Guide to FY2016 Research Funding at the Department of Defense (DOD)
Contact: James Murday, DC Office of Research Advancement
202 824 5863, Murday@usc.edu

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 FY2016. Additional information is available through the USC Mission Agency Program Summary (MAPS) website (more detail in Resources).

DOD funds research that is relevant to its mission, predominantly drawing on engineering, computer/information science, and physical sciences. The Department has identified seven priorities: Autonomy, Counter Weapons of Mass Destruction, Cyber Sciences, Data-to-Decisions, Electronic Warfare, Engineered Resilient Systems, and Human Systems.

Descriptive of DOD basic research funding opportunities pages 2-10
Brief descriptions of the DOD agencies and funding mechanisms pertinent to Universities. 2-6
Resources for additional basic research information: 7
Table 1: FY11/13 DOD basic and applied research funding at Universities (~$2B/yr) 8
Table 2: DOD Basic Research Budget funding pertinent to Universities (~$1.5B) 9
Table 3: DOD Basic Research Budget Evolution – FY2014 to FY2016 10

Descriptive of Selected DOD applied research funding opportunities pages 11-17
Brief descriptions of the DOD agencies and funding mechanisms pertinent to Universities 11-16
Table 4: DOD Applied Research Budget Evolution – FY2014 to FY2016 17

Appendix 1: FY2016 Basic Research Program Significant Changes pages 18-21
The Service basic research budgets show increases compared to the President’s budget request of last year, but Congressional action added to the Service research accounts significantly in 2015. So the 2016 requests for the Air Force and Navy are about 12% smaller than the funds available to them in 2015.

| ARO | Life Sciences | from 7.8 to 9.8 | 18 |
|     | Physics      | from 13.6 to 16.3 | 18 |
| ONR | Counter Improvised Explosive Device Sciences | from 14.6 to 16.5 | 18 |
|     | Medical/Biological | from 18.2 to 18.2 | 19 |
|     | Ocean Sciences | from 79.3 to 80.7 | 19 |
|     | Weapons       | from 17.9 to 18.2 | 19 |
| DARPA | Big Mechanism (medical data) | | 19 |
|      | Mining and Understanding Software Enclaves | from 8 to 12 | 19 |
|      | Building Resource Adaptive Software from Specs | from 2.5 to 9.5 | 20 |
|      | Transparent Computing | from 10 to 15.4 | 20 |
|      | Next Generation Atomic Clock | from 0 to 4.6 | 20 |
|      | Electronic Globalization (chip security) | from 0 to 3 | 20 |
|      | Nanoscale & Emergent Effects and Engn Devices | from 13 to 20 | 21 |
|      | Applying Biological Complexity at Scale | from 0 to 10 | 21 |
|      | Harnessing Biological Systems | from 0 to 10 | 21 |
## Appendix 2: FY2016 Selected Applied Programs with Significant Change

<table>
<thead>
<tr>
<th>Program Name</th>
<th>$M growth from FY14</th>
<th>page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-submarine Warfare Distributed Search</td>
<td>from 13.5 to 21.4</td>
<td>24</td>
</tr>
<tr>
<td>Future Naval Capabilities initiating in FY2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational Planning Tool</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Advanced Topcoat System (ATS)</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Densified Propellant Fire From Enclosure - Confined Space Propulsion</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Incapacitation Prediction for Readiness in Expeditionary Domains</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Combined EO/IR Surveillance and Response System (CESARS)</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Flexible Sea-based Force Projection (FSFP)</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Ship-launched EW Extended Endurance Decoy (SEWEED)</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Surface Ship Periscope Detection and Discrimination (SSPDD)</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Soft kill Performance and Real-Time Assessment (SPARTA)</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>Reactive Electronic Attack Measures (REAM)</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>DARPA – those programs initiating in 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Optimization in Complex Environments</td>
<td>from 0 to 11.8</td>
<td>27</td>
</tr>
<tr>
<td>Scalable Optical Nodes for Networked Edge Traversal</td>
<td>from 0 to 3.5</td>
<td>27</td>
</tr>
<tr>
<td>Electronic Globalization</td>
<td>from 0 to 12</td>
<td>27</td>
</tr>
<tr>
<td>Strategic Mobility</td>
<td>from 0 to 8</td>
<td>28</td>
</tr>
<tr>
<td>Mobile Infantry</td>
<td>from 0 to 6</td>
<td>29</td>
</tr>
<tr>
<td>Gremlin</td>
<td>from 0 to 8</td>
<td>29</td>
</tr>
<tr>
<td>Understanding Machine Intelligence (UMI)</td>
<td>from 0 to 12.7</td>
<td>29</td>
</tr>
<tr>
<td>Biological-Computational Platforms</td>
<td>from 0 to 10.5</td>
<td>30</td>
</tr>
<tr>
<td>Biological Robustness in Complex Settings (BRICS)</td>
<td>from 0 to 8.1</td>
<td>30</td>
</tr>
<tr>
<td>Hi power Amp using Vac Electronics for Overmatch Capab</td>
<td>from 0 to 12</td>
<td>30</td>
</tr>
<tr>
<td>Next Generation Atomic Clock (NGAC)</td>
<td>from 0 to 8.4</td>
<td>31</td>
</tr>
<tr>
<td>Precise Robust Inertial Guidance for Munitions (PRIGM)</td>
<td>from 0 to 10</td>
<td>31</td>
</tr>
<tr>
<td>Near Zero Energy RF and Sensor Operations (N-ZERO)</td>
<td>from 0 to 4.5</td>
<td>31</td>
</tr>
<tr>
<td>Microwaves and Magnetics (M&amp;M)</td>
<td>from 0 to 5</td>
<td>31</td>
</tr>
<tr>
<td>MultiPLEX</td>
<td>from 0 to 8</td>
<td>31</td>
</tr>
<tr>
<td>Diamond Enhanced Devices (DiamEnD)</td>
<td>from 0 to 6</td>
<td>31</td>
</tr>
<tr>
<td>DTRA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection Technologies</td>
<td>from 0 to 26</td>
<td>32</td>
</tr>
<tr>
<td>CBWD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percutaneous Protection</td>
<td>from 0 to 5</td>
<td>32</td>
</tr>
</tbody>
</table>

## Appendix 3: Illustration of a program officer data sheet on the USC MAPS website

33

## Appendix 4: Acronym Glossary

<table>
<thead>
<tr>
<th>Category</th>
<th>Acronyms</th>
<th>page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency Specific</td>
<td>Acronym Glosary</td>
<td>34-35</td>
</tr>
<tr>
<td>General</td>
<td>Acronym Glosary</td>
<td>36</td>
</tr>
</tbody>
</table>
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 limited social science, medical, and life science 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. The better knowns are the three Services (Air Force, Army, and Naval) and the Defense Advanced Research Projects Agency. 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. The Department has 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 basic research, 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, basic research will not be classified or restricted, with results to be reported in the open literature.

The Office of the Assistant Secretary of Defense (Research & Engineering) has identified high priority basic research topics: a) metamaterials and plasmonics, b) quantum information science, c) cognitive neuroscience, d) nanoscience and nanoengineering, e) synthetic biology, and f) computational modeling of human and social behavior. On occasion, 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. In November 2014 the DOD released a solicitation through AFOSR that requested input on Future Direction Topics for basic research (solicitation #FDWRFI 0004).
Funding for basic research is available from several DOD agencies, each having its own particular focus:

  - Focus: soldier, ground force mission (6.1 only)
  - Focus: pilot, aerospace mission (6.1 only)
- **Office of Naval Research (ONR):** [www.onr.navy.mil/](http://www.onr.navy.mil/)
  - Focus: sailor, marine, ship, ocean mission (6.1 - 6.3)
  - Focus: defense-wide technology innovation (6.1 – 6.3)
- **Defense Threat Reduction Agency (DTRA):** [www.dtra.mil/](http://www.dtra.mil/)
  - Focus: weapons of mass destruction (6.1 – 6.3)
- **Chemical Biological Defense Program (CBDP):** [www.jpeocbd.osd.mil/](http://www.jpeocbd.osd.mil/)
  - Focus: chemical/biological warfare defense (6.1 - 6.3) – managed through DTRA
  - Focus: overarching Defense issues
- **Defense Medical R&D Program (DMDRP):** [dmrdp.dhhq.health.mil/home.aspx](http://dmrdp.dhhq.health.mil/home.aspx)
  - Focus: military specific medical research (6.1 – 6.3)
- **Congressional Directed Medical Research Program (CDMRP):** [cdmrp.army.mil/](http://cdmrp.army.mil/)
  - Focus: medical research of interest to a Congress person (6.1 only)

**Generic Basic Research Broad Agency Announcements - Single Investigator Efforts**

The majority of DOD basic research funding is invested in single investigator efforts and advertised through relatively generic Broad Area Announcements (BAAs). 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.

While peer review is used to differing degrees by the various DOD agencies, the program officers have far greater latitude than do NSF program officers. So it is essential 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 very useful (often required). The program officers don’t want to waste your time writing, or 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. Guides to interacting with the program officers and preparing proposals are in the MAPS web site, Tabs 2-4.

