

**DEPARTMENT OF THE NAVY (DON)
20.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions**

IMPORTANT

- **The following instructions apply to STTR topics only:**
 - **N20B-T026 through N20B-T030**
- **The information provided in the DON Proposal Submission Instruction document takes precedence over the DoD Instructions posted for this Broad Agency Announcement (BAA).**
- **DON updates the Technical Volume (Volume 2) page limit to not exceed 10 pages.**
- A Phase I proposal template specific to DON topics will be available to assist small businesses to generate a Phase I Technical Volume (Volume 2). The template will be located on https://www.navysbir.com/links_forms.htm.
- The DON provides notice that Basic Ordering Agreements (BOAs) may be used for Phase I awards, and BOAs or Other Transaction Agreements (OTAs) may be used for Phase II awards.
- The optional Supporting Documents Volume (Volume 5) is available for the STTR 20.B BAA cycle. The optional Supporting Documents Volume is provided for small businesses to submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 3). Volume 5 is available for use when submitting Phase I and Phase II proposals. DON will not be using any of the information in Volume 5 during the evaluation.

INTRODUCTION

The Program Manager of the DON STTR Program is Mr. Steve Sullivan. For program and administrative questions, contact the SYSCOM Program Manager listed in [Table 1](#); **do not** contact them for technical questions. For technical questions about a topic, contact the Topic Authors listed within the topic during the period **6 May 2020 through 2 June 2020**. Beginning **3 June 2020**, the SBIR/STTR Interactive Technical Information System (SITIS) (<https://www.dodsbirsttr.mil/submissions>) listed in Section 4.15.d of the Department of Defense (DoD) SBIR/STTR Program Broad Agency Announcement (BAA) must be used for any technical inquiry. For general inquiries or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-703-214-1333 (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET) or via email at dodsbirsupport@reisystems.com.

TABLE 1: DON SYSTEMS COMMAND (SYSCOM) STTR PROGRAM MANAGER

<u>Topic Numbers</u>	<u>Point of Contact</u>	<u>SYSCOM</u>	<u>Email</u>
N20B-T026 to N20B-T030	Ms. Donna Attick	Naval Air Systems Command (NAVAIR)	navairsbir@navy.mil

The DON SBIR/STTR Programs are mission-oriented programs that integrate the needs and requirements of the DON's Fleet through research and development (R&D) topics that have dual-use potential, but primarily address the needs of the DON. Firms are encouraged to address the manufacturing needs of the defense sector in their proposals. More information on the program can be found on the DON SBIR/STTR website at www.navysbir.com. Additional information pertaining to the DON's mission can be obtained from the DON website at www.navy.mil.

PHASE I GUIDELINES

Follow the instructions in the DoD SBIR/STTR Program BAA at <https://www.dodsbirsttr.mil/submissions> for requirements and proposal submission guidelines. Please keep in mind that Phase I must address the feasibility of a solution to the topic. It is highly recommended that proposers follow the Phase I Proposal Template that is specific to DON topics as a guide for structuring proposals. The template will be located on https://navysbir.com/links_forms.htm. Inclusion of cost estimates for travel to the sponsoring SYSCOM's facility for one day of meetings is recommended for all proposals.

PHASE I PROPOSAL SUBMISSION REQUIREMENTS

The following MUST BE MET or the proposal will be deemed noncompliant and may be REJECTED.

- **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR BAA section 5.4(a).
- **Technical Proposal (Volume 2).** Technical Proposal (Volume 2) must meet the following requirements:
 - Content is responsive to evaluation criteria as specified in DoD SBIR/STTR Program BAA section 6.0
 - Not to exceed **10** pages, regardless of page content
 - Single column format, single-spaced typed lines
 - Standard 8 ½" x 11" paper
 - Page margins one-inch on all sides. A header and footer may be included in the one-inch margin.
 - No font size smaller than 10-point*
 - Include, within the **10-page limit of Volume 2**, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified.

*For headers, footers, listed references, and imbedded tables, figures, images, or graphics that include text, a font size smaller than 10-point is allowable; however, proposers are cautioned that the text may be unreadable by evaluators.

Volume 2 is the technical proposal. Additional documents may be submitted to support Volume 2 in accordance with the instructions for Supporting Documents Volume (Volume 5) as detailed below.

Disclosure of Information (DFARS 252.204-7000)

In order to eliminate the requirements for prior approval of public disclosure of information (in accordance with DFARS 252.204-7000) under this or any subsequent award, the proposer shall identify and describe all fundamental research to be performed under its proposal, including subcontracted work, with sufficient specificity to demonstrate that the work qualifies as fundamental research. Fundamental research means basic and applied research in science and

engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons. Simply identifying fundamental research in the proposal does NOT constitute acceptance of the exclusion. All exclusions will be reviewed and noted in the award. NOTE: Fundamental research included in the technical proposal that the proposer is requesting be eliminated from the requirements for prior approval of public disclosure of information, must be uploaded in a separate document (under “Other”) in the Supporting Documents Volume (Volume 5).

Phase I Options are typically exercised upon selection for Phase II. Option tasks should be those tasks that would enable rapid transition from the Phase I feasibility effort into the Phase II prototype effort.

- **Cost Volume (Volume 3).** The Phase I Base amount must not exceed \$140,000 and the Phase I Option amount must not exceed \$100,000. Costs for the Base and Option must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.
- **Period of Performance.** The Phase I Base Period of Performance must be exactly six (6) months and the Phase I Option Period of Performance must be exactly six (6) months.
- **Company Commercialization Report (Volume 4).** As specified in DoD SBIR/STTR Program BAA section 5.4(e).
- **Supporting Documents (Volume 5).** The optional Volume 5 is provided for small businesses to submit additional documentation to support the Technical Proposal (Volume 2) and the Cost Volume (Volume 3). Volume 5 is available for use when submitting Phase I and Phase II proposals. A template for Volume 5 is available on https://navysbir.com/links_forms.htm. DON will not be using any of the information in Volume 5 during the evaluation.

