MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)
STTR 06 Proposal Submission Instructions

INTRODUCTION

The MDA STTR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). If you have any questions regarding the administration of the MDA STTR program please call 1-800-946-2636. Additional information on the MDA STTR Program can be found on the MDA STTR home page at http://www.winmda.com . Information regarding the MDA mission and programs can be found at http://www.acq.osd.mil/mda

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (1 Feb 2006 through 13 Mar 2006), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website through 13 March 2006. After 13 March 2006, technical questions regarding topics will only be accepted via the online SITIS Interactive Topic System on the https://www.dodsbir.net/ web site.

As funding is limited, MDA will select and fund only those proposals considered to be superior in overall technical quality and most critical. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $100,000.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

Please ensure your e-mail address listed in your proposal is current and accurate. MDA cannot be responsible for notification to companies that change their mailing address, their e-mail address, or company official after proposal submission.

Phase I Proposal Submission

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained. MDA accepts Phase I proposals not exceeding $100,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

If you plan to employ NON-U.S. Citizens in the performance of a MDA STTR contract, please identify these individuals in your proposal as specified in Section 3.5.b (7) of the program solicitation.

It is mandatory that the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD website at: http://www.dodsbir.net/submission. If you have any questions or problems with the electronic proposal submission contact the DoD Helpdesk at 1-866-724-7457.

This COMPLETE electronic proposal submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal submission must be submitted via the submission web site on or before the 6 a.m.14 April 2006 deadline. Proposal submissions received after the closing date and time will not be processed.

PHASE II GUIDELINES

This solicitation solicits Phase I Proposals. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal will be eligible to submit a Phase II proposal.

Invitations to submit a Phase II proposal will be made by the MDA STTR Program Manager (PM) or one of MDA's executing agents for STTR. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000.

PHASE II PROPOSAL INVITATION

An MDA Program begins the process for a Phase II Invitation by making a recommendation (all MDA Topics are sponsored by MDA Programs). The MDA Program recommendation is based on several criteria. The Phase II Prototype/Demonstration (*What is being offered at the end of Phase II?)*, Phase II Benefits/Capabilities (*Why it is important)*, Phase II Program Benefit (*Why it is important to an MDA Program)*, Phase II Partnership (*Who are the partners and what are their commitment? Funding? Facilities? Etc? This also can include Phase III partners*), and the Potential Phase II Cost. This is the basic business case for a Phase II invitation and requires communication between the MDA Program, the Phase I STTR Offeror, and the Phase I Technical Monitor.

The MDA Program recommends the Phase II Invitation to the MDA SBIR Steering Group. The MDA SBIR Steering Group will review the Phase II invitation recommendations and make a recommendation to the MDA SBIR Selection Official based on the above criteria and the availability of funding. The MDA Selection Official has the final authority. If approved by the MDA Selection Official then a Phase II Invitation is issued.

Phase II Proposal Submission

If you have been invited to submit a Phase II proposal, please see the MDA STTR website: http://www.winmda.com for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline or may be declined.

MDA FASTTRACK Dates and Requirements:

The complete Fast Track application must be received by MDA 120 days from the Phase I award start date. The Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the MDA STTR Program Manager at the address listed below, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC) for the contract, and the appropriate Execution Activity STTR Program Manager.

Missile Defense Agency
MDA/SB Attn STTR Program Manager
7100 Defense Pentagon
Washington, DC 20301-7100

The information required by MDA, is the same as the information required under the DoD FastTrack described in the front part of this solicitation. Phase I interim funding is not guaranteed. If awarded, it is expected that interim funding will generally not exceed $30,000. Selection and award of a Fast Track proposal is not mandated and MDA retains the discretion not to select or fund any Fast Track proposal.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria <u>must be met</u> or your proposal will be REJECTED.

____1. Your technical proposal, the DoD Proposal Cover Sheet, the DoD Company Commercialization Report (required even if your firm has no prior STTRs), and the Cost Proposal have been submitted electronically through the DoD submission site by 6 a.m. 14 April 2006.

____2. The Phase I proposed cost does not exceed $100,000.

MDA STTR 06 Topic Index

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MDA STTR 06 Topic Descriptions

MDA06-T001 TITLE: Test-Ready Model for Flexible Systems of Systems

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BC/MP/GM

OBJECTIVE: Investigate development of a robust, system-of-systems (SoS) test-ready model that contains sufficient information to automatically produce test cases for implementation. This model should be a complete and accurate representation of the systems of systems implementation to include all features, functions, properties, and capabilities of the system. Additionally, the model should preserve the level of detail that is essential for testing fault tolerance while abstracting out unnecessary detail, while preserving all system configurations, system states, guard conditions, triggers, and actions in the system model.

DESCRIPTION: Traditional software development focuses upon code verification at a relatively low level which is adequate for small to medium scale sub-system and system level development. For larger systems, technology that evaluates “higher level models” has been developed as well and is effective for large software intensive systems. For systems of systems development, the aforementioned approaches fail to scale adequately. The requirement is for a system-of-systems test-ready model that encompasses the entire system-of-systems implementation.

As one develops a test-ready model, the issues of validation and verification of the model arise. The expression of requirements is typically in the form of natural language where employment of traceability techniques is tedious and the constraints of natural language can lead to misinterpretations, inability to detect incomplete or conflicting logic statements, and limited verification of robustness. Further, for systems whose environment cannot be precisely predicted prior to system use, it can be a great challenge to accurately specify requirements that adequately characterize stakeholder needs in all possible situations. Finally, traditional system developments rely on unit testing and integration testing to verify whether the system meets its requirements – an exercise late in the process, when detailed code has been developed and changes to requirements or design are very expensive. Despite exhaustive testing prior to fielding, even this approach becomes ineffective when the number of possible system configurations gets large, and the actual system configuration may not be known ahead of time. We believe that acquisition organizations can benefit from techniques that include sufficient rigor and definition so that the functional model formed by the specifications is verifiable and produce a test-ready model.

