NASA STTR 2023-I Solicitation

PROPOSAL NUMBER: 23-1- **T9.02-1099**

SUBTOPIC TITLE: Rapid Development of Advanced High-Speed Aerosciences Simulation Capability

PROPOSAL TITLE: Anisotropic Metric-Based Mesh Adaption for Hypersonic Flow

Small Business Concern

Firm: **ATA Engineering, Inc.**
Address: **13290 Evening Creek Drive South, San Diego, CA 92128 - 4695**
Phone: **(858) 480-2000**

Research Institution:

Name: **Mississippi State University**
Address: **Lee Boulevard, MS -**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Design of reentry vehicles is driven by aeroheating concerns at elevated flow enthalpies. As such, accurate simulation of hypersonic flow phenomena such as detached bow shocks is of critical importance for reducing conservatism in design and unlocking improved performance. Adaptive mesh refinement (AMR) is an enabling technology to efficiently reduce numerical error in hypersonic reacting flow simulations by providing mesh resolution only where it is needed, based on flow phenomena or an engineering quantity of interest. ATA Engineering, Inc., proposes to develop, in collaboration with Mississippi State University, a toolset for **H**ypersonic **A**nisotropic **A**daptive **M**esh **R**efinement (HAAMR). HAAMR will offer anisotropic AMR, the efficiency of which improves as the square of anisotropy when compared to an isotropic approach. Furthermore, its metric-based adaptation will align the mesh faces to the underlying metric field. This approach will align the adapted mesh to a hypersonic bow shock, greatly reducing the numerical error associated with prediction of key figures of merit such as surface heat flux in unstructured grids.

In addition to the HAAMR framework, the team will make improvements to the analysis workflow components. The metric-based anisotropic adaptation algorithms within the Advancing-Front/Local-Reconnection (AFLR) suite of meshing tools will be enhanced to enable higher-quality 3D grids, and robust numerical methods for gradient calculations will be implemented into the Loci/CHEM computational fluid dynamics (CFD) solver, enabling stable simulation on highly anisotropic adapted meshes. The team will leverage several decades of experience developing the underpinning CFD algorithms and AMR approaches. Phase I will conclude with a quantitative assessment of the value added by the envisioned toolset: comparisons of time to solution and accuracy for a reentry heatshield problem will be made using HAAMR, current AMR approaches, and legacy NASA tools.

Potential NASA Applications (Limit 550 characters):

HAAMR will address a critical NASA bottleneck—mesh generation and adaption—across all atmospheric entry missions, such as high-speed crew return, high-mass Mars landers, and Venus and gas/ice giant probes. The unstructured AMR capability, targeted for hypersonic reacting flow solvers, will focus on the well-known spurious heat flux prediction problem intrinsic to steady-state simulation of hypersonic bow shocks, with modular design for future enhancements like unsteady flow.

Potential Non-NASA Applications (Limit 400 characters):

Potential applications of HAAMR include improving the workflow for analysis and optimization of DoD and prime contractor hypersonic vehicles. The toolset could also prove useful to industry developing future supersonic and hypersonic commercial transport aircraft. Aside from hypersonics, any commercial CFD analysis could benefit from a more efficient mesh adaptation process.

Duration: **13**

PROPOSAL NUMBER: 23-1- **T14.01-1133**

SUBTOPIC TITLE: Advanced Concepts for Lunar and Martian Propellant Production, Storage, and Usage

PROPOSAL TITLE: Fast Elemental and Molecular Interrogation Sensor (FEMIS) for In-Situ Lunar and Martian Resource Utilization

Small Business Concern

Firm: **Brimrose Technology Corporation**
Address: **19 Loveton Circle, P.O. Box 616, Sparks, MD 21152 - 9201**
Phone: **(410) 472-2600**

Research Institution:

Name: **University of Georgia**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

