Guide to FY2018 Research Funding at the
Department of Defense (DOD)
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Summary and Index

This document provides insights into the various DOD funding agency opportunities for University basic research (6.1) and for some applied research (6.2) efforts, with special attention to changes anticipated in FY2018.

DOD funds research that is relevant to its mission, predominantly drawing on engineering, computer/information science, and physical sciences, but there is also attention to social sciences.

Overview

Since DOD relies heavily on technological advantage, contributions from research, development and engineering must be marshaled to meet tomorrow's defense challenges. DOD funds research and development (R&D) that is relevant to its mission, predominantly drawing on engineering, computer/information science, and physical sciences. However, DOD also funds some social science, life science, and medical research.

The DOD has many different funding organizations that engage in Research, Development, Test and Evaluation (RDT&E), each with its own foci and idiosyncrasies. Information on the RDT&E budgets can be found in the annual DOD R-1 Document that summarizes the budget at a high level, and the R-2 documents (Research and Development Descriptive Summaries) that address each agency program in more detail. (http://comptroller.defense.gov/budgetmaterials.aspx)

As part of its investment in R&D, DOD funds basic research (labeled 6.1, or BA1), applied research (6.2, or BA2) and advanced technology development (6.3, or BA3). Taken together, these three budget lines are referred to as the S&T investment. In 2011 the Department identified seven Science and Technology (S&T) priorities: Autonomy, Counter Weapons of Mass Destruction, Cyber Science and Technology, Data-to-Decisions, Electronic Warfare / Electronic Protection, Engineered Resilient Systems, and Human Systems.

Universities get about 60% of the 6.1, 10% of the 6.2, and 5% of the 6.3 funding. However, the 6.2 and 6.3 funding at Universities includes University Affiliated Research Centers (UARCs) and other entities that are structured to handle the greater deadline, security classification, and reporting requirements. On 6.2/6.3 projects, it is not unusual for a University professor to be a collaborator with industry, a university affiliated organization (such as the Information Sciences Institute (ISI) and the Institute for Creative Technologies (ICT) at USC), or a DOD laboratory/center.

Basic Research

DOD defines basic research as systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and/or observable facts without specific applications toward processes or products in mind. With very few exceptions, the results of basic research will not be classified or restricted, and are reported in the open literature.

The Office of the Assistant Secretary of Defense (Research & Engineering) has identified six strategic areas of interest: a) synthetic biology, b) quantum information science, c) cognitive neuroscience, d) understanding human and social behavior, e) novel engineered materials, f) advanced manufacturing, and g) artificial intelligence.
(http://www.acq.osd.mil/rd/basic_research/focus_areas/)
  The DOD Office of Basic Research sponsors workshops in emerging areas of science/engineering that it perceives as important to the DOD; these workshops are meant to guide research investment.
(http://www.acq.osd.mil/rd/basic_research/references/workshops.html)

Funding for basic research is available from several DOD agencies, each having its own particular focus:

Agencies with >$40M basic research monies available to Universities
- Air Force Office of Scientific Research (AFOSR): www.wpafb.af.mil/afrl/afosr/
    Focus: pilot, aerospace mission (6.1 only)

- Army Research Office (ARO): www.arl.army.mil/www/default.cfm?page=29
    Focus: soldier, ground force mission (6.1 only)
- Office of Naval Research (ONR): www.onr.navy.mil/
    Focus: sailor, marine, ship/sub, ocean mission (6.1 - 6.3)
- Defense Threat Reduction Agency (DTRA): www.dtra.mil/
    Focus: weapons of mass destruction – detect, protect, defeat (6.1 – 6.3)
- Defense Advanced Research Projects Agency (DARPA): www.darpa.mil/
    Focus: defense-wide technology innovation (6.1 – 6.3)
- Congressionally Directed Medical Research Program (CDMRP): cdmrp.army.mil/
    Focus: medical research topics of interest to a Congress person (6.1 only)

Other Agencies with smaller amounts of basic research monies available to Universities
- Army Research Inst for Behavioral and Social Sciences (ARI): https://sslweb.hqda.pentagon.mil/ari/
    Focus: basic research in behavioral science (6.1 - 6.3)
- Army Corps of Engineers (USACE): http://www.erdc.usace.army.mil/
    Focus: support of the Engn Res and Development Center (ERDC) research interests (6.1 - 6.3)
- Chemical Biological Defense Program (CBDP): www.jpeocbd.osd.mil/
    Focus: chemical/biological warfare defense (6.1 - 6.3) – managed through DTRA
- Defense Medical R&D Program (DMDRP): http://cdmrp.army.mil/dmrdp/
    Focus: military specific medical research (6.1 – 6.3) – managed through CDMRP
- Office Secretary of Defense (OSD): http://www.acq.osd.mil/chieftechnologist/index.html
    Focus: overarching Defense issues (6.1 – 6.3)
- Naval Postgraduate School (NPS); http://my.nps.edu/web/research/funding-opportunities
    Focus: support of NPS core mission in graduate education and research (6.1 - 6.3)

Single Investigator Efforts - Generic Basic Research Announcements
The majority of DOD basic research funding is invested in single investigator efforts and is advertised through relatively generic Broad Area Announcements (BAAs) from the three services. The funding for these efforts typically ranges between $100-200K/yr for three years; continuation is possible. Approximately 20% of the projects will be turned over annually. The six DARPA offices also each have a generic BAA, and can fund single investigator "seedling" efforts which tend to be $300-500K for 12-18 months. DTRA has a generic Fundamental Research to Counter Weapons of Mass Destruction BAA. NPS, USACE and ARI issue generic solicitations, but usually without significant monies devoted to them. For more information see MAPS DOD Charts 38 to 108.

While peer review is used to differing degrees by the various DOD agencies, the DOD program officers have far greater latitude than do NSF program officers. So it is <u>essential</u> to contact a program officer and explore mutual interests. To identify the appropriate program officers, one can use the USC MAPS website keyword search engine, and/or contact Murday. A white paper is <u>very</u> useful (often required). The program officers don't want to waste your time writing, nor their own time reading, an inappropriate proposal. Proposals to the long-range BAA programs may be submitted at any time, but late spring is when many tentative decisions are being made for new starts in the coming fiscal year (which starts 1 Oct). There is no standard DOD proposal format; each agency/office has its own requirements.

Young Investigators
Each of the three services, DTRA, and DARPA have special announcements for young faculty programs (except ARO where it is part of the generic BAA). The eligibility typically is within five

years of Ph.D. or equivalent degree, but DARPA and ONR are five years from initial tenure-track appointment. US Citizenship or "green card" status is required by the Services, but not by DARPA and DTRA. The available funding ranges from $50K/yr (Army) to $250K/yr (DARPA). Submission deadlines vary. For more information, see MAPS DOD Charts 154-159; a listing of prior awardees and their research topics is available from the DC office.

Senior Investigators – Vannevar Bush Faculty Fellowship (VBFF, was the NSSEFF)

http://www.acq.osd.mil/rd/basic_research/program_info/vbff.html

This is a special program to support outstanding faculty in topics-of-interest to DOD; it is competed intermittently as funding allows. A Vannevar Bush awardee receives ~$600K/yr for five years. Awardees are generally ~20 years post PhD, have impressive credentials, and address a science/engineering basic research topic of interest to DOD. For more information, see MAPS DOD Charts 162-163; a listing of the prior awardees and their topics is available from the DC office. In 2015 DOD created the Laboratory University Collaborative Initiative (LUCI) which funds a DOD scientist/engineer to work with a VBFF fellow.

Special Research Program Announcements

During the year, DOD agencies can announce special program opportunities about a specific topic; DARPA, DTRA and CDMRP, in particular, use this approach predominantly. These opportunities range from large, center efforts [e.g., University Affiliated Research Centers (UARCs), Collaborative Research Alliances (CRA), and Centers of Excellence (CoE)] to single investigator programs [e.g., DARPA/DTRA/CDMRP topic solicitations, and ONR's Basic Research Challenges]. These announcements have specific application due dates.

Multidisciplinary Efforts – Multidisciplinary University Research Initiatives (MURIs)

http://www.onr.navy.mil/en/Science-Technology/Directorates/office-research-discovery-invention/Sponsored-Research/University-Research-Initiatives/MURI.aspx

As part of DOD's University Research Initiative budget line, the multidisciplinary university research initiative (MURI) program has ~20 topics announced in the March-June time frame each year, with white papers due about 1-2 months after the announcement, and proposals about three months after the white paper. These require multidisciplinary teaming efforts; the funding is up to $1-2.5M/yr for five years (presuming acceptable performance). Successful proposals have typically engaged 3-5 Universities, but single University efforts can be successful. For more information, see MAPS DOD Charts 132-135; a listing of prior awardees/topics is available from the DC office.

