

I. OVERVIEW OF THE FUNDING OPPORTUNITY

Extramural Program Announcement for the Department of Defense

Congressionally Directed Medical Research Programs

Medical Simulation and Information Sciences Research Program (MSISRP)

Toward A Next-Generation Trauma Care Capability: Foundational Research for Autonomous, Unmanned, and Robotics Development of Medical Technologies (FORWARD) Award

Announcement Type: Initial

Funding Opportunity Number: W81XWH-17-MSISRP-FOR

**Catalog of Federal Domestic Assistance Number: 12.420 Military Medical Research and
Development**

SUBMISSION AND REVIEW DATES AND TIMES

- **Pre-Application Submission Deadline:** 5:00 p.m. Eastern time (ET), November 20, 2017
- **Application Submission Deadline:** 11:59 p.m. ET, February 5, 2018
- **End of Application Verification Period:** 5:00 p.m. ET, February 12, 2018
- **Peer Review:** April 2018
- **Programmatic Review:** May 2018

This Program Announcement must be read in conjunction with the General Application Instructions, version 20170516. The General Applications Instructions document is available for downloading from the Grants.gov funding opportunity announcement by selecting the “Package” tab, clicking “Preview,” and then selecting “Download Instructions.”

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II. DETAILED INFORMATION ABOUT THE FUNDING OPPORTUNITY

II.A. Program Description

Applications to the Fiscal Year 2017 (FY17) Medical Simulation and Information Sciences Research Program (MSISRP) are being solicited by the U.S. Army Medical Research Acquisition Activity (USAMRAA). The execution management agent for this Program Announcement is the Congressionally Directed Medical Research Programs (CDMRP). The MSISRP plans, coordinates, and oversees a science and technology program focused on improving military medical training and education through medical modeling and simulation systems addressing combat casualty training, medical readiness, health-focused initiatives, and developer tools for medical educators as well as improving health information sciences through increased interoperability, strategic planning, process development, and medical applications. The mission of the MSISRP is to explore the implications of models, technology, and informatics for medical education, and for the provision, management, and support of healthcare services in the military. The MSISRP plans, coordinates, and oversees a responsive world-class, tri-service (Army, Air Force, and Navy) science and technology program.

The MSISRP Toward A Next-Generation Trauma Care System: Foundational Research for Autonomous, Unmanned, and Robotics Development of Medical Technologies (FORWARD) award is expected to facilitate cutting-edge, next generation scientific studies and to promote significant innovation in the state-of-the-art and basic, foundational, and ground-breaking research in technologies, including biologically-inspired models of cognitive computing, neural networks, environmental sensing and other approaches to adaptive, autonomous inference generation and artificial intelligence in the medical domain to dramatically advance first responder/point of injury trauma care and outcomes. MSISRP is seeking highly imaginative and innovative basic research ideas and concepts for a next-generation military and civilian trauma care system that is responsive to remote, mass casualty, disaster and/or military combat-related trauma care requirements.

Basic research includes all scientific study and experimentation directed toward increasing fundamental knowledge and understanding related to long-term national security needs without specific applications towards processes or products in mind. It is farsighted high payoff research that provides the basis for technological progress and may lead to subsequent applied research and advanced technology developments, and new and improved military functional capabilities.

II.B. Award Information

The MSISRP FORWARD Award mechanism is being offered for the first time in FY17. This mechanism supports basic research to increase knowledge/understanding through discovery and hypothesis generation, and should focus on providing basic fundamental knowledge that will inform and enable the future development of novel autonomous and/or robotic medical systems to care for wounded soldiers/patients through breakthrough, exploratory research.

NOTE: THIS FUNDING OPPORTUNITY IS INTENDED FOR ELIGIBLE EXTRAMURAL APPLICANTS ONLY.

The objective of the FY17 MSISRP FORwARD Award is focused on addressing the following Topic Areas:

1. Autonomous and Unmanned Medical Capability – Identify novel ideas, approaches and research towards the conceptualization of autonomous and unmanned technologies for next-generation, high-quality medical capabilities with limited or absent medical care personnel, or personnel with limited skills. Research novel concepts, plausible approaches and advanced concept designs using biologically inspired cognitive computing models, machine learning, artificial intelligence, soft robotic semi-autonomous/autonomous resuscitation concepts and advanced applications of information sciences among other innovative, exploratory research towards advancing the state-of-the-art in delivery of forward resuscitative care at the point of injury.
2. Medical Robotics Research – Identify novel ideas, approaches and research towards the conceptualization of medical robotics and real-time tele-presence capabilities exploring the limits of machine perception for tele-robotic semi-autonomous and autonomous trauma care within remote and dispersed geographic settings. This could include exploratory research in semi-autonomous robotic surgery to improve the safety profile and efficacy of tele-surgical procedures and outcomes using hard robotics in challenging situations (e.g., combat casualties on the multi-domain battlefield or mass casualty situations) and remote or austere geographic locations, among other innovative, exploratory research aims and novel concepts.

The FY17 MSISRP FORwARD Award supports basic research that dramatically advances the state of the art in civilian and military trauma care at the first responder point of care, during prolonged field care of combat casualties, and extended en-route care that can potentially be mitigated by leveraging novel ideas and designs that are yet to be invented in soft robotic, semi-autonomous and autonomous concepts and systems for hemorrhage control, resuscitation, vascular and surgical control of combat casualties, and transport for critical care patients in unmanned vehicles. Likewise, future deployment of surgical robots (hard robotics) will enable the Army to deliver immediate damage control surgery/interventions at the point of injury. Ultimately, solutions to these gaps will reduce mortality and morbidity rates in remote and austere future battlefields demanding an adaptive, responsive and automated trauma care system for casualties. Based on the increased understanding of basic principles and identification of promising strategies anticipated from the basic research, the Government will later initiate applied research in this domain to design and conduct proof-of-concept demonstrations leading to future integration of robotic, semi-autonomous and autonomous medical capabilities with unmanned systems (UMS) to maximize advancements towards a vision of autonomous delivery of care and evacuation across multiple casualty situations and events.

Candidate proposals are expected to reflect awareness of the [Multi-Domain Battlefield \(MDB\) Concept](#) (Appendix 2), wherein air, ground and maritime forces project power into other domains (space, cyberspace, the electromagnetic spectrum, the information environment, and the cognitive dimension of warfare) to support joint and coalition capabilities across all military operations. Distributed units will be required to form quickly and converge into larger

formations; and then disaggregate and dynamically reconfigure as the situation changes. Future forces, ranging from small units to traditional military formations, may be widely dispersed with minimal, if any, pre-established health care infrastructure. Further, enemy anti-access /area-denial capabilities may inhibit the availability of both tactical and strategic medical evacuation assets. These limitations on evacuation may result in wounded service members experiencing prolonged periods of care prior to air or ground evacuation across the roles of care. The future of forward medical care must keep pace with rapid operational transitions, be highly agile, address a wide range of threats, and provide medical support to multiple units operating on multiple, disparate lines of communication. Further discussion regarding Medical Robotic and Autonomous System Technology can be found at the following publication by Nathan Fisher and Gary Gilbert at <http://smallwarsjournal.com/jrnl/art/medical-robotic-and-autonomous-system-technology-enablers-for-the-multi-domain-battle-2030->

To be considered for funding, each application for the FY17 MSISRP FORwARD Award must address **one, and only one**, of the Topic Areas listed below. **If applicants wish to address more than one Topic Area, separate applications must be submitted.** The Government also reserves the right to reassign the application's Topic Area if submitted under an inappropriate Topic Area. Applications involving multidisciplinary collaborations among academia, industry, military services, Department of Veterans Affairs (VA), and other Federal agencies are highly encouraged.

Applications proposing research outside of the Topic Areas listed below or applications addressing more than one Topic Area will be administratively withdrawn and not considered for funding.

FY17 MSISRP FORwARD Topic Areas:

1. Autonomous and Unmanned Medical Capability

Intent: Conduct basic, exploratory research in future conceptual technology designs leading to medical care, transport and resupply through autonomous and UMS supporting complex environments including the MDB concept of operations.

Breakthrough research candidate ideas, concepts, designs and models are those that have potential to provide dramatic and next generation innovation in monitoring, diagnosis, and critical care including therapeutic delivery systems (such as for trauma resuscitation or telesurgery) in future far forward environments using dynamic closed loop design concepts, artificial intelligence, and next-generation digital signal processing algorithms. Investigation will address automation of all phases of trauma casualty care from initial diagnosis and monitoring to stabilization, interventional therapeutics, resuscitation and recovery during prolonged field care, and extended evacuation in resource-constrained environments.

The application must address at least two of the following research objectives:

- Develop novel ideas, concepts and plausible design approaches to automated vascular access, automated needle thoracotomy, and closed loop resuscitation.

- Identify and define possible models of pathophysiology of injury in trauma simulations that could be amenable to automated therapeutics within autonomous medical systems.
- Develop novel ideas, concepts and plausible research designs for algorithms or models of closed-loop Functional Hemodynamic Monitoring (FHM)-driven resuscitation to infuse blood, fluids and vasoactive drugs and other critical care patient management interventions.
- Research strategies for incorporating and de-conflicting multiple closed-loop autonomous systems for use in poly-trauma models of care.

2. Medical Robotics

Intent: Conduct foundational research to determine next generation, advanced robotics concepts for approaches to semi-autonomous/autonomous robotic surgery to improve the safety profile and efficacy of tele-robotic surgery (hard robotics) in remote, austere, and/or combat environments.

The application must address at least two of the following objectives:

- Theorize, model and characterize innovative, next generation designs to mitigate the deleterious effects of signal latency and constrained bandwidth on complex tele-robotic surgical tasks through advanced machine perception in cognitive processing several steps in advance in surgical procedures or recall of existing procedures learned from stored knowledge.
- Theorize, model, research and prioritize possible procedures amenable to full automation for the purpose of extending tele-robotic operations.
- Explore potential semi-autonomous robotic assistance protocols as signal latency counter-measures based on machine learning/artificial intelligence applied from stored knowledge and investigate strategies to optimize these protocols for surgical efficiency, precision, and safety.
- Investigate innovative, next generation approaches to optimization and translation of robotic assistance protocols across extended distances.
- Theorize and model possible artificial intelligence conceptual frameworks for knowledge representation of semi-autonomous/autonomous medical behaviors supporting creation of a future library of surgical tasks as stored knowledge for automatic recall. Theorize, model and design artificially intelligent and/or machine learning algorithms, knowledge representations and schemes as part of concept formation to learn, analyze, mimic, or enhance maneuvers of experienced surgeons performing defined surgical tasks (damage control surgery). It is theorized that a repository of stored surgical tasks could be called upon by a remote patient-side robot that could store this library of semi-autonomous tasks locally. Such semi-autonomous tasks could, in the future, be called upon to continue a procedure over longer periods of time under no/low communications conditions and scenarios.

The anticipated total costs budgeted for the entire **2 year** period of performance for an FY17 MSISRP FORwARD Award will not exceed **\$1.3 million (M) per award**. Refer to [Section II.D.5, Funding Restrictions](#), for detailed funding information.

