DIRECTORATE FOR ENGINEERING (ENG) $833,490,000
-$82,190,000 / -9.0%

ENG Funding

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Chemical, Bioengineering, Environmental, and Transport Systems (CBET)	$183.76	-	$168.20	-$15.56	-8.5%
Civil, Mechanical, and Manufacturing Innovation (CMMI)	216.27	-	202.20	-14.07	-6.5%
Electrical, Communications, and Cyber Systems (ECCS)	113.89	-	102.85	-11.04	-9.7%
Engineering Education and Centers (EEC)	107.51	-	100.28	-7.23	-6.7%
Industrial Innovation and Partnerships (IIP)	239.87	-	223.21	-16.66	-6.9%
Emerging Frontiers and Multidisciplinary Activities (EFMA)	54.37	-	36.75	-17.62	-32.4%
Total	**$915.68**	**-**	**$833.49**	**-$82.19**	**-9.0%**

About ENG

Fundamental research supported by ENG, combined with the creativity of well-educated engineers and the resources of state-of-the-art facilities, has resulted in many important discoveries. These discoveries have fueled exciting technological innovations—such as nanotechnology-enabled consumer, industrial, and healthcare products and manufacturing; resilient infrastructure to withstand disaster and disruption; novel light-based devices and tools for brain-related research and neurological imaging; secure, efficient devices and systems for communications and computing; and Internet-enabled smart manufacturing systems and supply chains—that in turn have stimulated economic growth and are improving the quality of life for all Americans.

In FY 2018, ENG's approach aims to bring about new breakthroughs for national priorities and grand challenges by (1) implementing NSF-wide investment priorities, and (2) supporting core programs in frontier engineering research and education.

The directorate will continue to invest throughout its core programs in emerging and frontier basic research areas, such as advanced materials and manufacturing; systems science and engineering; engineering biology; the food-energy-water nexus; and secure, next-generation electronic devices and systems.

In addition, ENG will help launch exciting technological innovations and support the Nation's innovation ecosystem through support for three main activities:

- Academic partnerships with industry via Engineering Research Centers (ERCs), Industry-University Cooperative Research Centers (IUCRCs), Grant Opportunities for Academic Liaison with Industry (GOALI), and Partnerships for Innovation (PFI),
- Experiential entrepreneurship training through NSF Innovation Corps (I-Corps™), and
- Small business R&D via the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs.

ENG will help prepare the future engineering workforce through leadership in engineering education research and hands-on research opportunities for both undergraduate and graduate students. Enrollment in engineering programs continues to grow significantly across the Nation. At the same time, the engineering education ecosystem continues to face major challenges in attracting women and underrepresented groups. ENG will continue its investments to identify and support systemic innovations to meet these critical and compelling challenges.

ENG will also lead or contribute directly to NSF-wide strategic investments in programs such as Risk and Resilience, Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS), Understanding the Brain (UtB), NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science), Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS), and the NSF Innovation Corps (I-Corps™).

ENG funding of disciplinary and multidisciplinary research lays the groundwork for crucial aspects of the NSF Big Ideas. ENG investments contribute to Harnessing the Data Revolution through, for example, fundamental research in data-driven engineered systems for smart and connected communities and cyber-physical systems, spectrum efficiency and sharing, and devices and systems for the Internet of Things. The directorate creates a foundation for Quantum Leap through, for example, support for quantum sensing, communication and computing research, and investment in quantum technologies for secure communication systems. ENG investment supports Work at the Human–Technology Frontier through research in robotics, smart materials, control and communication systems, and other areas. ENG supports Understanding the Rules of Life by investing in nanotechnologies that help reveal life's fundamental processes, biomechanics and tissue engineering, and new methods for engineering biology. ENG investments contribute to Navigating the New Arctic through research in water supply and treatment, sustainability, advanced materials, and resilient infrastructure. The directorate is a committed partner to NSF INCLUDES and provides critical leadership for engineering communities. ENG has made a special contribution to Growing Convergent Research by originating the concept of convergence nearly 15 years ago as an outgrowth of the National Nanotechnology Initiative.

ENG provides about 43 percent of federal funding for basic research at academic institutions in the engineering sciences.

Major Investments

ENG Major Investments

(Dollars in Millions)

Area of Investment	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
BioMaPS	$1.50	-	-	-$1.50	-100.0%
CAREER	84.19	-	76.00	-8.19	-9.7%
CEMMSS	110.00	-	101.25	-8.75	-8.0%
Advanced Manufacturing	*98.00*	-	*90.00*	*-8.00*	*-8.2%*
CIF21	8.00	-	-	-8.00	-100.0%
I-Corps™	13.08	-	13.00	-0.08	-0.6%
NSF INCLUDES	1.41	-	1.40	-0.01	-0.9%
INFEWS	9.84	-	5.00	-4.84	-49.2%
IUSE	6.90	-	-	-6.90	-100.0%
NRT[1]	2.59	-	-	-2.59	-100.0%
Risk and Resilience	12.00	-	10.00	-2.00	-16.7%
SaTC	3.25	-	3.25	-	-
SEES	3.00	-	-	-3.00	-100.0%
Understanding the Brain	18.00	-	16.75	-1.25	-6.9%
BRAIN Initiative	*18.00*	-	*16.75*	*-1.25*	*-6.9%*

Major investments may have funding overlap and thus should not be summed.

[1] In FY 2016, the NRT line includes a final funding increment of $1.81 million for the Integrative Graduate Education and Research Traineeship (IGERT).

All funding decreases/increases represent changes over the FY 2016 Actual.

- BioMaPS (-$1.50 million, to a total of zero): ENG formal support for Research at the Interface of the Biological, Mathematical and Physical Sciences (BioMaPS) ends as funds transition to core programs to support engineering biology.

