ARMY
14.3 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

INTRODUCTION

The US Army Research, Development, and Engineering Command (RDECOM) is responsible for execution of the Army SBIR Program. Information on the Army SBIR Program can be found at the following Web site: https://www.armysbir.army.mil.

Solicitation, topic, and general questions regarding the SBIR Program should be addressed according to the DoD Program Solicitation. For technical questions about the topic during the pre-release period, contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period, visit http://www.dodsbir.net/sitis. Specific questions pertaining to the Army SBIR Program should be submitted to:

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The Army participates in three DoD SBIR Solicitations each year. Proposals not conforming to the terms of this Solicitation will not be considered. Only Government personnel will evaluate proposals.

PHASE I PROPOSAL SUBMISSION

SBIR Phase I proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a 20-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any other attachments. Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 20-page limit.

Only the electronically generated Cover Sheets, Cost Volume and Company Commercialization Report (CCR) are excluded from the 20-page limit. The CCR is generated by the proposal submission website, based on information provided by you through the Company Commercialization Report tool. **Army Phase I proposals submitted containing a Technical Volume over 20 pages will be deemed NON-COMPLIANT and will not be evaluated.**

Phase I proposals must describe the "vision" or "end-state" of the research and the most likely strategy or path for transition of the SBIR project from research to an operational capability that satisfies one or more Army operational or technical requirements in a new or existing system, larger research program, or as a stand-alone product or service.

Phase I proposals will be reviewed for overall merit based upon the criteria in Section 6.0 of the DoD Program Solicitation.

14.3 Phase I Key Dates

Solicitation closes, proposals due	22 Oct 2014
Phase I Evaluations	24 Oct – 31 Dec 2014
Phase I Selections	07 Jan 2015
Phase I Award Goal	08 May 2015

**Subject to the Congressional Budget process*

PHASE I OPTION MUST BE INCLUDED AS PART OF PHASE I PROPOSAL

The Army implements the use of a Phase I Option that may be exercised to fund interim Phase I activities while a Phase II contract is being negotiated. Only Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible to have the Phase I Option exercised. The Phase I Option, which **must** be included as part of the Phase I proposal, should cover activities over a period of up to four months and describe appropriate initial Phase II activities that may lead to the successful demonstration of a product or technology. The Phase I Option must be included within the 20-page limit for the Phase I proposal.

PHASE I COST VOLUME

A firm fixed price or cost plus fixed fee Phase I Cost Volume ($150,000 maximum) must be submitted in detail online. Proposers that participate in this solicitation must complete Phase I Cost Volume not to exceed a maximum dollar amount of $100,000 and six months and a Phase I Option Cost Volume not to exceed a maximum dollar amount of $50,000 and four months. The Phase I and Phase I Option costs must be shown separately but may be presented side-by-side in a single Cost Volume. The Cost Volume DOES NOT count toward the 20-page Phase I proposal limitation. When submitting the Cost Volume, complete the Cost Volume form on the DoD Submission site, versus submitting within the body of the uploaded proposal.

PHASE II PROPOSAL SUBMISSION

Commencing with Phase II's resulting from a 13.1 Phase I, invitations are no longer required. Small businesses submitting a Phase II Proposal must use the DoD SBIR electronic proposal submission system (http://www.dodsbir.net/submission/). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheet, the Company Commercialization Report, the Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8:00 a.m. to 5:00 p.m. ET).

A single Phase II proposal can be submitted by a Phase I awardee only within one, and only one, of four submission cycles shown below and must be submitted between 4 to 17 months after the Phase I contract award date. Any proposals that are not submitted within these four submission cycles and before 4 months or after 17 months from the contract award will not be evaluated. Any follow-on Phase II proposal (i.e., a second Phase II subsequent to the initial Phase II effort) shall be initiated by the Government Technical Point of Contact for the initial Phase II effort and must be approved by Army SBIR PM in advance.

SUBMISSION CYCLES	TIMEFRAME
Cycle One	30 calendar days starting on or about 15 October*
Cycle Two	30 calendar days starting on or about 1 March*
Cycle Three	30 calendar days starting on or about 15 June*
Cycle Four	30 calendar days starting on or about 1 August*

*Submission cycles will open on the date listed unless it falls on a weekend or a Federal Holiday. In those cases, it will open on the next available business day.