Background:

Many trauma patients receive varying levels of care in the United States, depending on when or where they are injured. Far too many needlessly die or sustain lifelong disabilities as a result. In the civilian sector, where injury is the leading cause of death for Americans under age 46, as many as 1 in 5 deaths from traumatic injuries may be preventable with optimal trauma care, equating to 200,000–300,000 lives that could be saved over the a 10-year period. In the military setting, between 2001 and 2011, approximately 1,000 American Service members who perished on the battlefield (roughly 25 percent of all battlefield deaths) died of wounds they could potentially have survived with optimal trauma care. The MDB predicts military operational environments involving greater dispersion and near-isolation over great distances, straining medical care delivery even more. Much like mass casualties from terrorist events and natural disasters such as floods and hurricanes, future military medical scenarios are likely to cause severe restrictions on mobility for medical missions and shortfalls in both human and materiel resources. Combat units will need to be more self-sufficient and less dependent on logistical support. Combatant commanders with an increased number of sick or wounded Soldiers will face degradation of medical resources and encumbered combat effectiveness without trauma casualty management, medical situational awareness/command and control, and Force multiplier strategies for specialty care. Robotic and autonomous or semi-autonomous patient support systems in stand-alone configurations and integrated with general purpose unmanned vehicle platforms could serve as Force multipliers for medical operations in future casualty and disaster environments especially in enabling expedited civilian and military casualty evacuation (CASEVAC).

In alignment with the National Academy of Medicine’s report *A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury* (see <https://nam.edu/a-national-trauma-care-system/>), extramural research emphasis will be directed toward providing novel, innovative, futuristic solutions to export medical expertise for improved patient care and enhanced provider capabilities for both civilian and military applications in multiple and/or remote geographic locations through the use of advanced next generation research into autonomous medical care and robotics.

Use of Military and VA Populations and/or Resources: If the proposed research plan involves access to active duty military and/or VA resources, the PI is responsible for demonstrating such access. If possible, access to target active duty military and/or VA resource(s) should be confirmed at the time of application submission by inclusion of a letter of support, signed by the lowest-ranking person with approval authority, for studies involving VA-controlled study materials, and military and/or VA databases. If access cannot be confirmed at the time of application submission, the Government reserves the right to withdraw or revoke funding until the PI has demonstrated support for and access to the relevant resource(s).

The CDMRP intends that information, data, and research resources generated under awards funded by this Program Announcement be made available to the research community (which

includes both scientific and consumer advocacy communities) and to the public at large. For additional guidance, refer to the General Application Instructions, Appendix 2, Section K.

Awards will be made no later than September 30, **2018**. For additional information refer to [Section II F.1, Federal Award Notices](#).

II.C. Eligibility Information

II.C.1. Eligible Applicants

II.C.1.a. Organization:

Intramural DoD Organization: A Department of Defense (DoD) laboratory, DoD military treatment facility, and/or DoD activity embedded within a civilian medical center.

Extramural Organization: An eligible non-DoD organization. Examples of extramural organizations include academia, biotechnology companies, foundations, Government, and research institutes.

This Funding Opportunity is intended for eligible extramural applicants only. Submissions from intramural applicants to this Funding Opportunity will be rejected. It is permissible, however, for an intramural applicant to be named as a collaborator in an application submitted by an extramural applicant. Funding to intramural DoD and other Federal agencies will be managed through a direct funds transfer.

All extramural organizations, including international organizations, are eligible to apply.

Government Agencies within the United States: Local, state, and Federal Government agencies are eligible to the extent that applications do not overlap with their fully funded internal programs. Such agencies are required to explain how their applications do not overlap with their internal programs.

Note: Applications from an extramural non-DoD Federal organization may be submitted through a research foundation.

The USAMRAA makes awards to eligible organizations, not to individuals.

II.C.1.b. Principal Investigator:

An eligible Principal Investigator, regardless of ethnicity, nationality, or citizenship status, must be employed by, or affiliated with, an eligible organization.

The CDMRP encourages all PIs to participate in a digital identifier initiative through Open Researcher and Contributor ID, Inc. (ORCID). Registration for a unique ORCID identifier can be done online at <http://orcid.org/>.

II.C.2. Cost Sharing

Cost sharing/matching is not an eligibility requirement.

II.C.3. Other

Organizations must be able to access **.gov** and **.mil** websites in order to fulfill the financial and technical deliverable requirements of the award and submit invoices for payment.

Each investigator may be named on only one FY17 MSISRP FORWARD Award application per Topic Area as a PI.

For general information on required qualifications for award recipients, refer to the General Application Instructions, Appendix 3.

Refer to [Section II.H.2, Administrative Actions](#), for a list of administrative actions that may be taken if a pre-application or application does not meet the administrative, eligibility, or ethical requirements defined in this Program Announcement.

II.D. Application and Submission Information

Extramural Submission is defined as an application submitted by a non-DoD organization to Grants.gov.

II.D.1. Address to Request Application Package

The electronic Biomedical Research Application Portal (eBRAP) is a multifunctional web-based system that allows PIs to submit their pre-applications electronically through a secure connection, to view and edit the content of their pre-applications and full applications, to receive communications from the CDMRP, and to submit documentation during award negotiations and period of performance.

Pre-application content and forms can be accessed at the electronic Biomedical Research Application Portal (eBRAP) (<https://eBRAP.org>). Full application packages can be accessed at Grants.gov.

Contact information for the CDMRP Help Desk and the Grants.gov Contact Center can be found in [Section II.G, Federal Awarding Agency Contacts](#).

II.D.2. Content and Form of the Application Submission

Submission is a two-step process requiring both *pre-application* and *full application* as indicated below. The submission process should be started early to avoid missing deadlines. There are no grace periods.

Pre-Application Submission: All pre-applications for extramural organizations must be submitted through eBRAP (<https://eBRAP.org/>).

Full Application Submission: Full applications must be submitted through the online portal as described below.

Full applications from extramural organizations must be submitted through Grants.gov. Applications submitted by extramural organizations (e.g., research foundations) on behalf of intramural DoD or other Federal organizations or investigators will be considered extramural submissions.

A key feature of eBRAP is the ability of an organization's representatives and PIs to view and modify the full application submissions associated with them. eBRAP will validate full application files against the specific Program Announcement requirements and discrepancies will be noted in an email to the PI and in the Full Application Files tab in eBRAP. It is the applicant's responsibility to review all application components for accuracy as well as ensure proper ordering as specified in this Program Announcement.

The application title, eBRAP log number, and all information for the PI, Business Official(s), performing organization, and contracting organization must be consistent throughout the entire pre-application and application submission process. Inconsistencies may delay application processing and limit or negate the ability to view, modify, and verify the application in eBRAP. If any changes need to be made, the applicant should contact the CDMRP Help Desk at help@eBRAP.org or 301-682-5507 prior to the application deadline.

II.D.2.a. Step 1: Pre-Application Submission Content

During the pre-application process, each submission is assigned a unique log number by eBRAP. This unique eBRAP log number will be needed during the full application submission process.

If an error has been made in the selection of extramural versus intramural and the pre-application submission deadline has passed, the PI or Business Official must contact the CDMRP Help Desk at help@eBRAP.org or 301-682-5507.

An invitation to submit a full application package is not required. The pre-application components for the FY17 MSISRP FORWARD Award include a Letter of Intent (LOI).

All pre-application components must be submitted by the PI through eBRAP (<https://eBRAP.org/>).

PIs and organizations identified in the pre-application should be the same as those intended for the subsequent application submission. If any changes are necessary after submission of the pre-application, the PI must contact the CDMRP Help Desk at help@eBRAP.org or 301-682-5507.

The pre-application consists of the following components, which are organized in eBRAP by separate tabs (refer to the General Application Instructions, Section II.B., for additional information on pre-application submission):

- **Tab 1 – Application Information**

- **Tab 2 – Application Contacts**

Enter contact information for the PI. Enter the organization’s Business Official responsible for sponsored program administration (the “person to be contacted on matters involving this application” in Block 5 of the Grants.gov SF424 (R&R) Form). The Business Official must be either selected from the eBRAP list or invited in order for the pre-application to be submitted.

Select the performing organization (site at which the PI will perform the proposed work) and the contracting organization (organization submitting on behalf of the PI, which corresponds to Block 5 on the Grants.gov SF424 (R&R) Form), and click on “*Add Organizations to this Pre-application.*” The organization(s) must be either selected from the eBRAP drop-down list or invited in order for the pre-application to be submitted.

It is recommended that PIs identify an Alternate Submitter in the event that assistance with pre-application submission is needed.

- **Tab 3 – Collaborators and Key Personnel**

Enter the name, organization, and role of all collaborators and key personnel associated with the application.

FY17 Medical Robotics, Autonomous, and Unmanned Capabilities Army Science and Technology (S&T) Steering Committee Members should not be involved in any pre-application or application. For questions related to the membership or advisors of these groups and pre-applications or applications, refer to [Section II.H.2.c, Withdrawal](#), or contact the CDMRP Help Desk at help@eBRAP.org or 301-682-5507.

Submissions that include an FY17 Medical Robotics, Autonomous, and Unmanned Capabilities Army S&T Steering Committee Members (listed below) as an investigator, consultant, collaborator, or in a key personnel role will not be considered.

Mr. Richard Abraham	U.S. Army Tank Automotive Research, Development and Engineering Center
Mr. Tyler Bennett	U.S. Army Medical Materiel Agency (USAMMA)
COL Michael Breslin	Medical Evacuation Proponency Division , U.S. Army Medical Department Center and School (AMEDDC&S), Medical Command (MEDCOM)
LTC Charles Cook	USAMMA
LTC Jason Corley	U.S. Army Medical Department Blood Program, MEDCOM
Col Michael Davis	Combat Casualty Care Research Program
LTC Stephen DeLellis	U.S. Army Special Operations Command (SOCOM)
Col Mark Ervin	U.S. Air Force 59th Medical Wing

Mr. Nathan Fisher	Telemedicine and Advanced Technology Research Center (TATRC)
Mr. James (Jake) Fox	U.S. Army Medical Materiel Development Activity
Dr. Gary Gilbert	TATRC
LCDR David Gribben	U.S. Navy Bureau of Medicine
LTC Stephan Porter	U.S. AMEDDC&S, Health Readiness Center of Excellence
Mr. John Preston	Aviation and Missile Development and Engineering Center, U.S. Army Research, Development and Engineering Command (RDECOM)
Dr. Jaques Reifman	TATRC
Dr. Jose Salinas	U.S. Army Institute of Surgical Research
MSG John Sims	U.S. Army SOCOM
MAJ Eric Wirtz	Tripler Army Medical Center
Mr. Stuart Young	Army Research Laboratory, RDECOM

To preserve the integrity of its peer and programmatic review processes, the CDMRP discourages inclusion of any employee of its review contractors having any role in pre-application or application preparation, research, or other duties for submitted pre-applications or applications. For FY17, the identities of the peer review contractor and the programmatic review contractor may be found at the CDMRP website (<http://cdmrp.army.mil/about/2tierRevProcess>). Pre-applications or applications that include names of personnel from either of these companies will be administratively withdrawn unless plans to manage conflicts of interest (COIs) are provided and deemed appropriate by the Grants Officer. Refer to the General Application Instructions, Appendix 3, for detailed information.

- **Tab 4 – Conflicts of Interest**

List all individuals other than collaborators and key personnel who may have a COI in the review of the application (including those with whom the PI has a personal or professional relationship). Refer to the General Application Instructions, Appendix 3, Section C, for further information regarding COIs.

- **Tab 5 – Pre-Application Files**

Note: Upload documents as individual PDF files unless otherwise noted. eBRAP will not allow a file to be uploaded if the number of pages exceeds the limit specified below.

Letter of Intent (one-page limit): Provide a brief description of the research to be conducted. Include the FY17 MSISRP FORWARD Topic Area and objectives under which the application will be submitted. LOIs are used for program planning purposes only (e.g., reviewer recruitment) and will not be reviewed during either the peer or programmatic review sessions.

- **Tab 6 – Submit Pre-Application**

This tab must be completed for the pre-application to be accepted and processed.