- Faculty Early Career Development (CAREER) (-$8.19 million, to a total of $76.0 million): CAREER awards support promising junior faculty to serve as role models for outstanding research and education, and to lead advances in their organizational mission.

- CEMMSS (-$8.75 million, to a total of $101.25 million): ENG support for CEMMSS will build upon existing frontier engineering research and advance connections among breakthrough materials, advanced manufacturing, robotics, and cyber-physical systems leading to transformative research.

- Advanced Manufacturing (-$8.0 million, to a total of $90.0 million): ENG provides support for research in nanosystems design and scalable nanomanufacturing; additional emphasis on the Factory of the Future: cyber-enabled, adaptive, agile, distributed, and secure manufacturing; and an increased focus on advanced biomanufacturing. ENG will maintain close connections with efforts by other agencies to raise U.S. manufacturing capacity by ensuring appropriate links with NSF investments in fundamental research and education in manufacturing.

- CIF21 (-$8.0 million, to a total of zero): ENG sunsets Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) support as planned and transitions investment to the National Strategic Computing Initiative (NSCI), which advances knowledge to enable low-power computing and future high-performance computing (HPC) systems in the post-Moore's Law era.

- I-Corps™ (-$80,000, to a total of $13.0 million): ENG will continue to lead the NSF-wide I-Corps™ program. In FY 2018, ENG will support I-Corps™ Teams, Sites, and Nodes to further expand and sustain a national innovation ecosystem that trains high-tech entrepreneurs and accelerates the development of advanced technologies that benefit the Nation.

- NSF INCLUDES (-$10,000, to a total of $1.40 million): ENG investments are aligned with Foundation goals in this NSF-wide effort to increase participation of underrepresented groups in science, technology, engineering, and mathematics (STEM) fields.

- INFEWS (-$4.84 million, to a total of $5.0 million): ENG will continue to co-lead this NSF-wide initiative with the Directorate for Geosciences (GEO) in FY 2018. The goal is to catalyze well-integrated, interdisciplinary research efforts to transform understanding of the food-energy-water nexus to improve system function and management, address system stress, increase resilience, and ensure sustainability. ENG will focus on supporting fundamental engineering research to enable innovative system and technological solutions that address critical challenges in the food-energy-water nexus. INFEWS will leverage existing ENG programs in energy, water, and environmental technologies that support projects, for example, to reduce water consumption in power plants.

- IUSE (-$6.90 million, to a total of zero): ENG support for the NSF-wide Improving Undergraduate STEM Education (IUSE) initiative, which integrates the agency's investments in undergraduate education, will pause in FY 2018 as support for the IUSE/Professional Formation of Engineers: REvolutionizing engineering and computer science Departments (PFE:RED) solicitation moves to a biennial cycle. PFE:RED enables research and innovations leading to and propagating interventions that improve both the quality and quantity of engineering graduates.

- NSF Research Traineeship (NRT) (-$780,000, to a total of zero): ENG sunsets support for the NRT program.

- Risk and Resilience (-$2.0 million, to a total of $10.0 million): ENG co-leads this priority area with GEO to advance knowledge of risk assessment and predictability, and to support the creation of tools and technologies for increased resilience. In FY 2018, ENG will continue to support the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) program by catalyzing interdisciplinary research collaborations that deepen fundamental knowledge and stimulate innovations to improve resilience, interoperations, and performance of our critical infrastructure.

- Secure and Trustworthy Cyberspace (SaTC) ($3.25 million, equal to the FY 2016 Actual): ENG support for SaTC will focus on the engineering aspects of the Networking and Information Technology Research and Development (NITRD) Strategic Plan for the Federal Cybersecurity Research and Development Program. NITRD's research thrusts cover a set of interrelated priorities for U.S. government agencies that conduct or sponsor research and development in cybersecurity.

- SEES (-$3.0 million, to a total of zero): ENG formal support for Science, Engineering, and Education for Sustainability (SEES) ends as planned. ENG will continue to support SEES-related research through unsolicited core programs.

- UtB (-$1.25 million, to a total of $16.75 million): ENG investments in neuroimaging and neurotechnology research are critical to success of the BRAIN Initiative. Research will drive integration across scales and disciplines; accelerate the development of novel experimental and analytical approaches, such as computational and data-enabled modeling; and enable neural technology innovation.

ENG Funding for Centers Programs and Facilities

ENG Funding for Centers Programs

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total, Centers Programs	**$67.14**	**-**	**$72.50**	**$5.36**	**8.0%**
Engineering Research Centers (EEC)	56.39	-	57.50	1.11	2.0%
Nanoscale Science and Engineering Centers (Multiple)[1]	0.75	-	-	-0.75	-100.0%
Science & Technology Centers (Multiple)	10.00	-	15.00	5.00	50.0%

[1] The Nanoscale Centers program will sunset as planned in FY 2017.

For detailed information on individual centers programs, see the NSF-Wide Investments chapter.

ENG Funding for Facilities

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total, Facilities	**$29.70**	**-**	**$26.58**	**-$3.12**	**-10.5%**
Cornell High Energy Synchrotron Source (CHESS)	5.00	-	4.00	-1.00	-20.0%
National Nanotechnology Coordinated Infrastructure (NNCI)	11.70	-	10.83	-0.87	-7.4%
Natural Hazards Earthquake Engineering Research Infrastructure (NHERI)	13.00	-	11.75	-1.25	-9.6%

For detailed information on individual facilities, see the Facilities and the Major Research Equipment and Facilities Construction chapters.

Funding Profile

ENG investments support fundamental engineering research, engineering education, and innovation, as well as research infrastructure such as facilities.

In FY 2018, the number of competitive proposals received, which includes SBIR/STTR proposals, is expected to be about 12,800, which includes about 10,000 research grant proposals. ENG expects to award approximately 2,250 competitive grants, including an estimated 1,600 research grants in FY 2018. Average annualized award size and duration are estimated to be $124,000 and 2.7 years, respectively, in FY 2018.

