MISSILE DEFENSE AGENCY (MDA)
15.C Small Business Technology Transfer (STTR)
Proposal Submission Instructions

INTRODUCTION

The Missile Defense Agency's (MDA) mission is to develop and deploy a layered Ballistic Missile Defense System (BMDS) to defend the United States, its deployed forces, allies, and friends from ballistic missile attacks of all ranges in all phases of flight.

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

Missile Defense Agency
SBIR/STTR Program Office
MDA/DVR
Bldg 5224, Martin Road
Redstone Arsenal, AL 35898

Email: sbirsttr@mda.mil
Phone: 256-955-2020

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 with active non-disclosure agreements will evaluate proposals.

Please read the entire DoD solicitation and MDA instructions carefully prior to submitting your proposal. Please go to https://www.sbir.gov/about/about-sttr#sttr-policy-directive to read the STTR Policy Directive issued by the Small Business Administration.

Federally Funded Research and Development Centers (FFRDCs) and Support Contractors

The offeror's attention is directed to the fact that non-Government advisors to the Government may review and provide support in proposal evaluations during source selection. Non-Government advisors may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. These advisors will not establish final assessments of risk and will not rate or rank offeror's proposals. They are also expressly prohibited from competing for MDA SBIR or STTR awards in the SBIR/STTR topics they review and/or on which they provide comments to the Government.

All advisors are required to comply with procurement integrity laws. Non-Government technical consultants/experts will not have access to proposals that are labeled by their proposers as "Government Only." Pursuant to FAR 9.505-4, the MDA contracts with these organizations 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.

Non-Government advisors 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. 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.

OFFEROR SMALL BUSINESS ELIGIBILITY REQUIREMENTS

Each offeror must qualify as a small business at time of award per SBA's regulations at 13 CFR 121.701-121.705 and certify to this in the Cover Sheet section of the proposal. Additionally, in accordance with the Small Business Administration's (SBA) STTR Program Policy Directive dated 18 October 2012, offerors must re-certify at certain points during the Phase I and Phase II period of performance to ensure that the awardee is in compliance with the program's requirements.

SBA Company Registry

Per the STTR Policy Directive, all STTR applicants are required to register their firm at SBA's Company Registry prior to submitting an application. Upon registering, each firm will receive a unique control ID to be used for submissions at any of the 11 participating agencies in the SBIR or STTR programs. For more information, please visit the SBA's Firm Registration Page: http://www.sbir.gov/registration.

Performance Benchmark Requirements for Phase I Eligibility

MDA does not accept proposals from firms that are currently ineligible for Phase I awards as a result of failing to meet the benchmark rates at the last assessment. Additional information on Benchmark Requirements can be found in the DoD Instructions of this solicitation.

ORGANIZATIONAL CONFLICTS OF INTEREST

Contract awards to firms owned by or employing current or previous Federal Government employees could create conflicts of interest for those employees which may be a violation of federal law. Proposing firms should contact the MDA SBIR/STTR PMO for further guidance in this situation.

The basic rules are covered in FAR 9.5 as follow (the Contractor is responsible for compliance):

(1) the Contractor's objectivity and judgment are not biased because of its present or planned interests which relate to work under this contract;

(2) the Contractor does not obtain unfair competitive advantage by virtue of its access to non-public information regarding the Government's program plans and actual or anticipated resources; and

(3) the Contractor does not obtain unfair competitive advantage by virtue of its access to proprietary information belonging to others.

All other applicable rules under the FAR Section 9.5 apply to Contractors.

USE OF FOREIGN NATIONALS

See the "Foreign Nationals" section of the DoD program solicitation for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals MUST disclose this information regardless of whether the topic is subject to export control restrictions. Identify any foreign citizens or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a STTR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted with a foreign national listed will be subject to security review during the contract negotiation process (if selected for award). 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 is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale.