Army SBIR Phase II Proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a 38-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes), data assertions and any attachments. Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 38 page limit.

Only the electronically generated Cover Sheet, Cost Volume and Company Commercialization Report (CCR) are excluded from the 38-page limit. The CCR is generated by the proposal submission website, based on information provided by you through the Company Commercialization Report tool.

Army Phase II Proposals submitted containing a Technical Volume over 38 pages will be deemed NON-COMPLIANT and will not be evaluated.

Army Phase II Cost Volumes must contain a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of $1,000,000. During contract negotiation, the contracting officer may require a Cost Volume for a base year and an option year. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Volume Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

Small businesses submitting a proposal are required to develop and submit a technology transition and commercialization plan describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal.

DoD is not obligated to make any awards under Phase I, II, or III. For specifics regarding the evaluation and award of Phase I or II contracts, please read the DoD Program Solicitation very carefully. Phase II proposals will be reviewed for overall merit based upon the criteria in Section 8.0 of the solicitation.

BIO HAZARD MATERIAL AND RESEARCH INVOLVING ANIMAL OR HUMAN SUBJECTS

Any proposal involving the use of Bio Hazard Materials must identify in the Technical Volume whether the contractor has been certified by the Government to perform Bio Level - I, II or III work.

Companies should plan carefully for research involving animal or human subjects, or requiring access to government resources of any kind. Animal or human research must be based on formal protocols that are reviewed and approved both locally and through the Army's committee process. Resources such as equipment, reagents, samples, data, facilities, troops or recruits, and so forth, must all be arranged carefully. The few months available for a Phase I effort may preclude plans including these elements, unless coordinated before a contract is awarded.

FOREIGN NATIONALS

If the offeror proposes to use a foreign national(s) [any person who is NOT a citizen or national of the United States, a lawful permanent resident, or a protected individual as defined by 8 U.S.C. 1324b (a) (3) – refer to Section 3.5 of this solicitation for definitions of "lawful permanent resident" and "protected individual"] as key personnel, they must be clearly identified. **For foreign nationals, you must provide**

country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. Please ensure no Privacy Act information is included in this submittal.

OZONE CHEMICALS

Class 1 Ozone Depleting Chemicals/Ozone Depleting Substances are prohibited and will not be allowed for use in this procurement without prior Government approval.

CONTRACTOR MANPOWER REPORTING APPLICATION (CMRA)

The Contractor Manpower Reporting Application (CMRA) is a Department of Defense Business Initiative Council (BIC) sponsored program to obtain better visibility of the contractor service workforce. This reporting requirement applies to all Army SBIR contracts.

Offerors are instructed to include an estimate for the cost of complying with CMRA as part of the Cost Volume for Phase I ($100,000 maximum), Phase I Option ($50,000 maximum), and Phase II ($1,000,000 maximum), under "CMRA Compliance" in Other Direct Costs. This is an estimated total cost (if any) that would be incurred to comply with the CMRA requirement. Only proposals that receive an award will be required to deliver CMRA reporting, i.e. if the proposal is selected and an award is made, the contract will include a deliverable for CMRA.

To date, there has been a wide range of estimated costs for CMRA. While most final negotiated costs have been minimal, there appears to be some higher cost estimates that can often be attributed to misunderstanding the requirement. The SBIR Program desires for the Government to pay a fair and reasonable price. This technical analysis is intended to help determine this fair and reasonable price for CMRA as it applies to SBIR contracts.

- The Office of the Assistant Secretary of the Army (Manpower & Reserve Affairs) operates and maintains the secure CMRA System. The CMRA Web site is located here: https://cmra.army.mil/.