In FY 2018, funding for centers accounts for 11 percent of ENG's non-SBIR/STTR Request.

In FY 2018, funding for facilities is just over four percent of ENG's non-SBIR/STTR Request.

ENG Funding Profile

	FY 2016 Actual Estimate	FY 2017 (TBD)	FY 2018 Estimate
Statistics for Competitive Awards:			
Number of Proposals	12,575	-	12,800
Number of New Awards	2,503	-	2,250
Funding Rate	20%	-	18%
Statistics for Research Grants:			
Number of Research Grant Proposals	9,883	-	10,000
Number of Research Grants	1,795	-	1,600
Funding Rate	18%	-	16%
Median Annualized Award Size	$102,789	-	$102,000
Average Annualized Award Size	$124,817	-	$124,000
Average Award Duration, in years	2.7	-	2.7

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- The ERC program periodically commissions program-level evaluations by external evaluators to determine the effectiveness of ERC graduates in industry, the benefits of ERC membership to industry and others. In FY 2015, NSF funded the National Academy of Engineering (NAE) in collaboration with the National Research Council (NRC) to study The Future of Center-Based, Multidisciplinary Engineering Research. This topic arose from discussions NAE held with the NRC on the future of NSF's center-based, multidisciplinary engineering research. To help inform the study, the National Academies held a public symposium on April 6, 2016, and published a proceedings.[1] The study report[2], delivered May 2, 2017, articulates a vision for the future of NSF-supported center-scale, multidisciplinary engineering research, which ENG will carefully consider for the path ahead.
- A study of the feasibility of performing rigorous impact evaluation of the I-Corps™ Teams program was completed in FY 2014. Based on the feasibility study, NSF initiated a rigorous evaluation of the I-Corps™ Teams program in FY 2016. A report will be available in FY 2018.
- During FY 2017, ENG engaged in developing an evaluation framework for the directorate that identifies outcomes to be monitored across programs so that individual program evaluation efforts are minimized. A measurement framework with four areas of activity: research, human capital development and partnerships, centers and networks, and construction of physical, virtual and cyber infrastructure was developed with participation of representatives from all divisions. It is expected that this framework will be used to develop an outcome monitoring system for all programs using internal Research Performance Progress Report (RPPR) data, external data sets (patents and bibliometric data), and potentially a common survey. This activity eliminated the need for individual longitudinal outcome monitoring systems (e.g., for the Emerging Frontiers in Research and Innovation (EFRI) program).
- In FY 2016, IIP collected data for the PFI: Accelerating Innovation Research (AIR) and PFI: Building Innovation Capacity (BIC) programs based on their theories of action and, in FY 2017, ENG finalized

[1] A Vision for the Future of Center-Based Multidisciplinary Engineering Research symposium proceedings: www.nap.edu/catalog/23645/a-vision-for-the-future-of-center-based-multidisciplinary-engineering-research

[2] A New Vision for Center-Based Engineering Research report: www.nap.edu/catalog/24767/a-new-vision-for-center-based-engineering-research

a report for the longitudinal outcomes of the PFI:AIR program to date. A report for the PFI:BIC program is being finalized.

Workshops and Reports:

- With support from ECCS, Boston University organized a Smart Cities workshop on December 3-4, 2015, and prepared a report.[3] The workshop brought together researchers and technical leaders from academia, industry, and municipal government to set a short- and long-term research agenda for emerging issues in Smart and Connected Communities. Such issues span a variety of fields and specialized disciplines such as: transportation, environment, energy, building design and management, urban planning, sensor and actuator networks, social science, economics, software platform design, and data management. The workshop outcomes were incorporated in the focus of the NSF solicitation, S&CC: Smart and Connected Communities (16-610), funded in FY 2017.
- With support from CBET, the Department of Energy and others, a National Academies workshop on The Changing Landscape of Hydrocarbon Feedstocks for Chemical Production-Implications for Catalysis was held on March 7-8, 2016. The workshop proceedings[4] identified gaps and opportunities in catalysis research in an era of shifting feedstocks, from crude oil to natural gas, for chemical production. This activity helps U.S. researchers and funding agencies understand the most critical areas of science and engineering research to help realize the potential of the shale gas revolution for the U.S. chemical industry.
- In FY 2016, EFMA co-funded a three-year study on Grand Challenges in Environmental Engineering by the National Academies of Sciences, Engineering, and Medicine.[5] The study will identify high-priority challenges for environmental engineering and science for the next several decades. The report will shape the growth of university departments, inspire the next generation of engineers and scientists to address the most pressing global environmental challenges, and improve the training of environmental engineers and scientists to better meet these challenges. It will also help inform NSF program directors of emerging areas for research. The first of three planned public workshops associated with the study was held May 4-5, 2017.
- CMMI supported a three-day workshop on Predictive, Theoretical, and Computational Approaches for Additive Manufacturing, hosted by the National Academies of Sciences, U.S. National Committee on Theoretical and Applied Mechanics during October 7-9, 2015. The goal of the workshop was to identify key knowledge gaps in theoretical and computational approaches to additive manufacturing from computer science, materials science, and engineering perspectives. The workshop identified key needs for an understanding of material behavior during additive processes, in-situ measurement and real-time analytic methods for process validation and control, multi-scale and multi-physics modeling, and increased leveraging of high power computing for predictive models of process-structure-property-performance relationships in additively produced parts, and the workshop proceedings[6] set out a roadmap for the additive manufacturing community. The activity motivated follow-up workshops on Mechanical Behavior of Additive Manufactured Components, sponsored by the American Society for Testing and Materials (ASTM) and the National Institute of Standards and Technology (NIST), as well as proposed additive manufacturing benchmark tests performed by researchers at NIST.
- In FY 2015, EFMA funded the Exploring Innovation Frontiers Initiative (EIFI), a two-year, national public-private effort to shape and strengthen future U.S. innovation and competitiveness led by the Council on Competitiveness. Diverse leaders from academia, industry, and government have participated in a series of regional dialogues during 2015-2016: at the Georgia Institute of Technology