**Special Program Announcements**

During the year, DOD agencies can announce special program opportunities; 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 Technology Alliances (CTA), and Centers of Excellence (CoE)] to single investigator programs [e.g., DARPA/DTRA/CDMRP topic solicitations, and ONR’s Basic Research Challenges]. These opportunities can be found by monitoring: 1) the funding agency sites, 2) the “grants.gov” website and/or 3) the “defenseinnovationmarketplace.mil” website. The DC Office of Res. Advancement does this and provides alerts to pertinent USC investigators.
Young Investigators
Each of the three services, DTRA, and DARPA has 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 156-161; a listing of prior awardees and their research topics is available from the DC office.

Senior Investigators - National Security Science and Engineering Faculty Fellowship
http://www.acq.osd.mil/rd/basic_research/program_info/nsseff.html
This is a special program to support outstanding faculty in topics-of-interest to DOD; it is competed intermittently as funding allows. Awardees are generally ~20 years post year of PhD and have impressive credentials. An NSSEFF awardee receives ~$600K/yr for five years. For more information see MAPS DOD Chart 165; a listing of the prior awardees/topics is available from the DC office.

Multidisciplinary Efforts – Multidisciplinary University Research Initiatives (MURIs)
As part of DOD’s University Research Initiative budget line, the multidisciplinary university research initiative (MURI) program has topics announced in the Jul – Sept time frame each year, with white papers due about a month later, and proposals about three months later. These require multidisciplinary teaming efforts; the funding is up to $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 129-133; 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 155). The Army also has University COE, Collaborative Technology Alliances (CTA), and Collaborative Research Alliances (CRA) that engage Universities. 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 178)

Human Social, Cultural, and Behavioral Modeling (HSCB)
http://minerva.dtic.mil/
In addition to Service core HSCB programs, the Office of the Secretary of Defense (OSD) funds S&T programs to address understanding and modeling of human behavior in social and cultural contexts. The basic research component is entitled the Minerva Initiative (see MAPS DOD Chart 128); it is presently administered by ONR.
**Medical**

Congressionally Directed Medical Research Program (CDMRP)


Congress typically adds funds to the DOD budget for support of medical basic research; these total ~$0.5-1B/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 141-152 and/or visit the CDMRP website (which is very informative).

**Agency**

DOD has a relatively small extramural effort in medical basic research. In 2010 the DOD established a joint program, the Defense Medical Research and Development Program (DMRDP) with 6.1-6.3 funding (see MAPS DOD Charts 134-140). The Army Medical Research and Materiel Command (USAMRMC) issues a generic BAA for basic research, but generally without much available money. In addition, USAMRMC manages the Armed Forces Institute of Regenerative Medicine (AFIRM), which funds University-based consortia (see DOD Chart 55). DARPA has a Basic Operational Medical Science (6.1) effort (see MAPS DOD Charts 87-89). ONR has a Biological and Biomedical Division with interest in selected medical topics (see MAPS DOD Chart 69).

**Instrumentation**


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 strong preference for instrumentation in support of funded DOD research efforts. For more information, see MAPS DOD Charts 129-133. ARO also has its own research instrumentation program (see MAPS DOD Chart 51).

**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 Undergraduate/graduate education (the National Defense Education Program (NDEP - http://www.ndep.us/). Each of the Services also has a STEM education effort. The DOD research laboratories fund postdoctoral positions through the National Research Council (NRC), the American Society for Engineering Education (ASEE), and the Oak Ridge Associated Universities (ORAU) 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 170-171).
Resources

Defense-wide central resource website: defenseinnovationmarketplace.mil

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


Mission Agency Program Summaries (MAPS)
The DC Office of Research Advancement has created the Federal Mission Agency Program Summaries 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
Dr. James S. Murday DC Office of Research Advancement
Tel: 202 824 5863 Email: Murday@usc.edu
Table 1: FY2013 and FY2014 DOD Research Funding ($M)
Obligations at Universities/Colleges

<table>
<thead>
<tr>
<th></th>
<th>2013 Basic</th>
<th>2013 Applied</th>
<th>2014 Basic</th>
<th>2014 Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total for DOD</td>
<td>1862</td>
<td>4093</td>
<td>2094</td>
<td>4732</td>
</tr>
<tr>
<td>Total at Universities</td>
<td>974</td>
<td>507</td>
<td>1084</td>
<td>624</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astronomy</td>
<td>0</td>
<td>-</td>
<td>236</td>
<td>33</td>
</tr>
<tr>
<td>Chemistry</td>
<td>61</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td>125</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Environmental Sciences</td>
<td></td>
<td></td>
<td>88</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric</td>
<td>12</td>
<td>1</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Geological</td>
<td>3</td>
<td>-</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Oceanology</td>
<td>58</td>
<td>19</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>2</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Mathematics and Computer</td>
<td></td>
<td></td>
<td>179</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Sciences</td>
<td>168</td>
<td>101</td>
<td>179</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>74</td>
<td>1</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Other</td>
<td>36</td>
<td>14</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Engineering</td>
<td>321</td>
<td>204</td>
<td>355</td>
<td>247</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aeronautical</td>
<td>54</td>
<td>18</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Astronautical</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Chemical</td>
<td>38</td>
<td>24</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Civil</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Electrical</td>
<td>65</td>
<td>46</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Mechanical</td>
<td>32</td>
<td>4</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Metal/Materials</td>
<td>58</td>
<td>13</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>69</td>
<td>92</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Life Sciences</td>
<td>139</td>
<td>131</td>
<td>149</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Biological</td>
<td>91</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Environmental</td>
<td>3</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Medical</td>
<td>38</td>
<td>104</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Psychological</td>
<td>15</td>
<td>1</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>23</td>
<td>9</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>Other Sciences</td>
<td>27</td>
<td>14</td>
<td>31</td>
<td>16</td>
</tr>
</tbody>
</table>

Because the entries for FY2015 are Budget Request only, they are not reported here.
Basic 2013 Tables 30, 77 and 80-86
Applied Research 2013 Tables 44, 88 and 91-97
Basic 2014 Table 31 and 78
Applied Research 2014 Table 45 and 89
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 projected budgets in the table are parsed differently than most of the organization’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 3: Summary of Basic Research Funding
(Taken from the President’s Budget Requests to Congress)

<table>
<thead>
<tr>
<th>Service</th>
<th>Actual* FY 14</th>
<th>Estimate* FY15</th>
<th>PBR FY15</th>
<th>PBR FY16</th>
<th>% inc PRB FY16-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Research</td>
<td>511</td>
<td>551</td>
<td>454</td>
<td>485</td>
<td>7</td>
</tr>
<tr>
<td>Defense Res Sciences</td>
<td>364</td>
<td>390</td>
<td>315</td>
<td>330</td>
<td></td>
</tr>
<tr>
<td>Army</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Research</td>
<td>425</td>
<td>460</td>
<td>424</td>
<td>425</td>
<td>-</td>
</tr>
<tr>
<td>Defense Res Sciences</td>
<td>217</td>
<td>248</td>
<td>238</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td>ARO (H57)</td>
<td>78</td>
<td>81</td>
<td>81</td>
<td>87</td>
<td>7</td>
</tr>
<tr>
<td>ICT (J08)</td>
<td>7.8</td>
<td>7.5</td>
<td>7.5</td>
<td>6.1</td>
<td>-20</td>
</tr>
<tr>
<td>Navy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Research</td>
<td>604</td>
<td>650</td>
<td>576</td>
<td>587</td>
<td>2</td>
</tr>
<tr>
<td>Defense Res Sciences</td>
<td>477</td>
<td>497</td>
<td>444</td>
<td>452</td>
<td></td>
</tr>
<tr>
<td>DARPA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Research</td>
<td>293</td>
<td>332</td>
<td>362</td>
<td>333</td>
<td>-8</td>
</tr>
<tr>
<td>Basic Operational Medical Res Science</td>
<td>48</td>
<td>61</td>
<td>50</td>
<td>57</td>
<td>14</td>
</tr>
<tr>
<td>DTRA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Research</td>
<td>45</td>
<td>38</td>
<td>38</td>
<td>38</td>
<td>-</td>
</tr>
<tr>
<td>CBDP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Research</td>
<td>51</td>
<td>48</td>
<td>51</td>
<td>46</td>
<td>-10</td>
</tr>
<tr>
<td>OSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDEP</td>
<td>73</td>
<td>58</td>
<td>45</td>
<td>49</td>
<td>9</td>
</tr>
<tr>
<td>MINERVA (0601110DBZ)</td>
<td>9.2</td>
<td>9.4</td>
<td>8.9</td>
<td>9.5</td>
<td>7</td>
</tr>
<tr>
<td>DHP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDF-Basic Operational Med Res Sciences (0601117HP - 371A)</td>
<td>5.8</td>
<td>7.5</td>
<td>7.5</td>
<td>7.4</td>
<td>-</td>
</tr>
</tbody>
</table>

* The FY14-15 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).

Note that Congress added funds to the Service research accounts in 2015, more than restoring the proposed reductions in the Presidential Budget request. While the 2016 PBR numbers grow over the 2015 PBR, it remains to be seen if Congress will again increase those accounts. If not, then AFOSR and ONR will experience significant reductions in 2016 compared to 2015.

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 opportunities elaborated 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**

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.

