Research Announcement
Young Faculty Award
Microsystems Technology Office
DARPA-RA-15-32
February 26, 2015

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Part I: Overview Information

- **Federal Agency Name** – Defense Advanced Research Projects Agency (DARPA), Microsystems Technology Office (MTO)
- **Funding Opportunity Title –** Young Faculty Award (YFA)
- **Announcement Type –** Initial Announcement
- **Funding Opportunity Number –** DARPA-RA-15-32
- **Catalog of Federal Domestic Assistance Numbers (CFDA)** – 12.910 Research and Technology Development
- **Dates**
  - Posting Date: February 26, 2015
  - Proposal Due Date: April 13, 2015
  - Estimated period of performance start: August 30, 2015
- **Concise description of the funding opportunity:** This Research Announcement (RA) solicits ground-breaking single-investigator proposals from junior faculty for research and development in the areas of Physical Sciences, Engineering, Mathematics, Medicine, Biology, Information and Social Sciences of interest to DARPA's Defense Sciences Office (DSO), Microsystems Technology Office (MTO), and Biological Technology Office (BTO).
- **Anticipated individual awards** – Multiple awards are anticipated.
- **Anticipated funding type** - 6.1
- **Types of instruments that may be awarded** –
  DARPA intends to award grants to eligible university faculty and nonprofit research organizations; each grant will encompass funding for a 24-month base period consisting of two 12-month phases (a maximum of $250,000 per 12-month phase) and a 12-month option period (a maximum of $500,000).
- **Any cost sharing requirements –** None.
- **Agency contact**
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    DARPA/MTO

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PROPOSERS ARE CAUTIONED THAT EVALUATION RATINGS MAY BE LOWERED AND/OR PROPOSALS REJECTED IF PROPOSAL PREPARATION (PROPOSAL FORMAT, CONTENT, ETC.) AND/OR SUBMITTAL INSTRUCTIONS ARE NOT FOLLOWED.

PROPOSERS ARE STRONGLY ENCOURAGED TO READ THE INSTRUCTIONS PROVIDED AT SECTION IV(B)(4) REGARDING THE TIME REQUIRED TO RECEIVE VALIDATION OF SUBMISSIONS MADE THROUGH GRANTS.GOV. PROPOSALS THAT ARE VALIDATED AFTER THE PROPOSAL DUE DATE/TIME WILL BE CONSIDERED LATE AND, AS SUCH, WILL NOT BE REVIEWED.

Part II: Full Text of Announcement

Sec. I: FUNDING OPPORTUNITY DESCRIPTION

The Defense Advanced Research Projects Agency (DARPA) often selects its research efforts through the Research Announcement (RA) process. The RA is being issued, and any resultant selection will be made, using procedures under Federal Acquisition Regulation (FAR) 35.016 and Chapter 1, Subchapter C of Title 32, Code of Federal Regulations, Part 22 - Department of Defense Grant and Agreement Regulations (DoDGARs), Award and Administration. Any negotiations and/or awards will use the procedures under Part 22 of the DoDGARs and 2 CFR Chapter 2, Part 220 – Cost Principles for Educational Institutions (OMB Circular A-21), as applicable. The RA will appear on the Grants.gov website at http://www.grants.gov/ and on the Federal Business Opportunities (FedBizOpps) website at http://www.fbo.gov/. The following information is for those wishing to respond to the RA.

The DARPA Young Faculty Award (YFA) program aims to identify and engage rising stars in junior faculty positions in academia and equivalent positions at non-profit research institutions and expose them to Department of Defense (DoD) and National Security challenges and needs. In particular, this YFA will provide high-impact funding to elite researchers early in their careers to develop innovative new research directions in the context of enabling transformative DoD capabilities. The long-term goal of the program is to develop the next generation of scientists and engineers in the research community who will focus a significant portion of their future careers on DoD and National Security issues.

DARPA is soliciting innovative research proposals in physical sciences, engineering, materials, mathematics, biology, computing, informatics, and manufacturing of interest to DARPA's Defense Sciences Office (DSO), Biological Technology Office (BTO) and Microsystems Technology Office (MTO). Further detail regarding technical areas of interest can be found in the Technical Areas topics list. Proposals that fail to respond directly to a Technical Area will be considered nonresponsive.

Proposals responding to this RA should clearly describe the DoD problem being addressed, the current state-of-the-art technology, new insights to address the problem, a credible research plan and schedule, and critical, quantitative milestones to be pursued over each 12 month phase. Proposers should familiarize themselves with and address the Heilmeier Catechism in responding to this RA.

Proposed research should focus on innovations that will enable revolutionary advances in the selected topic area. High-risk/high-payoff ideas that could potentially transform a field or technology are strongly encouraged. Proposed research should investigate innovative approaches that enable revolutionary advances in science, devices, or systems. Specifically excluded is research that primarily results in evolutionary improvements to the existing state of practice.

Proposals that offer only incremental advances upon existing R&D and technologies will be deemed nonresponsive to this RA.

The RA seeks proposals for a research activity consisting of a 24-month base period broken into two 12-month phases with a maximum funding level of $250,000 per phase ($500,000 maximum total funding for the 24-month base period). For exceptional YFA project performance over the 24-month base period, a limited number of YFA performers will be awarded a "Director's Fellowship" with a maximum of an additional $500,000 in follow-on funding for an additional estimated 12-month period.

Proposals should include a 24-month base period (consisting of two 12-month phases) accompanied by a short summary of the proposed follow-on work for the estimated12-month "Director's Fellowship" option period. Proposals that do not include a detailed breakdown of the 12-month option will not be considered for the option. During the second 12-month phase of the base YFA program, the performers who are nominated to receive the Director's Fellowship may be required to update their proposals (including costs) to reflect expected future technical tasks based on the actual progress made previously.

During the 24-month base period, a number of visits/exercises at a variety of DoD sites and facilities will be scheduled. These briefings and visits will provide YFA recipients a unique, first-hand exposure to DoD personnel and technologies in the field, issues faced by the Services in execution of their missions, and current National Security challenges. It is expected that YFA recipients will participate in a subset of the visits/exercises made available to them. Participation in all such opportunities is not a requirement; however, lack of participation may impact the award of the Director's Fellowship. Proposers are expected to include the necessary travel funds within the total budget of their proposal.

Participation is limited to untenured Assistant or Associate Professors within 5 years of appointment to a tenure-track position at a U.S. institution of higher education or equivalent at a non-profit science and technology research institution.

Previous YFA recipients are not eligible to apply to this or any future YFA program. Applicants are limited to a maximum of three (3) applications to the DARPA YFA program during their term of eligibility. As this was a new requirement as of the 2009 YFA program, previous unsuccessful submissions to the program prior to 2009 will NOT be counted against the limit. Applicants should clearly state on the cover sheet any prior YFA submissions.

A. Technical Topic Areas:

This RA solicits single investigator proposals for research and development in the specific technical areas of interest to DARPA's Microsystems Technology Office (MTO) and Defense Sciences Office (DSO) articulated below. **Proposers must specify ONE and only one of these topic areas for their proposal and identify this on the cover page.** Note: DARPA reserves the right to assign proposals to a different topic area than that which was indicated by the proposer.

Applicants who have questions about specific topic areas should email DARPA-RA-15-32@darpa.mil with the topic area stated in the subject line. Your question will be distributed to the appropriate contact.

Proposers are encouraged to review the DARPA mission statement and current program descriptions at the DARPA website http://www.darpa.mil/ to view examples of current DARPA investments. This is not meant as instruction to duplicate those efforts, but rather to illustrate that current programs are aimed at research which will substantially advance our capabilities in these areas. Once awards are made, each YFA performer will be assigned a DARPA Program Manager with interests closely related to their research topic. The Program Manager will act as project manager and mentor to the YFA performer.

1. Technical Area One: **Threshold-Defined Logic Engines:** YFA proposers are invited to submit ideas for CMOS chip architectures which enable a single fixed chip design and layout to present as multiple disparate logic engines, where each logic engine is defined solely by the threshold voltages asserted on each device during manufacturing. The logic engines must be distinct from one another, with each being stable and robust to conventional process / voltage / temperature (PVT) tolerances. Proposers should not offer conventional ROM/ROS memory array solutions which are personalized by threshold or enhancement/depletion mode NMOS or PMOS; but rather very specific true logic engines which assume very different personalities given the same inputs, dependent only upon the threshold voltages selected. Assume that the threshold voltages available are limited to the three typical current device offerings made available by the major fabs:
    - High Vt, low leakage, lower performance bulk PFETs and NFETs
    - Regular Vt, nominal leakage, nominal performance bulk PFETs and NFETs
    - Low Vt, high leakage, high performance bulk PFETs and NFETs

    Solutions may not involve changing the polarity of devices for PFET to NFET, or NFET to PFET, but rather only change the threshold voltages of the devices. Assume that gate dielectric thicknesses may not be changed. VDD and substrate/well biases may not be varied from device to device depending upon threshold personalization, and should be at conventional voltages for the given lithography node. Solutions should strive to remain high performance and low power in each of its realizations, and respect conventional reliability rules for NBTI, PBTI, Hot Electron Effect, and electromigration wear-out effects.

