Office of the Secretary Defense (OSD)
16.2 Small Business Innovation Research (SBIR)
Direct to Phase II Proposal Instructions

INTRODUCTION

The Army and Navy are participating in the OSD SBIR Direct to PH II Program for this solicitation. The Service laboratories act as OSD's agent in the management and execution of the contracts with small businesses.

Please review the U.S. Department of Defense Small Business Innovation Research (SBIR) Program Solicitation 16.2. The Office of the Secretary of Defense (OSD) 16.2 Direct to Phase II proposal submission instructions are intended to clarify the Department of Defense (DoD) instructions as they apply to OSD requirements.

For general inquiries or problems with the electronic submission, contact the DoD SBIR/STTR Help Desk at 800-348-0787 or Help Desk email at sbirhelp@bytecubed.com (9:00 a.m. to 6:00 p.m. ET Monday through Friday). For technical questions about the topics during the pre-solicitation period (22 April 2016 through 22 May 2016), contact the Topic Authors listed for each topic on the Website. For information on obtaining answers to your technical questions during the formal solicitation period (23 May 2016 through 22 June 2016), go to https://sbir.defensebusiness.org/.

The OSD SBIR Program is a mission-oriented program that integrates the needs and requirements of the OSD through R&D topics that have military and/or commercial potential. Efforts under the SBIR program fall within the scope of fundamental research. The Under Secretary of Defense (Acquisition, Technology, & Logistics) defines fundamental research as "basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community," which is 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. See DFARS 252.227-7018 for a description of your SBIR/STTR rights.

Small businesses that are owned in majority part by multiple venture capital operating companies (VCOCs), hedge funds, or private equity funds are ineligible to submit applications or receive awards for opportunities in this solicitation. Firms must qualify as a small business concern as defined in the DoD SBIR solicitation at the time of Phase II award. Firms are highly encouraged to review the DoD SBIR/STTR Solicitation requirements.

All Phase II proposals must be prepared and submitted through the Department of Defense (DoD) SBIR/STTR electronic submission site: https://sbir.defensebusiness.org. The offeror is responsible for ensuring that their proposal complies with the requirements in the most current version of this instruction. Prior to submitting your proposal, please review the latest version of these instructions as they are subject to change before the submission deadline.

<u>DIRECT TO PHASE II</u>

15 U.S.C. §638 (cc), as amended by NDAA FY2012, Sec. 5106, PILOT TO ALLOW PHASE FLEXIBILITY, allows the Department of Defense to make an award to a small business concern under Phase II of the SBIR program with respect to a project, without regard to whether the small business concern was provided an award under Phase I of an SBIR program with respect to such project. **OSD is conducting a "Direct to Phase II" implementation of this authority for this 16.2 SBIR solicitation and does not guarantee Direct to Phase II opportunities will be offered in future solicitations. Each eligible topic requires documentation to determine that Phase I feasibility described in the Phase I section of the topic has been met and the technical requirements for a Direct to Phase II proposal.**

NOTE: Office of the Secretary of Defense reserves the right to not make any awards under this Direct to Phase II solicitation. The Government is not responsible for expenditures by the offeror prior to award of a contract. All awards are subject to availability of funds and successful negotiations.

Direct to Phase II proposals must follow the steps outlined below:

STEP 1:

1. Offerors must create a Cover Sheet using the DoD Proposal submission system (follow the DoD Instructions for the Cover Sheet located in section 5.4.a. Offerors must provide documentation that satisfies the Phase I feasibility requirement* that will be included as an Appendix to the Phase II proposal. Offerors must demonstrate that they have completed research and development through means other than the SBIR/STTR program to establish the feasibility of the proposed Phase II effort based on the criteria outlined in the topic description.

The Cover Sheet and applicable documentation must be submitted to <u>https://sbir.defensebusiness.org</u> by 6:00 a.m. (ET) 22 June 2016.

STEP 2:

1. Offerors must submit a Phase II proposal using the OSD Phase II proposal instructions below.
2. The Phase II proposal must be submitted by 6:00 a.m. (ET) on 22 June 2016.

* NOTE: Offerors are required to provide information demonstrating that the scientific and technical merit and feasibility has been established. **OSD will not evaluate the offeror's related Phase II proposal if it determines that the offeror has failed to demonstrate that technical merit and feasibility has been established or the offeror has failed to demonstrate that work submitted in the feasibility documentation was substantially performed by the offeror and/or the principal investigator (PI)**. Refer to the Phase I description (within the topic) to review the minimum requirements that need to be demonstrated in the feasibility documentation. **Feasibility documentation MUST NOT be based on work performed under prior or ongoing federally funded SBIR or STTR work.**

NOTE: 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 OSD Phase II award timeframe. If you do not have a DCAA approved accounting system in place in time, it will delay / prevent Phase II contract award.

PROPOSAL SUBMISSION

The complete proposal, i.e., DoD Cover Sheet, technical volume, cost proposal, and Company Commercialization Report, must be submitted electronically at https://sbir.defensebusiness.org/. Only one Phase II proposal file can be uploaded to the DoD Submission Site. Ensure your complete technical volume and additional cost volume information is included in this sole submission. The required submission format is Portable Document Format (.pdf). Graphics must be distinguishable in black and white. VIRUS-CHECK ALL SUBMISSIONS.

Phase II proposals require a comprehensive, detailed submission of the proposed effort. OSD Direct to Phase II efforts are for 18 to 24 months (base) with a 12 month option. OSD Direct to Phase II efforts are awarded up to a maximum value of $1.5M per contract award, $1M base and a $500,000 option. Commercial and military potential of the technology under development is extremely important. Proposals emphasizing dual-use applications and commercial exploitation of resulting technologies are sought.

PHASE II PROPOSAL PREPARATION INSTRUCTIONS AND PROPOSAL REQUIREMENTS

The technical proposal is limited to 38 pages, and the feasibility documentation is limited to 20 pages. The Cover Volume, Cost Volume and Commercialization Report do not count toward the 38-page limitation.