Funding opportunities for applied research (6.2) and advanced technology development (6.3) are distributed among many DOD organizations, each having its own particular focus:

**Organizations managing a 6.1-6.3 investment portfolio**

- **Office of Naval Research (ONR, Naval includes the Navy and Marine Corps)**
  

  Focus: develop/transition cutting-edge technology products to Naval acquisition managers

- **Defense Advanced Research Projects Agency (DARPA)**
  
  [www.darpa.mil](http://www.darpa.mil)

  Focus: defense-wide technology innovation

- **Defense Threat Reduction Agency (DTRA)**
  

  Focus: countering weapons of mass destruction – chem, bio, radiological, nuclear, explosive

**Other S&T organizations (w/o basic research)**

- **Defense Forensics and Biometrics Agency (DFBA)**
  
  [http://biometrics.dod.mil/](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](http://www.dla.mil/Pages/default.aspx)

  Focus: support the weapon system sustainment program

- **Missile Defense Agency (MDA)**
  

  Focus: system to defend against ballistic missile attacks

- **Special Operations Command (SOCOM)**
  

  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/](https://www.serdp-estcp.org/)

  Focus: develop and demonstrate innovative, cost-effective, and sustainable solutions

**Service Research Laboratories/Centers**

- **Army Research Laboratory (ARL, mostly 6.1 and 6.2)**
  

  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

• 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)

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

• Navy Medical Research Center
  http://www.med.navy.mil/sites/nmrc/Pages/ott_main.htm
  Focus: battlefield medical problems and naturally occurring infectious diseases

• Naval Postgraduate School
  http://www.nps.edu/Research/rspa.html
  Focus: research and unique research laboratory facilities to support Fleet and OPNAV needs.
Technology Transition

- ManTech
  https://www.dodmantech.com/
  Focus: responsive, world-class manufacturing capability to affordably meet warfighters needs
- Small Business Innovative Research (SBIR and STTR)
  http://www.acq.osd.mil/osbp/sbir/about/
  Focus: cooperative research and development projects with small businesses
- Rapid Innovation Fund (RIF)
  http://www.acq.osd.mil/osbp/sb/opportunities.shtml
  Focus: transition technologies, mostly small business, resolving DOD operational challenges

For more information on these activities, see MAPS DOD Charts 175-206.

Office of Naval Research (ONR)
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 a 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 201-202)

Defense Advanced Research Projects Agency (DARPA)
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 207-213.

**Defense Threat Reduction Agency (DTRA)**

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 214-222.

**Defense Forensics and Biometrics Agency (DFBA)**

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 223.

**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 Chart 224.

**Missile Defense Agency (MDA)**

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 225.
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 R&D focuses on five primary technical areas to support the Army and the Corps:

- Warfighter Support – geospatial information; system development; operational support; force protection; and force projection and sustainment
- Installations – transformation; operations; and environmental issues
- Environment – remediation and restoration; land planning, stewardship and management; threatened and endangered species; and cultural resources
- Water Resources – infrastructure, water resources, environmental issues, and navigation; and flood control and storm damage reduction
- Information Technology – informatics; geospatial technologies; computational services; high-performance computing applications

For more information see MAPS DOD Chart 52.

Special Operations Command (SOCOM)

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;
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 226.

SERPD and ESTCP - Environmental Protection

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. (see MAPS DOD Charts 227-228)

DOD Laboratories, Centers, and Schools

The DOD has an extensive intramural research program distributed among various laboratories and centers (see above and MAPS DOD Charts 175-206 for more detail). Those entities do have some opportunities to fund University-based efforts, usually (but not always) involving applied research. Generic BAAs are published to announce the areas of 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. Especially for AFRL, there are also BAAs addressing specific topics.

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. (see MAPS DOD Charts 230-236)

**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. (see MAPS DOD Chart 237)

**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. (see MAPS DOD Chart 238)

**NNMI**
http://www.manufacturing.gov/nmni.html
The National Network for Manufacturing Innovation (NNMI) consists of linked Institutes for Manufacturing Innovation (IMIs) with common goals, but unique concentrations. In an IMI, industry, academia, and government partners leverage existing resources, collaborate, and co-invest to nurture manufacturing innovation and accelerate commercialization. Typically an IMI has ~$70-100M Federal monies over five years, with a requirement of at least an equivalent amount of matching funds. The IMIs have some limited funds available for University research.

DOD has reallocated fiscal resources to begin five IMIs.
**FY2013:**
(a) National Additive Manufacturing Innovation Inst (NAMII, now named America Makes)
**FY2014:**
(a) Digital Manufacturing and Design Innovation (DMDI)
(b) Lightweight and Modern Metals Manufacturing Innovation (LM3I, now named Lightweight Innovations for Tomorrow)
**FY2015:**
(a) Integrated Photonics
(b) Flexible Hybrid Electronics.
For more information see MAPS DOD Chart 239
Table 4: Summary of Applied Research Funding
(Taken from the President’s Budget Requests to Congress)

<table>
<thead>
<tr>
<th>Service</th>
<th>Actual* FY14</th>
<th>Estimate* FY15</th>
<th>PBR FY15</th>
<th>PBR FY16</th>
<th>% inc PRB FY16-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force</td>
<td>1124</td>
<td>1100</td>
<td>1081</td>
<td>1217</td>
<td>12</td>
</tr>
<tr>
<td>Army</td>
<td>931</td>
<td>981</td>
<td>863</td>
<td>880</td>
<td>2</td>
</tr>
<tr>
<td>Navy</td>
<td>844</td>
<td>870</td>
<td>821</td>
<td>865</td>
<td>5</td>
</tr>
<tr>
<td>DARPA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomedical</td>
<td>121</td>
<td>115</td>
<td>112</td>
<td>114</td>
<td>1</td>
</tr>
<tr>
<td>Information &amp; Comms</td>
<td>371</td>
<td>324</td>
<td>334</td>
<td>356</td>
<td>7</td>
</tr>
<tr>
<td>Bio Warfare Defense</td>
<td>26</td>
<td>44</td>
<td>45</td>
<td>30</td>
<td>-25</td>
</tr>
<tr>
<td>Tactical</td>
<td>218</td>
<td>300</td>
<td>305</td>
<td>315</td>
<td>3</td>
</tr>
<tr>
<td>Materials and BioTech</td>
<td>159</td>
<td>150</td>
<td>160</td>
<td>220</td>
<td>40</td>
</tr>
<tr>
<td>Electronics Tech</td>
<td>222</td>
<td>269</td>
<td>179</td>
<td>175</td>
<td>-2</td>
</tr>
<tr>
<td>DTRA</td>
<td>152</td>
<td>151</td>
<td>152</td>
<td>155</td>
<td>2</td>
</tr>
<tr>
<td>CBDP</td>
<td>195</td>
<td>226</td>
<td>226</td>
<td>208</td>
<td>-8</td>
</tr>
<tr>
<td>OSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyber Security</td>
<td>12</td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>-9</td>
</tr>
<tr>
<td>DHP</td>
<td>60</td>
<td>73</td>
<td>74</td>
<td>58</td>
<td>-22</td>
</tr>
</tbody>
</table>

* The FY14-15 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).
Appendix 1: FY2016 Basic Research Program Significant Changes

Army Research Office (ARO)

Life Sciences from $7.8M in FY2015 to $9.8M
Increase in funding and new directions identified
- Research and design neuro-cognitive computational models that detect a single-sound source (amongst multiple audible stimuli) to determine whether it is possible to link brain data to the segregated/isolated sound sources from noisy environments (may lead to new applications for effective auditory prostheses, automatic speech recognition, and other tools for enhanced Soldier auditory situational awareness in distracting environments);
- Screen analogs of cellular cyclic diguanylate to identify and characterize a key potential pathway that mediates the formation of bacterial persister cells, a unique state that is known to and other influences to human actions, and
- Auditory and signal processing research to map the cognitive implications of multisensory information integration.

Physics from $13.6M in FY2015 to $16.3M
Increase in funding and new directions identified
- Develop new imaging methods such as non-linear optical spectroscopies for detecting spin-orbit coupling in advanced materials (may lead to new electronic technologies for sensors and computational hardware);
- Investigate novel photon-photon interactions in a strongly-interacting cold atomic gas (may enable the first observation of the crystallization of a gas of strongly interacting photons, and in the long term, may lead to improvements in computation, measurement, and sensing);
- Develop robust techniques for quantum sensing and measurement to overcome the fragility of quantum information due to unwanted environmental interactions (may provide unprecedented computation and communication capabilities); and
- Characterize the unique electron dynamics of a particular class of magnetic materials known as ferroplasmons and develop theories to effectively model this behavior (may lead to lighter and smaller electronic components).

Office of Naval Research

Counter Improvised Explosive Device Sciences from $14.6M in FY2015 to $16.5M
Increase in funding and new directions identified
- Initiate research into the improved biomechanics and physiology of detection dogs for use in the detection of explosive hazards.
- Initiate research efforts to produce the knowledge and understanding necessary to detect and locate asymmetric explosive threats and their components by exploring combination of their unique passive and active characteristic responses at safe stand-off distances from various expeditionary platforms.
- Initiate research efforts to explore new lightweight multifunctional material design and techniques to optimize existing materials to improve protection from detonation effects.
- Initiate research efforts to neutralize or prevent explosive threats with or without direct knowledge of their locations.
- Initiate research efforts to provide understanding of the human and social elements and their relationships with asymmetric explosive threats to predict and prevent explosive events.

