MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) PROGRAM
STTR 09B Supplemental Proposal Submission Instructions

INTRODUCTION

The MDA STTR Program is implemented, administrated and managed by the MDA SBIR/STTR Program Management Office (PMO), located within the Advanced Technology (DV) Directorate. Specific questions pertaining to the MDA SBIR Program should be submitted to:

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Washington, DC 20301-7100
FAX: (703) 882-6350

If you have any questions regarding the administration of the MDA SBIR/STTR Program please call 703-882-8300 or e-mail: sbirsttr@mda.mil.

Additional information on the MDA SBIR/STTR Program can be found on the MDA SBIR/STTR home page at http://www.mdasbir.com/. Information regarding the MDA mission and programs can be found at http://www.mda.mil.

MDA participates in one DoD STTR Solicitation each year (x.B). Proposals not conforming to the terms of this Solicitation will not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded. Only Government personnel will evaluate proposals.

Questions about STTR and Solicitation Topics

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8:00 am to 5:00 pm EDT). For technical questions about the topic during the pre-solicitation period (27 July 2009 through 23 August 2009), contact the Topic Authors listed under each topic on the http://www.dodsbir.net Web site by 23 August 2009. Please Note: During the pre-release period, you may talk directly with the Topic Authors to ask technical questions about the topics. Their names, phone numbers, and e-mail addresses are listed within each solicitation topic. For reasons of competitive fairness, direct communication between proposers and topic authors is not allowed when DoD begins accepting proposals for each solicitation. However, proposers may still submit written questions about solicitation topics through the SBIR/STTR Interactive Topic Information System (SITIS), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing until the solicitation closes. All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other significant information, relevant to the SBIR/STTR topic under which they are proposing.

Federally Funded Research and Development Centers (FFRDCs) and Support Contractors
Only Government personnel will evaluate proposals. In some circumstances, non-government, technical personnel from the following Federally Funded Research and Development Centers (FFRDCs) and

support contractors will provide advisory and assistance services to MDA, including providing technical analyses of proposals submitted against MDA topics and of applications submitted to the MDA Phase II Transition Program.

FFRDCs: The Aerospace Corporation, Massachusetts Institute of Technology Lincoln Laboratory, Oak Ridge National Laboratory.

Universities / Non-Profit Organizations: Draper Laboratory, Institute of Defense Analyses, Johns Hopkins University Applied Physics Laboratory (JHU/APL,), Utah State University Space Dynamics Laboratory, Aerospace Corporation, MITRE Corporation, University of Connecticut, Sandia National Laboratory.

Support Contractor Organizations: BAE Systems, The Boeing Company, Booz Allen Hamilton, Cobham Analytic Services (Sparta, Inc), CACI International, Inc., Computer Sciences Corporation (CSC), deciBel Research, Inc., Dynamic Research Corporation, Inc., ERC, Inc., General Dynamics Information Technology, L-3 Communications Corporation, Lockheed Martin, MacAulay Brown, Inc., Millennium Engineering and Integration, Inc., Modern Technology Solutions, Inc., Northrop Grumman Corporation, Paradigm Technologies, Photon Research Associates, Inc. (Raytheon), Radiance Technology, Raytheon Company, Schafer Corp, Science Applications International Corporation (SAIC), SYColeman Corporation, United International Engineering, Universal Technology Corporation.

Individual support contractors from these organizations will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. These organizations are expressly prohibited from rating proposals or making recommendations for award selection. In accomplishing their duties related to the source selection process, employees of the aforementioned organizations may require access to proprietary information contained in the offerors' proposals.

Pursuant to FAR 9.505-4, the MDA contracts with these support contractors include a clause which requires them to (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. In addition, MDA requires the employees of those support contractors that provide technical analysis to the SBIR/STTR Program to execute non-disclosure agreements. These agreements will remain on file with the MDA SBIR/STTR PMO.

Conflicts of Interest

You must avoid any actual or potential organizational conflicts of interest (OCI) while participating in any MDA-funded contracts, regardless of whether it was awarded by MDA. You must report to the MDA SBIR/STTR Program Office via e-mail any potential OCI before submitting your proposal or application. The MDA SBIR/STTR Program Office will review and coordinate any possible solutions or mitigation to the potential conflict with the contracting officer. If you do not make a timely and full disclosure and obtain clearance from the contracting officer, MDA may reject your proposal or application, or terminate any awarded contracts for default. See FAR Subpart 9.5 for more information on organizational conflicts of interest.

PHASE I GUIDELINES

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept. Only UNCLASSIFIED proposals will be entertained. Phase I proposals may be submitted for an amount not to exceed $100,000.

A list of the topics currently eligible for proposal submission is included in section 8, below, 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 assure that your mailing address, e-mail address, and point of contact (Corporate Official) listed in the proposal are current and accurate. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.

PHASE I PROPOSAL SUBMISSION

Read the front section of the DoD solicitation, including Section 3.5, for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this solicitation will not be considered.

If the offeror proposes to use foreign nationals: Identify the foreign nationals you expect to be involved on this project, country of origin and level of involvement. If a proposal is selected for award, provide the following information about any foreign national: individual's full name (including alias or other spellings of name); date of birth; place of birth; nationality; registration number or visa information; port of entry; type of position and brief description of work to be performed; address where work will be performed; and copy of visa card or permanent resident card. Please Note: If selected for award - proposals submitted to ITAR restricted topics and/or with a foreign national listed, will be subject to security review during the contract negotiation process. If the security review disqualifies a foreign national from participating in the proposed work, the contractor may propose a suitable replacement. In the event a proposed foreign person or firm is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but will not disclose the underlying rationale.

The technology within some of the MDA topics is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. You must ensure that your firm complies with all applicable ITAR provisions. Please refer to the following URL for additional information: http://www.pmddtc.state.gov/compliance/index.html.

You must submit the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report electronically through the DoD SBIR/STTR Web site at www.dodsbir.net/submission/SignIn.asp. If you have any questions or problems with the electronic proposal submission, contact the DoD SBIR/STTR Helpdesk at 1-866-724-7457. Refer to section 3.0 of the DoD solicitation for complete instructions and requirements.

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MAXIMUM PAGE LIMIT FOR MDA IS **20 PAGES**

Only proposals submitted via the Submission Web site on or before the deadline of 6:00 am (ET) on 23 September 2009 will be processed. ***Please Note:*** The maximum page limit for your technical proposal is twenty (20) pages. Any pages submitted beyond this, will not be evaluated. Your cost proposal and Company Commercialization Report DO NOT count towards your maximum page limit.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. The following have been submitted electronically through the DoD submission site by 6:00 am (ET) 23 September 2009.