2. Technical Area Two: **Interference Mitigation for Digital Beam Forming:** Transformative digital beamforming architectures require the digitization of array signals at the element level. Such architectures will provide unprecedented flexibility and capability in the control of simultaneous send/receive beams, sidelobe management, and beam nulling against interference. Elemental digital architectures, however, remain especially susceptible to interference from strong signals impinging onto the array from directions outside of the desired beam.

    This YFA topic will focus on techniques that leverage the array's elemental digital nature to mitigate the effects of strong out of beam interferers. Of particular interest are techniques that process beam shape and sidelobes as to maintain beam integrity upon the threshold of nonlinearities due to excessive levels of receive power. Note the proposed effort should be viewed as a complement to elemental-level nonlinear equalization, which acts on each element independently. The proposed effort aims to adapt the array as a whole to potential degradations in performance due to incoming interference.

3. Technical Area Three: **Reconfigurable RF Technologies:** Reconfigurable RF components, such as antennas, filters, and data converters expand the range of environments in which signals can be sent and received efficiently. These components are vital to the ability of transceivers and sensors to adapt within a limited environment. These components are integral to meeting the ever changing environment with optimized functions as DoD missions dictate. There are many considerations and trade-offs when designing with passive and active elements. This program seeks an ideal balance between the use of passive and active elements to yield high performance under tight constraints in a constantly changing signal environment. Proposers should deftly use the co-design of active and passive elements to create components that can produce results that are superior to what can be achieved by using these elements individually. This program seeks superior improvement in areas such as linearity, ENOB, loss, and especially frequency tuning range. Incremental improvements to the design of antennas, filters, and data converters will be considered nonresponsive. Example elements include, but are not limited to:
    - High – Q resonators
    - Delay lines
    - Passive radiators
    - Active transistors

    Example elements may be considered in relation to, but are not limited to:
    - Field-programmable antenna types (Yagi-Uda, fractal, loop, etc.)
    - Adaptive radio frequency components such as filters and data converters.

4. Technical Area Four: **High Power GaN Transistors for RF Applications:** High power RF transistors are a key enabling technology for defense electronic systems. While state-of-the-art GaN devices are capable of generating more than 6 Watt/mm linear RF output power future power amplifier applications require more than 60W/mm transistors.

    This YFA topic will focus on fundamental research efforts aimed at enabling reliable GaN power amplifier transistors operating at temperatures above 275C, with a power density greater than 60 W/mm. The technical areas of interest include, but are not limited to, (1) the theoretical and/or experimental study of fundamental GaN, and associated epitaxy material limitations, (2) novel device architecture concepts to increase the breakdown voltage and/or drive current, while minimizing the transistor speed penalty, and (3) innovative material or epitaxy development that will enable high power transistor structure. Consideration will also be given to alternative material systems that are capable of reaching these goals. The proposed research activities are required to define the target RF frequency and specific linear power goals being pursued.

5. Technical Area Five: **Transient Compound Semiconductor Devices:** DARPA has initiated studies of transience in silicon-based semiconductor components aimed at determining the transient characteristics of device materials, in the presence of natural triggers, and identifying external triggers for on-demand transience. Transient electronics hold great promise as a complement to traditional COTS technologies, providing short-

lived devices for environmental and hazardous material mapping and/or allowing for accelerated, on-demand transience. Such transient devices are expected to perform robustly until nearing the end of their operating life and/or their triggered demise.

This YFA topic seeks to expand the study of transience to compound semiconductor devices. More specifically, DARPA is soliciting innovative proposals to study and demonstrate transience modes (e.g., sublimation, dissolution, fragmentation, etc.) and triggering mechanisms (e.g., optical, RF, chemical, mechanical, etc.) that will lay the foundation for transient compound semiconductor-based systems. Applicants should focus primarily on engineering the transience of active materials typically found in COTS compound semiconductor systems, but should also address common associated materials (e.g. gate dielectrics) that may require transience engineering. Electronically- and/or optically-active materials of interest include, but are not limited to, III-N, III-As, InP, and Sb-based compound semiconductors. Organic electronics are explicitly not of interest to this call. DARPA is especially interested in triggering mechanisms readily available in natural or built environments; those based on energetic materials are explicitly excluded from this call.

Transience studies should achieve complete physical deconstruction (to the naked eye) of demonstration devices (e.g. HEMT, LED, etc.) that reveal the material's electronic (e.g., electron mobility) and transience (e.g., transience rate) characteristics. While the overall goal of the effort should be to trigger the fastest complete transience rates, comprehensive transience characteristics of these demonstration devices (and their associated electronic performance) should be investigated and documented. Proposals should include technical justification for the anticipated range of transience rates based on the active material properties and the selected transience mode. Proposals should detail the target materials characteristics (electronic and transience) and the planned demonstration device. Practical considerations associated with deploying these transient devices should be discussed in the proposal, for example safe handling of the final system, robustness of the device performance over time, trigger stability, etc.

6. Technical Area Six: **Nanostructures for Minimizing Thermal Boundary Resistance:** Thermal Boundary Resistances (TBRs), at interior interfaces between epitaxial layers, are a key limiting factor in the performance of compound semiconductor devices. The heat removal benefit associated with high thermal conductivity substrates is severely constrained by phonon transport across the structurally-disordered, nanoscale boundary region. Nano-engineered boundary structures, that reduce phonon scattering and optimize phonon populations, can enhance heat transfer across boundary regions but have yet to be demonstrated.

This YFA topic is aimed at achieving a "proof of concept" experiment that demonstrates in a clear and unequivocal manner that nanostructure engineering can be successfully applied to the reduction of Thermal Boundary Resistances to the order of 1 m2K/GW, in relevant compound semiconductor material sets. Particular interest is directed to the boundary region between GaN epitaxy and supporting, high thermal conductivity substrates, such as SiC and diamond. It is expected that the effort will include theoretical

phonon transport analysis, computer-based design of the TBR-reducing nanostructure, nanofabrication of the selected structure, and experimental demonstration of a low TBR stackup, involving the selected materials and the boundary region.

7. Technical Area Seven: **Fundamental Antenna Design Principles:** Design of simple wire and plate antenna elements is now considered routine, largely due to the strong link between the underlying theory and current engineering practice. More exquisite antenna concepts, such as those incorporating electromagnetic band gap structures, using the theory of characteristic modes, and leveraging exotic materials such as metaferrites, among others, are uniquely enabled by our current modeling and simulation capability, but have yet to make the transition from academia to engineering practice because of the lack of fundamental understanding of their basic design principles. Applicants to this topic should propose research that combines theoretical analysis, experimental measurement, and numerical simulation to develop a fundamental understanding of these antenna concepts, and translate this understanding into a set of engineering design rules for next-generation antenna structures. The antennas thus produced should support communication in the radio bands from HF to UHF.

8. Technical Area Eight: **A Radically More Efficient Circuit Design Methodology:** As Moore's Law advances slow down, improvements in integrated circuit (IC) performance through process technology are increasingly limited. As a result, future IC performance improvements increasingly will be made through design and architecture advances, rather than through the traditional technology advances driven by Moore's Law. Many of these design/architecture advances can only be made through use of application-specific ICS that require custom design.

Design of application-focused ICs is currently constrained by the high cost and effort required to design circuits in leading-edge CMOS technology. Specifically, only systems that can justify large design expenses and long circuit development cycles can utilize leading-edge CMOS technology. Much of the cost and time required to design leading-edge ICs is determined by the current set of design methodologies and tools. New methods and approaches will be required to enable the design of a broad range of application-focused ICs.

In this topic we are seeking development of methods to sharply reduce the time/effort required to design custom integrated circuits in CMOS technology at and beyond 14nm. The goal is to reduce design time of all portions of the design cycle by at least 5X. Proposed advances should have particular application to integrated circuits for the DoD and may apply to the design of digital and/or analog circuits. The over-arching goal is to enable more designers to more easily design application-specific circuits in leading-edge CMOS technologies.

9. Technical Area Nine: **Microbial Mediation of Host Tolerance to Infection:** DARPA is proposing a new approach for medical countermeasure discovery against biological threats by exploiting host tolerance to infection. Traditional treatment of infection has focused primarily on pathogen growth inhibition and eradication within the host. This

approach relies on a priori identification of the pathogen, is limited to a subset of pathogens, and has contributed to the increased prevalence of drug-resistant organisms. However it may be possible to maintain a homeostatic state in the host under high pathogen burden, i.e. tolerance. Commensal and pathogenic bacteria have been known to induce changes in host immune mechanisms which affect the ability of the host to tolerate infection. In some cases, these mechanisms modulate the host's innate immune response allowing a pathogen to become "integrated" within a microbiome niche. It is of interest to understand if these microbial-induced processes may be exploited to improve host tolerance to infection.