**Medical/Biological**  
from $18.2M in FY2015 to $18.2M  
No change in the total funding, but some new directions identified  
- Initiate research in partnership with the Army to study regenerative medicine (Armed Forces Institute for Regenerative Medicine II (AFIRM II)).  
- Initiate research to investigate novel mechanisms to manage the mammalian circadian system for optimized health and performance.  
- Initiate research to develop strategies for nerve cell regeneration.

**Ocean Sciences**  
from $79M in FY2015 to $81M  
Minor increase in funding, but new directions identified  
- Initiate research on extreme currents and highly variable flow generated by flow encountering abrupt topography in the Western Pacific.  
- Initiate research on the structure and variability of the Northern Arabian Sea circulation using autonomous, unmanned sampling systems in order to provide critical basic understanding.  
- Initiate geoacoustic inversion studies with an emphasis on the New Jersey and Arctic Shelves.

**Weapons**  
from $17.9M in FY2015 to $18.2M  
Minor increase in funding, but one new direction identified  
- Initiate hypersonic aerodynamics, aerothermodynamics and high temperature materials research focused on challenges resulting from unique Navy platform constraints.

**DARPA**

**CCS-02 Math and Computer Sciences**  
**Big Mechanism**  
from $16M in FY2015 to $24M  
- Demonstrate prototype technologies in production mode by identifying drug targets and drugs for one or more specific classes of cancer.  
- Demonstrate automated testing of machine-generated hypotheses.  
- Create new modes for visualizing and exploring models of huge scope that in their entirety exceed human cognitive capabilities.  
- Formulate statistical approaches for uncovering causal relationships in numerical data/time series and categorical data/symbol sequences.  
- Develop and implement scalable algorithms that reveal causality networks in large, complex, heterogeneous datasets.

**Mining and Understanding Software Enclaves**  
from $8M in FY2015 to $12M  
- Implement scalable database technologies and mining algorithms that allow the ingestion and analysis of tens of millions of lines of open-source software.  
- Integrate machine-learning algorithms that can direct and assimilate mining activities on analysis artifacts stored in the database.  
- Evaluate component-level synthesis techniques that automatically construct implementations of complex protocols from discovered specifications.  
- Identify key challenge problems in automated repair and security analysis, along with novel solutions that directly exploit the latent semantic content in the database.
Building Resource Adaptive Software from Specifications  from $2.5M in FY2015 to $9.5M
- Integrate specifications within an operational environment to monitor resource changes and trigger signals when resource invariants are violated.
- Develop compile-time and runtime transformations that ensure survivable operation in the face of unexpected environment changes.
- Build validation tools that certify that transformed applications satisfy specification assumptions in the context of new operating environment guarantees.

CYS-01 Cyber Sciences
Transparent Computing  from $10M in FY2015 to $15.4M
- Implement adaptive security policy schemes in software prototypes with flexibility and scalability suitable for use on distributed surveillance systems, autonomous systems, and enterprise information systems.
- Perform initial assessments of security policy prototypes in simulated laboratory and cloud environments.
- Develop and implement behavioral attestation techniques in software prototypes scalable to big data applications.
- Develop and implement causal dependency tracking across software/hardware abstraction layers.

ES-01 Electronic Sciences
Next Generation Atomic Clock  from 0 in FY2015 to $4.6M
- Develop low-CSWaP application-specific laser devices, optical modulators, shutters, and isolators.
- Demonstrate integration of application-specific optical components into robust photonic integrated circuits.
- Develop techniques for alkali metal vapor pressure control over the full DoD temperature range.
- Develop low-CSWaP ultra-high vacuum technology operating without perturbative magnetic fields.
- Demonstrate clock operation with integrated enabling component devices.

Electronic Globalization  from 0 in FY2015 to $3M
The Electronic Globalization program will examine various approaches for trusting circuits in an untrusted environment. It will develop the abilities to design circuits with functionality that is benign in an untrusted environment.
- Define the value proposition offered by the proposed material, identifying a specific Concepts of Operations.
- First pass intrinsic physics-level modeling and simulation of structures and materials.
- Design of proof-of-concept test sites.
- Fabricate test coupons and characterization of new morphological materials and structures.
- Characterization of experimental hardware.
MS-01 Materials Science
Nanoscale & Emergent Effects and Engn Devices from $13M in FY2015 to $20M
- Continue development of methods to stabilize extended solids at ambient temperatures and pressures.
- Demonstrate synthesis and stability to ambient temperature and pressure of high density extended carbon based materials (e.g., clathrates, allotropes, and oxides) at the multimilligram scale.
- Demonstrate methods to synthesize bulk cubic boron nitride at reduced pressure with purities of >50%.
- Refine and implement development of retrosynthetic pathways that are synthetically achievable for multistep reaction schemes to fabricate extended solids at reduced pressures based on computational analysis and stabilization results.
- Demonstrate the ability to assemble micron-scale, 3D, multiple material structures from nanoscale material constructs while preserving desirable nanoscale material properties.
- Demonstrate pick and place assembly of cm-scale materials from micron-scale constructs while preserving desirable nanoscale material properties.

TRS-01 Transformative Sciences
Applying Biological Complexity at Scale from 0 in FY2015 to $10M
Investigate dynamics and thresholds for transgene stability/instability in systems of infectious disease vectors.
- Study methods for achieving transient phenotypes in infectious disease vectors.
- Investigate predictive design rules and engineering approaches for integrated biosystems.
- Investigate microbial community evolution and communication as it applies to their application (e.g., microbiome impacts on health or catabolism).

MED-01 Basic Operational Medical Science
Harnessing Biological Systems from 0 in FY2015 to $10M
- Investigate predator effectiveness against pathogens of interest.
- Initiate basic science studies of the relevant underlying mechanisms of predation.
- Begin basic science studies to enhance understanding of biological adaptability in response to external pressures.
- Identify and understand fundamental mechanisms that control the transition between unicellular and multicellular function.
- Examine biological basis for naturally occurring evolutionary advances.
- Investigate novel methods to integrate evolved biological traits.
- Research basic science processes by which bacteria grow and spread throughout a community.
Appendix 2: FY2016 Selected Applied Research Program Significant Changes

Navy

**Common Picture Applied Research**

**Appd Information Sciences For Decision Making**

- Minor increase in funding, but new directions identified
- Initiate efforts for reconstructing events from a loose network of heterogeneous cameras.
- Initiate Maritime domain awareness toolkit development for small vessel tracking.
- Initiate cyber information awareness decision tools for hull, mechanical and electrical security for Naval vessels.
- Initiate development for methods and tools for semi-/fully- automated software model extraction and online program execution monitoring toward achieving adaptive and resilient computing system.

**Warfighter Sustainment Applied Research**

**Human Factors And Organizational Design**

- Decrease in funding, but new directions identified
  - Initiate data collection activity using prototype panoramic camera aboard a sea vessel. 
    Initiated research on integrating automated image processing technologies onboard the prototype panoramic camera.
  - Initiate development of testbeds and tool chains for rapid disaster analysis and response.
  - Initiate development of novel information feeds for Pacific Command.

**Medical Technologies**

- Decrease in funding, but new directions identified
  - Initiate research into improved cognitive agility for divers and diving supervisors
  - Initiate research into diver Human Systems Integration (displays and biometric monitoring)

**Warfighter Sustainment**

**Training Technologies**

- Decrease in funding, but new directions identified
  - Initiate development of skill decay models for psychomotor, perceptual, and cognitive skills and refresher training strategies.
  - Initiate development of intelligent avatars to interact with learners from different cultural, linguistic backgrounds, and preferences.
  - Initiate development of scenarios generators that produce integrated training (e.g., individual and collective) training.

**Electromagnetic Systems Applied Research**

**Electronic Warfare Technology**

- Increase due to adding new INP Electromagnetic Maneuver Warfare Command & Control (EMC2) EW EO/IR technology subprogram
  - Initiate the development of SSDs leveraging multiband EO/IR components and subsystems from prior DoD investments to demonstrate advanced ES and EA capabilities covering a broad range of EO/IR wavelengths in support of Navy and Marine Corps mission areas.
- Initiate Wideband Airborne Multifunction System design
- Initiate LowRIDR SubSystem build
- Initiate Electromagnetic Warfare Command and Control system design

**Solid State Electronics** from $9.6M in FY2015 to $10M
Solid State Transistors and Devices subprogram
- Initiate development of ultra-efficient mm-wave transistors.
High Efficiency, Highly Linear Amplifiers subprogram
- Initiate research into harmonic mm-wave amplifiers

**Ocean Warfighting Environment Applied Res**
**Coastal Geosciences/Optics** from $6.6M in FY2015 to $6.3M
Decrease in funding, but new directions identified
- Initiate studies to reduce uncertainties in data-assimilative littoral models in data-sparse environments
- Initiate analysis of historic remote sensing modalities to determine whether robust climatologies can be developed which provide utility for initialization of littoral geosciences forecast models in data-poor regions.