Note: Even if you are not providing documentation within Volume 5, DSIP will require you to respond to a “yes” or “no” question regarding the volume. Failure to respond may stop you from submitting and certifying your proposal.

- Letters of Support relevant to this project
- Additional Cost Information
- SBIR/STTR Funding Agreement Certification
- Technical Data Rights (Assertions)
- Allocation of Rights between Prime and Subcontractor
- Disclosure of Information (DFARS 252.204-7000)
- Prior, Current, or Pending Support of Similar Proposals or Awards
- Foreign Citizens

NOTE: The inclusion of documents or information other than that listed above (e.g., resumes, test data, technical reports, publications) may result in the proposal being deemed “Non-compliant” and REJECTED.

A font size smaller than 10-point is allowable for documents in Volume 5; however, proposers are cautioned that the text may be unreadable.

- **Fraud, Waste and Abuse Training Certification (Volume 6).** DoD has implemented the optional Fraud, Waste and Abuse Training Certification (Volume 6). DON does not require evidence of Fraud, Waste and Abuse Training at the time of proposal submission. Therefore, DON will not require proposers to use Volume 6.

DON STTR PHASE I PROPOSAL SUBMISSION CHECKLIST

- **Subcontractor, Material, and Travel Cost Detail.** In the Cost Volume (Volume 3), proposers must provide sufficient detail for subcontractor, material and travel costs. Enter this information in the “Explanatory Material” field in the online DoD Volume 3. Subcontractor costs must be detailed to the same level as the prime contractor. Material costs must include a listing of items and cost per item. Travel costs must include the purpose of the trip, number of trips, location, length of trip, and number of personnel. When a proposal is selected for award, be prepared to submit further documentation to the SYSCOM Contracting Officer to substantiate costs (e.g., an explanation of cost estimates for equipment, materials, and consultants or subcontractors).

For Phase I a minimum of 40% of the work is performed by the proposing firm, and a minimum of 30% of the work is performed by the single research institution. The percentage of work is measured by both direct and indirect costs.

To calculate the minimum percentage of effort for the proposing firm the sum of all direct and indirect costs attributable to the proposing firm represent the numerator and the total proposals costs (i.e. costs before profit or fee) is the denominator. The single research institution percentage is calculated by taking the sum of all costs attributable to the single research institution as the numerator and the total proposal costs (i.e. costs before profit or fee) as the denominator.

- **Performance Benchmarks.** Proposers must meet the two benchmark requirements for progress toward Commercialization as determined by the Small Business Administration (SBA) on June 1 each year. Please note that the DON applies performance benchmarks at time of proposal submission, not at time of contract award.
- **Discretionary Technical and Business Assistance (TAB A).** If TAB A is proposed, the information required to support TAB A (as specified in the TAB A section below) must be added in the “Explanatory Material” field of the online DoD Volume 3. If the supporting information exceeds the character limits of the Explanatory Material field of Volume 3, this information must be included in Volume 5 as “Additional Cost Information” as noted above. Failure to add the required information in the online DoD Volume 3 and, if necessary, Volume 5 will result in the denial of TAB A. TAB A may be proposed in the Base and/or Option periods, but the total value may not exceed \$6,500 in Phase I.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TAB A)

The SBIR and STTR Policy Directive section 9(b) allows the DON to provide TAB A (formerly referred to as DTA) to its awardees. The purpose of TAB A is to assist awardees in making better technical decisions on SBIR/STTR projects; solving technical problems that arise during SBIR/STTR projects; minimizing the technical risks associated with SBIR/STTR projects; and commercializing the SBIR/STTR product or process, including intellectual property protections. Firms may request, in their Phase I Cost Volume (Volume 3) and Phase II Cost Volume, to contract these services themselves through one or more TAB A providers in an amount not to exceed the values specified below. This amount is in addition to the award amount for the Phase I. The Phase II TAB A amount is up to \$25,000 per award. The TAB A amount, of up to \$25,000, is to be included as part of the award amount and is limited by the established award values for Phase II by the SYSCOM (i.e. within the \$1,700,000 or lower

limit specified by the SYSCOM). As with Phase I, the amount proposed for TABA cannot include any profit/fee application by the SBIR/STTR awardee and must be inclusive of the applicable indirect costs. A Phase II project may receive up to an additional \$25,000 for TABA as part of one additional (sequential) Phase II award under the project for a total TABA award of up to \$50,000 per project.

Approval of direct funding for TABA will be evaluated by the DON SBIR/STTR Program Office. A detailed request for TABA must include:

- TABA provider(s) (firm name)
- TABA provider(s) point of contact, email address, and phone number
- An explanation of why the TABA provider(s) is uniquely qualified to provide the service
- Tasks the TABA provider(s) will perform
- Total TABA provider(s) cost, number of hours, and labor rates (average/blended rate is acceptable)

TABA must NOT:

- Be subject to any profit or fee by the STTR applicant
- Propose a TABA provider that is the STTR applicant
- Propose a TABA provider that is an affiliate of the STTR applicant
- Propose a TABA provider that is an investor of the STTR applicant
- Propose a TABA provider that is a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g., research partner, consultant, tester, or administrative service provider).