DARPA is interested in research that explores the effects that microbes have on mammalian hosts in order to improve a host's tolerance to infection. Specific topics of research may include, but are not limited to, symbiotic effects on innate and adaptive immune responses, exploration of host mechanisms that distinguish pathogens from commensals that could be leveraged for resilience, discovery and development of interventions that mimic microbial processes implicated in host resiliency, and -omics research to identify the differential host response to elucidate a microbial-induced state of tolerance. DARPA is not interested in microbiome research that examines microbiome effects on pathogens and which excludes exploration of host interactions, or host-pathogen research of interactions that modulate pathogenicity without addressing host tolerance. Research should justify how exploring these resilience mechanisms may be translatable to humans, although no human research will be accepted under this topic.

10. Technical Area Ten: **The Neuroscience of Architecture:** DARPA is interested in harnessing biological complexity at multiple scales and contexts and exploring how engineering changes in the immediate contextual environment drives human performance. More than any other species, humans design habitats for a variety of functions, including shelter, labor, education, healing and leisure. It is unclear whether these built environments complement innate biological processes, or whether the materials, workflows, and constructed spaces we inhabit compete against evolved functions and needs for light, atmosphere, or even human to human interactions. DARPA seeks to understand the degree to which the built environment could contribute to or detract from overall human performance by exploring the intersections of architecture and biology, with a specific interest in neuroscience. Research questions to consider when addressing this topic include: The critical, interesting, and untapped connections forming between the architecture and neuroscience; How the built environment can enhance the human experience for learning, training, or restoration of health; Identification of physiological measures that indicate responsiveness to changes in environments, both positive and negative; Methods for applying this knowledge to the classically intuitive or heuristic processes of architectural design; and the intersection of neuroscience and architectonics.

For this call, DARPA is specifically interested in tightly integrated collaborations between scientists from the broad fields related to neuroscience (neuroscientists, psychologists, molecular biologists, bioengineers, etc.) and designers and architects (including landscape architects).

11. Technical Area Eleven: **Understanding and Leveraging Biophysical Mechanisms of Acoustic Neuromodulation:** The physical properties of biological tissue introduce unique challenges to neural communication and modulation technologies. Acoustic approaches, such as ultrasound, represent one promising solution for achieving targeted, non-invasive neural interfaces. However, despite successful examples of ultrasound imaging and neuromodulation, the mechanisms underlying the acoustic transduction of energy through biological tissue are not well characterized.

As such, DARPA seeks innovative theoretical and experimental research to develop a deep understanding of the underlying biophysical mechanisms for modulating neural activity in peripheral nerves using ultrasound. It will be necessary to develop physical models and validate these against experimental data. Of particular interest are demonstrations in mammalian tissue, which have been limited to date. It is expected that this new understanding will lead to precise, safe, effective, and low-power techniques to stimulate and record from peripheral nerves. While device development is not the focus of this topic, it may be necessary to validate models using existing or novel devices.

Proposers should explicitly address how their proposed approach is new, addresses the limitations of our current understanding in this space, and will result in transformative knowledge beyond our current understanding.

12. Technical Area Twelve: **Restoring Lower Limb Sensation through Peripheral Nerve Stimulation:** Recent advances in nerve stimulation technologies have led to demonstrations of restored cutaneous and proprioceptive sensation in upper limbs. However, to date little focus has been placed on the application of these technologies to lower limbs, despite the high prevalence of lower limb loss within both military and civilian amputee populations. The use of lower limb prosthetics presents specific challenges such as maintaining bipedal balance and locomotion. It remains unclear how sensory feedback contributes to these functions and what benefits may be gained through the incorporation of sensation into lower limb prostheses.

DARPA seeks innovative proposals to understand the role of sensation in lower limb function and to restore sensory feedback to human subjects with lower limb sensory loss (e.g., as a result of amputation or diabetic neuropathy) through peripheral nerve stimulation. The impact of sensory feedback on functions that rely on lower limbs, such as balance and locomotion, should be assessed. Proposals should include a credible plan to identify and stimulate the cutaneous and proprioceptive nerve fibers that are relevant to improving balance and locomotion. Focus should be placed on achieving naturalistic sensations of touch and proprioception, not sensory substitution. Existing or modified technologies should be leveraged to as great an extent as possible; efforts that focus primarily on electrode development or prosthesis sensorization are outside the scope of this topic.

13. Technical Area Thirteen: **Advanced Neural Modeling of Sensory Pathways:** DARPA seeks proposals for neural mapping, transduction, and encoding software that models, as fully as possible, complete end-to-end nervous system pathways from the human sensory

periphery all the way to cortex. Example primary foci could be, but are not limited to, one or more of the following sensorimotor pathways:

- Auditory/vestibular: audio signals impinging on the outer ear through middle and inner ear, Cochlea, all the way to auditory cortex
- Visual: 2d still and moving images projected onto retinal cones and rods all the way to V1 and possibly successive layers deeper in the visual cortex.
- Motor control for verbal utterances, i.e. Cerebellum to spinal cord to vocal cord, mouth and tongue control musculature.

Transduction functions should be bi-directional so that they can be used to both encode raw sensory stimulus and translate it to a cortical neural activity patterns, and to decode cortical activity representations and use them to reconstruct estimates of the original sensory stimuli that would have induced such cortical activity.

Computational efficiency is a critically-important factor for scalable real-time implementation of these transduction operations on power-constrained computing platforms. Awardees will be expected to supply theoretical descriptions, documented source code, and operating software along with analyses of algorithmic scalability in applications to manage 2D planes and 3D volumes of neural tissue in the chosen sensory cannels.

Software APIs should adhere to industry-standard data formats where they exist; for example, sensory IO data formats should use one of the popular commercial standards such as MPEG4 or HEVC for video, JPEG for still image frames, and MP3 for audio. DARPA is open to a multiplicity of neural activity encoding strategies which best embody the activities, deterministic function, information content, and statistics of the neural tissue to be transcoded.

Subtask: Machine learning implementations that can automate the establishment and tuning of these transduction functions for individual subjects' unique neural structure would be well received, though are not required.

Additional program extension options would involve the implementation and demonstration of these software systems in ultra-low power computing platforms.

14. Technical Area Fourteen: **Human Robot Interaction:** Robots and other unmanned systems hold great promise to protect people by keeping them out of harm's way, and to make people more productive by performing tasks cost-effectively. Advances in human-robot interaction are expected to help realize that promise, transitioning the robot from a tool to a teammate. Benefits include reducing the resources required to manage robots, resulting in greater situation awareness and greater team capabilities.

- Models of robot information exchange, behavior, and transparency, and use of those models to develop more natural ways for human-robot information exchange
- Methods to improve human shared mental models, team situation awareness, and overall trust in robotic systems

- Identification, design, and integration of multimodal human-robot interaction capabilities, such as natural language, tactical displays, auditory understanding, and interactive representations of the robot's "mental model"
- Models of social dynamics supporting context for perceptual understanding, tactical movements, socially conscious behaviors, and environmental considerations
- Tools for investigating critical HRI issues, such as simulation testbeds, advanced simulation capabilities, and common HRI metrics for T&E

15. Technical Area Fifteen: **Novel Abstractions for Engineering Design:** Engineering design universally relies upon useful abstractions to provide insights into design choices and trades. Abstractions such as 2D drawings, 3D solid models, and circuit diagrams have very obvious ties to a given final system. Others like block diagrams, signal flow diagrams, bond graphs, phase diagrams, and Nyquist diagrams have more subtle linkages to the system being considered. In this topic we are interested in exploring and developing novel abstractions based on mathematical or computation paradigms that will enable faster, more effective design of complex engineering systems. Abstractions of particular interest include those that accommodate and exploit functional and behavioral phenomena that can be produced using additive manufacturing processes; enable form to be derived or "compiled" from functional specifications; and those with potential to integrate with or extend state of the art computer aided design systems.

16. Technical Area Sixteen: **Autonomy in Unstructured Environments:** This topic seeks new ideas toward unification of sensing, reasoning and action for autonomous operations in unstructured environments. We aim to provide increasingly higher values in practical human/robotic/machine systems through expanded capabilities to learn and perform progressively complex tasks. The autonomy capability in current autonomous systems is often brittle, built on disconnected paradigms for sensing, planning, and action. The operations are usually limited to a fixed environment and fixed set of tasks. They are unable to deal with unexpected deviations (even if small), and their task level scalability is limited. Research is sought in mathematical and computational methods that increase autonomy enabling integrated context-aware reasoning, perception and control suitable for real-world applications (from an individual system to cooperative systems of multiple robots/agents and humans) . Of interest are methods that enable real-time decision making in unstructured environments and problem solving for performing autonomous tasks that are similar but not identical to situations for which robotic agents were initially trained.

Extensions of such methods for cognitive and linguistic dialog for cooperative systems with multiple robots/agents and humans to further enable progressive autonomy (reduce human involvement with experience), are of interest. Methods should be platform agnostic suitable for transferring learned and experienced skills from one platform to another. Research should also address accelerating speed and scope of learning. Proposal should include practical examples preferably with plans for demonstrations and/or simulations of the newly derived autonomy capabilities in high value scenarios applicable

to multiple practical situations (e.g., disaster relief; vehicle repair and logistics; value-added through reducing robot programming costs for variety of complex operations).