**National Oceanographic Partnership Program (NOPP)** from $8.8M in FY2015 to $8.3M
Decrease in funding, but new directions identified
- Initiate marine mammal tagging as a component of the marine arctic ecosystem dynamics study.
- Initiate development of coupled Arctic System Models to support improved forecasting and prediction of sea ice and other operational parameters
- Initiate efforts to seamlessly nest high-resolution regional ocean models into tide-resolving global HYCOM ocean forecasts
- Initiate project to understand the role of the ocean in providing skill in extended-range predictions of the environment through systematic model intercomparisons

**Ocean Acoustics** from $3.5M in FY2015 to $2.6M
Decrease in funding, but new directions identified
- Initiate marine mammal tagging as a component of the marine arctic ecosystem dynamics study.
- Initiate development of coupled Arctic System Models to support improved forecasting and prediction of sea ice and other operational parameters
- Initiate efforts to seamlessly nest high-resolution regional ocean models into tide-resolving global HYCOM ocean forecasts
- Initiate project to understand the role of the ocean in providing skill in extended-range predictions of the environment through systematic model inter-comparisons

**Physical Oceanography** from $10.7M in FY2015 to $10.5M
Decrease in funding, but new directions identified
- Initiate multi-scalable visualization tools using GPU’s, tablets and remote sensing data.
- Initiate testing of Air-Deployed Ocean Profiler in research and fleet test.
- Initiate development of a coupled atmosphere-ocean-cryosphere-wave prediction system capable of forecasts from the submesoscale to decadal.
- Initiate development of a high resolution Arctic ice/ocean/weather/wave prediction system that can assimilate SAR data.
- Initiate Synthetic Aperture Radar Data Assimilation for Tropical Storm Forecasts
- Initiate Expendable Expeditionary Data Fusion Development

**Joint Non-Lethal Weapons Applied Res** from $5.9M in FY2015 to $6.1M
- Initiate evaluation of the susceptibility of targets to candidate vehicle and vessel stopping designs.

**Undersea Warfare Applied Res**

**Anti-Submarine Warfare Distributed Search** from $13.5M in FY2015 to $21.4M
Funding increase from FY 2015 to FY 2016 is due to 3 new programs funded in this PE: The Virtual Acoustic Sensing Array (VASA), Forward Deployed Energy & Communications Outpost (FDECO) (FY16-FY19) INP, and the Anti Submarine Warfare Mission Packages (ASW MP) (FY16-FY20).
- Initiate development of signal and information processing algorithms for improved ASW performance of high duty cycle active sonar systems.
- Initiate the Forward Deployed Energy & Communications Outpost (FDECO) Innovative Naval Prototype project.

**Future Naval Capabilities (FNC) Applied Research**
This FNC projects include announced new starts in FY2016 along with the program manager.

1. **Capable Manpower (Cmp)** from $8.3M in FY2015 to $9.3M
EC: CMP-FY16-01 Operational Planning Tool
Dr. William “Kip” Krebs, William.krebs@navy.mil
- Develop decision support analytic tools that enhance collaborative planning for generating and executing safe and effective navigation & operational plans.

2. **Enterprise And Platform Enablers (EPE)** from $12.4M in FY2015 to $11.7M
EC: EPE-FY16 Advanced Topcoat System
Mr. William (Bill) Nickerson, William.nickerson@navy.mil
Leverage commonality in current state-of-the-art topcoat systems for air and ground vehicle (topcoats ~80% common)
- Aviation: Type IV Polyurethane – Lower film thickness, focus on flexibility, erosion, color/gloss retention IH restrictions.
- Ground: Type IV/II Polyurea – Higher film thickness

3. **Expeditionary Maneuver Warfare (EMW)** from $6.7M in FY2015 to $6.3M
Emw-Fy16-01 Densified Propellant Fire From Enclosure - Confined Space Propulsion Technologies
Mr. Dan Simons, dan.simons@navy.mil
- Confined Space (FFE/CS) Propulsion Technologies
- Refine tungsten-propellant mix, grain dimensions and configuration, and the fabrication process to reach suitable rocket nozzle exit velocities and sound pressure levels.

4. **Force Health Protection (FHP)** from $9.2M in FY2015 to $8.7M
EC: FHP-FY16 Incapacitation Prediction for Readiness in Expeditionary Domains
Dr. Timothy (Tim) Bentley, timothy.b.bentley@navy.mil
- Integrated in-silico model of the human body and internal organs that includes physiologically-based injury prediction capabilities
- Quantitative validation method to ensure biofidelity

5. Forcenet (FNT)  from $28M in FY2015 to $32M
EC: FNT-FY15-01 Advanced Airborne Early Warning Electronic Protection (AAEWEP)
- Initiate Advanced AEW Electronic Protection
- Develop techniques to improve E2-D electronic protection.

EC: FNT-FY15-02 Data Focused Naval Tactical Cloud
- Initiate Naval Tactical Cloud Analytics (formerly known as ASW Naval Tactical Cloud, EXW Naval Tactical Cloud, and IAMD Naval Tactical Cloud) - Perform the data science activities to ingest all relevant data (acoustic, IR, EO, magnetic, radar, SIGINT, METOC) into the Naval Tactical Cloud to enable efficient decision support analytics in support of effective ASW, EXW and IAMD mission execution based on Commander's Intent.

EC: FNT-FY16-02 Combined EO/IR Surveillance And Response System (Cesars)
Dr. Peter Craig, peter.craig@navy.mil
- Initiate Multispectral EO/IR Countermeasures against Advanced Threats (MEIRCAT) - Investigate multiband laser, window, and sensing technologies as well as advanced countermeasure techniques for shipboard defense.
- Shipboard Panoramic EO/IR Cueing and Surveillance System (SPECSS) - Investigate small pixel Mid-Wave Infra-red (MWIR) Focal Plane Array (FPA) technologies and innovative approaches for seamless stitching of multiple FPAs to create large format, high pixel-count imagers.
- Combined EO/IR Surveillance and Response System

6. Sea Basing (BAS)
EC: BAS-FY16 Flexible Sea-based Force Projection
Dr. Geoff Main, Geoffrey.main@navy.mil
- Inflatable/fillable rigid structures deploy as wave mitigation barriers to reduce the local sea state near the Sea Base
- Systems utilize this new technology with existing sea base components to form interface platforms

7. Sea Shield (SHD)  from $46.5M in FY2015 to $52.8M
EC: SHD-FY16-04 Ship-Launched Electronic Warfare Extended Endurance Decoy (SEWEED)
Mr. John Kinzer, john.kinzer@navy.mil
- Develop preliminary vehicle, payload, rocket, and launcher conceptual designs and sizing.

EC: SHD-FY16-05 Surface Ship Periscope Detection And Discrimination (SSPDD)
Mr. Mike Wardlaw, mike.wardlaw@navy.mil
- Develop specialized interface hardware for technology components.

EC: SHD-FY16-06 Next Generation Airborne Passive System (NGAPS)
- Develop an 'A-size' deep, long-duration, passive sonobuoy for area surveillance that takes advantage of Reliable Acoustic Path detection against modern quiet submarines and is tethered to a surface float containing a radio.
EC: SHD-FY16-07 Softkill Performance And Real-Time Assessment (SPARTA)
Col. Norman Eliasen, norman.eliasen@navy.mil
- Develop and establish design criteria, system requirements and software requirements.

EC: SHD-FY16-OSD Advanced Sea Mines
- Develop acoustic propagation modeling, algorithms for tracking and tracking, and algorithms to exploit the acoustic communications environment

8. Sea Strike (STK) from $34.4M in FY2015 to $43M
The FY 2015 to FY 2016 increase was due primarily to the planned ramp-up of STK-FY15-01, STK-FY15-02 and STK-FY15-03, and the initiation of STK-FY16-01 and STK-FY16-02.

EC: STK-FY16-02 REACTIVE ELECTRONIC ATTACK MEASURES (REAM)
Dr. Peter Craig, peter.craig@navy.mil
- Develop signal detection and classification techniques that can recognize new and agile radar threats.

Mine & Expeditionary Warfare Applied Res
Special Warfare/EOD from $11.8M in FY2015 to $11.1
Decrease in funding, but new directions identified
- Initiate development of technologies for ultra light-weight, low cost, highly capable autonomous robotic systems for complex dismounted operations.
- Initiate applied research into for autonomous ISR and mapping in canopied coastal and riverine environments
- Initiate 'through the sensor' in-stride mapping of coastal and riverine land and seascapes using operational EO/IR, radar and acoustic sensors
- Initiate investigation of techniques to detect deeply buried explosive threats and ordnance from a safe standoff distance
- Initiate investigation of techniques to neutralize or render safe explosive threats that result in low collateral damage to surrounding infrastructure.

Defense Advanced Research Projects Agency (DARPA)
BT-01 / Biomedical Technology
Neuro-Adaptive Technology from $22M in FY2015 to $31M
- Develop and apply data co-registration and fusion methods for neural activity, wiring and behavior.
- Generate and annotate first intact neural tissue volumes to elucidate microstructure and connections in three dimensions.
- Design algorithms for automatic cell identification and optical-signal estimation.
- Elucidate neural circuit dynamics using structurally-informed network models.
- Refine optical techniques for imaging large volumes of neural tissue.
- Expand data curation architecture, databases, and analytical tools to distribute generated data to the neuroscience community.
- Develop methods for automatically detecting and removing noise or contamination from datasets.
- Deliver a hierarchical computational model of key brain networks that captures features relevant for psychiatric illness and its treatment.
- Develop and refine neural state acquisition, classification and control algorithms to support closed-loop control in an implantable neural device.
- Characterize neural network plasticity during behavioral training.