University Centers of Excellence (COE)

Both the Army and Navy support University Affiliated Research Centers (UARCs) that, in addition to basic research, also address applied research and development (see MAPS DOD Chart 153). The Army also has University COE, Collaborative Technology Alliances (CTA), and Collaborative Research Alliances (CRA) that engage Universities (see MAPS DOD Charts 185-194). The Air Force supports University Centers of Excellence (~5yr lifetime) that are associated with specific Air Force Research Laboratory technical directorates. (see MAPS DOD Chart 180)

Human Social, Cultural, and Behavioral Modeling (HSCB)

DARPA DSO and the service OXRs have social/behavioral efforts.

MINERVA

http://minerva.defense.gov/

In addition to Service core HSCB programs, the Office of the Secretary of Defense (OSD) funds S&T projects to address understanding and modeling of human behavior in social and cultural contexts. The basic research component is entitled the Minerva Initiative. For more information, see MAPS DOD Chart 131; it is presently administered by ONR.

Army Research Institute for Behavioral and Social Sciences (ARI)
https://sslweb.hqda.pentagon.mil/ari/research.aspx
ARI supports research projects that are designed to expand fundamental knowledge and discover general principles in the behavioral and social sciences, but generally focused on individual and unit performance and readiness.   In addition to programmatic efforts to develop and evaluate psychological and behavioral theory, researchers are encouraged to propose novel, state-of-the-art, and multidisciplinary approaches that address difficult problems. For more information, see MAPS DOD Chart 63.

Medical
Congressionally Directed Medical Research Program (CDMRP)
http://cdmrp.army.mil.
Congress typically adds funds to the DOD budget for support of selected medical basic research topics; these total ~$1B/yr in recent years. Each year the funds are inserted by a congressperson for specific topics for that year only. Those topics are openly competed through the Congressionally Directed Medical Research Program (CDMRP) solicitations. The Army's Medical Research and Materiel Command manages the CDMRP with a contractor (presently SAIC) providing the administrative functions. Since there is no certainty of continued funding, there are no program officers per se. For more information on the CDMRP, see MAPS DOD Charts 142-151 and/or visit the CDMRP website (which is very informative).

Defense Health Program
http://cdmrp.army.mil/dmrdp/
DOD budgets a relatively small extramural effort in medical basic research (<$10M). In 2010 the DOD established a joint program, the Defense Medical Research and Development Program (DMRDP) with 6.1-6.3 funding. The DMRDP is organized about six Joint Program Committees (JPC), which consist of DOD and non-DOD medical and military technical experts. Its solicitations are administered through the CDMRP process. For more information, see MAPS DOD Charts 136-141.

Agency Level Programs
The Army Medical Research and Materiel Command (USAMRMC) issues a generic BAA for basic research, but generally without much money available. In addition, USAMRMC manages the Armed Forces Institute of Regenerative Medicine (AFIRM), which funds University-based consortia (see DOD Charts 59-62). DARPA has a Basic Operational Medical Science (6.1) effort (see MAPS DOD Charts 100-102). ONR has a Warfighter Protection and Application Division with interest in selected medical topics (see MAPS DOD Chart 77). DTRA funds Medical research in support of defense against weapons of mass destruction. For more information, see MAPS DOD Charts 127-128.

Instrumentation
http://www.onr.navy.mil/en/Science-Technology/Directorates/office-research-discovery-invention/Sponsored-Research/University-Research-Initiatives/DURIP.aspx
As part of the University Research Initiative (URI) budget line, the Defense University Research Instrumentation Program (DURIP) is competed each summer.   The awards range from $50K to

$1.5M; matching funds are not required, but are very useful for the high priced instruments. While anyone may submit, there is a <u>strong</u> preference for instrumentation in support of funded DOD research efforts.   For more information, see MAPS DOD Charts 134. ARO also has its own research instrumentation program (see MAPS DOD Chart 57).

Education/Training/Sabbaticals
In addition to funding research itself, there are DOD programs in support of PhD education (the National Defense Science and Engineering Graduate (NDSEG) program (http://ndseg.asee.org/), and the National Defense Education Program (NDEP, http://www.ndep.us/) for undergraduate/graduate education (which includes the Science, Mathematics and Research for Transformation (SMART) Scholarship for Service Program (http://smart.asee.org/).   Each of the Services also has a STEM education effort, generally focused on K-12.

The DOD research laboratories fund postdoctoral positions through the National Research Council (NRC, http://sites.nationalacademies.org/pga/rap/), the American Society for Engineering Education (ASEE, https://www.asee.org/fellowship-programs), and the Oak Ridge Associated Universities (ORAU, http://orau.org/science-education/internships-scholarships-fellowships/default.aspx) programs. In addition, there are many programs to support faculty working at the various DOD laboratories. For more information on these programs see MAPS DOD Charts 166-167).

Resources

Defense-wide central resource: defenseinnovationmarketplace.mil

Office of the Secretary of Defense (OSD) Basic Research:
http://www.acq.osd.mil/rd/basic_research/

Naval S&T Strategic Plan
http://www.onr.navy.mil/About-ONR/science-technology-strategic-plan.aspx

Army Research Laboratory S&T Campaign Plans 2015 -2035
https://www.google.com/search?q=Army+S%26T+Strategic+Plan&ie=utf-8&oe=utf-8#

Mission Agency Program Summary (MAPS)
The DC Office of Research Advancement has created the Federal Mission Agency Program Summary website to:
1. connect PIs with appropriate funding agency programs/program officers
2. assist in development of white papers/charts/elevator speeches
The website (http://web-app.usc.edu/web/ra_maps) can be accessed using one's USC NetID and Password.

MAPS will have the following resources:
1. *Search Tab* for a searchable database of programs/program officers
   > One can do keyword searches to locate many of the associated mission agency (DHS, DOD, DOE, DOT, ED, EPA, NASA, NIST, NOAA and USDA) programs and program officers.
2. *Mission Agency Tab* (DHS, DHHS, DOD, DOE, DOJ, DOT, ED, EPA, INTEL, NASA, NIST, NOAA, and USDA)
   > Guide to Agency Funding for FYXX
   > Agency Research Program Charts
   > Agency Planning Documents
   Chart numbers in the "Guides to Funding" reference the Agency Research Program Chart file.
3. *Presentation Tab* for charts from recent USC Center of Excellence in Research workshops
4. *Proposal Tab* for reports / guides on writing proposals
5. *Email Alerts Tab* for URLs at which one can arrange for automatic solicitation updates
6. *Grantee Tab* for URLs at which one can find previous agency/program officer awardees
7. *Visiting DC Tab* for information about DC Office services

Personal Assistance in Locating Funding and Preparing Proposals
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Table 1: FY2015 and FY2016 DOD Research Funding ($M) Obligations at Universities/Colleges

	2015		2016	
	Basic	**Applied**	**Basic**	**Applied**
Total for DOD	**2133**	**4558**	**2327**	**5005**
Total at Universities	**1056**	**507**	**1135**	**559**
Physical Sciences	**193**	**36**	**207**	**38**
Astronomy	-	-		
Chemistry	34	2		
Physics	119	23		
Other	40	12		
Environmental Sciences	**59**	**14**	**63**	**16**
Atmospheric	15	2		
Geological	2	-		
Oceanology	32	11		
Other	10	2		
Mathematics and Computer	**210**	**76**	**225**	**85**
Computer Sciences	113	73		
Mathematics	61	2		
Other	36	2		
Engineering	**249**	**205**	**261**	**223**
Aeronautical	45	26		
Astronautical	5	2		
Chemical	12	9		
Civil	14	9		
Electrical	43	56		
Mechanical	19	9		
Metal/Materials	60	16		
Other	52	84		
Life Sciences	**114**	**121**	**119**	**138**
Agriculture	7	0		
Biological	58	10		
Environmental	3	-		
Medical	35	111		
Other	11	0.1		
Psychological	**20**	**8**	**26**	**9**
Social Sciences	**10**	**-**	**16**	**-**
Other Sciences	**199**	**45**	**217**	**49**

Table 2: Projected DOD Basic Research Funding ($M) for FY2018:
From the President's Budget Request Submitted to Congress.

