DIRECTORATE FOR ENGINEERING (ENG) $1,002,730,000
+$86,540,000 / 9.4%

ENG Funding

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Chemical, Bioengineering, Environmental, and Transport Systems (CBET)	$180.40	$183.82	$198.42	$14.60	7.9%
Civil, Mechanical, and Manufacturing Innovation (CMMI)	225.55	216.39	233.92	17.53	8.1%
Electrical, Communications, and Cyber Systems (ECCS)	118.97	113.95	122.77	8.82	7.7%
Engineering Education and Centers (EEC)	117.95	107.61	120.32	12.71	11.8%
Industrial Innovation and Partnerships (IIP)	227.26	239.93	268.90	28.97	12.1%
Emerging Frontiers and Multidisciplinary Activities (EFMA)	53.41	54.49	58.40	3.91	7.2%
Total, ENG	**$923.53**	**$916.19**	**$1,002.73**	**$86.54**	**9.4%**

Totals may not add due to rounding.

FY 2015 Actual includes $21.18 million in carryover from the prior fiscal year as follows: CMMI - $11.32 million, ECCS - $6.48 million, EEC - $200,000, and EFMA - $3.19 million.

The FY 2017 Budget Request for ENG is $1,002.73 million, of which $946.41 million is discretionary funding and $56.32 million is new mandatory funding. The major focus of the mandatory funding is support for core activities, with special emphasis on supporting early-career investigators, advancing engineering research through effective use of data and cyberinfrastructure, and investing in disruptive technologies to enable post-Moore's Law computing systems. Examples of activities include, but are not limited to:

- Expand support for early-career investigators and stimulate breakthrough research ideas, encourage risk taking and innovative thinking among young investigators.
- Support engineering research directions that combine mainstream engineering fields for transformative use of stored and real-time streaming data to advance discovery and stimulate data-intensive fundamental engineering research through ENG core programs. Examples include: simulation and modeling for nanosystems science and engineering; understanding of interdependent and interconnected infrastructure systems; understanding of energy landscapes of chemical reactions; modeling and simulation of biological functions and complexity across multiple length scales; novel system science and engineering that are better suited for a data rich world; and mitigation of, preparedness for, response to, and recovery from multi-hazard disasters by leveraging data from diverse sources.
- Support fundamental engineering research in materials, devices, and systems architecture that will potentially establish a viable path forward for future advanced computing systems in the post-Moore's Law era, thus enabling future possibilities for the advancement of computing.

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 – including, for example, nanotechnology-enabled consumer, industrial, and health care products and manufacturing; novel laser-based tools for brain research and

neurological diseases; devices and systems for communications and computing; and Internet-enabled smart advanced manufacturing systems and supply chains – that in turn have stimulated economic growth and are improving the quality of life for all Americans.

In FY 2017, ENG's approach aims to bring about new breakthroughs for national priorities and grand challenges by (1) implementing key Administration and NSF-wide investment priorities, and (2) supporting core programs in frontier engineering research.