II.D.2.b. Step 2: Full Application Submission Content

All contributors and administrators to the application must use matching compatible versions of Adobe software when editing and preparing application components. The use of different software versions will result in corruption of the submitted file. Refer to the General Application Instructions, Section III, for details on compatible Adobe software.

The CDMRP cannot make allowances/exceptions to its policies for submission problems encountered by the applicant organization using system-to-system interfaces with Grants.gov.

Each application submission must include the completed full application package for this Program Announcement. The full application package is submitted by the Authorized Organizational Representative through Grants.gov (<http://www.grants.gov/>) for extramural organizations or through eBRAP (<https://ebrap.org/>) for intramural organizations. See Table 1 below for more specific guidelines.

II.D.2.b.i. Full Application Guidelines

Extramural organizations, including non-DoD Federal agencies, must submit full applications through Grants.gov.

Table 1. Full Application Submission Guidelines

Application Package Location
Download application package components for W81XWH-17-MSISRP-FOR from Grants.gov (http://www.grants.gov/).
Full Application Package Components
SF424 (R&R) Application for Federal Assistance Form: Refer to the General Application Instructions, Section III.A.1, for detailed information.
Descriptions of each required file can be found under Full Application Submission Components: <ul style="list-style-type: none"> • Attachments • Research & Related Senior/Key Person Profile (Expanded) • Research & Related Budget • Project/Performance Site Location(s) Form • R&R Subaward Budget Attachment(s) Form (if applicable)

Application Package Submission
<p>Submit package components to Grants.gov (http://www.grants.gov). If either the Project Narrative or the budget fails eBRAP validation or if the Project Narrative or the budget needs to be modified, an updated Grants.gov application package must be submitted via Grants.gov as a “Changed/Corrected Application” with the previous Grants.gov Tracking ID prior to the application submission deadline.</p>
<u>Application Verification Period</u>
<p>The full application package submitted to Grants.gov may be viewed and modified in eBRAP until the end of the application verification period. During the application verification period, the full application package, <i>with the exception of the Project Narrative and Budget Form</i>, may be modified.</p>
Further Information
<p>Refer to the General Application Instructions, Section III, for further information regarding Grants.gov requirements.</p>

The organization’s Business Official or Authorized Organization Representative (or Resource Manager/Comptroller) should approve/verify the full application submission prior to the application verification deadline.

Application viewing, modification, and verification in eBRAP are strongly recommended, but not required. *The Project Narrative and Budget cannot be changed after the application submission deadline.* Prior to the full application deadline, a corrected or modified full application package may be submitted. Other application components may be changed until the end of the application verification period. After the end of the application verification period, the full application cannot be modified.

Material submitted after the end of the application verification period, unless specifically requested by the Government, will not be forwarded for processing.

The full application package must be submitted using the unique eBRAP log number to avoid delays in application processing.

II.D.2.b.ii. Full Application Submission Components:

- **Extramural Applications –**

SF424 (R&R) Application for Federal Assistance Form: Refer to the General Application Instructions, Section III.A.1, for detailed information.

Attachments:

Each attachment to the full application components must be uploaded as an individual file in the format specified and in accordance with the formatting guidelines listed in the General Application Instructions, Appendix 4.

For all attachments, ensure that the file names are consistent with the guidance. Attachments will be rejected if the file names are longer than 50 characters or incorrect file names that contain characters other than the following: A-Z, a-z, 0-9, underscore, hyphen, space, and period. In addition, there are file size limits that may apply in some circumstances. Individual attachments may not exceed 20 MB and the file size for the entire full application package may not exceed 200 MB.

- **Attachment 1: Project Narrative (20-page limit):** Upload as “ProjectNarrative.pdf.” The page limit of the Project Narrative applies to text and non-text elements (e.g., figures, tables, graphs, photographs, diagrams, chemical structures, drawings) used to describe the project. Inclusion of URLs that provide additional information to expand the Project Narrative and could confer an unfair competitive advantage is prohibited and may result in administrative withdrawal of the application.

Describe the proposed project in detail using the outline below.

- **Relevance to Topic Area:** State the FY17 MSISRP FORwARD Topic Area and objectives that are being addressed. Establish the relevance of the study to the FY17 MSISRP FORwARD Topic Area and explain the applicability of the proposed findings.
- **Background:** Describe in detail the rationale for the study and include a literature review that led to the development of the proposed project. The background section should clearly support the choice of study variables and should explain the basis for the study questions and/or study hypotheses.
- **Objectives/Specific Aims/Hypotheses:** State the purpose and objectives of the study with detailed specific aims and/or study questions/hypotheses.
- **Study Design:** Describe the experimental design, methods, and analyses/evaluations in sufficient detail for analysis. **Address potential problem areas and present alternative methods and approaches.**
- **Project Milestones:** Identify timelines for critical events that must be accomplished for the project to achieve success in terms of cost, schedule, and performance.
- **Attachment 2: Supporting Documentation:** Combine and upload as a single file named “Support.pdf.” Start each document on a new page. If documents are scanned to PDF, the lowest resolution (100 to 150 dpi) should be used. The Supporting Documentation attachment should not include additional information such as figures, tables, graphs, photographs, diagrams, chemical structures, or drawings. These items should be included in the Project Narrative. Any additional material viewed as an extension of the Project Narrative will be removed or may result in administrative withdrawal of the application.

There are no page limits for any of these components unless otherwise noted. Include only those components described below; inclusion of items not requested will result in

the removal of those items or may result in administrative withdrawal of the application.

- References Cited: List the references cited (including URLs, if available) in the Project Narrative using a standard reference format that includes the full citation (i.e., author[s], year published, title of reference, source of reference, volume, chapter, page numbers, and publisher, as appropriate).
- List of Abbreviations, Acronyms, and Symbols: Provide a list of abbreviations, acronyms, and symbols.
- Facilities, Existing Equipment, and Other Resources: Describe the facilities and equipment available for performance of the proposed project and any additional facilities or equipment proposed for acquisition at no cost to the award. Indicate whether or not Government-furnished facilities or equipment are proposed for use. If so, reference should be made to the original or present Government award under which the facilities or equipment items are now accountable. There is no form for this information.
- Publications and/or Patents: Include a list of relevant publication URLs and/or patent abstracts. If publications are not publicly available, then copies of up to five published manuscripts may be included in Attachment 2. Extra items will not be reviewed.
- Letters of Organizational Support: Provide a letter (or letters, if applicable), signed by the Department Chair or appropriate organization official, confirming the laboratory space, equipment, and other resources available for the project. Letters of support not requested in the Program Announcement, such as those from members of Congress, do not impact application review or funding decisions.
- Letters of Collaboration (if applicable): Provide a signed letter from each collaborating individual or organization that will demonstrate that the PI has the support or resources necessary for the proposed work. If an investigator at an intramural organization is named as a collaborator on an application submitted through an extramural organization, the application must include a letter from the collaborator's Commander or Commanding Officer at the intramural organization that authorizes the collaborator's involvement.
- Intellectual Property: Information can be found in Code of Federal Regulations, Title 2, Part 200.315 (2 CFR 200.315), "Intangible Property."
 - Intangible property acquired, created, or developed under this award will be subject to all rights and responsibilities established at 2 CFR 200.315. Should the applicant intend to use, in the performance of this program, pre-existing, legally protected and perfected intangible property and for which no Federal funds had been used in the development of said property, the applicant must:
 - ❖ Clearly identify all such property;

- ❖ Identify the cost to the Federal Government for use or license of such property, if applicable; or
- Intellectual and Material Property Plan (if applicable): Provide a plan for resolving intellectual and material property issues among participating organizations.
- Data and Research Resources Sharing Plan: Describe how data and resources generated during the performance of the project will be shared with the research community (if applicable). Refer to the General Application Instructions, Appendix 2, Section K, for more information about the CDMRP expectations for making data and research resources publicly available.
- **Attachment 3: Technical Abstract (one-page limit):** Upload as “TechAbs.pdf.” The technical abstract is used by all reviewers. Abstracts of all funded research projects will be posted publicly. *Do not include proprietary or confidential information.* Use only characters available on a standard QWERTY keyboard. Spell out all Greek letters, other non-English letters, and symbols. Graphics are not allowed.

The technical abstract should be clear and concise and, at a minimum, provide the following information:

- **Background:** State the FY17 MSISRP FORwARD Topic Area and objectives that will be addressed by the proposed research. Provide a brief statement of the ideas and theoretical reasoning behind the proposed work.
- **Objective/Hypothesis:** State the objective to be reached or the hypothesis to be tested. Provide evidence or rationale that supports the objective/hypothesis.
- **Specific Aims:** State concisely the specific aims of the study.
- **Study Design:** Briefly describe the study design.
- **Impact:** Provide a brief statement explaining the relevance of the proposed work to improving patient care and enhanced medical provider capabilities in multiple and/or remote geographic locations through the use of advanced and novel technologies.
- **Attachment 4: Lay Abstract (one-page limit):** Upload as “LayAbs.pdf.” The lay abstract is used by all reviewers. Abstracts of all funded research projects will be posted publicly. *Do not include proprietary or confidential information.* Use only characters available on a standard QWERTY keyboard. Spell out all Greek letters, other non-English letters, and symbols. Graphics are not allowed.

Lay abstracts should be written using the outline below:

- Describe the objectives and rationale for the proposed study in a manner that will be readily understood by readers without a background in science or medicine.

- Describe the ultimate applicability and impact of the research.
 - How might it improve patient care and enhance medical provider capabilities in multiple and/or remote geographic locations?
 - What are the potential clinical applications, benefits, and risks?
 - What types of military and/or civilian patients will it help, and how will it help them?
- **Attachment 5: Statement of Work (SOW) (three-page limit):** Upload as “SOW.pdf.” The suggested SOW format and examples specific to different types of research projects are available on the eBRAP “Funding Opportunities & Forms” web page (<https://ebrap.org/eBRAP/public/Program.htm>). For the FY17 MSISRP FORwARD Award mechanism, use the SOW format example titled “SOW for Basic Research.” The SOW must be in PDF format prior to attaching.

The SOW should include a list of major tasks that support the proposed specific aims, followed by a series of subtasks outlined related to the major tasks and milestones within the period of performance. The SOW should describe only the work for which funding is being requested by this application and, as applicable, should also:

Include the name(s) of the key personnel and contact information for each study site/subaward site.

Briefly state the methods to be used.

Identify cell line(s) and commercial or organizational source(s) to be used. If human anatomical substances (including cell lines) will be used, specify whether or not identifiable information is accessible to the research team by any means.

Current Quad Chart: For the FORwARD mechanism, use the format example titled, “Generic Award Charts,” available on the eBRAP “Funding Opportunities & Forms” web page (<https://ebrap.org/eBRAP/public/Program.htm>). The Quad Chart should be representative of the research proposed during the period of performance.

- **Attachment 6: Outcomes and Impact Statement (one-page limit):** Upload as “Impact.pdf.” Explain in detail why the proposed research project is important, as follows:
 - Describe the potential immediate and long-term effect on patient care and how the proposed work would impact the healthcare needs of Service members and/or U.S. Veterans as well as their families, caregivers, and the general public.
 - Describe the anticipated outcome(s)/results(s), design, and/or plan that will be directly attributed to the results of the proposed research.