Discipline / Agency	Army	AF	Navy	DARPA	DTRA	CBDP	DHP	OSD
Biology / Life Sciences				0				
Human Systems	4		16					
Biology / Medical	6		19					
Chemistry	14							
Propulsion		34						
Physics	18	21						
Electronics/Photonics	9	80	50	87				
Materials	13	70	57	76				
Mechanics	6	31						
Mechanics Structural								
Mechanics Fluid								
Environment								
Ocean			75					
Atmosphere and Space			26					
Environmental Science								
Computer, Information Sciences, Mathematics			45	168				
Mathematics	6	27						
Computing Sciences	7							
Information Sciences		20						
Networks	12	26						
Simulation and Training	2							
Cyber				41				
Air/Ground/Sea Vehicles			57					
Weapons			19					
Counter IED Devices			24					
Science Education Career and Outreach		22	50					
International Outreach		12						
Transformative / Basic Research Challenge			21	60				
Chemical/Biological Warfare Defense						45		
Weapons of Mass Destruction Defeat					37			
Hi-Energy Laser Multidisciplinary Res Initiative		14						
Multidisciplinary Univ Research Initiatives	53	84	86					
Defense Univ Research Instrumentation Program	8	15	23					
National Defense S & E Graduate Program and ASSURE		49						
National Defense Educ Program (NDEP)								74
Social / Cultural / Human – MINERVA, HSCB	1							10
Vannevar Bush Faculty Fellowship (was NSSEFF)								28
PECASE	5		9					
Basic Operational Medical					43		7	
Total	164	505	577	475	37	45	7	112

The reported Army funding by discipline reflects only the ARO budget available for University single investigator proposal submission (budget line item HR 57), not the total Army basic research funding; from a different basic research budget line the Army also funds University Centers through special competitions. For the Navy, about 25% of the reported total basic research funding is provided to the Naval Research Laboratory; for the Air Force, about 30% is provided to the AF Research Laboratories.

Since the academic disciplines in the table are different from most of the agency's program taxonomies, clear assignment of funds by academic taxonomies is not always possible.   The Table should be considered a best estimate.   In some cases, the amount of funding in a discipline is included under other headings and is thereby unknown; physics and chemistry at ONR and DARPA are good examples. Table 1 provides the academic discipline parsed funding as reported by DOD to NSF.

Table 3: Summary of Basic Research Funding
(From the President's Budget Request Submitted to Congress)

Service		Actual* FY 16	Estimate* FY17	PBR FY17	PBR FY18	% inc PRB FY18-17
Air Force	Basic Research	511	500	500	505	1
	Defense Res Sciences	365	341	330	343	4
Army	Basic Research	451	429	429	430	-
	Defense Res Sciences	272	253	253	264	4
	ARO (H57)	84	95	94	96	2
	ICT (J08)	5.8	6.2	6.2	6.3	2
Navy	Basic Research	649	543	543	595	10
	Defense Res Sciences	489	423	423	458	8
DARPA	Basic Research (DRS)	317	362	362	432	20
	Basic Operational Medical Res Science	53	58	57	43	-25
DTRA	Basic Research	38	35	38	37	-3
CBDP	Basic Research	47	45	46	43	-7
OSD	NDEP	53	69	49	74	150
	MINERVA (0601110D8Z)	9.2	9.4	8.9	9.5	7
DHP	GDF-Basic Operational Med Res Sciences (0601117HP – 371A)	9	6.4	6.4	6.9	8

* The FY16-17 numbers may include Congressional changes and Congressional special adds (CA, sometimes labeled Congressional Special Interest, CSI) which do not appear in the President's Budget Request (PBR).

Other reports on budget changes might show different percentages than those in table 3. For instance, the AAAS estimate for change to DOD basic research compared the FY17 PBR to the Estimate FY16. In recent years Congress has tended to add funds into the basic research accounts - as can be seen by comparing the PBR FY17 to the Estimate FY17. So, for instance, the AAAS cited percentages are lower than those shown in Table 3 when Congress has augmented the PBR funding.

Each of the Services has a strategic S&T plan which provides guidance into priorities; these can found at the USC MAPS DOD website. In addition to the funding growth identified in Appendix 1, approximately 20% of the projects in a DOD basic research program are turned over each year. So there are opportunities in many programs even in the absence of budget growth or modest decline.

Applied Research and Advanced Technology Development

http://www.acq.osd.mil/chieftechnologist/index.html

DOD defines applied research (6.2 or BA2) as systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. Advanced technology development (6.3 or BA3) includes all efforts that have moved into the development and integration of hardware for field experiments and tests. The S&T investment is led by a DOD executive committee comprised of the major departmental S&T organizations. Underpinning that leadership there are 16 communities of Interest (COIs) that encourage multi-agency coordination and collaboration. The COI identify appropriate thrust areas, gaps and opportunities, investment profiles and engagement opportunities.

Since not much 6.3 funding goes to Universities, only the Applied Research Budget lines are provided in Table 4. Applied funding opportunities are distributed among many DOD agencies, each having its own particular focus:

DOD S&T Funding Agencies managing a 6.1-6.3 investment portfolio
- Office of Naval Research (ONR, Naval includes the Navy and Marine Corps)
  http://www.onr.navy.mil/Science-Technology/Directorates/Transition/
  Focus: develop/transition cutting-edge technology products to Naval acquisition managers
- Defense Advanced Research Projects Agency (DARPA)
  www.darpa.mil
  Focus: defense-wide technology innovation
- Defense Threat Reduction Agency (DTRA)
  http://www.dtra.mil/Research.aspx
  Focus: countering weapons of mass destruction – chem, bio, radiological, nuclear, explosive

Other DOD S&T Funding Agencies (w/o basic research)
- Defense Forensics and Biometrics Agency (DFBA)
  http://biometrics.dod.mil/
  Focus: forensics and biometrics activities and operations in support of identity operations
- Defense Logistics Agency (DLA)
  http://www.dla.mil/Pages/default.aspx
  Focus: support the weapon system sustainment program
- Missile Defense Agency (MDA)
  http://www.mda.mil/business/advanced_research.html
  Focus: system to defend against ballistic missile attacks
- Special Operations Command (SOCOM)
  http://www.socom.mil/Sordac/Pages/Default.aspx
  Focus: development, acquisition, and fielding of critical items to enable the SOF Warfighter
- Strategic Environmental Research and Development Program (SERDP)
  Environmental Security Technology Certification Program (ESTCP)
  https://www.serdp-estcp.org/
  Focus: develop and demonstrate innovative, cost-effective, and sustainable solutions

In addition, especially with the Air Force Research Laboratory, there are some funding opportunities emanating from the Service laboratories/centers/institutes.

Office of Naval Research (ONR)
http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Future-Naval-Capabilities-FNC.aspx
In addition to its Discovery and Invention program (most of the 6.1 and about half of the 6.2), ONR has a Future Naval Capabilities (FNC) program that invests about half of the Naval 6.2 and most of the 6.3 monies in the following areas:

- Capable Manpower: Intuitive systems and personnel tools for matching Sailors and Marines to the right jobs and training for mission-essential competencies
- Enterprise and Platform Enablers: Cross-cutting technologies to lower acquisition, operations, and maintenance costs
- Expeditionary Maneuver Warfare: Naval ground forces with special emphasis on regular and irregular warfare
- Force Health Protection: Medical equipment, supplies and procedures to reduce morbidity and mortality when casualties occur
- FORCEnet: C4ISR, networking, navigation, decision support and space technologies that provide an architectural framework for naval warfare in the information age
- Power and Energy: Energy security, efficient power and energy systems, high energy, pulse power
- Sea Basing: Logistics, shipping and at-sea transfer technologies that provide operational independence
- Sea Shield: Missile defense, antisubmarine warfare, mine warfare and fleet/force protection technologies that provide global defensive assurance
- Sea Strike: Weapons, aircraft and expeditionary warfare technologies that provide precise and persistent offensive power

ONR also has an Innovative Naval Prototypes program (INP) that explores high 6.2 and 6.3 technologies that can dramatically change the way naval forces fight. Programs in this category may be disruptive technologies, which for reasons of high risk or radical departure from established requirements and concepts of operation, are unlikely to survive without top leadership endorsement, and, unlike Future Naval Capabilities, are initially too high risk for a firm transition commitment from the acquisition community. For more information, see MAPS DOD Charts 202-205.

Defense Advanced Research Projects Agency (DARPA)
http://www.darpa.mil/default.aspx
DARPA invests 6.1-6.3 monies through six offices: Defense Sciences, Biological Technologies, Information Innovation, Microsystems Technology, Strategic Technologies, and Tactical Technologies. While all of the offices have this range of funding, DSO has the most emphasis on basic research and STO / TTO the most emphasis on advanced technology development. DARPA typically issues solicitations for larger scale, multi-participant efforts that are held to milestones and must deliver a prototype in a three-year time frame. The solicitations are frequently preceded by a proposer day where interested parties can gain more information on the effort, and/or by Requests for Information (RFI) that are used to shape a pending solicitation. For more information, see MAPS DOD Charts 215-221.