17. Technical Area Seventeen: **Mathematics of Art:** This topic aims to explore how performing arts can enable development of novel engineering design methodologies or complementary methods for scientific analysis, creativity, and discovery. As an example, can a well-choreographed dance shed light on designing an effective collection of cooperative agents or robots? What are the underlying interactions and dynamics in such an artistic performance that can be generalized to design of engineering systems?

Among interests include development of novel scientific and mathematical methods to model principles of human communication present in performing art including the vocabulary (e.g. visual or movements), compositional structure, rules, interactions, emergent expression or behavior and emotional connection found in an artistic production. Such representation has the ability to model interactions and communications in the group. For example, a performing art such as dance reflect many kinds of human movements and expressions through subtle gestures and physical communications that are interpreted clearly with great speed and emotion beyond the usual world of articulated thoughts and actions. Leveraging latest technologies it is possible to autonomously capture a mathematical representation of movements (jointly with other modalities such as visuals and sounds) present in a scene. This representation can be used to model the collaborative dynamics of natural movements and interactions in a group dance, an artistic blend of choreographed and improvised, leading to emergent collective behavior of the ensemble and its emotional constructs. Modeling the elements of this non-verbal communication, or even emotional connection, in a group dance may have implications for effective human-machine interface design.

Potential applications include developing a language for understanding basic constructs of human emotions, inspiration, and non-verbal communication using combination of scientific and artistic evaluation or exploration methods. Such effort will help better understanding verbal and non-verbal communications in the context of synchronizing team/squad dynamics, and how combination of various individual proficiencies translates into a collective proficiency. Other applications include understanding patterns and dynamics in swarms, perception and movements in collaborative robotics, and human factors in human-machine interaction.

18. Technical Area Eighteen: **Imaging, Communication, and Sensing through Highly Scattering Complex Media:** DARPA seeks innovative experimental and theoretical research focused on optical transmission through highly scattering complex media. Media of interest include, but are not limited to:

- Biological Tissues
- The Brain (through skull, at the neuronal level)
- Fog/Clouds
- Sand/Dust Storms
- Water (including turbid/murky seawater)
- Turbulent Atmosphere (including precipitation)

All proposed research should address more than one (and preferably as many as possible) media of interest. Approaches that combine disparate modalities (e.g., using acoustic waves to produce reference points for optical probing) are acceptable and encouraged. Proposals should provide experimental and/or theoretical approaches that directly address the problems of imaging, sensing, and/or communications through complex media.

Imaging – The approach should reveal 2D or 3D imaging information through >100 scattering lengths at the primary interrogation wavelength. The target temporal and spatial resolutions of the resulting image should be relevant to the particular media and application of interest, and should be clearly indicated in the proposal.

Communication – The approach should enable two-way communications through >100 scattering lengths of highly scattering media. Technical approaches can exploit multiple sources and detectors on two sides of a scattering region, and should address the possibility of multiple regions of media in one communications channel.

Sensing – The approach should detect specific objects or phenomena of interest through >100 scattering lengths at the primary interrogation wavelength. Examples include the non-invasive accumulation of diagnostically relevant information about cellular structures (i.e., non-invasive pathology) or the ability to track a specially designed traffic-lane marker through thick fog that would otherwise have zero visibility.

19. Technical Area Nineteen: **Multidimensional Spectroscopy at the Extremes of Coherence:** Multidimensional modalities have long been employed in magnetic resonance spectroscopy to determine the structure of complex molecules with congested spectra. While the high frequencies and fast time-scales associated with optical spectroscopies have impeded the general implementation of such techniques, multidimensional approaches are now being used to probe correlations between coupled modes and the dynamics of complex molecular and semiconductor systems in the optical domain. Optical multidimensional spectroscopic techniques may further lead to enhanced sensitivity in chemical detection applications with simultaneously improved chemical identification in the presence of spectral clutter.

This topic seeks to explore, experimentally and theoretically, multidimensional spectroscopy for chemical sensing at the "extremes of coherence." Specific areas of interest include the role of temporal coherence in optical spectroscopy: how multidimensional spectroscopies may exploit the exquisite coherence of optical frequency combs for enhanced sensitivity and chemical selectivity in spectroscopically congested environments; and how multidimensional spectroscopies may be carried-out with broadband incoherent light sources for cost effective chemical sensing in spectroscopically congested environments. Additional topics of interest include: incorporating imaging capabilities with multidimensional spectroscopy modalities; and incorporating compressive sensing concepts with multidimensional spectroscopy for enhanced spectral resolution with undersampled, computationally accessible data sets.

20. Technical Area Twenty: **Physics, Duality and Topology:** DARPA seeks theoretical research into new physics-based paradigms for describing strongly coupled and exotic many bodied quantum systems, as well as applications of these paradigms to pure mathematical advancements.

Over the last few decades, a rich tapestry of quantum many body systems in in high energy and condensed matter physics have been discovered which are not describable by the traditional methods of perturbative Quantum Field Theory and spontaneous symmetry breaking. These quantum systems include high temperature superconductors, topological phases of matter (including the [Fractional] Quantum Hall Effect) and confining phases of Quantum Chromodynamics and often have exotic properties such as fractional charge and statistics or anomalous scaling.

More recently, a new suite of theoretical tools has been proposed as possible explanations for these states of matter; these include topological quantum field theories (TQFTs) and also a rich set of dualities between theories that enable computation. These dualities can be of the "strong-weak" variety (such as S-duality, where questions in a strongly coupled theory can be translated to a weakly coupled one where perturbation theory applies) or "gauge-gravity" duality, where questions can be recast as those in classical theories of gravity. TQFTs and dualities have also found applications in pure mathematics, where they have been used to discover and calculate new topological invariants (which are often more discriminating than those discovered by pure mathematicians).

These methods are still in their infancy, however, and have only scratched the surface of new theoretical paradigms for quantum systems. This topic seeks develop the landscape of new theoretical approaches and methods for exploring these quantum phases of matter and also applying them to purely mathematical inquiries (work may be proposed in either, or both, thrusts).

Target applications for the DoD include possible future development for long-range, high temperature conductivity and uses of these phases in robust approaches to quantum computation. The mathematical applications of this effort may also contribute to the data analysis goals of the DoD (in, for example, topological data analysis).

21. Technical Area Twenty One: **Geometric Approaches to Statistics and Inference:** DARPA seeks new research into geometric approaches to statistical inference. Much of the bottleneck of the analysis of "big data" is related to the poor scaling and technical challenges of fitting statistical distributions to high dimensional data (especially if the data is highly correlated). Though approaches such as simulated annealing and message passing have helped, a disruptive innovation is needed to make further progress in the field.

There has been some recent evidence to suggest that, somewhat surprisingly, techniques from pure mathematical subjects such as differential geometry, algebraic geometry, and algebraic topology can be leveraged for this problem. This topic seeks develop these geometric algorithms for use in statistical inference. Focus areas are expected to include

computational topology, information geometry and algebraic statistics for application to (but not limited by):

- Asymptotic properties of statistical estimators
- Existence or non-existence of maximum likelihood estimators
- Robust and fast approximations of inference algorithms
- Experimental design
- Hypothesis testing
- Incorporation of geometric techniques into machine learning algorithms (for example, use of geometric features)

22. Technical Area Twenty Two: **New Theoretical Approaches to High-Dimensional Optimization:** DARPA seeks theoretical research into new technical approaches to convex and non-convex optimization for large (terabyte scale) and extremely high dimensional datasets. As the DoD's ability to collect data continues to grow with the availability of cheap storage and small, affordable and deployable sensors, the gap between data acquisition and analysis will continue to grow unless a more comprehensive theoretical approach to optimization is developed.

Current approaches to large scale optimization and machine learning are bottlenecked by:

- Non-convex objective functions, and exponentially or high degree polynomial scaling algorithms.
- Algorithms which are not optimized for parallelization and large scale implementation.
- Poor understanding of heuristic and relaxation approaches for high dimensional approximation.
- Algorithms not optimized for the known structure of datasets (long tailed degree distributions, lack of medium scale clustering, etc.)

Recent advances in optimization have suggested that it might be possible to execute terabyte scale problems in a mission actionable time. This topic seeks to leverage these advances to discover new theoretical approaches to algorithmic construction. Focus areas include, but are not limited to:

- Optimization algorithmic design tailored to large scale parallel implementations.
- Stochastic preconditioning and other randomized approaches enabling the breaking of classical theoretical scaling ceilings.
- Convex relaxations of non-convex problems and a complete mathematical understanding of the relationship between exact and relaxed objective functions.
- The leveraging of prior dataset knowledge for algorithmic speedup.
- Higher risk approaches such as numerical algebraic geometry.

23. Technical Area Twenty Three: **Generation of Fine-Structured Adaptive Illumination Patterns:** DARPA seeks innovative theoretical and experimental research for generation, projection and manipulation of fine-structured illumination patterns targeting objects at near and far ranges (for example, near may be on the order of 10's to 100's of meters, and far on the order of kilometers to 10's of kilometers).

