REQUEST FOR PROPOSALS

ASTM INTERNATIONAL EXO TECHNOLOGY CENTER OF EXCELLENCE
ANNOUNCEMENT FOR RESEARCH TO STANDARDS FOR EXOSKELETONS AND RELATED TECHNOLOGIES

WHITEPAPERS DUE: 15 MAY BY 5:00 P.M. (EASTERN STANDARD TIME)
(Late submissions cannot be accepted)
TABLE OF CONTENTS

I. PROGRAM DESCRIPTION ........................................................................................................3
   OVERVIEW .........................................................................................................................3

II. AWARD INFORMATION ....................................................................................................4
   GENERAL INFORMATION .................................................................................................4
   AWARD ORGANIZATION ....................................................................................................4
   FUNDING AVAILABILITY ....................................................................................................4
   COST SHARING OR MATCHING .........................................................................................5
   AWARD PERIOD ..................................................................................................................5
   ELIGIBILITY ..........................................................................................................................5
   RESEARCH TO STANDARDS TOPICS ..............................................................................5
   QUALIFICATIONS ...............................................................................................................8
   PROTECTION OF HUMAN SUBJECTS ..............................................................................8
   INTELLECTUAL PROPERTY ..............................................................................................8

III. SUBMISSION INFORMATION ..........................................................................................8
   SUBMISSION PROCESS .....................................................................................................8
   REQUIRED FORMS FOR SUBMISSION ............................................................................9
      Whitepaper Format .........................................................................................................9

IV. SUBMISSION REVIEW INFORMATION ...........................................................................10
   EVALUATION AND SELECTION CRITERIA .....................................................................10
   REVIEW AND SELECTION PROCESSES .........................................................................11
   KEY DATES ..........................................................................................................................11
   INQUIRIES AND QUESTIONS .........................................................................................11

V. REFERENCES ....................................................................................................................12

VI. APPENDIX A ...................................................................................................................14
    DETAILED NEEDS ............................................................................................................14

VII. APPENDIX B ..................................................................................................................18
     SAMPLE BUDGET CATEGORIES .......................................................................................18
     PRE-SUBMISSION CHECKLIST .......................................................................................18
I. PROGRAM DESCRIPTION

OVERVIEW

Exoskeleton technology presents a tremendous opportunity to transform society through the augmentation of cognition, perception, and physical performance, with applications in healthcare, industry, agriculture, construction, public safety, recreation, and defense. Because exo systems interact directly with humans and interface with other machines and technologies both directly and remotely, users need demonstrated proof of their safety and reliability prior to adopting them.

The ASTM Exo Technology Center of Excellence (ET CoE) was formed to pursue safe and reliable exo technologies for all of humanity. The ET CoE acts as a fulcrum to leverage the expertise and resources of the federal, academic, and private sectors in order to measure and demonstrate the safety and reliability of exoskeletons and related technologies. The ET CoE will accomplish this critical goal by bringing together a diverse group of end users, suppliers, researchers, and stakeholders across academia, government, healthcare, and other related industries that together both positively and proactively impact the ET landscape through organized and focused attention on ASTM standards and standards related activities.

The core activities of the ET CoE are:

- Research to Standards - providing the needed research, data, and expertise to develop new standards or modifying existing standards
- Consortia - collaborations with industry, academia, and government to identify research-to-standards projects, education and workforce development initiatives, and other community needs
- Coordination - connecting research, testing, and education efforts throughout the community and providing forums to discuss common challenges
- Education & Workforce Development - providing a wide range of learning and training opportunities on exoskeletons, including online, hands-on, and virtual
- Interlaboratory Study Programs and Proficiency Testing – connecting standards development and manufacturing practices with opportunities to verify test methods
- Certification – providing opportunities to develop applicable certification programs for the exo technologies industry

This Request for Proposals (RFP) is specifically to support the Research to Standards core activity of the ET CoE. The Research to Standards projects are expected to be targeted toward addressing immediate, critical needs that advance new standards, revise existing standards, or support lagging work items. Section II has information on Research to Standards topics to consider.

ASTM anticipates up to three awards under this RFP. ASTM will consider proposed gaps for Research to Standards projects; up to nine months in duration. The total
anticipated amount for the award is **$102K with up to $34K per project**. Detailed information about funding is available in Section II.