- The CMRA requirement consists of the following items, which are located within the contract document, the contractor's existing cost accounting system (i.e. estimated direct labor hours, estimated direct labor dollars), or obtained from the contracting officer representative:

  (1) Contract number, including task and delivery order number;
  (2) Contractor name, address, phone number, e-mail address, identity of contractor employee entering data;
  (3) Estimated direct labor hours (including sub-contractors);
  (4) Estimated direct labor dollars paid this reporting period (including sub-contractors);
  (5) Predominant Federal Service Code (FSC) reflecting services provided by contractor (and separate predominant FSC for each sub-contractor if different);
  (6) Organizational title associated with the Unit Identification Code (UIC) for the Army Requiring Activity (The Army Requiring Activity is responsible for providing the contractor with its UIC for the purposes of reporting this information);
  (7) Locations where contractor and sub-contractors perform the work (specified by zip code in the United States and nearest city, country, when in an overseas location, using standardized nomenclature provided on Web site);

- The reporting period will be the period of performance not to exceed 12 months ending September 30 of each government fiscal year and must be reported by 31 October of each calendar year.

- According to the required CMRA contract language, the contractor may use a direct XML data transfer to the Contractor Manpower Reporting System database server or fill in the fields on the Government Web site. The CMRA Web site also has a no-cost CMRA XML Converter Tool.

Given the small size of our SBIR contracts and companies, it is our opinion that the modification of contractor payroll systems for automatic XML data transfer is not in the best interest of the Government. CMRA is an annual reporting requirement that can be achieved through multiple means to include manual entry, MS Excel spreadsheet development, or use of the free Government XML converter tool. The annual reporting should take less than a few hours annually by an administrative level employee.

Depending on labor rates, we would expect the total annual cost for SBIR companies to not exceed $500.00 annually, or to be included in overhead rates.

DISCRETIONARY TECHNICAL ASSISTANCE

In accordance with section 9(q) of the Small Business Act (15 U.S.C. 638(q)), the Army will provide technical assistance services to small businesses engaged in SBIR projects through a network of scientists and engineers engaged in a wide range of technologies. The objective of this effort is to increase Army SBIR technology transition and commercialization success thereby accelerating the fielding of capabilities to Soldiers and to benefit the nation through stimulated technological innovation, improved manufacturing capability, and increased competition, productivity, and economic growth.

The Army has stationed eight Technical Assistance Advocates (TAAs) across the Army to provide technical assistance to small businesses that have Phase I and Phase II projects with the participating organizations within their regions.

For more information go to: https://www.armysbir.army.mil/sbir/TechnicalAssistance.aspx.

As noted in Section 4.22 of this solicitation, firms may request technical assistance from sources other than those provided by the Army. All such requests must be made in accordance with the instructions in Section 4.22. It should also be noted that if approved for discretionary technical assistance from an outside source, the firm will not be eligible for the Army's Technical Assistance Advocate support.

COMMERCIALIZATION READINESS PROGRAM (CRP)

The objective of the CRP effort is to increase Army SBIR technology transition and commercialization success and accelerate the fielding of capabilities to Soldiers. The CRP: 1) assesses and identifies SBIR projects and companies with high transition potential that meet high priority requirements; 2) matches SBIR companies to customers and facilitates collaboration; 3) facilitates detailed technology transition plans and agreements; 4) makes recommendations for additional funding for select SBIR projects that meet the criteria identified above; and 5) tracks metrics and measures results for the SBIR projects within the CRP.

Based on its assessment of the SBIR project's potential for transition as described above, the Army utilizes a CRP investment fund of SBIR dollars targeted to enhance ongoing Phase II activities with expanded research, development, test and evaluation to accelerate transition and commercialization. The CRP investment fund must be expended according to all applicable SBIR policy on existing Phase II availability of matching funds, proposed transition strategies, and individual contracting arrangements.

NON-PROPRIETARY SUMMARY REPORTS

All award winners must submit a non-proprietary summary report at the end of their Phase I project and any subsequent Phase II project. The summary report is unclassified, non-sensitive and non-proprietary and should include:

- A summation of Phase I results
- A description of the technology being developed
- The anticipated DoD and/or non-DoD customer
- The plan to transition the SBIR developed technology to the customer
- The anticipated applications/benefits for government and/or private sector use
- An image depicting the developed technology

The non-proprietary summary report should not exceed 700 words, and is intended for public viewing on the Army SBIR/STTR Small Business area. This summary report is in addition to the required final technical report and should require minimal work because most of this information is required in the final technical report. The summary report shall be submitted in accordance with the format and instructions posted within the Army SBIR Small Business Portal at https://portal.armysbir.army.mil/SmallBusinessPortal/Default.aspx and is due within 30 days of the contract end date.