_____ a. DoD Proposal Cover Sheet

_____ b. Technical Proposal (**DOES NOT EXCEED 20 PAGE**S): *Any pages submitted beyond this, will not be evaluated. Your cost proposal and Company Commercialization Report DO NOT count towards your maximum page limit.*

_____ c. DoD Company Commercialization Report (required even if your firm has no prior SBIRs).

_____ d. Cost Proposal **(Online cost proposal form is REQUIRED by MDA)**

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

MDA PROPOSAL EVALUATIONS

MDA will utilize the Phase I Evaluation criteria in Section 4.2 of the DoD solicitation, including potential benefit to the Ballistic Missile Defense System (BMDS) in assessing and selecting for award those proposals offering the best value to the Government.

MDA will use the Phase II Evaluation criteria in Section 4.3 of the DoD solicitation, including potential benefit to BMDS and ability to transition the technology into an identified BMDS, in **inviting,** assessing and selecting for award those proposals offering the best value to the Government. In the Phase II Evaluations, Criterion C is more important than criteria A and B, individually. Criteria A and B are of equal importance.

In Phase I and Phase II, firms with a Commercialization Achievement Index (CAI) at the 20th percentile will be penalized in accordance with DoD Section 3.5d.

Please note that potential benefit to the BMDS will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price. Where technical evaluations are essentially equal in merit, cost or price to the government will be considered in determining the successful offeror.

It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Technical reviewers will base their conclusions on information contained in the proposal and their personal knowledge. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal and will count toward the applicable page limit.

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. MDA is not responsible for any money expended by the proposer before award of any contract.

INFORMATION ON PROPOSAL STATUS

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Coversheet will be notified by e-mail regarding proposal selection or non - selection. If your proposal is tentatively selected to receive an MDA award, the PI and CO will receive a single notification. If your proposal is not selected for an MDA award, the PI and CO may receive up to two messages. The first message will provide notification that your proposal has not been selected for an MDA award and provide information regarding the ability to request a proposal debriefing. The second message will contain debrief status information (if requested), or information regarding the debrief request. **Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced.**

IMPORTANT: We anticipate having all the proposals evaluated and our Phase I contract decisions in the December 2009 timeframe. All questions concerning the evaluation and selection process should be directed to the MDA SBIR/STTR Program Management Office (PMO).

MDA SUBMISSION OF FINAL REPORTS

All final reports will be submitted in accordance with the Contract Data Requirements List (CDRL) of the resulting Contract. Refer to section 5.3 of the DoD Solicitation for additional requirements.

PHASE II GUIDELINES

This Solicitation is for Phase I Proposals. For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. 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 will be issued at the discretion of MDA to firms based upon the results of their Phase I effort, the probable value of those results to MDA requirements, and the potential for outside investment in the technology. MDA makes no commitments to any offeror invited to submit a Phase II Proposal. MDA will evaluate and select Phase II proposals using the evaluation criteria in section 4.3 of the DoD SBIR solicitation. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I.

Invitations to submit a Phase II proposal will be made by the MDA SBIR/STTR PMO. Phase II proposals may be submitted for an amount normally not to exceed $750,000. MDA may consider making Phase II Invitations not to exceed a maximum of $2.5M. **You may only propose up to the total cost for which you are invited.**

The MDA SBIR/STTR PMO does not provide “debriefs” for firms who were not invited to submit a Phase II proposal.

PHASE II PROPOSAL SUBMISSION

Phase II Proposal Submission is by Invitation only: *A Phase II proposal can be submitted only by a Phase I awardee and only in response to an invitation by MDA.* Invitations are generally issued at or near the Phase I contract completion, with the Phase II proposals generally due one month later. In accordance with SBA policy, MDA reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards. If you have been invited to submit a Phase II proposal, please see the MDA SBIR/STTR Web site http://www.mdasbir.com/ for further instructions.

Classified proposals are not accepted under the DoD SBIR/STTR Program. Follow Phase II proposal instructions described in Section 3.0 of the Program solicitation at www.dodsbir.net/solicitation and specific instructions provided in the Phase II Invitation. Each Phase II proposal must contain a Proposal Cover Sheet, technical proposal, cost proposal and a Company Commercialization Report submitted through the DoD Electronic Submission Web site at www.dodsbir.net/submission/SignIn.asp **by the deadline specified in the invitation.**

2009 KEY DATES (PROJECTION)

MDA SBIR/STTR Industry Day (Long Beach) ….………….….…………………….. August 11-12, 2009
09.B Solicitation Pre-release……………………………….………………….July 27 – August 23, 2009
09.B Solicitation Opens ……………………………………….…………….August 24 – September 23, 2009
Solicitation Closes ………………………………….………………...06:00 a.m. ET 23 September 2009
Phase I Evaluations……………….……….……...…………………….October – November 2009*
Phase I Selections……………….……….………..………………………………December 2009*
Letters Distributed …………………..………………..…………..……………………December 2009*
Contract Award Goal ……………...…………………………..……..…………...………..February 2009*

Phase II Recommendation Period (from 08.B PH I) ……………………………...……….August 2009*
Phase II Invitations (from 08.B PH I) …………………….…………………..………….September 2009*
PH II Proposals Due …………………………………..…………………..……………October 2009*
Phase II Evaluations ……………………………….....……………...…November – December 2009*
Phase II Selections…..…………………………..…………………………………….December 2009*
Letters Distributed ……………………………..…………………..…………………..…January 2009*
Contract Award Goal...…...………...…………….…………..….……………………………..April 2010*

*This information is listed for GENERAL REFERENCE ONLY at the time of publication of this solicitation. This date is subject to update/change.

MDA STTR 09.B Topic Index by Research Area

MANUFACTURING, PRODUCIBILITY AND FIELD SUSTAINABILITY
The Manufacturing, Producibility and Field Sustainability Research Area focuses on innovative technologies for manufacturing, assembly, production and fielded systems sustainment in all areas of the Ballistic Missile Defense System (BMDS).

MDA09-T001 Producibility of Gallium Nitride Semiconductor Materials
MDA09-T002 Ultrahigh Temperature Materials for Missile Defense Propulsion and Aerothermal Applications

RADAR
The Radar Research Area focuses on finding the next "game changing" technology development for Ballistic Missile Defense (BMD) radars. Radar Technology also focuses on innovative and/or enhanced technology development or technology that improves radar functionality, packaging and/or affordability.

MDA09-T003 Software Defined Multi-Channel Radar Receivers for X-band Radars
MDA09-T004 Low Cost, High Performance Transmit/Receive Integrated Circuits on a single chip

SPACE TECHNOLOGY
The Space Technology Research area focuses on developing and transitioning technologies to enable or improve the operation of Ballistic Missile Defense System Elements in the long-term orbital environment. Primary emphasis is on technologies to support space-based tracking of targets in the ascent phase, but technologies enabling other systems are of term interest as well. One of the over-arching requirements for all work in this area is the ability to survive and operate in orbit: this means a tougher natural radiation environment (and potential enhancement by man-made threats) than on earth, the absence of atmosphere, and micro-gravity. Most of the efforts are hardware oriented, however, software improvements are also of interest.