II. AWARD INFORMATION

GENERAL INFORMATION

Applicants, by submitting proposals, acknowledge that all activities fall under standards development. Because of financial constraints, ASTM is able to provide support for only a limited number of proposals received. ASTM realizes the preparation of a research proposal often represents a substantial investment of time and effort by the applicant. Therefore, in an attempt to minimize this burden, ASTM strongly encourages applicants interested in submitting proposals to make preliminary inquiries as to the general need for the type of research effort contemplated, before expending extensive effort in preparing a whitepaper.

*NOTE: ASTM will not be obligated by any discussion that arises out of preliminary inquiries.*

AWARD ORGANIZATION

ASTM International  
100 Barr Harbor Drive  
PO Box C700  
West Conshohocken, PA 19428-2959

FUNDING AVAILABILITY

ASTM anticipates no more than three awards of up to $34K per project; maximum of $102K funding available across all projects.

Selected projects will receive funds based upon milestones. Typically, projects of the length requested under this RFP will have three milestones:

- **Milestone 1:** Project selection and initiation  
  - Allocation of 30% of the total project funding.

- **Milestone 2:** The second milestone will typically be the completion of data gathering or final design of an apparatus, artifact, or other physical deliverable.  
  - Next payment of 30% (total allocated at this point: 60% of the project funding).

- **Milestone 3:** Ballotable draft standards within ASTM (test method, specification, practice, etc.) and any associated adjuncts, apparatuses or artifacts  
  - Final 40% payment.

The total amount of funding made available to a successful proposal may vary, based on the quality of received proposals, the availability of funds, and the in-kind support and program development resources from ASTM’s related pre-existing activities. These
include ASTM education and training, certification and proficiency testing program development, connection with top ET experts through ASTM’s technical committees, and the offered workshops, meetings, conferences, and more that are designed for ASTM’s over 30,000 members.

COST SHARING OR MATCHING

ASTM expects the applicants to share in the costs at a level which reflects their interest in the research, the potential benefits they may derive, and their ability to cost share. The minimum ratio of cost sharing is expected to be 1:1. Cost sharing is defined as all contributions, including cash, in-kind, and third party in-kind. For this RFP, cost sharing and matching are synonymous.

AWARD PERIOD

Not to exceed nine (9) months.

ELIGIBILITY

Eligible applicants under this RFP include institutions of higher education, nonprofit organizations, federal, state and local governments, foreign organizations, foreign public entities, and for-profit organizations (i.e. large and small businesses) for scientific research. Whitepapers will be evaluated only if they are for applied scientific study and experimentation directed toward advancing new standards, revising existing standards, or supporting lagging work items.

There is no restriction on the place of performance for awards issued under this RFP.

RESEARCH TO STANDARDS TOPICS

In developing the Research to Standards topics, ASTM conducted and analyzed industry surveys, reviewed the available literature, and consulted with members of the exo community. Some of the key research questions are:

1. How do we design-in safety to exo technologies and promote safe practices across the community?
2. How do we objectively measure the performance and reliability of exo technologies?
3. How do we determine the best fit of the technology to the user and task?
4. What process do we use to determine where to employ exo technologies?
5. How does the community recycle the data, lessons learned, and innovations into the next generation of exo technologies?

Figure 1 is a mind map that shows a snapshot of the scope of the research topics that may fall under the CoE’s purview.
Figure 1: Mind Map of the ET CoE Research to Standards Topics

**Exo Technology CoE R&D Topics**

**Comfort**
- Fit
- Sizing
- Shape
- Skin Interaction
- Injury
  - Abrasion
  - Bruising
  - Pinch
  - Cut
  - Crush
  - Ischemia and ulcers

**Augmentation**
- Physical
  - Rehabilitation
    - Walking dose
    - Grip strength
    - Mobility regained
    - Functional improvement
    - Functional outcome measures
    - Plan of care
- Balance
  - Mobility
    - Range of motion
    - Functional
    - Movement quality
    - Distance
    - Speed
    - Agility
    - Efficiency
- Metrics
  - Metabolic cost
  - Biomechanical loading
  - Fatigue reduction
  - Muscle activity
  - Watts
  - Time on task
  - Accuracy
- Strength
  - Grip
  - Load carrying
  - Lift
  - Push/Pull
- Endurance
- Cognitive
  - Short term
  - Long term
- Perception
  - Visual
  - Auditory
  - Tactile

**Models**
- Dynamic, rapid loading
- Interfaces between exo and skin
- Entire population fitting
- Job task simulations
- Digital human