EXPORT CONTROL RESTRICTIONS

The technology within some MDA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export controlled items based on user, country, and purpose. You must ensure that your firm complies with all applicable export control regulations. Please refer to the following URLs for additional information: http://www.pmddtc.state.gov/regulations_laws/itar.html and http://www.bis.doc.gov/index.php/.

Proposals submitted to export control-restricted topics will be subject to security review during the contract negotiation process (if selected for award). In the event a firm is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale.

CLAUSE H-08 PUBLIC RELEASE OF INFORMATION (Publication Approval)

Clause H-08 pertaining to the public release of information is incorporated into all MDA SBIR and STTR contracts and subcontracts without exception. All materials which relate to work performed by the contractor under MDA SBIR and STTR contracts must be submitted to MDA for review and approval prior to release to the public. Subcontractor public information materials must be submitted for approval through the prime contractor to MDA.

FRAUD, WASTE, AND ABUSE

To Report Fraud, Waste, or Abuse, Please Contact:

MDA Fraud, Waste & Abuse
Hotline: (256) 313-9699
MDAHotline@mda.mil

DoD Inspector General (IG) Fraud, Waste & Abuse
Hotline: (800) 424-9098
hotline@dodig.mil

Additional information on Fraud, Waste and Abuse may be found in the DoD Instructions of this solicitation; sections 3.6 and 4.19.

PROPOSAL FUNDAMENTALS

Proposal Submission

All proposals MUST be submitted online using the DoD SBIR/STTR submission system (https://sbir.defensebusiness.org). Any questions pertaining to the DoD SBIR/STTR submission system should be directed to the DoD SBIR/STTR Help Desk: 1-800-348-0787.

Classified Proposals

Classified proposals **are not** accepted under the MDA SBIR/STTR Program. Contractors currently working under a classified MDA SBIR/STTR contract must use the security classification guidance provided under that contract to verify new SBIR/STTR proposals are unclassified prior to submission. Phase I contracts are not typically awarded for classified work. However, in some instances, work being performed on Phase II proposals will require security clearances. If a Phase II contract will require classified work, the proposing firm must have a facility clearance and appropriate personnel clearances in order to perform the classified work. For more information on facility and personnel clearance procedures and requirements, please visit the Defense Security Service Web site at: http://www.dss.mil/index.html.

Communication

All communication from the MDA SBIR/STTR PMO will originate from the sbirsttr@mda.mil email address. Please white-list this address in your company's spam filters to ensure timely receipt of communications from our office.

Proposal Status

The MDA SBIR/STTR PMO will distribute selection and non-selection email notices to all firms who submit a MDA SBIR/STTR proposal. The email will be distributed to the "Corporate Official" and "Principal Investigator" listed on the proposal coversheet. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.

Debriefing

MDA offers debriefings to unsuccessful offerors in accordance with Federal Acquisition Regulation (FAR) Subpart 15.5. Requests for debriefing must be submitted in writing to the MDA SBIR/STTR PMO within 30 calendar days of non-selection notification. Non-selection notifications will provide instructions for requesting a proposal debriefing.

Discretionary Technical Assistance (DTA)

Section 9(b) of the SBIR and STTR Policy Directives allows agencies to enter into agreements with vendors to provide technical assistance to SBIR or STTR awardees, which may include access to a network of scientists and engineers engaged in a wide range of technologies or access to technical and business literature available through on-line data bases.

The purpose of this technical assistance is to assist STTR awardees in:

- Making better technical decisions on STTR projects;

- Solving technical problems that arise during STTR projects;
- Minimizing technical risks associated with STTR projects; and
- Commercializing the STTR product or process.

MDA permits award recipients to obtain technical assistance in accordance with the SBIR and STTR Policy Directives through MDA. Alternatively, an SBIR or STTR firm may acquire the technical assistance services described above on its own. Firms must request this authority from MDA and demonstrate in its SBIR or STTR proposal that the individual or entity selected can provide the specific technical services needed. In addition, costs must be included in the cost volume of the offeror's proposal. The DTA provider may not be the requesting firm, an affiliate of the requesting firm, an investor of the requesting firm, or a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g. research partner or research institution).

