The USAF has a need to develop software capability that captures this field data and directly maps the full ultrasonic c-scan 3D dataset to 3D models to not only provide the location of interest but to also enable depth visualization. In many cases, the c-scan images within the data files must be manipulated so that accurate alignment to models can be performed. The software system must have the capability to identify and size anomalies while the user compares c-scan images with previously stored images of the same asset at prior inspection cycles. This will enable NDI technicians and engineers to identify the growth of porosity and other defects within the structure. The software must support the capability for USAF personnel to also map and track repairs/replacements to models in a similar way to the c-scan images (area and depth). Accurately mapping all this data will provide a better holistic of the structure. Finally, the software shall incorporate analytical features that leverage the image comparisons in order to precisely determine the change of any anomaly or region of interest. In addition, USAF personnel need the ability to enter flight hours, number of flights, and flight profiles, and the USAF users must be able to correlate and extrapolate future states given current c-scan or other maintenance data and known flight operations/profiles.

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**Focus Area:** Metallurgical Laboratory Artificial Intelligence

The US Air Force is seeking a method of performing thermal spray coupon metallurgical inspection that uses artificial intelligence to reduce subjectivity and expedite the inspection process.

Mission-critical components that are coated using thermal spray methods require process verification coupons to be coated simultaneously with the components. These coupons then undergo rigorous processing and inspection in the metallurgical laboratory to ascertain the coatings have achieved quality microstructure characteristics such as porosity, unmelts, oxides, integrity, etc. To measure these characteristics, specimens that have been mounted in an epoxy resin are examined with the use of a microscope such as the Zeiss Axio. The Zeiss software provides some assistance with the identification of defects, such as comparing “light” vs “dark” regions; however, the laboratory technician must still use subjectivity in making these measurements. Also, inspection of the micro-structure is still performed by a visual comparison to OEM photo standards.

A system is needed that will provide artificial intelligence to reduce subjectivity and expedite the inspection process. The system would initially “learn” as the technician performs the inspections and, in time would be able to complete the inspection without the aid of the technician except for a final review. The system would need to interface with the Zeiss Zen software. Benefits of the AI system include: A) repeatability, B) standardization between technicians and elimination of subjectivity, C) reduce time to perform inspections, D) reduce the rate of critical part recalls. The research would need to identify how this system could integrate with any existing thermal spray management processes and data. The research would also need to include identification of requirements at other DOD facilities to expand the use of the system.

The system has potential applications with any DOD repair depot performing thermal spray coating application, including the Air Force, Navy, and Army as well as commercial applications with OEMs like General Electric, Pratt and Whitney, Rolls Royce, etc. Thermal spray has many applications outside of the aerospace industry. Any component that experiences wear and/or corrosion could benefit from a thermal spray coating. Utilizing artificial intelligence to reduce subjectivity and expedite the thermal spray inspection process makes the thermal spray process more efficient for existing users and more viable for non-users to employ. This project is complementary to a number of successful ongoing research and development efforts aimed at improving the thermal spray process.

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**Focus Area: Open Software-Defined Radio (SDR) 2.0**

To implement direct data transfer from a Field Programmable Gate Array (FPGA) on an RF Digitizer card/module to a Graphical Processor Unit (GPU) through a Peripheral Component Interconnect – Express (PCI-e) bus on a general (back end) processing card/module.

The envisioned developmental outcomes are increased SDR processing power, interchangeable FPGA resource manager with any RF digitizer card, increased technology insertion/growth opportunities due to leaner SDR architecture.

The USAF is pursuing a Sensor Open Systems Architecture (SOSA) approach to address legacy and new Electronic Warfare systems design and development. This open systems approach will minimize platform-specific sub-system acquisitions, vendor-lock, and unique stove-piped systems that are often obsolete by the time they are fielded. SOSA enables rapid low-cost upgrades that will keep pace with constantly changing operational threats.

A key technology for modern Electronic Warfare (EW) systems is the Software Defined Radio (SDR). Common SDR configurations today make use of a Field-programmable gate array (FPGA) located on an RF digitizer card (‘RF Front End’) that provides data through a Network Interface Controller (NIC), to a Peripheral Component Interconnect Express (PCI-e bus) and on to a GPU located on a separate card (‘Back End’) for processing. This transfer is controlled by a Central Processing Unit (CPU) and requires that copying data twice – once to the NIC and once to the PCI-e bus – which results in unacceptably long data transfer times (latency) and an unacceptably low amount of data that can be sent in a given period of time (bandwidth). Since low data latency and high bandwidth are of primary concern in EW systems, this bottleneck is a significant product development and performance constraint that must be addressed and resolved.