**Economics**
- ROI metrics
- Cost benefit tools
- Lessons learned
- Reliability/Quality

**Safety**
- Slips, trips, and falls
- Personal Protective Equipment
- Donning and Doffing time
- Cyber security
- Ergonomics/kinematics
- Material biocompatibility
- Electrical
- Flammability and fire safety
- Design guidelines
- Risk assessment
- Load
  - Load and Moment levels
  - Load transfer to other parts of body
  - Catastrophic fatigue/load failure
- Exposure limits
  - Temperature
  - Noise
  - Vibrations
  - Chemicals
  - Biologics
  - Radiation
  - Human error
  - First aid accessibility
  - Hygiene
  - Cleaning and disinfecting
  - Decontamination

**Usability**
- Human machine interface
- Digital
- Physical
- Learning/training time
- Augmented Reality
- Virtual Reality
- In Person
- Distance
- Compatibility with tools, controls, and/or PPE
- Maintenance and logistics
- User Adaptation
- User acceptance
- Usefulness for tasks
- Physical
- Cognitive
- Psychosocial impacts
- Social
- Organizational
- Supervisory

**Components/Materials**
- Software/Hardware
  - Algorithms
  - Machine learning
  - AI
  - Processors
  - Communications
- Weight
- Distribution/COG
- Stress/Strain/Failure
- Power
- Battery
- Tethered
- Mechanical
- Fatigue and fracture
- Sensors
- Surface
- Implants
- Environmental conditions
- Characteristics/Interactions
  - Additive
  - Fabric
  - Metal
  - Polymer
  - Ceramic
  - Carbon
  - Composite
The topics in the mind map are not listed in any priority. Some topics may be outside the cost or schedule of this RFP and are included for completeness and context. Appendix A includes tables and a figure with additional detail of the needs that have been identified by the exo community. Applicants are encouraged to consult this and the References in Section V as they contemplate projects.

In order to narrow the scope and provide a starting point for the development of project proposals, the following are priority needs that have been identified.

There is a critical need for the development of test methods that can be used to test and certify exoskeletons.

Example test methods, that will lead to performance standards, should be considered:

- Test methods for exoskeleton overhead work
- Test methods for exoskeleton mobility and load carrying
- Test methods for exoskeleton slips, trips, and falls
- Test methods for exoskeletons used for walking rehabilitation in a clinical setting
- Test methods for lower limb exoskeletons for reliability and environmental conditioning
- Test methods for determining optimal exoskeleton fit to the user
- Test methods for fatigue and fracture of exoskeleton systems and components
- Test methods for determining dermal biocompatibility of exoskeletons and their components

The following ASTM work items have been identified as needing research support:

- WK65587 Assessing System Training
- WK65346 Safety Considerations in Designing and Selecting Exoskeletons for Industrial, Medical and Military Applications
- WK68929 Ergonomics of the Exoskeleton/Exosuit System
- WK65346 New Guide for Safety Considerations in Designing and Selecting Exoskeletons for Industrial, Medical and Military Applications
- WK65056 Revision of F3269 - 17 Standard Practice for Methods to Safely Bound Flight Behavior of Unmanned Aircraft Systems Containing Complex Functions

ASTM strongly encourages applicants interested in submitting proposals to make preliminary inquiries as to the general need for the type of research effort contemplated.
QUALIFICATIONS

The following qualifications are expected of applicants:

- the management capability and adequate financial and technical resources to execute proposed projects
- a satisfactory record of executing such programs or activities, and
- a satisfactory record of integrity and business ethics.

The proposed team should include at least one member of ASTM. Membership may be Participating ($75), Organizational ($400), or Student (Free).

PROTECTION OF HUMAN SUBJECTS

The applicant must protect the rights and welfare of individuals who participate as human subjects in research under this award. The recipient must not begin performance of research involving human subjects, also known as human subjects research (HSR), until you provide ASTM with a formal notification of approval by your own or an outside Institutional Review Board (IRB).

INTELLECTUAL PROPERTY

ASTM will serve as the standards developing organization (SDO) for the activity, providing the structure for the activity within ASTM committee or subcommittee and all managerial and administrative support for the organization of the activity and its subsequent standards development and delivery. All standards and their derivative works, developed by or for ASTM International, are copyrighted by ASTM International.