MDA09-T005 Technology Improvements for Multi Junction Solar Cells for Satellite Applications, and Radiation Protection of Solar Cells
MDA09-T006 Development for Radiation Hardened Applications of Advanced Electronics Materials, Processes, and Devices
MDA09-T007 STTR Solid State Cooling of Infrared Focal Plane Arrays

~~**COMMAND, CONTROL, BATTLE MANAGEMENT AND COMMUNICATIONS (C2BMC)**~~
~~The Command, Control, Battle Management and Communications (C2BMC) Research Area funds technological innovations related to supporting this integrating element of the Ballistic Missile Defense System (BMDS). The C2BMC Research Area seeks technological innovations that apply novel solutions to inherent challenges in Ballistic Missile Defense.~~

~~MDA09-T008 Decision Making~~

INTERCEPTOR TECHNOLOGY
The Interceptor Research Area funds innovative technologies that have the potential to increase the capabilities and effectiveness of present or future interceptors for the Ballistic Missile Defense System (BMDS). The goal of this research area is to introduce technologies that could be incorporated into interceptor designs to enable the development of agile interceptors that are highly accurate.

MDA09-T009 Propulsion Modeling

DIRECTED ENERGY

The ultimate Directed Energy Research Area technical objective is to take innovative optics, laser, and RF technology developed by dynamic small businesses and insert the technology into air and ground weapon systems for integration into the Ballistic Missile Defense community.

MDA09-T010   Novel Directed Energy Options in Ballistic Missile Defense

MDA STTR 09.B Topic Index

MDA STTR 09B Topic Descriptions

MDA09-T001 TITLE: Producibility of Gallium Nitride Semiconductor Materials

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: DEP

OBJECTIVE: Develop and apply innovative manufacturing processes that improve the producibility of gallium nitride substrates and advanced epitaxial device structures.

DESCRIPTION: Gallium nitride (GaN) based RF devices have expanded the scope of device applications beyond those of silicon and gallium arsenide. Exploitation of GaN semiconductors holds promise for revolutionary improvements in the cost, size, weight and performance of Missile Defense Agency (MDA) radar systems. The development of these capabilities is currently hampered by the absence of native GaN substrates of sufficiently quality and affordability. GaN polishing processes capable of producing epitaxial ready surfaces are necessary to eliminate subsurface damage observed in early device prototypes. Furthermore, innovative MOCVD and/or MBE homo-epitaxial growth processes are essential for achieving desired device performance. Innovative concepts are sought to develop and demonstrate novel GaN substrate and/or epitaxial manufacturing processes.

PHASE I: Demonstrate scalability of bulk GaN crystal growth process enabling production of centimeter-thick, low defect density semi-insulating boules; and/or demonstrate feasibility of chemical-mechanical polishing process capable of producing epi-ready surfaces that are suitable for large volume manufacturing; and/or demonstrate homo-epitaxial growth processes or innovative device structures capable of producing high performance RF devices. Deliver materials for Government evaluation.

PHASE II: Validate methodology developed in Phase I with reproducible growth of semi-insulating GaN crystals greater than two centimeters in length with dislocation densities below 10E5 cm^-2. Establish reproducible polishing processes capable of eliminating GaN substrate subsurface damage and obtain angstrom level surface roughness. Demonstrate the producibility of pseudomorphic HEMT structures with room temperature μ > 1500 cm^2/V•s, n(s) > 2.5 x 10^13 cm^-2 and sheet resistance < 250 Ohm/sq on a native GaN substrates. Deliver materials for Government evaluation. Identify radar components suitable for insertion utilizing proposed technology. Identify any commercial benefit or application opportunities of the innovation. Partnership(s) with current or potential supplier(s) of MDA system components is highly desirable.

PHASE III: Target MDA industrial partners for technology transition with potential integration into one or more BMDS systems. Validate performance, cost and reliability benefits to be achieved through a prototype device demonstration.

COMMERCIALIZATION: Proposed technology is expected to garner a high level of interest for next generation RF power amplifiers.

REFERENCES:
1. Kuzmík, J., “Power Electronics on InAlN/(In)GaN: Prospect for a Record Performance,” IEEE Electron Device Letters, VOL. 22, NO. 11, November 2001.

2. Blevins, J., “Wide Bandgap Semiconductor Substrates: Current Status and Future Trends,” Compound Semiconductor Manufacturing Technology Conference, May 2004, Miami.

KEYWORDS: GaN, MOCVD, MBE, chemical mechanical polishing, AlGaN, InAlN, HEMT, and HVPE.

MDA09-T002 TITLE: Ultrahigh Temperature Materials for Missile Defense Propulsion and Aerothermal Applications

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: DEP, AB

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: The Manufacturing and Producibility Directorate of the Missile Defense Agency (MDA) is seeking highly innovative and significantly lower cost materials and processes for fabricating new, ultra-high-temperature (UHT) materials systems for future compact, high performance divert and attitude control systems (DACS, ~5000ºF capability), as well as for future hypersonic thermal protection systems (TPS, ~4000ºF capability.)

DESCRIPTION: MDA DACS propulsion systems and hypersonic TPS exhibit stringent performance requirements while simultaneously exposing materials to severe operating conditions. Future performance requirements will require new propulsion materials which will enable 5000ºF flame temperature non-aluminized propellants, and will require new TPS nosetip/nosecone materials which will enable non-ablating 4000ºF surface temperature capability. Current UHT continuous fiber composites employ high cost fabrication processes, and are typically porous which increases design complexity. Lower cost ablation-resistant materials, such as monolithic ceramics, do not have adequate thermal shock resistance (due to extremely large temperature gradients) to be satisfactorily used in such systems. New, innovative materials and processes approaches are desired for propulsion and hypersonics applications.

In addition, current structural insulator materials are temperature or thermal conductivity / diffusivity limited. For propulsion and hypersonics applications, new structural insulators are required with extremely low thermal conductivity / diffusivity and UHT capabilities which approach or exceed 4000ºF.

Areas of interest include:

• New highly innovative and low-cost UHT ablation-resistant materials. Such materials include Zr- or Hf-based materials that will be subjected to pressures up to 3000 psi and flame temperatures from 4000°F to 5000°F in flow-path DACS application. SiC-based composites may be considered, but are known to be temperature limited relative to these goals. The materials must be able to tolerate large temperature gradients such as those experienced at motor initiation. A typical strength minimum is a tensile strength of 50 ksi (345 MPa).

• For aerothermal applications, surface temperatures in excess of 4000ºF with extreme thermal gradients represent challenges with respect to ablation, thermal stress, and in-depth conduction to lower temperature substrates. Materials systems of interest include UHT monolithics, ceramic matrix composites, and others, which can meet these TPS design constraints for hypersonic missile defense systems. Infiltrated, functionally graded, as well as coated material technologies that can be shown to adequately function in 10 to 100 second exposures to hypersonic flight are of particular interest. Typical TPS thermal environments exceed 3200ºF surface temperatures and may approach or exceed 4000ºF. These TPS materials systems must accommodate steep thermal gradients to minimize structural substrate temperature rise. Additional system requirements include minimized wall thicknesses (maximum of 0.5 inch) and must be manufacturable in nosetip/nosecone missile configurations.