[3] Smart Cities workshop report: www.bu.edu/systems/files/2016/07/NSFWorkshopReport_SmartCities_2015.pdf
[4] Changing Landscape of Hydrocarbon Feedstocks for Chemical Production workshop proceedings: www.nap.edu/catalog/23555/the-changing-landscape-of-hydrocarbon-feedstocks-for-chemical-production-implications
[5] Grand Challenges in Environmental Engineering project site: www8.nationalacademies.org/cp/projectview.aspx?key=49849
[6] Predictive Theoretical and Computational Approaches for Additive Manufacturing workshop proceedings: www.nap.edu/catalog/23646/predictive-theoretical-and-computational-approaches-for-additive-manufacturing-proceedings-of

on June 9, 2015; the University of California Riverside on November 23, 2015, and at Texas A&M University on November 15, 2016. A fourth regional dialogue will be held in June 2017 at Washington University in St. Louis. Reports from the EIFI workshops will help inform NSF and the community of actionable, interdisciplinary frameworks for next-generation business and research innovation models.

Committees of Visitors (COVs):

- In 2016, COVs reviewed EEC and IIP. The COVs presented their reports to the ENG Advisory Committee, which convened in April and October of 2016. Both COV reports were approved by the ENG Advisory Committee.
- In 2018, COVs will review ECCS and EFMA.
- In 2019, COVs will review CBET and CMMI.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. See this chapter for additional information.

Number of People Involved in ENG Activities

	FY 2016 Actual Estimate	FY 2017 (TBD)	FY 2018 Estimate
Senior Researchers	9,187	-	8,800
Other Professionals	1,921	-	1,800
Postdoctoral Associates	418	-	400
Graduate Students	7,509	-	7,200
Undergraduate Students	4,366	-	4,100
K-12 Teachers	-	-	-
K-12 Students	-	-	-
Total Number of People	23,401	-	22,300

DIVISION OF CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, AND TRANSPORT SYSTEMS (CBET)

$168,200,000
-$15,560,000 / -8.5%

CBET Funding
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total	**$183.76**	**-**	**$168.20**	**-$15.56**	**-8.5%**
Research	**177.45**	**-**	**163.36**	**-14.09**	**-7.9%**
CAREER	43.49	-	36.00	-7.49	-17.2%
Centers Funding (total)	5.33	-	5.00	-0.33	-6.2%
Nanoscale Science and Engineering Centers	0.33	-	-	-0.33	-100.0%
STC: Center for Emergent Behavior of Integrated Cellular Systems	5.00	-	5.00	-	-
Education	**2.63**	**-**	**1.15**	**-1.48**	**-56.2%**
Infrastructure	**3.68**	**-**	**3.69**	**0.01**	**0.3%**
NNCI	3.68	-	3.69	0.01	0.3%

CBET supports research to enhance and protect U.S. national health, energy, food, water, environment, process manufacturing, and security. Through CBET, the physical, chemical, life, and social sciences are integrated in engineering research and education, resulting in advances in the rapidly evolving fields of biotechnology, bioengineering, biomanufacturing, advanced materials, environmental engineering, and sustainable energy. CBET also invests in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. CBET investments contribute significantly to the knowledge base and to the workforce development of major U.S. economy components, such as chemicals, pharmaceuticals, medical devices, specialty chemicals, and materials for advanced manufacturing, natural gas and petroleum production, food, textiles, utilities, and microelectronics.

CBET supports the chemical, environmental, biomedical, mechanical (transport), and civil (environmental) engineering disciplines. To serve these communities and achieve its goals, CBET is organized into four thematic clusters: Chemical Process Systems; Engineering Biology and Health; Environmental Engineering and Sustainability; and Transport Phenomena.

In general, 79 percent of the CBET portfolio is comprised of new research grants, and 21 percent supports continuing grants.

FY 2018 Summary

All funding decreases/increases represent changes over the FY 2016 Actual.

Research

- CAREER funding represents over 21 percent of CBET's funding. CAREER funding decreases by $7.49 million, to a total of $36.0 million in FY 2018. This decrease will result in 15 fewer awards.
- Support for NSF-wide INFEWS decreases by $2.0 million, to a total of $5.0 million, focusing on fundamental engineering research to enable innovative system and technological solutions that address critical challenges in the food-energy-water nexus. CBET programs invest in fundamental engineering research in energy, water, and biotechnology, and in research projects focusing on sustainable water

and energy use. Support will also be provided for projects to advance the understanding of the complex food-energy-water system and water-energy, food-energy, and food-water subsystems, as well as their interdependencies.

- CBET support for the NSF-wide CEMMSS investment decreases by $3.0 million, to a total of $7.0 million, as the DMREF program moves to a biennial solicitation and support for the National Robotics initiative within the division is discontinued.
- Support for Sustainable Chemistry, Engineering, and Materials will be reduced by $1.29 million as the NSF-wide SEES investment sunsets in FY 2017 as planned. Some support will continue in this important area through core unsolicited programs.
- Support for UtB research totals $7.0 million, equal to the FY 2016 Actual. This activity holds promise for revealing fundamental principles underlying brain structure and function and for enhancing understanding of the brain through the development of new technologies and theories. Support will focus on proposals from interdisciplinary teams of researchers poised to promptly address targeted issues in frontier experimentation; neurotechnology innovation; modeling and simulation; and quantitative theory development. One major objective of these investments is to establish truly transdisciplinary team-based brain research that rises above the work of existing disciplines.
- CBET will continue support for research in Engineering Biology to improve the ability to engineer biological systems that could help address major economic and societal challenges in energy, the environment, sustainable manufacturing, and healthcare. CBET support encompasses fundamental engineering research in synthetic biology, systems biology, metabolic engineering, and protein engineering and design, as well as the creation of new tools and technologies that have enormous potential to revolutionize biomanufacturing, to enable new materials, and to foster innovative solutions that will allow the unraveling of the mysteries of complex biological systems.
- CBET will continue to support research in advanced biomanufacturing, through its core programs Cellular and Biochemical Engineering and Engineering Biomedical Systems, that focuses on studying theories and technologies of design, engineering, and manufacturing bio-related (natural or synthetic) products, such as cells and cell-based therapeutic products (i.e., proteins, individualized tissues, and organoids), or devices with biomaterials and/or cells as components.
- Science and Technology Center (STC) funding is maintained at $5.0 million to continue support for the STC on Emergent Behaviors of Integrated Cellular Systems.
- CBET support for the Nanoscale Science and Engineering Center (NSEC) program decreases by $330,000, to a total of zero, as the program sunsets as planned.