Any project funded by ASTM shall be the sole intellectual property (IP) of ASTM, including inventions, data, software, technology, patents, other related reports and materials. Permissions to use or share this IP shall be handled through a separate license.

Parties using IP owned by the ASTM for Academic Uses shall provide credit to ET CoE and/or ASTM and/or their designee (as directed by ET CoE) for its or their support of the project.

III. SUBMISSION INFORMATION

SUBMISSION PROCESS

Applicants are requested to submit whitepapers. Whitepapers should present the effort in sufficient detail to allow evaluation of the concept's scientific merit and its potential contributions of the effort to the ET CoE's mission. Appendix B includes a notional pre-submission checklist to help the applicant.

Whitepapers should be submitted via email as follows:
• **Email Instruction:** Email with subject header “ASTM ET CoE Research to Standards RFP: name of applicant/organization” to bizdev@astm.org. Whitepapers should NOT contain any confidential, proprietary, or restricted information.

• **Due Dates and Time:** ASTM ET CoE must receive whitepapers no later than 15 May at 5:00 p.m. Eastern Standard Time (EST) to be considered. ASTM ET CoE highly recommends submitting ideas early.

• **Electronic Form and Idea Attachment:** All required forms should be combined as a single PDF document for attachments.

Whitepapers that are delivered in a different form than prescribed in this RFP, that do not follow the required confidentiality requirements, or are received after the designated time and date, may be rejected.

**REQUIRED FORMS FOR SUBMISSION**

**Whitepaper Format**
Whitepapers should focus on describing details of the proposed research, including how it advances standards, how it addresses needs of the exo community, ET CoE relevance, and potential impact.

Whitepapers must be in the following format, but do not require any special forms:
- Page Size: 8 ½ x 11 inches
- Margins –1 inch
- Spacing –single
- Font –Times New Roman, 12 point

Format and content of whitepapers:

I. **Cover Page** (1-page limit): The whitepaper cover page shall include at a minimum:
   a. Title of the whitepaper,
   b. Name of the individual and organization submitting the whitepaper,

II. **Project Abstract** (up to 300 words) - project abstract shall include a concise statement of work and basic approaches to be used in the proposed effort. The abstract should include an overview of objectives, methods, and the significance of the proposed effort to the advancement of exo technology standards. The project abstract shall be publicly releasable.

III. **Table of Contents** (1-page limit)

IV. **Organization Description** (1-page limit).

V. **Technical Content** (5-page limit):
   a. A complete discussion stating the background and objectives of the proposed work, the scientific approaches to be considered, the relationship to competing or related research, and the level of effort to be employed. Include also the nature and extent of the anticipated results
and how they will significantly advance exoskeleton standards. Also, if known, include the manner in which the work will contribute to the accomplishment of the CoE’s pursuit of safe and reliable exo technologies for humanity. Ensure the proposal identifies any scientific uncertainties and describes specific approaches for the resolution or mitigation of the uncertainties.

VI. **Budget Sheet** (2-page limit) The cost portion of the whitepaper shall contain a brief cost estimate revealing all the component parts of the proposal, including research hours, burden, material costs, travel, etc. (See the Appendix B for Sample Budget Categories)
   a. The type of support, if any, the applicant requests of the ASTM, such as administrative, facilities, equipment, software, data, personnel, or materials.
   b. Facilities, Equipment, and Other Resources - The applicant should include a listing of facilities, equipment, and other resources already available to perform the research proposed.

VII. **Biographical Sketch** (3-pages per key personnel) - This section shall contain the biographical sketches for key personnel only.
   a. Primary Principal Investigator (PI): The Primary PI provides a single or initial point of communication between the ASTM and the awardee organization(s).
   b. Relevant experience and employment history
   c. Relevant experience developing standards, a list of the relevant standards or work items that you have participated in or led the development, and any standards leadership roles.

VIII. **References Cited** (2-page limit)

ASTM will not consider submissions that include confidential or proprietary information. In addition, please do not submit or propose any efforts that would include information restricted under International Traffic in Arms Regulations (ITAR), Export Administration Regulations (EAR) or other regulation.

IV. **SUBMISSION REVIEW INFORMATION**

**EVALUATION AND SELECTION CRITERIA**

The ET CoE will assess submitted whitepapers based on their ability to accelerate standardization in ET. The following criteria will be used:

- The overall scientific or technical contribution to advancing exo technology standards.
- The potential contributions to the ET CoE mission and the extent to which the research will address the most pressing needs of the community.
- The applicant's capabilities, related experience, facilities, techniques, or unique combinations of these, which are integral factors for achieving the proposed objectives.
• The qualifications, capabilities, and experience of the proposed PI, team leader, or other key personnel who are critical to achievement of the proposed objectives.
• The applicant's record of past performance.