- Describe the extent to which the research has the potential to generate preliminary data that can be used as a foundation for future research projects.
- Describe how the proposed research project impacts an important scientific question relevant to at least two of the objectives within the applicable FY17 FORwARD Topic Area.
- **Attachment 7: Innovation Statement (two-page limit):** Upload as “Innovation.pdf.” Describe how the proposed project is innovative. Research deemed innovative may introduce a new paradigm, challenge current paradigms, look at existing problems from new perspectives, or exhibit other creative qualities. Investigating the next logical step or incremental advancement on published data is not considered innovative. This may include a description of the innovate features of the proposed conceptual framework, design, and/or plan of key components and how they integrate/communicate with each other.
- **Attachment 8: DoD Military Budget Form(s), if applicable:** Upload as “MFBudget.pdf.” If a military facility (Military Health System facility, research laboratory, medical treatment facility, dental treatment facility, or a DoD activity embedded with a civilian medical center) will be a collaborator in performance of the project, complete the DoD Military Budget Form, available for download on the eBRAP “Funding Opportunities & Forms” web page (<https://ebrap.org/eBRAP/public/Program.htm>), including a budget justification, for each military facility as instructed. The costs per year should be included on the Grants.gov Research and Related Budget form under subaward costs. Refer to the General Application Instructions, Section III.A.7, for detailed information.

Research & Related Senior/Key Person Profile (Expanded): Refer to the General Application Instructions, Section III.A.3, for detailed information.

- PI Biographical Sketch (five-page limit): Upload as “Biosketch_LastName.pdf.” The suggested biographical sketch format is available on the “Funding Opportunities & Forms” web page (<https://ebrap.org/eBRAP/public/Program.htm>) in eBRAP. The National Institutes of Health Biographical Sketch may also be used. All biographical sketches should be submitted in the portable document format (PDF) that is not editable.
- PI Previous/Current/Pending Support (no page limit): Upload as “Support_LastName.pdf.”
- Key Personnel Biographical Sketches (five-page limit each): Upload as “Biosketch_LastName.pdf.”
- Key Personnel Previous/Current/Pending Support (no page limit): Upload as “Support_LastName.pdf.”

Research & Related Budget: Refer to the General Application Instructions, Section III.A.4, for detailed information.

Budget Justification (no page limit): Upload as “BudgetJustification.pdf.” The budget justification for the entire period of performance must be uploaded to the Research & Related Budget after completion of the budget for Period 1.

Project/Performance Site Location(s) Form): Refer to the General Application Instructions, Section III.A.5, for detailed information.

R&R Subaward Budget Attachment(s) Form (if applicable): Refer to the General Application Instructions, Section III.A.6, for detailed information.

- **Extramural Subaward:** Complete the Research & Related Subaward Budget Form through Grants.gov. (Refer to the General Application Instructions, Section III.A.6, for detailed information.)

Intramural DoD Collaborator(s): Complete the DoD Military Budget Form and upload to Grants.gov as **Attachment 8**. (Refer to the General Application Instructions, Section III.A.7, for detailed information.) Intramural DoD Collaborator(s) costs per year should be included on the Grants.gov Research and Related Budget form under subaward costs. **DoD Military Budget Form:** A military facility collaborating in the performance of the project should be treated as a subaward for budget purposes. However, do not complete the Grants.gov R&R Subaward Budget Attachment Form; instead, complete the DoD Military Budget Form (**Attachment 8**) to show all direct and indirect costs. The costs per year should be included on the Grants.gov Research & Related Budget Form under subaward costs. Refer to the General Application Instructions, Section III.A.7, for detailed information.

II.D.3. Dun and Bradstreet Data Universal Numbering System (DUNS) Number and System for Award Management (SAM)

Applicant organizations and all subrecipient organizations must have a DUNS number to submit applications to Grants.gov. The applicant organization must also be registered in the Entity Management functional area of the SAM with an “Active” status to submit applications through the Grants.gov portal. Verify the status of the applicant’s organization’s Entity registration in SAM well in advance of the application submission deadline. Allow 3 to 4 weeks to complete the entire SAM registration process. If an applicant has not fully complied with the requirements by the time the Federal awarding agency is ready to make a Federal award, the Federal awarding agency may determine that the applicant is not qualified to receive a Federal award and use that determination as a basis for making a Federal award to another applicant. Refer to the General Application Instructions, Section III, for further information regarding Grants.gov requirements.

II.D.4. Submission Dates and Times

All submission dates and times are indicated in [Section I, Overview of the Funding Opportunity](#). Pre-application and application submissions are required. The pre-application and application submission process should be started early to avoid missing deadlines. There are no grace periods. Failure to meet either of these deadlines will result in submission rejection.

Applicant Verification of Full Application Submission in eBRAP

Prior to the end of the application verification period, PIs and organizational representatives can review and modify in eBRAP certain components of a submitted application. Following retrieval and processing of the full application, eBRAP will notify the organizational representatives and PI by email to log into eBRAP to review, modify, and verify the full application submission. eBRAP will validate retrieved files against the specific Program Announcement requirements and discrepancies will be noted in both the email and in the Full Application Files tab in eBRAP. eBRAP does not confirm the accuracy of file content. It is the applicant's responsibility to review all application components and ensure proper ordering as specified in the Program Announcement. ***If either the Project Narrative or the budget fails eBRAP validation or needs to be modified, an updated full application package must be submitted prior to the application submission deadline.*** The Project Narrative and Budget Form cannot be changed after the application submission deadline.

II.D.5. Funding Restrictions

The maximum period of performance is **2** years.

The anticipated total costs budgeted for the entire period of performance will not exceed **\$1.3M**. If indirect cost rates have been negotiated, indirect costs are to be budgeted in accordance with the organization's negotiated rate. No budget will be approved by the Government exceeding **\$1.3M** total costs or using an indirect cost rate exceeding the organization's negotiated rate.

All direct and indirect costs of any subaward or contract must be included in the total direct costs of the primary award.

The applicant may request the entire maximum funding amount for a project that may have a period of performance less than the maximum **2** years.

For this award mechanism, direct costs must be requested for:

Travel costs for the PI to disseminate project results at one DoD In-Progress Review meeting per year of funding. For planning purposes, it should be assumed that the meeting will be held in the National Capital Area. These travel costs are in addition to those allowed for annual scientific/technical meetings.

May be requested for (not all-inclusive):

- Salary
- Research supplies
- Equipment
- Travel between collaborating institutions, including travel to military/Government facilities
- Support for multidisciplinary collaborations, including travel

- Travel costs for up to two investigators to travel to two scientific/technical meetings per year in addition to the required meeting described above

Must not be requested for:

- Clinical trial costs

Extramural (non-Federal) awards will consist solely of assistance agreements (Cooperative Agreements and Grants). For extramural awards with an intragovernmental component, direct transfer of funds from an extramural award recipient to a DoD or other Federal agency is not allowed except under very limited circumstances. Funding to intramural DoD and other Federal agencies will be managed through a direct fund transfer.

Refer to the General Application Instructions, Section III.A.4, for budget regulations and instructions for the Research & Related Budget. *For Federal agencies or organizations collaborating with Federal agencies, budget restrictions apply as are noted in the General Application Instructions, Section III.A.4.*

The MSISRP expects to allot approximately \$2.6M of the FY17 Army RDT&E 6.1-Basic Research appropriation to fund approximately one (1) FORwARD award application per Topic Area for a total of two (2) awards for the FORwARD mechanism, depending on the quality and number of applications received.

II.D.6. Other Submission Requirements

Refer to the General Application Instructions, Appendix 4, for detailed formatting guidelines.

II.E. Application Review Information

II.E.1. Criteria

II.E.1.a. Peer Review

To determine technical merit, all applications will be evaluated according to the following scored criteria, of which **Innovation** is the most significant. The remaining scored criteria are of equal importance:

- **Innovation**
 - To what extent the proposed research will provide new insights, paradigms, technologies, or applications with the potential to impact the research field and/or patient care.
 - To what extent the proposed research represents more than an incremental advance upon published data or more than the next logical step in a research project.
- **Research Strategy and Feasibility**
 - To what degree the stated objectives are clear, valid, and logical.

- How well the scientific rationale supports the proposed research project and its feasibility.
- To what degree the hypothesis proposed is clearly defined and testable.
- To what extent the specific aims, experimental design, methods, and analyses are appropriate to test the hypothesis.
- How well potential problems are identified and alternative approaches are addressed.
- Whether the proposed timeline is appropriate and tasks outlined in the application are logical in their progression.
- **Scientific Design Excellence**
 - To what degree does the proposed plans, methods, techniques, and procedures are feasible, clear, valid, adequately referenced, and state-of-the-art.
 - To what extent were literature searches used to document the strengths of the proposed project.
 - Whether the proposed product/technology development plan is feasible.
 - How well is the engineering/technical design likely to achieve the goals indicated; adequacy of the engineering/design solutions; and how well the perceived engineering/design strengths and weaknesses are addressed.
- **Impact/Relevance**
 - To what extent the proposed research project addresses an important scientific question relevant to at least two of the objectives within the applicable FY17 FORwARD Topic Area.
 - To what extent the research has the potential to generate preliminary data that can be used as a foundation for future research projects.
 - To what extent the proposed research has potential for short-term and/or long-term impact on the field of study and/or patient care.
- **Personnel**
 - How the composition and balance of the research team (including other organization personnel, sub-awards, and consultants, as applicable) are appropriate.
 - To what degree the PI's and research team's backgrounds and expertise are appropriate and complementary to accomplishing the proposed work.
 - To what degree the levels of effort by the PI and other key personnel are appropriate to ensuring the success of proposed research.

- Whether there is evidence for appropriate institutional commitment.

In addition, the following unscored criteria will also contribute to the overall evaluation of the application:

- **Budget**

- Whether the budget is appropriate for the proposed project and within the limitations of this Program Announcement.

- **Intellectual Property and Transition Plan**

- If applicable, to what degree the intellectual property plan is appropriate.
- To what degree the transition plan is appropriate.

- **Application Presentation**

- To what extent the writing, clarity, and presentation of the application components influence the review.

- **Environment**

- To what degree the research environment and the accessibility of institutional resources support the proposed study (including collaborative arrangements).

II.E.1.b. Programmatic Review

To make funding recommendations and select the application(s) that, individually or collectively, will best achieve the program objectives, the following criteria are used by programmatic reviewers:

- Ratings and evaluations of the peer reviewers
- Relevance to the mission of the Army and FY17 MSISRP, as evidenced by the following:
 - Adherence to the intent of the award mechanism
 - Program portfolio composition
 - Military relevance and public purpose
 - Relative impact and innovation
 - Proposed project timelines with respect to the proposed budget

- Data and Resource Sharing Plan
 - To what degree the intellectual property components may limit future flexibility or adaptation of the technology to meet future Government needs
 - Degree of public accessibility of outcomes

II.E.2. Application Review and Selection Process

All applications are evaluated by scientists, clinicians, and consumers in a two-tier review process. The first tier is peer review of applications against established criteria for determining technical merit. Each application is evaluated for its own merit, independent of other applications. The second tier is a programmatic review that makes recommendations for funding to the Commanding General, USAMRMC, based on technical merit, the relevance to the mission of the Army and MSISRP, the specific intent of the award mechanism, and to other specified evaluation criteria in the Program Announcement. Programmatic review is a comparison-based process in which applications with scientific and technical merit compete in a common pool.

The highest-scoring applications from the first tier of review are not automatically recommended for funding. Funding recommendations depend on various factors as described in [Section II.E.1.b, Programmatic Review](#). Additional information about the two-tier process used by the CDMRP can be found at <http://cdmrp.army.mil/about/fundingprocess>.

All CDMRP review processes are conducted confidentially to maintain the integrity of the merit-based selection process. Panel members sign a statement that application and evaluation information will not be disclosed outside the panel. Violations of confidentiality can result in the dissolving of a panel(s) and other corrective actions. In addition, personnel at the applicant or collaborating organizations are prohibited from contacting persons involved in the review process to gain protected evaluation information or to influence the evaluation process. Violations of these prohibitions will result in the administrative withdrawal of the organization's application. Violations by panel members or applicants that compromise the confidentiality of the review process may also result in suspension or debarment from Federal awards. Furthermore, the unauthorized disclosure of confidential information of one party to another third party is a crime in accordance with 18 USC 1905.

