Topic 1: Multi-Functional, High-Temperature Materials and Structures

Technical Discipline: Materials, Structures, and Manufacturing (MSM)

Introduction

The Joint Hypersonics Transition Office (JHTO) is soliciting innovative research proposals in the area of multi-functional thermal protection systems (TPS). Multi-functional, in this case, refers to features or capabilities beyond the main function (thermal management, oxidation/ablation resistance and structural integrity) that a TPS traditionally provides to a hypersonic vehicle. Examples could include, but are not limited to, power generation, sensing/transmission, drag reduction, propulsion enhancement, or enhanced lethality. Successful multifunctional systems will be demonstrably more efficient/effective than separate instantiations of the functions. Multifunctional approaches for this solicitation should be broadly applicable across different hypersonic platforms including boost-glide and air-breathing cruise vehicles.

Background

TPS serves as either an insulator over a cold structural frame or a hot structure that carries structural, aerodynamic, and thermal loads [1]. Although there is ongoing research on improving the thermal ablation resistance, this solicitation seeks to move beyond the thermal and structural functions of TPS systems and impart additional functionality by adjusting either locally or globally the composition and/or architecture of conventional TPS materials, in order to perform additional capabilities as outlined in the Description/Scope section. Currently these capabilities are incorporated as individual components, each demanding their own space and presenting opportunities for failure at integration points. Combining these capabilities within the TPS could solve these challenges and create a more efficient system. Integrating additional functions with TPS could greatly improve vehicle versatility and effectiveness.

For hypersonic platform design, it is important to consider that: 1) minimizing weight and volume help maximize speed and range, and 2) all components are intimately linked such that the performance of each subcomponent affects the performance of the system. Components that are multi-functional can potentially lead to weight and volume savings, enhanced subsystem performance, or reduce the need for failure-prone, bulky joints between different subcomponents. The challenge is that the physical properties required for multi-functionality are often competing; for example, a material with low thermal conductivity (for insulation) may have poor electrical conductivity (for sensing or data transfer), or a material with a high melting temperature (for ablation resistance) may have poor transmittance (for windows or apertures). These competing characteristics are often intrinsic material properties that stem from composition, crystal structure, or material architectures. Achieving multi-functionality will require new approaches such as novel compounds or unique combinations of materials and architectures. However, for realistic insertion into a hypersonic platform, it is critical that the multi-functional TPS solution be capable of being fabricated at the scale and contour of the relevant final component.

Description/Scope

A multi-functional TPS is not a combination of parts that achieve individual functions; rather it is a single system that achieves one or more functions in addition to providing thermal protection. Examples of multi-functional TPS include but are not limited to the following: (Note: no priority is assumed in the ordering of these examples.)

- TPS that can function as a heat exchanger where the transmitted heat can be repurposed for power generation or alternative methods for storing/syncing thermal energy;
- TPS with integrated sensors and components that can measure environmental responses, transmit data, and respond to stimuli, including integrated morphing capability or other means of flowfield modification;
- TPS that can contribute to lethality or kinetic end effects;
- TPS that can also serve as a window or radome (TPS that is transparent in defined wavelengths).

Although actively and passively cooled TPS (e.g., heat pipes or transpiration cooling) is of interest and could be included in the solution set, it cannot be the additional function of the TPS. Multi-functionality in this solicitation must address functions beyond thermal control.

To fully explore the complexity of the multi-functionality of the TPS system, teams from multiple disciplines may be required. In order to advance the technology, testing will be required to demonstrate performance. Guidance performance metrics of the thermal protection are provided in Table 1; the multifunctional capabilities should not degrade these metrics. Values are expected to be measured in air or a representative environment. Characteristics and metrics for any secondary functions must be clearly described; proposers are encouraged to consult with an industrial or DoD partner for specific representative values for the additional function(s).

Table 1. Guidance for TPS Performance Metrics.

	Performance Metric	**Value**
Thermal Properties	Max OML Temperature	≥ 1200 °C
	Max IML Temperature	≤ 600 °C
Structural Properties (at RT)	Test Time	≥ 2 minutes
	Tensile Strength	≥ 20 ksi
	Compressive Strength	≥ 15 ksi
	ILT Strength	≥ 0.5 ksi

ILT = interlaminar tensile; IML = inner mold line; OML = outer mold line; RT = room temperature

Proposals should include:

- A detailed description of the additional function(s), the target goals of the additional function(s), and a quantitative discussion of why the chosen multi-functional approach is more advantageous than separate components.
- Quantitative details (e.g., models, studies, or experimental evidence) that illustrate the

viability of the proposed multi-functional TPS solution.