Patterns of interest include, but are not limited to:

- Fringes with sinusoidal spatial light intensity distribution, of adjustable spatial orientations and spatial frequency;
- 2-dimensional lattice of illuminated patches with orthonormal spatial and temporal codes (e.g., Haddamard, DCT, KL basis sets, or CDMA codes) ;
- Single tight illuminated spot;
- 2-dimensional regular lattice of light spots with ability to change spot size and lattice periodicity.

Light pattern generator should be capable of generating patterns with spatial and temporal variability. Specifically, what is desired is the capability to laterally shift patterns with high positional accuracy, temporally change projected patterns and projected codes, and ability to rotate 2-dimensional patterns.

Source of illumination can be coherent or incoherent. In the former case, some means of mitigating or completely eliminating speckle should be explored and quantified. However, speckle mitigation should not affect quality of illumination patterns (contrast, sharpness of fringes, size of light spots, etc.).

DARPA is specifically interested in research of new materials, techniques and approaches to generate and project illumination patterns at large distances, comprising single and multiple points of light. Light spots are required to have the smallest possible linear size, substantially smaller (sub-diffraction-limited) than what conventional optical projection techniques are capable of under similar conditions. An important goal of the research is developing understanding of fundamental physical limits to achieving smallest possible light spots, and to achieving controllable and repeatable illumination patterns of this kind.

Sec. II. AWARD INFORMATION

Multiple awards are anticipated. The amount of resources made available under this RA will depend on the quality of the proposals received and the availability of funds.
The Government reserves the right to select for negotiation all, some, one, or none of the proposals received in response to this solicitation, and to make awards without discussions with proposers. The Government also reserves the right to conduct discussions if it is later determined to be necessary. If warranted, portions of resulting awards may be segregated into pre-priced options. Additionally, DARPA reserves the right to accept proposals in their entirety or to select only portions of proposals for award. In the event that DARPA desires to award only portions of a proposal, negotiations may be opened with that proposer. The Government reserves the right to fund proposals in phases with options for continued work at the end of one or more of the phases.

Awards under this RA will be made to proposers on the basis of the evaluation criteria listed below (see section labeled “Application Review Information”, Sec. V.), and program balance to provide overall value to the Government. The Government reserves the right to request any

additional, necessary documentation once it makes the award instrument determination. Such additional information may include, but is not limited to, Representations and Certifications. The Government reserves the right to remove proposers from award consideration should the parties fail to reach agreement on award terms, conditions and cost/price within a reasonable time or the proposer fails to timely provide requested additional information.

Fundamental Research

It is DoD policy that the publication of products of fundamental research will remain unrestricted to the maximum extent possible. National Security Decision Directive (NSDD) 189 established the national policy for controlling the flow of scientific, technical, and engineering information produced in federally funded fundamental research at colleges, universities, and laboratories. The Directive defines fundamental research as follows:

> 'Fundamental research' means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons."

As of the date of publication of this RA, the Government expects that program goals as described herein may be met by proposers intending to perform fundamental research. The Government does not anticipate applying publication restrictions of any kind to individual awards for fundamental research that may result from this RA. Notwithstanding this statement of expectation, the Government is not prohibited from considering and selecting research proposals that, while perhaps not qualifying as fundamental research under the foregoing definition, still meet the RA criteria for submissions. If proposals are selected for award that offer other than a fundamental research solution, the Government will either work with the proposer to modify the proposed statement of work to bring the research back into line with fundamental research or else the proposer will agree to restrictions in order to receive an award.

Proposers should indicate in their proposal whether they believe the scope of the research included in their proposal is fundamental or not. While proposers should clearly explain the intended results of their research, the Government shall have sole discretion to select award instrument type and to negotiate all instrument terms and conditions with selectees. Appropriate clauses will be included in resultant awards for non-fundamental research to prescribe publication requirements and other restrictions, as appropriate.

III: ELIGIBILITY INFORMATION

A. Eligible Applicants

This RA solicits single investigator proposals for research and development in the specific Technical areas of interest to DARPA's Defense Sciences Office (DSO), Microsystems Technology Office (MTO) and Biological Technology Office (BTO) as outlined in Part II, Section I.

Participation is limited to untenured Assistant or Associate Professors within 5 years of appointment to a tenure-track position at a U.S. institution of higher education or equivalent at a non-profit science and technology research institution.

Previous YFA recipients are not eligible to apply to this or any future YFA program. Applicants are limited to a maximum of three (3) applications to the DARPA YFA program during their term of eligibility. As this was a new requirement as of the 2009 YFA program, previous unsuccessful submissions to the program prior to 2009 will NOT be counted against the limit. Applicants should clearly state on the cover sheet any prior YFA submissions.

Applicants are also limited to ONE submission to this RA.

Proposers should provide in their proposal a listing of past, current, and pending support, including sponsor, funding level, performance dates, and level of all federally funded research efforts. DARPA is particularly interested in identifying outstanding researchers who have previously not been performers on DARPA programs, but the program is open to all qualified applicants with innovative research ideas. If you have been or currently are a performer on a DARPA program, please list this clearly on the cover sheet as indicated in Section IV.B.3.a.

All responsible sources capable of satisfying the Government's needs may submit a proposal that shall be considered by DARPA.

Unless otherwise stipulated herein, non-U.S. organizations and/or individuals may participate to the extent that such participants comply with any necessary nondisclosure agreements, security regulations, export control laws, and other governing statutes applicable under the circumstances.

B. Procurement Integrity, Standards of Conduct, Ethical Considerations, and Organizational Conflicts of Interest

Current federal employees are prohibited from participating in particular matters involving conflicting financial, employment, and representational interests (18 U.S.C. §§ 203, 205, and 208). Once the proposals have been received, and prior to the start of proposal evaluations, the Government will assess potential conflicts of interest and will promptly notify the proposer if any appear to exist. The Government assessment does NOT affect, offset, or mitigate the proposer's responsibility to give full notice and planned mitigation for all potential organizational conflicts, as discussed below.

Without prior approval or a waiver from the DARPA Director, in accordance with FAR 9.503, a contractor cannot simultaneously provide scientific, engineering, technical assistance (SETA) or similar support and also be a technical performer. As part of the proposal submission, all members of the proposed team (prime proposers, proposed subcontractors, and consultants) must affirm whether they (their organizations and individual team members) are providing SETA or similar support to any DARPA technical office(s) through an active contract or subcontract. All affirmations must state which office(s) the proposer, subcontractor, consultant, or individual supports and identify the prime contract number(s). All facts relevant to the existence or

potential existence of organizational conflicts of interest (FAR 9.5) must be disclosed. The disclosure must include a description of the action the proposer has taken or proposes has taken to avoid, neutralize, or mitigate such conflict. If in the sole opinion of the Government after full consideration of the circumstances, a proposal fails to fully disclose potential conflicts of interest and/or any identified conflict situation cannot be effectively mitigated, the proposal will be rejected without technical evaluation and withdrawn from further consideration for award.

If a prospective proposer believes a conflict of interest exists or may exist (whether organizational or otherwise) or has questions on what constitutes a conflict of interest, the proposer should send his/her contact information and a summary of the potential conflict to DARPA-RA-15-32@darpa.mil before time and effort are expended in preparing a proposal and mitigation plan.

C. Cost Sharing/Matching

Cost sharing is not required; however, it will be carefully considered where there is an applicable statutory condition relating to the selected funding instrument (e.g., for any Other Transactions under the authority of 10 U.S.C. § 2371). Cost sharing is encouraged where there is a reasonable probability of a potential commercial application related to the proposed research and development effort.

Sec. IV: APPLICATION AND SUBMISSION INFORMATION

A. Address to Request Application Package

This solicitation contains all information required to submit a proposal. No additional forms, kits, or other materials are needed. This notice constitutes the total RA solicitation. No additional information is available nor will a formal Request for Proposal (RFP) or additional solicitation regarding this announcement be issued. Requests for the same will be disregarded.

B. Content and Form of Application Submission

DARPA policy is to treat all submissions as source selection information (see FAR 2.101 and 3.104), and to disclose their contents only for the purpose of evaluation. Restrictive notices notwithstanding, during the evaluation process, submissions may be handled by support contractors for administrative purposes and/or to assist with technical evaluation. All DARPA support contractors performing this role are expressly prohibited from performing DARPA-sponsored technical research and are bound by appropriate nondisclosure agreements.

Submissions will not be returned. The original of each submission received will be retained at DARPA and all other non-required copies destroyed. A certification of destruction may be requested, provided the formal request is received at this office within 5 days after unsuccessful notification.

1. Security Information

The Government anticipates proposals submitted under this RA will be UNCLASSIFIED.

2. Proprietary Information

Proposers are responsible for clearly identifying proprietary information. Submissions containing proprietary information must have the cover page and each page containing such information clearly marked with a label such as "Proprietary" or "Company Proprietary." Note, "Confidential" is a classification marking used to control the dissemination of U.S. Government National Security Information as dictated in Executive Order 13526 and should not be used to identify proprietary business information.