Education

- CBET contributes to a number of education and diversity activities, including Research Experiences for Undergraduates (REU) and NSF's Career Life Balance (CLB) activities. Total CBET funding for these activities in the FY 2018 Budget Request is $1.15 million.

Infrastructure

- CBET provides continued support for infrastructure in FY 2018 through investments in the National Nanotechnology Coordinated Infrastructure (NNCI) at the FY 2016 Actual level.

DIVISION OF CIVIL, MECHANICAL, AND MANUFACTURING INNOVATION (CMMI)

$202,200,000
-$14,070,000 / -6.5%

CMMI Funding
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total	**$216.27**	**-**	**$202.20**	**-$14.07**	**-6.5%**
Research	**198.85**	**-**	**186.85**	**-12.00**	**-6.0%**
CAREER	25.47	-	25.00	-0.47	-1.9%
Centers Funding (total)	0.31	-	5.00	4.69	1512.9%
Nanoscale Science and Engineering Centers	0.31	-	-	-0.31	-100.0%
STC: Center for Mechano-Biology	-	-	5.00	5.00	N/A
Education	**2.53**	**-**	**1.70**	**-0.83**	**-32.7%**
Infrastructure	**14.90**	**-**	**13.65**	**-1.25**	**-8.4%**
NHERI	13.00	-	11.75	-1.25	-9.6%
NNCI	1.90	-	1.90	-	-

CMMI funds fundamental research in support of the Foundation's strategic goals directed at advances in the disciplines of civil, mechanical, industrial, systems, manufacturing, and materials engineering. In addition, the division has a focus on the reduction of risks and damage resulting from earthquakes, wind, and other hazards. CMMI encourages discoveries enabled by the use of cross-cutting technologies such as adaptive systems, nanotechnology, and high-performance computational modeling and simulation. The division promotes cross-disciplinary research partnerships at the intersections of traditional research disciplines to achieve transformative research results that promote innovative manufacturing technology; enable the design and analysis of complex engineered systems; enhance the sustainability and resilience of U.S. infrastructure (for example, buildings, transportation, and communication networks); help protect the Nation from extreme natural and human-induced events; and apply engineering principles to improve the Nation's service and manufacturing enterprise systems, such as healthcare.

In general, 84 percent of the CMMI portfolio is comprised of new research grants and 16 percent supports continuing grants.

FY 2018 Summary

All funding decreases/increases represent change over the FY 2016 Actual.

Research

- CAREER funding in FY 2018 decreases by $470,000, to a total of $25.0 million, resulting in one fewer award.
- Support for disciplinary and interdisciplinary research decreases by $10.32 million. Fundamental core research in support of advanced manufacturing will be maintained, to the extent possible, as part of the NSF-wide CEMMSS activity. Areas of continued emphasis include nanomanufacturing, cybermanufacturing, materials engineering and processing, service and manufacturing enterprise systems and operations engineering, smart manufacturing, and design and manufacturing of complex engineered systems. CMMI support of the CPS solicitation will be discontinued as support shifts to the Cybermanufacturing Systems program (created as a CMMI core program in FY 2016). Support of

DMREF research will pause as the activity moves to a biennial solicitation, and support for formal NRI activities will be reduced.

- Support for the agency's Risk and Resilience focus through the CRISP program will be maintained at $10.0 million. The CRISP program will (1) foster an interdisciplinary research community of engineers, computer and computational scientists, and social and behavioral scientists that will create new approaches and engineering solutions for the design and operation of infrastructure processes and services; (2) enhance the understanding and design of Interdependent Critical Infrastructure (ICIs) systems and processes that provide essential goods and services despite disruptions and failures from any cause—natural, technological, or malicious; (3) create the knowledge for innovation in ICIs so that they safely, securely, and effectively expand the range of goods and services they enable; and (4) improve the effectiveness and efficiency with which ICIs deliver existing goods and services.
- Support for Sustainable Chemistry, Engineering, and Materials will be reduced by $500,000 as the NSF-wide SEES investment sunsets in FY 2017 as planned.
- Support for CIF21 decreases by $400,000, to a total of zero, as the program sunsets as planned; focus shifts to investments in NSCI. Within NSCI, CMMI will continue to support research on computationally-based approaches for engineering design, analysis, and predictive modeling, particularly under high degrees of uncertainty.
- CMMI support for the NSEC program decreases by $310,000, to a total of zero, as the program sunsets as planned.
- STC funding increases by $5.0 million as CMMI initiates support of the Center for Mechano-Biology.

Education

- CMMI contributes to a number of education and diversity activities, including REU and CLB. Total CMMI funding for these activities in the FY 2018 Request is $1.70 million.