A. Proposal Requirements. A Phase II proposal should provide sufficient information to persuade the OSD that the proposed advancement of the technology represents an innovative solution to the scientific or engineering problem and is worthy of support under the stated criteria. All sections below count toward the page limitation, unless otherwise specified.

B. Proprietary Information. Information constituting a trade secret, commercial or financial information, confidential personal information, or data affecting national security must be clearly marked. It shall be treated in confidence to the extent permitted by law. Be advised, in the event of proposal selection it is likely the Work Plan or Statement of Work (SOW) will be incorporated into the resulting contract, in whole or part, by reference or as an attachment. Therefore, segregate any information to be excluded from public release pursuant to the Freedom of Information Act (FOIA). See Section 5.3 of the DoD Solicitation regarding marking of proprietary information.

C. General Content. Proposals should be direct, concise, and informative. Type shall be no smaller than 11-point on standard 8 ½ x 11 paper, with one-inch margins and pages consecutively numbered. Offerors are discouraged from including promotional and non-programmatic items.

D. Proposal Format. Please follow the instructions below based on the topic to which you are submitting.

1. If you are proposing to topic OSD162-002, follow the NAVSEA Full Proposal Template, pages 2-7, at http://www.navysbir.com/phaseii.htm.
2. If you are proposing to topics OSD162-003X - OSD162-007X, follow the Army Phase II proposal format at https://www.armysbir.army.mil//sbir/PhaseII.aspx.

E. Feasibility Documentation

1. Maximum page length for feasibility documentation is 20 pages. If you have references, include a reference list or works cited list as the last page of the feasibility documentation. This will count towards the page limit.
2. Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI). Technology in the feasibility documentation is subject to intellectual property (IP) rights, the offeror must provide IP rights assertions. Provide a good faith representation that you either own or possess appropriate licensing rights to all IP that will be utilized under your proposal. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights that describes the nature of the restriction and the intended use of the intellectual property in the conduct of the proposed research. Please see section 11.5 of the DoD instructions for information regarding technical data rights.

F. Cost Proposal: A detailed cost proposal must be submitted. Cost proposal information will be treated as proprietary. Proposed costs must be provided by both individual cost element and contractor fiscal year (FY) in sufficient detail to determine the basis for estimates, as well as the purpose, necessity, and reasonableness of each. This information will expedite award of the resulting contract if the proposal is selected for award.

1. If you are proposing to topic OSD162-002, the downloadable Cost Proposal must be converted into a PDF and appended to the end of the Technical Volume PDF for upload.
2. If you are proposing to topic OSD162-003X - OSD162-007X, please use the Army cost proposal format provided in the DoD SBIR/STTR Small Business Portal.

METHOD OF SELECTION AND EVALUATION CRITERIA

Other factors considered during the selection process include appropriate demonstration of feasibility of the technology, equivalent to that resulting from Phase I type efforts; commitment for Phase III funding; possible duplication with other R/R&D; program balance; budget limitations; and potential, if successful, of leading to a product of continuing interest to DoD. Where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the Government will be considered in determining the successful offeror. OSD anticipates pricing will be based on adequate price competition. The next tie-breaker on essentially equivalent proposals is the inclusion of manufacturing considerations. Phase II evaluations may include on-site assessment of the offeror's research results to date, or of the Contractor's facility, by Government personnel. The reasonableness of proposed costs for the Phase II effort will be examined to determine proposals offering the best value to the Government.

OSD Topics OSD162-003X - OSD162-007X are a new departmental initiative, and proposals for these topics will receive an initial evaluation. Those small businesses with proposals deemed to have the highest scientific and technical merit will be notified of their initial standing. Those firms will be required to present their ideas, either in person or via video teleconference, to subject matter experts (SME) for final adjudication. The SMEs will follow the same evaluation criteria as all DoD SBIR proposals.

CERTIFICATIONS

In addition to the standard Federal and DoD procurement certifications, the SBA SBIR/STTR Policy Directives require the collection of certain information from firms at the time of award and during the award life cycle. Each firm must provide this additional information at the time of the Phase II award, prior to receiving 50% of the total award amount for a Phase II award, and prior to final payment on the Phase II award.

OSD SBIR 16.2 Direct to Phase II Topic Index

OSD SBIR 16.2 Direct to Phase II Topic Descriptions

OSD162-002 TITLE: Large Caliber Steel Cartridge Case

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop a manufacturing technique that economically manufactures large caliber steel cartridge cases within required dimensional and mechanical parameters.

DESCRIPTION: The Navy uses 5-inch steel cartridge cases, which are manufactured using a deep draw production process, in some of its guns. The deep draw production process and the associated equipment are economical for high volume production but not for low volume production. The Navy is seeking innovative manufacturing techniques or processes that enable equitable manufacturing of the cartridge cases in low volumes. A maximum total cost is targeted at $800/unit for an initial production year run of 8,000 units. Subsequent year target cost is $350/unit for additional production runs of 8,000 units/year. Specifications for the shell casing will be provided upon contract award.

The present deep-draw steel cartridge case is one with specific mechanical properties built into the case which the new manufacturing process must meet. These properties are such that the steel will expand to the gun chamber surface and obturate satisfactorily during firing, but must still be resilient enough to recover after firing to allow for extraction. The required mechanical properties (i.e., strength, expansion, and contraction capabilities and metal integrity) are produced and controlled by judicious use of heat-treating and metal-forming techniques during casing production. These properties are required to be varied along the entire length of the case.

When a gun is fired, the propelling charge is ignited and the resultant internal gas pressure causes the case to expand to the diameter of the gun chamber, after which case and gun expand together. The gun expands elastically; the case expands elastically and plastically. The elastic characteristic of the gun is fixed and both the elastic and plastic characteristics of the case are functions of the case material's composition and yield strength. The taper profile on the 5-inch cartridge case prevents net shape forming via conventional flow forming techniques. One would neither be able to remove the part from the mandrel nor be able to flow form the exterior taper (standard flow forming techniques create straight walls). Furthermore, the required material properties along the length of the case have been difficult to reproduce.