This new approach will result in data being moved directly from the field-programmable gate array ( FPGA) on the RF Front End card through the PCI-e bus to the GPU on the back end-processing card. This eliminates one of the data copies, which reduces data latency and increases bandwidth.

Ultimately, this task will develop the new approach in a SOSA aligned configuration, resulting in improved performance on an open, highly modifiable system that will improve aircrew survivability against modern threats.

What other resources do you need? (Funding, policy support, manpower, senior advocacy, etc.)

SBIR Phase I and SBIR Phase II funding support

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**Focus Area: Hypersonic Vehicle Power and Thermal Subsystem Technology**

The Air Force is seeking innovative approaches to power generation and/or thermal subsystem management for hypersonic vehicles. Air-breathing and boost-glide vehicles each present unique challenges to compact electrical power generation and electronics/actuation system thermal management. Standalone and integrated technologies that reduce mass and volume, and/or provide added system capability are needed for the next generation of hypersonic vehicles. Technology areas include, but are not limited to:

* Compact auxiliary power units, gas generators, and ram/bleed air turbines
* High-temperature turbine materials and/or innovative turbine cooling technology
* High temperature, high efficiency thermoelectric, thermophotovoltaic, and thermionic electrical generators
* Passive electronics cooling (phase change, expendable, transport, etc.)
* Compact and/or structure-integrated batteries (thermal batteries, primary shelf-stable or rechargeable batteries, etc.)
* Thermally-driven power cycles and supporting component technologies
* High-temperature electronics, generators, and electromechanical actuation systems to reduce cooling needs and extend flight time (integrated circuits rated for > 400 °C, motors, and generators)

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any power and/or thermal subsystem technology applicable to the hypersonic vehicle environment that may impact future Air Force missions and vehicles.

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**Focus Area: Cyber Capabilities Center Front Door**

The U.S. Air Force (USAF) Headquarters Cyberspace Capabilities Center (CCC) is responsible for the processing and development of Air Force’s Information Technology (IT) network requirements, strategies, and assists in core service design and transition of service to ensure secure, interoperable, and effective capabilities and services are delivered to warfighters in time of need. Currently, there is no central/single location/organization where Air Force users and organizations can request changes to the IT infrastructure/services. The CCC is chartered to create a one-stop, “Front Door,” where customers can go to submit IT requests for service or change. This front door needs to be able to guide users through multiple types of requests, provide immediate feedback if critical information is missing, sort the requests automatically into one of several areas via an automated gatekeeper like system. Also, the capability must provide users the status on where they stand in the process, how long they have been at the current step, and what steps remain. On the backside, the more than 980 technicians, engineers, and approvers need the ability to request additional information from the customer, as well as seeing the status updates, and receiving notifications on when there is an action they need to take. For this Focus Area, we desire a proof of concept built to handle external firewall requests, just one of many different types of requests, with the ability to expand the program’s capabilities later.

Technology Areas of Interest:

* Website / web application
* Workflow automation
* Application development
* Customer support chatbot, help interface, Searchable Frequently Asked Questions.

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**Focus Area: Propulsion, Power, and Thermal Management Systems**

The Air Force is seeking commercial innovations to air-breathing propulsion, power, and thermal management systems for manned and unmanned vehicles. Applying digital engineering, additive manufacturing, advanced sensors, and heat exchangers will help the Air Force soar higher, faster, and more efficiently. This is intended to be an open call for air-breathing propulsion, power, and thermal system ideas and technologies including, but not limited to those listed below:

* Rapid Manufacturing and Prototyping
* Digital Engineering and Modeling of Complex Systems
* Ignition Systems
* Heat Exchangers
* Sensors
* Small Engine Materials and Designs
* Controls and Prognostics

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**Focus Area: ABMS Sensor Systems**

PEO Digital is interested in distributed and mobile sensor systems that can be integrated with other ABMS components. Integrating sensors and systems with ABMS requires an open Application Programming Interface (API) so that data and control can be communicated between connected systems. PEO Digital interest in sensor systems is focused in the following areas

* Unmanned aerial systems (UAS) that operated autonomously or cooperatively in swarms
* On-board processing in distributed and mobile sensors
* Distributed ground-based sensor networks for detection and tracking of UAS and small aircraft using active (cognitive radar, LIDAR) and passive (visual, IR, RF) detection and tracking

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**Focus Area: Low Observable Sustainment**

A focus area for Low Observable Sustainment is needed to support the 5th Generation and future weapons systems.  Low Observable systems are complex and historically require both time and labor-intensive practices to maintain and sustain them.  A need exists to bring technological advancements to address the areas of more durable materials, simpler and faster repairs, and more streamlined inspection methods. Examples of areas of interest include the following:

* Material solutions for aircraft outer mold-line (OML) coatings, energy-absorbing materials, tapes, pastes and gap fillers that are more durable and easier to repair
* More durable consolidated topcoat that includes rain erosion coating
* OML inspection technologies to reduce inspections times and improve accuracy for OML damage identification and characterization
* Coating removal technologies that reduce time and labor required to remove OML coatings
* Improved film adhesives or pressure-sensitive adhesives
* Streamlined application processes for materials

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any technology that may impact future LO sustainability improvements.

