MISSILE DEFENSE AGENCY (MDA)
20.2 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

I. INTRODUCTION

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

The MDA Small Business Innovation Research (SBIR) Program is implemented, administered, and managed by the MDA SBIR/STTR Program Management Office (PMO), located within the Advanced Technology (DV) directorate. Specific questions pertaining to the administration of the MDA SBIR 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 Announcement will not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by MDA will be funded. MDA reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues).

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

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

Only Government personnel with active non-disclosure agreements will evaluate proposals. Non-Government technical consultants (consultants) to the Government may review and provide support in proposal evaluations during source selection. Consultants 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. Consultants will not establish final assessments of risk and will not rate or rank offerors' proposals. They are also expressly prohibited from competing for MDA SBIR awards in the SBIR topics they review and/or on which they provide comments to the Government.

All consultants are required to comply with procurement integrity laws. Consultants will not have access to proposals that are labeled by the offerors 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 consultants 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.

II. OFFEROR SMALL BUSINESS ELIGIBILITY REQUIREMENTS

Each offeror must qualify as a small business at time of award per the Small Business Administration's (SBA) regulations at 13 CFR 121.701-121.705 and certify to this in the Cover Sheet section of the proposal. Small businesses that are selected for award will also be required to submit a Funding Agreement Certification document prior to award.

SBA Company Registry

Per the SBIR/STTR Policy Directive, all SBIR applicants are required to register their firm at SBA's Company Registry prior to submitting a proposal. Upon registering, each firm will receive a unique control ID to be used for submissions at any of the eleven (11) participating agencies in the SBIR program. 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 Announcement.

III. ORGANIZATIONAL CONFLICTS OF INTEREST (OCI)

The basic OCI rules for Contractors which support development and oversight of SBIR topics are covered in FAR 9.5 as follows (the Offeror 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 applicable rules under the FAR Section 9.5 apply.

If you, or another employee in your company, developed or assisted in the development of any SBIR requirement or topic, please be advised that your company may have an OCI. Your company could be precluded from an award under this BAA if your proposal contains anything directly relating to the development of the requirement or topic. Before submitting your proposal, please examine any potential

OCI issues that may exist with your company to include subcontractors and understand that if any exist, your company may be required to submit an acceptable OCI mitigation plan prior to award.

IV. USE OF FOREIGN NATIONALS, GREEN CARD HOLDERS AND DUAL CITIZENS

See the "Foreign Nationals" section of the DoD SBIR Program Announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals, green-card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Identify any foreign nationals 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 SBIR 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 to export control-restricted topics and/or those with foreign nationals, dual citizens, or green card holders listed will be subject to security review during the contract negotiation process (if selected for award). MDA reserves the right to vet all uncleared individuals involved in the project, regardless of citizenship, who will have access to Controlled Unclassified Information (CUI) such as export controlled information. If the security review disqualifies a person from participating in the proposed work, the contractor may propose a suitable replacement. In the event a proposed person is found ineligible by the government to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale. 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.

V. EXPORT CONTROL RESTRICTIONS

The technology within most 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. The offeror must ensure that their firm complies with all applicable export control regulations. Please refer to the following URLs for additional information: https://www.pmddtc.state.gov/ and https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear.

Most MDA SBIR topics are subject to ITAR and/or EAR. If the topic write-up indicates that the topic is subject to International Traffic in Arms Regulation (ITAR) and/or Export Administration Regulation (EAR), your company may be required to submit a Technology Control Plan (TCP) during the contracting negotiation process.

VI. 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 contracts and subcontracts without exception. Any information relative to the work performed by the contractor under MDA SBIR contracts must be submitted to MDA for review and approval prior to its release to the public. This mandatory clause also includes the subcontractor who shall provide their submission through the prime contractor for MDA's review for approval.

VII. FLOW-DOWN OF CLAUSES TO SUBCONTRACTORS

The clauses to which the prime contractor and subcontractors are required to comply include, but are not limited to the following clauses: MDA clause H-08 (Public Release of Information) , DFARS 252.204-7000 (Disclosure of Information), and DFARS clause 252.204-7012 (Safeguarding Covered Defense Information and Cyber Incident Reporting). Your proposal submission confirms that any proposed subcontract is in accordance to the clauses cited above and any other clauses identified by MDA in any resulting contract.

VIII. OWNERSHIP ELIGIBILITY

Prior to award, MDA may request business/corporate documentation to assess ownership eligibility as related to the requirements of the Guide to SBIR Program Eligibility. These documents include, but may not be limited to, the Business License; Articles of Incorporation or Organization; By-Laws/Operating Agreement; Stock Certificates (Voting Stock); Board Meeting Minutes for the previous year; and a list of all board members and officers. If requested by MDA, the contractor shall provide all necessary documentation for evaluation prior to SBIR award. Failure to submit the requested documentation in a timely manner as indicated by MDA may result in the offeror's ineligibility for further consideration for award.

X. FRAUD, WASTE, AND ABUSE

All offerors must complete the fraud, waste, and abuse training (Volume 6) that is located on the Defense SBIR/STTR Innovation Portal (DSIP). Please follow guidance provided on DSIP to complete the required training.

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 Announcement; sections 3.6 and 4.19.

XI. PROPOSAL FUNDAMENTALS

Proposal Submission
All proposals MUST be submitted online using DSIP (https://www.dodsbirsttr.mil). Any questions pertaining to the DoD SBIR/STTR submission system should be directed to the DoD SBIR/STTR Help Desk: 703-214-1333 or DoDSBIRSupport@reisystems.com.

It is recommended that potential offerors email topic authors to schedule a time for topic discussion during the pre-release period from 06 May 2020 – 02 June 2020.

Classified Proposals

Classified proposals **ARE NOT** accepted under the MDA SBIR Program. The inclusion of classified data in an unclassified proposal MAY BE grounds for the Agency to determine the proposal as non-responsive and the proposal not to be evaluated. Contractors currently working under a classified MDA SBIR contract must use the security classification guidance provided under that contract to verify new SBIR 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 contracts will require security clearances. If a Phase II contract will require classified work, the offeror 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 Contracting Office will distribute selection and non-selection email notices to all firms who submit an MDA SBIR proposal. The email will be distributed to the personnel 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. MDA anticipates that selection and non-selection notifications will be distributed to all offerors in the September 2020 timeframe.