II.E.3. Integrity and Performance Information

Prior to making an assistance agreement award where the Federal share is expected to exceed the simplified acquisition threshold (currently \$150,000) over the period of performance, the Federal awarding agency is required to review and consider any information about the applicant that is available in the Federal Awardee Performance and Integrity Information System (FAPIIS).

An applicant, at its option, may review FAPIIS, accessible through SAM, and submit comments to FAPIIS on any information about itself that a Federal awarding agency previously entered and is currently available in FAPIIS.

The Federal awarding agency will consider any comments by the applicant, in addition to other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics and record of performance under Federal awards when

determining a recipient's qualification prior to award, according to the qualification standards of the Department of Defense Grant and Agreement Regulations (DoDGAR), Section 22.415.

II.E.4. Anticipated Announcement and Federal Award Dates

All application review dates and times are indicated in [Section I, Overview of the Funding Opportunity](#).

Each PI and organization will receive email notification of posting of the funding recommendation in eBRAP. Each PI will receive a peer review summary statement on the strengths and weaknesses of the application.

II.F. Federal Award Administration Information

II.F.1. Federal Award Notices

Awards will be made no later than September 30, 2018. Refer to the General Application Instructions, Appendix 2, for additional award administration information.

Awards are made to organizations, not to individual PIs. The types of awards made under the Program Announcement will be assistance agreements (grants or cooperative agreements). The level of involvement on the part of DoD during project performance is the key factor in determining whether to award a grant or cooperative agreement.

An assistance agreement (grant or cooperative agreement) is appropriate when the Federal Government transfers a "thing of value," to a "state, local government," or "other recipient," to carry out a public purpose of support or stimulation authorized by a law of the United States, instead of acquiring property or service for the direct benefit and use of the U.S. Government. An assistance agreement can take the form of a grant or cooperative agreement. If "no substantial involvement" on the part of the funding agency is anticipated, a grant award will be made (31 USC 6304). Conversely, if substantial involvement on the part of the funding agency is anticipated, a cooperative agreement will be made (31 USC 6305). Substantial involvement may include collaboration, participation, or intervention in the research to be performed under the award. The award type, along with the start date, will be determined during the negotiation process.

After email notification of application review results through the eBRAP, and if selected for funding, a representative from the USAMRAA will contact the business official authorized to negotiate on behalf of the PI's organization.

Only an appointed USAMRAA Grants Officer may obligate the Government to the expenditure of funds. No commitment on the part of the Government should be inferred from discussions with any other individual. The award document signed by the Grants Officer is the official authorizing documents.

After email notification of application review results through the eBRAP, and if selected for funding, a representative from the CDMRP will contact the business official authorized to negotiate on behalf of the PI's organization.

II.F.1.a. PI Changes and Award Transfers

Changes in PI are not allowed, except under extenuating circumstances that will be evaluated on a case-by-case basis and at the discretion of the Grants Officer. An organizational transfer of an award will not be allowed in the last year of the (original) period of performance or any extension thereof.

Refer to the General Application Instructions, Appendix 2, Section B, for general information on organization or PI changes.

II.F.2. Administrative and National Policy Requirements

In-person presentations may be requested for each funded year of the award. Applicable requirements in the DoDGARs found in 32 CFR, Chapter 1, Subchapter C and 2 CFR, Chapter XI, apply to grants and cooperative agreements resulting from this Program Announcement.

Refer to the General Application Instructions, Appendix 2, for general information regarding administrative requirements.

Refer to the General Application Instructions, Appendix 5, for general information regarding national policy requirements.

Refer to full text of the [USAMRAA General Research Terms and Conditions for Institutions of Higher Education, Hospitals, and Non-Profit Organizations](#) and the [USAMRAA General Research Terms and Conditions with For-Profit Organizations](#) for further information.

II.F.3. Reporting

Refer to the General Application Instructions, Appendix 2, Section A, for general information on reporting requirements. Annual progress reports as well as a final progress report will be required.

Quarterly progress reports and quad charts will be required.

Awards resulting from this Program Announcement will incorporate additional reporting requirements related to recipient integrity and performance matters. Recipient organizations that have Federal contract, grant, and cooperative agreement awards with a cumulative total value greater than \$10,000,000 are required to provide information to FAPIIS about certain civil, criminal, and administrative proceedings that reached final disposition within the most recent 5-year period and that were connected with performance of a Federal award. Recipients are required to disclose semiannually information about criminal, civil, and administrative proceedings as specified in the applicable Terms and Conditions. The applicable Terms and Conditions for institutions of higher education, hospitals, and nonprofit organizations are available in OAR Article I, Section B, in the [July 2016 R&D General Terms and Conditions](#).

The applicable Terms and Conditions for for-profit organizations are available in Section 34 of the [February 2017 USAMRAA General Research Terms and Conditions with For-Profit Organizations](#).

II.G. Federal Awarding Agency Contacts

II.G.1. CDMRP Help Desk

Questions related to Program Announcement content or submission requirements as well as questions related to the pre-application or intramural application submission through eBRAP should be directed to the CDMRP Help Desk, which is available Monday through Friday from 8:00 a.m. to 5:00 p.m. ET. Response times may vary depending upon the volume of inquiries.

Phone: 301-682-5507

Email: help@eBRAP.org

II.G.2. Grants.gov Contact Center

Questions related to extramural application submission through Grants.gov portal should be directed to the Grants.gov Contact Center, which is available 24 hours a day, 7 days a week (closed on U.S. Federal holidays). Note that the CDMRP Help Desk is unable to provide technical assistance with Grants.gov submission.

Phone: 800-518-4726; International 1-606-545-5035

Email: support@grants.gov

Sign up on Grants.gov for “send me change notification emails” by following the link on the Synopsis page for the Program Announcement or by responding to the prompt provided by Grants.gov when first downloading the Grants.gov application package. If the Grants.gov application package is updated or changed, the original version of the application package may not be accepted by Grants.gov.

II.H. Other Information

II.H.1. Program Announcement and General Application Instructions Versions

Questions related to this Program Announcement should refer to the Program name, the Program Announcement name, and the Program Announcement version code 20170516d. The Program Announcement numeric version code will match the General Applications Instructions version code 20170516.

II.H.2. Administrative Actions

After receipt of applications, the following administrative actions may occur:

II.H.2.a. Rejection

The following will result in administrative rejection of the application:

- Project Narrative exceeds page limit.
- Project Narrative is missing.
- Budget is missing.

II.H.2.b. Modification

- Pages exceeding the specific limits will be removed prior to review for all documents other than the Project Narrative.
- Documents not requested will be removed.

II.H.2.c. Withdrawal

The following may result in administrative withdrawal of the pre-application or application:

- An FY17 Medical Robotics, Autonomous, and Unmanned Capabilities Army S&T [Steering Committee Member](#) is named as being involved in the research proposed or is found to have assisted in the pre-application or application processes including, but not limited to, concept design, application development, budget preparation, and the development of any supporting documentation.
- The applicant does not address at least two of the research objectives within one of the two Topic Areas.
- The applicant is named on more than one FY17 MSIS FORwARD award application per Topic Area as a PI.
- The application fails to conform to this Program Announcement description to the extent that appropriate review cannot be conducted.
- Inclusion of URLs, with the exception of links in References Cited and Publication and/or Patent Abstract sections.
- Page size is larger than 8.5 inches x 11.0 inches (approximately 21.59 cm x 27.94 cm).
- To preserve the integrity of its peer and programmatic review processes, the CDMRP discourages inclusion of any employee of its review contractors having any role in the preparation, research or other duties for submitted applications. For FY17, the identities of the peer review contractor and the programmatic review contractor may be found at the CDMRP website (<http://cdmrp.army.mil/about/2tierRevProcess>). Applications that include names of personnel from either of these companies will be administratively withdrawn unless plans to manage COIs are provided and deemed appropriate by the Grants Officer. Refer to the General Application Instructions, Appendix 3, for detailed information.

- Personnel from applicant or collaborating organizations are found to have contacted persons involved in the review process to gain protected evaluation information or to influence the evaluation process.
- Applications from extramural organizations, including non-DoD Federal agencies, received through eBRAP may be withdrawn.

II.H.2.d. Withhold

Applications that appear to involve research misconduct will be administratively withheld from further consideration pending organizational investigation. The organization will be required to provide the findings of the investigation to the USAMRAA Grants Officer for a determination of the final disposition of the application.

II.H.3. Application Submission Checklist

Application Components	Action	Completed
SF424 (R&R) Application for Federal Assistance	Complete form as instructed.	
Attachments	Project Narrative: Upload as Attachment 1 with file name "ProjectNarrative.pdf."	
	Supporting Documentation: Upload as Attachment 2 with file name "Support.pdf."	
	Technical Abstract: Upload as Attachment 3 with file name "TechAbs.pdf."	
	Lay Abstract: Upload as Attachment 4 with file name "LayAbs.pdf."	
	Statement of Work: Upload as Attachment 5 with file name "SOW.pdf."	
	Outcomes and Impact Statement: Upload as Attachment 6 with file name "Impact.pdf."	
	Innovation Statement: Upload as Attachment 7 with file name "Innovation.pdf."	
	DoD Military Budget Form(s): Upload as Attachment 8 with file name "MFBudget.pdf," if applicable.	
Research & Related Senior/Key Person Profile (Expanded)	Attach PI Biographical Sketch (Biosketch_LastName.pdf) to the appropriate field.	
	Attach PI Previous/Current/Pending Support (Support_LastName.pdf) to the appropriate field.	
	Attach Biographical Sketch (Biosketch_LastName.pdf) for each senior/key person to the appropriate field.	
	Attach Previous/Current/Pending (Support_LastName.pdf) for each senior/key person to the appropriate field.	
Research & Related Budget	Complete as instructed. Attach Budget Justification (BudgetJustification.pdf) to the appropriate field.	
Project/Performance Site Location(s) Form	Complete form as instructed.	
R&R Subaward Budget Attachment(s) Form, if applicable	Complete form as instructed.	