While prior research has shown flow forming as a potential technical and economical long term solution, the current processes in both metal forming and heat treating technologies are inadequate. Economically, flow forming is a slower process and generally not as efficient. An innovative manufacturing technique could include pre and post machining, and heat treating as an effective solution. The innovative manufacturing techniques or processes developed under this topic will likely have application in the Army's and Navy's family of large caliber ammunition (e.g. Navy 76mm, 5-inch, and 155m; Army 105mm cannon and 105mm artillery).

PHASE I: The offeror will develop an approach for innovative manufacturing techniques that meets the parameters of producing a 5-inch cartridge case. The approach must be economical for low and high production yields of the cartridge and demonstrate a feasible path to fabricating a conforming cartridge case as described in the description.

PHASE II: The offeror will develop, demonstrate, and validate the approach developed during Phase I to produce a prototype of the innovative manufacturing technique. The process will be validated through performance of risk reduction prototype testing on samples as necessary to mature and validate the manufacturing technique or process.

At least two rounds of full scale prototypes will be fabricated and analyzed for metallurgy and function, including case to munition interface and handling equipment operation. A final delivery of 50 cartridge cases will be delivered for demonstration testing by the Naval Gunnery Program Office.

DIRECT TO PHASE II (DP2): Offerors interested in submitting a DP2 proposal in response to this topic must provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of this topic has been met and describes the potential commercial applications. The offerors related DP2 proposal will not be evaluated without adequate PH I feasibility documentation. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/result. Please read the OSD SBIR 16.2 Direct to Phase II Instructions.

PHASE III DUAL USE APPLICATIONS: The offeror will demonstrate the production of the innovative manufacturing technique for 5-inch steel casings that conform to the casing requirements. The offeror is expected to provide 100 production representative 5-inch shell casings for qualification tests to be conducted by the Naval Gunnery Program Office in the Major Caliber Program Production of shells. Nominally, this testing will proceed similar to a First Article Test and live fire tests using complete propelling charges. The technology developed under this topic has potential use in both Navy and Army large-caliber guns.

REFERENCES:
1. AMCP 706-247 Engineering Design Handbook: Ammunition Series Section 4: Design for Projection, Jul 1964.

2. AMCP 706-249 Engineering Design Handbook: Ammunition Series Section 6: Manufacture of Metallic Components of Artillery Ammunition, Jul 1964.

3. Felmley,T and McHenry, J. "Flow Formed Cartridge Testing" National Center for Excellence in Metalworking Technology. 08 Jan 1998.

4. Creeden, T.P., Bagnall, C, McHenry, J.C., Gover, J., Kovalcik, C.M., Dong, H., and Ucok, I. Optimized Flow-Formed Steel Cartridge Casings: Product and Process Analysis. 30 Jun 2000.

5. Onesto, E.J. and Bagnall, C. "Optimized Flowformed 5-inch/54 Steel Cartridge Cases." 02 Jan 2002.

KEYWORDS: flow forming; deep draw; large caliber; steel cartridge case; major caliber; heat treating

OSD162-003X TITLE: Augmented Reality User Interfaces for Tactical Drones

TECHNOLOGY AREA(S): Electronics, Human Systems

OBJECTIVE: Design and fabricate an Augmented Reality (AR) user interface for tactical air and ground vehicles that demonstrates minimal formal Soldier training, embedded Soldier training, and minimal Soldier cognitive burden during semi-autonomous ground and air tactical vehicle operations for acquiring image products, performing area reconnaissance, and performing remote sensing of airborne chemical, biological radiological, or nuclear toxins.

DESCRIPTION: The DoD has a critical need for breakthrough user interface technologies in order to plan and monitor the acquisition of mission critical image products and remote sensing, while enabling the Soldier to maintain their focus on primary tactical operations. This topic seeks to integrate state-of-the-art augmented reality user interface display content and human computer interface technologies with existing ground Soldier communications interfaces for training, embedded training, mission command, and semi-autonomous vehicle route planning and operations monitoring and controlling. This topic is open to a multiplicity of AR user interface architectures that first and foremost, demonstrate significant improvements in minimizing Soldier training and operational cognitive burden for monitoring and controlling tactical semi-autonomous vehicles, and secondly integrate with existing Nett Warrior interface standards including android operating system for the operating system, MIL-STD 2525B for mission command graphics, H.264 for video, Joint Architecture for Unmanned Systems (JAUS) for tele-robotic communications and Cursor on Target eXtended Markup Language (CoT XML) for robotic waypoint and route control.

The gaming and computing industry has pushed advances in the fidelity and daylight visibility of AR display hardware. These advances have enabled the probable use of AR displays for ground Soldiers. However, the time lag between AR hardware advancements, AR user interface content and user interface controls that are tactically relevant to ground Soldiers continues to be lengthy. Developing and demonstrating an AR display concept and style guide for semi-autonomous ground and aerial vehicles that leverages current mission command graphics and commercial advances in direct view AR graphics should yield a minimally cognitive burden Soldier experience.

Similarly, the gaming industry has pushed advances in the fidelity and user experience for control of the gaming experience but the ground Soldier tactical equipment has not had similar advancements. Voice commands, head gestures, virtual joysticks, or other emerging user input devices are needed to enable ground Soldiers to operate in a near hands-free posture as much as possible in order to remain in tactical, hands-on weapon posture when needed. Additionally, while tactical aerial vehicle operation has become more routine with the advent of control loops to automatically maintain desired height above ground, the current training time and on-demand training technologies are archaic. This topic also seeks the development of the same operational AR user interfaces and controls to provide formal and embedded aerial and ground vehicle operations and mission management training. This topic should leverage existing mission command satellite imagery and digital terrain elevation data; physical models of vehicle mobility and payload operations; and AR user interfaces and computer input devices to provide a train as you fight training prototype for tactical vehicles.

Proposals should target the design, development and demonstration of AR user interface components and Soldier input device components. Essential elements of the AR user interface components include low cognitive burden for the three phases of operation: training, planning, and operating the tactical ground and aerial vehicles. The essential elements of the control input are near hands-free operation, low cognitive burden and high Soldier acceptance for managing tele-robotic operations as well as mission operations.