Proposal Feedback

MDA will provide written feedback to unsuccessful offerors regarding their proposals upon request. Requests for feedback 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 proposal feedback. Only firms that receive a non-selection notification are eligible for written feedback.

Technical and Business Assistance (TABA)

Section 9(b) of the SBIR Policy Directives allows agencies to enter into agreements with suppliers to provide technical assistance to SBIR 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.

MDA permits award recipients to obtain technical assistance in accordance with the SBIR/STTR Policy Directive. All requests for TABA must be included on the MDA SBIR/STTR Phase I TABA Form (https://www.mda.mil/global/documents/pdf/SBIR_STTR_PHI_TABA_Form.pdf) and included as a part of Volume 5 of the proposal package.

An SBIR firm may acquire the technical assistance services described above on its own. Firms must request this authority from MDA and demonstrate in its SBIR 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 TABA 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 supports the need for this requirement sufficiently as determined by the Government, MDA will permit the awardee to acquire such technical assistance, in an amount up to $5,000 per year. This will be an allowable cost on the SBIR award. The per year amount will be in addition to the award and is not subject to any burden, profit or fee by the offeror. The per-year amount is based on the original contract period of performance and does not apply to period of performance extensions. Requests for TABA funding outside of the base period of performance (6 months) for Phase I proposal submission will not be considered.

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

1. Making better technical decisions on SBIR projects;
2. Solving technical problems that arise during SBIR projects;
3. Minimizing technical risks associated with SBIR projects; and
4. Developing and commercializing new commercial products and processes resulting from such projects including intellectual property protections.

The MDA Phase I TABA form can be accessed here: (https://www.mda.mil/global/documents/pdf/SBIR_STTR_PHI_TABA_Form.pdf) and should be included as part of Volume 5 using the "Other" category.

XII. PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (available at https://www.dodsbirsttr.mil) will lead you through the preparation and submission of your proposal. Read the front section of the DoD Announcement for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this Announcement will not be considered. To be considered for evaluation the proposal package must be formally submitted on DSIP.

MAXIMUM PHASE I PAGE LIMIT FOR MDA IS 15 PAGES FOR VOLUME 2, TECHNICAL VOLUME

Any pages submitted beyond the 15-page limit within the Technical Volume (Volume 2) will not be evaluated. Letters of support and TABA requests should be included as part of Volume 5 and will not count towards the 15-page Technical Volume (Volume 2) limit. Any technical data/information that should be in the Technical Volume (Volume 2) but is contained in other Volumes will not be considered.

MDA's objective for the Phase I effort is 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 $150,000. A list of topics currently eligible for proposal submission is included in these instructions, followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time.

Phase I Proposal

A complete Phase I proposal consists of five volumes (six if letters of support and/or TABA is included):

- Volume 1 (required): Proposal Cover Sheet *(does not count towards 15-page limit)*
- Volume 2 (required): Technical Volume (maximum of 15 pages)

- Volume 3 (required): Cost Volume *(does not count towards 15-page limit)*
- Volume 4 (required): Company Commercialization Report *(does not count towards 15-page limit)*
- Volume 5 (optional): Supporting Documents: Letters of Support and/or TABA *(does not count towards 15-page limit)*
- Volume 6 (required): Fraud, Waste, and Abuse Training Certification

Volume 5 Information

MDA will only accept letters of support and/or TABA as part of Volume 5. Any other type of documentation included as part of Volume 5 will not be considered. Letters of support should be loaded within Volume 5 using the "Letters of Support" category on the DoD submission website. TABA should be loaded within Volume 5 using the "Other" drop-down category.

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 purpose for Phase I is to determine the scientific and technical merit and feasibility of the proposed effort.

It is not intended for any formal end-item contract delivery and ownership by the Government of your hardware, computer software, or technical data. As a result, your technical proposal should not contain any reference to the term "Deliverables" when referring to your hardware, computer software, or technical data. Instead use the term: "Products for Government Testing, Evaluation, Demonstration, and/or possible destructive testing."

FAR 52.203-5 Covenant Against Contingent Fees

As prescribed in FAR 3.404, the following FAR 52.203-5 clause shall be included in all contracts awarded under this Broad Agency Announcement (BAA):

(a) The Contractor warrants that no person or agency has been employed or retained to solicit or obtain this contract upon an agreement or understanding for a contingent fee, except a bona fide employee or agency. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability or to deduct from the contract price or consideration, or otherwise recover, the full amount of the contingent fee.

(b) Bona fide agency, as used in this clause, means an established commercial or selling agency, maintained by a contractor for the purpose of securing business, that neither exerts nor proposes to exert improper influence to solicit or obtain Government contracts nor holds itself out as being able to obtain any Government contract or contracts through improper influence.

"Bona fide employee," as used in this clause, means a person, employed by a contractor and subject to the contractor's supervision and control as to time, place, and manner of performance, who neither exerts nor proposes to exert improper influence to solicit or obtain Government contracts nor holds out as being able to obtain any Government contract or contracts through improper influence.

"Contingent fee," as used in this clause, means any commission, percentage, brokerage, or other fee that is contingent upon the success that a person or concern has in securing a Government contract.

"Improper influence," as used in this clause, means any influence that induces or tends to induce a Government employee or officer to give consideration or to act regarding a Government contract on any basis other than the merits of the matter.

XIII. PHASE I PROPOSAL SUBMISSION CHECKLIST

____1. The following have been submitted electronically through the DoD submission site by 12:00 p.m. (noon) EDT July 2, 2020.

- ✓ Volume 1: DoD Proposal Cover Sheet
- ✓ Volume 2: Technical Volume (DOES NOT EXCEED 15 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.**

  If proposing to use foreign nationals, green card holders, and/or dual citizens; identify the personnel 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.
- ✓ Volume 3: Cost Volume. **(Online Cost Volume form is REQUIRED by MDA)**
- ✓ Volume 4: Company Commercialization Report. (required even if your firm has no prior SBIR/STTR awards).
- ✓ Volume 5 (optional): Letters of Support and/or TABA.
- ✓ Volume 6 (required): Fraud, Waste, and Abuse Training Certification.