If the awardee demonstrates this requirement sufficiently, MDA will permit the awardee to acquire such technical assistance itself, in an amount up to $5,000 per year, as an allowable cost of the SBIR or STTR award. The per year amount will be in addition to the award and is not subject to any profit or fee by the requesting firm and is inclusive of all indirect rates. The per-year amount is based on the original contract period of performance and does not apply to period of performance extensions. Requests for DTA funding outside of the Phase I or Phase II proposal submission will not be considered.

PHASE I PROPOSAL GUIDELINES

The DoD SBIR/STTR Proposal Submission system (available at https://sbir.defensebusiness.org) will lead you through the preparation and submission of your proposal. Read the front section of the DoD solicitation for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this solicitation will not be considered.

MAXIMUM PHASE I PAGE LIMIT FOR MDA IS 20 PAGES

Any pages submitted beyond the 20-page limit within the Technical Volume (Volume 2) will not be evaluated**. Your Proposal Cover Sheet (Volume 1), Cost Volume (Volume 3), and Company Commercialization Report (Volume 4) DO NOT count toward your maximum page limit.**

Phase I Proposal

A complete Phase I proposal consists of four volumes:

Volume 1: Proposal Cover Sheet
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept. The contract period of performance for Phase I shall be six (6) months and the award shall not exceed $100,000. A Phase I Option may be submitted with a period of performance of 6 months and an amount not to exceed $25,000. A list of topics currently eligible for proposal submission is included below, followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time.

References to Hardware, Computer Software, or Technical Data

In accordance with the SBIR Directive, SBIR contracts are to conduct feasibility-related experimental or theoretical R/R&D related to described agency requirements. The object of the Phase I is to determine the scientific and technical merit and feasibility of the proposed effort and quality of performance of the Small Business Concern. It is not for formal end-item contract delivery, and ownership by the Government of your hardware, computer software, or technical data.

Based on this, in your technical proposal, do not use the term "Deliverables" when referring to your hardware, computer software, or technical data. Instead use the term: "Products for Government Testing, Evaluation, and/or Demonstration."

The standard formal deliverables for a Phase I are the Report of Invention and Disclosure, Midterm Status Report, Certificates of Compliance, Computer Software Product (normally not applicable for a Phase I), Prototype Design and Operation Document (normally not applicable for a Phase I), and the Final Report.

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 a.m. (ET) 28 October 2015.

_____ a. Volume 1: DoD Proposal Cover Sheet

_____ b. Volume 2: Technical Volume (DOES NOT EXCEED 20 PAGES)**: Any pages submitted beyond this will not be evaluated. Your Proposal Cover Sheet, Cost Volume, and Company Commercialization Report DO NOT count toward your maximum page limit.**

_____ **c. If proposing to use foreign nationals; identify the foreign national(s) you expect to be involved on this project, the type of visa or work permit under which they are performing, country of origin and level of involvement.**

_____ d. Volume 3: Cost Volume. **(Online Cost Volume form is REQUIRED by MDA)**

_____ e. Volume 4: Company Commercialization Report. (Required even if your firm has no prior SBIR/STTR awards).

____2. The Phase I proposed cost plus option does not exceed $125,000.

____3. Your firm must be registered with SBA's Company Registry.

MDA PROPOSAL EVALUATIONS

MDA will evaluate and select Phase I and Phase II proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. MDA reserves the right to award none, one, or more than one contract under any topic. MDA is not responsible for any money expended by the proposer before award of any contract. 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 Phase I and Phase II proposals will be evaluated based on the criteria outlined below, including potential benefit to the Ballistic Missile Defense System (BMDS). Selections will be based on best value to the Government considering the following factors which are listed in descending order of importance:

a) The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b) The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
c) The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

In Phase I and Phase II, firms with a Commercialization Achievement Index (CAI) at or below the 20th percentile will be penalized in accordance with the DoD program solicitation.

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.

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. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained in the proposal and will count toward the applicable page limit.