APPENDIX 1: ACRONYM LIST

AMEDDC&S	U.S. Army Medical Department Center and School
CASEVAC	Casualty Evacuation
CDMRP	Congressionally Directed Medical Research Programs
CFR	Code of Federal Regulations
COI	Conflict of Interest
DoD	Department of Defense
DoDGAR	Department of Defense Grant and Agreement Regulations
DUNS	Data Universal Numbering System
eBRAP	Electronic Biomedical Research Application Portal
ET	Eastern Time
FAD	Funding Authorization Document
FAPIIS	Federal Awardee Performance and Integrity Information System
FHM	Functional Hemodynamic Monitoring
FORwARD	Toward A Next-Generation Trauma Care System: Foundational Research for Autonomous, Unmanned, and Robotics Medical Technologies
FY	Fiscal Year
LOI	Letter of Intent
M	Million
MDB	Multi-Doman Battlefield
MEDCOM	U.S. Army Medical Command
MIPR	Military Interdepartmental Purchase Request
MSISRP	Medical Simulation and Information Sciences Research Program
ORCID	Open Researcher and Contributor ID, Inc.
PI	Principal Investigator
RDECOM	U.S. Army Research, Development and Engineering Command
RDT&E	Research, Development, Test, and Evaluation
S&T	Science and Technology
SAM	System for Award Management
SOCOM	U.S. Army Special Operations Command
SOW	Statement of Work
TATRC	Telemedicine and Advanced Technology Research Center
USAMMA	U.S. Army Medical Materiel Agency
USAMRAA	U.S. Army Medical Research Acquisition Activity
USAMRMC	U.S. Army Medical Research and Materiel Command
USC	United States Code
UMS	Unmanned Systems
VA	Department of Veterans Affairs

Multi-Domain Battle: Combined Arms for the 21st Century



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Distribution Statement A

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Purpose and Scope

This *Multi-Domain Battle: Combined Arms for the 21st Century* white paper describes a coordinated Army and Marine Corps approach for ground combat operations against a sophisticated peer enemy threat in the 2025-2040 timeframe. It is intended to promote thought and discussion concerning the methods and capabilities required to confront sophisticated threats. It offers specific hypotheses to inform further concept development, wargaming, experimentation, and capability development. This paper encompasses the views of the Army and Marine Corps regarding an endeavor that involves the entire joint team. It is therefore published with the expectation that the ideas herein will, in concert with the other Services, be refined and expanded into appropriate joint concepts.¹

Background

To address challenges of defeating a numerically superior adversary, the U.S. Army and U.S. Air Force began development of the AirLand Battle concept in the late 1970s. Approved as doctrine in 1982, AirLand Battle defined the manner in which large-scale ground combat operations would be conducted against a peer adversary. Among its key characteristics were the notions of Integrated Battle and the Extended Battlefield. Integrated Battle necessitated that every asset at a commander's disposal be employed to achieve defeat of the enemy while the Extended Battlefield embraced the concept of the 'deep battle.'² The concept propelled military advances through the end of the Cold War.

When the Cold War ended, U.S. defense policy postulated that a new era had dawned in which conflict against a peer adversary was unlikely. This hypothesis was supported by operations throughout the 1990s in which the U.S. military applied the relative conventional superiority it developed in competition with the Warsaw pact to dominate a larger conventionally armed opponent and subsequently conducted a number of low-intensity or limited-commitment conflicts. The loss of a clear strategic peer adversary, combined with the resultant shift in operational commitments and budgetary considerations, triggered a reduction in military capacity that was, at the time, justified by the nature of ongoing operations.

The limited operations of the 1990s realized an expansion in the reliance on systems that enabled precision standoff strike capability, while the capacity and capabilities required for the close fight, such as maneuver forces and counter-IED, atrophied. Technologically advanced deep-strike systems underpinning the standoff approach were seen as cheaper alternatives to even more expensive personnel and organizations, so capacity in ground combat organizations was reduced. Although assets for the close fight were periodically updated to extend service life,

¹ The Joint Operational Access Concept (JOAC) identifies the problem of projecting military force into an operational area and sustaining it in the face of armed opposition by increasingly capable enemies and within contested domains. The JOAC proposes employing cross-domain synergy—the complementary vice merely additive employment of capabilities in different domains such that each enhances the effectiveness and compensates for the vulnerabilities of the others—to establish superiority in some combination of domains that will provide the freedom of action required by the mission.

² John Romjue, *From Active Defense to AirLand Battle: The Development of Army Doctrine, 1973-1982*, pp. 23-44. Douglas Skinner, *AirLand Battle Doctrine*. Professional Paper 463 September 1988, Center For Naval Analysis pp 17-20.

there was little innovation in close fight capabilities during this period. Entering a new century, defense planners envisioned future conflict in which the ground combat forces played a reduced role in destroying enemy combat forces.

However, soon after the 21st Century began, the U.S. conducted two decisive, offensive joint campaigns, extending into unanticipated counterinsurgency campaigns. These campaigns did not necessitate the procurement of advanced ground combat platforms because the adversary employed capabilities that placed a premium on U.S. protective adaptations. The focus of training and equipping the force shifted from defeating a peer adversary to defeating an asymmetrical and terrorist threat. A decade and a half of counterinsurgency campaigns, coupled with the drawdown and repositioning of forward deployed forces to CONUS, and the continued stagnation of close fight capabilities further eroded the ability of the U.S. military to confront a peer adversary.

Concurrent with the decline of U.S. conventional capabilities for the close fight, potential adversaries were analyzing the manner in which U.S. armed forces deployed combat power and executed operations to develop methods for countering American advantages in all domains.

Adversary developments, as will be discussed, challenge U.S. abilities to conduct decisive operations and necessitate a reexamination of the method for executing operations against a peer adversary.

Whereas AirLand Battle focused primarily on two domains, the modern operating environment calls for new concepts to counter adversary adaptations by fighting in a coherent manner across five domains. Today and into the future, the U.S. will have to confront adversaries contesting the physical domains of air, land, sea, and space, the ‘abstract’ domain of cyberspace, as well as the electromagnetic spectrum (EMS), the information environment, and the cognitive dimension of warfare.³ As a result, U.S. forces must evolve the way they are organized, trained, equipped, and postured in order to deter and, if necessary, defeat potential adversaries.

The Emerging Operational Environment

Studies of the emerging operational environment describe a future of contested norms and persistent disorder.⁴ Revisionist states, operating under the threshold that would trigger decisive U.S. response, seek to alter the post-Cold War security order by coercing

Highlights of Emerging Operational Environment

- *Aggressive revisionist peer states challenge U.S. and allied interests*
- *U.S. comparative military advantage has diminished*
 - *U.S. forces are challenged in all domains, the EMS, and the cognitive dimension of warfare*
 - *Presumptive loss of air supremacy*
- *Ground combat capabilities and capacities are out of balance for conflict with peer adversaries*
- *U.S. forces are ill postured to deter conflict*

³ The Joint services recognize five domains – air, land, maritime, space and cyberspace. This paper highlights the EMS, information environment and cognitive dimension of warfare as additional contested areas that must be addressed by U.S. forces.

⁴ Contested norms involves increasingly powerful revisionist states and select non-state actors using any and all elements of power to establish

neutrals, U.S. partners, and allies through economic pressure, disinformation, and the threat of military force. Potential enemies will use deception, surprise, speed, and all elements of national power to exploit seams within established U.S. operating methods. Moreover, their own set of rules unfavorable to the United States and its interests. Persistent disorder is characterized by an array of weak states that become increasingly incapable of maintaining domestic order or good governance. Publications supporting this assessment include the Joint Operating Environment 2035; Worldwide Threat Assessment of the U.S. Intelligence Community, Senate Select Committee on Intelligence, Feb 2016; Military and Security Developments Involving the People's Republic of China 2015, Annual Report to Congress; RAND, The Challenges of the "Now" and Their Implications for the U.S. Army.

These adversaries may manipulate the risks of escalation by threatening use of weapons of mass destruction or disruption.⁵ These actions exploit perceived U.S. weaknesses such as time and distance for force deployment, sustainment, and vulnerable bases, ports, and command and control networks. By operating in this manner, adversaries achieve their objectives by creating a *fait accompli* before U.S. forces can adequately respond.⁶

Adversaries have studied the manner in which the U.S. coordinates technical reconnaissance, satellite-based communications, and air and maritime power to enable ground freedom of maneuver and overmatch.⁷ Highly advanced potential adversaries are developing methods to counter U.S. strengths in the air and maritime domain as well as degrading key capabilities by disrupting access to land, space, cyberspace, and the EMS. Adversaries will also use information warfare to influence U.S. decision makers and domestic and international sentiment. These methods conceivably turn long-presumed strengths into potential weaknesses. As a result, the current U.S. comparative military advantage and the ability to conduct uncontested operations against a sophisticated enemy have diminished.

U.S. forces can no longer assume continuous superiority in any domain because potential adversaries have made strides to disrupt the effectiveness, or deny the use of U.S. combat capabilities. Increasingly complex air, land, sea, space, and cyber capabilities allow adversaries to potentially contest U.S. force dominance.⁸ This situation is exacerbated by the optimization of ground and air forces towards counterinsurgency operations which further reduces the ability to effectively counter sophisticated threats. In contrast to counterinsurgency operations, future U.S. forces will likely confront the sensor-rich militaries of peer states that employ both massed and precision-guided munitions across the depth and breadth of highly lethal battlefields. U.S. forces must anticipate being contested in all domains across a vastly extended area of operations by enemies that possess systems that match or exceed existing U.S. ground combat capabilities.

⁵ Weapons of mass disruption potentially include cyber-attack or wide area electromagnetic pulse (EMP) attack.

⁶ A *fait accompli* is a thing accomplished and presumably irreversible. (Merriam-Webster Dictionary).

⁷ Overmatch is defined as the application of capabilities or unique tactics either directly or indirectly, with the intent to prevent or mitigate opposing forces from using their current or projected equipment or tactics.

⁸ Joint Vision 2020 called for full spectrum dominance wherein that U.S. forces [would be] able to conduct prompt, sustained, and synchronized operations with combinations of forces tailored to specific situations and with access to and freedom to operate in all domains; space, sea, land, air, and information. A key enabler to this was the ability to achieve superiority in all domains and the information environment.

A critical concern for future U.S. operations is the loss of presumptive air superiority resulting from adversary advancements. The difficulty in achieving air supremacy, or even localized air superiority, against sophisticated adversaries has significant implications under current operational constructs.⁹ Forces designed for, and accustomed to, air supremacy will face significant challenges in executing effective and efficient operations such as close air support for ground combat, air reconnaissance, and air mobility. Thus, the emerging operational environment is significantly different from the recent past as adversaries challenge U.S. air supremacy.

More specifically, adversaries can contest U.S. air supremacy through the development of complex integrated air defense networks, missile capabilities, electronic warfare capabilities, and highly sophisticated 4th and 5th generation aircraft. In strategically important regions, the density of complex integrated air defense networks enables adversaries to contest or deny friendly air superiority from the ground, and the resilience and density of these systems means that even major strike operations against these networks may only achieve localized and temporary results.¹⁰ Unless countered, these integrated air defense networks further complicate friendly ground combat operations by providing protection under which adversary ground forces can operate relatively free from the effects of airpower. Provided the dispersion, deception, and camouflage inherent in their employment, current integrated air defense networks can inhibit effective targeting and prevent joint fires from striking throughout the depth of enemy formations.

Enemy missile capabilities provide another significant challenge to friendly forces by enabling deep strike without reliance on manned aircraft. Peer adversaries possess numerous, modernized ballistic and cruise missiles with ever increasing precision and speed threatening command and control nodes as well as maneuver and support forces and infrastructure.

Complementing enemy missile capability are offensive electronic warfare capabilities, a fleet of fourth and fifth generation aircraft and the full range of armed and unarmed unmanned aerial vehicles, which provide additional highly capable methods for long-range strike and targeting, especially when facing limited U.S. ground-based air defenses. Designed under the presumption of friendly air and maritime supremacy, current U.S. ground forces require large-signature sustainment facilities and command nodes that are vulnerable to long-range missile and rocket attacks. Similarly, adversary coastal defense cruise missile capabilities increase hazards to maritime maneuver by placing naval assets at risk. The extended range and increasing number of these adversary missiles, coupled with significant reductions in friendly air defense capabilities, place large and fixed airbases at risk and limits the ability to project air power.

Adversary missiles, protected by an effective air defense network and sophisticated aircraft, compel U.S. forces to operate at greater ranges and in a more dispersed manner, placing a

⁹ Air supremacy is defined as that degree of air superiority wherein the opposing force is incapable of effective interference within the operational area using air and missile threats. Air superiority is that degree of dominance in the air battle by one force that permits the conduct of its operations at a given time and place without prohibitive interference from air and missile threats. (JP 3-01).

¹⁰ As an example, Russia has effectively used these systems to achieve air superiority from the ground in the Ukraine.

premium on command and control to effectively coordinate operations and provide persistent sustainment.