____2. Phase I proposal is not to exceed $150,000. (or not to exceed $155,000 if TABA is included)

____3. The proposal must be formally submitted on DSIP. Proposals that are not submitted will not be evaluated.

XIV. MDA SECURITY REVIEW OF ABSTRACTS, BENEFITS, AND KEYWORDS

Proposal titles, abstracts, anticipated benefits, and keywords of proposals that are selected for contract award will undergo an MDA Policy and Security Review. Proposal titles, abstracts, anticipated benefits, and keywords are subject to revision and/or redaction by MDA. Final approved versions of proposal titles, abstracts, anticipated benefits, and keywords may appear on DSIP and/or the SBA's SBIR/STTR award site (https://www.sbir.gov/sbirsearch/award/all).

XV. MDA PHASE I PROPOSAL EVALUATIONS

MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this Announcement 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 offeror 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 as determined by MDA will be funded.

Phase I 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 its commercialization.

Firms with a Commercialization Achievement Index (CAI) at or below the 20th percentile will be penalized in accordance with the DoD program Announcement.

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

Qualified letters of support should be included as part of Volume 5 within the "Letters of Support" category on the DoD submission site and will **not** count towards the 15-page Volume 2 page limit. Letters of support will be evaluated towards criterion C if included as part of Volume 5, but are not required for Phase I or Phase II. Letters of support shall not be contingent upon award of a subcontract.

A qualified letter of support is from a relevant commercial or Government Agency procuring organization(s) working with MDA, articulating their pull for the technology [i.e..., what BMDS requirements does the technology support 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 Volume 5. Letters of support which are faxed, e-mailed separately, or otherwise not included as part of Volume 5 will NOT be considered.

Phase II Proposal Submission

Per DoD SBIR Phase II Proposal guidance, all Phase I awardees from the 20.2 Phase I Announcement will be permitted to submit a Phase II proposal for evaluation and potential negotiation. Details on the due date, content, and submission requirements of the Phase II proposal will be provided by the MDA SBIR/STTR PMO after contract award. Only firms who receive a Phase I award resulting from the 20.2 Announcement may submit a Phase II proposal.

MDA will evaluate and select Phase II proposals using the Phase II evaluation criteria listed in the DoD Program Announcement. 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. Please reference www.dcaa.mil/small_business/Accounting_System.pdf for more information on obtaining a DCAA approved accounting system.

MISSILE DEFENSE AGENCY (MDA) SBIR 20.2 Phase I Topic Index

MDA20-001 TITLE: Automated Factor-Based Sensitivity Analysis

RT&L FOCUS AREA(S): Artificial Intelligence/ Machine Learning; General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.
OBJECTIVE: Develop an automatic software analysis tool to understand the behavior and performance of Missile Defense (MD) mission-critical algorithms.

DESCRIPTION: This topic seeks to gain a deeper understanding of how the Aegis Weapon System (AWS) MD Engage-ability prelaunch Figure of Merit (FOM) algorithm directly contributes to performance in a given MD scenario/vignette. A conceptual factor-based sensitivity analysis tool offers an innovative means to uncover and understand the inherent sensitivities and limitations of mission-critical algorithms. By controlling the data flow into and out of an algorithm under test, the tool can force the system down processing paths that otherwise would not have been exercised with the actual AWS. The outcomes of these off-nominal cases can then be aggregated and analyzed to establish behavioral and performance trends which will aide in understanding the AWS FOM selection logic and should aide in the analysis of impacts to software upgrades and how they impact missile intercept probabilities.

PHASE I: Develop a proof of concept product around the AWS FOM algorithm. Perform an analysis to demonstrate the concept and an initial understanding of the AWS FOM calculations. Phase I should be a feasibility concept study that supports a proposed design solution and down selection of alternatives.

PHASE II: Enhance and refine the proposed tool based on the results and findings of the Phase I and expand its capabilities to generalize the prototype tool to analyze any algorithm in the AWS MD system. The Phase II objective will be to validate a new technology solution that a customer can transition in Phase III. Validate the feasibility of the Phase I concept by development and demonstrations that will be tested to ensure performance objectives are met. The Phase II effort should result in a prototype with substantial commercialization potential.

PHASE III DUAL USE APPLICATIONS: Productize the tool to expand the capabilities to other interested users in the government. Develop and execute a Phase III incremental test & integration plan that will produce a final prototype.

REFERENCES:

1. Statistical Issues in Defense Analysis and Testing, “Sources of Variability”, https://www.nap.edu/read/9686/chapter/4
2. “Sensitivity Analysis”, https://www.sciencedirect.com/topics/computer-science/sensitivity-analysis
3. Donald E. Knuth, Selected Papers on the Analysis of Algorithms (Stanford, California: Center for the Study of Language and Information, 2000) ISBN 1-57586-212-3.
4. “Determining the significance of input parameters using sensitivity analysis”, https://link.springer.com/chapter/10.1007/3-540-59497-3_199

5. "A sensitivity analysis algorithm for hierarchical decision models", https://www.sciencedirect.com/science/article/abs/pii/S0377221707000264
6. Aegis Ballistic Missile Defense Fact Sheet: https://www.mda.mil/global/documents/pdf/aegis.pdf

KEYWORDS: Aegis BMD, Algorithm, Aegis Weapon System, Weapon Control System, Figure of Merit, Robustness and Sensitivity Analysis

TPOC-1: Christopher Angevine
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Email: christopher.angevine@mda.mil

MDA20-002 TITLE: Lightweight Structural Metamaterials for Second and Third Stage Rocket Motors

RT&L FOCUS AREA(S): Hypersonics; General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Weapons; Space Platform; Battlespace

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop structural metamaterials to improve technology readiness levels of constituent technologies essential to a high capacity future interceptor.

DESCRIPTION: This topic seeks to develop lightweight structural metamaterials for second and third stage rocket motors that are able to withstand the mechanical and thermal stresses of terminal missile defense maneuvers. Modern missile defense forces are expected to confront large raids of ballistic, non-ballistic/high Mach, and strategic cruise missiles in the near to mid timeframe. To gain the advantage over the threat, missile defense assets will require a compact, highly agile, high loadout interceptor for the terminal defense segment that is capable of very high axial and lateral accelerations.
MAX phase materials are metallic ceramics known for combining favorable mechanical properties such as good machinability and high elastic stiffness with good thermal shock resistance, low thermal expansion coefficients, and rigidity at high temperature. MAX phase composite metamaterials may prove effective as low-density, lightweight structures, for rocket motor casings, combustion chambers, nozzles, and control surfaces. Candidate solutions should demonstrate the feasibility of rocket motor components that meet the following technical goals:

- Half the weight (or less) of components made from traditional steel alloys.
- Operates at high temperatures, up to 1400°C.
- Withstands very large axial and lateral accelerations.
- Maintains rigidity and structure during variable thrust or multiple pulse operations.
- Demonstrates self-healing characteristics.