Qualified advocacy letter(s) will count towards the proposal page limit and will be evaluated towards criterion C. Advocacy letters are not required for Phase I or Phase II.

A qualified advocacy letter is from a relevant commercial or Government Agency procuring organization(s) working with MDA, articulating their pull for the technology (i.e., what BMDS need(s) the technology supports and why it is important to fund it), and possible commitment to provide additional funding and/or insert the technology in their acquisition/sustainment program. This letter should be included as the last page(s) of your technical upload. Advocacy letter(s) which are faxed or e-mailed separately will NOT be considered.

Phase II Proposal Submission

Per DoD STTR Phase II Proposal guidance, all Phase I awardees from the 15.C Phase I solicitation will be permitted to submit a Phase II proposal for evaluation and potential award selection. Details on the due date, content, and submission requirements of the Phase II proposal will be provided by the MDA SBIR/STTR Program Management Office either in the Phase I award contract or by subsequent notification. Only firms who receive a Phase I award resulting from the 15.C solicitation may submit a Phase II proposal. The one and only time that Phase II proposals based on the 15.C Phase I awards may be submitted is during this 15.C Phase II solicitation window.

MDA will evaluate and select Phase II proposals using the Phase II evaluation criteria listed in the DoD Program Solicitation. While funding must be based upon the results of work performed under a Phase I award and the scientific and technical merit, feasibility and commercial potential of the Phase II proposal; Phase I final reports will not be reviewed as part of the Phase II evaluation process. The Phase II proposal should include a concise summary of the Phase I effort including the specific technical problem or opportunity addressed and its importance, the objective of the Phase I effort, the type of research conducted, findings or results of this research, and technical feasibility of the proposed technology. 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 does NOT participate in the DoD Fast Track program.

All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system. It is strongly urged that an approved accounting system be in place prior to the MDA Phase II award timeframe. If you do not have a DCAA approved accounting system, this will delay/prevent Phase II contract award.

MDA STTR 15.C Topic Index

MDA15-T001	Contextual Reasoning for Object Identification
MDA15-T002	System of Systems Control Interactions
MDA15-T003	Aerospace Vehicle Signature Modeling Technologies
MDA15-T004	Spectral Crosstalk Reduction for Dual-band Long Wave Infrared Detectors
MDA15-T005	Gold Contaminated Solder Joint Characterization for Quantifying Risks Associated with Gold Embrittlement

MDA STTR 15.C Topic Index by Research Area

CR-C2BMC (C2BMC)
MDA15-T001 Contextual Reasoning for Object Identification

DES (DE-Modeling & Simulation)
MDA15-T002 System of Systems Control Interactions

DV-Advanced Technology (DVR)
MDA15-T003 Aerospace Vehicle Signature Modeling Technologies
MDA15-T004 Spectral Crosstalk Reduction for Dual-band Long Wave Infrared Detectors

QS-Quality, Safety & Mission Assurance (QS)
MDA15-T005 Gold Contaminated Solder Joint Characterization for Quantifying Risks Associated with Gold Embrittlement

MDA STTR 15.C Topic Descriptions

MDA15-T001 TITLE: Contextual Reasoning for Object Identification

TECHNOLOGY AREA(S): Information Systems, Sensors

OBJECTIVE: Develop a technique to incorporate variable contextual information to aid object identification and target designation.

DESCRIPTION: When dealing with well-understood threats in a clean environment, a simple formula using a previously defined set of sensor features may be adequate to identify the threat object. However, when encountering novel threats or complex scenarios, a greater capacity to reason with the scene and its environment may be needed. For example, using a broad range of marginal information and behaviors to guide classification logic for the system may be needed. Additionally, expanding individual object identification to include information about all objects in the scene and reasoning on the whole could help resolve the true classification.