3. Proposal Submission Information

The YFA proposal process consists of a full-proposal submission only. **There will not be a proceeding abstract phase.** Proposers are required to submit full proposals by the time and date specified in the RA. **Early submission of full proposals is strongly encouraged. Applicants are strongly encouraged to discuss their YFA submission with their Office of Sponsored Research (or equivalent) several weeks in advance of the submission deadline.** DARPA will review all full proposals submitted using the published evaluation criteria. The typical proposal should express a consolidated effort in support of one or more related technical concepts or ideas. Disjointed efforts should not be included into a single proposal.

All administrative correspondence and questions on this solicitation, including requests for information on how to submit full proposal to this RA should be directed to DARPA-RA-15-32@darpa.mil. DARPA intends to use electronic mail for correspondence regarding DARPA-RA-15-32. DARPA encourages use of the Internet for retrieving the RA and any other related information that may subsequently be provided.

THIS RA SEEKS ONLY GRANT PROPOSALS. PROPOSALS FOR ANY OTHER INSTRUMENT TYPE WILL BE CONSIDERED NON-COMPLIANT WITH THE RA AND, AS SUCH, WILL NOT BE REVIEWED.

Proposers may submit proposals through one of the following methods: (1) hard-copy mailed directly to DARPA; or (2) electronic upload per the instructions at http://www.grants.gov/applicants/apply-for-grants.html. Proposals may not be submitted through any other means. If proposers intend to use Grants.gov as their means of submission, then they must submit their entire proposal through Grants.gov; applications cannot be submitted in part to Grants.gov and in part as a hard-copy. Proposers using the Grants.gov APPLY do not submit paper proposals in addition to the Grants.gov APPLY electronic submission.

Grants.gov requires proposers to complete a one-time registration process before a proposal can be electronically submitted. If proposers have not previously registered, this process can take between three business days and four weeks. See the Grants.gov registration checklist at http://www.grants.gov/documents/19/18243/OrganizationRegChecklist.pdf for registration requirements and instructions.

Once Grants.gov has received a proposal submission, Grants.gov will send two email messages to advise proposers as to whether or not their proposals have been validated or rejected by the system; IT MAY TAKE UP TO TWO DAYS TO RECEIVE THESE EMAILS. The first email will confirm receipt of the proposal by the Grants.gov system; this email only confirms receipt,

not acceptance, of the proposal. The second will indicate that the application has been successfully validated by the system prior to transmission to the grantor agency or has been rejected due to errors. If the proposal is validated, then the proposer has successfully submitted their proposal. If the proposal is rejected, the proposed must be corrected and resubmitted before DARPA can retrieve it. If the solicitation is no longer open, the rejected proposal cannot be resubmitted. Once the proposal is retrieved by DARPA, the proposer will receive a third email from Grants.gov. To avoid missing deadlines, proposers should submit their proposals in advance of the final proposal due date with sufficient time to receive confirmations and correct any errors in the submission process through Grants.gov. For more information on submitting proposals to Grants.gov, visit the Grants.gov submissions page at: http://www.grants.gov/web/grants/applicants/apply-for-grants.html.

Proposers electing to submit their proposal in hard-copy must complete the SF 424 R&R form (Application for Federal Assistance, Research and Related) available on the Grants.gov website http://apply07.grants.gov/apply/forms/sample/RR_SF424_2_0-V2.0.pdf.

Technical support for Grants.gov submissions may be reached at 1-800-518-4726 or support@grants.gov.

If submitting hard-copy, an original and (1) copy of the proposal and (1) electronic copy of the proposal on a CD-ROM shall be submitted to DARPA/MTO, via 675 North Randolph Street, Arlington VA 22203-2114 (Attn: DARPA-RA-15-32), no later than time and date specified in Section IV.B.5 Submission Dates and Times.

Proposals may not be submitted by fax or email; any proposals sent via these methods will be disregarded.

4. Full Proposal Format

All full proposals must be in the format given below. Nonconforming proposals may be rejected without review. Proposals shall consist of two volumes. All pages shall be printed on 8-1/2 by 11 inch paper with type not smaller than 12 point. Smaller font may be used for figures, tables and charts. The page limitation for full proposals includes all figures, tables, and charts. Volume I, Technical and Management Proposal, may include an attached bibliography of relevant technical papers or research notes (published and unpublished) which document the technical ideas and approach upon which the proposal is based. Copies of not more than three (3) relevant papers may be included with the submission. The bibliography and attached papers are not included in the page counts given below. The submission of other supporting materials along with the proposals is strongly discouraged and will not be considered for review. **Full proposals, (consisting of Section II of Volume I, Technical and Management Proposal), shall not exceed 8 pages.** All full proposals must be written in English.

a. Volume I, Technical and Management Proposal

Section I. Administrative

A. Cover sheet to include:

(1) RA number (DARPA-RA-15-32);

(2) Technical topic area (proposers may only submit to ONE topic area, and salient subtopic area(s) if applicable);
(3) Lead Organization submitting proposal;
(4) Proposer's reference number (if any);
(5) Proposer's title;
(6) Technical point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail;
(7) Administrative point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail;
(8) Date proposal was submitted;
(9) Number of previous submissions to YFA RA(s) and submission date(s);
(10) Date of Tenure-track appointment position; AND
(11) List of any and all current and past involvement with DARPA as a performer

B. Official transmittal letter

Section II. Detailed Proposal Information

A. Executive summary slide to include the following (see Attachment 1 for template format):
- High Level Vision: What's the Big Idea/What Problem are you Solving and Who Cares?
- Project Impact
- Potential Department of Defense application
- Technical Approach
- Major Technical Risks and Risk Mitigation Strategies

B. **Technical proposal and Statement of Work (SOW)** specifically address the following questions as they relate to the topic area-variants of the Heilmeier Catechism. Note each question should be recapitulated and clearly addressed within the proposal:

(1) What are you trying to do/what big problem are you trying to solve? Objectives should be articulated using absolutely no jargon. (Note this must relate to the Technical Area that you are addressing)

(2) What is the end goal? Who cares? This should focus on the ultimate project vision.

(3) SOA: How is it done today, and what are the limits of current practice?

(4) What is the new technical idea proposed? What recent discoveries support the idea or increase the likelihood of success?

(5) What is the impact if successful? Be quantitative to the extent possible.

(6) What is the technical approach and plan? How will the project be organized?

(7) How will you measure progress of your work? What are the midterm and final 'exams' over the first and second phases of the base period of the project to check for success?

(8) What are the major technical challenges/risks to this project, and how will you plan to address each?

(9) Proposed follow-on work for "Directors Fellowship": Include a short summary for proposed follow-on work if successful during the 24-month base period. If selected as a Director's Fellow the proposed follow-on work will be updated as necessary prior to the start of the 12-month option period.

Statement of Work (SOW): Succinctly and clearly define the technical tasks/subtasks to be performed, their durations, and dependencies among them. Include the completion criteria for each task/activity - a product, event or milestone that defines its completion. An example template is shown below:

SOW:
Phase I (12 months)

Task	Description	Completion Criteria	Months
1.1			(e.g.0-6 mos)
1.2			
…			
2.1			

Phase II (12 months)

Task	Description	Completion Criteria	Months
			(e.g.12-18 mos)

Option (12 months)

Task	Description	Completion Criteria	Months
1.1			(e.g.24-30 mos)
1.2			
…			
2.1			

C. Biosketch

Section III. Additional Information

A. A brief bibliography of relevant technical papers and research notes (published and unpublished) which document the technical ideas upon which the proposal is based.
B. Listing of past, current, and pending support, including sponsor, funding level, performance dates, and level of effort.

b. Volume II, Cost Proposal – {No Page Limit}

Cover sheet to include:

(1) RA number (DARPA-RA-15-32);
(2) Technical topic area (proposers may only submit to ONE topic area);
(3) Organization submitting proposal;
(4) Proposer's reference number (if any);
(5) Proposal title;
(6) Technical point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail (if available);
(7) Administrative point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), and electronic mail (if available);
(8) Place(s) and period(s) of performance;
(9) Total proposed cost separated by basic award and option(s) (if any);
(10) Name, address, and telephone number of the proposer's cognizant Defense Contract Management Agency (DCMA) administration office (*if known)*;
(11) Name, address, and telephone number of the proposer's cognizant Defense Contract Audit Agency (DCAA) audit office (*if known*);
(12) Date proposal was prepared;
(13) DUNS number;
(14) TIN number;
(15) CAGE Code; and
(16) Proposal validity period

The Government requests and recommends that tables included in the cost proposal also be provided in MS Excel™ format with calculations formulae intact to allow traceability of the cost proposal numbers across the performer. If the PDF submission differs from the Excel submission, the PDF will take precedence. Each copy must be clearly labeled with the DARPA RA number, proposer organization, and proposal title (short title recommended).

The Government also requests and recommends that the Cost Proposal include MS Excel file(s) that provide traceability between the Bases of Estimate (BOEs) and the proposed costs across all elements and phases. This includes the calculations and adjustments that are utilized to generate the Summary Costs from the source labor hours, labor costs, material costs, etc. input data. It is requested that the costs and Subcontractor proposals be readily traceable to the Prime Cost Proposal in the provided MS Excel file(s). The Government prefers receiving cost data as Excel files; however, this is not a requirement.