Reviewers may consider questions such as the following during the review of the whitepaper:
• Will this project address a need for the exo technology standards community?
• If successful, what difference will it make to the development of exo technology standards?
• What are the risks and the payoffs?
• How much will it cost and is this an appropriate usage of ET CoE resources?
• How long will it take, and will it be relevant to our community when it is completed?

REVIEW AND SELECTION PROCESSES

Project Selection Process
Whitepapers will be validated by the F48.90.05 Innovation and Research subcommittee. Validated whitepapers/proposals will then be reviewed by the ET CoE Research Team for selection and award of funding.

Peer Review Disclosure Procedures
For transparent review procedures, all review panels will include nondisclosure agreements that prohibit disclosure of any information submitted to other parties.

Confidentiality of Ideas and Peer Reviews: ASTM will receive whitepapers in confidence. In addition, the identity of reviewers will be kept confidential to the maximum extent possible. All reviewers will sign nondisclosure agreements that prohibit disclosure of any information submitted to other parties.

KEY DATES
Inquiries and questions must be received in writing by email no later than 1 May at 5:00 p.m. (EST) to be considered.

Whitepapers must be received electronically by 15 May at 5:00 p.m. (EST) to be considered.

INQUIRIES AND QUESTIONS
Submit all questions by email to the contact information individual below.

Include “Inquiries: ASTM ET CoE Research to Standards RFP” in the subject line.

*Note: If a question is submitted by telephone, there may not be a response.
Idea inquiries and questions must be received by email no later than 1 May, at 5:00 p.m. (EST).

CONTACT INFORMATION
Submit all proposal questions by email, addressed to:
ASTM International Global Exo Technology Programs
Email: wbillotte@astm.org
Phone: +1.202.813.6563

ASTM International F48 Developmental Operations Mr. Pat A. Picariello, J.D., CStd, FSES
Email: PPicariello@astm.org
Phone: +1.610.832.9720

V. REFERENCES

Army Research Laboratory Broad Agency Announcement For Basic And Applied Scientific Research, W911NF-17-S-0003 01 April 2017 –31 March 2022

Automotive Exoskeleton Group (AExG), 2019 Survey to members

ASTM International, 2020 ET CoE Survey of Needs to ASTM committee members


U.S. Consumer Product Safety Commission, Staff Report, Potential Hazards Associated with Emerging and Future Technologies, January 18, 2017
VI. APPENDIX A

DETAILED NEEDS

As follows is the compiled information from various studies, surveys, workshops, and meetings.

Table 1: Needs from 2018 Ergo-X Symposium\(^1\)

<table>
<thead>
<tr>
<th>Need</th>
<th>Solution/Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing exoskeleton systems require a period of adaptation by the</td>
<td>Return on investment (ROI) considerations</td>
</tr>
<tr>
<td>end user. For a new user, task performance is not likely to reach a</td>
<td></td>
</tr>
<tr>
<td>steady state immediately. How do we account for familiarization and</td>
<td></td>
</tr>
<tr>
<td>learning effects, and hence, what are acceptable test durations?</td>
<td></td>
</tr>
<tr>
<td>Size, shape, and fit of exoskeletons on users. We need to understand</td>
<td>Longitudinal effects of exoskeleton usage</td>
</tr>
<tr>
<td>how it restricts or limits natural movement</td>
<td></td>
</tr>
<tr>
<td>What metrics are right for measuring safe, effective, or reliable</td>
<td>Improved methods of virtual simulation with the entire population. Human measurement</td>
</tr>
<tr>
<td>system design and integration?</td>
<td>and modeling methods are an opportunity to inform the design and evaluation of</td>
</tr>
<tr>
<td>Skin injury and protection are significant concerns for clients</td>
<td>exoskeletons</td>
</tr>
<tr>
<td>We need dynamic, rapid-loading models for crash tests.</td>
<td>Interaction of the exoskeleton with PPE: coveralls, fall harnesses, tool belts, hard</td>
</tr>
<tr>
<td>What are specific variables to measure for addressing adaptation to</td>
<td>hats, etc.</td>
</tr>
<tr>
<td>exoskeleton systems?</td>
<td>Which of these measures are most useful (and feasible) for guiding decision making?</td>
</tr>
<tr>
<td>Methods to design testing with a representative group of users (per</td>
<td>How do we resolve inconsistencies between measures and/or studies?</td>
</tr>
<tr>
<td>age, gender, occupation, and experience using the device)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Does every device and every new iteration of a device need to be empirically tested?</td>
</tr>
<tr>
<td></td>
<td>Are there better approaches?</td>
</tr>
</tbody>
</table>