TABA must be included in the Cost Volume (Volume 3) as follows:

- Phase I: The value of the TABA request must be included on the TABA line in the online DoD Volume 3 and, if necessary, Volume 5 as described above. The detailed request for TABA (as specified above) must be included in the “Explanatory Material” field of the online DoD Volume 3 and be specifically identified as “Discretionary Technical and Business Assistance”.
- Phase II: The value of the TABA request must be included on the TABA line in the DON Phase II Cost Volume (provided by the DON SYSCOM). The detailed request for TABA (as specified above) must be included as a note in the Phase II Cost Volume and be specifically identified as “Discretionary Technical and Business Assistance”.

TABA may be proposed in the Base and/or Option periods. Proposed values for TABA must NOT exceed:

- Phase I: A total of \$6,500
- Phase II: A total of \$25,000 per award, not to exceed \$50,000 per Phase II project

NOTE: Section 9(b)(5) of the SBIR and STTR Policy Directive requires that a firm receiving technical or business assistance from a vendor during a fiscal year submit a report with a description of the technical or business assistance received and the benefits and results of the technical or business assistance provided. More information on the reporting requirements of awardees that receive TABA funding through the DON can be found on https://www.navysbir.com/links_forms.htm. Awardees that receive TABA funding through the DON will upload the report to <https://www.navysbirprogram.com/navydeliverables/>.

If a proposer requests and is awarded TABA in a Phase II contract, the proposer will be eliminated from participating in the DON SBIR/STTR Transition Program (STP), the DON Forum for SBIR/STTR Transition (FST), and any other assistance the DON provides directly to awardees.

All Phase II awardees not receiving funds for TABA in their awards must attend a one-day DON STP meeting during the first or second year of the Phase II contract. This meeting is typically held in the spring/summer in the Washington, D.C. area. STP information can be obtained at: <https://navystp.com>. Phase II awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

EVALUATION AND SELECTION

The DON will evaluate and select Phase I and Phase II proposals using the evaluation criteria in Sections 6.0 and 8.0 of the DoD SBIR/STTR Program BAA respectively, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. As noted in the sections of the aforementioned Announcement on proposal submission requirements, proposals exceeding the total costs established for the Base and/or any Options as specified by the sponsoring DON SYSCOM will be rejected without evaluation or consideration for award. Due to limited funding, the DON reserves the right to limit awards under any topic.

Approximately one week after the Phase I BAA closing, e-mail notifications that proposals have been received and processed for evaluation will be sent. Consequently, the e-mail address on the proposal Cover Sheet must be correct.

Requests for a debrief must be made within 15 calendar days of select/non-select notification via email as specified in the select/non-select notification. Please note debriefs are typically provided in writing via email to the Corporate Official identified in the firm proposal within 60 days of receipt of the request. Requests for oral debriefs may not be accommodated. If contact information for the Corporate Official has changed since proposal submission, a notice of the change on company letterhead signed by the Corporate Official must accompany the debrief request.

Protests of Phase I and II selections and awards must be directed to the cognizant Contracting Officer for the DON Topic Number, or filed with the Government Accountability Office (GAO). Contact information for Contracting Officers may be obtained from the DON SYSCOM Program Managers listed in Table 1. If the protest is to be filed with the GAO, please refer to the instructions provided in section 4.11 of the DoD SBIR/STTR Program BAA.

Protests to this BAA and proposal submission must be directed to the DoD SBIR/STTR BAA Contracting Officer, or filed with the GAO. Contact information for the DoD SBIR/STTR BAA Contracting Officer can be found in section 4.11 of the DoD SBIR/STTR Program BAA.

CONTRACT DELIVERABLES

Contract deliverables for Phase I are typically a kick-off brief, progress reports, and a final report. Required contract deliverables must be uploaded to <https://www.navysbirprogram.com/navydeliverables/>.

AWARD AND FUNDING LIMITATIONS

Awards. The DON typically awards a Firm Fixed Price (FFP) contract or a small purchase agreement for Phase I. In addition to the negotiated contract award types listed in Section 4.14.b of the DoD SBIR/STTR Program BAA for Phase II awards, the DON may (under appropriate circumstances) propose the use of an Other Transaction Agreement (OTA) as specified in 10 U.S.C. 2371/10 U.S.C. 2371b and related implementing policies and regulations. The DON may choose to use a Basic Ordering Agreement (BOA) for Phase I and Phase II awards.

Funding Limitations. In accordance with the SBIR and STTR Policy Directive section 4(b)(5), there is a limit of one sequential Phase II award per firm per topic. Additionally, to adjust for inflation DON has

raised Phase I and Phase II award amounts. The maximum Phase I proposal/award amount including all options (less TABA) is \$240,000. The Phase I Base amount must not exceed \$140,000 and the Phase I Option amount must not exceed \$100,000. The maximum Phase II proposal/award amount including all options (including TABA) is \$1,700,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than \$1,700,000 based on available funding. The structure of the Phase II proposal/award, including maximum amounts as well as breakdown between Base and Option amounts will be provided to all Phase I awardees either in their Phase I award or in a minimum of 30 days prior to the due date for submission of their Initial Phase II proposal.

PAYMENTS

The DON makes three payments from the start of the Phase I Base period, and from the start of the Phase I Option period, if exercised. Payment amounts represent a set percentage of the Base or Option value as follows:

Days From Start of Base Award or Option	Payment Amount
15 Days	50% of Total Base or Option
90 Days	35% of Total Base or Option
180 Days	15% of Total Base or Option

TRANSFER BETWEEN SBIR AND STTR PROGRAMS

Section 4(b)(1)(i) of the SBIR and STTR Policy Directive provides that, at the agency's discretion, projects awarded a Phase I under a BAA for STTR may transition in Phase II to SBIR and vice versa. Please refer to instructions provided in section 7.2 of the DoD SBIR/STTR Program BAA.