Critical to the design of the system is minimizing Soldier cognitive burden while maximizing mission performance. In addition, proposals should detail the intended AR user interface components, (i.e. symbology, overlay style, notifications, FMV, training tools, and available functions), their interface design to robotic systems, computer input devices, mission messaging, and map data that will ultimately yield the lowest cognitive burden, lowest training time, and highest Soldier acceptance for vehicle control and mission image product generation. Offerors are to first uncover and understand the critical integration challenges that may limit the translation and commercial-viability of current AR user controls and AR content, symbols, and overlays.

Technical challenges may include:
• The development of a standard AR style for diverse user interface spectrum including tele-robotics, image product collection, remote toxin sensing, and mission status.
• The development of a spectrum of input controls for tactical vehicle control operation using AR displays.
• Development of high fidelity vehicle performance metrics to ensure training environment adequately mimics live vehicle operation.
• Establishing optimal trade-offs between head tracking, FMV processing, AR content overlay, and control inputs required to minimize the real time delay between external, physical environment and AR displayed content.

PHASE I: Explore and determine the fundamental feature list, sub-systems integration, and cognitive burden limitations in implementing a fully-integrated AR user interface for Soldier deployed, ground and aerial tele-robotics and autonomous mobility and payload control including embedded AR training mode. Phase I deliverables are a final report and proof of concept demonstration. The Final Report should identify: the AR user interface features for robotics control and embedded training; the feature list and ergonomic limitations of computer human input devices for controlling the wearable AR system; the technical challenges, relevant modular and extensible physics based control modeling of tactical ground and aerial semi-autonomous vehicle mobility and payload control; and the feature list and limitations of AR based embedded training for Soldier deployed, ground and aerial tele-robotics and autonomous control. The demonstration deliverable should include a proof of concept system that shows the key AR display and user control components in a bench-top prototype, for either a tactical ground or aerial vehicle along with all the design documents and complete specifications, along with documentation of committed sources and service providers for the fabrication of the ultimate integrated AR vehicle and payload control as well as the embedded AR training system to be produced in Phase II; full specifications and a complete Bill of Materials are required, itemizing each component and system that comprises the final prototype system. This demonstration should be performed at the contractor's facility.

PHASE II: Development, demonstration, and delivery of a working, fully-integrated AR user interface for ground and aerial tele-robotics and autonomous mobility including training mode. The Phase II demonstration should operate within the existing set of ground Soldier interface standards: Universal Serial Bus (USB) 2.0 for peripheral electronic integration, H.264 for video, JAUS for tele-robotic communications, and Cursor on Target eXtended Markup Language (CoT XML) for autonomous waypoint commands. The Phase II final deliverables shall include (1) full system design and specifications detailing the AR user interface concept software (executable and source code) to be integrated for achieving the three mission sets of reconnaissance, terrain mapping and remote sensing; (2) full system design and specifications detailing the electronics and software (executable and source code) for AR Soldier control device(s) to be integrated; (3) full system design and specifications detailing the embedded training software (executable and source code) and details of the aerial aerodynamic physics models and configuration parameters; and (4) full system design and specifications detailing the embedded training software (executable and source code) and details of the ground mobility physics models, gripper physics models, arm physics models and camera models and the associated configuration parameters for each.

DIRECT TO PHASE II (DP2): Offerors interested in submitting a DP2 proposal in response to this topic must provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of this topic has been met and describes the potential commercial applications. The offerors related DP2 proposal will not be evaluated without adequate PH I feasibility documentation. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/result. Please read the OSD SBIR 16.2 Direct to Phase II Instructions.

PHASE III DUAL USE APPLICATIONS: Refine and mature AR user interface software applications for military reconnaissance and commercially for real estate, disaster relief and other reconnaissance operations. Refine prototype hardware and associated ergonomics for AR user interface control hardware to be used in Military and Department of Homeland Security, and disaster relief environments. Refine, and mature AR embedded training software applications for Military, Department of Homeland Security, and disaster relief types of tactical ground and aerial vehicles.

REFERENCES:
1. Gagnon, S. A., Brunye, T. T., Gardony, A. L., Noordzij, M. L., Mahoney, C. R., & Taylor, H. A. (2014). Stepping into a map: Initial heading direction influences spatial memory flexibility. Cognitive Science, DOI 10.1111/cogs.12055.

2. McCaney, Kevin. " Army's move to Samsung reflects a flexible mobile strategy." Defense Systems, 24 Feb 2014. (https://defensesystems.com/articles/2014/02/24/army-nett-warrior-samsung-galacy-note-ii.aspx)

KEYWORDS: augmented reality, human factors engineering, ergonomics, training, prototype

OSD162-004X TITLE: Augmented Reality Training for Dismounted Soldiers

TECHNOLOGY AREA(S): Electronics, Human Systems

OBJECTIVE: Design and fabricate an integrated Augmented Reality system for use by Dismounted Soldiers that demonstrate high levels of immersion in live indoor and outdoor environments and demonstrate future interoperability in both single and multiplayer (collective) configurations with evolving Synthetic Training Environment (STE).

DESCRIPTION: Perceived as an emerging technology of the future, Augmented Reality (AR) is making its way into Smartphones and Tablets, as next generation image capturing and Heads-Up Display (HUD) technologies mature. The US Army of 2025 and beyond requires a robust, realistic, and adaptable training capability. Augmented Reality (AR) technologies will enable the integration of synthetic simulations with live training environments. This topic seeks to integrate state-of-the-art electronics, packaging, and augmentation technologies with the latest low-power data, computing, and rendering components in a single man-wearable package.

Currently, the COTS industry has several emerging capabilities that show great promise for home and/or industrial use. These capabilities appear to have some degree of dismounted Soldier training value when combined as a wholly integrated solution. The integration of these capabilities as-is may not be sufficient, however, because of concerns of ruggedness, interference (e.g., wireless, magnetic, optical occlusion), weather resistance, and so on. The system may result in the modification of these COTS components and/or the creation of new components to address any capability gaps. Soldiers utilizing the system should experience minimal encumbrance to their existing tactical/training equipment and gear. The system should be able to support a squad-level size unit. The system should have a clear design and architecture path to scale up to a platoon level.