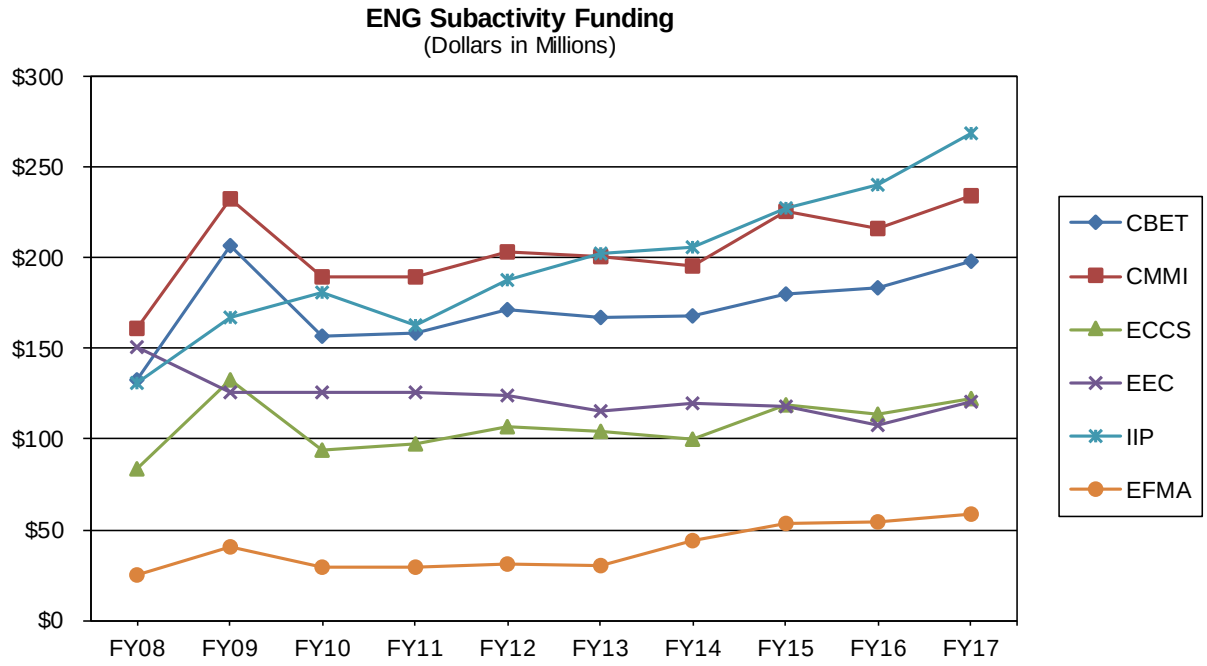
The directorate will continue to invest throughout its core programs in emerging and frontier basic research areas, including, for example, advanced materials and manufacturing, systems science and engineering, engineering biology, food-energy-water nexus, and next-generation electronic devices, circuits, and systems. Through support of small businesses and academic partnerships with industry, ENG will help launch exciting technological innovations and support the Nation's innovation ecosystem.

ENG will strive to prepare the future engineering workforce through leadership in engineering education research and through providing hands-on research opportunities to both undergraduate and graduate students. Engineering education is undergoing major changes with significant increases in student enrollments across the Nation. At the same time, the engineering education ecosystem continues to face major challenges in attracting women and underrepresented minorities. ENG will continue to focus its investments to identify and support systemic innovations to meet these critical and compelling challenges.

ENG investments will support major Administration priorities and investments, such as the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, the Advanced Manufacturing Partnership (AMP), clean energy, the National Robotics Initiative (NRI), the National Strategic Computing Initiative (NSCI), and the Strategy for American Innovation. Targeted ENG investments will make unique and essential contributions to these far-reaching national challenges.

ENG also will lead or contribute directly in 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 provides about 40 percent of federal funding for basic research at academic institutions in the engineering sciences.



FY 2009 reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2017 Summary by Division

- CBET's FY 2017 Request will support research and education in areas of the food, energy, and water nexus by contributing to the NSF-wide INFEWS investment, and will continue to support transformative work in neurotechnology through the UtB initiative. CBET will bolster CEMMSS support through investments in advanced biomanufacturing that focus on studying theories and technologies of design, engineering, and manufacturing bio-related (natural or synthetic) products; and robotics research to assist those with physical disabilities or cognitive impairments. CBET will enhance support of 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. The division will increase investment in novel ideas for clean energy technologies, and will continue to support a Science and Technology Center (STC).

- CMMI's FY 2017 Request will enable contributions to the CEMMSS investment through research and education in advanced manufacturing; robotics; interdisciplinary research in advanced materials and manufacturing processes; scalable nanomanufacturing; cyber-manufacturing to enable research on the networked integration of manufacturing machines, equipment, and systems into an increasingly accessible manufacturing service infrastructure; and cyber-physical systems with a stronger emphasis on Smart and Connected Communities to enable innovative applications and services for more livable, workable, and sustainable communities. CMMI will contribute to the NSF-wide Risk and Resilience priority through the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) program to deepen fundamental knowledge and stimulate innovations to improve resilience, interoperations, performance, and readiness in interdependent critical infrastructure systems. Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) support will focus on research and education on computational-based approaches for engineering design, analysis, and predictive modeling, particularly under high degrees of uncertainty.