ADDITIONAL NOTES

Human Subjects, Animal Testing, and Recombinant DNA. Due to the short timeframe associated with Phase I of the SBIR/STTR process, the DON does not recommend the submission of Phase I proposals that require the use of Human Subjects, Animal Testing, or Recombinant DNA. For example, the ability to obtain Institutional Review Board (IRB) approval for proposals that involve human subjects can take 6-12 months, and that lengthy process can be at odds with the Phase I goal for time-to-award. Before the DON makes any award that involves an IRB or similar approval requirement, the proposer must demonstrate compliance with relevant regulatory approval requirements that pertain to proposals involving human, animal, or recombinant DNA protocols. It will not impact the DON's evaluation, but requiring IRB approval may delay the start time of the Phase I award and if approvals are not obtained within two months of notification of selection, the decision to award may be terminated. If the use of human, animal, and recombinant DNA is included under a Phase I or Phase II proposal, please carefully review the requirements at <http://www.onr.navy.mil/About-ONR/compliance-protections/Research-Protections/Human-Subject-Research.aspx>. This webpage provides guidance and lists approvals that may be required before contract/work can begin.

Government Furnished Equipment (GFE). Due to the typical lengthy time for approval to obtain GFE, it is recommended that GFE is not proposed as part of the Phase I proposal. If GFE is proposed and it is determined during the proposal evaluation process to be unavailable, proposed GFE may be considered a weakness in the proposal.

International Traffic in Arms Regulation (ITAR). For topics indicating ITAR restrictions or the potential for classified work, limitations are generally placed on disclosure of information involving topics of a classified nature or those involving export control restrictions, which may curtail or preclude the

involvement of universities and certain non-profit institutions beyond the basic research level. Small businesses must structure their proposals to clearly identify the work that will be performed that is of a basic research nature and how it can be segregated from work that falls under the classification and export control restrictions. As a result, information must also be provided on how efforts can be performed in later phases if the university/research institution is the source of critical knowledge, effort, or infrastructure (facilities and equipment).

Partnering Research Institutions. The Naval Academy, the Naval Postgraduate School, and other military academies are Government organizations but qualify as partnering research institutions. However, DON laboratories DO NOT qualify as research partners. DON laboratories may be proposed only IN ADDITION TO the partnering research institution.

PHASE II GUIDELINES

All Phase I awardees can submit an **Initial** Phase II proposal for evaluation and selection. The Phase I Final Report, Initial Phase II Proposal, and Transition Outbrief (as applicable) will be used to evaluate the proposer's potential to progress to a workable prototype in Phase II and transition technology to Phase III. Details on the due date, content, and submission requirements of the Initial Phase II Proposal will be provided by the awarding SYSCOM either in the Phase I contract or by subsequent notification.

NOTE: All SBIR/STTR Phase II awards made on topics from solicitations prior to FY13 will be conducted in accordance with the procedures specified in those solicitations (for all DON topics, this means by invitation only).

The DON typically awards a Cost Plus Fixed Fee contract for Phase II; but, may consider other types of agreement vehicles. Phase II awards can be structured in a way that allows for increased funding levels based on the project's transition potential. To accelerate the transition of SBIR/STTR-funded technologies to Phase III, especially those that lead to Programs of Record and fielded systems, the Commercialization Readiness Program was authorized and created as part of section 5122 of the National Defense Authorization Act of Fiscal Year 2012. The statute set-aside is 1% of the available SBIR/STTR funding to be used for administrative support to accelerate transition of SBIR/STTR-developed technologies and provide non-financial resources for the firms (e.g., the DON STP).

PHASE III GUIDELINES

A Phase III SBIR/STTR award is any work that derives from, extends, or completes effort(s) performed under prior SBIR/STTR funding agreements, but is funded by sources other than the SBIR/STTR programs. This covers any contract, grant, or agreement issued as a follow-on Phase III award or any contract, grant, or agreement award issued as a result of a competitive process where the awardee was an SBIR/STTR firm that developed the technology as a result of a Phase I or Phase II award. The DON will give Phase III status to any award that falls within the above-mentioned description, which includes assigning SBIR/STTR Technical Data Rights to any noncommercial technical data and/or noncommercial computer software delivered in Phase III that was developed under SBIR/STTR Phase I/II effort(s). Government prime contractors and/or their subcontractors must follow the same guidelines as above and ensure that companies operating on behalf of the DON protect the rights of the SBIR/STTR firm.

NAVY SBIR 20.B Topic Index

N20B-T026	Rapid Material Development for Lightweight Additive Manufactured (AM) Structures and Repairs
N20B-T027	High Speed Vertical Cavity Surface Emitting Laser (VCSEL)
N20B-T028	Advanced Electromagnetic Modeling and Analysis Tools for Complex Aircraft Structures and Systems
N20B-T029	Accelerated Burn-In Process for High Power Quantum Cascade Lasers to Reduce Total Cost of Ownership
N20B-T030	1 Micrometer Integrated Transmitter for Balanced Radio-Frequency-Over-Fiber Photonic Links

N20B-T026 TITLE: Rapid Material Development for Lightweight Additive Manufactured (AM) Structures and Repairs

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platform, Materials, Weapons

OBJECTIVE: Develop a novel high-performance alloy for structural components and repairs capable of being produced by Additive Manufacturing (AM), and that exhibits high strength, low density, high corrosion resistance, and improved process-ability traits. Tools such as integrated computational materials engineering (ICME), AM, accelerated testing concepts, and data mining to accelerate the development and qualification of the alloy should be used.