• New structural insulation materials which support ablation-resistant flowpath liner materials. DACS components are attached to missile primary structures and electronic components that cannot tolerate high temperatures. Currently, most non-pyrolyzing insulation materials have poor mechanical properties and only modest temperature capabilities. Optimal structural insulation materials will be dimensionally stable to high temperatures and will exhibit 15 ksi (34.5 Mpa) strengths or higher. Desired structural insulators will have high fracture toughness and thermal stress resistance, exhibit low thermal diffusivity, and will have low-cost and reliable production techniques. Materials are desired for use at 4000°F with a future temperature goal approaching 5000°F.

PHASE I: Develop an innovative and low-cost material or fabrication approach with utility for the stated applications. Identify and conduct critical experiments verifying the proposed materials and fabrication processes. Assess microstructure-processing-property relationships. Collect and analyze data on relevant materials properties.

PHASE II: Design and develop the proposed UHT divert liner, hypersonic TPS, or insulator material using the innovative composition and/or fabrication techniques identified in Phase I. Identify critical properties for the selected propulsion and/or hypersonic application, and conduct property characterization to provide confidence for successful demonstration testing. Fabricate prototype components for demonstration testing in relevant environments. Conduct an initial fabrication series which demonstrates production reproducibility, and enables initial database development concerning critical ablation, physical, thermal, and mechanical properties.

PHASE III: Transition the UHT material into an MDA propulsion and/or hypersonic system. With adequate propulsion prime investment, continue application demonstrations and development of appropriate physical, thermal, and mechanical property databases.

COMMERCIALIZATION: New and highly innovative UHT materials may have applicability to other DOD missile systems, space launch vehicles, gas turbines, and automotive technologies.

REFERENCES:
1. George T. Sutton, “Rocket Propulsion Elements; Introduction to the Engineering of Rockets” Seventh Edition, John Wiley and Sons, 2001.

2. Missile Defense Agency Link: http://www.acq.osd.mil/mda/mdalink/html/mdalink.html

3. Ballistic Missile Defense Basics: http://www.acq.osd.mil/mda/mdalink/html/basics.html

4. M. Opeka, Thermodynamics-Based Materials Selection for Corrosion-Resistant Performance in High-Temperature Missile Propulsion Systems. Part I. Consideration of Condensed Phase Equilibria, Proceedings ECS Conference on Ultra-High-Materials, 2004.

5. Russell, G.W. “DoD High Speed Aerothermal Analysis and Design - Historical Review and New State of the Art Approaches,” NASA Thermal and Fluids Analysis Workshop, NASA Langley Research Center, Hampton, VA, Aug. 2003.

KEYWORDS: Composites, Ceramics, Divert and Attitude Control System, High Temperature Material, Insulation, Thermal Protection Systems.

MDA09-T003 TITLE: Software Defined Multi-Channel Radar Receivers for X-band Radars

TECHNOLOGY AREAS: Sensors, Electronics

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: Investigate and develop Software-Defined Multi-channel Receivers to enhance X-Band radar systems performance.

DESCRIPTION: Future X-Band radar systems will employ low-cost antenna array technology and digital beamforming architecture that requires multiple receiver channels. Demonstrating the utility of software defined, scalable multi-channel receiver technology that reduces cost, weight, and size while enhancing radar system flexibility and performance is the optimal goal of this research. With recent development of the state-of-the-art receiver technology coupled with high-speed computing devices, multi-channel receiver (consisting of up to 100s of channels) controlled by software may possible. The advantage of software defined multi-channel receiver is that the reconfiguration of hardware components can be done relatively quickly. The benefit of employing software defined receiver is that the implementation would rely heavily on the digital signal processing algorithm and requiring fewer hardware components. Subsequent benefits such as improvement in dynamic range, quadrature coherency, reliability, and low cost. The primary objective of this research is to investigate the feasibility of software-defined technology that offers the potential of a low-cost robust multi-channel receiver solution. The multi-channel receive takes X-Band RF signals and outputs digitized In-phase and Quadrature (I&Q) data. The receiver should cover a 25-40% operating bandwidth centered at X-Band. The receiver should cover a tunable instantaneous bandwidth of 1GHz (goal), 400MHz (threshold), with an instantaneous dynamic range of 52+ dB. The control interfaces should utilize Open System Architecture to the maximum extend possible for ease of integration within the radar systems.

PHASE I: Investigate the feasibility, technical issues, and risks of developing software-defined multi-channel receiver at X-Band. Conduct computer modeling and demonstrate proof of concept implementation. The research will result in a detail report on how the software defined multi-channel receiver would be built to meet the performance while attaining the low cost and small size objective.

PHASE II: Demonstrate the operation of the developed prototype software defined multi-channel receiver using low-cost components. Validate performance, cost and reliability benefits to be achieved through a prototype device. Quatify the benefits of digital signal processing implemention and approach and identify commercial radar application opportunity.

PHASE III: Design and validate the software defined multi-channel receiver prototype developed in Phase II for X-Band radar systems for military and commercial applications. Work closely with missile defense agency (MDA) to target potential technology insertion and integration into MDA ballistic missile defense systems.

COMMERCIALIZATION: The proposed technology has a number of related commercial applications in radio frequency (RF) sensors. Commercial radar systems, commercial RF communications systems that require software defined multi-channel receiver.

REFERENCES:
1. J. H. Reed, “Software Radio A Modern Approach to Radio Engineering”, Prentice Hall Communications Engineering and Emerging Technologies Series, 2002.

2. R. Seal, J. Urbina, M. Sulzer, S. Gonzalez, N. Aponte, “Design of an FPGA-based radar controller”, National Radio Science Meeting, Boulder, CO, Jan 2008.

3. J. Mitola, "Cognitive radio: an integrated agent architecture for software defined radio", Ph.D. dissertation, KTH Royal Institute of Technology, Stockholm, Sweden, 2000.

4. T. Quach et al, “X-Band Receiver Front-End Chip in Silicon Germanium Technology”, IEEE 8th Topical Meeting on Silicon for RF Systems, Jan 2008.

5. R. Dragenmeister et al, “Multi-Chip-Module Based X-Band Receiver Utilizing Silicon Germanium MMICs”, GOMACTECH 2008, Mar. 2008.

KEYWORDS: Antenna Array, Multi-channel Receiver, Analog to digital converter, Radar receiver, Digital Beamforming, phased array radar.

MDA09-T004 TITLE: <u>Low Cost, High Performance Transmit/Receive Integrated Circuits on a single chip</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

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: Develop a single chip transmit / receive function with on-chip controller and compensation networks for next generation X-band radar systems.