The DoD has a critical need for breakthrough man-wearable technologies to develop and demonstrate an advanced AR technology prototype system that demonstrate lightweight and affordable approaches which enhance the ability of live soldiers to train with virtual and live entities in live environments. The advanced AR system prototype is a system that must include real-time live/virtual bridging, correlated content, low-latency augmented reality with static / dynamic occlusion and depth sensing, indoor and outdoor operations, support all lighting conditions (dark night to bright sunlight), real-time localized haptics feedback, full weapon and existing soldier equipment integration, multimodal man-machine interfaces, and support sensing of full-body articulation to be used with virtual content interaction (equipment, avatars, etc.) and presentation to other virtual / gaming / constructive training systems within the Army's synthetic training environment (STE) initiatives. The approach must also provide for methods to rapidly map live 3D spaces for new deployments and use in future training exercises along with natural blending of virtual content into the live display (static / dynamic lighting, shadows, etc.). The systems must also provide reliable real-time telemetry to allow for high-fidelity distributed after action review (AAR), remote monitoring and configuration, and support cloud development and content delivery strategies.

Proposals should target the design and implementation of a COTS-based man-wearable augmented reality system and it's supporting components. Essential elements of this component include a wide field of view, wireless head mounted display (WHMD), human articulation tracking technologies, flexible direct electronic interfaces to haptics sensors, and low power pre-processing circuitry to 6-DOF pose and 3D depth sensing sensor signals into formats that can be transmitted wirelessly to after action and monitoring systems. Packaging must leverage state-of-the-art miniaturized sensors, processing, and rendering packaging that incorporates on-board wireless power reception and conditioning circuitry.

Technical challenges may include:
• The development of a wide field of view, high contrast, wireless HMD capable of providing clear mixed/augmented reality displays under indoor and outdoor conditions and in a wide variety of lighting conditions and operational spaces which a soldier can wear for long periods of time without significant eye/head fatigue.
• Maximizing the scalability and bandwidth-power product of both the on-board devices and external wireless data and power interfaces, but doing so within safe heat dissipation limits for human extended use.
• Establishing optimal trade-offs between physical, electronic, and data transmission specifications required to minimize the componentry bill of materials (BoM) and hence the size and weight of the devices mounted on the human.
• Determining optimal power-bandwidth tradeoffs and scalability to support extended training exercises using the man-wearable technologies.
• Developing enhanced virtual content capable of naturally blending into the live lighting environment
• Demonstrate the ability for multiple dismounted soldiers to train together in a common location without interference or degradation of AR sensor / wireless telemetry performance
• Providing for distributed training concepts where the immersed human seamlessly trains and interacts with live soldiers and other training system interfaces (virtual, game, constructive)
• Developing enhanced augmented reality dismounted solider training scenarios which exploit the additional

capabilities associated with mixed / augment reality

PHASE I: Determine the feasibility/approach for the development of integrated augmented reality technologies to meet training requirements in support of US Army dismounted solider training initiatives within live training domain environments. The tasks include a cognitive task analysis to understand the competencies and knowledge requirements associated with dismounted training; a technology analysis to guide the application and trade off key components, approaches, and subsystems; and research conducted to evaluate the impact of augmented reality technologies on trainee understanding.

PHASE II: Development, demonstration, and delivery of a working prototype augmented reality based dismounted soldier training (full Army squad 9 man) capability that can be utilized within live domain training environments. Prototype system will need to track soldier training timelines, objectives, soldier actions taken or received by others, and provide visual/haptic cues in response to the actions taken or received. Demonstrations will be at TRL 6. Phase II deliverables include full system design and specifications to include executable and source code.

DIRECT TO PHASE II (DP2): Offerors interested in submitting a DP2 proposal in response to this topic must provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of this topic has been met and describes the potential commercial applications. The offerors related DP2 proposal will not be evaluated without adequate PH I feasibility documentation. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/result. Please read the OSD SBIR 16.2 Direct to Phase II Instructions.

PHASE III DUAL USE APPLICATIONS: Refine design and continue technology investigation and integration into a prototype baseline, and implement basic modeling methods, algorithms and interfaces. Pursue full integration within the Live Training Transformation (LT2) and Tactical Engagement Simulation Systems (TESS) product lines, to define an implementation solution. Continue to develop models, procedures, actions and reactions with virtual content, ensure complete traceability to dismounted soldier training requirements. Ensure product line development between live domain and virtual / gaming solutions with a target for integration into the Army's synthetic training environment (STE) and planned training technology matrices with cloud based content and development strategies.

REFERENCES:
1. Naval Research Laboratory Washington, D.C. 20375-5320, "Advancing Human Centered Augmented Reality Research" (2004).

2. Naval Research Laboratory Washington, D.C. 20375-5320, "The Development of Mobile Augmented Reality" (2012).

3. Livingston, M., Gabbard, J., Swan II, J., Sibbley, C., & Barrow, J. (2012). "Basic Perception in Head-worn Augmented Reality Displays", In Human Factors in Augmented Reality Environments (pp. 33-66). New York, New York: Springer.

4. (4) G. Kim, C. Perey, M. Preda, eds., "Mixed and Augmented Reality Reference Model," ISO/IEC CD 24-29-1, July 2014.

5. Crutchfield, Richard., et al. "Live Synthetic Training, Test & Evaluation Infrastructure Architecture, A Service Oriented Architecture Approach", MITRE Technical Report, MTR 150046, 20 February 2015

6. R. Kumar et al, "Implementation of an Augmented Reality System for Training Dismounted Warfighters," paper No. 12149, in Interservice/Industry Training, Simulation, and Education Conf. (I/ITSEC) 2012.

7. S. You, U. Neumann, R. Azuma, "Orientation Tracking for Outdoor Augmented Reality Registration," IEEE Computer Graphics and Applications, November/December 1999.