ARMY SUBMISSION OF FINAL TECHNICAL REPORTS

A final technical report is required for each project. Per DFARS clause 252.235-7011 (http://www.acq.osd.mil/dpap/dars/dfars/html/current/252235.htm#252.235-7011), each contractor shall (a) Submit two copies of the approved scientific or technical report delivered under the contract to the Defense Technical Information Center, Attn: DTIC-O, 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6218; (b) Include a completed Standard Form 298, Report Documentation Page, with each copy of the report; and (c) For submission of reports in other than paper copy, contact the Defense Technical Information Center or follow the instructions at http://www.dtic.mil.

ARMY SBIR PROGRAM COORDINATORS (PC) and Army SBIR 14.3 Topic Index

Participating Organizations	PC	Phone
Communications-Electronics Research, Development and Engineering Center (CERDEC)	**Joanne McBride**	**(443) 861-7587**
PEO Aviation	**Randy Robinson**	**(256) 313-4975**

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

This is a Checklist of Army Requirements for your proposal. Please review the checklist to ensure that your proposal meets the Army SBIR requirements. You must also meet the general DoD requirements specified in the solicitation. **Failure to meet these requirements will result in your proposal not being evaluated or considered for award**. Do not include this checklist with your proposal.

1. The proposal addresses a Phase I effort (up to **$100,000** with up to a six-month duration) AND an optional effort (up to **$50,000** for an up to four-month period to provide interim Phase II funding).

2. The proposal is limited to only **ONE** Army Solicitation topic.

3. The technical content of the proposal, including the Option, includes the items identified in Section 5.4 of the Solicitation.

4. SBIR Phase I Proposals have four (4) sections: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a 20-page limit including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents [e.g., statements of work and resumes] and all attachments). However, offerors are instructed to NOT leave blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in others sections of the proposal submission as THESE WILL COUNT AGAINST THE 20-PAGE LIMIT. ONLY the electronically generated Cover Sheet, Cost Volume and Company Commercialization Report (CCR) are excluded from the 20-page limit. As instructed in Section 5.4.e of the DoD Program Solicitation, the CCR is generated by the submission website, based on information provided by you through the "Company Commercialization Report" tool. Army Phase I proposals submitted over 20-pages will be deemed NON-COMPLIANT and will not be evaluated.

5. The Cost Volume has been completed and submitted for both **the Phase I and Phase I Option** and the costs are shown separately. The Army prefers that small businesses complete the Cost Volume form on the DoD Submission site, versus submitting within the body of the uploaded proposal. The total cost should match the amount on the cover pages.

6. Requirement for Army Accounting for Contract Services, otherwise known as CMRA reporting is included in the Cost Volume (offerors are instructed to include an estimate for the cost of complying with CMRA).

7. If applicable, the Bio Hazard Material level has been identified in the Technical Volume.

8. If applicable, plan for research involving animal or human subjects, or requiring access to government resources of any kind.

9. The Phase I Proposal describes the "vision" or "end-state" of the research and the most likely strategy or path for transition of the SBIR project from research to an operational capability that satisfies one or more Army operational or technical requirements in a new or existing system, larger research program, or as a stand-alone product or service.

10. If applicable, Foreign Nationals are identified in the proposal. An employee must have an H-1B Visa to work on a DoD contract.

Army SBIR 14.3 Topic Index

A143-092	Human-Centered Mission Command Metrics for the Tactical Computing Environment
A143-093	Validated Mathematical Model of Spatial Orientation (SO)

A143-092 TITLE: Human-Centered Mission Command Metrics for the Tactical Computing Environment

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Perform research and technology development, resulting in software that is integrated, demonstrated, and evaluated with a representative Army System of Record, which generates a set of metrics that show the effectiveness of Mission Command (MC) in austere operating environments.