U.S. forces cannot assume unhindered access to any domain or the EMS required for current reconnaissance and command and control systems to function effectively. Adversaries are developing capabilities specifically designed to attack U.S. platforms, systems, and networks.

U.S. forces currently possess limited countermeasures to such attacks that could severely limit friendly battlespace awareness by degrading reconnaissance; command and control systems; position, navigation, and timing (PNT); and disrupt force deployment activities and other logistics operations. The loss of assumed superiority in the air, maritime, space, and cyberspace domains severely inhibits the effectiveness of stand-off targeting and strikes. A lack of situational understanding, when coupled with adversary advances that threaten disruption of supporting fires, diminishes U.S. forces' ability to win major ground combat operations.

When coupled with the loss of assured superiority in other domains and more than a decade focusing on counterinsurgency, U.S. ground combat capabilities and capacities are out of balance to effectively confront emerging conditions presented by potential adversaries. Aging ground combat assets and the limited procurement of technologically advanced systems have created a situation in which adversary ground formations now have parity or overmatch with U.S. forces in capability and capacity. The U.S. is now at a marked disadvantage in the range, lethality, protection, and mobility of many ground-based weapons systems. For example, the latest generation of adversary combat vehicles offer equivalent, and in some cases, superior protection and lethality to U.S. tanks, fighting vehicles, and amphibious vehicles. Furthermore, potential enemies have artillery systems with greater ranges and in greater quantity than comparable U.S. systems, as well as munitions with greater lethality. Some nations have demonstrated the ability to locate and identify targets with UAS and mass long range fires with devastating effects.¹¹ Absent a modernized U.S. tactical air defense network as well as the ability to provide effective counterfire, adversaries may create overmatch by using their UAS to locate, track, and target exposed U.S. forces and facilities, and then employ massed direct and indirect fires to destroy vital assets and formations.

Current adversary capability developments present an expanded battlefield that can contest U.S. forces from deployment to employment. Not only do U.S. ground combat forces lack sufficient capacity of capabilities, but they are also out of position to deter adversaries, assure allies, and deny or defeat enemies if hostilities start. The time required to deploy U.S. forces from distant locations forfeits the initiative to adversary conventional and unconventional forces. Complex defensive networks can disrupt flexible deterrent options and subsequent build-up of U.S. and allied combat power should deterrence fail. Given these conditions, forward-positioned air, ground, and maritime forces capable of persisting within the arc of enemy long range fires are a decisive factor in deterring adversary aggression.¹² These forces provide both a political

¹¹ Russia recently exhibited an effective tactical-level linkage of UAS reconnaissance capability with long range artillery fires in Ukraine.

¹² Maritime forces are those forces that operate on, under, or above the sea to gain or exploit command of the sea, sea control, or sea denial and/or to project power from the sea. (DoDD 5100.01: The Navy and Marine Corps comprise the Nation's principal maritime force.)

deterrent as well as the ability to contest aggression until additional combat power can be deployed.

Implications of the Operational Environment

Over the last 25 years, assumptions of air, land, maritime, space, and cyberspace domain superiority drove the doctrine, equipment, and posture of U.S. forces. These assumptions are proving to be invalid in light of recent changes to adversary capabilities, capacities, and approaches. Potential adversaries now possess capabilities that allow them to contest both the deployment and employment of U.S. forces in greatly expanded areas of operation, interest, and influence. U.S. forces are not organized, trained, equipped, and postured to properly contest emerging and potential threats. As a result, the freedom of action required to support U.S. policy, by deterring, and if necessary, defeating potential enemies is at risk.

Military Problem

U.S. ground combat forces, operating as part of a joint, interorganizational, and multinational teams, are currently not sufficiently trained, organized, equipped, nor postured to deter or defeat highly-capable peer enemies to win in future war.¹³

Solution Synopsis

Multi-Domain Battle: Combined Arms for the 21st Century requires ready and resilient Army and Marine Corps combat forces capable of outmaneuvering adversaries physically and cognitively through the extension of combined arms across all domains¹⁴. Through credible forward presence and resilient battle formations, future Army and Marine Corps forces integrate and synchronize capabilities as part of a joint team to create temporary windows of superiority across multiple domains and throughout the depth of the battlefield in order to seize, retain, and exploit the initiative; defeat enemies; and achieve military objectives.

Multi-Domain Battle: Combined Arms for the 21st Century evolves combined arms methodology to include not only those capabilities of the physical domains, but also greater emphasis on space, cyberspace, and other contested areas such as the EMS, the information environment, and the cognitive dimension of warfare. Combined arms integrates capabilities in such a way that to counteract one, the adversary must become more vulnerable to another.¹⁵ Application of combined arms from the air, land, sea, and space has proven to be a combat tested method for success. The incorporation of other domains and contested areas is necessary to confront the realities of the modern battlefield and to generate advantages not possible through the application of combined arms solely in the air, land, or maritime domains. Multi-domain combined arms provide commanders numerous options for executing simultaneous and sequential operations

¹³ Interorganizational refers to elements of U.S. government agencies; state, territorial, local, and tribal agencies; foreign government agencies; intergovernmental, nongovernmental and commercial organizations. (Does not include forces). (Derived from JP 3-08).

¹⁴ Outmaneuvering adversaries in the cognitive dimension is the use of information to confound the enemy's situational understanding and decision making, thereby creating advantage for the joint force.

¹⁵ Combined arms is the synchronized and simultaneous application of arms to achieve effect greater than if each arm was used separately or sequentially.

using surprise and speed of action to present multiple dilemmas to an adversary in order to gain physical and psychological advantages, influence and control over the multi-domain operational environment. In executing this concept, air, ground and maritime forces project power outward from land and sea into other domains and contested spaces to support U.S. freedom of action. Thus, U.S. forces strive to affect an adversary in both the physical and abstract domains creating dilemmas too numerous to counter.

To generate and exploit psychological, technological, temporal and spatial advantages over an adversary, ground combat forces must physically and cognitively outmaneuver enemies. This is achieved by holistically employing reconnaissance, movement, fires, and information to avoid surfaces, identify gaps, and create and exploit windows of advantage.¹⁶ U.S. forces must simultaneously use signature control, defensive systems, and over-watch fires to establish temporary zones of protection for friendly forces to operate. The exploitation of gaps and seams in enemy intelligence, surveillance, reconnaissance, protection, and strike systems should be synchronized with the establishment of temporary protective zones for friendly forces. This should allow maneuver elements to sequence opportunistic action to exploit enemy vulnerabilities and seize positions of relative advantage.

The Army and Marine Corps will meet the demands of future conflict by task-organizing units that are empowered with decentralized, multi-domain combined arms capabilities.

Respective of distinct Army and Marine Corps characteristics and responsibilities, these will be Marine Air-Ground Task Forces (MAGTF) for the USMC and multifunctional battle teams for the Army.¹⁷ These units must be flexible and resilient, with the ability to operate in degraded conditions and with sufficient endurance and redundancy to sustain losses and continue operating for extended periods and across wide areas. These formations may be task-organized at multiple echelons, depending on the situation and nature of the mission. *The guiding principle is that they must be able to employ multi-domain combined arms capabilities at the lowest practical echelons to enable dispersed operations, thereby reducing vulnerabilities to enemy massed fires while maintaining the ability to rapidly aggregate to mass at decisive points to create overmatch.* Mutually supporting dispersed tactical formations must possess organic capabilities to generate levels of localized *domain superiority* in the form of temporary zones of protection. The generated areas of control and periods of superiority are not sanctuaries; control is temporary and dynamic requiring ground combat forces to achieve surprise and sustain high tempo operations to open and exploit windows of advantage.

¹⁶ Surfaces are hard spots—enemy strengths—and gaps are soft spots—enemy weaknesses. (MCDP 1)

¹⁷ A multifunctional battle team is a temporarily task organized combined arms element that possesses multi-domain combined arms capabilities and is optimally structured to accomplish a specific mission. The Army envisions multifunctional teams at several echelons with composition and formal naming to be determined

Components of the Solution

Executing *Multi-Domain Battle: Combined Arms for the 21st Century* has three key components: create and exploit temporary windows of advantage, restore capability balance and build resilient battle formations, and alter force posture to enhance deterrence. Creating and exploiting temporary windows of advantage provides a means to achieve positions of advantage in or across domains, the EMS, and information environment to seize, retain, and exploit the initiative to defeat the enemy. Restoring capability balance and building resilient battle formations is essential to developing credible future forces capable of fighting and winning against adept and elusive enemies. Altering the force posture prevents conflict by providing a credible deterrence through the introduction of ground and maritime maneuver forces with multi-domain fires capabilities into positions of advantage that disrupt potential fait accompli strategies.

Components of the Solution

- Create and exploit temporary windows of advantage
- Restore capability balance and build resilient battle formations
- Alter force posture to enhance deterrence

Create and Exploit Temporary Windows of Advantage

Future operational and tactical commanders will use cross-domain fires, using both kinetic and information warfare means, to enable the opening of successive and/or simultaneous windows of advantage in the physical and abstract domains. As such, the fundamentals of maneuver warfare remain valid with this concept. In cases where overmatch in troop strength or combat power is not possible, U.S. forces will create and exploit temporary windows of advantage in domains that provide the most decisive method for rapidly defeating an enemy. Such windows of advantage may facilitate maneuver to achieve positions of relative advantage in a physical domain or enable suppression of a capability in an abstract domain that is critical to enemy success. As adversaries contest joint forces in physical and/or abstract domains, U.S. forces will possess the ability to rapidly refocus effort and capitalize on successive and/or simultaneous windows of advantage.

Opening a domain window may require combinations of integrated, synchronized, and sequenced capabilities, to include capabilities provided by other U.S. agencies, other military components, or foreign partners. The timing of cross-domain fires and maneuver is predicated on the duration the window of advantage is required to achieve the desired objective. Friendly forces may exploit windows of advantage to disrupt or dislocate the enemy by using simultaneous ground and sea-based maneuver along with other multi-domain capabilities. U.S. forces may employ multi-domain capabilities to attack the enemy's critical capabilities through the most vulnerable physical or abstract domain. Capitalizing on these windows of advantage, ground and maritime forces use speed and surprise to seize, retain, and exploit the initiative. The mission dictates how future combat forces will apply these capabilities as there is no default approach; every mission requires reevaluation of where vulnerabilities exist or can be created because adversaries are adaptive.

Fire and maneuver forces coordinate, plan, and execute fire support tasks to defend the force from attack and surveillance, and create exploitable lethal and nonlethal effects in support of a

scheme of maneuver. Fire and maneuver places enemy high value assets at risk compelling him to either increase his vulnerability by remaining in range or abandon his position, losing any advantage. When enemy countermeasures to air power and precision fires (such as dispersion, concealment, deception, and intermingling with civilian populations) limit the effectiveness of stand-off fires capabilities, ground-based fires and maneuver augment other joint capabilities providing the commander with additional options.

This concept calls for the integration of physical fire and maneuver with the abstract capability of information warfare. Information warfare spans several capabilities and functions such as: military information support operations, military deception, operations security, EW, physical attack, special technical operations, information assurance, computer network operations, public affairs, and civil military operations. Information warfare capabilities provide the opportunity to compete with adversaries early, below the threshold of armed conflict. When information warfare is integrated with kinetic fire and maneuver, commanders will be better equipped to outmaneuver an adversary by degrading his command and control, disrupting weapons and intelligence, surveillance, and reconnaissance systems' functionality, and impacting key audience perception and activities beyond the application of physical power.