Infrastructure

- Support for NHERI decreases by $1.25M, to a total of $11.75 million. NHERI is the successor to NEES, which received final year funding of $18.14 million in FY 2014 and ceased operations in FY 2015. The large NHERI facilities are distributed, multi-user, national facilities that provide the natural hazards engineering community with access to research infrastructure (earthquake and wind engineering experimental facilities, cyberinfrastructure, computational modeling and simulation tools, and research data), coupled with education and community outreach activities. The reduction in overall operations costs will require facilities managers to create leaner organizations, with the likely result that user fees may be increased to provide the necessary level of support to facility users.
- CMMI provides continued support for infrastructure through investments in the NNCI at the FY 2016 Actual level.

DIVISION OF ELECTRICAL, COMMUNICATIONS, AND CYBER SYSTEMS (ECCS)

$102,850,000
-$11,040,000 / -9.7%

ECCS Funding
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total	**$113.89**	**-**	**$102.85**	**-$11.04**	**-9.7%**
Research	**106.21**	**-**	**96.66**	**-9.55**	**-9.0%**
CAREER	14.72	-	15.00	0.28	1.9%
Centers Funding (total)	5.11	-	5.00	-0.11	-2.2%
Nanoscale Science and Engineering Centers	0.11	-	-	-0.11	-100.0%
STC: Center for Energy Efficient Electronics Science	5.00	-	5.00	-	-
Education	**1.56**	**-**	**0.95**	**-0.61**	**-39.0%**
Infrastructure	**6.12**	**-**	**5.24**	**-0.88**	**-14.4%**
NNCI	6.12	-	5.24	-0.88	-14.4%

ECCS addresses fundamental research issues underlying electronic and photonic devices and component technologies (such as bioelectronic, flexible, and quantum devices), power, controls, computation, networking, communications (such as secure, efficient spectrum utilization for wireless), and cyber technologies. The division supports the integration and networking of intelligent systems principles at the nano, micro, and macro scales for applications in: healthcare, security, disaster mitigation, energy, telecommunications, transportation, robotics, manufacturing, and other systems-related areas. ECCS research and education investments emphasize interdisciplinary collaboration and the convergence of technologies to take on major technological challenges for future generations of innovative devices and systems.

In general, 80 percent of the ECCS portfolio is comprised of new research grants and 20 percent supports continuing grants.

FY 2018 Summary

All funding decreases/increases represent change over the FY 2016 Actual.

Research

- CAREER funding increases by $280,000, to a total of $15.0 million, in FY 2018. This increase is consistent with ECCS's emphasis on supporting early-career researchers.
- ECCS support for the NSF-wide CEMMSS investment decreases by $3.50 million to a total of $10.68 million as the DMREF program moves to a biennial solicitation and support for the National Robotics initiative within the division is discontinued.
- Support for CIF21 activities will decrease $400,000, to a total of zero, as funding transitions to the NSCI. Building on the CIF21 investment, ECCS plans to invest in NSCI through supporting research to enable future HPC systems in the post-Moore's Law era of device and hardware systems.
- Leveraging investment in CPS, ECCS will continue to support fundamental research to enable Smart and Connected Communities. ECCS will support activities focused on multidisciplinary research, enabling effective integration of networked computing systems, physical devices, data sources, and

infrastructure to transform society, allow cities, communities, and regions to surmount deeply interlocking physical, social, economic, and infrastructural challenges.

- Support will continue for multidisciplinary research in the optics and photonics area, with emphasis on nanoscale devices and systems. Applications in high-speed optical communications and environmental and biomedical research will be encouraged.
- ECCS support decreases by $1.0 million, to a total of $5.0 million in support of research on more efficient radio spectrum use and greatly improved low-power energy-conserving device technologies, and emphasize research in the millimeter-wave and terahertz bands through the Spectrum Efficiency, Energy Efficiency and Security (SpecEES) activity.
- ECCS will maintain support at $2.50 million for UtB research that aims for the development of innovative technologies, tools and instrumentation, theory, and models that will accelerate the integration of knowledge across multiple experimental scales and across science, engineering, and computational disciplines. ECCS will focus on research in noninvasive and minimally invasive brain imaging by sensing electric and magnetic fields. Projects may include novel high-sensitivity sensors and sensing algorithms to enhance spatial and temporal resolutions.
- ECCS maintains support, at $5.0 million, for the STC for Energy Efficient Electronics Science.
- ECCS support for the NSEC program decreases by $110,000, to a total of zero, as the program sunsets as planned.

Education

- ECCS contributes to a number of education and diversity activities, including REU and CLB. Total ECCS funding for these activities in FY 2018 is $950,000, a decrease of $610,000 from the FY 2016 Actual.

Infrastructure

- ECCS reduces support for infrastructure by $880,000, to a total of $5.24 million, through investments in the NNCI consistent with cooperative agreement funding levels.

DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC)

$100,280,000
-$7,230,000 / -6.7%

EEC Funding
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total	**$107.51**	**-**	**$100.28**	**-$7.23**	**-6.7%**
Research	**81.79**	**-**	**83.85**	**2.06**	**2.5%**
CAREER	0.51	-	-	-0.51	-100.0%
Centers Funding (total)	56.39	-	57.50	1.11	2.0%
Engineering Research Centers	56.39	-	57.50	1.11	2.0%
Education	**25.72**	**-**	**16.43**	**-9.29**	**-36.1%**

EEC integrates disciplinary basic research and education conducted in other divisions of ENG and across NSF into strategic frameworks critical for addressing societal grand challenges and promoting innovation. Research included in the EEC portfolio spans both the physical/life sciences and engineering, from nanostructured materials to new device concepts, subsystems, and systems. Applications range across a wide spectrum, such as energy, medicine, telecommunications, nanoelectronics, manufacturing, civil infrastructure, the environment, computer networks, cybersecurity, and others. Also included are formal scholarly studies in the professional formation of engineers, which can lead to innovations in engineering education and career development.