- ECCS's FY 2017 Request will enable its support to critical areas of national importance such as UtB and clean energy technology. The division will contribute to CEMMSS through supporting research in robotics, smart health research, and cyber-physical systems in the area of integration of intelligent decision-making algorithms and hardware into physical systems. ECCS will continue to support fundamental research in cyber-physical systems with an emphasis on Smart and Connected Communities applications. The goal is to advance the 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. In FY 2017, ECCS will continue the phase-down of formal CIF21 research activities and plans to shift the investment to the NSCI through supporting research to enable low-power computing and future high-performance computing (HPC) systems in the post-Moore's Law device and hardware systems era. Leveraging NSF's CIF21 investments, ECCS will continue to support data-intensive science and research activities building on ECCS-led Dynamic Data Systems in partnership with the Air Force Office of Scientific Research. FY 2016 is the final year of formal investment in the Enhancing Access to the Radio Spectrum (EARS) program. Building on the EARS investment and through its core and crosscutting programs, ECCS will continue to support 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. ECCS will also continue to support an STC.

- EEC's FY 2017 Request will provide funding for a combination of Engineering Research Centers (ERCs) and Nanosystems Engineering Research Centers (NERCs), including planned growth supplements for the three centers awarded in the ERC Class of 2015. In FY 2017, EEC will continue support of Improving Undergraduate STEM Education (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. PFE:RED is under the framework of the NSF-wide IUSE initiative, which integrates the agency's investments in undergraduate education. EEC will continue to support research and innovations leading to and propagating interventions that improve both the quality and quantity of STEM graduates. (For more information regarding IUSE and NSF's undergraduate framework, see the IUSE narrative in the NSF-Wide Investments chapter.) Support for the Research Experiences for Undergraduates (REU) program will be maintained, with a particular focus on providing early opportunities to conduct research.

- IIP's FY 2017 Request reflects its commitment to enhancing the Nation's innovation ecosystem. Through programs for Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR), IIP will continue to support technological breakthroughs that benefit society. Through the I-Corps™, Partnerships for Innovation (PFI), and Industry/University Cooperative Research Centers (I/UCRC) programs, as well as other activities, the division will enable academic researchers to translate fundamental research discoveries into market realities, and encourage academia and industry to collaborate and prepare students to be innovators and entrepreneurs.

- EFMA's FY 2017 Request will provide support for 16 Emerging Frontiers in Research and Innovation (EFRI) interdisciplinary teams to pursue cutting-edge research with the potential for transformative impacts on national needs and grand challenges. In FY 2016, ENG announced a Dear Colleague Letter (DCL) through EFMA for Germination of Research Ideas for Large Opportunities and Critical Societal Needs (GERMINATION). The DCL seeks EAGER (EArly-concept Grants for Exploratory Research) proposals with exploratory ideas to design learning frameworks, platforms and/or environments to

enable early- and mid-career faculty, as well as graduate students and post-doctoral fellows to conceive research ideas and questions with potentially transformative outcomes. In FY 2017, ENG will continue to enable researchers to expand the long-term impacts of ENG's basic research investment.

Major Investments

ENG Major Investments
(Dollars in Millions)

Area of Investment	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
ADVANCE	$3.26	$3.26	$3.26	-	-
BioMaPS	3.00	1.50	-	-1.50	-100.0%
CAREER	74.23	63.38	64.23	0.85	1.3%
CEMMSS	110.77	110.00	112.00	2.00	1.8%
Advanced Manufacturing	*95.77*	*82.00*	*84.00*	*2.00*	*2.4%*
Clean Energy Technology	138.00	140.87	177.38	36.51	25.9%
CIF21	10.00	8.00	4.00	-4.00	-50.0%
NSF I-Corps™	11.05	13.00	13.00	-	-
NSF INCLUDES	-	1.47	1.40	-0.07	-4.8%
INFEWS	-	10.00	13.00	3.00	30.0%
IUSE	4.94	6.00	6.00	-	-
NRT[1]	2.85	2.59	2.50	-0.09	-3.5%
NSCI	-	-	10.00	10.00	N/A
Risk and Resilience	12.00	12.00	14.00	2.00	16.7%
SaTC	3.25	3.25	3.25	-	-
SEES	19.39	3.00	3.00	-	-
Understanding the Brain	11.00	16.75	16.75	-	-
BRAIN Initiative	*11.00*	*16.75*	*16.75*	-	-

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

[1] Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are $1.13 million in FY 2015, $1.81 million in FY 2016, and zero funding in FY 2017.

- ADVANCE ($3.26 million): ENG will continue to participate in the NSF-wide program ADVANCE as part of its ongoing commitment to build strategies and models to increase the participation, retention, and advancement of women in all STEM academic careers.

- BioMaPS (-$1.50 million, to a total of zero): ENG formal support ends as funds transition to core programs to support engineering biology.