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**Focus Area: The Cyber Resiliency Office for Weapon Systems (CROWS)**

CROWS is an Air Force level, interdisciplinary organization established under the Assistant Secretary of the Air Force (Acquisition, Technology & Logistics) to ensure Air Force weapon systems can perform their missions in a cyber-contested environment.

We partner with acquisition, operational, and test communities to assess the fielded fleet and with Program Executive Offices to prototype mitigation solutions. We also deliver tools, cyber-focused intelligence, a common security environment, education, training, and a cyber-savvy workforce to program offices—providing them the capability to do for their systems what CROWS does for the Acquisition Enterprise.

We operate at every stage of the acquisition life cycle from development planning through sustainment.

MISSION - Increase cyber resiliency of Air Force weapon systems to maintain mission effective capability under adverse conditions.

GOALS - Bake cyber resiliency into new weapon systems.  Mitigate critical vulnerabilities in fielded weapon systems.

VISION - Cyber resiliency embedded into Air Force weapon systems and ingrained in Air Force culture.

**Problem Statements**

1. How might we enable operators to **e**ffectively detect, monitor, and protect weapon system platforms’ information flows while considering a contested operating environment, as they aim to securely communicate, navigate, and execute mission objectives?
2. How might we alert an operator when a system deviates from normal operations while considering architectures that utilize real-time operating systems, limited processor and memory resources, SWAP constraints, and various bus protocols?
3. How might we prevent unauthorized users from accessing operational data through encryption of a system’s hard drive without causing significant processing delays while protecting the integrity of the data?
4. How might we authenticate users of automatic test systems in a disconnected environment to meet cybersecurity challenges?
5. How might we emulate the performance of aircraft hardware components to assess the integrated system performance of software without hardware-in-the loop?
   * How might we characterize threats without ambiguity or delay?​
   * How might we rapidly search massive data sources for valuable information presentation?​
   * How might we consolidate data analysis and assess emerging threats?​
   * How might we integrate multiple and cross-classified data sources?

**Technologies of Interest**

* **Communication:**
* Reliable Air-Space and Air-Ground Laser Communications
* Multi-level secure communication
* Secure Multi-band Antenna
* Satellite signal and location detection
* Civil aviation data link protections (i.e. Aircraft Communications Addressing and Reporting System (ACARS), Controller–pilot data link communications (CPDLC), Automatic Dependent Surveillance-Broadcast (ADS-B), Automatic Dependent Surveillance-Contract (ADS-C, etc.)
* **Cyber:**
* Laboratory-based cyber test and cybersecurity tools
* Cyber Test Bed concepts
* Cyber Configuration Management for Firmware and Software
* Intrusion Detection
* AI-based malicious behavior detection
* Analytic decision tools, including ingesting existing and untapped data resident on/in weapon systems to better understand and predict aircraft, munitions, and equipment condition during operation and prior to induction into major inspection and maintenance (i.e., AI/ML, etc.)
* **Interfaces & Protocols:**
* Standards for secure interfaces/instantiation
* Securing open protocols and encryption
* Software-defined infrastructure security
* Evolving standards; promote openness and community participation.

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**Focus Area: Develop novel approaches to detect fake images such that the source of generation is inconsequential**

We are seeking to develop novel approaches to detect fake images such that the source of generation is inconsequential.

Misinformation and deception is not a new problem in the collection and analysis of intelligence data. However, the use of deep neural networks to synthetically generate very realistic fake multimedia, referred to as deepfakes, has become a serious issue within the Department of Defense (DoD). This issue is further compounded by the DoD’s recognition of the importance of Open Source Intelligence (OSINT) collection and processing. Open-source information can be extremely valuable in cueing intelligence collection and operations, as well as identifying events, activities, and patterns that other assets are not specifically looking for [1]. In fact, according to Lt. Gen Jack Shanahan, director of the Pentagon’s Joint Intelligence Center: deepfakes are a national security issue, and the Department of Defense needs to invest heavily in technology that can counter it [2].