DESCRIPTION: Conventional Transmit/Receive Integrated Circuits (TRIC) approaches are based on a modular concept where there is a clear delineation between RF and digital functionality. Typically, III-V semiconductor technologies (GaAs, InP, GaN) are employed for RF circuits and silicon CMOS technology is reserved for control and timing circuits. With this approach, significant yield and cost impact are derived from assembly and characterization methodologies. For example, packaging the RF portion of the TRIC involves numerous surface mount components, requiring high-yield low-loss interconnects for DC / RF input and output terminals. Moreover, there is a RF performance uniformity issue for TRIC chips from wafer-to-wafer. The net result is that high degree of testing is required to ensure performance uniformity at the element level which can become cost prohibitive. This topic will explore the idea of a single chip solution where the entire T/R function (both RF and digital) is implemented monolithically. The TRIC should include on-chip digital control compensation networks to ensure performance uniformity at the element level.

The notional focus of this TRIC development shall be X-Band operation over a 25%-40% bandwidth with transmitter output power ranging from 0.5-2W and transmitter efficiency greater than 20%. This typically equates to a power amplifier operating with greater than 30% power-added-efficiency (PAE). For the receive function, system noise figure goals shall be below 3 dB or the low noise amplifier (LNA) will be required to operate below 2dB noise figure. A salient feature of this topic is to achieve a low cost/ high yield / high uniformity single chip TRIC.

PHASE I: Develop single chip TRIC architecture including on-chip controller and compensation networks to support X-band radar. Critical components of the system should be identified and trade studies conducted resulting in selection of the best architecture and components for Phase II.

PHASE II: Design and fabricate a single chip TRIC to validate benefits to be achieved through a demonstration. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Refine prototype components developed in Phase II for targeted MDA and commercial applications. Work with MDA to target potential integration into one or more BMDS systems.

COMMERCIALIZATION: The proposed technology has a number of related commercial applications in radio frequency (RF) sensors. Commercial radar systems and commercial RF communications systems all require TRIC components and have increasing needs for low-cost TRIC technology.

REFERENCES:
1. M. Mitchell and J.D. Cressler, "An X-Band SiGe Single-MMIC Transmit/Receive Module for Radar Applications," Proceedings of the 2007 IEEE Radar Conference, pp. 664-669, 2007.

2. B. Kane et al., "Smart Phased Array SoCs: A Novel Application for Advanced SiGe HBT BiCMOS Technology", Proceedings of the IEEE, vol. 93, no. 9, Sept. 2005 Page(s):1656 – 1668.

KEYWORDS: Transmit/Receive Integrated Circuit, Low-Cost, Power Amplifier, Low Noise Amplifier, Phase Shifter, Attenuator, Beam Contro, Digital Compensation, Phased Array Radar

MDA09-T005 TITLE: Technology Improvements for Multi Junction Solar Cells for Satellite Applications, and Radiation Protection of Solar Cells

TECHNOLOGY AREAS: Air Platform, Space Platforms

ACQUISITION PROGRAM: STSS

OBJECTIVE: Design and demonstrate an operating multi-junction solar cell which incorporates the developing technologies of quantum dots/quantum wells to improve efficiency and absorptive spectrum properties of the underlying multi-junction device. The intent is to improve the operational capabilities of multi-junction cells such that lighter weight solar arrays may be utilized in satellite programs to increase the operational payload of the satellite as well as reduce volume of the overall system on launch vehicles.

DESCRIPTION: Recent advances in the development of quantum dot and quantum well technologies at the academic level hold significant promise for improvements in efficiency and range of spectral absorption for satellite multi-junction solar cells, with potential applications to terrestrial CIGS and silicon arrays as well. It is anticipated that this Phase I proposal will incorporate an academic/government lab/business partnership to develop the theoretical underpinning for insertion of the developing technologies into actual devices. There exist already, technical papers on quantum dot and quantum well technology developments for application to solar cells (see References). However, actual demonstration of efficiency and spectral absorption improvements have yet to be validated. Therefore, the intent of this solicitation is to marry the theoretical and academic experimental work with actual incorporation into current device technology, as a demonstration of the capabilities for improvement in the performance of solar arrays for satellite applications.

PHASE I: Design and develop a representative proof of concept model for a multi-junction solar cell incorporating quantum technologies. This effort should include development of an actual multi-junction cell with the advanced technology to provide a functioning composite device as a demonstration of the concept and the improvements to be obtained from the technology improvement. It is desirable that the eventual device show a significant improvement in performance over the standard multi-junction technology without the quantum dot/well addition. The contractor will identify key technical challenges and establish a plan to address and overcome the challenges. The contractor will also develop a Phase II program plan, including (but not limited to) further development strategies which will incorporate additional aspects of the overall needs of the program schedule, and estimated costs. Proposing firms are also encouraged to consider MDA satellite contractors who understand system requirements. to help insure applicability of their efforts. and to begin work towards technology transition.

PHASE II: Using the modeling and technology understanding developed from the proof of concept in Phase I, design and build a solar panel which incorporates the technology developments, and demonstrate by accepted testing regimes the full potential of the addition of quantum technology to standard manufacture multi-junction solar cells. The success of this effort will be continuously evaluated against current multi-junction cell performance, wherein it is expected that a strong relationship with solar cell prime contractor will be established to provide relevant data for incorporation of the technology advancement into spacecraft power systems. The contractor should also keep in mind the goal of commercialization of this innovation for a potential Phase III effort, to which end the proposer should have a working relationship with, and support from, system contractors.

PHASE III: The technologies developed as a result of the Phase II contract(s) will be applicable to many military and commercial satellite applications that can benefit from the enhanced capabilities provided by the insertion of quantum technology into standard solar cell manufacturing.

COMMERCIALIZATION: The commercial potential for enhancement of performance in commercial satellite platforms as well as terrestrial applications of solar cells is substantial. And it should be noted that DoE applications will also be an important consideration for the performance enhancements.

REFERENCES:
1. R. Oshima, Y. Nakamura, A. Takata, and Y. Okada, 22nd European Photovoltaic Solar Energy Conference, 3-7 September 2007, Milan, Italy

2. M. Green, G. Conibeer, E-C. Cho, D. König, S. Huang, D. Song, G. Scardera, Y-H. Cho, X. Hao, T. Fangsuwannarak, S. Park, I. Perez Wurfl, Y. Huang, S. Cheng, E. Pink, D. Bellet, E. Bellet-Amalric and T. Puzzer, 22nd European Photovoltaic Solar Energy Conference, 3-7 September 2007, Milan, Italy

3. K. Barnham, I. Ballard, B. Browne, C. Calder, J. Connolly, M. Fuhrer, R. Ginige, G. Hill, D. Johnson, M. Mazzer, J. Roberts, and T. Tibbits, 17th International Photovoltaic Science and Engineering Conference, 3-7 December 2007, Fukuoka, Japan

4. S. Bremner, A. Pancholi, K. Ghosh, S. Dahal, G. Liu, K. Ban, M. Levy, and C. Honsberg, 33rd IEEE PVSC, 11-16 May 2008, San Diego, CA

KEYWORDS: Solar Cells, multi-junction, quantum dots, quantum wells

MDA09-T006 TITLE: <u>Development for Radiation Hardened Applications of Advanced Electronics Materials, Processes, and Devices</u>