DESCRIPTION: Magnesium (Mg) is the lightest structural metal with a density that is 35% lower than aluminum, making it a prime candidate for light weighting in the aerospace and automotive industries [Ref 1]. The helicopter industry has capitalized on the low density of Mg in the past, mainly in transmission casings (e.g., H-60, H-53) [Ref 2]. However, most applications of Mg are non-structural or semi-structural due to the limited mechanical properties of legacy Mg alloys. Mg's process-ability issues (i.e., flammability) and poor corrosion resistance further restricts the use of Mg on U.S. Navy (USN) aircraft [Ref 2]. In fact, many components manufactured from legacy Mg alloys corrode relatively quickly in-service, which leads to unscheduled maintenance to repair or replace those components. The various forms of AM can provide opportunities to repair those components or to build one-off replacements for them, which could help reduce life-cycle maintenance time and costs for USN aircraft. However, the legacy Mg alloys are currently limited to wrought/cast product forms due to Mg's high oxygen affinity and low melting/evaporation points, which make it difficult to process with AM [Refs 2-4].

A novel high-performance alloy for structural components and repairs that possesses high strength, low density, high corrosion resistance, and improved process-ability traits is sought. To decrease development time, an ICME framework should be used to design the alloy. The alloy should be designed to be produced in powder form, and to be processed using powder-based AM to further reduce development time [Ref 5]. Flammability and oxidation should be key design considerations to improve the process-ability of the alloy by reducing the risk of ignition during production and post-processing. The alloy should have a density comparable to that of a magnesium alloy (less than 0.0838 lb/in³) and mechanical properties that meet or exceed the following:

- Specific Ultimate Strength: 700 ksi /(lb/in³)
- Specific Yield Strength: 500 ksi /(lb/in³)
- Ultimate Elongation: 8%.

The alloy should have improved corrosion resistance and improved fatigue resistance in comparison to legacy Mg alloys such as AZ31 or WE43. Experimentally show the feasibility of the alloy design, and once the material composition has been refined, coupons should be produced and tested to verify the performance of the new, lightweight alloy.

The results of this STTR effort could reduce lifecycle maintenance and costs for USN aircraft: the alloys created could be an alternative to conventional magnesium alloys, albeit with superior corrosion resistance and better process-ability for component maintenance/rework. This alloy could also reduce the logistical footprint of USN aircraft by providing the capability to replace cast Mg components with AM equivalent components without the high costs and lead-times associated with foundries. A new high-strength, lightweight alloy that is capable of being produced with AM would allow newly designed components to have increased structural efficiency (i.e., higher strength to weight ratios), and would enable the production of ultra-lightweight topology optimized parts.

PHASE I: Formulate a novel high-performance alloy using ICME tools and produce a sample batch of the alloy in powder form. Process the demonstration powder in a powder-based AM system and establish the feasibility of the alloy design by generating limited test data, such as static/fatigue strength data (per ASTM E8 and ASTM E466, respectfully), microstructural characterization (per ASTM E3, ASTM E112, and ASTM E407). The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Refine the alloy composition through an iterative approach that includes modeling, AM fabrication, and testing of ASTM E8/E466 [Refs 6,7] coupons and prototype parts. Initiate the development of the material properties database for an optimized alloy design. Develop an optimized heat-treatment for the alloy if heat treatment is required to achieve desired properties.

PHASE III DUAL USE APPLICATIONS: Fully develop the design allowable database for the high-performance alloy. Demonstrate and validate the performance of the new material through component testing in a service environment. Transition the newly developed alloy for use in the fabrication of USN and commercial aircraft structural components.

The high-performance alloy developed in this effort could be directly transitioned into applications for both commercial aerospace and automotive industries. Beyond aircraft applications, the missile and satellite industries are long-time users of magnesium components and could also benefit from an improved lightweight structural alloy. This effort would also produce the groundwork needed to develop additional AM-tailored materials for other commercial applications. For example, an excellent fit for an AM-capable magnesium is the biomedical industry. Magnesium offers properties that makes it suitable as a biodegradable metal [Ref 3], which would be useful in applications such as repairing fractured bones.

REFERENCES:

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9. "ASTM Standard E11213: Standard Test Methods for Determining Average Grain Size." ASTM International: West Conshohocken, PA, 2014, <https://www.astm.org/Standards/E112>

10. "ASTM Standard E407(2015)e1: Standard Practice for Microetching Metals and Alloys." ASTM International: West Conshohocken, PA, 2015. <https://www.astm.org/Standards/E407>

KEYWORDS: Additive Manufacturing, AM, Powder, Integrated Computational Materials Engineering, ICME, Magnesium, Material, Structure

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N20B-T027 TITLE: High Speed Vertical Cavity Surface Emitting Laser (VCSEL)

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Electronics, Air Platform, Ground Sea

OBJECTIVE: Develop and package an uncooled vertical cavity surface emitting laser (VCSEL) that operates error free in a fiber optic transmitter at no less than 100 gigabits per second binary non-return to zero serial for air platform fiber optic link applications.