DESCRIPTION: The Mission Command (MC) philosophy is the "exercise of authority and direction by the commander using mission orders to enable disciplined initiative within the commander's intent to empower agile and adaptive leaders in the conduct of unified land operations."1 New ways of delivering MC capabilities that ensure that Commanders, wherever they are on the battlefield, can still lead effectively, regardless of the situations they face and the computing and network resources they have, are emerging. Several ongoing Army efforts are focused on developing guidance, architectures, and systems to enable MC capabilities to be delivered across lower echelons – that is, outside the traditional Command Post (CP). These include Army Common Operating Environment (COE) activities, as well as the Command Post, Mounted, and Mobile / Hand Held Computing Environments (CEs).

The body of work desired involves research and technology development that results in a software prototype that delivers a set of metrics that can be used to assess the performance of systems that deliver Mission Command (MC) capabilities to Commanders. While the metrics and the means by which they are calculated should be valid in any operational environment, the focus is lower echelon operations (Battalion and Company), where systems, computing, and network capabilities are limited, but where Commanders still need to lead.

PHASE I: During Phase I, the contractor will begin by performing a feasibility study to identify a set of metrics that relate to the effectiveness of the performance of Mission Command (MC) functions by Commanders, to include the propagation and execution of Commander's Intent by command staff. To gain insight into what can be measured, an assessment of the consistency and differences in MC functions across lower echelons is expected. Commanders' and staff members' key tasks and domain expertise in each of those echelons should be considered.

With the ultimate goal of the SBIR being a way to assess and help to optimize the delivery of MC capabilities and the synchronization of supporting activities in the more austere environments across lower echelons and several computing environments, an analysis of the associated warfighting network, one that has challenging communications networks, dispersed and limited computing resources, and the social/cognitive and information networks that are underpinnings of shared situation awareness and decision making, is expected.

The relationship of MC to all seven warfighting functions (Movement and Maneuver, Command and Control, Sustainment, Protection, Intelligence, Fires, and Engagement), including both kinetic and non-kinetic activities that are part of them, should be considered. All aspects of MC (situational understanding, cultural understanding, military effects, maneuverability, sustainability, and survivability) are important. The metrics that relate to a Commander's effectiveness should be relevant in any computing environment (Command Post, Mounted, and Mobile / Hand Held), with a desired focus on echelons at Battalion and Company echelon.

A preliminary set of Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) based on a consideration of aspects of the human dimension that can be measured during the performance of multi-echelon and computing platform-agnostic MC is desired. MOEs and MOPs should be quantitative and able to be validated through experimentation, so that they can be leveraged for related modeling, simulation, and system development efforts. A specific list of the types of metrics being proposed based on those measures, and their relationships to network configuration (hierarchical or edge), should also be developed. To support agile operations, near-real time measurement of key factors to support the dynamic balancing of the goals of maneuverability, military effects, and survivability is a goal.

To generate metrics that capture the effectiveness of the expression, propagation, and understanding of Commander's Intent, factors such as the following should be considered: individual and team cognitive load, human

dynamics, communications networks, socio-cognitive networks, training, user interfaces, cognitive psychology, behavioral science, neuro-economics, sociology, formations, organizational configuration, and command and control agility.

Underlying the effort are (1) an understanding of the challenges and opportunities presented by agile operations in an austere environment, and (2) a desire not to merely measure the performance of MC systems but to measure the performance of individual soldiers and teams involved in MC.

The contractor should follow the feasibility study with a proposed design for a software system. The desire is that the software be MC system-agnostic to the extent possible. The contractor should describe where possible interfaces with representative existing MC systems, as well as how the software would operate as more of a plug-in technology, with minimal integration efforts being of interest.

Technical reports for Phase I effort should include:
(1) findings related to the individual data items that will be considered in the MOE and MOP development, to include the feasibility of capturing, manipulating, and using the associated data in a representative system
(2) analysis of how those data would be collected during prototype development and in an experimental environment
(3) discussion and analysis of the metrics associated with those measures
(4) a preliminary design for a software prototype that describes how the measures and metrics would be incorporated in an MC system, to include a consideration of architecture, database, and network issues germane to the proposed design, considering both experimental prototypes as well as representative and/or relevant MC systems

PHASE II: During Phase II, the contractor will begin work on the software prototype. During the early stages of Phase II, and as data are collected during ongoing prototype development and evaluation, additional efforts to refine the measures and metrics are anticipated.