This test-ready model should meet the following requirements:

- The model should be a complete and accurate representation of the implementation to include all features, functions, properties, and capabilities of the system.
- The model should preserve the level of detail that is essential for testing fault tolerance while abstracting out unnecessary detail.
- The model should represent all system configurations, system states, guard conditions, triggers, and actions in the system model.

For this effort, we would like to identify the process and procedures that developers would follow to employ tools such as formal methods to develop and validate a test-ready model of an SoS. The development of formal specifications in a test-ready model can lead to a significantly high level of confidence in the implementation phase of a software development. The development of formal specifications typically clarifies the specification, surfaces latent errors and ambiguities, and supports the shaping of the desired system behaviors. Formal specifications can help developers find defects in specifications and designs earlier than they would be otherwise and greatly reduce the incidence of mistakes in interpreting and implementing correct requirements and designs. For this research, we define a formal specification as the precise definition of a system behavior that is typically expressed in mathematical terms. Such specifications should support validation and verification methods that can address large sets of possible configurations with a single generalized analysis. Additionally, the development and verification of formal specifications can support the development of error-handling specifications to appropriately manage runtime errors and logic breaks.

PHASE I: Develop a methodology that supports the development of a test-ready model of a system-of-systems that includes the desired behaviors of the system-of-systems with respect to a variety of possible configurations as well as desired fault tolerance behaviors.

PHASE II: Develop a test-ready model for a system-of-systems that tests system behaviors and error-handling procedures in the model for all valid and invalid inputs. Assess the test coverage of the test-ready model with respect to exhaustive testing. Update the proposed methodology from Phase I for use by acquisition organizations that desire to develop a test-ready model to verify system behaviors prior to committing to system production and code development.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Complex Systems of Systems Software Development, Commercial Aviation, Pharmaceutical Analysis & Verification

REFERENCES:
[1] Binder, R. V. Testing Object-Oriented Systems: Models, Patterns, and Tools, Reading, Mass.: Addison-Wesley, June 2001.
[2] Leffingwell, D. and Widrig, D. Managing software requirements: a unified approach. Addison-Wesley, 2003.
[3] Sitaraman, M. and Gandi, G. Design-time error detection using assertions. ICSE Workshop on Dynamic Analysis, Portland, OR, Copyright 2003.
[4] Standish Group, CHAOS: A Recipe for Success, The Standish Group International, 1999.
[5] Standish Group, The Chaos Report, The Standish Group International, 1994.
[6] Standish Group, CHAOS Chronicles Version 3.0, West Yarmouth, MA.: The Standish Group, 2003.

KEYWORDS: Software Development, Software Requirements, Formal Specifications, Test-Ready Model, Validation, Verification

MDA06-T002 TITLE: Advanced Signal Processing for Improved Feature Extraction

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: AS

OBJECTIVE: The objective of this research and development effort is to develop advanced signal processing techniques to induce or enhance discrimination features

DESCRIPTION: Develop enhanced Physics-based feature-extraction algorithm to identify characteristics of objects, e.g. Size, Shape, Material properties, thermodynamics, etc. Discrimination of threat/non-threat objects remains important for the BMDS. New ideas for features that can help discriminate objects are needed. Some existing feature extraction algorithms provide erroneous results for some observation geometries. This task seeks to develop more accurate feature extraction algorithms based on measurable physical properties that can be used for lethal object discrimination.

Furthermore, countermeasures will be deployed against midcourse defense weapons in order to generate difficulties in discriminating the real warhead from the decoys. There is always a need for advanced discrimination concepts and technologies to sort through the countermeasures anticipated with threats. These countermeasures may be spread over large areas (clusters >30 km2), or in the vicinity of suspected lethal objects and must be intercepted or correctly interrogated in order to create a highly reliable defense. The potentially large number of threat objects require k-factors in excess of 5 in order to achieve high probabilities of designation (>90%). Therefore, this topic calls for new innovative technologies that could effectively discriminate the decoys from the warhead and if possible eliminate the decoys and/or the warhead. Threats include high traffic and penetration aids, anti-simulation threats, etc. This project involves the technology necessary to develop improved midcourse sensors and weapons ability to discriminate lethal objects from other associated objects. The BMDS could improve with the Advanced Discrimination techniques and Counter Counter Measure capabilities developed under this program.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed concepts.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed concepts; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Develop technology that has direct insertion potential into the BMDS midcourse elements.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have applicability to commercial space platforms, high altitude communication platforms, etc.

REFERENCES :

1. Joseph Z. Ben-Asher,Isaac Yaesh, “Advances in Missile Guidance Theory” Volume 180, Progress in Astronautics and Aeronautics, 1998.

2. J.S. Przemieniecki, “Critical Technologies for National Defense”, AIAA Education Series, 1991.

3. Lyons, Richard G., Understanding Digital Signal Processing, 2nd Edition, Prentiss Hall, 2004.

4. Richards, Mark, Radar Signal Processing, McGraw-Hill, 2005.

KEYWORDS: discrimination; kill vehicle; counter measures; BMDS midcourse elements; Advanced discrimination techniques; decoys.