The complex, integrative role of EEC requires a comprehensive infrastructure of people, equipment, and centers. Fresh, creative approaches to developing the engineering workforce are vital, as a lack of properly prepared engineers is a critical barrier to a healthy U.S. economy. EEC invests in faculty, graduate and undergraduate students, post-doctoral scholars, and K–12 teachers. As nontraditional students—such as part-time, delayed enrollment, veteran, and others—comprise more than 70 percent of the general undergraduate population, EEC is defining unique alternative pathways for these students, especially veterans, to successfully earn degrees in engineering.

The programs in EEC are administratively managed within four categories: (1) Major Centers and Facilities; (2) Engineering Education Research; (3) Engineering Workforce Development; and (4) Broadening Participation in Engineering. Major Centers and Facilities is comprised of the signature Engineering Research Centers (ERC) program and the sunsetting Nanoscale Science and Engineering Centers (NSECs). They provide the framework for interdisciplinary research and education, development, and technology transfer in partnership with academia, industry, and government. Engineering Education Research advances new productive engineering pedagogy and learning strategies in traditional and non-traditional environments. This category also includes EEC's participation in the NSF-wide activity, IUSE, which integrates the agency's investments in undergraduate education. Engineering Career Development includes programs such as REU and Research Experiences for Teachers (RET). Broadening Participation in Engineering supports research and activities that enhance opportunities for underrepresented groups by addressing structural inequalities and biases within educational and workforce systems. This category also includes EEC's engagement with the NSF INCLUDES initiative, which integrates the agency's investments to build on and scale up what works in broadening participation programs.

In general, 26 percent of the EEC portfolio is comprised of new research grants. The remaining 74 percent funds continuing grants and cooperative agreements made in previous years. This high fraction of multi-year commitments is primarily a consequence of centers funding, which includes awards made as five-year

cooperative agreements.

FY 2018 Summary

All funding decreases/increases represent change over the FY 2016 Actual.

Research

- Support for the ERC program increases by $1.11 million, to a total of $57.50 million. This funding level provides support for 14 existing centers. The ERC program supports basic and translational research of national priorities such as water, clean energy, advanced manufacturing, and critical civil infrastructure. The program will also invest in research related to NSCI to enable future HPC systems in the post-Moore's Law era of device and hardware systems. EEC's ERC portfolio includes four Nanosystems ERCs: three whose funding began in FY 2012 and one whose funding began in FY 2015.

Education

- In FY 2018, EEC will pause support (-$3.98 million, to a total of zero) for IUSE/Professional Formation of Engineers: REvolutionizing engineering and computer science Departments (IUSE/PFE:RED), which enables engineering departments to achieve significant sustainable changes necessary to overcome long-standing issues in their undergraduate programs and educate inclusive communities of engineering students prepared to solve 21st century challenges. The program is moving to an every-other-year solicitation cycle.
- Funding for the REU Sites program is decreased by $2.65 million, to a total of $10.75 million. REU projects involve students in meaningful ways in ongoing research programs or in research projects specifically designed for the REU program. REU has been found to be one of the most effective avenues for attracting and retaining students in engineering and for preparing them for careers in this field. REU projects also offer an opportunity to tap the Nation's diverse student talent pool and broaden participation in science and engineering.
- Funding for RET is increased by $20,000, to a total of $4.25 million. Over the past ten years, the RET in Engineering Sites program has provided K–12 teachers and community college faculty the opportunity to gain research experience in university laboratories. The professional development gained by the participants through this unique experience has enriched their performance in the classroom and their guidance of students toward engineering. The increase will support these participants in areas of national need such as sustainability, energy, manufacturing, robotics, and others.
- EEC will provide $1.40 million, roughly equal to the FY 2016 Actual, to support the agency's broadening participation program NSF INCLUDES.

DIVISION OF INDUSTRIAL INNOVATION AND PARTNERSHIPS (IIP)

$223,210,000
-$16,660,000 / -6.9%

IIP Funding
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total	**$239.87**	**-**	**$223.21**	**-$16.66**	**-6.9%**
Research	**239.31**	**-**	**223.06**	**-16.25**	**-6.8%**
SBIR/STTR	188.52	-	176.21	-12.31	-6.5%
Education	**0.57**	**-**	**0.15**	**-0.42**	**-73.6%**

IIP contributes to the NSF innovation ecosystem by: (1) supporting innovation research that builds on fundamental research discoveries that exhibit potential for societal and economic impact; (2) encouraging research partnerships between academia and industry; and (3) offering hands-on experience in the innovation process to current and future entrepreneurs and innovators.

IIP is home to two cross-agency small business research programs, the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. These programs seek to transform scientific discovery into societal and economic benefit by catalyzing private sector commercialization of technological innovations. The SBIR/STTR programs provide the opportunity for startups and small businesses to undertake cutting-edge, high-quality scientific research and development with the goal of achieving technology commercialization and enabling new products, processes, or services. SBIR/STTR technology topics draw upon the breadth of NSF scientific and engineering research disciplines and are aligned with national and societal priorities.

IIP also supports academic research through three research programs: Industry–University Cooperative Research Centers (IUCRCs), Partnerships for Innovation (PFI), and Grant Opportunities for Academic Liaison with Industry (GOALI). These programs aim to stimulate academia-industry partnerships, leverage industrial support, accelerate technology commercialization, and empower future generations in science and engineering. University grantees in these programs collaborate with industry to create enabling technologies that meet national needs, such as managing the electrical power system, improving manufacturing and biological processing, and supporting new information and communications technologies.

IIP also leads the I-Corps™ program that connects NSF-funded science and engineering research with the technological, entrepreneurial, and business communities, and fosters a national innovation ecosystem that links scientific discovery with technology development, societal needs, and economic opportunities.

In general, 97 percent of the IIP portfolio is comprised of new research grants and 3 percent supports continuing grants.

FY 2018 Summary

All funding decreases/increases represent change over the FY 2016 Actual.