For lunar (expandable to Martian) ISRU applications, a novel small SWaP LIBS suite, Fast Elemental and Molecular Interrogation Sensor (FEMIS), is designed to provide real-time identification of geochemical composition of lunar regolith using an innovative elemental + molecular LIBS technology. Having rapid and intense signal responses, obviating the need to physically touch the surface in order to collect a sample for analysis, and affected very little by the surface shape, roughness, and composition irregularity, this proposed FEMIS instrument will be an integrated system with a small SWaP UV/Visible/NIR + LWIR LIBS laser detector suite to collect the broadband (both UV-Visible-NIR and long-wave IR) signals from the operational surface. FEMIS offers real-time identifications of elemental abundances, REEs, and regolith mineral/chemical composition within seconds without the need of preparing the abrasive lunar/Martian regolith samples. Spectral data processing algorithms and prediction models will

be developed for FEMIS to achieve fully automated real-time sorting/mapping of lunar/Martian regolith resource with minimum maintenance.

Potential NASA Applications (Limit 550 characters):

The particularly superior sensitivity of the LWIR LIBS on carbon and oxygen-rich material identification will find great applications in water and organic materials signatures detection and identification in NASA missions.

NASA applications include: In-situ composition analysis in small bodies explorations, Organic materials and life signatures detection and identification, Resource identification and water-hydroxyl differentiation, In-situ fabrication and repair feasibility study.

Potential Non-NASA Applications (Limit 400 characters):

In addition to NASA applications, the proposed method and instrument can be used for: chemical and explosive detection, identification for security/military applications, Qazi-nondestructive detection/evaluation in manufacturing industry, composition analysis and counterfeit detection in pharmaceutical products.

Duration: **13**

PROPOSAL NUMBER: 23-1- **T7.04-1097**

SUBTOPIC TITLE: Lunar Surface Site Preparation

PROPOSAL TITLE: Refuse-to-get-stuck Rovers

Small Business Concern

Firm: **Cislune Company**
Address: **301 North Almansor Street, Alhambra, CA 91801 - 2622**
Phone: **(661) 390-1060**

Research Institution:

Name: **The University of Central Florida Board of Trustees**
Address: **70 Washington Square South, FL 32826 - 3231**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Cislune and UCF propose to develop anti-slip algorithms to identify wheel slip autonomously to avoid getting stuck, a potentially mission ending danger that if you can lower the risk of, allows faster traverse and more productive missions. The algorithms will also be optimized to create continuous recompaction of lunar roads and landing zones, avoiding the wheel-churn of driving.

Using some of the same data and rover parts, we will develop algorithms and testing to generate normal and axial shear stress geotechnical data using un-modified rover wheels. Cislune and UCF will develop proof of concept algorithms in lab and field testing. Based upon this data, we will create an architecture and ConOps for preparing a lunar landing site with pads, berms, and pathways.

These innovations together will enable effective construction of bulk regolith infrastructure that is then tested to verify the as-built characteristics to meet the civil engineering requirements that will be developed.

Potential NASA Applications (Limit 550 characters):

Refuse-to-get-stuck and wheel geotechnical data gathering directly map to NASA STMD's Strategic Framework thrusts of Live - ISRU, advanced construction, and advanced habitation systems as well as Explore - advanced robotics, autonomous systems, and advanced manufacturing. These technologies can be applied to existing rovers enabling greater autonomy and efficiency.

Potential Non-NASA Applications (Limit 400 characters):

Lunar commercial rovers and excavation companies will benefit from these algorithms to avoid getting stuck and having greater autonomy. Particularly as rovers and excavators begin to operate in PSR and during both lunar day and night periods when surface visual conditions are significantly different.

Duration: **13**

PROPOSAL NUMBER: 23-1- **T8.07-1101**

SUBTOPIC TITLE: Photonic Integrated Circuits

PROPOSAL TITLE: Heterogeneously integrated visible photonic integrated circuit platform with high responsivity photodetectors

Small Business Concern

Firm: **Nexus Photonics, LLC**
Address: **6500 Hollister Avenue, Suite 140 , Goleta, CA 93117 - 3011**
Phone: **(805) 895-4733**

Research Institution:

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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

We propose to improve, refine and mature Nexus proprietary heterogeneous SiN based platform to improve the short-wavelength propagation losses, and integrate high-responsivity/high-quantum efficiency photodetectors in visible in a wafer-scale process for NASA needs and infusion into existing and upcoming instruments.