As a result, the DoD has invested in programs like the Defense Advanced Research Projects Agency (DARPA) Media Forensics (MediFor) program and Semantic Forensics (SemaFor). MediFor is “…developing technologies to automatically assess the integrity of an image or video and integrating these in an end-to-end media forensics platform [3]”. SemaFor’s objective is to “…develop innovative semantic technologies for analyzing media. These technologies include semantic detection algorithms, which will determine if multi-modal media assets have been generated or manipulated. Attribution algorithms will infer if multi-modal media originates from a particular organization or individual. Characterization algorithms will reason about whether multimodal media was generated or manipulated for malicious purposes [4].” These programs and current research has focused on specific weaknesses in the generation of the synthetic data. An assortment of papers looks at various indicators of deepfakes including abnormal blinking patterns [5], facial warping [6], inconsistency between speech and mouth movement [7], and unnatural facial expressions and gestures [8]. While this research will undoubtedly produce better detection algorithms, it is unlikely that it will produce software that will detect all current and future deepfakes. Built into the technology is a discriminator, which determines if the generated data looks real or fake. This ensures that the algorithms can include any synthetically detectable activity and correct it, thereby guaranteeing more sophisticated fakes. Therefore, any approach that is developed must not focus on such artifacts. Instead, the focus should be on developing detectors that can identify more fundamental issues with the synthetic generation of the data.

Currently, there are several papers that investigate the possibility of a general detector for fake imagery. The research found that generative adversarial networks (GANs) leave unique fingerprints [9] but have not turned this information into a generalized detector. Despite the variations in architecture and the commonality of leaving fingerprints, one would think there is a commonality among generators, among fake imagery. This proposal seeks ways of creating a general detector of fake imagery, whether it be by investigating the filters/layers of the GANs, counter adversarial learning techniques, image/video forensics, more robust fingerprint, etc.

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**Focus Area: Cyber-secure Wireless Armament Testing Capability**

Deliver a solution that eliminates the armament tester cables through the development of a cyber-secure, wireless testing method. This technology will need to eliminate the tester cables used during Armament testing as part of the maintenance process.

These cables create many issues, such as:

* + High failure rates
  + Expensive to repair
  + Heavy, hard to maneuver when testing
  + Trip Hazards

There is potential for this to be performed wirelessly through a combination of two wireless devices (transmitter and receiver on the aircraft and tester unit). Cyber secure, wireless technology for armament testing would compliment and enhance the Air Force maintenance process tremendously by :

* + minimizing high rates of failure caused by the cables
  + saving a great amount of cost due to the expensive cables
  + Significant reduction in logistics footprint (Cables are 50% of testing package)
  + Increasing ease of use with the absence of heavy cables
  + eliminating trip hazards for the maintainers.

Discovering a technology solution to this cyber-secure wireless armament testing capability can potentially lead to innovation for the Army and Navy with their armament testing. It can be applied commercially wherever cables are currently being used to execute testing. The electronics industry is vast and can see great benefits from this solution.

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**Focus Area: Hardware-In-the-Loop (HIL) Test Technology**

The Air Force requires the ability to integrate munition guidance, navigation, and control technologies and establish design viability in a ground test environment before fielding weapon demonstrations or updating operational systems. This is a critical part of the development and sustainment process that requires continual HIL test technology development to maintain pace with the leading edge sensors, algorithms, and architectures being evaluated. Proposed Focus Area technologies must be relevant to munition technologies currently under development or known technology limitations within the following areas:

Real-time Scene Phenomenology Modeling  
 Hypersonic Sensor Effects  
 IR, UV, Visible, Polarization Return Models  
 Active and Passive Radar Simulation Techniques  
 Background, weather, atmospheric Simulation  
 Target Variations for Algorithm Training

Physical Target Simulators  
 Scene Projection – Radiometric, Temporal, Spatial Correctness  
 RF Target Simulation for Imaging Radars   
 Multi-Modal Scene Simulation – Multi-band, Active, Passive, Semi-Active  
 Hyper-spectral Scene Simulation

Flight Motion Simulators  
 High-Bandwidth Motion Simulators  
 Composite, Low-inertia Gimbals  
 Target Motion Simulators  
 Wide Field of View Test Systems

Airframe and Environment Modeling  
 Fin Actuator Testing  
 Fluid Thermal Structural Interaction Models  
 Alternate Navigation Simulators  
 Space Environment Simulators

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**Focus Area: Advanced Battle Management System (ABMS) Infrastructure**

ABMS is the USAF vision for interfacing with the Department of Defense Joint All Domain Command and Control (JADC2) architecture. Successful implementation of this vision requires the infrastructure necessary for designing, building, operating, and maintaining these interfaces and applications. Program Executive Office (PEO) Digital is interested in ABMS infrastructure components, with emphasis on those listed below.