DESCRIPTION: Current airborne military (mil-aero) core avionics, electro-optic (EO), communications and electronic warfare systems require ever-increasing bandwidths while simultaneously demanding reductions in space, weight and power. The replacement of shielded twisted pair wire and coaxial cable with earlier generation length-bandwidth product multimode optical fiber has given increased immunity to electromagnetic interference, bandwidth, and throughput, and a reduction in size and weight on aircraft. For Ethernet, the serial rate using binary non-return to zero signaling for multimode fiber links has increased from 1 gigabit per second in 1998 to 25 gigabits per second in 2015 [Ref 1]. To meet commercial sector demands for higher aggregate bandwidth capacity, optical interconnects based on 850 nanometers (nm) VCSELs have evolved to higher lane rates, more parallel architectures, and more advanced modulation formats [Ref 2]. Digital fiber optic transmitters employing VCSELs have been shown to operate reliably at extended temperatures (-40 to +85-degrees Celsius) without active cooling. Current digital fiber optic transmitters consist of an uncooled VCSEL operating at 850 nm wavelength and custom designed integrated circuitry (IC) to drive the VCSEL. The IC includes electrical waveform shaping to improve the signal response of the VCSEL. A slightly overdamped frequency response can limit the amount of optical overshoot and but can be effectively controlled with electrical pre-emphasis [Ref 3]. Oxide confined VCSELs have been matured for use in digital multimode fiber optic links up to about 50 gigabits per second [Refs 4-5]. Microwave and optical test procedures have evolved to characterize VCSEL responses including relative intensity noise, optical modulation response (scattering parameter S_{21}), and high-resolution optical spectra [Ref 6]. Research is ongoing exploring more advanced VCSEL technology [Ref. 7].

Historically, avionics has mostly preferred the use of conventional binary non-return to zero serial/single lane links over higher numbered lane links, parallel links, pulse amplitude modulated links and wavelength division multiplexed links. To meet the expected growth in aggregate bandwidth required onboard future generation aircraft, new optical component technologies that enable much higher speed binary non-return to zero serial links will be required. It is envisioned that a VCSEL based transmitter operating in a single lane at no less than 100 gigabits per second at a yet to be determined or specified emission wavelength or optical fiber type can be enabled by the development of more advanced VCSEL technology. One aspect of this research is to specify the VCSEL bandwidth requirement, S_{21} , for a VCSEL operating in a transmitter at no less than 100 gigabits per second. Another related VCSEL design consideration relates to the average fiber coupled power based on typical avionics link-loss power budget and link margin requirements, i.e., 5 connectors in series and 3 dB end-of-life margin [Refs 8-9]. Another related VCSEL design consideration relates to the reliability and technology readiness. Highly accelerated life testing can be used to assess VCSEL technology readiness [Ref. 10].

It is anticipated that an uncooled VCSEL based transmitter and the corresponding receiver will include electrical equalization in order to achieve necessary performance. The VCSEL therefore must be capable of working with these electronic benefits. The desired high speed VCSEL mounted on a carrier in a fiber optic transmitter will be capable of transmitting error free digital data and video over optical fiber in a short reach (30 to 100 meters), binary non-return to zero serial link operating at no less than 100 gigabits per second. The uncooled VCSEL mounted on a carrier must perform reliably over a -40 degrees Celsius to +95 degrees Celsius temperature range, and maintain EO performance upon exposure to typical Naval

air platform vibration, humidity, temperature, altitude, thermal shock, mechanical shock, and temperature cycling environments [Refs 11-14].

PHASE I: Design an uncooled high speed VCSEL and provide an approach for determining VCSEL performance parameters and testing. Demonstrate feasibility of the laser design, showing path to meeting Phase II goals. Design a high-speed VCSEL laser package prototype that is compatible with digital fiber optic transmitter interface circuitry and coupling to optical fiber. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the VCSEL and VCSEL package designs from Phase I. Build and test the VCSEL, and packaged VCSEL, to meet performance requirements. Characterize the VCSEL over temperature and perform highly accelerated life testing. If necessary, perform root-cause analysis and remediate VCSEL and/or packaged VCSEL failures. Deliver packaged VCSEL prototype for 100 Gb/s transmitter application.

PHASE III DUAL USE APPLICATIONS: Verify and validate the VCSEL performance in an uncooled 100 Gb/sec fiber optic transmitter that operates from -40 to +95 degrees Celsius for transition to military and commercial fiber optic transmitter manufacturing sites. Commercial sector telecommunication systems, fiber optic networks, and data centers optical networks could benefit from the development of high speed VCSELs.

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KEYWORDS: Vertical Cavity Surface Emitting Laser, VCSEL: Digital Fiber Optic Transmitter, Binary Non-return to Zero Signaling, 100 Gigabits per Second, Highly Accelerated Life Testing

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N20B-T028 TITLE: Advanced Electromagnetic Modeling and Analysis Tools for Complex Aircraft Structures and Systems

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop a software package that ensures geometric fidelity is not compromised for the generation of a computational electromagnetics (CEM) mesh formed by high-order curved elements. Apply the software package to model large-scale problems (thousands of wavelengths long in each dimension) using exact physics methods.

DESCRIPTION: The field of computational electromagnetics (CEM) came to existence in the middle 1960s. Since that time, there has been substantial progress in the mathematical aspects of CEM as well as in taking advantage of advances in computer technology. The combination of these two has resulted in electromagnetic modelling and simulation (EM&S) software that can successfully address a variety of EM scenarios. There are still, however, problems of large electrical size that current CEM technologies cannot address. One example of interest is the radiation characteristics of installed antenna arrays coupled with radomes with the cavity-like structures where the array resides (and other objects within that cavity) and with the external structure of the aircraft platform. Another example of equal importance is the signature of maritime targets in a variety of sea states. The computational domain in this case can be enormous especially for near-grazing incidence. It is not possible to address such problems with sufficient accuracy using approximate (high frequency) methods; moreover, near-field parameters of interest may not be obtainable at all by such methods as, for example, the driving point or the mutual impedance of a platform installed antenna array. Exact-physics methods, on the other hand, generate such a large number of unknowns that would challenge even the largest computer clusters. For these reasons, there has been a movement in recent years in both time-domain and frequency-domain, toward high-order algorithms that use large cell sizes (~10 wavelengths) to minimize the number of cells in the volume computational domain and thus the computational burden for solving very large problems that are in thousands of wavelengths in each dimension [Refs 1-2]. While using such large cell sizes, however, it is imperative to use high-order curved elements [Refs 3-6] instead of many small, flat facets to capture the geometry with the necessary fidelity. For targets with small- and large-scale geometric features, the process of creating high-order, curved elements is still in a state of infancy to guarantee no grid crossovers and no negative Jacobian in any cell in the computational domain.