- A detailed description of the fabrication methods and candidate materials capable of producing the proposed concept at both the coupon-scale and full production-scale, as well as metrics for down-selection.
- Identification of the bench-top screening and methods for testing of a relevant geometry that can measure performance metrics for both thermal management and the additional function(s).
- The proposed program schedule, including screening and final testing of a relevant geometry.
- Identification of any modeling and simulation that will be used to guide and support validation of TPS performance.
- A description of the plan to fabricate a demonstration component that is both relevant in scale and in geometric shape.

Screening tests may be small (1-2 inch) flat coupons, but proposers must clearly outline the feasibility of fabricating the solution at the relevant scale and geometry of a final component. The selected fabrication method must therefore be safe, scalable and would ideally be transferable into current industrial processes to enable transition of the multi-functional component. A representative part, which was parameterized from a design project by Materials Research and Design (MR&D) and C-CAT, is shown in Figure 1.

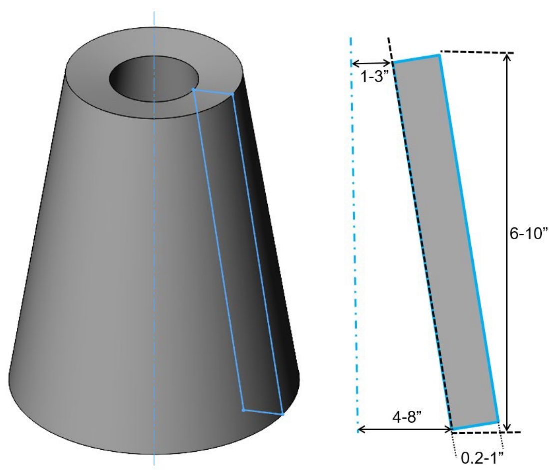

Figure 1. Notional geometry for aeroshell component. Numbers are parametrized and should be considered as guidance on final demonstration article size and complexity.

Proposals should outline plans for assessing functionality and performance against design and materials specifications. Component or material screening may include any appropriate standardized tests, number of statistically relevant samples, failure margins/criteria, and destructive and non-destructive evaluation methods.

Milestones / Deliverables

Along with deliverables described in Section 1.1, the following are minimum deliveries expected for this program:

- Performance analysis of the multi-functional TPS and the relevant models, simulations and data from a fundamental physics approach or from a design and structural approach used to assess performance.
- Screening test results verifying performance of the multi-functional TPS on coupon or plate test articles.
- An analysis of fabrication scalability clearly outlining the path for full-scale production.
- A multi-functional TPS demonstration article with complex geometry (≥1D curvature, see Figure 1 for an example)
- A final report with a detailed assessment of the fabrication and characterization of the multi-functional TPS including all test data and analysis.

Milestones should be established that are commensurate with proposed schedule of deliverables. A successful technical outcome may lead to the opportunity to seek follow-on funding to test the multi-functional TPS demonstration article with complex geometry.

Topic 2: Effects of Flow Interactions on End Game Control Effectiveness

Technical Discipline: Aerodynamics and Aerothermodynamics (AERO)

Introduction

The Joint Hypersonics Transition Office (JHTO) is soliciting innovative research proposals that enable revolutionary advances in multi-fidelity Modeling and Simulation (M&S) tools that can quantitatively assess control surface performance during extreme maneuvers at hypersonic speeds and altitudes lower that 80,000 feet. Advances in M&S tools will enable the development of force and hinge-moment requirements for faster response control-surface deflections, which increase maneuverability. This effort will provide updated M&S tools validated by ground testing and will support the leap-ahead capability of robust operation in adverse environments.

Background

In the hypersonic end-game environment, aerodynamic control geometries (e.g., wings, tails, canards, elevons) create very complicated flow interactions on the hypersonic vehicle. Wings, tails, and canards usually consist of planar fins with specific airfoil geometries that have material and leading-edge considerations for extreme hypersonic heating. Elevons on the trailing edge of rigid wings/fins are an alternative to provide trim and maneuverability.