* Interface Management: The ABMS vision is based on the agility derived from system interfaces (especially the Application Programming Interface (API)) that are secure, discoverable, and reliable. Interfaces on ABMS systems need to meet these requirements throughout their lifecycle. Solutions for this focus area include
  + API validation and test
  + Operational API management – load balancing, proxying.
* Distributed Authentication and Authorization: With queries and taskings flowing across system boundaries the existing identity management and role-based access control may need to be enhanced to improve its flexibility and responsiveness. For example, access to data should be limited based on operational considerations, but that access needs to be as flexible as the ABMS system’s ability to allocate resources. For example, if an operator in one domain requires information from a sensor that is outside his operational area, authorizations are needed to approve that use and those authorization need be managed effectively
* Confidential Computing: There are well-established ways to provide protection for “data at rest” and “data in motion”. Protecting “data in use,” though is especially tough because applications need to have data in the clear—not encrypted or otherwise protected—in order to compute. But that means malware can dump the contents of memory to steal information. A Confidential Computing Consortium aims to define standards for confidential computing and support the development and adoption of open-source tools. This focus area involves evaluating the state-of-the-art on confidential computing technologies such as a Trusted Execution Environment (TEE) for applicability to securing execution environments.

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**Focus Area: Multi-Function Sensor for Advanced Search and Rescue**

Description: The Special Warfare community has a national defense-related search and rescue mission need in the area of multi-function sensors to be able to quickly and accurately determine atmospheric and water conditions from the open-ocean environment (intended drop zone area) back to the aircraft and/or Recovery Team (RT). This data will then be used by jumpmaster and/or aircrew in preparing for the aerial insertion of RT and/or cargo parachute equipment during open water rescue operations. Technology development in the area of Atmospheric Dropsondes and buoys has progressed significantly over the last couple of years but an integrated system does not exist. This idea/requirement has gained momentum in the last 12 months after a downed pilot perished due to the inability of the rescue to team reconcile atmospheric data with actual sea state (wave height and drift).

The goal of this is to research and develop devices, techniques, communication protocols, and the potential integration of this information into a single system for use by maritime recovery teams.

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**Focus Area: Reduction of SOF Operator Cable Tangle Hazards**

Description: Special Warfare operators are required to carry a significant amount of equipment to support their missions. Stable communications, sufficient power, and reliable power distribution systems are critical to the success of any mission. However, the price that is paid to ensure this occurs is that operators are often loaded down with dozens of bulky cables that create potentially dangerous situations relating to tangle hazards. Reducing the possibility of tangle hazards is a top operator requirement. With technological advances, one primary solution involves the implementation and/or creation of safe wireless personal area networks that cannot be detected or intercepted.

The goal of this project is to research and develop techniques, devices, and processes to ameliorate the problem of tangle hazards using wireless solutions. Advancements in commercial wireless standards, including WiGig (IEEE 802.11ad) at 60GHz and other “5G” wireless standards, show promise to provide this secure communications backbone but require additional development to perform reliably in the Air Forces operational environments. These 5G wireless technologies are available at very low cost compared to existing military solutions and have a reliable supply and logistics chain because of their use in consumer electronics. Recent work has shown promise for a Low Probability of Intercept/Detect (LPD/LPI) 60GHz personal area network for individual soldiers. The 60GHz signal provides extremely high-bandwidth communications channel as well as inherent LPI/LPD qualities due to its absorption by oxygen molecules, but the consumer-grade 60GHz radio modules are not suitable for use within the Special Warfare community without modifications such as additional processing capabilities, upgraded encryption schemes, ruggedized connectors, and packaging compatible with operational environments.

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**Focus Area: Advanced Ordnance Architectures**

The Air Force Research Laboratory Munitions Directorate Ordnance Division (AFRL/RWM) seeks innovative approaches to the development of Advanced Ordnance Architectures to provide increased survivability, lethality, and effectiveness to our ordnance systems. This list includes, but is not limited to, the following:

* Controlled Manufacturing Processes (Additive/subtractive manufacturing, lithography, etc.)
  + Scalability to produce large pieces/quantities fast
  + Tailorable structures (e.g., manufactured fragmentation)
  + Graded functionalities/compositions through cross-section
  + Blending/bonding dissimilar materials – same or different classes (i.e., polymer-polymer vs polymer-metal)
  + Composite mixing while printing
* Machine Learning (ML) Enablers
  + Parameters/prerequisites to create/curate ‘good’ data
  + Identification/application of suitable ML techniques
  + Predict precursor materials to achieve specific properties
  + Prediction of final material properties of heterogeneous mixtures
  + Prediction of weapon effects (i.e., shock-induced mechanical failure, penetration capability of fragments)
* Dynamic Modeling & Simulations (M&S)
  + M&S of shock & blast events (pressure, temperature, impulse predictions)
  + Models of natural fragmentation/strain localization
* Diagnostics
  + In-Situ AM process monitoring
  + Pressure & temperature measurements (microsecond time resolution)
  + Blast quantification gram -kilogram quantities