MDA06-T003 TITLE: Advanced Radar Data Fusion

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: AS/BC/GM/SE/TH

OBJECTIVE: Develop robust algorithms, software, and/or hardware necessary to collect, process, and fuse information from multiple radars (either at the same or different frequencies) and/or other sensors to form a single integrated picture of the battlespace. Solutions must be capable of accurately and reliably supporting acquisition, track, discrimination, and engagement of threatening objects across a spectrum of threat classes and environments.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) performance is heavily dependent upon data from dispersed and disparate radars and other types of sensors. Timely and accurate fusion of data collected from a variety of radars and/or other sensors that acquire information from multiple perspectives and/or different frequencies may provide a more accurate picture of the adversary threat cloud than any single radar or group of radars operating independently. The goal of the data fusion process is to operate on a combination of sensor measurements, features, track states, and object type and identification likelihoods to produce a highly accurate integrated picture of the battlespace. Algorithms, software, and/or hardware that enable this synergistic fusion and interpretation of data from disparate BMDS radars and/or other sensors should enhance system acquisition, tracking and discrimination of threat objects in a cluttered environment and provide enhanced battlespace awareness. Fusion of data at several levels may be required. Technical issues that must be addressed include: spatial and temporal registration of radars, data throughput within and between sensor platforms, processing speed and capacity, data latency and gap handling, target feature exploitation, and sensor calibration.

3-D Imaging with Multi-Sensors. Of particular interest are methods for fusing multi-sensor data for 3-dimensional imaging for discrimination purposes. This includes multiple radar data, as well as on-board IR sensor data and active LADAR device data. Further fusion of data with other radar or a-priori data would also be useful..

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced radar data fusion concepts using simulated sensor data.

PHASE II: Update/develop technology (algorithms, software, hardware, or a combination thereof) based on Phase I results and demonstrate technology in a realistic environment using data from multiple Radars. Demonstrate ability of technology to work in real-time in a high clutter environment.

PHASE III: Integrate technology into BMDS system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to air traffic control and weather radar applications.

REFERENCES:
1. Martinez, David, et.al., “Wideband Networked Sensors”, MIT Lincoln Labs, http://www.fas.org/spp/military/program/track/martinez.pdf, October 2000
2. D. Hall and James Llinas, “An Introduction to Multisensor Data Fusion,” Proceedings of the IEEE, 85 (No. 1) 1997
3. D.C. Cowley and B. Shafai, “Registration in Multi-Sensor Data Fusion and Tracking,” Proceedings of the American Control Conference, June 1993
4. Bar-Shalom and W.D. Blair, Editors, Multi-Target/Multi-Sensor Tracking: Applications and Advances, Vol. III, Artech House, Norwood, MA, 2000
5. . Sakamoto and T. Sato, “A fast Algorithm of 3-dimensional Imaging for Pulsed Radar Systems,” Proceedings IEEE 2004 Antennas and Propagation Society Symposium, Vol. 2, 20-25 June 2004
6. Streilein, et al. “Fused Multi-Sensor Mining for Feature Foundation Data,” Proceeding of Third International Conference of Information Fusion, Vol. 1, 10-13, July 2000

KEYWORDS: Sensor Fusion; Data Fusion; Sensor Integration; Signal Processing; Algorithm; Multi-Sensor, 3-D Imaging

MDA06-T004 TITLE: Solid Rocket Motor Insensitive Munitions (IM) Improvements

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: QS

OBJECTIVE: Develop and validate new rocket motor designs including new propellant ingredients/formulations that will allow the development of Insensitive Munition (IM) compliant solid rocket motors without loss of motor performance.

DESCRIPTION: Future solid propulsion systems will be required to be compliant with IM technical requirements. There is some technology to mitigate undesired affects at the system level; however, these approaches complicate system design and result in additional safety concerns. Currently, there is little work being done to develop novel rocket motor designs to address IM shortfalls, especially in larger diameter high performance solid rocket motors. This topic seeks new approaches to case designs, propellant formulations, propellant configurations and other innovative technology that could be employed in rocket motor development programs. Motor designs that mitigate responses to unplanned stimuli (eg. shock and thermal), while maximizing the retention of motor performance is the ultimate goal of this topic.

PHASE I: Propose and assess possible rocket motor IM propellant or design improvements. Outline testing techniques that will be used to determine how IM compliant the design changes will be. Rank possible formulations and conduct preliminary evaluations to demonstrate feasibility.

PHASE II: Take the top 1-5 rocket motor propellant or design improvements and conduct 6 degrees of freedom simulation work to determine effects on guided missile performance. Conduct small scale motor testing.

PHASE III: Move to full scale IM testing and incorporate into a solid rocket motor development program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Solid rocket motors used as commercial space launch systems will be the primary beneficiary. The energetic materials industry also may benefit from new formulations by gains in safer storage, handling and transportation.

REFERENCES:
1. US Patent 6,358,339 B1. (2) US Patent 6,552,201 B2
2. Tartakovsky, V.A., "The Design of Stable High Nitrogen Systems", Mat. Res. Soc. Symp. Proc., Vol. 418, 15-24, 1996.
3. E.A Smolenskii, G.M. Makeev, and Academician N.S. Zefirov, "Correlation between Structure and Impact Sensitivity of Nitro Compounds". Doklady Chemistry, Vol.344,Nos.4-6,1995,pp244-247. Murphy, M.R., Singh, S.K., and Shanley, E., "Computationally Evaluate Self-Reactivity Hazards", CEP Magazine, www.cepmagazine.org, 54-61, February 2003.
4. Belik, V.A., Potemkin, V., and Zefirov, N., "Relationship Between Geometric Structure of the Molecules of Explosives and Sensitivity to Shock", Doklady Akademii Nauk SSSR, Vol 308, 882-886, 1989.

KEYWORDS: Propellant, Insensitive Munitions, Formulations, Design, Solid Rocket Motors, Energetics

MDA06-T005 TITLE: Close Coupling of Excited Oxygen with Iodine Injection in COIL Lasers

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors

ACQUISITION PROGRAM: AL

OBJECTIVE: More efficient delivery of the Singlet Delta Oxygen from its generation location to the point where Iodine injection occurs as well as improved mixing and optimized chemical kinetics.