Understanding and predicting these complex flow interactions is essential for designing vehicles with the desired maneuverability at these extreme conditions. Current integrated guidance and control simulations employ complex six-degree-of-freedom (6-DOF) vehicle models that include aerodynamics across a parameter space of altitude, angle-of-attack, angle-of-sideslip, and Mach number. This parameter space grows factorially with the number of control surfaces of the vehicle, making it impractical if not intractable to use these 6-DOF models with scale-resolving methods (direct numerical simulation or wall-modelled large eddy simulation). As a result, a large portion of the parameter space is filled with the results from significantly lower-fidelity and less expensive computations (e.g., local methods, inviscid Euler, Reynolds-averaged-Navier-Stokes) that may not be sufficient for design at extreme conditions. This effort is aimed at improving both the low-fidelity and the high-fidelity M&S tools and how they can be used together to yield quantitative predictions of aerodynamic control surface effectiveness at hypersonic speeds below an altitude of 80,000 feet.

Description/Scope

Based on the complexity of the experimental and computational portions of this effort, proposals for this effort are permitted to have a total greater than $1.500 M, but they are not to exceed a total of $2.000 M over the three-year period of performance.

The objective of this program is to develop validated, computational framework(s) capable of assessing the performance of traditional or novel control surface designs and quantify loads on the surfaces. A framework, in the context of this effort, is a process that utilizes several independent pieces of M&S software to predict the quantities of interest. While thermal loading is important, the emphasis of this project is on the mechanical loads. Preference will be given to approaches that are broadly applicable across different hypersonic configurations including boost-glide and air-breathing ramjet/scramjet vehicles.

Computational

The goal of the computational portion of this effort is to assess and improve the current M&S capabilities and framework(s) to predict control surface performance in this end game flight regime. The computational effort will require duplicating the wind tunnel environment and outer mold lines (OMLs) of the control surface mechanical design.

The computational campaign is expected to assess the sensitivity of current M&S capabilities to inputs (e.g., freestream flow properties, boundary layer effects, and wall temperature), assumptions (e.g., reacting/non-reacting gas, isothermal walls) and fidelity (e.g., modeling, scale-resolving simulations). This sensitivity study will guide future efforts to determine the level of M&S fidelity required to design effective control surfaces as a way to drive the M&S development effort. A key outcome for the computational effort is to demonstrate the ability to capture relevant physical phenomena, but also to achieve reasonable confidence for rapidly evaluating these phenomena across a range of flow conditions at a tractable computational cost.

Experimental

The goal of the experimental portion of this effort is to validate the M&S framework(s) within the scope of the computational effort. Thus, specific conditions and configurations are expected to be tailored to the specifics of the computational research. The wind tunnel(s) selected should closely match the Mach, enthalpy, and/or Reynolds numbers of the hypersonic environment with a sufficiently long runtime to measure the control system's response. Definitions of boundary conditions, the as-built geometry, and mechanical designs that can be duplicated with physics-based modeling and simulation must be available. The experimental setup must include the ability to measure the mechanical loads or their proxies (e.g., forces and moments). In addition, it is desired to have as much detailed information about the flow (e.g., freestream bulk flow properties, species concentrations, distortion, turbulence intensities, wall boundary layer profiles) as feasible. Quantitative and qualitative flow field and surface quantity visualization through high-speed Schlieren, oil-flow, pressure-sensitive paint, temperature-sensitive paint, and/or particle-image velocimetry should be used, when applicable, to corroborate findings from other measurement sources to assist in validation of the modeling and simulation efforts. Uncertainty quantification of the mechanical design and experimental measurements should also be included to build confidence and support the sensitivity study of the multi-fidelity solution.

Milestones / Deliverables

Along with deliverables described in Section 1.1, the following are minimum deliveries expected for this program:

- Detailed analysis reportof the M&S capabilities and framework(s) to predict control effectiveness of control surfaces during extreme maneuvers at hypersonic speeds and lower altitudes.
- Validated multi-fidelity M&S tools and capabilities, and the supporting wind tunnel data, that can accurately and efficiently describe control effectiveness of control surfaces, across a flight envelope, for end-game maneuvering. These tools and data shall be made available

to support the design of future vehicle concepts that meet high maneuverability requirements.