Defense Threat Reduction Agency (DTRA)
http://www.dtra.mil/Research.aspx
DTRA is the combat support agency for countering weapons of mass destruction. It addresses the entire spectrum of chemical, biological, radiological, nuclear and high yield explosive threats. DTRA's programs include research and development, operational support to U.S. warfighters on the

front line, and an in-house weapons-of-mass-destruction think tank that aims to anticipate and mitigate future threats.   For more information, see MAPS DOD Charts 222-229.

Defense Forensics and Biometrics Agency (DFBA)
http://biometrics.dod.mil/About/mission.aspx
Biometrics and forensics are critical to identifying known and unknown individuals by matching them with automated records (such as for access control) or with anonymous samples (such as crime scene investigations). This agency is responsible for applying biometrics and forensics capabilities through various tactics, techniques and processes. It has a generic BAA for research addressing its needs.   For more information see MAPS DOD Chart 232.

Defense Logistics Agency (DLA)
http://www.dla.mil/SmallBusiness/Pages/default.aspx
The Defense Logistics Agency (DLA) Logistics Research & Development (R&D) Branch is charged with conducting research and development in all areas relevant to the DLA mission and across all DLA supply chains. White papers submitted to DLA may be based on fundamental R&D; concept formulation; assessment of system and subsystem requirements and processes; development, analysis and evaluation of concepts, systems and subsystems; development of associated industrial capabilities support techniques and processes; development of associated manufacturing techniques and processes; modeling and simulation; simulation-based acquisition; integrated data environments and product data managers; and development of operational systems. For more information, see MAPS DOD Charts 233 - 234.

Missile Defense Agency (MDA)
http://www.mda.mil/business/advanced_research.html
The Ballistic Missile Defense System (BMDS) includes operational elements for sensing, monitoring, and intercepting ballistic missiles during all three phases of flight; boost, mid-course, and terminal. BMDS elements include a network of space, ground, and sea based sensors for detecting and tracking threat missiles; interceptor missiles launched from silos, trucks and ships; and tools for command and control. The BMDS must have the ability to detect, track, identify and kill ballistic missiles. The MDA has a University Research Program for advancing and solving complex technological problems, ultimately contributing to enhancing a more robust Ballistic Missile Defense System; these efforts are advanced research. For more information, see MAPS DOD Chart 235.

Special Operations Command (SOCOM)
http://www.socom.mil/Sordac/Pages/Default.aspx
SOCOM has a long-term goal to develop technologies to meet Special Operations Forces (SOF) mission requirements. The intent is to accelerate the delivery of these innovative capabilities to the SOF warfighter. Prior studies and analyses have determined technical challenges to be:
1) trade space between weight, protection, power, and mobility; 2) cost; and 3) system component integration. SOCOM is interested in receiving white papers from all responsible sources from industry, academia, individuals, and Government laboratories capable of providing experiments and tests, feasibility studies, modeling and simulation, design, construction, and testing of SOF-related technologies. For more information, see MAPS DOD Chart 236.

SERPD and ESTCP - Environmental Protection
https://www.serdp-estcp.org/
The DOD provides support for environmental efforts through the Strategic Environmental Research and Development Program (SERDP). It is a 6.3 (advanced development) budget line, but does fund

6.1 or 6.2 work, if the circumstances are right. In addition the DOD has the Environmental Security Technology Certification Program (ESTCP) that identifies and demonstrates the most promising innovative and cost-effective technologies and methods that address DOD's high-priority environmental requirements. For more information, see MAPS DOD Charts 237 - 239.

DOD Laboratories, Centers, Institutes and Schools

The DOD has an extensive intramural research program distributed among various laboratories, institutes and centers (see Table 6). Those entities do have opportunities to fund University-based efforts, usually (but not always) involving applied research. There are also opportunities for collaboration; for instance, relative to Universities, most DOD laboratories are far better equipped and manpower limited.   Generic BAAs are published to announce the areas of potential interest, but contacting the institution prior to submitting a white paper / proposal is a good idea since there may be no interest in your ideas or no funding available.

Air Force Research Laboratory (AFRL)
Of the three service laboratories, AFRL issues the largest number of solicitations for extramural research. AFRL also creates University Centers of Excellence in support of specific AFRL interests.
For more information, see MAPS DOD charts 177 - 183.

Army Research Laboratory (ARL)
http://www.arl.army.mil/www/default.cfm
ARL has a generic solicitation identifying basic and applied research extramural opportunities, but, beyond ARO, ARL is more interested in collaborations than funding efforts. ARL has instituted an Open Campus policy (http://www.arl.army.mil/www/default.cfm?page=2357). The Open Campus is not a funding opportunity. Through the Open Campus framework, ARL scientists and engineers (S&Es) will work collaboratively and side-by-side with visiting scientists in ARL's facilities, and as visiting researchers at collaborators' institutions. Central to the research collaborations is mutual scientific interest and investment by all partners. For more information, see MAPS DOD Charts 184 - 200.

US Army Corps of Engineers Engineering Research and Development Center (ERDC)
http://www.erdc.usace.army.mil/About/MissionandVision.aspx
The U.S. Army Corps of Engineers' (USACE) Engineer Research and Development Center (ERDC) helps solve our Nation's most challenging problems in civil and military engineering, geospatial sciences, water resources, and environmental sciences. ERDC has a generic solicitation.
For more information, see MAPS DOD Chart 201.

Naval Postgraduate School (NPS)
The Naval Postgraduate School (NPS) is interested in receiving proposals for research initiatives that offer potential for advancement and improvement in the NPS core mission of graduate education and research. Also, the Naval Postgraduate School Center for Multi-INT Studies (CMIS) supports innovative, independent research to vastly improve the current state of the art in intelligence, surveillance and reconnaissance (ISR). For more information, see MAPS DOD Charts 81 - 84.

Advanced Manufacturing

Small Business Innovative Research (SBIR and STTR)
http://www.acq.osd.mil/osbp/sbir/about/
The SBIR/STTR Programs are structured in three phases. Phase I (project feasibility) determines the scientific, technical and commercial merit and feasibility of the ideas submitted. Phase II

(project development to prototype) is the major research and development effort, funding the prototyping and demonstration of the most promising Phase I projects. Phase III (commercialization) is the ultimate goal of each SBIR/STTR effort and statute requires that Phase III work be funded by sources outside the SBIR/STTR Program. For more information, see MAPS DOD Charts 241 - 247.

Rapid Innovation Fund (RIF)
http://www.acq.osd.mil/osbp/sb/opportunities.shtml
The Rapid Innovation Fund provides a collaborative mechanism for small businesses to provide DOD with innovative technologies that can be rapidly inserted into acquisition programs that meet specific defense needs. The RIF is administered by the Office of the Secretary of Defense (OSD) Assistant Secretary of Defense for Research and Engineering (ASD R&E) and Office of Small Business Programs (OSBP). The RIF can be a source of the SBIR/STTR Phase III funding. For more information, see MAPS DOD Chart 248.

Mantech
https://www.dodmantech.com/
All ManTech projects and initiatives are selected and executed through the Service and Agency ManTech Programs. The Army executes primarily through Army Research, Development and Engineering Centers and Army Laboratories; the Navy ManTech Program relies almost exclusively on Centers of Excellence; the Air Force partners with industry, other government agencies, and academia; DLA uses multi-contractor, 5 year competitive contracts; and the OSD's Defense Manufacturing S&T Program is executed through the Air Force primarily using Broad Area Announcements.   For more information, see MAPS DOD Chart 249.

Manufacturing USA
https://www.manufacturingusa.com/
Manufacturing USA (formerly the National Network for Manufacturing Innovation) consists of linked Manufacturing Innovation Institutes (MIIs) with common goals, but unique concentrations. In an MII, industry, academia, and government partners leverage existing resources, collaborate, and co-invest to nurture manufacturing innovation and accelerate commercialization. Typically, an MII has ~$70-100M Federal monies over five years, with a requirement of at least an equivalent amount of matching funds. The MIIs have some limited funds available for University research. For more information, see MAPS DOD Charts 250 - 251.