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: STSS

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: The requested proposals should address extension of advanced electronics toward production readiness by demonstrating the capability to move the technology from the conceptual research stage to producing functional applications. The degree of functionality expected for demonstration is medium scale integration (MSI) such as an 8 bit ALU (arithmetic logic unit), a 16 Kbit memory, or device of similar complexity. The demonstration device is expected to be a milestone step in the progress of the advanced technology toward production. Selected technologies will demonstrate a path to radiation hardened space and missile applications for MDA systems. Potential technologies may include but are not limited to molecular electronics, chalcogenide based electronic applications, vacuum microelectronics, carbon nanotube based electronics, silicon carbide based electronics, 3-D electronics, etc. Applications may be based on analog, digital, or mixed signal functions and may address requirements in the frequency band from dc through RF and microwave. The advanced electronics technology should show the capability for achieving performance in the following environments: (1) Operating temperature range of -40 deg. C. to +80 deg. C., (2) Total Ionizing Dose Tolerance > 300Krad (Si), (3) Immunity to catastrophic single event effects (e.g., single event latch-up) for particles with LET (linear energy transfer) levels up to 100 Mev-cm**2/mg, (4) Single event upset hardness for memory and registers less than 1.0E-10 errors per bit day for a geosynchronous orbit with one solar flare as estimated with the CREME96 code, and (5) no functional errors for single event transients less than 1.0 ns.

DESCRIPTION: The Missile Defense Agency seeks research proposals for technical investigations related to the development and application of advanced electronics materials, processes, and devices to meet the need for radiation hardened, high performance electronics for space and missile requirements. As the silicon based semiconductor industry continues to follow Moore’s Law of ever decreasing critical dimensions and reduced price per bit, significant changes in materials and processes have been required to achieve its goals. Although there have been predictions of impending physical barriers that will halt the progress of the technology, the ingenuity of the industry has been able to overcome significant impediments as it has pushed farther into the nano-scale regime. Nevertheless, the advances are becoming more difficult and costly, and there is a clear need for advanced materials, processes, and devices if we are to continue to reap the benefits of ever higher functional density and decreased cost per function.

PHASE I: Perform the design and analytical tasks to develop a viable plan and schedule for demonstrating a radiation hardened, prototype, MSI level circuit function based on an advanced electronic material, process, or device.

PHASE II: Demonstrate the viability of the advanced electronic material, process, or device by fabricating the MSI level circuit function. Verify the expected performance by performing functional and parametric testing in the thermal and radiation environments identified in the description.

PHASE III: Military: The STTR will provide a path for developing advanced electronics for operation in elevated temperature and radiation environments associated with space and missile applications.

COMMERCIALIZATION:
Commercial: The STTR will provide the transition approach for developing microelectronics that can operate in harsh environments such as oil logging, nuclear reactor monitoring and instrumentation, and commercial space applications.

REFERENCES:
1. Novel nanowire integration schemes for massively parallel and manufacturable nanoscale electronics and photonics, Islam, M.S.; Kobayashi, N.P.; Shih-Yuan Wang; Nanoelectronics Conference, 2008. INEC 2008. 2nd IEEE International.

2. 3D Integration-Present and Future, Jiang, T.; Shijian Luo; Electronics Packaging Technology Conference, 2008. EPTC 2008. 10th. 9-12 Dec. 2008 Page(s):373 – 378.

KEYWORDS: Radiation hardened, nanotube, radiation hardened, advanced electronics

MDA09-T007 TITLE: STTR Solid State Cooling of Infrared Focal Plane Arrays

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms

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: Establish the feasibility of Solid State Cooling of space sensor EO/IR payloads at 35 K.

DESCRIPTION: to reduce payload jitter, mass, and power consumption associated with the payload cooling system. While traditional thermomechanical refrigerators are currently used for this application, solid state (i.e. no moving mechanical components) coolers have potential to further improve upon the performance of these mechanical systems. This research requires innovative approaches for the theoretical work regarding selection of materials as well empirical validation of the actual performance of the materials proposed in the actual operational range of interest. This operational range is discretionary under the following key performance parameters:
1. The objective cooling temperature is 35 K for any final stage of cooling to be accomplished by solid state refrigeration.
2. MDA space payloads normally reject heat in the range of 250-325 K, consequently the gap between that rejection sink temperature and 35 K must be bridged by stages of refrigeration.
3. Stages of refrigeration may be proposed as either traditional refrigerators or the solid state refrigerator of interest to this topic.
4. The last stage[s] of refrigeration, across not less than 15 K of cooling (i.e. at least 35-50 K) must be solid state cooling.
5. The objective goal is to support 2 W cooling at 35 K. The threshold goal for this topic is a net positive cooling supported at that temperature.
6. The objective goal thermodynamic efficiency of the refrigeration system is 12% of the Carnot (Second Law) efficiency limit. The threshold goal for this topic is a positive absolute efficiency.

PHASE I: Perform theoretical calculations and modeling to enhance the selection of new materials or design concepts which show promise for a solid state device capable of reaching 35K. Actual testing of potential solid state

materials in Phase I would be of high interest. Offerors are most strongly encouraged to work with system, payload, and/or refrigeration contractors to help ensure applicability of
their efforts and begin work towards technology transition.

PHASE II: Using the candidate materials identified in PHASE I, demonstrate a breadboard system assembly directly connected to a FPA mount simulator. Non solid state stages can be simulated using inexpensive SADA thermomechanical coolers. Perform initial tests and characterize the performance of the TE device. The contractor should keep in mind the goal of commercialization of this innovation for
the Phase III effort to which end they should have working relationships with, and support from system, payload, and/or refrigeration contractors.

PHASE III: Transition to the MDA STSS or other SMC electro optical IR sensor payload's technical baseline is highly encouraged

COMMERCIALIZATION: Devices which can provide solid state cooling well below ambient can greatly enhance the detection capability of night vision armament. At lower temperatures they can be used in space for surveillance, as well as in airborne sensors or superconductivity applications.

REFERENCES:
(1) "Colossal Seebeck Coefficient in Strongly Correlated Semiconductor FeSb2." Bentien, A., et al. EPL, 80 17008. doi 10.1209/0295-5075/80/17008, 2007

(2) "Thermal Conductivity Reduction and Thermoelectric Figure of Merit Increase by Embedding Nanoparticles in Crystalline Semiconductors." Kim, et al., Phys. Rev. Ltr, 96, 045901, 2006

(3) "Enhanced Seebeck coefficient from carrier-induced vibrational softening", D. Emin, Physical Review B 59 [9], 6205-6210 (1999)

(4) "Large Enhancement of Boron Carbides' Seebeck Coefficients through Vibrational Softening", T. L Aselage, D. Emin, S. S. McCready, R. V. Duncan, Physical Review Letters 81, 2316-2319 (1998)

(5) "Effect of FGMs on thermoelectric cooling properties of bismuth telluride", Iwama, A et al, Materials Science Forum; 2003; vol.423-425, p.377-80

(6) "Thermoelectric cooling at cryogenic temperatures", Harutyunyan, S., Applied Physics Letters; 15 Sept. 2003; vol.83, no.11, p.2142-4

(7) "Performance of Peltier elements as a cryogenic heat flux sensor at temperature down to 60 K", Haruyama, T., Cryogenics, 2001

(8) "Transition metal oxides: Promising functional materials", Raveau, B., Journal of the European Ceramic Society; 2005; vol.25, no.12, p.1965-9

(9) "High Temperature Proton Conductors for the Injection of Hydrogen into a Vacuum", Schober, T., and Meuffels P., J. Am. Ceram. Society, Vol. 84, pp. 1996-2000, 2001

(10) "Proton Conductive Membrane Compressor Driven Pulse Tube Cryocooler", Muller, J.R. et al, Cryocoolers 15, S. Miller and R. Ross eds. , Intern. Cryocooler Conf. Inc., Boulder CO, 2009.