**Prosthetic Hand Proprioception & Touch Interfaces** from $11M in FY2015 to $19M
- Integrate interface and electronic systems technology for use in human amputees to control and receive intuitive sensory feedback from a prosthetic device.
- Demonstrate closed-loop control of a government-furnished virtual prosthesis.
- Perform safety and efficacy testing of integrated HAPTIX system to capture motor control signals and provide electrical sensory stimulation through the peripheral nervous system.
- Demonstrate in vivo functionality of next-generation HAPTIX peripheral interface technology.
- Determine HAPTIX system prosthetic limb technology, complete sensorization, and begin manufacturing of devices.
- Implement draft version of outcome metrics for quantifying effects of HAPTIX technology and begin validation studies.

**Performance Optimization in Complex Environments** from 0 in FY2015 to $11.8M
- Begin development of new algorithms for sensing and modeling of physiological and cognitive state.
- Explore and identify primary sensing methods for reading biological signals.
- Begin research on biological interfaces for enabling input-output of information.
- Explore and study impact of various actuation mechanisms on physiological state and outcomes.

**IT-02 / High Productivity, High-Performance Responsive Architectures**

**Complexity Management Hardware** from $6M in FY2015 to $12.2M
- Design transistor level circuits implementing the complexity management algorithms.
- Demonstrate the ability to manage multiple data streams with interlaced information.

**Scalable Optical Nodes for Networked Edge Traversal** from 0 in FY2015 to $3.5M
- Identify common graph primitives that would accelerate the execution of DoD-specific applications.
- Explore the applications benefitting from the unique architecture and whether unique hardware design allows for processors for unique military applications.
- Design corresponding hardware, e.g. processor cores, to optimize performance for high bandwidth photonic networks.
- Design algorithms to execute DoD problems on a SONNET system and estimate system performance.

**Electronic Globalization** from 0 in FY2015 to $12M
- Develop a specific CONOP using the proposed structure, and identifying key enablers needed to realize it.
- Model designs such as encryption engines used to enable authorized chip operation.
- Create and model process module modifications for a standard fab gate recipe that result in desired behaviors.
- Demonstrate proof-of-concept of the ability of SHIELD-like devices to selectively authorize chip operation.
- Complete a high level design of piggyback chips, which can monitor and alter instruction execution of the host component.
IT-03 / INFORMATION ASSURANCE AND SURVIVABILITY

Edge-Directed Cyber Technol for Reliable Mission Comms  from $11M in FY2015 to $22M
- Initiate development of software prototypes suitable for laboratory experimentation with operational commands.
- Develop workarounds (fight-through strategies) that rapidly restore networked communication in the face of a wide variety of common network failure modes as well as cyber attacks against network infrastructure.
- Bring software prototypes to an initial field experiment in collaboration with an operational command.

Cyber Fault-tolerant Attack Recovery (CFAR)  from $10M in FY2015 to $20M
- Demonstrate functionally replicated systems and novel variants that provide performance close to optimal and exhibit sufficient variability to guarantee differences in behavior under attack.
- Implement and test techniques for quickly detecting differences across replicated systems.
- Implement and evaluate alternative architectures for achieving cyber fault-tolerance for mission-critical military applications with commodity computing technologies.
- Work with potential transition sponsors to evaluate military computing systems as candidates for technology refresh with CFAR technologies.

Adaptable Information Access and Control (AIAC)  from $7M in FY2015 to $17.6M
- Develop technologies to monitor heterogeneous distributed industrial control system networks, detect anomalies that require rapid assessment, and mitigate sensor spoofing and denial of service attacks.
- Extend simulation capabilities to understand the potential role of electric power markets in propagating or damping power grid anomalies.
- Develop techniques that use organic sensors, remote instrumentation, and other sources of cyber situation awareness information to continuously optimize cyber defenses.
- Explore defensive measures/counter-measures that can mitigate/thwart a coordinated cyber attack on national critical infrastructure.

Cyber Grand Challenge (CGC)  from $6M in FY2015 to $11.3M
- Conduct world’s first automated computer security contest: Cyber Grand Challenge Final Event.
- Release event results as cyber research corpus to measure and challenge future automated cyber capabilities.

IT-04 / Language Technology
Low Resource Languages for Emergent Incidents  from $11M in FY2015 to $22M
- Develop algorithms to exploit the universal properties of languages when rapidly ramping up for a low-resource language.
- Collect, generate, and annotate data for an initial set of resources in typologically representative medium-resource languages.
- Create a baseline toolkit to rapidly develop an initial situational awareness capability given a new low-resource language document collection.
TT-03 / Naval Warfare Technology
Strategic Mobility from 0 in FY2015 to $8M
- Create time and cost model of brigade level deployment technologies and processes.
- Perform refined technology trade studies to identify critical component technology.
- Initiate development of select logistics technologies with high military payoff.

TT-04 / Advanced Land Systems Technology
Mobile Infantry from 0 in FY2015 to $6M
- Complete trades of mission/vignette-driven collaborative command and control of a MI unit composed of a warfighter team and semi-autonomous systems.
- Complete trade studies and initial estimates of perception and autonomous algorithms required to match vignettes.
- Complete trade studies of candidate platforms and options for conversion, system integration, interfaces (electrical, mechanical, software, etc.), and define preliminary warfighter architectures to leverage.
- Modify and demonstrate optionally manned configuration on an available all terrain vehicle.

Gremlin from 0 in FY2015 to $8M
- Conduct exploratory trade studies to establish feasibility of technical approaches.
- Initiate studies on integration with existing Service systems and systems architectures.
- Study platform design trades and approaches to best meet performance goals at minimum cost.

Quantitative Methods for Rapid Response (QMRR) from $8.6M in FY2015 to $15.6M
- Develop quantitative models to track the development of ISIL force structure, funding, and logistics.
- Develop quantitative models to track the spread of ISIL ideology with emphasis on the roles of social media and the dark web.
- Develop quantitative models to track the spread of Ebola with emphasis on social and economic factors.

TT-13 / Network Centric Enabling Technology
Understanding Machine Intelligence (UMI) from 0 in FY2105 to $12.7M
- Formulate approaches for AI systems to explain their behavior and clarify the basis for and reliability of outputs.
- Develop automated drill-down techniques that provide users with logic/data that drives AI system outputs/behaviors.
- Develop a mathematically rigorous virtual stability theory for AI-enabled systems analogous to the (conventional) stability theory developed for dynamical systems.

MBT-02 / Biologically Based Materials And Devices
Adaptive Immunomodulation-Based Therapeutics from $13M in FY2015 to $23M
- Develop novel interface technologies to monitor and stimulate peripheral nerves to selectively alter organ function.
- Demonstrate superior specificity of novel interface technologies compared to FDA-approved state of the art whole-nerve stimulation devices.
- Define input/output models of mammalian autonomic functions such as the immune
- Identify peripheral intervention points and modulation parameters for control of mammalian autonomic function for improving health or treating disease.
- Develop multi-site electrode array and stimulator to improve targeting of vagal nerve stimulation.
- Initiate testing of advanced interface technologies.

**Biological-Computational Platforms**  
*from 0 in FY2015 to $10.5M*

- Analyze architectures and systems for utilizing complex biological signals generalizable across users.
- Explore mechanisms for direct neural interfacing to receive and react to operationally relevant environmental, physiological and neural information.
- Begin researching scalable models and algorithms to derive actionable biological signals from multiple users.

**Biological Robustness in Complex Settings (BRICS)**  
*from 0 in FY2015 to $8.1M*

- Develop technologies to design and build biological pathways that will function in undomesticated microbial species from a wide range of phyla (prokaryotic or eukaryotic).
- Develop analytical tools that allow the simultaneous measurement of relevant parameters, such as gene transcription, protein synthesis, and small molecule communication, within a multi-species consortium.
- Fabricate generalizable culture substrates that provide control over community structure and composition and support the growth of both prokaryotic and eukaryotic cells.
- Integrate promising component technologies that may be readily adapted into a platform for engineering robust, stable, and safe biological communities.

**ELT-01 Electronics Technology**

**Fast and Big Mixed-Signal Designs (FAB)**  
*from $4M in FY2015 to $10.8M*

- Continue to investigate choices for the RF and digital technologies and the best methods of co-integration (monolithic, through silicon via (TSV)s, interposer, etc.) in order to achieve program objectives, along with identifying partner(s) for fabrication and/or integration.
- Continue circuit design activities to determine performance benefits of new processes enabled by the program.
- Continue to study the best technology for various RF functional blocks for optimal use of mixed technologies.

**Direct On-Chip Digital Optical Synthesis (DODOS)**  
*from $3M in FY2015 to $8M*

- Develop DODOS system architectures and integration approaches.
- Validate device-level performance requirements, such as the control-loop bandwidths and optical link budget, needed to reach the DODOS program metrics at the system level.
- Prototype critical photonic components in processes consistent with subsequent co-integration.

**Hi power Amp using Vac Electronics for Overmatch Capab**  
*from 0 in FY2015 to $12M*

- Initiate the design of a wide-bandwidth, high power microwave vacuum electronic amplifier and identify specific component performance parameters and engineering tradeoffs.
- Design, fabricate, and test high current-density cathodes capable of producing beam
current consistent with amplifier output power requirements.