PHASE I: For candidate solutions, conduct a concept definition for advanced rocket motor components, to include a proof-of-principle study, design of notional components, and predicted technical performance of notional components. Technical performance parameters should include maximum thermal and mechanical tolerances.

PHASE II: For candidate solutions, develop and execute an incremental test and evaluation plan that will mature the constituent technologies and produce a prototype for assessment based on the design proposed in Phase I.

PHASE III DUAL USE APPLICATIONS: For candidate solutions, investigate applications of prototype components from Phase II for use in economical, reusable space launch vehicles in addition to missile defense interceptors.

REFERENCES:

1. Barsoum, M. W. (2013) "MAX Phases: Properties of Machinable Ternary Carbides and Nitrides." Wiley-VCH Verlag GmbH & Co. KGaA.
2. Farle, A et al. 2016. "Demonstrating the self-healing behavior of some selected ceramics under combustion chamber conditions," Smart Mater. Struct. 25 084019.
3. Gilbert, C.J. et al. 1999. "Fatigue-Crack Growth and Fracture Properties of Coarse and Fine-Grained Ti3SiC2," Scripta mater. 42 (2000) 761-767.
4. Aegis Ballistic Missile Defense Fact Sheet: https://www.mda.mil/global/documents/pdf/aegis.pdf

KEYWORDS: MAX Phases, Metalized Ceramics, Advanced Rocket Motors, Metamaterial

TPOC-1: LCDR Chester Hewitt
Phone: 540-663-7866
Email: chester.hewitt@mda.mil

MDA20-003 TITLE: Solid Rocket Motors for High Performance Interceptors

RT&L FOCUS AREA(S): Hypersonics; General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Weapons; Space Platform; Battlespace

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop highly loaded grain (HLG) rocket motors to improve technology readiness levels of constituent technologies essential to a future high performance interceptor.

DESCRIPTION: This topic seeks to develop advanced solid rocket motors for compact, high performance, interceptors. Modern missile defense forces are expected to confront large raids of ballistic, non-ballistic/high Mach, and strategic cruise missiles in the near to mid timeframe. To gain the advantage on the threat, missile defense assets require a compact, highly agile, high loadout interceptor for the terminal defense segment that is capable of very high axial and lateral accelerations. To meet this need, the government desires to develop HLG solid rocket motors with high density and specific impulse. HLG rocket motors pack more solid rocket propellant into a given volume and thus achieve a higher propellant-to-inert mass fraction, which leads to more total impulse achieved within the same volume. Candidate solutions should demonstrate the feasibility of rocket motor propellants that meet the following technical goals:

- Increase in total impulse of greater than 20% relative to current rocket motor propellants.
- Achieve vacuum specific impulse of at least 280s.
- Tailorable to very high thrust applications.
- Tailorable to variable thrust or multiple pulse operations.

PHASE I: For candidate solutions, conduct a concept definition for advanced rocket propellant, to include a proof-of-principle study, design of notional propellant grain, and predicted technical performance of the propellant. Technical performance parameters should include maximum thrust, specific impulse, and the ability to conduct multiple pulse operations.

PHASE II: For candidate solutions, develop and execute an incremental test and evaluation plan that matures the constituent technologies and produces a prototype for assessment based on the design proposed in Phase I.

PHASE III DUAL USE APPLICATIONS: For candidate solutions, investigate applications of prototype components developed in Phase II for use in more efficient space launch vehicles in addition to missile defense interceptors.

REFERENCES:

1. Giangreco, L. (2017, May 30) “USAF developing next generation air dominance missile.” Retrieved from https://www.flightglobal.com/news/articles/usaf-developing-next-generation-air-dominance-missil-437728/

2. Naval Air Warfare and Weapons: Counter Air Defense (CAD) Improvements, page 34. https://www.onr.navy.mil/-/media/Files/35/code-35-naval-air-warfare-and-weapons-program-guide.ashx?la=en&hash=66F4B02F6FC4269E790E8813A6B1FA47D3F3DCF0
3. Aegis Ballistic Missile Defense Fact Sheet: https://www.mda.mil/global/documents/pdf/aegis.pdf

KEYWORDS: Rocket propellant, Highly Loaded Grain, Solid Rocket Motor

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MDA20-004 TITLE: High Power, Single Mode, Diode Emitter for Directed Energy Applications

RT&L FOCUS AREA(S): Directed Energy
TECHNOLOGY AREA(S): Weapons; Space Platform; Materials; Air Platform

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Design, develop, and demonstrate high power (>1-3 W), single mode, direct diode emitters that meet the emerging government need for high-power, high-brightness laser systems with greatly reduced size, weight, and power (SWaP) consumption.

DESCRIPTION: This topic seeks the development of high power, single-mode, high-brightness, narrow linewidth, near diffraction limited diode emitters that can be spectrally or coherently beam combined for further power scaling. Most current electrically-powered high energy lasers require an additional gain medium to achieve necessary beam quality (high brightness). Since an additional gain medium creates power loss, it is desirable to eliminate the additional gain medium and use high power direct diodes directly.

Semiconductor laser sources offer reduced optical elements, higher efficiency, better SWaP, increased robustness, lifetime, reliability, manufacturability, and lower cost of operation and ownership when compared to other types of laser systems, such as fiber lasers. Diode lasers have proven to be very reliable, very compact, and should continue to prove to be cost effective compared to other laser sources. Maturing highly efficient laser diodes will directly benefit current research and development efforts in the field of next generation multi-kW laser sources, extending the efficiency, reliability, operating temperature, and providing multi-kW power scaling capabilities.