The purpose of this topic is to develop a method to utilize all available, relevant information obtained by multiple sensors to aid decision making for object selection. This analysis should involve all tracked objects and their respective features, as well as environmental information, or any type of information which could influence belief in the value of a target. The focus should be on the underlying logic, or calculus, that supports reliable generalization from possibly limited data. The developed technique should be robust to sensor or feature drop-outs and able to provide a system for real time decision making with variable information. In particular, the developed technique should enable reasoning as to which tracked object(s) in a missile complex should be targeted. This approach could utilize Bayesian statistics, probabilistic generative models, probabilistic programming or any reasonable approach which considers the entire engagement. This effort should be able to analyze existing data to learn patterns and structures, as well as to provide a system for real time decision making with variable information.

Recent research into cognitive science has produced representational systems and computational formalisms that may enable the BMDS to more effectively make decisions in novel situations. Static decision paradigms that classify an object with respect to a fixed set of features from a given set of sensors may not be adequate in real time for a highly uncertain engagement where sensors may be unavailable and features may be corrupted.

An innovative method to reason with the battlespace scene as described by multiple sensors is sought. It should be assumed that there are two sensors reporting for the baseline, either two radars, or one radar and one space-based EO/IR sensor. The designed system should demonstrate functionality in the case where one sensor drops out, or various types of corruption or confusion are introduced.

PHASE I: Develop and demonstrate, through proof-of-principle tests, a technique to combine information from multiple sources to identify the target of interest. The system should demonstrate robustness when the scene is degraded, a sensor is lost, and/or features are corrupted. The technique should demonstrate the ability to reason with the scene and use auxiliary information for target determination.

PHASE II: Refine and update concept(s) based on Phase I results and demonstrate the technology in a realistic environment using agency provided engagements. Demonstrate the technology's ability in a stressed environment; with few sensors and many targets with countermeasures.

PHASE III DUAL USE APPLICATIONS: Demonstrate the new technologies via operation as part of a complete system or operation in a system-level test bed to allow for testing and evaluation in realistic scenarios. Market technologies developed under this solicitation to relevant missile defense elements directly, or transition them through vendors.

Potential commercial and military uses include areas such as intelligence gathering and analysis, supply chain

distribution logistics, automated processing, robotics, and manufacturing processes.

REFERENCES:
1. Joshua B. Tenenbaum, et al. March 2011. "How to Grow a Mind: Statistics, Structure, and Abstraction." Science 331: 1279-1285.

2. Thomas M. Cover, Joy A. Thomas. 1991. "Elements of Information Theory." Wiley-Interscience.

3. Tin Kam Ho, Jonathan J. Hull, Sargur N. Srihari. January 1994. "Decision Combination in Multiple Classifier Systems." IEEE Transactions on Pattern Analysis and Machine Intelligence; Vol. 16, No. I.

4. José Quesada, Walter Kintsch, Emilio Gomez. 2002. "A Computational Theory of Complex Problem Solving Using Latent Semantic Analysis." Proceedings of the 24th Annual Conference of the Cognitive Science Society.

KEYWORDS: Contextual Reasoning, Cognitive Reasoning, Machine Learning, Target Identification, Target Characterization, Computer Vision

MDA15-T002 TITLE: System of Systems Control Interactions

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop and demonstrate innovative design and analysis techniques to characterize the stability and performance of a system of systems (SoS) as a function of sub-system dynamics, network structure and control/decision processes.

DESCRIPTION: Seek design approaches that balance multiple sub-system network configurations and sub-system and SoS design objectives. Approaches should incorporate the interaction of multiple internal and external control loops and sub-systems with substantially different capabilities. The design and analysis tools must include methods and tools for efficiently specifying, representing, and analyzing the interactions between control systems in SoS. Desire tools capable of determining the degree to which a SoS goal is attainable in a particular network of sub-systems and how changes in the system will alter the ability of the SoS to achieve that goal. The overall design approach should incorporate adaptive network configurations and adaptive control robustness of the SoS and sub-system controls. It must also be able to assure stability and convergence to the SoS goals. Approaches must be compatible with simulations, hardware-in-the-loop and human interaction with the simulation. The simulation must be useful for system design, training, and real-time evaluation.