Table 4: **Summary of Applied (6.2) Research Funding**
(Taken from the President's Budget Requests to Congress)

Service		Actual* FY 16	Estimate* FY17	PBR FY17	PBR FY18	% inc PRB FY18-17
Air Force		1241	1260	1260	1284	8
Army		1070	908	907	889	-2
Navy		951	861	861	886	3
DARPA						
	Biomedical	121	115	115	109	-7
	Information & Comms	332	354	354	393	11
	Bio Warfare Defense	25	21	21	13	-40
	Tactical	289	314	313	344	10
	Materials and BioTech	193	220	220	224	2
	Electronics Tech	168	222	175	295	70
DTRA		149	155	155	158	2
CBDP		202	189	189	201	6
OSD	Cyber Security	15	12	14	15	7
DHP	Applied Biomedical	65	57	57	63	11

* The FY16-17 numbers may include Congressional changes and Congressional special adds (CA, sometimes labeled Congressional Special Interest, CSI) which do not appear in the President's Budget Request (PBR).

Table 5: DOD S&T Communities of Interest

COIs were established in 2009 as a mechanism to encourage multi-agency coordination and collaboration in cross-cutting technology focus areas with broad multiple-component investment. COIs provide a forum for coordinating S&T strategies across the Department, sharing new ideas, technical directions and technology opportunities, jointly planning programs, measuring technical progress, and reporting on the general state of health for specific technology areas.

Communities of Interest Tier-1 Taxonomy
http://www.acq.osd.mil/chieftechnologist/COIs.html
- Advanced Electronics
- Air Platforms
- Autonomy
- Biomedical (ASBREM)
- Command, Control, Comms, Computers, and Intelligence (C4I)
- CounterIED
- CounterWMD
- Cyber
- Electronic Warfare
- Energy & Power Technologies
- Ground & Sea Platforms
- Human Systems
- Materials & Manufacturing Processes
- Sensors
- Space
- Weapons Technologies

The collection of COIs serves as an enduring structure to integrate technology efforts throughout the DoD S&T enterprise. While they cover the majority of the DoD's S&T investment, some Service specific investments are not included in these groups. (The former COI on Engineered Resilient Systems is listed as alumni).

Table 6: Service Research Laboratories/Centers/Institutes (mostly in-house efforts)

<u>Army</u>
- Army Research Laboratory (ARL, mostly 6.1 and 6.2)
  http://www.arl.army.mil/www/default.cfm?page=8
  Focus:
      Computational and Information Sciences
      Human Research and Engineering
      Sensors and Electron Devices
      Survivability/Lethality Analysis
      Vehicle Technology
      Weapons and Materials Research
- Army Research and Development Commands (RDECOM, mostly 6.2 - 6.4)
  http://www.army.mil/info/organization/unitsandcommands/commandstructure/rdecom/
  Focus:
      Edgewood Chemical Biological Center (ECBC)
      Soldier Research Development and Engineering Center (NSRDEC)
      Communication-Electronics RDE Center (CERDEC)
      Aviation & Missile RDE Center (AMRDEC)
      Tank-Automotive RDE Center (TARDEC)
      Armament RDE Center (ARDEC)
- Army Corps of Engineers, Engineering Research and Development Center (ERDC)
  http://www.usace.army.mil/Missions/ResearchandDevelopment.aspx
  Focus: solve nation's problems in geospatial sciences, water resources, and environmental
- Army Medical Research and Materiel Command (AMRMC)
  https://mrmc.amedd.army.mil/
  Focus: medical research, development, and acquisition and medical logistics management
- Army Research Institute for Behavioral and Social Sciences
  https://sslweb.hqda.pentagon.mil/ari/
  Focus: research in behavioral science (6.1 - 6.3)

<u>Air Force</u>
- Air Force Research Laboratories (AFRL)
  http://www.wpafb.af.mil/afrl
  Focus:
      Aerospace Systems (RQ)
      Sensors (RY)
      Materials and Manufacturing (RX)
      Munitions (RW)
      Directed Energy (RD)
      Space Vehicles (RV)
      Information (RI)
      Human Effectiveness (711 HPC)

<u>Navy and Marine Corps</u>
- Naval Research Laboratory
  http://www.nrl.navy.mil/
  Focus: S&T in support of the Navy and Marine Corps
- Naval Warfare Centers

Naval Surface Warfare Centers (NSWC)   www.navsea.navy.mil/nswc/default.aspx
Naval Air Warfare Centers (NAWC)
    Weapons   www.navair.navy.mil/nawcwd
    Aircraft   www.navair.navy.mil/NAWCAD
    Training Systems   www.navair.navy.mil/nawctsd
Naval Undersea Warfare Centers (NUSC)   www.navsea.navy.mil/nuwc/default.aspx
Space & Naval Warfare Sys Ctr (SPAWAR) www.public.navy.mil/spawar/Pages/default.aspx

- Navy Medical Research Center   www.med.navy.mil/sites/nmrc/Pages/ott_main.htm
  Focus: battlefield medical problems and naturally occurring infectious diseases
- Naval Postgraduate School   www.nps.edu/Research/rspa.html
  Focus: research and unique research laboratory facilities to support Fleet and OPNAV needs.

For more information on these activities, see MAPS DOD Charts 177-214.

Appendix 1: FY2018 Basic (6.1) Research Program Significant Changes
$M from 2017 to 2018
Derived from RDDS (R-2) in the President's Budget Submission

AFOSR
No funding changes of consequence

Army Research Office (ARO) (H57)
Expeditionary Materials Processing Science   **0 to 5.1**
This research will enable predictive material-to-materiel models for high confidence, certifiable article production, high-fidelity expeditionary and versatile material-to-materiel processing capabilities, and a new generation of materials responsive to applied field for shape shifting and phase transformation. Will demonstrate proof-of-concept through design, synthesis, and validation of adaptive compounds that elicit activated remodeling via mechanochemistry to create synthetic materials with stress-responsive behavior analogous to that observed in biological systems.

Basic Research in Social Sciences   **0 to 3.8**
Social science research focuses on generating fundamental understanding of how social dynamics unfold, taking into account individual-level biophysiological factors contributing to social interaction (e.g., genetics, health, cognition, perception), group processes (e.g., interpersonal forces that determine influence, power, conformity), and the impacts of social institutions (e.g., economic processes, legal/governance structures, religious/belief systems, kin networks), with attention to the interconnections among these levels of analyses, and to the physical and natural environments in which human social dynamics are situated. Will institute research to improve measurement and modeling of social dynamics by tying biometric measurement (e.g., facial thermography, neural imaging, nervous system monitoring, voice acoustic sensing) to interpersonal dynamics and perception networks in small and large groups in localized and dispersed environments; develop new analytic approaches to capture interdependence of actions and precursors of action as well as spatial and temporal dependencies across levels of analyses (i.e., individual-to-group-to-society) to improve predictive accuracy of models of social interaction; advance ecological modeling approaches developed to capture organizational and group dynamics to better understand human social dynamics at population levels; assess impact of media and information technology on cross-cultural diffusion of information, opinion, and influence.

Army University and Industry Research Centers
J08 Institute for Creative Technologies   **6.1 to 6.3**
The ICT actively performs research and engages industry and academic institutions internationally to incorporate the latest research results and hardware and software into its research program and application development and exploit dual-use technology. The ICT serves as a means for the military to learn about, benefit from, and facilitate the transfer of applicable technologies into military systems. In addition, the ICT works with creative talent from the entertainment industry to advance and leverage techniques and capabilities and adapt concepts of story and character to increase the degree of participant immersion in synthetic environments in order to improve the realism and usefulness of these experiences.

FF5 Distributed Collaborative Intelligent Systems   **0 to 4.2**
The DCIST CRA seeks to extend reach, situational awareness, and operational effectiveness against dynamic threats in contested environments through intelligent, resilient and collaborative behaviors of heterogeneous teams of Soldiers, intelligent systems, smart sensors, and knowledge sources.

FF7 Internet of Battlefield Things   **0 to 3.1**
The IoBT CRA seeks to gain fundamental understanding of IoT phenomena and its performance in tactical environments, ranging from sparse, remote settings to complex, dense urban environments. To enable an IoBT capability, research needs to address intelligent resourcing and influence in complex, constrained and uncertain networks (demand from massive numbers of dynamically connected devices, limited and unpredictable connectivity, shared civilian networks, computation at or near the device), heterogeneous sensing and actuation devices (efficient, smart devices with self-organizing/preservation/directing capabilities), and variable, and unreliable provenance and dynamisms of information and device signals.

Office of Naval Research

Air Ground and Sea Vehicles   **52 to 57**
Funding increase in 2018 is the result of several increased Department Research Initiatives in the areas of Science of Autonomy, Advanced Naval Power Systems, and Advanced Sea Platform Performance

Science Addressing Hybrid Threats (formerly Counter IEDS)   **17 to 24**
Funding increase in 2018 is the result of DON increased basic research to include a complex, hybrid adversary consisting of state and non-state actors in order to better reflect the threat environment that Naval Forces will face in the future.