The overall goal of this topic is to develop direct diode emitters that, when combined, produce high power direct diode laser (HPDDL) systems capable of achieving upwards of 10-100 kW (dependent on the beam combining technique) of high output power while maintaining the beam quality to a near diffraction limited spot size (M2< 1.2) in a low SWaP configuration. By combining multiple high-power, single-mode, direct diode emitters into elements, and multiple elements into a HPDDL system, the potential exists to meet these SWaP needs based on the inherently high (potentially>70%) electrical-to-optical power conversion efficiency (PCE) of direct diode systems. Solutions are highly desired to meet challenges such as short coherence length, multiple modes, and high divergence angles (which limits maintaining a tight spot while propagating over a long distance).

PHASE I: Collaborate with government and industry to review and adjust, as needed, the topic objectives in order to increase commercialization prospects. Identify any significant design trades and work with the government to resolve them. Complete a preliminary direct diode emitter design and perform modeling and simulation to estimate its performance with enough fidelity to quantify major specifications. Conduct additional research, analyses, and experimentation as needed to demonstrate feasibility and/or validate models. Determine the feasibility of manufacturing the product in realistic quantities and at commercially competitive costs. Complete preliminary cost and performance estimates and compare with existing

products. Complete a preliminary plan for fabricating and testing prototypes in Phase II and begin coordinating with potential service providers, suppliers, and sub-contractors.

PHASE II: Complete a prototype design. Model and simulate its performance with enough fidelity to quantify almost all of its specifications. Fabricate and test HPDDL prototypes in sufficient quantities to make a preliminary assessment of yield and performance variation. Compare test results with predictions. Begin initial qualification of the new design. Finalize the cost and performance estimates based on results and compare with existing products. Begin commercialization of the new approach. Seek commitments from potential customers in order to help fund Phase III.

PHASE III DUAL USE APPLICATIONS: Incorporate lessons-learned from the prototype into a product design. Begin producing and delivering products, at a low rate, to customers. Fully qualify the product for the intended application(s). Assist in integrating this product into a demonstrator system.

REFERENCES:

1. Y. Zhao and L. Zhu, "On-chip coherent combining of angled-grating diode lasers toward bar-scale single-mode lasers", Optical Society of America, Opt. Express 6375, Vol. 20, No. 6, March 2012.
2. Y. Zhao and L. Zhu, "Improved Beam Quality of Coherently Combined Angled-Grating Broad-Area Lasers," IEEE Photonics Journal, Vol. 5, No. 2, April 2013.
3. Leisher et al., "Feedback-Induced Failure of High Power Diode Lasers," IEEE Journal of Quantum Electronics, JQE-134992-2018.R1, Oct 2018.

KEYWORDS: High Power Direct Diode Laser, HPDDL, Direct diode emitters, Single mode, High brightness, Beam quality, Spectral and Coherent beam combining, Laser Power Scaling

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MDA20-005 TITLE: Low-Cost Space-Based Cryocoolers

RT&L FOCUS AREA(S): Space
TECHNOLOGY AREA(S): Sensors; Space Platform; Materials

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop innovative approaches for producing space-based cryocoolers at low cost and in large numbers.

DESCRIPTION: This topic seeks to develop innovative technologies to reduce the cost per unit for cryocoolers. Some types of infrared detectors must be cooled to cryogenic temperatures in order to perform within specifications, Cryocoolers are the components on a spacecraft that provide this cryogenic cooling. Currently, space-based cryocoolers are custom designed, fabricated, and qualified in low numbers and at great expense (e.g. $3-5M per unit). Production in large quantities, using existing designs and manufacturing technologies, might reduce this cost to less than $1M per unit. Further reductions in cost per unit will require innovative approaches and/or new technologies in both manufacturing processes and cryocooler designs. The objective of this topic is to develop these innovations and/or technologies. Proposed approaches will be considered in the following (decreasing) order of priority:

1. Process improvements in order to substantially reduce the cost of manufacturing existing (or slightly modified) cryocooler or subcomponent designs.
2. New cryocooler or subcomponent designs that are cheaper and/or easier to manufacture without compromising performance or reliability.
3. Innovations related to ancillary equipment such as control electronics or the cryocooler's mechanical, thermal, and electrical interfaces.
4. Other approaches will be considered if they show a clear potential to meet topic objectives.

Although a pulse-tube cryocooler appears best suited for space based application(s), any cryocooler type will be considered that shows a clear potential to meet the following objectives:

1. Less than $250K per unit (excluding ancillary equipment) at a production rate of 50 units per year.
2. At least 5 Watts of cooling at 77 Kelvin with a 300 Kelvin rejection temperature.
3. At least 5 years of continuous on-orbit operation with high reliability.
4. Approaches, meets, or exceeds the state-of-the-art in terms of performance, efficiency, size, weight, and power, electromagnetic interference, mean-time-to-failure, interfaces, and vibration.

These objectives may be adjusted in Phase I in order to increase potential customer demand and prospects for commercialization.

PHASE I: Study the scientific and technical feasibility of the proposed approach. Collaborate with government agencies and industry to develop a common set of requirements in order to increase demand. Conduct research, analyses, and experimentation as needed to demonstrate feasibility and/or validate models. Develop preliminary designs for any new equipment, if applicable. Complete preliminary cost

and performance estimates. Complete a preliminary plan for Phase II and begin coordinating with Phase II partners.

PHASE II: Demonstrate the proposed approach in order to validate predictions. Fabricate and test prototype equipment, if applicable. Begin initial qualification of any new designs, if applicable. Finalize the cost and performance estimates based on results. Begin commercialization of the new approach. Seek commitments from multiple potential customers to help fund Phase III.

PHASE III DUAL USE APPLICATIONS: Commercialize the new approach by supplying subcomponents to cryocooler integrators, by supplying equipment to cryocooler manufacturers, or by manufacturing cryocoolers in-house. Begin producing and delivering products, at a low rate, to customers. Fully qualify the product for the intended application(s). Assist in integrating the product into a demonstrator system.

REFERENCES:

1. R. Radebaugh, "Cryocoolers: the state of the art and recent developments," J. Phys.: Condens. Matter 21 (2009), 164219.
2. R. Radebaugh, "Pulse Tube Cryocoolers for Cooling Infrared Sensors," Proceedings of SPIE, The International Society for Optical Engineering, Infrared Technology and Applications XXVI, Vol. 4130, pp. 363-379 (2000).
3. Proceedings of the 20th International Cryocooler Conference.