Potential NASA Applications (Limit 550 characters):

We are specifically addressing existing need at NASA for PIC technologies: "On-chip detectors with high responsivity/quantum efficiency from 300 to 800 nm. Additionally, approaches demonstrated in, or compatible with, commercial foundries are of particular interest."

Potential Non-NASA Applications (Limit 400 characters):

The proposed platform is applicable to multiple market verticals including augmented reality/virtual reality, healthcare, quantum enabling us to leverage all these markets to push for commercialization while supporting NASA programmatic needs

Duration: **13**

PROPOSAL NUMBER: 23-1- **T12.08-1046**

SUBTOPIC TITLE: Manufacturing and Construction of Lunar Landing Pads Research

PROPOSAL TITLE: Novel Construction of Lunar Landing Pad Reinforcement Structures

Small Business Concern

Firm: **Linc Research, Inc.**
Address: **1000 Meridian Street, Hunstville, AL 35801 - 4661**
Phone: **(256) 426-5742**

Research Institution:

Name: **The University of Alabama in Huntsville**
Address: **301 Sparkman Drive, VBRH E26, AL 35899 -**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Early Apollo-era landings indicated a variety of hazards including obstruction of visibility, high-velocity ejecta, and plume cratering. These problems resulted in damaging the lander itself and nearby equipment. In order to safely complete landing and launch sequences, lunar landing pad designs are required to mitigate plume effects, redirect and/or capture exhaust flow, and dissipate the kinetic energy of debris and ejecta. The Lunar Plume Alleviation Device (LunarPAD) concept developed by the Lunar PAD team delivered several high-level 3D printed ISRU pad designs that were able to fulfill the required criteria through high level evaluations, design iterations and CFD simulations. However, the pad designs themselves had a heavy reliance on overhang features which current printing technology is unable to complete.

The research proposed in this project is to develop viable construction geometries and techniques relevant to the overhang areas of the lunar landing pads. Designs will be judged based on performance in appropriate software analysis. Completing this work addresses the technology needs identified in the Artemis mission plan and objectives.

Potential NASA Applications (Limit 550 characters):

As NASA looks to explore and settle on the moon and Mars, the utilization of in-situ resources will be necessary to reduce risk and cost while increasing versatility and potential for growth. A robust in-situ construction technology is capable of producing a variety of critical infrastructure. Among the most important pieces of lunar or Martian infrastructure to prioritize first is a landing and launch pad. The goal of landing and launch pads is to enable repeated land and launch cycles without damages due to high-speed ejecta.

Potential Non-NASA Applications (Limit 400 characters):

With advanced construction techniques capable of utilizing in-situ resources, government and commercial organizations are able create affordable housing for low-income families, build shelters to mitigate homelessness, and repair remote structures. The ability to additively construct landing pads on-site also enables the creation of emergency landing zones for humanitarian or military supplies.
Duration: **13**

PROPOSAL NUMBER: 23-1- **T10.05-1114**

SUBTOPIC TITLE: Integrated Data Uncertainty Management and Representation for Trustworthy and Trusted Autonomy in Space

PROPOSAL TITLE: Intelligent Automation of Trace Identification Processes for Complex Mission Critical Robotics Systems

Small Business Concern

Firm: **SAFA.AI,INC**
Address: **1400 East Angela Boulevard Rm 361, South Bend, IN 46617 - 1364**
Phone: **(623) 340-4520**

Research Institution:

Name: **University of Notre Dame**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters):

Achieving trustworthy and trusted autonomy starts early in the development process through performing hazard analysis, fault analysis, identifying mitigating requirements, and carefully and rigorously tracing those requirements all the way into design, models, implementation, and tests. However, traceability can be time-consuming, costly, and error-prone. To address these challenges, significant advances in automated traceability have used deep learning technologies to generate highly accurate trace links between software artifacts such as requirements, design,

code, and test cases across many different system domains. These links are then used to support requirements analysis tasks such as safety analysis, requirements satisfaction analysis, and to support requirements reuse. However, automated traceability underperforms in highly technical domains with terminology that differs significantly from the publicly available training data. The aim of this project is to address this problem by delivering a reliable and fully-automated solution for constructing, training, and validating a domain-specific language model that performs automated software and systems traceability tasks at high degrees of accuracy for the targeted domain. The language model is used to perform and augment a variety of requirements analysis tasks including change impact analysis, safety analysis, requirements reuse, and requirements analysis in order to design and deploy more reliable software systems. The approach will be applied to complex, mission-critical robotics problems in order to increase the rigor of developing robotics systems, especially those where achieving trustworthy and trusted autonomy is paramount. The traceability and requirements analysis solutions will be delivered through the highly interactive and visual SAFA tool.