Mathematics, Computer, and Information Sciences   **42 to 45**
Funding increase in 2018 is the result of increased research initiatives in the area of Extramural machine learning, reasoning and intelligence.

Materials/Processes   **53 to 57**
Funding increase in 2018 is the result of several increased research initiatives in the area of Extramural Structural Materials. Conduct basic research related to critical S&T for structural materials, including, but not limited to, the following: computer-aided materials design (CAMD), structural metals, polymer composite materials, solid mechanics, propulsion materials, sensors & NDE prognostics and structural cellular materials.

Medical and Biosciences   **17 to 19**
Funding increase in 2018 is the result of increased research initiatives primarily in the area of Naval Biosciences and Synthetic Biology for Sensing & Energy Production.

Ocean Sciences   **70 to 75**
Funding increase in 2018 is the result of several increased research initiatives in the areas of Ocean Acoustics, Physical Oceanography Processes, Marine Mammals, and Littoral Geoscience and Optics.

Basic Research Challenges   **19 to 21**
Initiate basic research topics in emerging fields of science including: Randomized numerical linear algebra for large-scale, efficient matrix computations; levitated optomechanics; exploring

compositional space to predict and evolve multi-principal element alloys; and guaranteed performance of multibody control systems (BAA N00014-17-S-BA13).

DARPA
CCS-02 Math and Computer Sciences
Lifelong Learning Machines (L2M)   **0 to 16**

Areas of research will include network structures that improve performance by processing new data seen in the field, learn new tasks without forgetting previous tasks, and incorporate context into their understanding of the environment. These capabilities could impact a broad array of military applications that require processing and understanding data, particularly in real world environments where unpredictable events may occur.

ES-01 Electronic Sciences
Joint University Microelectronics Program (JUMP)   **0 to 18**

The Joint University Microelectronics Program (JUMP) program is a government-industry joint research program to explore computing, sensing, communication, and data storage innovations for applications beyond the 2030 horizon. The program recognizes that the densely interconnected microsystems of the future will be built through the use of groundbreaking materials, revolutionary devices, advanced architectures, and unconventional computing. JUMP will therefore sponsor academic research teams focused on related key technology areas that will impact future DoD capabilities and national security. The JUMP program will not only push fundamental technology research but also establish long-range microelectronic research themes with greater emphasis on end-application and systems-level computation.

Beyond Scaling – Architectures and Designs   **0 to 7**

The Beyond Scaling - Architectures and Design program will investigate application-specific circuit architectures that ensure continued improvements in electronics performance with or without the benefit of continued scaling in silicon transistors (Moore's Law). Currently, improvements in electronics largely depend on a regular reduction in the size of silicon components. As Moore's Law slows and the nation loses the benefit of free, exponential improvements in electronics performance, DoD will need to maximize the benefits of available silicon technologies through circuit specialization. This program will investigate the potential for lowering the barriers to designing specialized circuits. Approaches include the use of machine learning and automated design tools to program specialized hardware blocks, integrate them into existing designs, and deploy them in complex systems. Further research would also develop tools to create exact representations of physical hardware.

Beyond Scaling – Materials   **0 to 14**

The Beyond Scaling - Materials program will pursue potential enhancements in electronics that do not rely on Moore's Law, including research not only into new materials but also into the implications of those materials at the device, algorithm, and packaging levels

TRS-01 Transformative Sciences
Functionalities for Biological Systems   **0 to 10**

Leveraging advances in synthetic biology and bioengineering, this program seeks to investigate novel approaches to identify and transfer biological functions into an organism or between organisms. Traditional research in this field has been limited to microbial systems and focused on imparting capabilities from one biological system to another. Instead, this work will investigate methods to biologically encode new functionalities in cell-free, multicellular, and/or multi-organism

systems, using innovations from related areas of microbiology as well as micro- and nanotechnology.

Basic Operational Medical Science
Predicting Disease Transmission from Animal Carriers **0 to 10**
This program will investigate how animal pathogens gain the ability to be transmitted to humans. Tools such as detailed molecular analysis of animal reservoirs and bioinformatics will be leveraged. Building on discoveries in this program, researchers will develop predictive models to forecast potential environments where conditions are most favorable for disease transmission between animals and humans.

Appendix 2: FY2018 Selected Appl Research (6.2) Program Significant Changes
$M from 2017 to 2018
Derived from RDDS (R-2) in the President's Budget Submission

Army Research Laboratory and Centers

C90 Advanced Distributed Simulation
Work in this Project is performed by the Army Research Laboratory (ARL), Human Research and Engineering Directorate, Simulation and Training Technology Center (STTC), Orlando, FL.

Rapid Soldier Capability Enhancement – Training   **0 to 2**
Research the relationship of augmentation agents and Soldier performance & behavior. Investigate the effects of augmentation agents (perceptual, cognitive, and/or physical), used either individually or coupled as a system of agents, on Soldier performance, resilience, and training during operationally relevant tasks. Development of guidelines and models for designing and employing augmentation agents. Implementation of guidelines will enhance augmented Soldier performance.

Synthetic Natural Environments   **0 to 6**
This effort investigates and develops tools and methods to improve the speed, fidelity and delivery of synthetic terrain and environmental data to support Training Aid Devices (TADs), simulation and mission rehearsal systems.

H91 Ground Vehicle Technology
Work in this Project is performed by the Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, Michigan.

Anti Tamper   **0 to 3.5**
This effort investigates and develops mature anti-tamper methodologies and technologies in combat and tactical vehicles. Technologies such as controllers and tactical information systems for autonomous appliques, active protection systems, and Command, Control, Communications, Computers & Intelligence (C4I), will be designed for enhanced protection against current and evolving threats. This includes: enhancing and defending technologies used to secure data in vehicle systems; defending against the threat of unwanted behavioral changes in multi-agent systems; the prevention of unauthorized control of, or denying service to a targeted platform; reverse engineering and conducting vehicle digital forensics; and responding to active attacks that have penetrated anti-tamper defenses in a platform.

H94 Electronics and Electronic Devices
Work in this Project is performed by the Army Research Laboratory (ARL), Adelphi, MD.

Technologies for Alternative Energy   **0 to 1M**
Design and develop novel concepts of energy generation, energy capture materials, and component technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design components to include microscale power devices for multimodal harvesting and efficient distributed power conversion

H95 Night Vision and Electro-Optic Technology

Work in this PE is performed by the United States (U.S.) Army Communications-Electronics Research, Development and Engineering Center (CERDEC)/Night Vision and Electronic Sensors Directorate (NVESD), Fort Belvoir, VA.

High Sensitivity High Speed Uncooled Longwave Infrared Technology   **0 to 5**

Develop a new class of uncooled high sensitivity/high speed IR imaging sensors to enable applications such as Hostile Fire Indication (HFI), Improvised Explosive Device (IED) and disturbed earth detection, driving/pilotage, unmanned ground/ air vehicles sensors, 360º situational awareness sensors, and missile seekers by leveraging commercial processes

Human Factors Engineering System Development

Work in this Project is performed by the Army Research Laboratory (ARL), Aberdeen, MD.

Rapid Soldier Capability Enhancement   **0 to 3**

Research the relationship of augmentation agents and Soldier performance & behavior. Investigates the effects of augmentation agents (perceptual, cognitive, and/or physical), used either individually or coupled as a system of agents, on Soldier performance, resilience, and training during operationally relevant tasks. Development of guidelines and models for designing and employing augmentation agents. Implementation of guidelines will enhance augmented Soldier performance.

Defense Advanced Research Projects Agency

BT-01 Biomedical Technology

Generalizing Complex Biological Signals   **0 to 9**

Recent advances in neurotechnology have created the ability to interface with the nervous system at high resolution and precision. To date, sending and receiving data via these interfaces has required researchers to develop new signal processing algorithms for each user. This program seeks to generalize complex biological signals across users via new architectures and systems, thus producing a flexible neural interface protocol among users that can receive and react to environmental, physiological, and neural information.

Pandemic Prediction   **0 to 14**

Effective pandemic response relies on the ability to anticipate where outbreaks will occur as well as rapidly accelerating medical countermeasure discovery, pre-clinical testing, and manufacturing. This program seeks to advance and integrate newly developed approaches including bioinformatics assessment of genetic sequencing and nucleic acid-based vaccines and to address technology bottlenecks associated with each stage of medical countermeasure development. Additional research within this program will investigate new methods improving the manufacturability, distribution, and delivery of novel therapeutics.