Develop methods for generating curved volume meshes for complex targets that will conform to a prescribed geometry and be suitable for use with high-order solvers. This should lead to more robust and computationally efficient EM tools to predict the near- and far-field characteristics of large-scale problems that involve complex structures, installed antenna arrays, radomes and interior regions accurately. The number of unknowns generated should be such that the solver could run in low-level clusters (128-256 cores and 2-4 GB standard memory size per core). A graphical user interface (GUI) that encompasses the entire computational process that includes the preprocessing tools for geometry import and generation of high-order curved elements, high-order processing tools, and a comprehensive set of post processing tools for data output and visualization, should intelligently guide the user through any projected application. The design of the GUI should consider ISO/IEC 25022:2016 usability metrics. While the main thrust of this SBIR topic is to develop a high-order mesh generation capability, there is also interest in producing an integrated high-order CEM environment. The environment must be capable of addressing large-scale problems accurately and efficiently, while utilizing minimal computational resources. The process of combining high-order curved elements with high-order solvers and large cell sizes (up to 10 wavelengths) must be demonstrated through test problems, such as a perfect electric conductor (PEC) sphere of 100-wavelength in diameter.

PHASE I: Develop and demonstrate procedures for high-order mesh generation from a hybrid linear element mesh, while retaining computer aided design (CAD) geometry fidelity. Develop a preliminary software package design that can create a high-order (up to 10th order) curved elements for a complex geometry. Demonstrate the process of combining high-order, curved elements with high-order solvers and large cell sizes (up to 10 wavelengths), for test problems such as a PEC sphere of 100-wavelength diameter, and provide accuracy measures when compared to Mie series solution for bistatic radar cross section. The Phase I effort will include plans for software to be developed in Phase II.

PHASE II: Complete the development of the software package from Phase I, compatible with existing high-order CEM software tools (time and frequency domain). The delivered software package, compatible with Windows and Linux OS platforms, must predict near-field and far-field characteristics of complex systems. Ensure the high-order curved elements preserve the small- and large-scale critical features of the geometry. Implement the tool(s) with a GUI for problem setup and results analysis. Ensure that the GUI design emphasizes ease-of-use in the context of configuring, visualizing, and executing on arbitrary complex targets. Port codes on clusters of central processing units and/or graphical processing units (CPUs/GPUs). Test and demonstrate the resulting codes on cases of interest.

PHASE III DUAL USE APPLICATIONS: Complete development of the CEM software application suitable for transition and for commercial use. The CEM software application will have widespread use in the DoD, industry and academia for analysis of highly complex electromagnetic problems.

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KEYWORDS: Computational Electromagnetics, Modeling, Curved Surfaces, Software Applications, High-Order Solver, Electrically Large, Perfect Electric Conductor, PEC: Electromagnetic Fields

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N20B-T029 TITLE: Accelerated Burn-In Process for High Power Quantum Cascade Lasers to Reduce Total Cost of Ownership

RT&L FOCUS AREA(S): Quantum Sciences, Directed Energy
TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop and fully validate an accelerated burn-in process for high power continuous wave (CW) Quantum Cascade Lasers (QCLs) that minimizes burn-in time.

DESCRIPTION: Quantum Cascade Lasers (QCLs) capable of delivering several watts of CW optical power in a high-quality beam in the emission wavelength range between 4.6 to 5 microns are of great interest to the Navy for a number of existing and emerging defense applications. The high price of Commercial Off-The-Shelf (COTS) QCLs is one of the main hurdles impeding widespread use by the U.S. warfighter. The Navy has recently initiated several programs to reduce QCL fabrication cost. However, post-production laser failure is one of the main contributors to the high price of QCL-based products. To avoid costly integration of defective high power QCLs into infrared system platforms, devices with short life expectancies must be screened out at an early fabrication/packaging stage. To minimize QCL fabrication cost, a large decrease in infant mortality of the QCLs reaching post-production must be achieved at either the chip or chip-on-submount levels.

Accelerated burn-in testing for diode lasers is typically done at an elevated current and/or temperature and laser degradation models are used to predict their long-term reliability based on observed changes in measured laser characteristics [Refs 1-2]. In contrast to diode lasers, a well-accepted burn-in process for QCLs does not exist [Refs 3-6]. The main goal for this STTR topic is to develop and experimentally validate an accelerated QCL burn-in process that is effective in screening out devices with infant mortality and accurately predicts lifetime [Ref 7] for high power QCLs suitable for DOD applications, while at the same time minimizes required burn-in time. The later requirement is critical for total cost QCL minimization by a factor of 5 in large volume applications.

PHASE I: Design and develop a QCL degradation model. Collect accelerated burn-in data for a statistically significant number of multi-watt continuous wave QCLs. Demonstrate that the new model is consistent with collected experimental data. Develop Phase II work plan that refines and further validates the model.

PHASE II: Build a multichannel QCL burn-in setup and collect long-term burn-in data for at least thirty devices under normal operational conditions. Demonstrate that the new accelerated burn-in process is an effective tool for screening out devices with infant mortality and for accurately predicting lifetime for high-power QCLs. Fully validate and document accelerated burn-in process for QCLs that requires minimal burn-in time.

PHASE III DUAL USE APPLICATIONS: Test and finalize the technology and methodology based on the research and development results developed during Phase II. Develop a cost-effective process for manufacturing high-reliability QCLs to be transitioned and integrated into Directional Infrared Counter Measures (DIRCM) systems for field deployment in a Navy platform.