Potential NASA Applications (Limit 550 characters):

SAFA would be directly applicable to the Space Technology Mission Directorate, Science Mission Directorate, Exploration Systems Development Mission Directorate, Space Operations Mission Directorate, and Aeronautics Research Mission Directorate, in addition to ARMD missions and goals for projects such as the Airspace Operations and Safety Program/ Advanced Air Mobility, Air Traffic Management-eXploration, and the National Airspace System.

Potential Non-NASA Applications (Limit 400 characters):

Within Non-NASA Applications, SAFA applies to safety-critical and mission-critical systems within aerospace/defense, automotive, robotics, medical devices, and drones. These industries are experiencing very similar difficulties as NASA regarding managing increasingly complex software with manual requirements tools.

Duration: **12**

PROPOSAL NUMBER: 23-1- **T8.06-1595**

SUBTOPIC TITLE: Quantum Sensing/Measurement and Communciation

PROPOSAL TITLE: Robust and deterministic source of photon number states

Small Business Concern

Firm: **Physical Sciences, Inc.**
Address: **20 New England Business Center , Andover, MA 01810 - 1077**
Phone: **(978) 689-0003**

Research Institution:

Name: **Board of Trustees of the University of Illinois (at Urbana-Champaign)**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Quantum Sensors have use in a wide variety of applications including microscopy, positioning systems, communication technology, electric and magnetic field sensors, as well as geophysical areas. Significant gains from Quantum Sensors include technologies important for a range of NASA missions including efficient photon detection, optical clocks, gravimetry, gravitational wave sensing, ranging, and optical interferometry. Entangled multi-particle states used for precision measurements provide tools to reach the so-called Heisenberg limit and thus, overcome the shot-noise limit (fundamental noise limit for classical systems) and hence perform measurements at a precision unachievable for classical sensors. Quantum photon-number states, also known as Fock states, are the key ingredient to realizing the most useful entangled multi-particle states. Furthermore, photon-number states have applications in quantum communication and quantum information sciences as well. Physical Sciences Inc. (PSI) and the University of Illinois Urbana-Champaign (UIUC) will develop a robust and deterministic source of photon-number states. The source is based on spontaneous parametric down-conversion inside a low-loss optical loop – a switchable quantum 'buffer' – and will produce quantum photon-number states on demand at the telecommunications wavelength, thus providing a key resource for advanced quantum sensors.
Potential NASA Applications (Limit 550 characters):

Exotic quantum states – including squeezed states, entangled states, and photon-number states – have a range of applications for multiple NASA missions and programmatic needs. For example, photon-number states are directly relevant for characterizing energy-resolving single-photon detectors, and as a resource to create optimal states for optical metrology, such as N00N states. Controllable production of fixed photon numbers in multiple spatial modes is also an assumed resource for advanced optical quantum processing, e.g., boson sampling.
Potential Non-NASA Applications (Limit 400 characters):

As highlighted by the National Quantum Initiative (NQI), quantum technologies are critical to our national security and competitiveness. Photon-number states and their derivatives are key

elements for improving the precision of optical metrology, e.g., light-wave interferometry, which in turn has myriad applications in device and materials characterization, studying biological systems, etc.
Duration: **13**

PROPOSAL NUMBER: 23-1- **T12.01-1570**

SUBTOPIC TITLE: Additively Manufactured Electronics for Severe Volume Constrained Applications

PROPOSAL TITLE: High Reliability Interconnects for Advanced Integrated Circuits in Additive Manufactured Electronics

Small Business Concern

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