IT-02 High Productivity, High-Performance Responsive Architectures

RF Machine Learning Systems (RFMLS)   **0 to 8**

The RF Machine Learning Systems (RFMLS) program will address the performance limitations of conventional radio frequency (RF) systems such as radar, signals intelligence, electronic warfare, or communications. Currently, the capabilities of these systems are fixed at the time of design and limited by their designer's vision. Conversely, a generic RFMLS system would learn how to reconfigure its circuits and processing to meet the requirements of a desired application in a specific environment. The relevant RF features are hand crafted and human specified today, and would instead be learned through machine learning algorithms applied within the RF system itself. The RFMLS system would later learn to adapt to changing conditions and requirements, making for a much more robust RF system solution.

IT-03 Information Assurance And Survivability
Cyber Assured Systems Engineering (CASE) **0 to 17**
The Cyber Assured Systems Engineering (CASE) program aims to enable the systematic design of networked cyber physical systems to be resilient against cyberattacks. The current state-of-practice for cyber resilience utilizes penetration testing after system construction to drive post-design re-engineering. The CASE technical approach is to formulate cyber resilience as an explicitly engineered property, similar to other holistic properties such as safety, durability, and reliability now standard in systems engineering. CASE will focus on the following technical areas: techniques to derive resilience-related requirements before system design and construction; architectural design and analysis tools to design-in the derived resilience requirements while providing feedback to the human designer to allow for informed tradeoffs between resilience and other system design goals; tools to adapt existing software to support system-level resilience requirements; and inference engines, satisfiability solvers, and provers scalable to complex networked cyber physical systems.

Automated Cyber Operations and Defense (ACOD) **0 to 12**
The Automated Cyber Operations and Defense (ACOD) program will develop a semi-automated cyber operations system to enable operators to detect and respond to cyber attacks more rapidly than unaided human operators. The ACOD capability is needed because highly-scripted, distributed cyber attacks exhibit speed, complexity, and scale that exceed the capability of human cyber defenders to respond in a timely manner. As with algorithmic trading of financial instruments, the program envisions high-intensity cyber operations conducted by computers under human supervision. To accomplish this, ACOD will combine automated cyber defense capabilities, such as those developed in DARPA's Cyber Grand Challenge, with humancentric cyber operations planning and execution capabilities, such as those developed under DARPA's Plan X program.

Cyber-Hunting at Scale (CHASE) **0 to 18**
The Cyber-Hunting at Scale (CHASE) program will develop data-driven tools for real-time cyber threat detection, characterization, and protection within enterprise-scale networks. U.S. computer networks are continually under attack, but at present no tools exist to efficiently extract the right data from the right device at the right time to analyze these attacks. The nature of the threat should be used to determine which data and analyses are required. For example, analysis of an in-memory exploit would require detailed data from a few devices, while analysis of a global botnet attack would require summary data from millions of devices.

TT-04 Advanced Land Systems Technology
Precision Light Strike Munition (PLSM) **0 to 10**
The Precision Light Strike Munition (PLSM) program will seek to develop a small, lightweight, shoulder-launched, guided missile weapon for the individual warfighter.

Urban Operations **0 to 10**
The goal of the Urban Operations program is to generate capabilities which would allow distributed forces to operate effectively in dense urban areas (e.g. megacities). Enabling capabilities would focus on enhanced tactical situational awareness, precise control of destructive and non-destructive effects, network operability and resilience, cyber- and electronic warfare robustness, freedom of movement, and agile logistic sustainment. The Urban Operations system would encompass subsystem and platform technologies supporting tactical mobility, operational endurance, precision

effects, extensive command and control, and enhanced protection for ground forces across the range of conflicts in highly populated, densely built-up areas.

TT-07 Aeronautics Technology
OFFensive Swarm-enabled Tactics (OFFSET) 0 to 10

The OFFSET program will design, develop, and demonstrate a swarm system architecture to advance the innovation, interaction, and integration of novel swarm tactics. The program will examine enabling technologies for advanced mobility, distributed perception, distributed decision-making, and collaborative autonomy for large teams of unmanned systems, including unmanned ground, air, and/or maritime capabilities through the use of both virtual, game-based and physical, live-fly testbeds. Key research thrusts include the development of new platforms, sensors, and algorithms; advances in communication, networking, and autonomy; improvement of swarm logistics and concepts of employment; and development of human-swarm teaming interface technologies.

TT-13 Network Centric Enabling Technology
Warfighter Analytics using Smartphones for Health (WASH) 0 to 15

The Warfighter Analytics using Smartphones for Health (WASH) program will pioneer analytic techniques for continuous and real-time assessment of warfighter physiological health and cognitive state based on the multiple sensor data streams generated by modern smartphones. Recent research in the area of smartphone biometrics has shown the feasibility of measuring user physiological and behavioral parameters for purposes of user authentication. WASH will explore extending these smartphone biometrics to provide the capability to reliably measure additional user physiological and behavioral parameters relevant to health assessment and the diagnosis of disease.

MBT-02 Biologically Based Materials And Devices
Engineering Function 0 to 8

The Engineering Function program will leverage advances in synthetic biology and bioengineering to enhance the natural capabilities of biological systems. To date, imparted functionality in engineered living systems has been limited by the vast biological complexity of the system and lack of understanding of the relationship between the living system and its local environment. This program will include research to develop discovery and automation tools as well as synthesis techniques that expand upon the toolbox of genetically encoded constructs and biologic structures for engineered living systems.

ELT-01 Electronics Technology
Atomic Magnetometry for Biological Imaging in Earth's Native Terrain 0 to 9

The AMBIIENT program will exploit novel physical architectures that are resistant to the impact of common noise sources. The AMBIIENT sensor itself must be able to detect the gradient of a local magnetic field while subtracting the much larger ambient signal, preferably using the sensing mechanism to do this subtraction.

Dynamic Range-enhanced Electronics and Materials 0 to 14

The Dynamic Range-enhanced Electronics and Materials (DREaM) program will develop intrinsically linear radio frequency (RF) transistors with improved power efficiency and extremely high dynamic range. Linearity, power efficiency, and dynamic range are fundamental characteristics that allow RF systems to reliably transmit clear signals. Improving these characteristics is essential

to operating in a crowded RF environment and to enabling next-generation communication, sensing, and electronic warfare systems.

Wireless Autonomous Vehicle Power Transfer   **0 to 9**
The Wireless Autonomous Vehicle Power Transfer (WAVPT) program will develop small footprint, efficient receivers to enable power beaming from a ground-based transmitter to a remote unmanned aerial vehicle (UAV).

Intelligent Design of Electronic Artifacts   **0 to 10**
The program would develop evolvable, open-source IC design tools and IC building block libraries that can be stored in publicly available cloud infrastructure. This would enable small teams of system and algorithm experts without chip design experience to develop custom ICs at a very low cost and quickly implement these designs in hardware.

Beyond Scaling – Architectures and Designs   **0 to 35**
This program will develop and demonstrate the tools required for rapidly designing and deploying specialized circuits. Research efforts will explore technologies and techniques such as new domain-specific circuit architectures; co-design of electronics hardware and software; tight integration of chip-scale processing blocks and artificial intelligence-enabled processing controllers; and open source circuit designs. Further research will also develop tools to create exact representations of outdated hardware in the field and to rapidly, cheaply, and safely upgrade these systems with next-generation electronics.

Chemical Biological Defense Program
Nothing of consequence

Appendix 3: Abbreviated illustration of a Program Officer Datasheet

Dr. David M. Stepp
ARO, Chief, Materials Sciences Division
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Biosketch:
Dr. David Stepp serves as the Chief of the Materials Science Division of the U.S. Army Research Office. Also, he is Adjunct Assistant Professor in the Department of Mechanical Engineering & Materials Science, Pratt School of Engineering, Duke University.