Milestones should be established that are commensurate with proposed schedule of deliverables. A successful technical outcome may lead to the opportunity to seek follow-on funding.

Topic 3: Adaptive Decisioning and Response

Technical Discipline: Navigation, Guidance, and Control (NG&C)

Introduction

The Joint Hypersonics Transition Office (JHTO) is soliciting innovative research proposals for executive decision-making algorithms to increase overall effectiveness of hypersonic vehicles designed for strike and intelligence, surveillance, and reconnaissance (ISR) missions that face an increasingly hostile operational environment due to kinetic threats. To ensure resilient engagement of time-critical and high-priority targets, a hypersonic vehicle must react quickly to changes in the operational environment. To that end, approaches are sought that enable adaptive, in-flight decision making to determine and initiate suitable courses of action.

Background

Adversarial capabilities continue to evolve. This increases the types and capabilities of threats faced by hypersonic flight vehicles. The inherently extreme operating environment and challenges in control already requires autonomous operation for hypersonic systems. However,to ensure future mission success, decision algorithms and approaches need to quickly process information (both received and sensed), develop situational awareness of the operational environment, and combine this information to intelligently direct commands to the navigation and guidance subsystems. Thus, this can be considered to be the creation of an intelligent pilot-equivalent as opposed to creation of an auto-pilot.

Description/Scope

Executive algorithms and approaches that enable a hypersonic vehicle to fuse information and determine an appropriate course of action to mitigate perceived in-flight operational changes (threats and otherwise) are sought in this solicitation. The hypersonic vehicle shall necessarily need to fuse information from disparate sources and utilize a combination of this data and on-board knowledge—perhaps compiled via off-line training—to determine a course of action. Examples of information sources include continuous on-board threat detection sensors and discrete communication with off-board sources.

The desired executive function shall issue commands in accordance with the chosen course of action. Example courses of action may include, but are not limited to, navigation, guidance, and control (NG&C) subsystem algorithm changes, evasive maneuvers, modification of sensor exploitation approaches, or communications to a team of assets. The desired outcome of the research is the demonstration of the efficacy and robustness of the algorithms for decision making rather than optimization and performance in a highly-specified scenario.

Performers shall be provided, in accordance with security and disclosure restrictions, low-fidelity sensor, threat, and environmental descriptions for the purpose of developing unclassified, abstracted models for simulation. Use of existing work in the literature or collaboration with government and industry partners is encouraged. Provided resources should be leveraged to emulate vehicle dynamics and to implement existing navigation and guidance solutions. Highly integrated navigation, guidance, and decisioning capabilities can alternatively be proposed.

Executive response solutions can be informed by pre-flight training but must be able to execute with computational efficiency in timeframes approaching real-life dyanmics. Proposals should show how the approach could be applied to hypersonic flight which may include modeling simplified relevant physics. This modeling would include at a minimum a consideration of three degrees of freedom (3-DOF) dynamics, but consideration of 3-DOF++ (also known as 5-DOF) or full, nonlinear 6-DOF vehicle dynamics is highly encouraged. How the executive algorithm or decisioning aid would improve mission success, including meeting desired target engagement conditions, should be directly considered. Broad hypersonic vehicle design factors, such as aerothermal heating, are important for consideration in overall mission success but should not be the primary focus of the proposed research effort.

Proposals may specify the design reference mission(s) to which the approach shall be applied, as well as the potential operational impact. However, these missions do not need to be specific to any one hypersonic system or expected operational use. Generalization of the proposed approach or framework, with applicability to a broad range of hypersonic systems, is highly encouraged. Algorithm development efforts should account for expected on-board computational resource constraints and consequently strive for fast and efficient architectures (i.e. low computational complexity).

Milestones/Deliverables:

Along with deliverables described in Section 1.1, the following are minimum deliveries expected for this program:

- An algorithm demonstration on a low-fidelity surrogate problem, with and feasible approach that expands into a comprehensive evaluation for how the algorithm would perform in a hypersonic use-case. This evaluation shall implement models of vehicle dynamics, low-fidelity threat model(s), and vehicle navigation and/or guidance algorithms into a simulation environment. The algorithm shall be trained or tuned for nominal design reference mission(s). An approach should be proposed but may be informed by existing methods that will be provided by the government project lead.
- An assessment of the algorithm performance in the low-fidelity surrogate problem including metrics on feasibility, efficacy (e.g. mission success), efficiency (e.g. run-times), robustness (e.g. to environmental, vehicle, and other uncertainties), and generalizability (e.g. efficacy over broader mission envelope) of the proposed decisioning architecture.
- A responsive research plan of corrective actions or steps towards increased Technical Readiness Level (TRL) for hypersonic mission insertion, based on the results of algorithm evaluation.