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**Focus Area: High Power, Midwave Infrared Single Device Quantum Cascade Laser**

The goal of this topic is to optimize the QCL (quantum cascade laser) technology in the 3.8μm to 4.2μm spectral band for increased wall plug efficiency and output power without sacrificing beam quality in CW (continuous wave) operation for single QCL devices. Incoherent quantum cascade emitting devices such as quantum cascade super luminescent emitters are also acceptable for this topic. Combined QCL devices is not an acceptable solution – single devices meeting the requirements is the goal.

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**Focus Area: Nondestructive Evaluation and Usage Monitoring**

Nondestructive Evaluation (NDE) techniques are a critical capability to ensure the safety and operation of existing systems, as well as the certification of upgraded and future systems. NDE is widely employed to inspect and characterize features in systems with the objective of minimizing disassembly or damage to the component being assessed. In systems intended for extended use, this capability must be integrated into sustainment operations, whereas for systems with limited time use, it should be sufficient to monitor the usage of the system to ensure its safe operation from a structural integrity perspective. Therefore, capability developments for these applications will be a function of their intended use as one solution does not necessarily address all systems. As USAF systems continue to age and as new systems require more complex materials, the need for these assessments continues to grow. The key attribute of this focus area is to reduce the overall time and cost of such assessments and to simplify and improve the accuracy of testing procedures. Examples of areas of interest include the following:

* Structural assessments that minimize disassembly
* Assisted analysis and execution of NDE processes, and procedures
* Whole field inspection methods, especially for turbine engine and landing gear components
* Replacement of legacy measurement methods that provide relatively crude measures of merit
* Qualification assessments of new materials or processes
* Usage monitoring systems for limited time use systems, data analysis, and quality control

The technical areas highlighted above are not meant to be exhaustive as this focus area is designed to be an open topic for any high-performance NDE-based technique or system.

The capabilities being requested from this solicitation have broad commercial applicability beyond the Department of Defense. Applications include civil aviation to ensure the safety of commercial airlines. However, the capabilities are also relevant for NDE and usage monitoring of oil and gas industries, such as the assessment of pipelines, plus power generation industries for large industrial turbines and other infrastructure, including nuclear power cooling systems. These industries have a broad range of NDE requirements, and technologies being solicited will impact the effectiveness in finding flaws of interest and efficiency in doing so faster and at lower cost. Another potential application that requires periodic NDE assessments and loads monitoring include civil infrastructure, such as bridges. Typical end-users of the solicited capabilities

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**Focus Area: Using Artificial Intelligence to Empower Legal Professionals Advising on Targeting Decisions**

The pace of future conflict is rapidly increasing. As both the United States and near-peer competitors deploy and arm more autonomous vehicles (including aircraft), these systems may prove able to observe-orient-decide-act faster than human operators and advisors. This is especially critical for decisions related to targeting, the use of force, and the concomitant compliance with the law of armed conflict and international humanitarian law. In a world where decision-making can take place at computer speed, where does that leave the flesh-and-blood legal advisor?

To that end, this focus area is looking for solutions that would provide an AI assistant, operating at computer/internet speed, to provide advice, guidance, and instruction to legal professionals advising commanders on the use of force decisions. More specifically, the AI assistant would support decision-making inside an air operations center, both during deliberate and dynamic targeting phases. Ideally, the system would incorporate both the deep expertise available from many legal professionals currently providing this advice and integrate with real-time or near-real-time feeds of data coming in from operations. Further, the AI assistant should be able to explain its reasoning (aligning the facts with the law) and supply a confidence value related to each recommendation, including multiple possible outcomes. Lastly, the AI assistant should have an easy-to-use interface, ensuring that the guidance provided to the legal professional is timely and relevant.

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**Focus Area: Global Positioning System Monitoring System (GPSMS)**

GPSMS seeks technical solutions related to a near-term, low-cost, deployable device capable of detecting and reporting inappropriate denial or deception of GPS signals. Solutions must monitor GPS L1 C/A, L1 P(Y), and L2 P(Y) signals in space, with a pathway to upgrade to GPS L1, L2 M-Code, L1C, L2C, and L5. The solution should adhere to principles of modular open systems architecture and must be capable of being transported, stored, operated, and maintained at any USAF aircraft operational facility worldwide.