KEYWORDS: cryocooler, cryogenic, Infrared Sensors, electronics cooling,Peltier, Seebeck

~~MDA09-T008 TITLE: Decision Making~~

~~TECHNOLOGY AREAS: Information Systems, Sensors, Weapons~~

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: Ballistic Missile Defense poses unique battle management and decision making challenges. A significant amount of work has been directed toward the mid-course engagement scenario. Less development has been focused on the challenging ascent phase in the target trajectory. To engage during ascent, severe time and information constraints exists upon which to allocate resources and support decision making. This topic seeks proposals for advanced, innovative, system discrimination and battle management techniques through the use of information fusion and decision logic. Proposed techniques should correlate real-time acquisition, tracking, and interceptor sensor views of the threat space coupled with interceptor inventory operational status, in order to facilitate accurate and efficient allocation of interceptor resources. This includes techniques for real-time intercept assessment and lower-tier interceptor assignment.

DESCRIPTION: Key functions of a missile defense system are to detect, track, discriminate, and engage threat objects. A missile defense system uses combinations of active and passive optical and microwave sensors to provide the required information to enable those functions. These sensors may be widely dispersed with respect to the missile threat and operate with widely varying phenomenology. This presents a significant information correlation challenge to the system battle manager. In addition, the battle manager must maintain accurate information of the status, location, and capability of all interceptor assets which will also be widely dispersed over the potential battle space. The challenge is to integrate all information unambiguously to facilitate robust system operation with a goal of 100% effectiveness against all threats, in all environments. The attached references describe the most significant approaches to system decision-making that have been used.

Innovative ideas and technologies are sought for information correlation and weapon assignment techniques, as described above, which offer continuous improvement in missile defense system battle management. Communications system requirements definition is an integral part of the overall battle management plan and must be addressed as part of the proposed system solution.

PHASE I: Develop an innovative Battle Management/Communications structure which will provide real-time information fusion and analysis. Show by detailed analysis how the resulting information will support automated decisions for the optimal allocation and timing of interceptor resources. Emphasis should be placed upon techniques suitable for addressing the ascent phase engagement scenario.

PHASE II: Develop and test a near-operational (demonstration) Battle Management/Communications structure, as defined in Phase I, to combine simulated data from at least 3 sensor sources and at least 3 interceptor systems including status reporting and interceptor kill assessment..

PHASE III: Develop and execute a plan to expand the demonstration system developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for engineering integration and testing.

COMMERCIALIZATION: The contractor will pursue commercialization of the various technologies and components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES:
1. Hosein P. and Athans, M., The Dynamic Weapon-Target Assignment Problem, Proceedings 1989 Symposium on Command and Control Research, Washington D.C., June 1989.

2. Bertsekas, D.P., Dynamic Programming and Optimal Control, Athena Scientific, Belmont MA, 2001.

3. Neapolitan, Richard E. Learning Bayesian Networks. Upper Saddle River: Prentice Hall, 2004.

4. D. Hall and James Llinas, "An Introduction to Multisensor Data Fusion," Proceedings of the IEEE, 85 (No. 1) 1997.

5. M. Ceruti, "Ontology for Level-One Sensor Fusion and Knowledge Discovery," 8th European Conference on Principles and Practice of Knowledge Discovery in Databases, Pisa, Italy, 2004.

6. Russomanno, D.J.; Kothari, C.; Thomas, O. "Sensor ontologies: from shallow to deep models." System Theory, 2005. SSST '05. Proceedings of the Thirty-Seventh Southeastern Symposium on, Vol., I., 20-22 March 2005. Pages: 107-112.

7. D.C. Cowley and B. Shafai, "Registration in Multi-Sensor Data Fusion and Tracking," Proceedings of the American Control Conference, June 1993.

KEYWORDS: Information Fusion, Battle Management, System Communications, Decision Making

MDA09-T009 TITLE: Propulsion Modeling

TECHNOLOGY AREAS: Weapons

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: Develop propulsion system related models, e.g., combustion chamber instability, thermo-mechanical and thermo-chemical models. The objective of the topics is to address at the fundamental level the liquid propellants instability issues and the solid propellant decomposition issues that result in throat erosion.

DESCRIPTION: While prior work has made progress in combustion instability and other combustion related effects, understanding is still needed in the instability issues associated with the liquid propellants operating in low temperature environments and the application of combustion instability methodologies to monopropellant systems. At the same time in the area of solid propellants we need to understand at the fundamental level, the mechanisms of interaction of the nozzle material and nozzle structural configuration with the flow of propellant decomposition products at high pressures (in the range of 1000 to 10,000 psi) and high temperatures (higher than 3000 degrees Kelvin).

Addressing this solicitation during a phase I and II effort to achieve reliable techniques for predicting and controlling combustion instabilities should include a better physical understanding of combustion instability phenomena, better diagnostic techniques, and improved predictive computational algorithms. Emphasis should be on design methodologies for avoiding instabilities in the design process, and eliminating them in an effective manner if they appear in the development cycle. Inclusion of the effects of vorticity, other flowfield interactions, and non-linear effects not incorporated in the classical theories and computational tools. Combustion instabilities are difficult to simulate due to: complex geometries, complex kinetics, the large numbers of mechanisms, the presence of acoustic waves, steep discontinuous or nearly discontinuous property gradients, complex, wrinkled wave fronts, multiphase effects, multiple time and length scales, different physics at subcritical and supercritical pressures, and the stochastic nature of the problem. Investigations should include: determining the necessary set of governing equations and the numerical algorithms having sufficient accuracy to enable accurate combustion stability predictions; identifying mechanisms which can be directly simulated and those for which models need to be developed for the identified rocket conditions; developing the necessary algorithms and models, understanding that different regions or regimes in the flow may require different equation sets or models; demonstrating the procedure for simulating a bombed engine test that would compare favorably with test data.