Milestones should be established that are commensurate with proposed schedule of deliverables. A successfully technical outcome may lead to the opportunity to seek follow-on funding.

Topic 4: Building Trust in Autonomous Mission Planning

Technical Discipline: Mission Planning (MP)

Introduction

The Joint Hypersonics Transition Office (JHTO) is soliciting innovative research proposals that build trust in the area of autonomy and its application to left-of-launch (prior to launch) hypersonic mission planning. The generation of high confidence trajectories and associated mission plans for hypersonic flight systems is computationally intense due to its extreme operating environment and velocities. Compressed engagement timelines and increasing operational capabilities of these systems will make human-in-the-loop mission planning less and less tractable. To ensure the robust and timely generation of high-impact hypersonic mission plans, approaches are sought to increase the confidence in automated mission planning approaches to enable the design of future autonomous mission planning systems built with trust as a quantifiable requirement.

Background

Hypersonic strike systems and their associated concept of operations (CONOPs) and tactics are developed to engage increasingly complex targets while mitigating evolving and more highly capable threats. The mission planning process incorporates a wide range of physical and operational constraints to enable the development of survivable, lethal, and executable trajectories for the warfighter. As the battlefield becomes more connected and advanced capabilities of hypersonic vehicles are introduced, the challenge to rapidly develop feasible mission plans in the compressed timeframes that are relevant to these systems is increased. Artificial intelligence (AI) and semi- or fully-automated processes have the potential to enable mission planners to confidently introduce hypersonic capabilities into the hands of the warfighter.

Confidence in flight vehicle performance models is most often obtained through verification and validation with extensive ground and flight test campaigns. The accelerated development and deployment timeline of hypersonics, however, when coupled with the cost, scale, and complexity of these systems, requires new capabilities to be developed to build trust in the generation and assessment of advanced CONOPs explored using hypersonic mission planning toolsets. Operator trust in a future automated mission planning process is critical for its use operationally, not just during tests, training, and exercises. Especially during wartime, operators must trust their tools. It is important that methods and processes be developed to assess and quantify confidence in auto-generated hypersonic mission plans as manual weapon planning becomes replaced with human-on-the-loop processes.

Description/Scope

This solicitation is seeking advancements to build trust through the development of approaches and metrics to quantify uncertainty vs. performance as it applies to automated hypersonic mission planning. Proposed solutions should not focus on developing novel methods for automating the mission planning process or the development and verification of computationally tractable trajectory generation algorithms, but rather on ways to build trust and confidence in mission planning algorithms through novel methods. Recall that the traditional approach of building confidence is through the use of extended ground- and flight-test campaigns. New methods to improve robustness and confidence in generated trajectories and mission plans should not rely upon these approaches but will still be able to expand trust/explainability of automated mission planning.

The identification and quantification of tradeoffs in trust and performance and the required level of expert involvement to reach a trusted mission plan is a desired outcome of this research. Performers are encouraged to examine how uncertainties in inputs (e.g. vehicle design, performance, launch conditions, etc.) and in underlying mission planning algorithms can be best propagated and included in assessments of developed trajectories and CONOPs in order to build confidence in resulting mission plans. Complimentary research areas such as uncertainty quantification, trusted AI (for transparency, explainability, metrics, and tradeoffs on AI decisions), and human-automation interaction can be leveraged in the development of proposal for this work.

Proposals should, at a minimum, consider 3-DOF dynamics of a hypersonic system and may specify the design reference mission(s) to which the approach shall be applied, as well as the potential operational impact. Generalization of the proposed approach or framework, with applicability to a broad range of hypersonic systems, is highly encouraged. Performers should propose assuming they will be provided with basic hypersonic vehicle models, environment models, candidate trajectory generation algorithms, and associated constraints but novel methods are also encouraged.

In addition to a description of the state of the art research, and the proposed approach, proposals should also include identification of any modeling or simulation tool(s) or framework(s) that will be used to conduct the program.