The desire is for increasingly mature software that delivers a set of metrics that show the effectiveness of Mission Command (MC) – how well direction by the commander is conveyed, which is also reflected in the performance based on his orders by his subordinates. Successively mature demonstrations of the collection of MC-relevant data and their analyses for MC metrics are desired. Simulation of some of the data that will be collected is expected, especially during the earlier prototypes. Refinement and more maturity are expected throughout Phase II.

The contractor will work with the government to collect data in representative instrumented environments, with the requirement for meaningful MOEs and MOPs and associated metrics to be generated. These data collection and analysis activities are expected to lead to additional software refinements. As work evolves, it is essential that the contractor and government work together to clearly articulate how to instrument a typical MC system for data collection.

A first version of prototype software should be completed and delivered to the government for installation, demonstration, and evaluation within 180 days of the start of Phase II. The contractor and government will work together to identify a target system for integration. Supplying that target system will be a government responsibility. Additional quarterly builds with incremental improvements are required.

The contractor and government will work together to identify the venue and target system for a capstone installation, demonstration, and experimental evaluation. It will be the responsibility of the government to facilitate that capstone event.

The following tasks are expected:
(1) a detailed design for the collection of the relevant data in a prototypical environment
(2) the development and ongoing refinement of prototype software that collects data and presents measures and metrics
(3) multiple demonstrations and evaluations of the software in a representative operational setting
(4) capstone demonstration and evaluation of the software

Phase II deliverables will include technical reports, working software prototypes, and associated source code.

Software delivered at the conclusion of Phase II should be at a Technology Readiness Level (TRL) 6.

PHASE III: A set of Mission Command metrics could have broad implications for Army system development, as guidance in the development of requirements specifications. When integrated with an Army system, they could also be invaluable in the analysis and/or tuning of unit performance, both in training exercises and in actual warfighting. Commercially, the work could also extend to virtually any environment where users are challenged with complex problems where collaboration is necessary for optimal solutions.

During Phase III, the contractor will continue to mature the prototype software, moving it to at least a TRL 7 level, and will work with the government to identify and then target and tailor the system for transition to an Army Program of Record as part of a current or emerging Army software system, as well as to one or more commercial applications.

As new Army MC solutions targeted to lower echelon and more austere environments are developed, the work should be of immediate interest to the Army Training and Doctrine Command, for use in training schools to help gain insight into how Commanders, during lower-echelon experimentation, perform Mission Command. Additionally, as the Army consolidates more capabilities into systems such as Nett Warrior, a plug-in that could, in near-real or real time, monitor how MC is being performed by a Company Commander could be invaluable. Lower-echelon systems will be in environments where more agile, less hierarchical command structures are required to maintain operational tempo, and those types of systems would be natural targets.

From a commercial perspective, Emergency Response Services, where remote users must quickly share information and collaborate to save lives, a means to instrument that network to assess efficiency and operation should be attractive. The technology developed under this SBIR should also be interest to any organization interested in validating the effectiveness of distributed users running teaming / collaborative software with a focus on quick and effective decisions. Financial instruments and commodity trading are examples.

REFERENCES:
1. Army Doctrine Reference Publication (ADRP) 6-0, Mission Command

2. Operationalizing Mission Command: Leveraging Theory to Achieve Capability, by Kathleen Conley, Institute for Defense Analyses, published in Joint Force Quarterly, Issue 68, 1st quarter 2013

3. Mission Command White Paper, 3 April 2012, Martin E. Dempsey, General, U.S. Army, Chairman of the Joint Chiefs of Staff

KEYWORDS: Mission Command, Command Post, Mounted, Mobile / Hand Held, situation awareness, cognition, Command and Control agility

A143-093 TITLE: Validated Mathematical Model of Spatial Orientation (SO)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and verify an improved mathematical model of human gravitoinertial spatial orientation (SO) which simulates perceptions resulting from the integration of orientation/motion cues provided by visual, auditory, vestibular, and somatosensory senses, especially those cues existing in the aerospace environment.