8. PEO-STRI, “Synthetic Training Environment (STE) Technology / Industry Day”, 1-2 September 2015

KEYWORDS: Head Mounted Display, Haptics, Augmented Reality, Human Computer Interaction, Training, Embedded Training

OSD162-005X TITLE: Accurate Situational Awareness using Augmented Reality Technology

TECHNOLOGY AREA(S): Electronics, Human Systems

OBJECTIVE: To provide an enhanced, real-world experimentation and prototype capability to Soldiers that are learning to use sensors, sensor imagery, geolocation information, Situational Awareness (SA) and command and control information in new and novel ways through the use of virtual reality, augmented reality, and augmented virtuality.

DESCRIPTION: Urban combat requires full situational understanding and informed, accurate information for rapid and decisive action. Current solutions require Warfighters to look away from the battlefield at a display and manually mark items – losing Situational Awareness, accuracy and understanding. Fusion of information to displays is inefficient and ineffective, affecting rapid and decisive action by small units in their Area of Responsibility (AOR). Further, there is a lack of connectivity and sharing of information between the mounted and dismounted Warfighter.

We seek the ability to provide imagery to soldiers in the back of a vehicle, but the issues associated with that capability are unknown. For example, what level of detail is sufficient to provide accurate SA to the soldier? What update rate is required to avoid motion sickness? Does the position of the soldier in the vehicle versus the location of the display affect understanding and efficacy? What are the problems with using geo-registration? A short range camera with a wide field of view (FOV) provides accurate location; how can a long range camera provide accurate geo-registration? How can we automate DTED data and horizon matching? If current solutions use landmarks, what can be used when those are not readily available? Overall, what is the accuracy of VR/AV solutions and how can we ensure that an icon is accurately matched to a target?

We believe the issues can be addressed with a capability that provides VR/AV prototypes in the context of target acquisition experimentation, with the goal of increasing Soldier performance and familiarization with the increased SA. Experimentation could include, but is not limited to, lightweight, flexible displays or optics that can be integrated into protective eyewear or helmet-mounted displays, mobile electronics, game-based systems, intelligent tutoring, enhanced character behaviors, and the efficient use of terrain databases and models for target acquisition experimentation.

PHASE I: The offeror will survey existing capabilities and propose solutions to the issues identified with providing SA imagery to mounted and dismounted soldiers. The offeror will select a limited number of challenge areas to research, in order to create an experimental design and methodology for augmenting target acquisition performance measurement and experimentation. The phase will result in a study and report of the challenges associated with VR/AV capability, an experiment design for use in a perception testing laboratory, and a detailed research plan to execute a Phase II prototype.

PHASE II: The offeror will implement one or two tactically correct prototype capabilities demonstrating a virtual vehicle simulation (i.e., Abrams tank, Tank Commander/Gunner crew positions) using advances in use of Augmented Reality, Virtual Reality, Augmented Virtuality, thru-sight tactical visualization, touch screens, motion tracking, software algorithms and models, and gaming technologies. The offeror will consider long-term requirements as defined by efforts such as the Synthetic Training Environment (STE). The offeror will conduct a statistically relevant set of experiments using the design and methodology to evaluate situational awareness, accuracy, and target acquisition performance measurement and experimentation developed in Phase I. The experimentation difficulty will vary from a novice level to an expert level of target acquisition, with the appropriate noise and blur applied to the imagery. Metrics will be developed and collected for evaluation of Soldier target acquisition performance under varying conditions, with and without enhanced SA.

DIRECT TO PHASE II (DP2): Offerors interested in submitting a DP2 proposal in response to this topic must provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of this topic has been met and describes the potential commercial applications. The offerors related DP2 proposal will not be evaluated without adequate PH I feasibility documentation. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/result. Please read the OSD SBIR 16.2 Direct to Phase II Instructions.

PHASE III DUAL USE APPLICATIONS: The offeror will work with available funding sources to transition capability into practical use within Army/DoD simulation systems, while consider options for dual use applications in broader domains including state/local governments, and commercial.

REFERENCES:

1. U. S. Army, Training and Education Modernization Strategy, 15 December 2014.

2. Live, Virtual, Constructive Integrating Architecture Initial Capabilities Document, 28 July 2004.

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KEYWORDS: virtual reality, augmented virtuality, modeling and simulation, synthetic training environment, interfaces, LVC, combat vehicles, aviation simulation

OSD162-006X TITLE: Future Virtual Collective Training – Virtual Reality, Augmented Virtuality

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Army M&S systems such as the Close Combat Tactical Trainer (CCTT) and Aviation Combined Arms Tactical Trainer (AVCATT) for virtual collective vehicle simulation are hardware-centric. They rely heavily on hardware for detailed, physical replication of the user environment (cockpit/crew stations). The STE concepts describe a coherent single training environment that is capable of delivering relevant training to the warfighter in a timely manner. The STE's capability roadmap has it replacing the Virtual Battle Spaces suite and the Synthetic Environment Core within the next 7 years, and replacing the AVCATT and CCTT within 10 years. The technological challenges associated with this effort are tremendous, but can be summed up in just one word: scalability.

New advances in Virtual Reality (VR), Augmented Virtuality (AV), touchscreens, motion tracking and gaming technologies will allow a software-centric approach to virtual vehicle simulation while providing a sufficient level of fidelity for collective training. In order to achieve true "point of need" delivery of collective training environments, new advances in software defined networks and information assurance is required. This topic will investigate use of these technologies in a software-centric virtual simulation environment to replicate the user interfaces (visual, aural, tactile, etc.) of those operating military vehicles to a high level of fidelity with all the included subsystems (Weapons, Mission Command, Communications, etc.) while minimizing the high-fidelity hardware-centric requirements. Applying these VR/AV advanced technologies will provide a more cost effective immersive environment and will enhance realistic training. Because user interactions must address low latency response times, this topic will also ensure that proper attention to information assurance/cybersecurity and bandwidth restricted networks are taken into account such that practical solutions are proffered.