(1) Total program cost broken down by major cost items:
    a. Direct Labor – a breakout clearly identifying the individual labor categories with associated labor hours and direct labor rates;
    b. Indirect Costs – Including Fringe Benefits, Overhead, General and Administrative Expense, Cost of Money, Fee, etc. (must show base amount and rate);
    c. Travel – Provide the purpose of the trip, number of trips, number of days per trip, departure and arrival destinations, number of people, etc.;
    d. Other Direct Costs – Itemized with costs; Back-up documentation is to be submitted to support proposed costs;
    e. Material/Equipment –

(i) A priced Bill-of-Material (BOM) clearly identifying, for each item proposed, the quantity, unit price, the source of the unit price (i.e., vendor quote, engineering estimate, etc.), the type of property (i.e., material, equipment, special test equipment, information technology, etc.), and a cross-reference to the Statement of Work (SOW) task/s that require the item/s. At time of proposal submission, any item that exceeds $1,000 must be supported with basis-of-estimate (BOE) documentation such as a copy of catalog price lists, vendor quotes or a written engineering estimate (additional documentation may be required during negotiations, if selected).

f. The source, nature, and amount of any industry cost-sharing;
g. Written justification required per Part II, Section II(A), "Fundamental Research," pertaining to prime and/or subcontracted effort being considered Contracted Fundamental Research; and
h. Major program tasks by month

(2) A summary of total program costs by phase (Phase I, Phase II, Director's Fellow Ship Option) and calendar fiscal year;

(3) A priced Bill-of-Materials (BOM) clearly identifying, for each item proposed, the source of the unit price (i.e., vendor quote, engineering estimate, etc.) and the type of property (i.e. material, equipment, special test equipment, plant equipment, information technology (IT), for each computer hardware cost, computer software cost, and other related costs such as computer maintenance fees or support services costs (NOTE: If you propose materials DARPA expects that you are able to defend it.);

(4) The source, nature, and amount of any industry cost-sharing. Where the effort consists of multiple portions which could reasonably be partitioned for purposes of funding, these should be identified as options with separate cost estimates for each;

(5) Identification of pricing assumptions of which may require incorporation into the resulting award instrument (e.g. use of Government Furnished Property/Facilities/Information, access to Government Subject Matter Expert(s), etc.); and

(6) A copy of the proposing organizations approved rate agreement.

PLEASE NOTE, PROPOSERS ARE CAUTIONED THAT EVALUATION RATINGS MAY BE LOWERED AND/OR PROPOSALS REJECTED IF PROPOSAL PREPARATION (PROPOSAL FORMAT, CONTENT, ETC.) AND/OR SUBMITTAL INSTRUCTIONS ARE NOT FOLLOWED.

5. Submission Dates and Times

a. **Full Proposal Date**

The full proposal must be submitted to DARPA/MTO on or before 4:00 PM., Eastern Time, April 13, 2015, in order to be considered during the single round of selections. Proposals received after this deadline will not be reviewed.

DARPA will post on a regular basis a consolidated Question and Answer (FAQ) document. To access the posting go to:
http://www.darpa.mil/Opportunities/Solicitations/MTO_Solicitations.aspx (the MTO office solicitations page) and select "DARPA-RA-15-32." The link will direct you to the YFA overview page and the FAQ will be posted in a PDF accessible file under the "Important Links" section. Submit your question/s by E-mail to DARPA-RA-15-32@darpa.mil. In order to receive a response sufficiently in advance of the proposal due date, send your question/s on or before 4:00 PM, Eastern Time, March 26, 2015.

DARPA will acknowledge receipt of complete submissions via email and assign control numbers that should be used in all further correspondence regarding proposals.

6. Funding Restrictions

The RA seeks proposals for a research activity consisting of a 24-month base period broken into two 12-month phases with a maximum funding level of $250,000 per phase ($500,000 maximum total funding for the 24-month base period). For exceptional YFA project performance over the 24-month base period, a limited number of YFA performers will be awarded a "Director's Fellowship" with a maximum of an additional $500,000 in follow-on funding for an additional estimated 12-month period.

7. Other Submission Requirements

All proposals should clearly indicate limitations on the disclosure of their contents. Proposers who include in their proposals data that they do not want disclosed to the public for any purpose, or used by the Government except for evaluation purposes, shall do the following:

> (1) Mark the title page with the following legend: This proposal includes data that shall not be disclosed – in whole or in part – for any purpose other than to evaluate this proposal. If, however, a contract is awarded to this proposer as a result of, or in connection with, the submission of this data, the Government shall have the right to duplicate, use, or disclose the data to the extend provided in the resulting contract. This restriction does not limit the Government's right to use information contained in this data if it is obtained from another source without restriction; and
> (2) Mark each sheet of data they wish to restrict with the following legend: Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal.

Markings such as "Company Confidential" or other phrases that may be confused with national security classifications should be avoided. The proposer may be required to remove such markings before the proposal will be accepted. "Proprietary" or "Company Proprietary" are acceptable notations.

Sec. V: APPLICATION REVIEW INFORMATION

A. Evaluation Criteria

Proposals will be evaluated using the following criteria, listed in descending order of importance: (a) Overall Scientific and Technical Merit; (b) Potential Contribution and Relevance to the DARPA Mission; (c) Cost Realism; and (d) Realism of Proposed Schedule.

(a) Overall Scientific and Technical Merit

The proposed technical approach is feasible, achievable, complete and supported by a proposed technical team that has the expertise and experience to accomplish the proposed tasks. Task descriptions and associated technical elements provided are complete and in a logical sequence with all proposed deliverables clearly defined such that a final outcome that achieves the goal can be expected as a result of award. The proposal identifies major technical risks and planned mitigation efforts are clearly defined and feasible.

(b) Potential Contribution and Relevance to the DARPA Mission

The potential contributions of the proposed effort are relevant to the national technology base. Specifically, DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their application.

(c) Cost Realism

The proposed costs are realistic for the technical and management approaches offered and demonstrates the proposer's practical understanding of the effort. The costs proposed are based on realistic assumptions, reflect a sufficient understanding of the technical goals and objectives of the RA, and are consistent with the proposer's technical approach (to include the proposed Statement of Work). At a minimum, the prime proposer and proposed subawardees substantiate the proposed costs with the type and number of labor hours proposed per task as well as the types and kinds of materials, equipment and fabrication costs proposed. It is expected that the effort will leverage all available relevant prior research in order to obtain the maximum benefit from the available funding. For efforts with a likelihood of commercial application, appropriate direct cost sharing may be a positive factor in the evaluation. DARPA recognizes that undue emphasis on cost may motivate proposers to offer low-risk ideas with minimum uncertainty and to staff the effort with junior personnel in order to be in a more competitive posture. DARPA discourages such cost strategies.

(d) Realism of Proposed Schedule

The proposed schedule aggressively pursues performance metrics in the shortest timeframe and accurately accounts for that timeframe. The proposed schedule identifies and mitigates any potential schedule risk.

B. Review and Selection Process

DARPA will conduct a scientific/technical review of each conforming proposal. Proposals will not be evaluated against each other since they are not submitted in accordance with a common work statement. DARPA's intent is to review proposals as soon as possible after they arrive; however, proposals may be reviewed periodically for administrative reasons.

Award(s) will be made to proposers whose proposals are determined to be the most advantageous to the Government, all factors considered, including the potential contributions of the proposed work to the overall research program and the availability of funding for the effort.

It is the policy of DARPA to ensure impartial, equitable, comprehensive proposal evaluations and to select the source (or sources) whose offer meets the Government's technical, policy, and programmatic goals. Pursuant to FAR 35.016, the primary basis for selecting proposals for acceptance shall be technical, importance to agency programs, and fund availability. In order to provide the desired evaluation, qualified Government personnel will conduct reviews and (if necessary) convene panels of experts in the appropriate areas.

For evaluation purposes, a proposal is the document described in "Proposal Information", Section IV.B.. Other supporting or background materials submitted with the proposal will be considered for the reviewer's convenience only and not considered as part of the proposal.

Restrictive notices notwithstanding, proposals may be handled for administrative purposes by support contractors. These support contractors are prohibited from competition in DARPA technical research and are bound by appropriate non-disclosure requirements.

Subject to the restrictions set forth in FAR 37.203(d), input on technical aspects of the proposals may be solicited by DARPA from non-Government consultants/experts who are strictly bound by the appropriate non-disclosure requirements.

Sec. VI: AWARD ADMINISTRATION INFORMATION

A. Selection Notices

As soon as the evaluation of a proposal is complete, the proposer will be notified that (1) the proposal has been selected for funding pending contract negotiations, or (2) the proposal has not been selected. These official notifications will be sent via email to the Technical POC identified on the proposal coversheet.

B. Administrative and National Policy Requirements

1. Meeting and Travel Requirements

There will be a program kickoff meeting and all key participants are required to attend. In addition, during the 24-month base period, a number of visits/exercises at a variety of DoD sites and facilities will be scheduled. Participation in all such opportunities are not required, however lack of participation may impact the award of the Director's Fellowship. Proposers are expected to include funds for two program review meetings and at least one three-day military visit within the total budget of their proposal.