Ground-based fires and information warfare, integrated with air and maritime power, support the achievement of localized sea and air control. Deep fires, including long-range precision fires, cyber and electronic warfare capabilities, and counter-fire capabilities help create windows of advantage across all domains. These windows of advantage enable the joint force to seize the initiative and dominate enemy forces through the execution of opportunistic maneuver in contested and highly competitive peer/near peer environments.

Army and Marine Corps forces, whether employing ground, air, or sea-based maneuver, seek to exploit windows of advantage to close with the enemy, overcome enemy countermeasures, compel outcomes, and consolidate gains. These forces provide lasting effects because they offer endurance and are difficult to displace once in position. Combat units offer many options. One option is to conduct turning movements behind the enemy's main line of defenses to attack critical targets.¹⁸ Another option is when enemy communications and reconnaissance are degraded by multi-domain operations, ground and maritime forces can infiltrate through dispersed enemy positions to attack from unexpected directions, emplace multi-domain fires in positions of advantage and destroy vital facilities to disrupt the enemy's defenses by attacking enemy fire support, air defense, sustainment, and command and control systems.¹⁹ While this concept reinforces the fundamentals of maneuver warfare by advocating attacking where the enemy is weak, forces must possess the capability to create advantage through the application of

¹⁸ A turning movement is a form of maneuver in which the attacking force seeks to avoid the enemy's principle defensive positions by seizing objectives behind the enemy's current positions thereby causing the enemy force to move out of their current positions or divert major forces to meet the threat. FM 3-90-1.

¹⁹ An infiltration is a form of maneuver in which an attacking force conducts undetected movement through or into an area occupied by enemy forces to occupy a position of advantage behind those enemy positions while exposing only small elements to enemy defensive fires. FM 3-90-1. Infiltration of a large unit likely will not go entirely undetected. Employing advanced counter-intelligence, reconnaissance and intelligence capabilities, deception measures, camouflage, concealment and related techniques are critical to success to limit detection and targeting by the enemy.

combined arms in the physical and abstract domains to defeat enemy forces with equivalent combat power. The multitude of methods of creating and exploiting temporary windows of advantage highlight the capabilities necessary for future Army and Marine forces to conduct Multi-Domain Battle: Combined Arms for the 21st Century.

Restore Capability Balance and Build Resilient Battle Formations

Empowering U.S. ground combat forces to fight effectively against sophisticated enemies demands restoring parity or providing capacity overmatch in critical capabilities. Attaining parity entails restoring, at a minimum, equivalency of warfighting capabilities. Achieving parity also requires improving survivability against attack, resiliency, and the endurance to not only survive, but to execute operations post-attack. Improving survivability, resiliency, and endurance will inevitably require capabilities to operate more dispersed over diverse operational environments. Employing the capabilities described here is anticipated to restore overmatch in critical areas to provide the depth, resiliency, and endurance needed for success. With these capabilities, ground and maritime forces ashore will be able to operate in the physical and abstract domains to sense, close with, and destroy enemy elements, influence and protect populations, and seize and occupy or control terrain to consolidate gains.

Ultimately, Army formations and MAGTFs will be task organized to the lowest practical level with capabilities that enable multi-domain distributed or semi-independent operations minimizing the need for enablers from higher echelons of command. Dispersed operations necessitate leaders, Soldiers and Marines capable of using mission command tenets such as initiative to exploit opportunities or respond to unexpected threats within the commander's intent. Army formations and MAGTFs will conduct distributed maneuver with the ability to aggregate and disaggregate combat power to respond in time and space to defeat enemy elements.

Improvements in protection, mobility, range, and lethality of key systems will help create advantages allowing ground combat forces to maneuver in close proximity to civilian populations and defeat enemy forces in close combat. Active protection, advanced armor, and hardened electronic systems will improve units' ability to absorb and survive first strikes of enemy fires. Maneuver units will also increase survivability and capacity by employing manned-unmanned teaming (MUM-T).²⁰ MUM-T will provide personnel protection by using autonomous or robotic systems to detect, identify, and penetrate high risk areas and may increase capacity to degrade, deny, and destroy enemy systems.

To prevent adversary aviation, UAS, artillery, and missile assets from striking with impunity, forces will employ a highly mobile and robust air and missile defense systems to counter long range fires in both forward and rear areas. These systems will provide early warning, identification, and strike capability and require adequate capacity to counter multiple air sorties or repetitive missile salvo fire to provide defense in depth. Mounted and dismounted friendly elements will have organic capabilities to counter adversary UAS, aircraft, rocket, artillery, and

²⁰ In the future OE, U.S. forces will often be outnumbered. Use of robotic and autonomous systems helps improve capabilities offsetting enemy numerical advantages.

mortar capabilities providing increased survivability and allowing varying levels of freedom of maneuver.

Army formations and MAGTFs will possess a family of UAS for reconnaissance, surveillance and attack missions, often teamed with fifth generation aircraft, possessing the range, endurance, protection, low observability, EW resistance, and lethality necessary to operate across the area of operations. As part of the future formations, vertical lift will support reconnaissance, attack, air assault, medical evacuation, and utility roles. Future vertical lift will provide increased speed, range and survivability to support dispersed forces over wider areas, better operability in degraded visual environments, and the capability for employing precision munitions to include air to air capabilities. Improved aviation protection and countermeasures including infrared and radar frequency gun and missile system detect and defeat, and EW detection, jamming, and attack will enhance survivability in highly contested airspace. Employing future vertical lift with MUM-T also will increase capacity, reach, and survivability.

Conceptually, maneuver formations will capitalize on the increased capability of multi-domain fires systems. Army formations and MAGTFs will have an expanded spectrum of organic and attached lethal and nonlethal fires, some with extended range systems as the mission dictates. Multi-domain and counter-fire sensors improve the commander's situational understanding, and enable rapid neutralization or destruction of enemy systems or forces.

Organic cyberspace and EMS sensors, EW attack and jamming capabilities, and automated electromagnetic battle management capabilities allow tactical formations to attack or disrupt enemy systems while minimizing vulnerabilities of friendly systems. Such capabilities will generate tempo by creating temporary windows of advantage in physical and abstract domains.

A renewed degree of emphasis must be placed on electronic emissions control and other measures of signature management. In future conflicts, every force should expect to be quickly and precisely targeted if unable to manage its signatures. Unmanaged signatures will be a critical vulnerability as peer competitors experiment with emerging technologies such as advanced detection methods, hypersonic platforms and directed energy weapons. Minimizing or masking system signatures through concealment and deception will complicate enemy targeting and build resiliency and endurance of U.S. forces. These capabilities are reinforced through counter intelligence capabilities, social media discipline, covered networks, low-profile basing, and a stealthy logistics infrastructure.

Headquarters and subordinate units alike must be capable of operating effectively despite severe degradation of command and control networks to include disrupted or blocked access to space, cyberspace, and the EMS. Optimized command and control systems in redundant, survivable, and highly mobile command posts allow forces to operate despite enemy attempts to attack, disrupt or degrade command and control infrastructure. Automated decision tools resident in command and control systems will analyze, filter, and report information helping commanders make informed decisions faster. Future units will maintain communications and PNT through an internal communication network for maneuver, fires, and sensors that is resilient and self-healing, i.e. able to re-route data and communications to the intended recipient, to minimize

disruptions and support command and control while moving.²¹ This internal network will limit susceptibility to detection and countermeasures, potentially using line of sight transmissions such as laser and other hard to detect frequencies supported by high altitude retransmission assets. Integrated and optimized command and control systems will support external connectivity to global support networks that will allow dynamic partnering between Army and Marine forces and other mission partners.

Reducing vulnerabilities inherent in deployment and sustainment activities also supports resiliency of U.S. forces. Dispersed, distributed, and resilient force deployment and sustainment using multiple lines of communications will reduce vulnerability to interdiction. Shallow draft transport vessels, amphibious transport capabilities, short take-off and landing aircraft, and future vertical lift capable of intertheater transit allow entry into austere locations and expeditionary advanced bases providing the commander more options. Autonomous sustainment tools will perform predictive analysis allowing supplies to be pushed forward to units. Using unmanned aerial resupply systems augments the capacity of limited manned systems allowing faster supply operations over dispersed areas and increasing combat capability of engaged units.

Sustainment forces will conduct convoy operations employing MUM-T techniques with ground transport vehicles. Demand reduction efforts will create units that need less fuel, energy, water, and other supplies. Additive manufacturing capabilities will allow units to make repair parts in forward areas.²² Simplified maintenance (such as line replaceable units) allows repairs at forward locations by the operators, reducing the need to move equipment to higher echelons for repairs. Additionally, forces will have enhanced prolonged care capability at the point of injury to increase personnel survivability because of potential higher casualty numbers against peer threats and possible delays in medical evacuation due to force dispersion.

Alter Force Posture to Enhance Deterrence

U.S. forces are not adequately postured or equipped to effectively deter peer competitors from acts of aggression. This deficiency requires deliberate examination of the forward stationed, rotational, and sea-based expeditionary forces. While long-range strikes or nuclear weapons offer strategic deterrence, adversaries often employ methods to achieve objectives that operate below the thresholds for employing these weapons. Robust enemy defensive networks impose limitations on the effectiveness of stand-off strike capabilities. Ground and maritime forces provide multiple options. Army forces stationed overseas and Marine Corps forces forward deployed afloat can deter enemy actions and reassure partners providing commanders with the capability to challenge enemy networks, in an effort to prevent enemies from achieving their objectives. Ground and maritime forces are also expeditionary and strategically mobile, able to rapidly aggregate to contingencies or reinforce forward deployed formations.

Ground forces communicate U.S. commitment prior to and during conflict. In the future, Army and Marine forces working with partners will strengthen forward defenses by bolstering partner

²¹ An internal network refers to systems for communication internal to a unit. An external network is for communication outside of the unit, such as higher echelons, adjacent units or other partners.

²² Additive Manufacturing (aka 3D printing) describes the technologies that build 3D objects by adding layer-upon-layer of material.

capacity and resolve to resist aggression and dissuading adversaries who employ methods below the threshold for war. When possible, Army forces may be permanently stationed in identified high risk areas, or move uncontested into allied or partner nations prior to the outbreak of hostilities through exercises or regular rotations. Army forward stationed forces and Marine sea-based forward presence are complementary. Using the sea as maneuver space and expeditionary advance bases, Marine forces will distribute for activities with partners and rapidly aggregate to deter adversary escalatory actions. Security cooperation activities assure partner states, build relationships and interoperability, enhance situational awareness, and set favorable conditions for inserting follow-on expeditionary forces if diplomacy and deterrence fail.

Having a ground and maritime combat capability in theater prior to hostilities disrupts enemy defensive networks, turning denied areas into contested spaces. Forward-positioned Army and Marine forces that can persist in the arc of enemy fires deter adversary aggression by restricting adversarial freedom of action and influencing the enemy in all domains and contested areas. Forward-positioned and resilient multi-domain fires capabilities provide additional deterrent value by holding at risk enemy centers of gravity. Should deterrence fail, these resilient forward-positioned forces can conduct delaying action to enable maneuver of additional forces into theater.

Conclusion

This paper is intended to promote discussion on solutions to overcome the problems of future conflict in 2025-2040, inform the development of a future warfighting concept, and drive experimentation and refinement of these solutions. Building on current service and joint doctrine, *Multi-Domain Battle: Combined Arms for the 21st Century* evolves the combined arms methodology to include not only those capabilities of the physical domains, but also those of abstract domains such as cyberspace, the EMS, the information environment, and the cognitive dimension of warfare. It provides not only recommendations towards suggested capabilities to be at a commander's disposal to defeat an enemy, but also a new framework for understanding the expansion of the 21st Century battlefield. Such understanding and capabilities are necessary if U.S. forces are to be successful in future conflict.