DESCRIPTION: Accurate perception of self-orientation, to include platform motion, is critical to survival, since failure to accurately know where "down" is can result in vehicle crashes or falls. Such perception requires rapid central integration of information from multiple sensory modalities, including vision, audition, vestibular sensation, and somatosensation (skin-muscle-joint). Models of human gravitoinertial orientation have focused on vestibular sensors but additional sensory modalities should be incorporated (Zupan & Merfeld, 2005). An enhanced model of orientation is needed that incorporates more sensory modalities and is accurate for a wider envelope of operations. Such a model is needed to improve the investigation of military and civil aviation mishaps, the development of orientation/locomotion algorithms for bipedal robots or exoskeletons, the development of advanced (e.g., multiple degree-of-freedom centrifuge-based) driving/flying simulators and to predict the orientation and physiological

responses experienced by aircrew of future highly dynamic platforms where advanced control laws may not have the pilot directly in the control loop.

All perception models currently in use by mishap investigators examining aircraft mishaps make two assumptions concerning the pilot's visual information. It is assumed that the pilot is not looking at the attitude indicator and does not have access to visual cues of the horizon. The Army and other services are considering the implementation of continuous auditory and tactile cueing to provide orientation information. The model will include incorporation of novel cueing from visual, auditory and tactile cues.

The model should incorporate the currently available information concerning the role of different sensory inputs in maintaining orientation and supplying helpful sensory substitution. The model should be fully functional and able to accurately predict self-orientation and self-motion perceptions in multiple degrees-of-freedom of body motion/orientation. It should also be easily usable by a non-specialist (e.g., a spatial orientation expert without specific expertise in mathematical modeling or modeling programs). The model should yield animation sequences for heuristic purposes when explaining real versus predicted perception, such as would occur when presenting findings to a mishap investigation board. The feasibility of the model should be demonstrated via initial empirical verification during pilot testing. The model does not need to explain geographic map orientation, but it should be able to explain orientation vis a vis the surface of the Earth or "down."

PHASE I: Identify the current state of knowledge concerning human perception of self-orientation and platform movement. Determine the desired capabilities of a working model in relation to the current state of knowledge. Develop a working mathematical model based on the latest principles. Make the model user-friendly via graphical-user-interfaces. Render the model capable of producing short cartoon animations showing a subject's actual versus felt (predicted) orientation and motion in a wide array of situations, especially those known to be disorienting to pilots. These simulations should transform known orientation/motion inputs (e.g., from aircraft acceleration recordings) into animations of self-orientation perceptions which match the literature.

PHASE II: The model should be empirically verified via a pilot test (and full report) on human subjects engaged in dynamic, complicated motions, e.g., by testing critical model predictions of perception versus actual perception of human subjects riding a multi-degree-of-freedom centrifuge). Refine and elaborate the working mathematical model based on findings from the pilot study. Make the model more user-friendly by incorporating user feedback. Expand the envelope of current models through experimentation to increase the number and quality of possible simulations and animations. Move the model from an initial demonstration prototype to a final prototype ready for validation and testing by the safety centers. Verify key model assumptions and predictions via a full study on human subjects. Refine the model according to the outcomes of a full study. Produce final report with specific recommendations concerning applications of the modeling algorithm and associated software to the reduction of aviation mishaps especially in degraded visual environments (and improvement of performance), the prediction of falling, and the control of automated (e.g., robotic) or semi-automated (e.g., aircraft or assistive exoskeleton) systems.

PHASE III DUAL USE APPLICATIONS: Transition the model through widespread commercialization and government acquisition. Deliver the final product(s) for the government and private sector market. Applications should include safety centers (Army, Navy, Air Force, FAA, and NTSB), centrifuge-based flying or driving simulation, robotic platforms, human fall prediction and fall-assistance devices, and prevention of spatial disorientation in flight.

REFERENCES:

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KEYWORDS: orientation, flight control, vestibular, model, acceleration, movement, mishap, degraded visual environments, robotics, falling