2. Human Subjects Research

All research selected for funding involving human subjects, to include use of human biological specimens and human data, must comply with the federal regulations for human subject protection. Further, research involving human subjects that is conducted or supported by the DoD must comply with 32 CFR 219, *Protection of Human Subjects* (and DoD Directive 3216.02, *Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research)* (http://www.dtic.mil/whs/directives/corres/pdf/321602p.pdf).

Institutions awarded funding for research involving human subjects must provide documentation of a current Assurance of Compliance with Federal regulations for human subject protection, such as a Department of Health and Human Services, Office of Human Research Protection Federal Wide Assurance (http://www.hhs.gov/ohrp). All institutions engaged in human subject research, to include subcontractors, must also hold a valid Assurance. In addition, all personnel involved in human subjects research must provide documentation of completion of human subjects research training.

For all proposed research that will involve human subjects in the first year or phase of the project, the institution must provide evidence of or a plan for review by an Institutional Review Board (IRB) upon final proposal submission to DARPA as part of their proposal, prior to being selected for funding. The IRB conducting the review must be the IRB identified on the institution's Assurance of Compliance with human subjects protection regulations. The protocol, separate from the proposal, must include a detailed description of the research plan, study population, risks and benefits of study participation, recruitment and consent process, data collection, and data analysis. It is recommended that you consult the designated IRB for guidance on writing the protocol. The informed consent document must comply with federal regulations (32 CFR 219.116). A valid Assurance of Compliance with human subjects protection regulations along with evidence of completion of appropriate human subjects research training all investigators should all accompany the protocol for review by the IRB.

In addition to a local IRB approval, a headquarters-level human subjects administrative review and approval is required for all research conducted or supported by the DoD. The Army, Navy, or Air Force office responsible for managing the award can provide guidance and information about their component's headquarters-level review process. Note that confirmation of a current Assurance of Compliance with human subjects protection regulations and appropriate human subjects protection training is required before headquarters-level approval can be issued.

The time required to complete the IRB review/approval process varies depending on the complexity of the research and the level of risk involved with the study. The IRB approval process can last between one to three months, followed by a DoD review that could last between three and six months. Ample time should be allotted to complete the approval process. DoD/DARPA funding cannot be used towards human subjects research until ALL approvals are granted.

3. Animal Use

Award recipients performing research, experimentation, or testing involving the use of animals shall comply with the rules on animal acquisition, transport, care, handling, and use as outlined in: (i) 9 CFR parts 1-4, Department of Agriculture rules that implement the Animal Welfare Act of 1966, as amended, (7 U.S.C. 2131-2159); (ii) National Institutes of Health Publication No. 86-23, "Guide for the Care and Use of Laboratory Animals"; (iii) DoD Instructions 3216.01, "Use of Animals in DoD Programs."

For projects anticipating animal use , proposals should briefly describe plans for Institutional Animal Care and Use Committee (IACUC) review and approval. Animal studies in the program

will be expected to comply with the Public Health Service PHS Policy on Humane Care and Use of Laboratory Animals, available at http://grants.nih.gov/grants/olaw/olaw.htm.

All award recipients must receive approval by a DoD certified veterinarian, in addition to an IACUC approval. No animal studies may be conducted using DoD/DARPA funding until the United States Army Medical Research and Materiel Command (USAMRMC) Animal Care and Use Review Office (ACURO) or other appropriate DoD veterinary office(s) grant approval. As a part of this secondary review process, the award recipient will be required to complete and submit an ACURO Animal Use Appendix, which may be found at https://mrmc-www.army.mil/index.cfm?pageid=Research_Protections.acuro&rn=1.

4. Subcontracting

This RA solicits single-investigator proposals only.

5. Electronic and Information Technology

All electronic and information technology acquired through this solicitation must satisfy the accessibility requirements of Section 508 of the Rehabilitation Act (29 U.S.C. § 794d) and FAR 39.2. Each proposer who submits a proposal involving the creation or inclusion of electronic and information technology must ensure that federal employees with disabilities will have access to and use of information that is comparable to the access and use by Federal employees who are not individuals with disabilities and members of the public with disabilities seeking information or services from DARPA will have access to and use of information and data that is comparable to the access and use of information and data by members of the public who are not individuals with disabilities.

6. System for Award Management (SAM) Registration and Universal Identifier Requirements

Unless the proposer is exempt from this requirement, as per FAR 4.1102 or 2 CFR 25.110 as applicable, all proposers must be registered in the System for Award Management (SAM) and have a valid Data Universal Numbering System (DUNS) number prior to submitting a proposal. All proposers must maintain an active registration in SAM with current information at all times during which they have an active Federal award or proposal under consideration by DARPA. All proposers must provide the DUNS number in each proposal they submit. Information on SAM registration is available at www.sam.gov.

7. Reporting Executive Compensation and First-Tier Subcontract Awards

FAR clause 52.204-10, "Reporting Executive Compensation and First-Tier Subcontract Awards," will be used in all procurement contracts valued at $25,000 or more. A similar award term will be used in all grants and cooperative agreements.

8. Controlled Unclassified Information (CUI) on Non-DoD Information Systems

Controlled Unclassified Information (CUI) refers to unclassified information that does not meet the standards for National Security Classification but is pertinent to the national interests of the United States or to the important interests of entities outside the Federal Government and under

law or policy requires protection from unauthorized disclosure, special handling safeguards, or prescribed limits on exchange or dissemination. All non-DoD entities doing business with DARPA are expected to adhere to the following procedural safeguards, in addition to any other relevant Federal or DoD specific procedures, for submission of any proposals to DARPA and any potential business with DARPA:

Do not process DARPA CUI on publicly available computers or post DARPA CUI to publicly available webpages or websites that have access limited only by domain or Internet protocol restriction.

Ensure that all DARPA CUI is protected by a physical or electronic barrier when not under direct individual control of an authorized user and limit the transfer or DARPA CUI to subcontractors or teaming partners with a need to know and commitment to this level of protection.

Ensure that DARPA CUI on mobile computing devices is identified and encrypted and all communications on mobile devices or through wireless connections are protected and encrypted.

Overwrite media that has been used to process DARPA CUI before external release or disposal.

C. Reporting

The number and types of reports will be specified in the award document, but will include as a minimum [monthly/quarterly] financial status reports. The reports shall be prepared and submitted in accordance with the procedures contained in the award document and mutually agreed on before award. Reports and briefing material will also be required as appropriate to document progress in accomplishing program metrics. A Final Report that summarizes the project and tasks will be required at the conclusion of the performance period for the award, notwithstanding the fact that the research may be continued under a follow-on vehicle.

D. Electronic Systems

1. Representations and Certifications

Accepted proposers are required to complete representations and certifications as presented by the grants officer after selection.

2. Wide Area Work Flow (WAWF)

Unless using another means of invoicing, performers will be required to submit invoices for payment directly via to http://wawf.eb.mil. Registration in WAWF will be required prior to any award under this RA.

3. i-Edison

The award document for each proposal selected for funding will contain a mandatory requirement for patent reports and notifications to be submitted electronically through i-Edison (http://s-edison.info.nih.gov/iEdison) .

Sec. VII: AGENCY CONTACTS

Administrative, technical or contractual questions should be sent via e-mail to DARPA-RA-15-32@darpa.mil. All requests must include the name, email address, and phone number of a point of contact.

The technical POC for this effort is:

Dr. Daniel Hammerstrom
DARPA/MTO
ATTN: DARPA-RA-15-32
675 North Randolph Street
Arlington, VA 22203-2114

Email: DARPA-RA-15-32@darpa.mil

Sec. VIII: OTHER INFORMATION

A. Intellectual Property

1. Data Rights Restrictions

Proposers responding to this RA shall appropriately identify any potential restrictions on the Government's use of any Intellectual Property contemplated under the resulting award. This includes both Noncommercial Items and Commercial Items. The Government may use the list during the evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer's assertions. If no restrictions are intended, then the proposer should state "NONE." Failure to provide full information may result in a determination that the proposal is not compliant with the RA – resulting in nonselectability of the proposal.

A sample list for complying with this request is as follows:

DATA RIGHTS ASSERTIONS				
Technical Data Computer Software To be Furnished With Restrictions	Summary of Intended Use in the Conduct of the Research	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(NARRATIVE)	(LIST)	(LIST)	(LIST)

2. Patents

Include documentation proving your ownership of or possession of appropriate licensing rights to all patented inventions (or inventions for which a patent application has been filed) that will be utilized under your proposal for the DARPA program. If a patent application has been filed for an invention that your proposal utilizes, but the application has not yet been made publicly

available and contains proprietary information, you may provide only the patent number, inventor name(s), assignee names (if any), filing date, filing date of any related provisional application, and a summary of the patent title, together with either: (1) a representation that you own the invention, or (2) proof of possession of appropriate licensing rights in the invention.

3. Intellectual Property Representations

Provide a good faith representation that you either own or possess appropriate licensing rights to all other intellectual property that will be utilized under your proposal for the DARPA program.