Addressing this solicitation during a Phase I and II effort for solid propulsion modeling should include an understanding the mechanisms of interaction of the nozzle material and nozzle structural configuration with the flow of the propellant decomposition products at high pressures (in the range of 1000 to 10,000 psi) and high temperatures (higher than 3000 degrees Kelvin). This includes thermo-chemical and thermo-mechanical interactions. Approach should be through tests, real-time measurements, microscopic analysis of nozzles, recovered at various stages of the test, formulation of hypotheses for erosion mechanisms, multi-scale modeling with analysis to investigate and improve the validity of the hypotheses. The problems of concern, are the nozzle erosion and mitigation of nozzle erosion due to the interaction of nozzle materials and nozzle structures with the flow due to propellant combustion and the resulting propellant decomposition products, associated high temperatures and high pressures. The mechanisms of erosion can involve combinations of nozzle materials, nozzle structural configuration, chemical reactions, high-strain-rate deformations including plastic flow, phase transition, micro-crack formation and propagation, thermal softening, hardening of nozzle material, removal of reaction products (flakes) or melts, and erosion due to particle impact if propellants are metalized.

PHASE I: Develop basic models and refine combustion model requirements in order to formulate a phase II effort. Proposing institutions are encouraged to consider contractors who understand combustion modeling requirements, to help ensure applicability of their efforts, and to begin work towards technology transition.

PHASE II: Develop a rigorous theoretical framework for assessing combustion phenomena in rocket propulsion systems. This theoretical and mathematical understanding will be validated and refined through simulation, and operational user review. In this respect, it is expected that a strong relationship with a propulsion or propulsion analysis contractor will be established to provide relevant data for model evaluation. The academic institution should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from propulsion and propulsion analysis contractors.

PHASE III: Potential Phase III opportunities to transfer this technology include NASA and DoD Departments.

COMMERCIALIZATION: Applications of this modeling technology include NASA, civil, and the commercial sector for combustion chamber modeling.

REFERENCES:
1. George P. Sutton, “Rocket propulsion Elements; Introduction to Engineering of Rockets,” 7th edition, John Willey & Sons, 2001.

2. Paschal N, Strickland B, Lianos D, “ Miniature Kill Vehicle Program”, 11th Annual AIAA/BMDO Technology Conference, Monterey, CA, August 2002.

3. Vigor Yang, Thomas B. Brill, and Wu-Zhen Ren, “Solid Propellant Chemistry, Combustion, and Motor Interior Ballistics”, AIAA, 2000.

4. Mark Dranovsky, Vigor Yang, Fred Culick, and Douglas Talley, “Combustion Instabilities in Liquid Rock Engines”, AIAA, 2007.

5. Vigor Yang, “Liquid Rocket Thrust Chambers: Aspects of Modeling, Analysis, and Design”, AIAA, 2004.

KEYWORDS: Interceptors, Propulsion

MDA09-T010 TITLE: <u>Novel Directed Energy Options in Ballistic Missile Defense</u>

TECHNOLOGY AREAS: Air Platform, Information Systems, Ground/Sea Vehicles, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: Advanced Technology

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: Investigate novel directed energy options in ballistic missile defense.

DESCRIPTION: This topic addresses the investigation and development of novel directed energy (DE) components, techniques, and systems for use in BMD. In particular, there is interest in the use of directed electromagnetic (EM) waves, but also including plasmas, ion beams, or other methods for the remote deposition of energy. These DE systems and techniques may be able to disrupt, damage, or destroy critical elements of adversary ballistic missile systems, rendering them ineffective. The goal is to be able to have these effects at long standoff distances. Since various types of DE systems would make use of common technologies in generating and projecting the energy, advances in these component technologies are also sought under this topic. These technologies include: capacitors, explosive pulsed-power generators, power conditioning (solid state switching, vector inversion generators, etc.), and electromagnetic sources (magnetrons, lightweight MILOs, etc.). Incorporating advances in these common technologies may enable directed energy systems to be reduced in size and integrated on compact platforms that are capable of forward basing and thus able to deal with ballistic missile threats at the most effective times.

For example, for directed EM waves, techniques for particular waveforms or modulations schemes may be useful for attacking and disrupting adversary electronics, optics, guidance, maneuvering, or fuzing components. However, one of the issues with many current EM wave-based counter electronic systems or concepts is their limited range. However, in recent years there has been limited data showing that modulated EM waves may be able to disrupt electronic devices at significantly lower irradiance levels Thus, ranges of counter electronics systems could possibly be increased. If coupled with high gain antennas, the range of counter-electronic directed energy systems could be further extended. Another option to increase the effective range of such systems is to increase the power radiated by each transmitting antenna. Thus, novel designs for efficient and compact broadband antennas, capable of handling high powers for extended times, would also be attractive. To enable basing such antennas on compact platforms, possibly even interceptor missiles, the antennas would also need to be capable of surviving high g-force launches. In addition, while some EM wave generators are very efficient, they can be limited in output power, reducing their effectiveness and/or range in ballistic missile defense applications. However, innovative schemes to phase-lock oscillators could enable higher power EM wave generators, making use of COTS sources. In addition to extending the range of potential counter-electronics weapons and jammers, such phasing techniques would also be of value in improving the performance of RF-based ballistic missile defense systems, including tracking radars, communications equipment, and ISR systems.

PHASE I: Design and evaluate potential directed energy components and systems that may be able to disrupt adversary ballistic missile systems. Investigate the operational suitability of the directed energy option – the size, mass, and power requirements, as well as the ability to propagate the directed energy to operationally-significant ranges. Analyze the potential to replace or supplement existing BMD system elements and provide demonstrable and verifiable levels of defeat that can be observed with a remote sensor. As part of Phase I, critical technology element experiment demonstrations must be performed to verify that the component, system, or technique has the potential capability to meet part or all these requirements.

PHASE II: Demonstrate the novel technique or prototype of the advanced directed energy component or system at the brassboard level. For potential directed energy systems, evaluate the effectiveness of a model of the system against critical ballistic missile threat objects. Determine the range and effectiveness of single or multiple DE “shots” to disrupt, damage, or destroy the threat objects. Through simulation, modeling and analysis show how observable effects may be used to determine if or how many additional "shots" are needed to achieve the desired effects. As an example, demonstrate a high performance antenna design is capable of meeting energy density and lethal number of shots requirements. Identify any technology transition risks, manufacturing issues, and platform integration requirements.

PHASE III: Scale and demonstrate that the technology, technique, or system is able to perform in an operational environment against full scale simulated targets at operationally significant ranges.

COMMERCIALIZATION: Improved directed energy antennas, sources, and other common technologies could potentially be used to increase the range and reduce the size of RF communications and radar systems, as well as provide new capabilities in chemical/material processing and medical diagnostics. Compact, high power microwave sources would also be attractive for proposed space-based power-beaming applications. Long range counter-electronics directed energy systems that could be enabled by the hardware and techniques developed under this project would have useful applications in non-lethal law enforcement and border-control applications.

REFERENCES:

1. R.J. Barker and E. Schamiloglu, High-Power Microwave Sources and Technologies, Wiley-IEEE (2001).

2. J. Benford, J.A. Swegle, and E. Schamiloglu, High Power Microwaves, 2nd Edition, CRC Press (2007).

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KEYWORDS: Antennas, Plasma, High Power Microwave, Directed Energy, Communications, Radars, Sensors