DESCRIPTION: The ABL Chemical Oxygen Iodine Laser (COIL) creates a lasing medium by producing Singlet Delta Oxygen (SDO) mixed with Helium in a SDO Generator (SOG) which is then delivered to a mixing plenum and injected with a mixture of Iodine, Helium and Nitrogen. This SDO is the primary energy driver for the COIL laser and is subject to a number of loss mechanisms typically associated with the transport and mixing process. Closer coupling of the excited Oxygen with the Iodine injection offers the prospect of higher chemical efficiency, more efficient high pressure operation and higher power. These in turn have system impacts ranging from simplifying the pressure recovery system to higher cavity energy density. If these results are realized, it would provide significant synergistic benefits to the ABL weapon system to include reduced payload weight, resulting in longer time on station, and more laser fluence on target due to increased laser power output for the same size device.

Proposal presenters are encouraged to show increased energy delivery to the COIL laser cavity based on close coupling of excited Oxygen with efficient Iodine mixing while maintaining flow uniformity both in species mixture and relative density.

PHASE I: Establish a list of innovative concepts for achieving the goals above. Select the most promising approaches and conduct fluid mechanical modeling of the most promising concepts that have a clear traceability to the ABL system. Based on modeling results, develop a Preliminary Design for a 1/40th scale device and Phase II Program Plan for the design, fabrication and test of the subscale device to validate the selected concept.

PHASE II: Execute the Program Plan developed in Phase I as directed by the government. Conduct subscale fabrication, integration, testing, and test reporting as specified in the proposed Program Plan. This report must discuss fully how key technical challenges were overcome and risks mitigated. Demonstrate clear traceability to a full-scale device. Develop a Phase III Program Plan that will include your integration and test strategy for a 1/10th scale device. Identify remaining key technical challenges, risks, and risk mitigation strategies. This plan should include proposals for actual lasing tests on a 1/10th scale laser either in-house, at a contractor facility, or in a government laboratory. Propose specific, high payoff technology transfer applications and experiments.

PHASE III: Design and build a 1/10th scale prototype, demonstrating its flow uniformity, cavity energy density and pressure recovery in a laboratory environment. Perform lasing tests on the prototype and provide a detailed evaluation report. Develop a Program Plan for design, fabrication, integration, testing, and test reporting for a full scale system or operation on a system level test-bed. Show near term application to one or more MDA element systems, subsystems, or components and investigate technology transfer applications. Propose and conduct specific, high payoff technology transfer experiments.

PRIVATE SECTOR COMMERCIAL POTENTIAL: More efficient chemical transport and mixing processes have potential commercial applications such as for advanced internal combustion engines, chemical decontamination processes and industrial scrubbers. These improved COIL processes also stand to benefit the industrial use of high power lasers for welding, cutting, and other material process applications which require lasers with high power output and excellent beam quality.

REFERENCES:
1. Carroll, D.L., King, D.M., Fockler, L., Stromberg, D., Madden, T.J., Solomon, W.C., and Sentman, L.H., "COIL for Industrial Applications," AIAA-98-2992, p. 1-11 (1998).
2. Manke II, Gerald C. and Hager, Gordon D., "Advanced COIL – physics, chemistry and uses," Journal of Modern Optics vol. 49 no. 3/4, p.465-474 (2002).
3. Vetrovec, John, "Prospects for an Industrial Chemical Oxygen-Iodine Laser," SPIE vol. 2092, p.723-726 (1996).
4. Carroll, D.L, Solomon, W.C, "Advanced Mixing Nozzle Concepts for COIL," Proceedings of the International conference on Lasers '99 p. 69-77

KEYWORDS: Airborne Laser, Singlet Oxygen Generator, Iodine Injection, Transport Losses, Pressure Recovery

MDA06-T006 TITLE: ABL (Airborne Laser) Detection Sensor Improvements

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: AL

OBJECTIVE: The objective of this effort is to enhance the ability of today's airborne surveillance systems to detect, classify, and track ballistic missiles for missile defense. While the primary focus of this effort is enhancement of detector capability, advancements in the other components of an infrared surveillance system that result in improved capability are also desired.

DESCRIPTION: The current ABL sensor system utilizes a scanning array based on 1970's technology. Recent and emerging technologies could make significant gains for ABL's surveillance capabilities. By sensor we mean lasers, entire transmitter systems, detectors, and/or entire receiver systems. ABL desires improvement in sensor capability in the following key areas (although all areas of improvement will be considered):

1) Increased FOV for each single measurement
2) Increased maximum detection range
3) Increased capability to correctly discriminate between ballistic missile targets and other types of tracks
4) Increased angular resolution for a 2-D passive only angle-angle track. Desired capability is for a 3-D position track with enhanced resolution. Finally, the optimal solution includes a 3-component velocity estimate with high accuracy.
5) Short pulses (of several ns duration or les to enable good range resolution)
6) Average power of greater than 12 Watts. Greater than 30 Watts average power is a long term goal. For multiple pixel FOVs, even higher average powers may be required.
7) Minimize weight, volume, power and cooling requirements to support airborne applications.
8) The following environmental capabilities are desirable: operate at 50k feet, survive temperatures of -30 to +60 C, and survive 10g shocks.

While the current ABL sensor system uses LWIR detectors and an active laser ranging system, the focus of this effort is not limited to any particular detector band or technology. The sensors could be direct detection systems or coherent detection systems. The ABL program is interested in all technology solutions that could improve its sensor performance that can be packaged for an airborne application.

PHASE I: Analyze proposed sensor technologies and applications for performance improvement. Evaluate initial packing issues and technology capability. Laboratory demonstrations of candidate technologies would be considered a plus.