Milestones / Deliverables

Along with deliverables described in Section 1.1, the following are minimum deliveries expected for this program:

- An algorithm demonstration on a low-fidelity surrogate problem for feasibility, efficacy, and efficiency of the proposed decisioning architecture for hypersonic systems.
- Development and demonstration of metrics to quantify, test, and evaluate the trusted AI and its application to automated hypersonic mission planning components.
- If any modeling and simulation framework has been abstracted from a military mission planning domain, a description of how the knowledge gained/methods developed could be transferred back to the military domain.

Milestones should be established that are commensurate with proposed schedule of deliverables. A successfully technical outcome may lead to the opportunity to seek follow-on funding.

Topic 5: Sensor Fusion Algorithms for Position, Navigation, and Timing in Hypersonics Environments

Technical Discipline: Navigation, Guidance, and Control (NG&C)

Introduction

The Joint Hypersonics Transition Office (JHTO) is seeking innovative research proposals to advance algorithms and methods used to fuse hypersonic-relevant navigation sensor data to assure sufficiently accurate and robust position, navigation, and timing (PNT) solutions remain available as the contested environment challenges continue to grow. Approaches are sought to develop new or improved methods to reliably determine and assess the validity of conventional and alternate PNT (alt-PNT) sensor outputs and their use in a fused PNT solution in a hypersonic-relevant environment. This effort will advance algorithms and methods for determining how to trust, exploit, and fuse sensor data, and supports robust, high-performance PNT solutions critical to both offensive and defensive hypersonic vehicle applications.

Background

Warfighter use of hypersonic vehicles anticipates future scenarios where GPS signal availability is either dramatically reduced or totally absent. A critical future capability of hypersonic vehicles is to have navigation system performance with GPS-like accuracy in the total absence of GPS signals.

In highly dynamic systems like hypersonics (Hypersonic vehicles fly with high accelerations (10s – 100s of G's) over a period of 10s to 100s of seconds.), GPS satellite signals are used to correct or calibrate data obtained from an inertial navigation system (INS) to provide a highly accurate, fused GPS/INS PNT solution necessary for mission success. Development of innovative system-level approaches for sensor fusion that go beyond current evolutionary advances (e.g. replace GPS signals with alt-Nav signal for INS solution correction), and provide techniques or methods to address sensor data integrity verification, are essential to assure U.S. hypersonic platforms remain relevant and viable for use in the future.

Description / Scope

This solicitation supports the development of a hypersonic flight platform navigation system that uses innovative sensor fusion algorithms and methods to provide GPS-like PNT solutions in the total absence of GPS signal availability. Research that supports the development of a robust PNT solution in highly contested environments through advancements in signal trust, exploitation, and fusion are solicited. Research and development efforts may include areas such as non-linear state-based estimation, autonomy (artificial intelligence, machine learning, etc.), and various statistical and heuristics-based methods. Proposals should consider a supporting aspect to an integrated alt-Nav PNT system, such as signal integrity.

The following list contains suggestions for area(s) of research that may be addressed within the proposal. The following list is not exhaustive, and other aspects may be explored:

Algorithm prototypes

Develop and demonstrate sensor fusion algorithm prototypes based on existing alt-PNT sensor models. Prototypes ideally anticipate and conform with industry-standard application programming interface (API) definitions such as those prescribed by pntOS. Exercise, evaluate, and document prototype algorithm performance metrics utilizing both synthetic and empirical data products.

Software-based simulation

Demonstrate candidate algorithm operability within high-fidelity simulation frameworks, ideally leveraging existing simulation capabilities within the DoD complex to the extent possible. Demonstrate and document algorithmic performance metrics including computational throughput and efficiency.

Hardware-based evaluation

Evaluate candidate algorithm operability within high-fidelity hardware framework. Proposals should be aware of current limits of computational and hardware capabilities. An analysis that supports developing a feasible solution, within both the current limits of computational capability and future expected limits, is preferred. These analyses may extend into including testing algorithms via a processor-in-the-loop (PIL) effort or full hardware in the loop (HWIL) based simulation with an accompanying simulation computing system.

Prototype refinements & down-selection

Refine algorithm prototype(s) based on simulation outcomes and evaluations of achieved PNT performance across a diverse set of use cases. Performers are advised to socialize experimental outcomes with stakeholders throughout the hypersonics community to downselect a primary solution based on feedback.