Table 2: Occupational Exoskeleton Needs

<table>
<thead>
<tr>
<th>Needs</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine which exoskeleton designs are most effective for different types of task demands</td>
<td>Understand and quantify the cognitive demands involved with using exoskeletons</td>
</tr>
<tr>
<td>Characterize the critical dimensions of adjustability in exoskeleton designs, to allow them to be applicable to and effective for use in a range of tasks, and to ensure fit, comfort, and usability for a broad set of users</td>
<td>Identify potential adverse consequences of prolonged use of occupational exoskeletons and quantify the extent to which such consequences occur for different types of exoskeletons</td>
</tr>
<tr>
<td>Identify environmental conditions that may contraindicate the use of an occupational exoskeleton</td>
<td>Explore important factors driving the adoption and use of occupational exoskeletons in diverse occupational sectors, in particular to identify key facilitators and barriers</td>
</tr>
<tr>
<td>Complete large-scale field studies to better identify the benefits and limitations of exoskeleton use</td>
<td>Develop and validate quantitative approaches for cost-benefit analyses of occupational exoskeletons</td>
</tr>
<tr>
<td>Generate approaches to effectively simulate or predict important impacts of exoskeletons in a range of occupational applications</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: AExG Survey Responses – Common Challenges Identified Across Users, Academia, and Vendors

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2 Maury A. Nussbaum, Brian D. Lowe, Michiel de Looze, Carisa Harris-Adamson & Marty Smets (2020): An Introduction to the Special Issue on Occupational Exoskeletons, IISE Transactions on Occupational Ergonomics and Human Factors, DOI: 10.1080/24725838.2019.1709695

3 Automotive Exoskeleton Group (AExG), 2019 Survey to members.
Table 3: ASTM Committee Research Support Needs Survey – Areas Needing Support from the CoE, January 2020

<table>
<thead>
<tr>
<th>WK65587 Asssessing System Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>WK65346 Safety Considerations in Designing and Selecting Exoskeletons for Industrial, Medical and Military Applications</td>
</tr>
<tr>
<td>WK68929 Ergonomics of the Exoskeleton/Exosuit System</td>
</tr>
<tr>
<td>WK65346 New Guide for Safety Considerations in Designing and Selecting Exoskeletons for Industrial, Medical and Military Applications</td>
</tr>
<tr>
<td>WK65056 Revision of F3269 - 17 Standard Practice for Methods to Safely Bound Flight Behavior of Unmanned Aircraft Systems Containing Complex Functions</td>
</tr>
</tbody>
</table>

- **Design of test apparatus to establish and measure safe/unsafe levels of forces and moments applied directly and indirectly by the exoskeleton to the human joints as well as measure joint trajectories. Human motion data for various motion tasks.**
- **Mobility tasks with and without an exoskeleton**
- **Load handling with mobility with and without an exoskeleton**
- **Optimal settings for exoskeletons when paired with tasks**
- **Donning and doffing exoskeletons**
- **Exoskeleton fit to the user**
- **Fatigue and fracture of materials for exoskeletons and exosuits**
- **Robotic or exoskeleton interfaces to unmanned aircraft systems (UAS) ground control stations.**
- **Develop tests for 3D printed prosthetic/exoskeleton components over simulated life cycles and characterize overall performance.**
- **Ergonomics/usability interface design, responsiveness of control systems. Does a lag between user input and device output create a potential for accidents?**
- **Preservation or protection of body kinematics. Do the kinematics of an exoskeleton match or complement those that are found in the human body?**
- **Interactions between an exoskeleton/exosuit and passive/active implants, interactions between the suit and user.**
- **Biocompatibility of materials in short-term/long-term contact with the body (ISO 10993 compliant). Are there any interactions between passive/active implants and an exoskeleton or an exo-suit that need to be evaluated (e.g. are exoskeletons safe for people that use pacemakers?) How biocompatible should the materials used in exoskeletons be?**