PHASE II: Develop and test a bread-board/brass-board level advanced sensor system. Include sufficient analyses to evaluate system performance across a spectrum of both operating conditions and inputs (including targets, clutter, and background effects). Evaluate and characterize packaging issues to support airborne installation and operation.

PHASE III: Develop flight-certified surveillance systems that can be installed on a variety of DoD aircraft (to include ABL and other airborne surveillance platforms). Private Sector Commercial Potential: These systems could be used to support Drug Enforcement and Homeland Defense (Border Control) activities. Additionally, the enhancements in the core detector technology could support a variety of manufacturing applications where process monitoring via proposed sensing technology occurs.

REFERENCES:
1. ABL Background: http://www.boeing.com/defense-space/military/abl/flash.html
2. Proceedings of the SPIE Infrared Technology and Applications Conference (#5406), 12-16 April 04

KEYWORDS: Surveillance, Detector, Missile Defense, and Airborne

MDA06-T007 TITLE: TaC Materials Development and Characterization for Boost Propulsion Nozzle Components

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: AB/ GM/ TH/ MP

OBJECTIVE: Develop and characterize tantalum carbide (TaC) based materials for use as non-eroding solid rocket nozzle components for high-performance, reduced-cost boost propulsion systems.

DESCRIPTION: Ceramics and ceramic composites will be required for advanced, boost rocket motors (aluminized propellants) that will operate at temperatures above 6000F and pressures up to 2000 psi for up to 2 minute burn times. There are only a few ceramics (TaC for boost propellant and HfC for tactical, low/min smoke propellants) that can potentially survive these extreme temperatures and erosive/corrosive environments. Such ceramics are desirable since they offer the potential to reduce nozzle cost (and fabrication time) versus state of the art (SOTA) carbon-carbon composites, and they provide materials candidates for the development of boost motor energy-management devices and systems. However, monolithic ceramics are typically brittle and will fracture when subjected to extreme thermal shock conditions such as those present in a solid rocket nozzle throat. Material microstructures that increase intrinsic resistance to fracture are therefore desirable. One material approach that could provide such a fracture resistant microstructure is di-tantalum carbide - tantalum carbide composites (Ta2C-TaC) where one phase has a high aspect ratio and the other phase a fine-grained, equaxied microstructure. In preliminary studies, it appears that the Ta2C phase can be formed into needle-like grain structures, which acts as a “reinforcement” in the TaC “matrix” (This type of microstructure has proven to be effective in increasing the fracture toughness in silicon nitride materials.). Processes are sought for the fabrication of Ta2C-TaC composites that will produce the desired high-aspect-ratio, two-phase microstructure without remnant metal in the structure. A second material approach that has shown high fracture resistance is TaC with excess carbon (TaC-C) with a eutectic-type microstructure. The excess C is believed to reduce the composite Youngs modulus and thermal expansion properties while providing internal compliance for the stiff TaC phase. For the material system proposed, near-net-shape fabrication processes are also desired (eg., for axis-symmetric geometries such as nozzles) which will minimize machining and finishing costs.

PHASE I: Offerers should provide technically sound descriptions of their process and illustrate how it will lead to the desired fracture resistant microstructure. They should conduct material fabrication trials, varying key process parameters in order to determine the effects on material microstructure. Offerors will produce enough material to conduct at least ten tensile tests and ten flexural bend tests (five at room temperature and five at temperatures above 3000F). Material characterization should include at least phase identification, standard fractography, density and density gradient determination. The offeror should also make some estimates of the time and cost of producing two-inch internal diameter nozzle throats. Deliverables will include untested tensile sample and all of the tested samples.

PHASE II: Phase II will focus on the manufacturability, testing and scale-up of the process. Repeatability and reliability issues need to be addressed through process analysis, process control studies, and nondestructive evaluation (NDE). Plates, cylinders, and small nozzles throats will be produced so that a full regimen of mechanical test data and small nozzle test bed firings can be generated in order to provide data to existing performance models developed under the Integrated High-Performance Rocket Propulsion Technology (IHPRPT) Phase III Solid Rocket Motor program. Offerers are encouraged to team with a major material testing house and a major rocket manufacturer to conduct mechanical testing, performance simulation, and instrumented nozzle throat test firings using IHPRPT Phase III-type propellants. Deliverable items will be the data, simulations, interim and final reports, test samples, and a representative 2-inch diameter nozzle throat.

PHASE III: The Phase III effort will focus on the scaling up of the nozzle size from 2-inch throats to at least 5-inch diameter nozzle throats. Again, manufacturability and reliability will be a major issue. The nozzle throat geometries should be selected to retrofit into existing commercial and military rocket designs. Several instrumented land-based test firings should be conducted to qualify the final nozzle designs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Private-sector applications of ceramic rocket nozzles include rocket motors for space-based systems such as the space shuttle solid propellant boosters and telecommunications satellite launch systems. DoD applications include all aluminized boost rocket motors. MDA applications include boosters for SM3 (all three stages), THAAD, and other Ground-Based Missile Interceptors.

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3. Aviation Week & Space Technology, p. 15, March 24, 2003.

KEYWORDS: Solid rocket nozzle throats; tantalum carbide; di-tantalum carbide; zero-erosion nozzle throats; acicular microstructure, eutectic microstructure

MDA06-T008 TITLE: <u>Securely configurable electronics</u>

TECHNOLOGY AREAS: Air Platform, Chemical/Bio Defense, Electronics, Battlespace, Space Platforms, Human Systems, Weapons

ACQUISITION PROGRAM: MP

OBJECTIVE: Develop reconfigurable gate arrays that are impossible to use unless securely configured and cannot be reverse engineered.