**Next Generation Atomic Clock (NGAC)** from 0 in FY2015 to $8.4M
- Demonstrate prototype clock operation utilizing low-CSWaP component technology.
- Evaluate environmental sensitivity, particularly temperature and acceleration.
- Identify technology gaps and complete a roadmap for NGAC development.

**Precise Robust Inertial Guidance for Munitions (PRIGM)** from 0 in FY2015 to $10M
- Model and design architectures for chip-scale optical gyroscopes based on waveguide technologies
- Design and fabricate heterogeneously-integrated, chip-scale waveguide optical gyroscopes
- Demonstrate high-bandwidth (100,000 degrees/s) inertial sensors
- Model and design optically interrogated MEMS inertial sensors
- Develop co-fabrication processes to support MEMS optical interrogation
- Demonstrate shock survivability of sensors and component technologies

**Near Zero Energy RF and Sensor Operations (N-ZERO)** from 0 in FY2015 to $4.5M
- Initiate development of hardware components enabling passive or near zero energy collection, processing and detection of communications and sensor information.
- Initiate development of RF and physical sensor microsystems that collect, processes and detect the presence of desired signals while consuming near zero power.
- Identify government application spaces and transition paths that will make use of N-ZERO signal processing and detection.

**Microwaves and Magnetics (M&M)** from 0 in FY2015 to $5M
- Investigate recent advances in magnetic materials science to identify new processing, fabrication, and integration techniques that can enable microwave components with reduced loss, increased bandwidth, and enhanced tunability.
- Leverage new microwave component design and modeling techniques to assess the performance of advanced magnetic materials in microwave circuits and applications.
- Initiate the design and development of magnetic components using advanced magnetic materials with reduced loss, increased bandwidth, and enhanced tunability.

**MultiPLEX** from 0 in FY2015 to $8M
- Design and simulate the complete channelized receiver and generate flow down specifications to component technologies.
- Demonstrate the high risk photonic components in a high yield, repeatable fabrication process compatible with silicon manufacturing.

**Diamond Enhanced Devices (DiamEnD)** from 0 in FY2015 to $6M
- Demonstrate that GaN epitaxy can be harvested from the SOA GaN on SiC epitaxy developed in the Wide Band Gap Semiconductors (WBGS)-RF program and mated with diamond substrates.
- Initiate effort to develop the diamond substrate materials and transistor technology to demonstrate GaN on Diamond devices with up to 25 W/mm.
Defense Threat Reduction Agency (DTRA)

Detection Technologies \textit{from 0 in FY2015 to $26M}

- Discover/identify nuclear threat signatures, characteristics, and corresponding detection modalities and collection systems.
- Develop algorithms/tools for rapidly and effectively analyzing all-source intelligence to identify nuclear threats.
- Prototype systems to remotely monitor small and wide areas, which may produce or contain nuclear threats.
- Develop algorithms/tools to synthesize the collection and analysis of multiple nuclear threat signatures to improve assessment confidence and cuing of potential nuclear threat events.
- Execute robust and operationally relevant testing and evaluation of developmental radiation detection systems to determine and select the best performing technologies and techniques for further development and transition to user groups.
- Down select sensor materials for the most effective/efficient capability and integrate into detection systems.
- Down select detection system algorithms for most effective/efficient processing and integrate into detection systems to improve user capabilities.
- Research and develop advanced three-dimensional imaging technologies for high-resolution source characterization and identification to provide new and improved capabilities to detect, locate, identify, and characterize threat materials.
- Investigate viability of ultra-low-power, long-duration programmable remote radiation monitoring systems.

Chemical Biological Defense Program

\textbf{CB2 / Chemical Biological Defense Applied Research} \textit{from 0 in FY2015 to $5M}

\textbf{Percutaneous Protection}

Develop both force protection and situational awareness through the improvement of multi-functional materials that exhibit broad reaching, crosscutting capabilities in chemical/biological sensing and detoxification. Validate response mechanisms of dynamic materials that conform to the challenge amount.

\textbf{TM2 / Techbase Medical Defense Applied Research} \textit{from 0 in FY2015 to $1M}

\textbf{Diagnostic Assays}

Appendix 3: Abbreviated illustration of a Program Officer Datasheet

Dr. David M. Stepp
ARO, Chief, Materials Sciences Division
(919) 549-4329
david.m.stepp@us.army.mil

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
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. ......

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
Korchagin Vladimir; Dolbow John; Stepp David INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES 44(11-12), 3973-3997 JUN 1 2007

Damage mitigation in ceramics: Historical developments and future directions in army research
Stepp DM
CERAMIC TRANSACTIONS 134, 421-428 2002