- Faculty Early Career Development (CAREER) (+$850,000, to a total of $64.23 million): Supports young investigators who exemplify the role of teacher–scholar through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations.

- CEMMSS (+$2.0 million, to a total of $112.0 million): Support 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 (+$2.0 million, to a total of $84.0 million): 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 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 the NSF investments in fundamental research and education in manufacturing.

- Clean Energy Technology (+$36.51 million, to a total of $177.38 million): ENG support of clean energy technology-related activities will enhance the fundamental scientific and engineering knowledge base to enable future clean energy technologies. Examples include research on theory and analytical tools for power networks with high levels of renewable energy generation; innovative processes for the sustainable production of electricity through renewable resources such as solar and wind energy; novel approaches to process intensification for biofuel and bioenergy; novel approaches to energy efficiency; and high-energy density and high-power density batteries suitable for transportation, and renewable energy storage applications. The ENG clean energy technology investment will be strategically coordinated across all divisions.

- CIF21 (-$4.0 million, to a total of $4.0 million): ENG support will focus on computational and data-enabled science and engineering research, infrastructure, and community-building, and access and connections to cyberinfrastructure facilities. Funding is in CBET, CMMI, and ECCS. In FY 2017, ENG will continue the phase-down of formal CIF21 research activities and plans to shift the investment to the NSCI through supporting research to enable low-power computing and future high-performance computing (HPC) systems in the post-Moore's Law device and hardware systems era.

- I-Corps™ ($13.0 million, equal to the FY 2016 Estimate): ENG will continue to lead the NSF-wide I-Corps™ program. In FY 2017, ENG will support I-Corps™ Teams, Sites, and Nodes to further build, utilize, and sustain a national innovation ecosystem that continues to augment the development of technologies, products, and processes that benefit the Nation. Funding is through IIP.

- NSF INCLUDES (-$70,000, 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 (+$3.0 million, to a total of $13.0 million): ENG will continue to co-lead this NSF-wide initiative with the Directorate for Geosciences (GEO) in FY 2017. The goal is to catalyze the 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 ($6.0 million, equal to the FY 2016 Estimate): ENG will participate in the NSF-wide IUSE initiative, which integrates the agency's investments in undergraduate education. In FY 2017, ENG will continue to support IUSE/PFE:RED to enable research and innovations leading to and propagating interventions that improve both the quality and quantity of engineering graduates.

- NSF Research Traineeship (NRT) (-$90,000, to a total of $2.50 million): ENG will continue to participate in the NRT program, which is the successor to the Integrative Graduate Education and

Research Traineeship (IGERT) program. The FY 2017 amount reflects funding only for NRT awards, as all remaining commitments to the IGERT program were completed in FY 2016.

- National Strategic Computing Initiative (NSCI) ($10.0 million): ENG will support research to enable low-power computing and future high-performance computing (HPC) systems in the post-Moore's Law device and hardware systems era, partially supported by funds redirected from CIF21.

- Risk and Resilience (+$2.0 million, to a total of $14.0 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 2017, ENG will continue to support the CRISP program by catalyzing collaborations among researchers across the domains of engineering, computer and computational science, and social, behavioral, and economic sciences to deepen fundamental knowledge and stimulate innovations to improve resilience, interoperations, performance, and readiness of our critical infrastructure.

- Secure and Trustworthy Cyberspace (SaTC) ($3.25 million, equal to the FY 2016 Estimate): 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, equal to the FY 2016 Estimate): ENG will continue to support Sustainable Chemistry research. FY 2017 represents the final year of investment as program activities sunset. Funds will be re-invested in INFEWS, Risk and Resilience, and other priorities within the ENG portfolio.

- UtB ($16.75 million, equal to the FY 2016 Estimate): ENG will invest in UtB, neuroscience and neurotechnology research critical to success of the BRAIN Initiative. Research will drive integration across scales and across disciplines, accelerate the development of novel experimental and analytical approaches, including computational and data-enabled modeling, and enable new neural engineering and technology research and innovation.

ENG Funding for Centers Programs and Facilities

ENG Funding for Centers Programs
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, Centers Programs	**$74.54**	**$67.25**	**$71.75**	**$4.50**	**6.7%**
Engineering Research Centers (EEC)	59.69	56.50	61.00	4.50	8.0%
Nanoscale Science & Engineering Centers (Multiple)	4.00	0.75	0.75	-	-
Science of Learning Centers (EEC)	0.85	-	-	-	N/A
Science & Technology Centers (Multiple)	10.00	10.00	10.00	-	-

Totals may not add due to rounding.