DESCRIPTION: Microcircuit tampering is a growing concern in advanced microelectronics, and the need to manufacture high-value circuitry offshore has become a prevalent issue. Given that even tiny amounts of unused silicon in a microcircuit floorplan could be exploited for the introduction of minimally-invasive but non-cooperative integrated probe circuitry, it is essential to evolve engineering practices to preclude undesirable monitoring of input/output structures by third parties. In special high-value systems, such as radiation-hardened gate arrays, the possibility of the circuits themselves being used by aggressors is a real possibility. In this case, the already elaborate schemes for device configuration may be enhanced to guarantee that, unless the user is validated, device configuration is impossible. If this objective can be met, then otherwise strategically significant circuitry can be reduced to ineffective silicon, minimizing the possibility of exploitation.

PHASE I: Investigate methods to preclude tampering in microcircuit engineering, and devise methodologies to lock silicon from unauthorized use. Methods may include: serialization, temporal leasing, volatile tokens, digital right management, and micro-signal profiling. Develop measures of effectiveness for these methodologies and implement / develop guidelines.

PHASE II: Demonstrate application of the Phase 1 methodologies using benchmark circuit designs.

PHASE III/DUAL USE APPLICATIONS: Offeror should seek large-scale demonstration of the concepts of the SBIR. Examples include teaming with gate array manufacturers.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The ideas of this SBIR apply to various manifestations of digital rights management and the protection of intellectual property.

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Lie, D.; Mitchell, J.; Thekkath, C.A.; Horowitz, M.;Specifying and verifying hardware for tamper-resistant software, Security and Privacy, 2003. Proceedings. 2003 Symposium on
11-14 May 2003, pp. 166 - 177

KEYWORDS: field programmable gate arrays, anti-tamper, secure configuration, bitstream encryption

MDA06-T009 TITLE: Computer Network Defense Technologies

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: MP/GM

OBJECTIVE: To conduct research into developing methodologies and technologies to: detect and mitigate insider threats; allow for computer forensics data gathering for rapid response after malicious attacks; use Variable Message Format (VMF) messages; and establish Information Assurance metrics.

DESCRIPTION: The insider threat is one of the most insidious and difficult to catch threats faced by cyber security specialists and network defenders. To facilitate early and accurate detection of the insider threat, a number of new methods and ideas should be explored. First, there must be a technique to understand the behavior of information system users and to be able to determine that a user's behavior is not normal. There must be ways to accurately model human behavior against stated security policies. Also, new techniques must be developed to correlate and fuse information gathered by the numerous network sensors that exist (intrusion detection systems, network managements systems, firewalls, etc…) Additionally, cyber forensics techniques are required that allow analysts to piece together evidence of misuse in a timely and accurate manner. Together, these techniques could help to provide not only early detection of, but also mitigation of the insider threat.

Current computer forensics methodologies and technologies collect disk and system state information after a successful attack. This information is then analyzed offline by computer forensics experts to determine attack type and source in order to develop countermeasures and collect legal evidence to support the prosecution of cyber crimes. In large geographically dispersed networks, data gathering and analysis may require days or weeks. While this approach may be sufficient for commercial entities that lack stringent continuity of operations and disaster recovery requirements, it is inadequate for systems that must maintain extremely high operational reliability. The needs for a real-time forensics data gathering capability to support large, geographically dispersed networks. This capability will aid in post-attack analysis, countermeasures development, and legal prosecution.

Current commercial intrusion detection systems (IDS) perform poorly in detecting new or previously unseen attacks. They also have difficulty detecting “low and slow” attacks designed specifically to evade IDS detection. These systems also have a high rate of false alarms, which limits the use of active defenses because of the possibility of interrupting legitimate traffic. Networks make use of Variable Message Format (VMF) communications for operations and support. VMF consists of simple binary code messages that contain only a few bits of essential data. It may be possible to take advantage of the simplicity of VMF message sets to significantly improve the accuracy and reliability of attack detection by using a combination of pattern matching and anomaly detection techniques. Instead of using pattern matching on known attacks, it may be possible to use pattern matching on the VMF message sets themselves to detect attacks with a very high degree of accuracy. Once highly accurate attack detection with low false alarms is achieved, security managers can then implement active network defense to prevent attacks from having adverse effects on the weapons system.

PHASE I: Develop a system design for an insider threat detection and mitigation system; or research data gathering tools and methodologies to support real time collection, storage, and maintenance of forensic data. Show the feasibility of such an approach, and show how the proposed tools and methodologies will protect the forensics data from malicious tampering; or research the application of pattern matching and anomaly detection to Variable Message Formats to support accurate detection with low false alarms to enable active defense against attacks. Show the feasibility of such an approach, and show how the proposed tools and methodologies will protect networks; or research tools and methodologies to support Information Assurance metrics. Show the feasibility of such an approach, and show how the proposed tools and methodologies will facilitate the development and application of IA metrics.

PHASE II: Develop and test the insider threat detection and mitigation system including techniques for modeling user behavior, anomaly detection algorithms and cyber forensics techniques; or develop a proof-of-concept prototype of the real time forensics data gathering tool; or develop a proof-of-concept prototype of the VMF intrusion detection and active network defense tool; or develop a proof-of-concept prototype of an IA metrics tool.

PHASE III: Develop a configurable insider threat detection and mitigation system for network defenders and cyber security analysts in civilian and military work environments. Develop engineering prototypes of real-time forensics tools, VMF intrusion detection and active network defense tools, and Information Assurance metrics tools.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These information system technologies could be applied in any information technology environment involving complex human machine interfaces or team interactions.

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2. Charles Pfleeger, Security in Computing, Prentice Hall Technical References, Copyright 2003, Chapter Five, Trusted Operating System Design, pages 250-265.
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KEYWORDS: Insider Threats, Intrusion Detection, Active Defense, Real-time Cyber Forensics, Variable Message Format messages, Information Assurance metrics.