If technology demonstration is successful, the GPSMS effort anticipates user interest and support for operational user assessments via the Joint Navigation Warfare Center (JNWC) and/or AF Special Operations Command (AFSOC), which have each expressed interest in a GPSMS capability as described above. The transition pathway will require a program sponsor to conduct the operational assessment.

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**Focus Area: Confined Space Fuel Tank Coating and Sealant Removal Method**

Various lasers and other nonconventional paint and sealant removal methodologies have been tested on aerospace substrates for decades. Present technologies are known to ablate organic coatings from a solid directly to a gas, capturing contaminants at the point of ablation. Technologies are known to contain motion/thermal/distance sensors for control of process parameters.

The Air Force is seeking technology that allows for substantially increased worker comfort by potentially eliminating the need for respirators and Tyvek suits in some confined spaces of the aircraft. This technology could eliminate 99+% of all waste products by ablating the coatings and sealants into a vapor and running them through an advanced filtration system. The technology could be substantially safer and more ergonomic than the current methodology of coating and sealant removal.

This project requires:

* Approved test plan
* Satisfaction of all testing requirements levied by approval authorities,
* Demonstration on an actual aircraft
* Delivery of ready-to-use system

Commercial applications span numerous industries, and broad interest is expected from both governmental and private entities, within the U.S. and abroad, concerned with aircraft maintenance and manufacturing, especially from a human health and safety perspective. Potential beneficiaries in aircraft industries alone include but are not limited to DoD components, FAA, and private (domestic) airline maintainers and manufacturers. Commercialization would increasingly extend to sealant application to other systems and mechanisms.

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**Focus Area: F-16 Emergency Power Unit (EPU) fuel/catalyst replacement**

NASA has tested two ‘Green’ propellants; however, with the current catalyst, it requires preheating of the catalyst bed which may not be possible in an emergency situation. The Air Force would like to develop a more reactionary catalyst for two ‘Green’ monopropellants. The Air Force hopes that catalyst and monopropellant can be as close to a drop-in replacement for hydrazine. NASA has developed replacement propellants for hydrazine; however, the new propellants tested in F-16 EPU failed at lower operating temperatures. The Air Force hopes to:

* Research and develop new catalysts that would catalyze the new propellants at low operational temperature
* Replace a hazardous propellant w/ safer propellant(s)
* Reduce the operational weight of aircraft
* Improve environmental impact with safer propellant(s)
* Seeking drop in catalyst to replace current iridium (rare earth metal) based catalyst for hydrazine.

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**Focus Area: Sensor Data Exploitation for future ISR Sensors**

The goal of this topic is to research and develop techniques and processes for data exploitation for onboard applications. New proficiencies in our adversary’s technologies have created challenging targets for our sensors to detect and identify targets of interest. Future ISR sensor efforts will combine multiple modalities of sensors (Signals, Infrared, Hyperspectral, LIDAR, RADAR, etc.) to assist the warfighter by improving capabilities in detection, classification, and identification. Data exploitation strategies and techniques are needed to process the data produced by these various sensor modalities, both individually and in combination (or fused), in order to best support The warfighter in detecting, classifying, and identifying targets of interest in both real-time and post-processing settings.

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**Focus Area: Air Force Cyber Systems and Process**

The Air Force is seeking cyber-related commercial innovations to improve our Cyber posture regarding CI/CD platforms and enterprise services architectures in application like LevelUP. The areas include, but are not limited to

* Securing and hardening software containers--automated, portable, and secure hardening process
* Employing zero-trust model (Service Mesh)--securely and efficiently--in a DevSecOps Software Factory and Production Environment (containers and microservices)
* Architecting/designing/building a container and microservices-based distributed enterprise platform to support Artificial Intelligence and Machine Learning
* Cross operation system malware detection and defense
* Blockchain technology to secure software chain of custody
* Employment of avocado security model in a container and microservices-based platform/environment,
* Software-based/virtual Cross Domain Solutions that support moving software containers (binaries) from low-to-high in an automated fashion without modifying containers or code in containers
* A multi-factor enabled (CAC) collaboration service that is able to prioritize communication via chat, voice, or video-based on bandwidth conditions, and support distributed, intermittent, and limited bandwidth connections
* Situational Awareness

The technical areas discussed are not all-inclusive and this focus area is designed to be an open topic area for any Cyber technologies that may impact present or future Air Force missions.