High-resolution study of water trees grown in silver nitrate solution
IEEE Transactions on Dielectrics and Electrical Insulation, 3(3), 392 - 398 1996
### Appendix 4: Acronym and Abbreviation Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFIRM</td>
<td>Armed Forces Institute for Regenerative Medicine</td>
</tr>
<tr>
<td>AFOSR</td>
<td>Air Force Office of Scientific Research</td>
</tr>
<tr>
<td>AFRL</td>
<td>Air Force Research Laboratories</td>
</tr>
<tr>
<td>AMRDEC</td>
<td>Aviation and Missile Research and Development Center (Army)</td>
</tr>
<tr>
<td>AMRMC</td>
<td>Army Medical Research and Materiel Command</td>
</tr>
<tr>
<td>ARDEC</td>
<td>Armament Research and Development Center (Army)</td>
</tr>
<tr>
<td>ARL</td>
<td>Army Research Laboratories</td>
</tr>
<tr>
<td>ARO</td>
<td>Army Research Office</td>
</tr>
<tr>
<td>BA</td>
<td>Budget Activity (new designation for the R&amp;D accounts)</td>
</tr>
<tr>
<td>BMDS</td>
<td>Ballistic Missile Defense System</td>
</tr>
<tr>
<td>BSV</td>
<td>Bio Surveillance</td>
</tr>
<tr>
<td>BTO</td>
<td>Biological Technologies Office (DARPA)</td>
</tr>
<tr>
<td>C2</td>
<td>Command and Control</td>
</tr>
<tr>
<td>C2ISR</td>
<td>Command, Control, Intelligence, Surveillance and Reconnaissance</td>
</tr>
<tr>
<td>C4ISR</td>
<td>Command, Control, Communications, Computers,...</td>
</tr>
<tr>
<td>CBDP</td>
<td>Chemical/Biological Defense Program</td>
</tr>
<tr>
<td>CBRNE</td>
<td>Chemical, Biological, Radiological, Nuclear and High Explosive</td>
</tr>
<tr>
<td>CBWD</td>
<td>Chemical/Biological Warfare Defense</td>
</tr>
<tr>
<td>CCRI</td>
<td>Cross-cut Research Initiative</td>
</tr>
<tr>
<td>CDMRP</td>
<td>Congressionally Directed Medical Research Program</td>
</tr>
<tr>
<td>CERDEC</td>
<td>Communication-Electronics Research and Development Center</td>
</tr>
<tr>
<td>CM</td>
<td>Counter Measures</td>
</tr>
<tr>
<td>CNA</td>
<td>Computer Network Attack</td>
</tr>
<tr>
<td>CoE</td>
<td>Center of Excellence</td>
</tr>
<tr>
<td>CONOPS</td>
<td>Concepts of Operation</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial Off-the-Shelf (products)</td>
</tr>
<tr>
<td>CSI</td>
<td>Congressional Special Interest (also known as budget “adds”)</td>
</tr>
<tr>
<td>CTA</td>
<td>Collaborative Technology Alliance</td>
</tr>
<tr>
<td>CWMD</td>
<td>Combating Weapons of Mass Destruction</td>
</tr>
<tr>
<td>D2D</td>
<td>Data to Decisions</td>
</tr>
<tr>
<td>DARPA</td>
<td>Defense Advanced Research Projects Agency</td>
</tr>
<tr>
<td>DDR&amp;E</td>
<td>Director, Defense Research and Engineering</td>
</tr>
<tr>
<td>DFBA</td>
<td>Defense Forensics and Biometrics Agency</td>
</tr>
<tr>
<td>DHP</td>
<td>Defense Health Program</td>
</tr>
<tr>
<td>DLA</td>
<td>Defense Logistics Agency</td>
</tr>
<tr>
<td>DMDI</td>
<td>Digital Manufacturing and Design Innovation (an IMI)</td>
</tr>
<tr>
<td>DMRDP</td>
<td>Defense Medical Research and Development Program</td>
</tr>
<tr>
<td>DMS&amp;T</td>
<td>Defense Manufacturing Science and Technology</td>
</tr>
<tr>
<td>DTIC</td>
<td>Defense Technical Information Center</td>
</tr>
<tr>
<td>DTRA</td>
<td>Defense Threat Reduction Agency</td>
</tr>
<tr>
<td>DURIP</td>
<td>Defense University Research Instrumentation Program</td>
</tr>
<tr>
<td>ECBC</td>
<td>Edgewood Chemical and Biological Center</td>
</tr>
<tr>
<td>EM</td>
<td>Electromagnetic</td>
</tr>
<tr>
<td>ERDC</td>
<td>Engineering Research and Development Center, Army Corp of Engineers</td>
</tr>
<tr>
<td>ERS</td>
<td>Engineered Resilient Systems</td>
</tr>
<tr>
<td>ESTCP</td>
<td>Environmental Security Technology Certification Program</td>
</tr>
<tr>
<td>EW</td>
<td>Electronic Warfare</td>
</tr>
<tr>
<td>FDW</td>
<td>Federal District of Washington (DOD)</td>
</tr>
<tr>
<td>FPA</td>
<td>Focal Plane Array</td>
</tr>
<tr>
<td>GDF</td>
<td>Guidance for the Development of the Force</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>HEL</td>
<td>High Energy Laser</td>
</tr>
<tr>
<td>HSCB</td>
<td>Human Social Cultural and Behavior Modeling</td>
</tr>
<tr>
<td>IED</td>
<td>Improvised Explosive Devices</td>
</tr>
<tr>
<td>IMI</td>
<td>Institute for Manufacturing Innovation</td>
</tr>
<tr>
<td>ISR</td>
<td>Intelligence, Surveillance and Reconnaissance</td>
</tr>
<tr>
<td>LM3I</td>
<td>Modern Metals Manufacturing Innovation (an IMI)</td>
</tr>
<tr>
<td>LVC</td>
<td>Live, Virtual and Constructive (environments)</td>
</tr>
<tr>
<td>MDA</td>
<td>Missile Defense Agency</td>
</tr>
<tr>
<td>Minerva</td>
<td>Name of DOD program engaging the social science community</td>
</tr>
<tr>
<td>MOVINT</td>
<td>The ability to track moving things on land and sea (Movement Intelligence)</td>
</tr>
<tr>
<td>MTO</td>
<td>Microsystems Technology Office (DARPA)</td>
</tr>
<tr>
<td>MURI</td>
<td>Multidisciplinary University Research Initiative</td>
</tr>
<tr>
<td>NAMII</td>
<td>National Additive Manufacturing Innovation Institute (an IMI)</td>
</tr>
<tr>
<td>NAWC</td>
<td>Naval Air Warfare Centers (Patuxent River-Aircraft Div, China Lake–Weapons Div)</td>
</tr>
<tr>
<td>NDEP</td>
<td>National Defense Education Program</td>
</tr>
<tr>
<td>NDSEG</td>
<td>National Defense Science and Engineering Graduate Fellowships</td>
</tr>
<tr>
<td>NMRC</td>
<td>Naval Medi</td>
</tr>
<tr>
<td>NPGS</td>
<td>Naval Postgraduate School</td>
</tr>
<tr>
<td>NRL</td>
<td>Naval Research Laboratory</td>
</tr>
<tr>
<td>NSRDEC</td>
<td>Natick Soldier Research and Development Command</td>
</tr>
<tr>
<td>NSSEFF</td>
<td>National Security Science and Engineering Faculty Fellowship</td>
</tr>
<tr>
<td>NSWC</td>
<td>Naval Surface Warfare Center (Dahlgren and Carderock Divisions)</td>
</tr>
<tr>
<td>NUWC</td>
<td>Naval Undersea Warfare Center</td>
</tr>
<tr>
<td>ONR</td>
<td>Office of Naval Research</td>
</tr>
<tr>
<td>OSD</td>
<td>Office of the Secretary of Defense</td>
</tr>
<tr>
<td>PACOM</td>
<td>DOD U.S. Pacific Command</td>
</tr>
<tr>
<td>PE</td>
<td>Program Element – term from DOD budgeting</td>
</tr>
<tr>
<td>PM</td>
<td>Program Manager (same as PO)</td>
</tr>
<tr>
<td>PO</td>
<td>Program Officer (same as PM)</td>
</tr>
<tr>
<td>QIS</td>
<td>Quantum Information Science</td>
</tr>
<tr>
<td>R&amp;E</td>
<td>Research and Engineering Enterprise (DOD Assistant Secretary)</td>
</tr>
<tr>
<td>R-1</td>
<td>RDT&amp;E Program Budget Summary Document</td>
</tr>
<tr>
<td>RDDS</td>
<td>Research and Development Descriptive Summary (R-2 Budget Document)</td>
</tr>
<tr>
<td>RDECOM</td>
<td>Army Research and Development Commands</td>
</tr>
<tr>
<td>RIF</td>
<td>Rapid Innovation Fund</td>
</tr>
<tr>
<td>RF</td>
<td>Radiofrequency</td>
</tr>
<tr>
<td>SIGINT</td>
<td>Signals Intelligence</td>
</tr>
<tr>
<td>SERDP</td>
<td>Strategic Environmental Research and Development Program</td>
</tr>
<tr>
<td>SOCOM</td>
<td>Special Operations Command</td>
</tr>
<tr>
<td>SOF</td>
<td>Special Operations Forces</td>
</tr>
<tr>
<td>SPAWAR</td>
<td>Space and Naval Warfare Systems Center</td>
</tr>
<tr>
<td>STO</td>
<td>Strategic Technology Office (DARPA)</td>
</tr>
<tr>
<td>TARDEC</td>
<td>Tank-Automotive Research and Development Center (Army)</td>
</tr>
<tr>
<td>TBI</td>
<td>Traumatic Brain Injury</td>
</tr>
<tr>
<td>TTO</td>
<td>Tactical Technology Office (DARPA)</td>
</tr>
<tr>
<td>UARC</td>
<td>University Affiliated Research Center</td>
</tr>
<tr>
<td>UCAR</td>
<td>Unmanned Combat Air Rotor</td>
</tr>
<tr>
<td>UCAV</td>
<td>Unmanned Combat Air Vehicle</td>
</tr>
<tr>
<td>USAMRMC</td>
<td>United States Army Medical Research and Materiel Command</td>
</tr>
<tr>
<td>UXV</td>
<td>Unmanned (X for ground (G), air (A), sea (S),...) Vehicles</td>
</tr>
<tr>
<td>YIP</td>
<td>Young Investigator Program</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>BAA</td>
<td>Broad Agency Announcement</td>
</tr>
<tr>
<td>CA</td>
<td>Congressional add</td>
</tr>
<tr>
<td>CFDA</td>
<td>Catalog of Federal Domestic Assistance Number</td>
</tr>
<tr>
<td>CMOS</td>
<td>Complementary Metal Oxide Semiconductor (electronics)</td>
</tr>
<tr>
<td>CSI</td>
<td>Congressional Special Interest</td>
</tr>
<tr>
<td>DHS</td>
<td>Department of Homeland Security</td>
</tr>
<tr>
<td>DOC</td>
<td>Department of Commerce</td>
</tr>
<tr>
<td>DOD</td>
<td>Department of Defense</td>
</tr>
<tr>
<td>DOE</td>
<td>Department of Energy</td>
</tr>
<tr>
<td>DoEd</td>
<td>Department of Education</td>
</tr>
<tr>
<td>DoI</td>
<td>Department of Interior</td>
</tr>
<tr>
<td>ED</td>
<td>Department of Education (alternative)</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
</tr>
<tr>
<td>FFO</td>
<td>Federal Funding Opportunity</td>
</tr>
<tr>
<td>FFRDC</td>
<td>Federally Funded Research and Development Center</td>
</tr>
<tr>
<td>FY</td>
<td>Fiscal Year</td>
</tr>
<tr>
<td>HTM</td>
<td>Hierarchical Temporal Memory</td>
</tr>
<tr>
<td>IHE</td>
<td>Institutions of Higher Education</td>
</tr>
<tr>
<td>IMI</td>
<td>Institute for Manufacturing Innovation</td>
</tr>
<tr>
<td>MAPS</td>
<td>Mission Agency Program Summary (provided by USC Research Advancement)</td>
</tr>
<tr>
<td>MEMS/NEMS</td>
<td>Micro- Nano-ElectroMechanical Systems</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NDI/E</td>
<td>Non-Destructive Inspection/Evaluation</td>
</tr>
<tr>
<td>NIST</td>
<td>National Institute for Standards and Technology (in DOC)</td>
</tr>
<tr>
<td>NNMI</td>
<td>National Network for Manufacturing Innovation</td>
</tr>
<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration (in DOC)</td>
</tr>
<tr>
<td>NSF</td>
<td>National Science Foundation</td>
</tr>
<tr>
<td>PBR</td>
<td>President's Budget Request (submitted to Congress)</td>
</tr>
<tr>
<td>PTSD</td>
<td>Post-traumatic Stress Syndrome</td>
</tr>
<tr>
<td>RDT&amp;E</td>
<td>Research, Development, Test and Evaluation</td>
</tr>
<tr>
<td>RF</td>
<td>Radio-frequency</td>
</tr>
<tr>
<td>RFA</td>
<td>Request for Application</td>
</tr>
<tr>
<td>RFI</td>
<td>Request for Information</td>
</tr>
<tr>
<td>S&amp;T</td>
<td>Science and Technology</td>
</tr>
<tr>
<td>SBIR</td>
<td>Small Business Innovative Research</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics (education)</td>
</tr>
<tr>
<td>STTR</td>
<td>Small Business Technology Transfer</td>
</tr>
<tr>
<td>TBA</td>
<td>To be announced</td>
</tr>
<tr>
<td>TBI</td>
<td>Traumatic Brain Injury</td>
</tr>
<tr>
<td>USDA</td>
<td>US Department of Agriculture</td>
</tr>
</tbody>
</table>