MDA06-T010 TITLE: Weapons Typing Assessment via Spectrally Diverse sensors and Air Sample

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: BC/AB/KI/GM/TH/AS

OBJECTIVE: Investigate techniques for weapons type assessment using air-born debris data from multiple, spectrally diverse sensors. This effort seeks to link debris cloud formation and projected fallout areas to potential ground-, sea-, air-, and space-based sensors. Efforts should fuse both RF and EO/IR algorithms and, where appropriate, analyze success of fused solutions.

DESCRIPTION: This topic develops techniques, features, and measurements to evaluate the multi-spectral phenomenology associated with intercepted objects, as well as sensor data associated with debris fallout and recovery. Topic develops techniques for assessing debris and confidence in assessment as a function of time. For Radars, measurement techniques include waveforms and their characteristics (e.g. Bandwidth, Pulse Repetition Frequency, and Coherent Processing). For EO/IR, measurement techniques may be both technology and processing techniques (New focal plane approach, Multi-frame processing approaches), and the processing of Focal Plane array data fed back from the interceptors just prior to target engagement. For Airborne sensors, measurement techniques also include atmospheric sampling if within or guided to debris fallout locations. Often within a region of operations there will be multiple elements that have opportunities of engagement at different parts of the timeline, presenting a global debris assessment challenge.

PHASE I: The contractor should develop the theoretical basis for the proposed technique that integrates different sensor data types, to include identification of the sensor capability assumptions, anticipated process and system interaction of their approach, and timeline estimates and confidence metrics.

PHASE II: The contractor should develop/update the technology to enable a relevant demonstration and explore the parameter sensitivity of the technique. Techniques applicable to an integration of multiple components that would demonstrate suitability for application at the BMDS, C2BMC level.

PHASE III: The contractor will work to integrate the technology into the BMDS system in coordination with C2BMC Program Office and other associated Program Element Offices. Partnership with traditional DoD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: RF based satellite or Space Shuttle damage assessment, NASA. RF and IR based debris assessment for first responder support functions. Optical Recognition and correlation systems.

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KEYWORDS: Weapons Typing, Kill assessment, discrimination, RF/IR mutli-spectral fusion

MDA06-T011 TITLE: Advanced Infrared (IR) Sensor Components for Missile Defense

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: AS/MP/TH/SS/GM

OBJECTIVE: Research and develop innovative concepts that will lead to the development of a new class of sensitive IR sensors for missile defense that are capable of providing a quantum leap in performance.

DESCRIPTION: Current MDA IR sensors use HgCdTe (MCT) and InSb for IR FPAs. These semiconductor materials are adequate to detect current threats at medium ranges. However, these materials may no longer be suitable to detect, track, and discriminate future threats at the more desirable longer ranges. Also, because of defect related tunneling in MCT, Focal Plane Arrays (FPAs) using MCT produce undesired levels of electronic noise and non-uniformities. The non-uniformities are corrected with algorithms that require powerful signal processors. The high cost of MCT FPAs, their low reliability, and associated manufacturing challenges provide additional incentives to develop a new class of IR detector arrays.

The primary justification for a new class of IR detector arrays rests on the assumption that future ballistic missile defense systems must be able to detect, track, and discriminate complex targets at longer ranges. This translates to the following FPA capabilities: Increased sensitivity, improved uniformity, longer cutoff wavelengths (out to 14 mm), large formats (in excess of 256 x256), two-color simultaneous waveband operation, and high operating temperatures (as high as possible). The ultimate goal is a thermoelectrically cooled detector array. The research may include currently studied IR materials, or be aimed at the discovery of new IR materials or structures such as type II superlattices, PbSnTe, high-efficiency quantum well IR photodetectors (QWIPs), and quantum- and nanotechnology-structured devices such as nano-antennas, quantum dots, and carbon tubes.

Cryogenic coolers are an enabling component of many space-based IR sensors. Dewar systems have largely been supplanted over the past decade by mechanical cryocoolers because of the tremendous mass savings afforded by these compact devices. However, current generation cryocoolers produce mechanical disturbances, and even the smallest such disturbance can be detrimental to the sensor's performance because of the resulting image jitter. Furthermore, long-life, high-reliability sensors typically must fly at least two cryocoolers to provide the required system reliability.

MDA is seeking improvements in both reliability and vibration reduction of IR sensors by soliciting the development of a "solid-state cryocooler," that is, a cryocooler with no moving parts. The maturation of a solid-state approach is expected to yield a cryocooler that can be flown with no backup, and includes coolers that are equivalent in efficiency to current mechanical systems. It is anticipated that the control electronics for such a cooler will be greatly simplified over that for current mechanical coolers, which in turn will greatly reduce the cost of the radiation hardened control electronics.

In summary, this topic seeks novel ideas for a new generation of infrared detector arrays and solid-state cryocoolers for future ballistic missile defense applications. The research involved may include currently studied technologies, or be aimed at the discovery of new concepts. Proposals can be submitted to support either the IR detector arrays aspect of this topic or the solid-state cryocooler aspect of this topic or the combination of the two areas of this topic.

PHASE I:
Infrared detector: Identify, research, explore, develop and analyze a novel concept of an infrared detector array that meets the capabilities described above. Determination of the feasibility of the concept by developing, demonstrating, and characterizing the performance of a single detector is strongly encouraged.
Cryocooler: Research practical means of providing cooling of up to 0.5 watts of focal plane array power dissipation at 35K and rejecting the heat at 300K. Comparisons to current state-of-the art Stirling or similar coolers shall be performed. At the end of this phase the STTR performer will demonstrate the most promising models and propose a design for a Phase II effort.