DESCRIPTION: This software-centric approach will sufficiently simulate the user interface for a trainee acting as a member of crew in a military combat vehicle (ground vehicles, rotary wing aircraft) while significantly reducing the level of hardware for physical replication of user environments in vehicles. VR, AV, touch screens, motion tracking and gaming technologies allow a software-centric approach built on high-fidelity three dimensional models and vehicle systems modeling. The innovative application of these technologies must address the multi-sensory immersive environment which includes visual systems, aural systems, tactile/haptic systems, tracking systems and other interaction systems. This solution for virtual training will be more adaptable to changes, more affordable to develop, and more easily provided to the "point of need" for the Soldier. In order to support this approach, three-dimensional software models will represent the actual vehicle interior and exteriors meticulously. However, some systems found inside vehicles will require physical representation for the user either because the resolution of the interface is not easily represented by 3D models (e.g. Mission Command Systems) or they require a high-fidelity tactile, physical interface (e.g. weapons systems, hand controls). Appropriate AV solutions will allow these required physical system components to be seen and interacted with in the fully immersive VR environment. Successful demonstration of AV solutions will also allow users to see their own physical body or other physical bodies in the VR environment, eliminating much of the requirement for creating detailed, animated human avatars. Successful solutions will provide high resolution calibration of the users' physical space with the environment presented to the user in VR. Successful bidders will provide solutions which maximize software-based solutions to minimize military hardware replication requirements.

A vision for future usage of the STE in the warfighter training cycle is to create a simulation based training system that can be used to exercise their traditional instruction and get a pass/fail grade from a distributed simulation based on demonstrated performance. The theory is that we can create virtual environments with the richness and fidelity needed to properly exercise critical thinking skills and allow soldiers to apply their classroom training in a collective training environment.

In order to create the rich environments needed to achieve this STE vision, a different approach to adapting traditional commercially available game technologies must be considered. This topic discusses a technology thrust that seeks to solve basic simulator limitations such as how to scale to hundreds or thousands of human participants in the same simulation at the same time. It is not enough to enable a distributed virtual environment to accept large numbers of participants, the environment itself needs to be realistic, believable, and populated with items capable of interaction. Since we are also attempting to exercise critical thinking to complete complex missions, the training environment must be presented in a non-determinant way. This means, the training audience must be allowed the free will to go anywhere and do anything they deem necessary to complete the mission (while simulating real-world constraints and limitations). All objects in the prototype simulator are treated as discrete agents. A skilled operator can take a simple object in the scene and add scripted behaviors to increase the fidelity of that agent to create complex interactions. We refer to this as computational steering as the simulation does not require halting or restarting, rather all of this manipulation is done while the simulator is running and the behaviors are distributed to all participants in real time.

Most virtual simulation based military training systems for Soldiers are limited to small unit operations due to the inability for the game engines to allow more than 30-50 humans to log into a scenario at once. In order to achieve the vision for a STE that reaches all warfighters, this software limitation must be lifted and turned into a resource allocation problem. A technological advancement must be made to current simulators in such a way that available computing and networking are the limiting factors to the size (scale) of the training activity.

Virtual simulators typically solve this problem by “sharding” the game scenario as copies across multiple servers. This would allow multiple small units to work the training scenario at once, but not in concert. Depending upon the training mission parameters, the introduction of more trainees and autonomous squad members to the training box may require the box to be larger in area. Traditionally, small unit training areas of operation were only a few city blocks or around one square kilometer. This was plenty of room for a squad to perform simple tasks in a market or building or small village. The next generation of simulation based trainers need to handle much more than the needs of a small unit and a hand full of opposing forces. Future demands for the simulation based training systems will be to train multiple small units in concert or to train larger units for expanded operations. Further, future training systems will also need to incorporate external behavior models for autonomous systems such as ground and air robotic platforms.

In the past, the representation of larger operational areas was the result of trade-offs made in the simulator. Resources were diverted from other aspects of the simulation, such as reducing the number of vehicles and actions in a scenario to support the demands of a larger land area. This practice was forced upon the scenario designers due to core limitations in the game based training systems.

PHASE I: The offeror will survey existing capabilities and propose solutions to representation, visualization, and reasoning needed for M&S for future virtual interfaces using a software-centric approach. The offeror will propose technological approaches to provide high-fidelity virtual collective training for multiple simultaneous ground vehicle and aircraft operators. The offeror will select a limited number of specific challenge areas to explore in greater detail, culminating in a detailed research plan to execute a Phase II prototype.

PHASE II: The offeror will implement one or two prototype capabilities demonstrating a virtual vehicle simulation (i.e., Abrams tank, Tank Commander/Gunner crew positions) using advancements in use of Virtual Reality, Augmented Virtuality, touch screens, motion tracking, high-fidelity three-dimensional software models and gaming technologies. The offeror will consider long-term requirements as defined by efforts such as the Synthetic Training Environment (STE). The offeror will also consider near-term requirements as defined by the AVCATT and CCTT Programs of Record (PoR). The offeror will demonstrate approaches, formats, and concepts needed to enhance next generation army M&S applications. The offeror will expand their architectural approaches based upon lessons-learned from the prototypes to include representative collective training activities at echelon levels up to battalion.

DIRECT TO PHASE II (DP2): Offerors interested in submitting a DP2 proposal in response to this topic must provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of this topic has been met and describes the potential commercial applications. The offerors related DP2 proposal will not be evaluated without adequate PH I feasibility documentation. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/result. Please read the OSD SBIR 16.2 Direct to Phase II Instructions.

PHASE III DUAL USE APPLICATIONS: The offeror will work with available funding sources to transition capability into practical use within Army/DoD simulation systems, while consider options for dual use applications in broader domains including state/local governments, and commercial.

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KEYWORDS: virtual reality, augmented virtuality, modeling and simulation, synthetic training environment, interfaces, LVC, combat vehicles, aviation simulation

OSD162-007X TITLE: Transparent Emissive Microdisplay

TECHNOLOGY AREA(S): Electronics, Human Systems

OBJECTIVE: Design and fabricate a full-color transparent emissive microdisplay for use in a multi-imaging plane system.

DESCRIPTION: The DoD has a need for breakthrough transparent emissive microdisplays for use in Augmented Reality systems. Transparency provides a platform to comingle multiple imaging sources with a single projection lens system without the need for combining prisms.