PHASE I: The proposed efforts should identify the fundamentals of the interaction of control loops and apply these fundamentals to the design and analysis of system components. Phase I should culminate in a proof of principle demonstration of these concepts and design tools on representative system components. It is expected that this work will progress from linear, time-invariant, single-input single-output control systems and build on these results in Phase II to include non-linear, multi-input multi-output (MIMO), and non-stationary systems.

PHASE II: Implement selected techniques from Phase I, with the evaluation based on simulation of actual system components. Develop the most promising approaches for application to non-linear, MIMO, and non-stationary systems typical of the system components. Address the issues of reachability of SoS goals given a set of sub-systems and the issues of scalability.

PHASE III DUAL USE APPLICATIONS: Finalize a product that can be used to design the control functions of SoS. This product will be applied to full-scale simulations for SoS design and training. Application to real-time decision-making should also be addressed.

REFERENCES:
1. F. Kazempour, J. Ghaisari. March 2013. "Stability analysis of model-based networked distributed control systems." Journal of Process Control; v 23, n 3: 444-52.

2. Xiaofeng Wang, Hovakimyan, N. October 2013. "Distributed control of uncertain networked systems a decoupled design." IEEE Transactions on Automatic Control; v 58, n 10: 2536-49.

3. M. Razeghi-Jahromi, A. Seyedi. 2013. "Stabilization of distributed networked control systems with constant feedback delay." IEEE 52nd Annual Conference on Decision and Control: 4619-24.

KEYWORDS: Distributed Control, Nonlinear Systems, Simulation, Complex Systems, Systems of Systems

MDA15-T003 TITLE: Aerospace Vehicle Signature Modeling Technologies

TECHNOLOGY AREA(S): Air Platform, Information Systems, Sensors

OBJECTIVE: Develop computational fluid dynamics (CFD) software tools to extend modeling capabilities, including turbulence, chemically reactive flow, radiative heat transfer and acoustics, for the prediction of aerospace vehicle signature phenomenology beyond the current state of the art.

DESCRIPTION: Seek CFD software tools that accurately model flight and environment conditions encountered by vehicles operating in the Mach 10 to Mach 20-plus regimes at upper stratospheric altitudes. Novel advanced computational technologies are required to extend current models and simulations of aerospace vehicles to support these high-Mach-number flight regimes. Modeling should include aero-thermal flow and associated atmospheric phenomena (heating, plasma, shock waves, etc.) to yield cross sections and signature predictions. Model output should support including radar (HF through SHF radio frequency) electro-optic/infrared, and acoustic sensors. Model documentation should include relevant physics and credible validation.

PHASE I: Develop concepts for enhancing existing CFD tools to model aero-thermal effects on aerospace vehicles in the extended performance envelope for signature prediction. Demonstrate credibility of proposed models and validation approaches. The contractor should identify the strengths/weaknesses associated with alternative solutions, methods, and concepts.

PHASE II: Develop and validate CFD tools to support aerospace vehicle signature predictions. Provide a performance analysis of the planned CFD capability, complete executable code for the developed modeling and/or signature prediction toolset, and an operator manual. Develop and implement verification and validation of the toolset. Coordinate development efforts with the government to ensure product relevance and compatibility with missile defense projects and government-owned-and-operated information technology.

PHASE III DUAL USE APPLICATIONS: Collaborate with existing CFD and signature tool developer/users on integration of product(s) into a missile defense application. Update toolset to accommodate new technology advances in aerospace vehicle design modeling. Transition the technology to the appropriate customer for integration and testing.

REFERENCES:
1. http://www.darpa.mil/our_work/tto/falcon_htv-2_three_key_technical_challenges.aspx

2. J.J. Bertin, RM Cummings. 2003. "Fifty Years of Hypersonic, Where We've Been, Where We're Going." Progress in Aerospace Sciences, Vol. 39: 511–536.