PHASE II:
Infrared detector: Apply the concept developed in Phase I to design, fabricate, and characterize an IR detector array. The contractor is encouraged to perform a prototype FPA demonstration with an existing ROIC.
Cryocooler: Complete the theoretical model of the cooler, and construct prototype cooler and control electronics. The prototype cooler shall be demonstrated and performance demonstrated and recorded. A detailed technical report will be produced that describes the cooler, the control electronics, benefits of the cooler over mechanical coolers and discusses the implications of operation in a nuclear environment. A preliminary design for a flight cooler will be produced.

PHASE III:
Infrared detector: Improve the performance of the IR detector array, support the integration of the detector array into an MDA seeker, address interface issues, and support the field testing of an MDA seeker prototype for use in Ballistic Missile Defense Systems capability upgrades.

Cryocooler: Assemble a prototype cooler and control electronics, perform characterization testing, vibration testing, reliability testing or modeling, and provide assurance either through modeling or testing that the performance in a radiation environment will either be unaffected or within acceptable limits.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The IR detector technologies being developed in this effort are expected to have potential for commercialization with reasonable cost and maintenance, in such applications as law enforcement, surveillance, medical diagnostics, industrial and environmental monitoring. The technology to develop a high reliability, high efficiency cryocooler for space applications will have direct applicability to ground based applications such as magnetic resonance imaging.

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KEYWORDS: Focal Plane Arrays, IR FPA, infrared materials and detectors, cryocoolers, thermal management.

MDA06-T012 TITLE: Innovative Technologies Supporting Affordable Increases in Power, Efficiency, and Bandwidth for Ballistic Missile Defense System (BMDS) X-Band Radars

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: GM

OBJECTIVE: Material, circuit, and electronic development leading to reductions in power density, increases in bandwidth, decreases in losses, and/or increases in power and efficiency based on advanced SiGe, GaAS, wide band-gap (WBG), or other materials/devices offering affordable performance enhancements in X-Band Radars for BMDS.

DESCRIPTION: By introducing power output stages fabricated from advanced semiconductor materials or materials/devices offering equal performance and footprint compared to semiconductors, there may be the possibility of lithography/ circuit/ item placement/ design iterations that reduce power density, increase bandwidth, decrease losses, and/or increase power and efficiency while eliminating much of the waste heat generated by inefficient Transmit/Receive (T/R) Modules. Low power density phased array antennas incorporating innovative chip and array technologies have the potential for enabling more affordable radars capable of robust mission and basing support and could be considered as an application. Material and/or circuit developments leading to reductions in power density and enabling full field of view beam steering, elimination of grating lobes, increases in bandwidth and efficiencies, and reduction in cost and footprint based on advanced SiGe or other materials as well as light weight, low cost antennas employing advanced ceramic materials capable of significantly increasing the FOV, bandwidth, and efficiency are also of interest. The goals of this research are to provide more compact, reliable, efficient, powerful, low cost power semiconductors or other materials/devices that will support affordable full field-of-view X-band radars while decreasing the hardware, logistics, and associated operating costs required by current systems.

PHASE I: Develop and conduct proof-of-principle demonstrations of lithography/ circuit/ item placement/ design iterations that could reduce power density, increase bandwidth, decrease losses, and/or increase power or efficiency at an affordable price.

PHASE II: Update/develop technology based on Phase I results and demonstrate technology in a realistic environment.

PHASE III: Integrate technology into BMDS system and demonstrate the total capability of the improved performance. Partnership with traditional DOD prime-contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable in commercial high power circuit design, radar, and communications systems.

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KEYWORDS: Lithography; circuit design; transmit/receive modules; power amplifiers, X-Band Radar, UEWR

MDA06-T013 TITLE: Physics Based Modeling of Supersonic Rain Erosion of Ballistic Missile Radomes

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/MP

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Research, identify and develop an analytical model of the major physical processes that cause supersonic rain erosion of ballistic missile radomes as a function of velocity, angle of attack, and droplet size and distribution.

DESCRIPTION: Launch conditions of ballistic missiles involve flight, at supersonic and hypersonic speeds, through heavy rain. In these environments the missile radome can be damaged by rain droplet impingement, which affects both the structural integrity and the electrical performance. In addition to flight, long duration captive carriage requirements, can also result in cumulative damage due to rain exposure. While the subsonic interactions of rain droplets on radome surface can be easily modeled, the supersonic/hypersonic interactions involve multi-physics modeling which will include particle/shock interactions and may also include: chemical reaction and ionization of rain droplets, micro-blast and micro-explosive degradation of radome surfaces, ballistic impact induced thermal shock of the radome materials, and electro magnetic radiation from the ballistic impact. The cumulative effect of different mechanisms needs to be modeled, and new experimental methods need to be developed to characterize different mechanics of ballistic rain-erosion conditions.

PHASE I: Research, analyze and identify gaps in existing methodologies. Identify the mechanics of rain-erosion at supersonic/hypersonic speeds. Develop analytical and/or numerical models of supersonic and/or hypersonic fluid/structure interactions. Incorporate potential electromagnetic radome materials in models to identify key challenges that need to be addressed in subsequent phases. Identify shock characterization experimental techniques and demonstrate their feasibility. Develop a risk mitigation plan and a Phase II program plan.

PHASE II: Contractors are encouraged to demonstrate the feasibility of their technology at a prototype level. Tasks shall include, but are not limited to, detailed analytical and numerical models including the multi-physics nature of the problem, with demonstrated correlations to various experimental techniques for characterizing different shock induced damage mechanisms on realistic radome materials.

PHASE III: Phase III will focus on specific customer applications and needs, including model implementation, design, and experimentation and scaling issues that may arise.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Besides missile defense contractors, satellite manufacturers and other space and ground based vendors will benefit from these innovations. These technologies will be procured by commercial customers thru the Phase III contract.

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KEYWORDS: Rain-Erosion, Supersonic Impact, Ballistic Radome, Ceramic/ Composites, Modeling and Simulation, Experimental Techniques