KEYWORDS: Cryocooler, manufacturing, pulse tube, cryogenic, space

TPOC-1: Aaron Williams
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MDA20-006 TITLE: High-Reliability Rad-Hard Space-Based Low-Voltage Direct Current (DC)-to-DC Converter

RT&L FOCUS AREA(S): Microelectronics; Space
TECHNOLOGY AREA(S): Nuclear; Electronics; Space Platform

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OBJECTIVE: Develop and produce a commercially-competitive, high-reliability, radiation-hardened, low-voltage DC-to-DC converter for future space-based missile defense applications.

DESCRIPTION: This topic seeks innovative low voltage DC-to-DC convertors for future space-based missile defense applications. DC-to-DC converters are used to step-down and condition a spacecraft's bus voltage (e.g. 28 V) to the low voltages (e.g. 5 V or lower) required to power modern space electronics (e.g. field programmable gate arrays). There are a large number of commercially available DC-to-DC converters for a variety of applications. However, very few of these converters have the high-reliability, radiation-hardness (against both natural and manmade environments), and performance needed for space-based missile defense applications. Of those converters that meet these requirements, further improvements in performance, size, weight, and/or cost are desirable. The government anticipates that small business respondents could achieve these improvements with an innovative design that incorporates new technologies. The government further anticipates that SBIR resources would be sufficient to finalize, fabricate, and test a prototype design by the end of Phase II, which would then lead to a low-rate production of a product (or series of products) in Phase III. The product resulting from this topic should meet or exceed the following objectives:

1. Minimum Time Between Failure (MTBF) of 10 Million hours or more.
2. Screened up to a class V assurance level.
3. Accumulate a Total Ionizing Dose (TID) of 1 Mrad(Si) or more while performing within specification
4. Immune to destructive Single Event Effects (SEEs) at Linear Energy Transfers (LETs) of 80 MeV-cm^2/mg or less.
5. Immune to non-destructive SEEs at LETs of 36 MeV-cm^2/mg or less.
6. Immune to prompt doses of 1E10 rad(Si)/s or less.
7. Survives prompt doses of 1E12 rad(Si)/s or less.
8. Contains no components that have increased susceptibilities to displacement damage caused by neutrons or protons.
9. Supports standard interfaces, input & output ranges, operating temperatures, under- & over-voltage protections, fault-tolerances, control functions, packaging, electromagnetic interference (EMI) & ripple suppression, line/load variations, and bandwidths.
10. Has a flexible design that could be easily modified in order to support additional voltages or power outputs.
11. Preferably monolithic, versus hybrid, design.
12. Costs the same as, or less than, comparable existing products.
13. Approaches, meets, or exceeds the current state-of-the-art in terms of efficiency, conditioning, size, and weight with respect to comparable existing products.

The Phase II prototype should (notionally) take a nominal 28 V input and produce a single, isolated output of up to 20 W at 5 V or 3.3 V. This objective, in addition to those listed above, will be reviewed during Phase I.

PHASE I: Collaborate with government and industry to review and adjust, as needed, the topic objectives in order to increase commercialization prospects. Identify any significant design trades and work with the government to resolve them. Complete a preliminary design for the DC-to-DC converter. Model and simulate its performance with enough fidelity to quantify its major specifications. Conduct additional research, analyses, and experimentation as needed to demonstrate feasibility and/or validate models. Determine the feasibility of manufacturing a resulting product in realistic quantities and at commercially competitive costs. Complete preliminary cost and performance estimates and compare with existing products. Complete a preliminary plan for fabricating and testing prototypes in Phase II and begin coordinating with potential service providers, suppliers, and sub-contractors.

PHASE II: Complete a prototype design for the DC-to-DC converter. Model and simulate its performance with enough fidelity to quantify its specifications. Fabricate and test prototypes in sufficient quantities to make a preliminary assessment of yield and performance variation. Compare test results with predictions. Begin initial qualification of the new design. Finalize the cost and performance estimates based on results and compare with existing products. Begin commercialization of the new approach. Seek commitments from multiple potential customers in order to help fund Phase III.

PHASE III DUAL USE APPLICATIONS: Incorporate lessons-learned from the prototype into a product design. Begin producing and delivering products, at a low rate, to customers. Fully qualify the product for the intended application(s). Assist in integrating this product into a demonstrator system.

REFERENCES:

1. P. C. Adell & L. Z. Scheick (2013). Radiation Effects in Power Systems: A Review, IEEE Transactions on Nuclear Science, Vol. 60, No. 3, June 2013.
2. P. C. Adell et. al (2002). Total-Dose and Single-Event Effects in Switching DC/DC Power Converters, IEEE Transactions on Nuclear Science, Vol. 49, No. 6, December 2002.

KEYWORDS: Power, Converter, DC-DC, Space, Radiation, Rad Hard, Reliability

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MDA20-007 TITLE: Flexible Thermal Protection System Materials

RT&L FOCUS AREA(S): Hypersonics; General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Materials; Air Platform

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OBJECTIVE: Develop innovative deformable/flexible (elastic) thermal protective materials capable of surviving high temperature, high Mach environments.

DESCRIPTION: This topic seeks the development of thermal protective materials that are flexible, can survive, and maintain elasticity when exposed to the high temperatures, oxidative environments and mechanical loads associated with high Mach flight. These capabilities would enable variable geometries to perform in-flight adaptation of aircraft aerodynamic surfaces in compliance with the most efficient shapes for each flight regime, providing both flow regulation and control to enhance flight performance, control authority, and multi-mission capability.

A flight vehicle's geometry has dramatic influences on its stability, maneuverability, and drag. Static geometry configurations are optimized for one flight regime; therefore suffering performance reductions outside of that regime. Extreme variations in altitude and velocities required for high Mach flight consequently render a static-geometry vehicle inherently non-optimal. Additionally, control surfaces are currently limited to unitary moving parts that impart additional drag and produce possible adverse flow disturbances, e.g., shock-shock interactions.

Proposers should strive to develop candidate materials and demonstrate their elasticity (maximum desired bend radius of a one (1) inch thick sample to be twelve (12) inches), and survivability when exposed to thermal environments above 3,000°F for durations of greater than five (5) minutes. Technologies desired for this topic can be applied to both powered (rocket and air-breathing) and glide vehicles. Variable geometry aerodynamic surfaces (e.g., aerodynamic surfaces, shape-adaptive air inlets) are also desired if they offer an advancement in vehicle performance.