3. M. Holden. January 2006. "Historical Review of Experimental Studies and Prediction Methods to Describe Laminar and Turbulent Shock Wave / Boundary Layer Interactions in Hypersonic Flows." AIAA-2006: 494.

4. J. McNamara, P. Friedmann. 2011. “Aeroelastic and Aerothermoelastic Analysis in Hypersonic Flow: Past, Present, and Future.” AIAA Journal; Vol. 49, No. 6: 1089-1122.

5. A. Culler, A. Crowell, J. McNamara. May 2009. “Studies on Fluid-Structural Coupling for Aerothermoelasticity in Hypersonic Flow.” AIAA-2009-2364, AIAA SDM Conference, Palm Springs, CA.

6. J.D. Anderson. 2006. “Hypersonic and High-Temperature Gas Dynamics” 2nd Edition. American Institute of Aeronautics and Astronautics, Reston, VA.

7. Zhang, Chuan-Hong, Tang, Qing, Lee, and Cun-Biao. February 2013. “Hypersonic boundary-layer transition on a flared cone.” Acta Mechanica Sinica; Vol. 29, Issue 1: 48-54.

8. R.T. Voland, L.D. Huebner, C.R. McClinton. 2005. “X-43 Hypersonic Vehicle Technology Development.” 10.2514/6.IAC-05-D2.6.01, International Astronautical Congress, Fukuoka, Japan.

KEYWORDS: Flight, Computational Fluid Dynamics, Modeling, Signature, Aerospace Vehicle, Midcourse, Tracking, Prediction

MDA15-T004 TITLE: Spectral Crosstalk Reduction for Dual-band Long Wave Infrared Detectors

TECHNOLOGY AREA(S): Electronics, Materials/Processes, Sensors

OBJECTIVE: Seeking solutions to reduce spectral crosstalk of dual-band long wave infrared (LWIR) III-V strained layer superlattice (SLS) based infrared (IR) focal plane arrays (FPA)/detectors.

DESCRIPTION: Multi-color FPAs made of III-V SLS semiconductor materials have shown very promising results in recent years. Further improvement in SLS device performance is desired to meet sensor system requirements for long wave applications. One particular technical challenge limiting the utility of dual-band SLS FPAs and detectors is unwanted spectral crosstalk. Some potential sources of spectral crosstalk include:

- Incomplete optical absorption of photons at one absorber due to broadband peak width.
- Low quantum efficiency in each absorber region.
- Radiative recombination of carriers generated by photons at band 1 and emitting into band 2.
- Flawed device barrier architecture.

This topic solicits innovative ideas for the design and fabrication of dual-band detectors and FPAs achieving spectral crosstalk less than 5% for each band while maintaining detector performance. Methods that will sharpen detector cutoff, increase FPA quantum efficiency, and optimize the device design and engineering to eliminate spectral crosstalk root cause, are encouraged.

For this solicitation, assume the following:

- The dual-band infrared detector uses two coupled III-V SLS photodetectors stacked back to back, one operating in the 6 to 8 micrometer band and the other in the 9 to 11 micrometer band.
- The transmission is approximately 90% inside each passband and approximately 0% outside the two passbands.
- An external dual-band filter in the incoming light path can be taken into consideration for out of band blocking. An effective detector anti-reflection coating is acceptable for increasing quantum efficiency and sensitivity.
- Crosstalk arises from leakage due to band overlap.

PHASE I: Determine the root cause(s) of spectral crosstalk via modeling and experimental study. Design, fabricate, and validate a single-element dual-band detector to analyze and verify the correlation of crosstalk reduction with device design parameters. Develop a detailed plan for Phase II implementation.

PHASE II: Demonstrate single-element dual-band detectors with spectral crosstalk of less than 5% (with the external filter). Validation of results at the FPA level is encouraged, with the following performance goal: quantum efficiency larger than 90% in band 1 and 50% in band 2, spectral crosstalk less than 5%, format and pitch: 512 x 512 or larger, 30 micrometer pitch. The FPA should be properly anti-reflection coated and passivated. The median dark current density should be within 10 times of Rule 07.