In order to bridge the gap between traditional night vision goggles (NVGs) and a fully digital night vision system with embedded augmented reality, an interim hybrid system is required. Traditionally, a hybrid system implements a beamcombiner prism and display to optically combine the two images and present it to the user. This methodology dramatically increases the size and weight of a typical night vision goggle.

This topic seeks to implement state of the art display drive electronics with a transparent display technology (e.g. TFEL, carbon nanotube emission, OLED, etc.). The preferred implementation utilizes a thin transparent and emissive display with 20µm or smaller pixel pitch, placed on the image intensifier output to optically combine the information without a beamcombiner. The emphasis of development is on full-color emissivity, with a minimum of interstitial pixel structure to minimize obscuration.

While basic in technology, the application requires careful consideration of the layered image structures. The image intensifier fiber optic output structure is a square 5 or 6 µm pixel pitch. A display layered on top requires a structure of equal spacing aligned to the intensifier output to minimize interference patterns (moire effects).

Proposals should target the design and implementation of a full-color, transparent, emissive display technology with pixel-pitch of 20µm (or smaller), and an area which exceeds the image intensifier's 18mm circular effective area. Refresh rates should be 30Hz or better, but power should not be sacrificed for refresh rate. Display drive circuitry should be implemented to receive a standard video or display drive format (e.g. HDMI, VGA, DisplayPort, Display Parallel, LVDS, or MIPI DSI) and show the incoming signal on the microdisplay. Test components can be demonstrated by using Schott or Incom fiber optics.

Critical to the design of the system is a path to field implementation. The requirements of a fielded system include:

- Mating to the 18mm fiber optic output of an image intensifier
- Emissive technology capable of variable brightness from zero (0) to greater than 6 footlamberts
- Overall transmission greater than 50%
- Small interstitial obscurance (less than 2µm)
- Approximately 18mm circular display
- Minimization of power consumption
- Minimization of rear-side substrate thickness (to minimize image plane separation)
- Electronics layout capable of being packaged within an image intensifier area footprint

Important design characteristics are those items which provide the user with a beneficial experience in an Augmented Reality implementation. Although important, these characteristics should be traded in deference to the critical characteristics. Those features include:

- Good color gamut
- Refresh rate of 30 Hz or faster
- Fast On/Off emission times (pixel response)
- Minimal pixel bleed-over or blurring at the image plane
- Good fill factor (>70%)
- Minimization of drive electronics
- Common video format (MIPI DSI preferred)

The proposer should carefully consider and document the technical challenges, both in display development and in systems implementation. Considerations such as video protocol, potential performance trades, image quality, and transition to production. Offerors are to first uncover and understand the critical integration challenges that may limit the translation and commercial-viability of display transparency as well as the potential pitfalls in overlaying two emissive display sources at slightly different image depths.

Technical challenges may include:

- The development of interface electronics to drive the emissive display.
- Reformatting existing display technologies to achieve the necessary transparency and form factor to achieve the stated goal.
- Eliminating visible flicker or refresh patterning.
- Establishing optimal trade-offs between physical, electronic, and optical performance specifications required to minimize the effect of the display on the overall night vision goggle system.
- Sourcing state-of-the-art display and electronics packaging support.

PHASE I: Explore and determine the fundamental technology, systems integration, and packaging limitations in implementing a full-color, transparent, emissive microdisplay. Provide a Final Report that identifies the technology utilized; details the technical challenges relevant to the implementation within the deployment environment; quantifies the limitations to the system relative to the information input/output of the display; details achievable performance metrics; describes integration process, system-level challenges; and a thorough business plan describing the Non-Recurring Costs, minimum rate of production, units per year required to achieve sustainable production of a transparent emissive microdisplay, and market analysis.

PHASE II: Develop a fully operational proof-of-concept demonstration of the key components and functional systems in a bench-top / PC-board scaled prototype along with all the design documents and complete specifications along with documentation of committed sources and service providers for the fabrication of the device to be produced in Phase II. Demonstrations should be performed with relevant components (i.e. fiber optic output) analogous to the final deployment environment in an image intensifier-based night vision goggle. Additionally; develop, demonstrate, and delivery a working fully-integrated transparent, emissive microdisplay. The Phase II demonstration should operate within a night vision goggle protoype that mimics as closely as possible the electrical and mechanical properties of a functional system. The integrated system should leverage COTS silicon and electro-optical devices wherever possible, and form a dual-layered imaging system, providing Augmented Reality inputs overlaid on a typical Image Intensified NVG system. The external interface should be a commercial standard interface, or display custom interface that may be readily adapted to. If the latter, drive electronics must accompany the unit which perform the interface operation. Proposers are encouraged to adapt modular componentry strategies that is generalizable to a wide range of video interfaces. The Phase II final report shall include (1) full system design and specifications detailing the electronics and proof-of-concept displays to be integrated; (2) expected performance specifications of the proposed components; and (3) expected improvements achievable through continued refinement of the design.

DIRECT TO PHASE II (DP2): Offerors interested in submitting a DP2 proposal in response to this topic must provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of this topic has been met and describes the potential commercial applications. The offerors related DP2 proposal will not be evaluated without adequate PH I feasibility documentation. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/result. Please read the OSD SBIR 16.2 Direct to Phase II Instructions.

PHASE III DUAL USE APPLICATIONS: Transparent displays are a smaller and lighter replacement technology for the traditional method of information injection into optical systems. The traditional method uses a beamcombiner prism and additional lens elements to combine two optical paths. A transparent display enables a single optical path, minimizing the volume required.   This method is useful in commercial areas such as:

- Digitally enhanced weapon sights (to inject range information, shot counters, configurable reticles, and images into the sight’s optical path).
- Binoculars (for display of azimuth, inclination, focus range, and even images). Specific desires exist for bird watching, to display images of the target bird in the binocular view while observing real subjects.
- Augmented Reality light-field displays for head-wearable see-through computing.

KEYWORDS: transparent emissive microdisplays, augmented reality