**Army Research Laboratory Broad Agency Announcement For Basic And Applied Scientific Research, W911NF-17-S-0003**

CCE-HS-2: Augmentation

Soldier cognition, perception, and physical performance can be augmented, aided, or protected by technology, or technology can impair Soldier performance if it is not designed, developed, and introduced in a way that is consistent with fundamental human capabilities and capacities. The goal is to augment Soldier capabilities such that they can surpass the baseline limits of performance. Through augmentation, a Soldier’s sensing and perceptual abilities can be greatly enhanced, thereby enabling the
warfighter to sense and perceive the environment faster, more accurately, and more comprehensively. Augmenting cognitive capabilities that are matched to individual capabilities and tuned to the operational environment will enable greater resilience to the extremes of warfighting and support the attainment and sustainment of situation awareness and ultimately, agile, knowledgeable decision making. Innovations are also expected to enhance warfighter physical capabilities by balancing load, improving protection, and enhancing performance. Core research areas include:

- Perceptual Augmentation: the characterization and augmentation of the perceptual requirements of visual, auditory, and tactile signals in complex, dynamic, militarily-relevant environments derived from laboratory and field studies and forming the basis of guidance principles for the system development community.

- Physical Augmentation: focus on ‘skin-out’ technology that may augment physical performance, and focus on advanced technology designed to increase the physical strength of the Soldier or increase their endurance.

The objectives of this research are to understand and augment fundamental human capabilities across both short and long time scales. Under this CCE, research will be conducted to develop and assess the effects of augmentation technologies or approaches on Soldier performance through the evaluation of performance metrics and prediction of operational benefit for mission tasks ranging from marksmanship and load carriage to communications tasks, driving and navigating, and distributed decision making. Many augmentation technologies constitute a direct approach such as an exoskeleton, but other approaches may be via indirect means such as insertion or manipulation of imagery, symbology, or virtual characters by means of augmented reality techniques.

n. Human Performance – The Soldier is the foundation of all Army capabilities. Technologies that reduce their mental or physical burden, allow them to react faster than their adversaries, to manage Research is needed to enhance Soldier capabilities in the following areas:

i. Human-machine interaction to ensure autonomous platforms are efficiently managed and exploited

ii. Measuring effectiveness of and enhancing training tools and techniques

iii. Methodologies and approaches for effective augmentation of Soldiers in areas of cognition, perception, and physical performance
VII. APPENDIX B

SAMPLE BUDGET CATEGORIES

Before issuance of an Award, an accounting system and financial management system must be established.

a. Direct Labor: Current and projected salary amounts may be shown in terms of man-hours, man-months, or annual salary to be charged.
b. Fringe Benefits and Indirect Costs (Overhead, G&A, and Other)
c. Travel: Forecasts of travel expenditures (domestic and foreign) that identify the destination. Allowance for air travel normally will not exceed the cost of round-trip, economy air accommodations. Requests for domestic travel should not exceed $3,000 per year per PI. Foreign travel requests should not exceed $1,800 each per year per PI.
d. ODCs: Itemize proposed costs for other anticipated direct costs such as communications, transportation, insurance, and rental of equipment other than computer related items. Unusual or expensive items must be fully explained and justified.

PRE-SUBMISSION CHECKLIST

- Team includes personnel that have knowledge and experience developing standards and specifically the type of standard proposed
- Team has the personnel and necessary critical equipment and infrastructure to immediately start the proposed work upon award
- Team has a membership in ASTM
- Team understands that all activities funded under this RFP are considered standards development and all ASTM policies apply, including the IP Policy. Any requests for modifications are included as part of the proposal.
- Team has an understanding of the standards needs of the exo technology community and has reached out to ASTM with any questions regarding the proposal idea
- If human subject research is proposed, the Team has the experience and resources to get the proposed work approved in a timely manner.
- Team has written the proposal to allow a reviewer to easily address questions such as:
  - Will this project address a need for the exo technology standards community?
  - If successful, what difference will it make to the development of exo technology standards?
  - What are the risks and the payoffs?
  - How much will it cost and is this an appropriate usage of ET CoE resources?
  - How long will it take, and will it be relevant to our community when it is completed?
Team understands that award funding will be paid in milestones with the final amount paid upon successful delivery of a ballotable draft standard.

Team has reviewed the proposal and acknowledges it contains no proprietary or restricted information.