This solicitation is not seeking proposals on new alt-PNT sensors or new alt-PNT methods, but is seeking innovations in techniques for trusting and fusing alt-PNT information. Proposals should not focus on improvements to Kalman filtering techniques for fusing of data, as this topic already has vast research investment. Explanations of new methods for signal integrity monitoring in combination with other filter methods, such as unscented particle filters, are of interest.

Milestones/Deliverables

Along with deliverables described in Section 1.1, the following are minimum deliveries expected for this program:

- Well-formed algorithm descriptions, any code or pseudo-code developed, and any associated interface control documents (ICDs).
- Prototype algorithms may be delivered as pseudo-code provided the associated documentation supports ready refactoring in a common high-level, object-oriented programming language such as C++. Source code for algorithms used for high-fidelity software simulation are required to be delivered as well-formed C/C++ (or comparable)

code listings, or in a model-based format that can readily support auto-generation of C/C++ source code.

Milestones should be established that are commensurate with proposed schedule of deliverables. A successfully technical outcome may lead to the opportunity to seek follow-on funding.

Topic 6: Open Topic

Technical Discipline: All

Introduction

The Joint Hypersonics Transition Office (JHTO) is soliciting innovative research proposals across a broad range of technology disciplines to advance technologies that will extend hypersonic and high-speed weapon system capabilities. The effort can be applicable to one or more weapon system types such as high-speed projectiles, boost-glide weapons, air-breathing tactical missiles and high-speed platforms. Areas of interest include, but are not limited to, efficient aerodynamic designs, robust guidance navigation and control systems, innovative hot and cold structural design, increased scramjet operational margins, novel sensors, increased lethality and mission planning.

Description/Scope

The solicitation is aimed at eliciting proposals to advance the state of hypersonics technologies. All proposals should provide available initial model studies or experimental evidence that illustrate the viability of the proposed technological advancements. While this topic does not have a single technical discipline, the focus of this solicitation should be on applied research related to aspects of the hypersonics mission including, but not limited to:

1) Aerodynamics and Aerothermodynamics (AERO)
    a) Aerothermal performance at high angles-of-attack
    b) Fluid-thermal structural interactions
    c) Boundary layer management
2) Materials, Structures, and Manufacturing (MSM)
    a) Ultra-high temperature ceramics and carbon-carbon composites materials, seals, and joints
    b) Shape stable or non-eroding leading-edge materials and nose tips
    c) New/novel precursors, material response models, processing & manufacturing technologies, modeling and optimization of infiltration processes, additive manufacture, test and evaluation of hypersonic components
3) Ordnance / Lethality (ORD)
    a) Ordnance integrated warhead design: temperature resilient components
    b) Intelligent ordnance packages, multi-blast technologies
    c) Lethality test and evaluation methods, prediction, and validation
4) Hypersonic Air Breathing Propulsion (PROP)
    a) Dual mode scramjet/ramjet, scramjet, combined-cycle, high-speed turbine, rotating detonation engines, solid fuel scramjets

   b) Engine feedback and active control, unstart: predicting & controlling / prevention / recovery
   c) Operability limits and expansion, scalability, including small-scale engines and large-scale engines, integrated power generation
   d) Propulsion-airframe integration

5) Systems Engineering, Design and Analysis (SEDA)
   a) Innovative vehicle concepts
   b) CONOPS and vehicle design for coordinated hypersonic engagement and teaming

Proposals should include:

- A detailed description of what the proposed effort will accomplish (including performance metrics) and why this is important to the success of the DoD's hypersonics research program.
- A detailed discussion of the state of the art and the limitations that you are overcoming.
- A program plan that includes technical approach and programmatic strategy, with a justification (studies, modeling, etc.) for why you believe the approach/strategy will overcome the limitation you have identified. Additionally, provide the methods to be used in the proposed concept, any scaling of hardware, and metrics for down-selection of final solutions. Identify laboratory, ground, or flight test methods required to demonstrate these performance metrics.

Milestones / Deliverables

Deliverables should follow guidelines described in Section 1.1.

Milestones should be established that are commensurate with proposed schedule of deliverables. A successful technical outcome may lead to the opportunity to seek follow-on funding.