Commercialize the technology based on the burn-in process developed from this program for law enforcement, marine navigation, commercial aviation enhanced vision, medical applications, and industrial manufacturing processing.

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KEYWORDS: QCL, Burn-In Process, Thermal Load, Reliability, Mid Wave Infrared (MWIR), Brightness

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N20B-T030

TITLE: 1 Micrometer Integrated Transmitter for Balanced Radio-Frequency-Over-Fiber Photonic Links

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground Sea, Electronics, Air Platform

OBJECTIVE: Develop and package a heterogeneously integrated optical transmitter operating at a wavelength near 1 micrometer for balanced radio-frequency (RF) photonic link applications on air platforms.

DESCRIPTION: Current airborne military communications and electronic warfare systems require ever-increasing bandwidths while simultaneously requiring reductions in space, weight, and power (SWaP). The replacement of the coaxial cable used in various onboard RF/analog applications with RF/analog fiber optic links will provide increased immunity to electromagnetic interference, reduction in size and weight, and an increase in bandwidth. Typically, RF-to-optical transmitters are made by integrating many discrete components into a single large module that routinely exceeds 300 cm³. However onboard RF/analog applications require the development of high performance, high linearity optoelectronic components that can operate over extended temperature ranges. Additionally, avionic platforms pose stringent SWaP requirements on components such as optical transmitters for avionic fiber communications applications. New optical component and packaging technology is needed to meet future requirements. Current analog optical transmitter technology typically consists of discrete lasers and modulators operating at 1550 nanometers (nm), with active cooling for operation in military environments. To meet avionic requirements, the transmitter should integrate a laser and modulator into a compact uncooled package that can maintain performance over full avionic temperature range (minimum -40 to +85 Celsius). It is envisioned that a laser emitting at approximately 1 micrometer wavelength can serve as the laser source in the transmitter. Innovative Lithium Niobate modulator design including heterogeneous packaging is necessary to integrate a wide-band dual-output (1X2) intensity modulator with the laser and a dual-core single mode fiber output. Recently low relative intensity noise (RIN) lasers and small form factor modulators have become commercially available. However, the challenges posed by integrating both components together in a package less than 150 cm³ via heterogeneous integration has yet to be accomplished for high performance wideband RF over fiber links, as typically the laser and modulator are of differing materials. Some work has been done to integrate optical components monolithically [Ref 1], and heterogeneously [Ref 2], but researchers have yet to demonstrate an integrated laser and modulator design with the low noise figures (sub-15dB) needed for practical RF/analog photonic links operating over extended temperature ranges.

The optical transmitter component is to be based on integration of a dual-output analog transmitter with a dual-core single mode optical fiber [Ref 3] pigtail with a multicore fiber connector at the end of the pigtail. Simultaneously, the transmitter must have performance requirements that support high-performance balanced RF link specifications such as RF noise figures below 25 dB (no RF or optical amplification) when connected directly to a separate balanced high current photodiode pair (0.7 Amp/Watt responsivity); and spur free dynamic ranges (SFDR) above 110 dB-Hz^{2/3}. The laser source must have a linewidth of <100 kHz, a wavelength of around 1,000 nm, and an output power greater than 200 mW, with RIN spectrum of -165 dBc/Hz from 50 MHz to 20 GHz. The optical modulator is required to operate at up to 20 GHz, and have dual output configuration for applications requiring noise cancellation utilizing balanced detection. The modulator's power output and modulation efficiency should be optimized to meet the 25 dB noise figure target utilizing both modulator outputs with the above photodiode specifications operated in a balanced detection configuration [Refs 4, 5].

Ideally, the transmitter should operate uncooled over a minimum temperature range of -40 to +85 degrees Celsius while maintaining RIN and linewidth performance. A dual output optical transmitter including an

integrated optical intensity modulator packaged in a ruggedized package is envisioned. It is desirable for this transmitter module to have a package dimension no greater than $17.5 \times 65 \times 115$ mm when both the bias control circuits for the modulator and the low noise CW laser power supply are contained in the module. The packaged transmitter must perform over the specified temperature range and maintain hermeticity and optical alignment upon exposure to typical Navy air platform vibration, humidity, thermal shock, mechanical shock, and temperature cycling environments [Ref 6].

PHASE I: Develop and analyze a new design and packaging approach for an uncooled 1 micrometer optical transmitter that meets the requirements outlined in the Description section. Develop fabrication process, packaging approach, and test plan. Demonstrate the feasibility that the optical transmitter can achieve the desired RF performance specifications with a proof of principle bench top experiment or preferably in an initial prototype. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the Phase I transmitter and package design and develop a prototype. Test prototype transmitter to meet design specifications in a Navy air platform representation of a relevant application environment [Ref 6], which can include unpressurized wingtip or landing gear wheel well (with no environmental control [Ref 7]) to an avionics bay (with environmental control). The prototype transmitter should be tested in a balanced RF photonic link over temperature with the objective performance levels reached. Demonstrate a prototype fully packaged transmitter for direct insertion into balanced analog fiber optic links.

PHASE III DUAL USE APPLICATIONS: Perform extensive operational reliability and durability testing [Refs 8, 9], as well as optimize manufacturing capabilities. Transition the demonstrated technology to Naval Aviation platforms and interested commercial applications.

Commercial sector data centers, industries utilizing local area networks, and telecommunication systems, as well as companies that install networks and telecommunications systems would benefit from the development of this transmitter technology.

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KEYWORDS: Multicore Fiber, Connector, 1 Micrometer, Responsivity, Avionics, Wide Band Dual-Output

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