PHASE III DUAL USE APPLICATIONS: Either solely, or in partnership with a suitable production foundry, the contractor will implement and verify, in full scale, that the Phase II demonstration technology is economically viable. The contractor will transition the technology to the appropriate prime contractor for the engineering integration and testing.

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6. W. Tennant. 2010. "Rule07" Revisited: Still a Good Heuristic Predictor of p/n HgCdTe Photodiode Performance?" Journal of Electronic Materials; Vol. 39, No. 7.

KEYWORDS: Infrared Focal Plane Array, Long Wave Infrared, Multi-color Infrared Detector, Spectral Crosstalk Reduction

MDA15-T005 TITLE: Gold Contaminated Solder Joint Characterization for Quantifying Risks Associated with Gold Embrittlement

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop a risk forecasting tool for quantifying the risks associated with gold-embrittled solder joints in electronic assemblies. Specifically, the model should accurately assess the likelihood of solder joint failure given specific environmental stress conditions (vibrational and thermal shock).

DESCRIPTION: Circuit card assemblies (CCAs) are common in military hardware and the reliability of these CCAs is strongly dependent on the solder joints that join components and connectors to the printed circuit boards. Maximizing the reliability of solder joints is essential to maximizing the reliability of the hardware. Assembly

standards for electronics, such as J-STD-001, list requirements designed to ensure solder joint reliability, including requirements designed to avoid or mitigate the risks associated with gold embrittled solder joints. The industry rule of thumb is that concentrations below 3 percent gold by weight are acceptable, but this is not a guarantee of risk mitigation as failures have been reported with joints having as low as 1.7 percent.

Considerable research (references 1-4) has documented the vulnerability of solder joints to gold embrittlement. As a result, industry standards have been developed to guide CCA manufacturers and mitigate the likelihood of circuit failure. However, under many conditions, CCA's cannot avoid some level of gold contamination in solder joints. The level of gold contamination can be quantified by non-destructive test.

The purpose of this topic is to develop a model that will determine the risk of failure of gold-contaminated solder joints, for a variety of solder joint configurations, due to mechanical and thermal shock The model could be used for both: Specifying the environmental limits for the relevant military hardware; and, quantifying the likelihood of failure of the hardware given its exposure to measured/or expected mechanical and thermal conditions. Project Managers must decide if the assembly will be accepted or rejected, balancing reliability, budgeting, and scheduling impacts.

PHASE I: Develop the conceptual framework for failure mode testing to evaluate the variables affecting the reliability of gold contaminated solder joints. This framework should include methods of assessing gold concentration and distribution for a variety of packaging and termination types, favoring non-destructive testing whenever possible. The framework should also consider if data generated is strictly empirical or if the data can be used for mechanistic modeling. Preference is given to mechanistic modeling as it allows for a flexible risk assessment approach. Simple physical tests should be conducted to demonstrate proof of concept.

PHASE II: Execute physical testing and integrate any applicable data into mechanistic modeling with statistical analysis. Demonstrate the measurement method for identifying gold concentration and distribution in solder joints and at interfaces. Identify and quantify solder joint and CCA specific risk variables.

PHASE III DUAL USE APPLICATIONS: Work with existing contractors and standards organizations to implement risk assessment parameters with preference given to a model that can be used across a wide variety of manufacturers. Measurement methods/protocols should be integrated into applicable industrial standards and best practices.

REFERENCES:
1. IPC J-STD-001F, Requirements for Soldered Electrical and Electronic Assemblies. See section 4.5, Removal of component surface finishes.

2. F.G. Foster. 1963. "Embrittlement of solder by gold from plated surfaces." ASTM Special Publication 319: 13-19.

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4. E. Hare. Last accessed 22 September 2014. "Gold Embrittlement of Solder Joints." http://www.semlab.com/papers/goldembrittlementofsolderjoints.pdf.

KEYWORDS: Solder Joint reliability, Gold Embrittlement, Au Embrittlement

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