Education
PhD in Mechanical Engineering and Materials Science from Duke University in 1998
MS in Mechanical Engineering and Materials Science from Duke University in 1995
BS in Engineering from Harvey Mudd College in 1993

Program: Mechanical Behavior of Materials
http://www.arl.army.mil/www/default.cfm?page=183
The Mechanical Behavior of Materials program seeks to establish the fundamental relationships between the structure of materials and their mechanical properties as influenced by composition, processing, environment, and loading conditions. The program emphasizes research to develop innovative new materials with unprecedented mechanical, and other complementary, properties.
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Recent MURI Topics:
FY11 Flex-Activated Materials
FY10 Ion Transport in Complex Heterogeneous Organic Materials
FY09 Tailored Stress-Wave Mitigation
FY09 Disruptive Fibers for Flexible Armor

Illustrative Papers Reflecting Personal Research Interests:
A theory of amorphous viscoelastic solids undergoing finite deformations with application to hydrogels
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Appendix 4: Acronym and Abbreviation Glossary

<u>Agency Specific</u>

AFIRM	Armed Forces Institute for Regenerative Medicine
AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratories
AMRDEC	Aviation and Missile Research and Development Center (Army)
AMRMC	Army Medical Research and Materiel Command
ARDEC	Armament Research and Development Center (Army)
ARL	Army Research Laboratories
ARO	Army Research Office
ASSURE	Awards to Stimulate and Support Undergraduate Research Experiences
BA	Budget Activity (new designation for the R&D accounts)
BMDS	Ballistic Missile Defense System
BSV	Bio Surveillance
BTO	Biological Technologies Office (DARPA)
C2	Command and Control
C2ISR	Command, Control, Intelligence, Surveillance and Reconnaissance
C4ISR	Command, Control, Communications, Computers,...
CBDP	Chemical/Biological Defense Program
CBRNE	Chemical, Biological, Radiological, Nuclear and High Explosive
CBWD	Chemical/Biological Warfare Defense
CCRI	Cross-cut Research Initiative
CDMRP	Congressionally Directed Medical Research Program
CERDEC	Communication-Electronics Research and Development Center
CM	Counter Measures
CNA	Computer Network Attack
CoE	Center of Excellence
CONOPS	Concepts of Operation
COTS	Commercial Off-the-Shelf (products)
CSI	Congressional Special Interest (also known as budget "adds")
CTA	Collaborative Technology Alliance
CWMD	Combating Weapons of Mass Destruction
D2D	Data to Decisions
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director, Defense Research and Engineering
DFBA	Defense Forensics and Biometrics Agency
DHP	Defense Health Program
DLA	Defense Logistics Agency
DMDI	Digital Manufacturing and Design Innovation (an IMI)
DMRDP	Defense Medical Research and Development Program
DMS&T	Defense Manufacturing Science and Technology
DTIC	Defense Technical Information Center
DTRA	Defense Threat Reduction Agency
DURIP	Defense University Research Instrumentation Program
ECBC	Edgewood Chemical and Biological Center
EM	Electromagnetic
ERDC	Engineering Research and Development Center, Army Corp of Engineers
ERS	Engineered Resilient Systems
ESTCP	Environmental Security Technology Certification Program
EW	Electronic Warfare
FDW	Federal District of Washington (DOD)
FPA	Focal Plane Array

GDF	Guidance for the Development of the Force
GPS	Global Positioning System
HEL	High Energy Laser
HSCB	Human Social Cultural and Behavior Modeling
IED	Improvised Explosive Devices
IMI	Institute for Manufacturing Innovation
ISR	Intelligence, Surveillance and Reconnaissance
LM3I	Modern Metals Manufacturing Innovation (an IMI)
LUCI	Laboratory University Collaboration Initiative
LVC	Live, Virtual and Constructive (environments)
MDA	Missile Defense Agency
Minerva	Name of DOD program engaging the social science community
MOVINT	The ability to track moving things on land and sea (Movement Intelligence)
MTO	Microsystems Technology Office (DARPA)
MURI	Multidisciplinary University Research Initiative
NAMII	National Additive Manufacturing Innovation Institute (an IMI)
NAWC	Naval Air Warfare Centers (Patuxent River-Aircraft Div, China Lake–Weapons Div)
NDEP	National Defense Education Program
NDSEG	National Defense Science and Engineering Graduate Fellowships
NMRC	Naval Medi
NPGS	Naval Postgraduate School
NRL	Naval Research Laboratory
NSRDEC	Natick Soldier Research and Development Command
NSSEFF	National Security Science and Engineering Faculty Fellowship
NSWC	Naval Surface Warfare Center (Dahlgren and Carderock Divisions)
NUWC	Naval Undersea Warfare Center
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
PACOM	DOD U.S. Pacific Command
PE	Program Element – term from DOD budgeting
PM	Program Manager (same as PO)
PO	Program Officer (same as PM)
QIS	Quantum Information Science
R&E	Research and Engineering Enterprise (DOD Assistant Secretary)
R-1	RDT&E Program Budget Summary Document
RDDS	Research and Development Descriptive Summary (R-2 Budget Document)
RDECOM	Army Research and Development Commands
RIF	Rapid Innovation Fund
RF	Radiofrequency
SIGINT	Signals Intelligence
SERDP	Strategic Environmental Research and Development Program
SOCOM	Special Operations Command
SOF	Special Operations Forces
SPAWAR	Space and Naval Warfare Systems Center
STO	Strategic Technology Office (DARPA)
TARDEC	Tank-Automotive Research and Development Center (Army)
TBI	Traumatic Brain Injury
TTCP	Technical Cooperation Program
TTO	Tactical Technology Office (DARPA)
UARC	University Affiliated Research Center
UCAR	Unmanned Combat Air Rotor
UCAV	Unmanned Combat Air Vehicle
USAMRMC	United States Army Medical Research and Materiel Command

| UXV | Unmanned (X for ground (G), air (A), sea (S),…) Vehicles |
| WRAIR | Walter Reed Army Institute of Research |

General

AMNPO	Advanced Manufacturing National Program Office
AMP	Advanced Manufacturing Partnership
ASEE	American Society for Engineering Education
BAA	Broad Agency Announcement
BRAIN	Brain Research through Advancing Innovative Neurotechnologies
CA	Congressional add
CDC	Centers for Disease Control (in DHHS)
CFDA	Catalog of Federal Domestic Assistance Number
CMOS	Complementary Metal Oxide Semiconductor (electronics)
COE	Center of Excellence
CSI	Congressional Special Interest
DHS	Department of Homeland Security
DHHS	Department of Health and Human Services
DNI	Director of National Intelligence
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOEd	Department of Education (alternative)
DOI	Department of Interior
DOJ	Department of Justice
DOS	Department of State
DOT	Department of Transportation
ED	Department of Education
EPA	Environmental Protection Agency
EPSCoR	Experimental Program to Stimulate Competitive Research
FAA	Federal Aviation Administration
FBO	Federal Business Opportunity
FDA	Food and Drug Administration
FFO	Federal Funding Opportunity
FFDRC	Federally Funded Research and Development Center
FHWA	Federal Highway Administration
FOA	Funding Opportunity Announcement
FY	Fiscal Year (1 Oct to 30 Sep for Federal government)
HBCU/MI	Historically Black Colleges/Universities and Minority Institutions
IHE	Institutions of Higher Education
IMI	Institute for Manufacturing Innovation
INTEL	The various agencies that gather intelligence
IR	Infra-Red
IT	Information Technology
IWG	Interagency Working Group
MAPS	Mission Agency Program Summary (provided by USC Res. Adv.)
MEMS/NEMS	Micro- Nano-ElectroMechanical Systems
MRL	Manufacturing Readiness Level
NASA	National Aeronautics and Space Administration
NDI/E	Non-Destructive Inspection/Evaluation

NIH	National Institutes of Health
NIST	National Institute for Standards and Technology (in DOC)
NNMI	National Network for Manufacturing Innovation
NOAA	National Oceanic and Atmospheric Administration (in DOC)
NOFO	Notice of Funding Opportunity
NRC	National Research Council
NRI	Nanoelectronics Research Initiative
NRO	National Reconnaissance Office
NSA	National Security Agency
NSF	National Science Foundation
NSTC	National Science and Technology Council
NTIA	National Telecommunications and Information Administration
OMB	Office of Management and Budget
OPM	Office of Personnel Management
ORAU	Oak Ridge Associated Universities
OSD	Office of the Secretary of Defense
OSTP	Office of Science and Technology Policy (White House)
PBR	President's Budget Request (submitted to Congress)
PCAST	President's Council of Advisors on Science and Technology
PECASE	Presidential Early Career Award for Scientists and Engineers
PTSD	Post-traumatic Stress Syndrome
RD&I	Research, Development and Innovation
RDT&E	Research, Development, Test and Evaluation
RF	Radio-frequency
RFA	Request for Application
RFP	Request for Proposal
S&T	Science and Technology
SBIR	Small Business Innovative Research
SME	Subject Matter Expert
SN	Special Notice
STEM	Science, Technology, Engineering and Mathematics (education)
STTR	Small Business Technology Transfer
TBA	To be announced
TBI	Traumatic Brain Injury
TRL	Technology Readiness Level
UARC	University Affiliated Research Center
USDA	US Department of Agriculture
YIP	Young Investigator Program