Research

- Funding for SBIR/STTR decreases by $12.31 million, to a total of $176.21 million, consistent with the levels specified in the SBIR/STTR Reauthorization Act of 2011 (P.L 112-81), which stipulates 3.2

percent and 0.45 percent of NSF's FY 2018 extramural research funding be allocated to the SBIR and STTR programs, respectively. Support for SBIR/STTR will continue to provide resources to the small business community to embark on cutting-edge, high-risk, and high-impact research projects.

- Funding for the PFI program decreases by $3.90 million, to a total of $16.75 million as the program undergoes a restructuring in FY 2018. The restructured PFI program will provide a continuum of opportunities that enable academic research discoveries to be translated along a path toward commercial reality, while engaging faculty and students in entrepreneurial and market-oriented thinking and supporting academic-industry partnerships that can accelerate the innovation.
- Funding for the I-Corps™ program decreases by $80,000, to a total of $13.0 million. The I-Corps™ program provides entrepreneurial education for federally-funded scientists and engineers, pairing them with business mentors for an intensive curriculum focused on discovering a demand-driven path from their lab work to a marketable product. Since NSF launched the I-Corps™ program in 2011, 892 Teams have completed this experiential education, and approximately 45 percent of these Teams have started their own companies; three of these companies have been acquired.
- Funding for IUCRC increases by $1.74 million, to a total of $12.50 million. Support in FY 2018 will include a "reverse" IUCRC pilot where industry members come together to identify pre-competitive research topics and NSF solicits proposals from university teams interested in the formation of an IUCRC in that area of research. IIP's support for GOALI decreases by $120,000 to $4.75 million. The program promotes university-industry partnerships by making project funds or fellowships/traineeships available to support an eclectic mix of industry–university linkages, including opportunities to support graduate students in industry experiences.

Education

- Support for the REU program decreases by $210,000 to a total of $150,000

OFFICE OF EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES (EFMA)

$36,750,000
-$17,620,000 / -32.4%

EFMA Funding
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual Amount	Change Over FY 2016 Actual Percent
Total	**$54.37**	**-**	**$36.75**	**-$17.62**	**-32.4%**
Research	**45.95**	**-**	**32.65**	**-13.30**	**-28.9%**
Education	**3.42**	**-**	**0.10**	**-3.32**	**-97.1%**
Infrastructure	**5.00**	**-**	**4.00**	**-1.00**	**-20.0%**
CHESS	5.00	-	4.00	-1.00	-20.0%

EFMA strategically pursues and funds projects in important emerging areas in a timely manner. The office also provides support to multidisciplinary education programs such as REU. Additionally, EFMA is the home to ENG's annual operations support of the Cornell High Energy Synchrotron Source (CHESS) facility. The largest activity in EFMA is the Emerging Frontiers in Research and Innovation (EFRI) program.

Each year EFRI recommends, prioritizes, and funds interdisciplinary topics at the frontiers of engineering research and education that have the potential for transformative impacts on national needs and/or grand challenges. Technological innovations have given rise to new industries, expanded access to quality healthcare, and fueled prosperity even as global competition has grown. To help ensure the Nation's continued success, EFRI provides critical, strategic support of fundamental discovery, particularly in areas that may lead to breakthrough technologies and strengthen the economy's technical underpinnings. EFRI is intended to have the necessary flexibility to target long-term challenges, while retaining the ability and agility to adapt as new challenges demand.

EFRI encourages the engineering community to submit new and paradigm-shifting proposals at the interface of disciplines and fields in important emerging areas. Their ideas and discoveries may potentially lead to new research areas for NSF and other agencies, new industries, or capabilities that result in a leadership position for the country, and/or significant progress on a recognized national need or grand challenge. Recent EFRI topics have included areas such as: integrated processes and systems designed to make U.S. infrastructures more resilient; sustainable energy sources; advances in robotics; and flexible technologies and regenerative engineering for healthcare.

During FY 2014–2015, EFRI invested in 2-Dimensional Atomic Layer Research and Engineering (2-DARE), a topic managed jointly by ENG and MPS. The EFRI 2-DARE topic promotes the exploration of the exciting prospects of two-dimensional (2-D) atomic layers and devices in the wide range of compositions beyond graphene that can stimulate technologically significant applications in the coming years.

In FY 2016 and FY 2017, EFRI has been investing in two new topic areas. Advancing Communication Quantum Information Research in Engineering (ACQUIRE) aims to enhance secure, scalable, and efficient data communication. ACQUIRE researchers are investigating fundamental engineering challenges in quantum communication systems to enable lossless, room temperature, point-to-point links combining components, repeaters, networks, and architectures. The second topic, New Light, EM (electronic), and Acoustic Wave Propagation: Breaking Reciprocity and Time-Reversal Symmetry (NewLAW), may disrupt how electronic, photonic, and acoustic devices are designed and employed, and enable breakthroughs in

secure communication, impact and blast protection, and smart infrastructure. EFRI is collaborating with MPS and CISE on these topics.

In general, 73 percent of the EFMA portfolio is comprised of new research grants, and 27 percent supports continuing increments for grants made in previous years.

FY 2018 Summary

All funding decreases/increases represent change over the FY 2016 Actual.

Research

- In FY 2018 EFRI support decreases by $3.0 million, to a total of $27.75 million, and will provide support for up to 13 interdisciplinary team projects aimed at addressing national challenges such as renewable energy, advanced manufacturing, and secure communication systems.
- Other EFMA investments will decrease by $10.30 million in support of NSF-wide multidisciplinary investments and other important national priorities.

Education

- EFMA support for the ADVANCE program ends in FY 2018, and the REU program is maintained at $100,000.

Infrastructure

- EFMA reduces support for CHESS by $1.0 million, to a total of $4.0 million, consistent with plans to transition the facility from NSF stewardship to a partnership model, which would begin in FY 2018.