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**Focus Area: Artificial Intelligence-Enhanced Atmospheric Optics Sensing for in-situ Turbulence and Refractivity Forecasting & Predictive Modeling**

Although adaptive optics has proven useful for both imaging and propagation of light through the atmosphere, the dependence of optical wave characteristics on a diverse set of atmospheric phenomena represents one of the most serious technical challenges for various military electro-optics, HEL DE and remote sensing platforms. The existing understanding and knowledge necessary to enable accurate prediction of the impact of atmospheric effects on laser beam and image propagation is either insufficient or even absent. This has been clearly indicated by strong mismatch between theoretical predictions and measurement results obtained in several recently performed laser beam propagation experiments and simulations especially in deep turbulence conditions and long-range distances.

The recently emerged artificial intelligence-based data processing framework provides opportunity for in-situ fusion and processing of multiple data streams coming from various sensors (e.g. meteorological sensors, scintillometers, sonic anemometer, wavefront sensing and differential image motion systems, etc.) to facilitate on-board information processing, data fusion, reduction, mining, interpolation and extraction. The solicitation is focused on technologies and concepts for:

* Integration of atmospheric sensors for in-situ measurements of atmosphere turbulence
* Deep learning-enhanced analysis of atmospheric optics effects
* Validated AI based processing approach
* Demonstrations of concepts in laser beam propagation experiments or imaging experiments
* Applications of these techniques DoD HEL weapon, remote sensing, free space communication and surveillance systems.

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**Focus Area: Brain Machine Interfaces for Intelligence, Surveillance, and Reconnaissance**

Objective

*Design, develop, and validate a multi-modal brain-machine interface (BMI) that simultaneously operates for both active and reactive actuation in an intelligence, surveillance, and reconnaissance (ISR) task environment.* Here, ‘multi-modal’ refers to the desire to demonstrate concurrent interaction of both active and reactive BMI paradigms. In this context, we define an active BMI paradigm as an internally driven processes where the user must volitionally modify brain signals to control an item of interest, such as a menu selection item on an ISR-relevant software interface. In contrast, a reactive paradigm is defined as an externally driven process where the presence of a stimulus, such as a potential ISR target, elicits a brain-based neural response that can be used for control and/or provide useful information. Proposers may consider ‘hybrid’ BMI architectures that facilitate the integration with other physiological and behavioral (e.g., eye tracking) technologies to inform the BMI if necessary to achieve the multi-modal interface. The task environment should focus on analysis of full-motion video (FMV) wherein active and reactive paradigms are used for both actuated control of the video interface and aid in target detection and/or identification from the FMV.

Background

The demand for Intelligence Surveillance and Reconnaissance (ISR) products within the Department of Defense (DOD) and Intelligence Community (IC) has exponentially increased over the last 15 years of operations. In support of these efforts, ubiquitous airborne sources (e.g. drones) provide valuable tactical information using full motion video (FMV). The increase use of FMV, more advanced sensor platforms, and fusion of data from other sensor systems/data sources has led to an overabundance of information operators must sift through to identify potential threats and actionable information.

A need, therefore, exists to accelerate the ability to process FMV and/or reduce the workload on operators processing images. Researchers have made significant progress developing technologies surrounding operators such as automated analysis tools and sophisticated image processing algorithms. These human operators, however, still play a role in the decision pipeline and ultimately must make decisions on actionable information. This is largely due to the strength of the human brain to rapidly identify actionable ISR-relevant objects in FMV from various contexts.

Past work has exploited this strength using electroencephalographic (EEG)-based technologies. Using static images, the Neurotechnology for Intelligence Analysts (NIA) program demonstrated a 10-fold increase in image analysis throughput without the loss of target detection sensitivity compared to standard operator performance. Similarly, the Cognitive Technology Threat Warning System (CT2WS) program demonstrated a two-fold increase and reduction in performance and workload respectively during threat identifying from real-time surveillance operations1. These efforts relied on reactive BMI paradigms, such the use of the P300 during rapid serial visual presentations.

In contrast, active BMI paradigms rely on internal volitional control of brain activity, which researchers have used for 3D control and simple task manipulation in academic communities. Applications that use this paradigm for ISR, however, remains limited. We predict that combining active and reactive paradigms will lead to further enhancements in FMV analysis beyond what is currently available. To this end, we are soliciting the design, development and validation of a multi-modal BMI for FMV analysis as described in the above objective statement. We desire validation of a prototype that can be easy-to-use and meet user acceptability in a relevant task environment.

Milestones

· Identify target for improvement in FMV analysis process that can be addressed using multi-modal BMI approach

· Identify/develop relevant experimental task/task environment (RTE) that accurately represents target area of improvement

· Develop reactive BMI algorithm(s) that can be applied to FMV RTE

· Develop active BMI algorithm(s) that can be applied to FMV RTE

· Integrate reactive and active BMI algorithms into multi-modal BMI

· Demonstrate enhanced performance in RTE

· Develop and validate user-friendly prototype in RTE

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