PHASE I: Collaborate with government agencies and industry to identify relevant environments and define initial material requirements, e.g., elasticity properties, thermal properties, etc., for the proposed application(s). Identify significant design trades, and work with the government to resolve them. Identify the intended applications, the methods of testing the materials' elastic and thermal properties, and its survivability at relevant temperatures. Evaluate producibility of candidate material(s) in realistic quantities and perform a top-level assessment of the industry base and raw material availability for production. Conduct additional research, analyses, and experimentation as needed to demonstrate feasibility and/or validate models. Complete preliminary cost and performance estimates and compare with existing products. Complete a preliminary plan for fabrication and testing of candidate materials in Phase II and begin coordinating with potential service providers, suppliers, and sub-contractors.

PHASE II: Develop test articles of the candidate materials. Model and simulate material performance with adequate fidelity to quantify primary material specifications. Plan and perform sufficient testing to

determine material feasibility in defined environments. Compare test results with predictions. Fully characterize and demonstrate elastic and thermal properties for top candidate(s). Demonstrate in a representative environment and compare with existing products. Develop cost and performance estimates based on results. Begin commercialization of the new approach and seek commitments from potential customers in order to help fund Phase III.

PHASE III DUAL USE APPLICATIONS: Incorporate lessons-learned from the prototype materials into a product design. Begin producing and delivering products, at a low rate, to customers. Fully qualify the product for the intended application(s). Assist in integrating the product into a demonstrator system.

REFERENCES:

1. Smith, Butt, Spakovsky, A Study of the benefits of Using Morphing Wing Technology in Fighter Aircraft Systems, AIAA Thermophysics Conference, June 2007.
2. Gaetano Arena, Rainer M. J. Groh, Alex Brinkmeyer, Raf Theunissen, Paul M. Weaver and Alberto Pirrera. Adaptive compliant structures for flow regulation. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences, Volume 473, Issue 2204, 16 August 2017.

KEYWORDS: Elastic, deformable, flexible, thermal protection system, survivability, high Mach, adaptive, morphing, variable geometry

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MDA20-008 TITLE: Additive Manufacturing for Radio Frequency Antennas, Waveguides, and Connectors on Flexible Substrates

RT&L FOCUS AREA(S): Microelectronics; Space
TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Characterize additive manufactured Radio Frequency (RF) antennas and wave guides to determine their signal loss relative to additively printed conductors and to determine the effects of voids within the materials on RF performance.

DESCRIPTION: This topic seeks to characterize the RF performance of additively manufactured antennas and wave guides with additively printed conductors on various flexible substrate types. As part of this characterization effort, RF performance effects of void densities and sizes within the materials will be established. To develop consistently capable RF additive printed electronics, characterization of various material sets are needed.

Flexible electronics usage in RF applications can be very beneficial to both government and commercial applications, since they may be lightweight, lower cost, and provide comparable performance. The antenna and wave guide performance will vary with the frequency range for which it was designed, power handling requirements, the material types, and voids induced in the production process. Currently, the capabilities of various printed material and substrate combinations are not well defined. Also, the voids induced by the different deposition methods will have an effect on RF performance, but these effects are not well understood in relation to void density and size.

To characterize the additive materials used for the antennas and waveguides, the printed conductors, and various flexible substrates, the government desires multiple test coupons to be manufactured for each of the following RF bands: L, S, C, X, and Ku. The proposer should develop a nondestructive process to establish void sizes and densities within the antennas, waveguides, and conductors. Each of the samples should then be characterized for RF signal performance for the bands stated above at 1W, 25W, and 50W. Environmental tests consisting of thermal cycling, vibration, and flexure should be conducted at -40°C, 25°C, and 125°C on the samples and compared to the baseline results.

PHASE I: Down select material types to be used for the antennas and waveguides, conductors, and flexible substrates. Establish material set combinations to be used for the characterization efforts and sample sizes needed for each material set. Design test coupons for antennas and waveguides at L, S, C, X, and Ku RF band center frequencies. Develop a nondestructive process to establish void sizes and densities for each material set. Develop a test plan for baseline characterizations and environmental tests, as well as acceptable changes in performance. Perform verification of the nondestructive void measurement process and the characterization plan for a representative test coupon.

PHASE II: Produce test coupons in quantities established in Phase I. Determine void sizes and densities in the material sets test coupons. Conduct a characterization test plan on all test coupons at -40°C, 25°C, and 125°C with power levels of 1W, 25W, and 50W. Produce a report summarizing test results.

PHASE III DUAL USE APPLICATIONS: Construct/Print additive manufactured Radio Frequency (RF) antenna(s) and wave guides on flexible substrate(s) for missile defense applications based on Phase II characterization and environmental test results to verify optimum material set performance for the program application.

REFERENCES:

1. “Volumetric 3D-printed antennas, manufactured via selective polymer metallization” https://arxiv.org/abs/1812.04080
2. “Printable Materials for the Realization of High Performance RF Components: Challenges and Opportunities”. https://www.hindawi.com/journals/ijap/2018/9359528/

KEYWORDS: Radio Frequency, Additive, Flexible Substrate

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MDA20-009 TITLE: High Toughness Thermal Protection Systems (TPS) for non-ballistic/high Mach Vehicles

RT&L FOCUS AREA(S): Hypersonics
TECHNOLOGY AREA(S): Space Platform; Materials; Air Platform

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OBJECTIVE: Develop a new process of forming thermal protective coverings for non-ballistic/high Mach vehicles.

DESCRIPTION: This topic seeks to demonstrate the production of thermal protection materials which conform to complex shapes and are low weight while providing high resistance to erosion and impact damage. Thermal protection materials today require long manufacturing times and have a large scrap rate due to manufacturing issues. These materials are also prone to erosion and interlaminate blistering under high Mach flight conditions.

The government is interested in developing thin shell (1/4 - 3/4 inch thick) Carbon-Carbon (C-C) TPS materials with high toughness and erosion resistance. Potential material solutions may include through shell reinforcements, including stitched laminates, chopped fiber, or carbon nanotube reinforced composites, or other methods for reducing surface failure in TPS panels. The vendor must develop a process with high repeatability and low statistical variation in performance while matching or improving thermal, strength, and weight characteristics of the current TPS state of the art. The material solution must be faster and cheaper to produce than current TPS solutions and have a low scrap rate.

PHASE I: Develop a methodology for providing through thickness reinforcement to shell TPS structures that produces high strength/high density structures with a short manufacturing time. Demonstrate the process on a sample >1/4 inch thick and >1/4 ft^2. Test the material properties of the sample. Document the process and the resulting material properties.

PHASE II: Mature the process for forming larger, production representative, C-C shells with through thickness reinforcement. Demonstrate a reduced production timeline for full scale parts (<6 months for fully densified parts). Produce sample structures for arc testing and mechanical properties testing and test them at appropriate high Mach test facilities. Demonstrate ablation performance and characterize material properties and performance of the reinforced TPS shells. Document the process and materials.

PHASE III DUAL USE APPLICATIONS: Transition the manufacturing process to a program of record to build prototype panels for use in test flights. Collect required performance data to support certification of C-C parts for use in production systems. Demonstrate <10% scrap rate for full scale (>3ft^2) parts.

REFERENCES:
1. Congressional Research Service Report 45811. Background and Issues for Congress. https://crsreports.congress.gov/product/pdf/R/R45811

2. Ultra-high temperature ceramic composite,
https://www.tandfonline.com/doi/full/10.1080/17436753.2018.1475140

KEYWORDS: TPS, C-C, Thermal Protection System, carbon-carbon 2D laminate, manufacturing, high Mach

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MDA20-010 TITLE: Jitter Reduction in Light Weight Beam Control Devices

RT&L FOCUS AREA(S): Directed Energy
TECHNOLOGY AREA(S): Weapons; Sensors

OBJECTIVE: Develop methods or system designs that reduce angular errors from vibration on low mass, high performance, laser beam control assemblies.

DESCRIPTION: This topic seeks innovative methods to reduce vibration and jitter in laser systems, while leveraging low mass components, to provide better beam control accuracy. Successful utilization of directed energy requires precision in pointing accuracy. However, many laser platforms are at a disadvantage as Size, Weight, and Power (SWAP) requirements work against the ability to dampen vibrations by traditional means. For this topic, innovative methods are sought that might include mechanisms that are either passive or active in nature, utilize beneficial tolerances for the assembly, or other means to improve pointing accuracy. Methods that enable the use of additive manufacturing, for rapid development cycles at reduced cost, or to further light weight beam control systems to meet technical objectives are also desired.

PHASE I: Develop a concept for a low jitter beam control system that utilizes light weight components. Manufacture prototypes of the key mechanisms in a beam control system or the active components, in order to demonstrate the concept to dampen jitter in a beam control system made of lightweight materials. Additive manufacturing can be used to facilitate prototyping. Develop test metrics and plans to mature the design in Phase II.

PHASE II: Develop and integrate the components needed to test the environmental performance in a more mature prototype. Utilize vibration tables or other means of inducing jitter to characterize the jitter of the prototype design. Additive manufacturing can be used to rapidly evolve the concept. Document the key characteristics of the design and the prototype's performance.

PHASE III DUAL USE APPLICATIONS: Transition design concepts to a government program of record for further development use in tests. Collect required data to support qualification of the design for program use.

REFERENCES:
1. High-power Military Lasers: The Pentagon's laser weapon plans expand https://www.laserfocusworld.com/lasers-sources/article/16555228/highpower-military-lasers-the-pentagons-laser-weapon-plans-expand
2. Services Report Progress on Directed Energy Programs https://www.nationaldefensemagazine.org/articles/2019/6/19/services-report-progress-on-directed-energy-programs

KEYWORDS: Beam Control, Low SWaP, Jitter Reduction, Lightweight Materials, Additive Manufacturing

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MDA20-011 TITLE: Non Destructive Evaluation (NDE) of Production Additive Manufactured Parts

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Space Platform; Materials; Air Platform

OBJECTIVE: Develop an innovative process for rapidly evaluating the suitability of 3D printed production metal parts through non-destructive means.

DESCRIPTION: This topic seeks to determine the statistical correlation between defects in 3D printed metal parts which result in a reduction in strength, toughness or fatigue life, and non-destructive performance parameters such as deflections from sub-yield forces, acoustic or electrical resonance or other easily testable metrics. Innovative methods are sought to correlate nondestructive tests with tests-to-failure for an assortment of representative part designs to determine if deviations from the predicted response to nondestructive inputs can be used to detect defects which would cause the failure of a part in service.

Additively manufactured prints of metal parts contain voids and intra-granular impurities which are difficult to detect in the finished part. Computerized Tomography (CT) scans are currently used to detect internal voids but require expensive equipment, substantial time, and experienced operators to run. It is also difficult to properly evaluate CT scans of complex parts with irregular overlapping structures. To facilitate certification of 3D printed flight hardware, innovative NDE tests which are fast and work well on irregular complex shapes are sought.

PHASE I: Identify one or more NDE technique(s) which have a high likelihood of detecting internal voids and defects, resulting in lower than expected failure resistance or fatigue life. Print multiple test bars using a common aerospace material, some with known defects and some without, and demonstrate that some combination of NDE techniques are capable of detecting the flawed parts. Test the printed samples to failure. Document results including the NDE methodology, correlation between the NDE results and the ultimate strength, and describe plans for Phase II.

PHASE II: Demonstrate the ability to detect internal flaws in multiple complex parts using cheap, fast NDE techniques. Print a large number of complex parts with assorted internal flaws and demonstrate the correlation between NDE results and the ultimate strength at failure with high statistical confidence. Document the minimum detectable flaw sizes and densities and their impact on ultimate strength and how this is affected by part shape and complexity. Demonstrate the ability of the NDE to validate the quality of a 3D print of prototype flight hardware with the same confidence as CT scans.

PHASE III DUAL USE APPLICATIONS: Develop necessary NDE performance specifications for 3D printed part(s) of a government flight hardware system. Demonstrate the screening of production quantities of the 3D printed parts using the developed methodology with sufficient confidence to permit flight certification of accepted parts. Transition the methodology to applications in aviation, maritime, and ground vehicles.

REFERENCES:
1. Consortium for Additive Manufacturing Materials Roadmap, http://www.cimp-3d.org/documents/camm_roadmap.pdf
2. Nondestructive Testing of Additive Manufactured Metal Parts Used in Aerospace Applications, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20180001858.pdf;

KEYWORDS: NDE, 3D printing, certification, production, Additive Manufacturing

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