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

- Engineering Research Centers (ERC): Support for the ERC program will increase (+$4.50 million, to a total of $61.0 million). Building on the long-standing ERC program model, this funding level will provide support for 14 existing centers and the addition of four new ones as part of the FY 2017 competition.

- Nanoscale Science and Engineering Centers (NSEC): Support remains at $750,000, equal to the FY 2016 Estimate, as the program continues to sunset as planned. It is anticipated core programs in ENG will increase support to nanoscale science and engineering, offsetting the reduction.

- Science of Learning Centers (SLC): Final funding commitments for SLCs ended in FY 2015.

- Science and Technology Centers (STC): ENG will continue to support two STCs in FY 2017. CBET will support the Center on Emergent Behaviors of Integrated Cellular Systems, and ECCS will support the Center for Energy Efficient Electronics Science.

ENG Funding for Facilities

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, Facilities	**$33.53**	**$28.33**	**$28.33**	**-**	**-**
Cornell High Energy Synchrotron Source (CHESS)	5.00	5.00	5.00	-	-
National Nanotechnology Coordinated Infrastructure (NNCI)	10.29	10.83	10.83	-	-
Natural Hazards Earthquake Engineering Research Infrastructure (NHERI)	18.24	12.50	12.50	-	-

Totals may not add due to rounding.

For detailed information on individual facilities, please see the Facilities chapter.

- Support for CHESS operations and maintenance costs are maintained at $5.0 million, equal to the FY 2016 Estimate.

- ENG continues support for nanotechnology research infrastructure through investment in the National Nanotechnology Coordinated Infrastructure (NNCI) at $10.83 million, equal to the FY 2016 Estimate. This network of user facilities replaced the National Nanotechnology Infrastructure Network (NNIN) in FY 2015.

- Support for the Natural Hazards Engineering Research Infrastructure is $12.50 million, equal to the FY 2016 Estimate. Funding for this facility network is consistent with operations support for the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), which ended in FY 2015.

Summary and Funding Profile

ENG investment supports basic engineering research, engineering education, and innovation, as well as research infrastructure such as facilities.

In FY 2017, the number of research grant proposals to ENG is expected to be about 10,200. ENG expects to award approximately 2,000 research grants in FY 2017. Average annualized award size and duration are estimated to be $123,000 and three years, respectively, in FY 2017.

In FY 2017, funding for centers accounts for nine percent of ENG's non-SBIR/STTR Request.

In FY 2017, funding for facilities is just over three and one-half percent of ENG's non-SBIR/STTR Request.

ENG Funding Profile

	FY 2015 Actual Estimate	FY 2016 Estimate	FY 2017 Estimate
Statistics for Competitive Awards:			
Number of Proposals	12,236	12,500	13,500
Number of New Awards	2,504	2,500	2,700
Funding Rate	20%	20%	20%
Statistics for Research Grants:			
Number of Research Grant Proposals	9,332	9,500	10,200
Number of Research Grants	1,851	1,850	2,000
Funding Rate	20%	19%	20%
Median Annualized Award Size	$103,355	$103,000	$104,000
Average Annualized Award Size	$122,201	$122,000	$123,000
Average Award Duration, in years	2.7	3.0	3.0

Program Monitoring and Evaluation

External Program Evaluations and Studies

- A study of the feasibility of performing rigorous impact evaluation of the NSF I-Corps™ Teams program was completed in FY 2014. Based on the feasibility study, NSF initiated a request for proposals to identify a contractor to perform a rigorous evaluation of the I-Corps™ Teams. A contractor was selected and engaged in FY 2015. The study will be initiated in FY 2016.
- During the first half of FY 2015, ENG completed a pilot test of the principal investigator (PI) survey questionnaire that evolved from the logic model developed for the Emerging Frontiers in Research and Innovation (EFRI) program. The study demonstrated that a longitudinal outcome data collection effort is fruitful and possible. The response rate from the PIs was over 75 percent. PIs reported an acceptable level of burden by this additional data collection, as well as being positive about the availability of data needed to respond. A permanent longitudinal outcome monitoring system for the EFRI program will be developed and a contract issued in the second quarter of FY 2016.
- In the first quarter of FY 2015, IIP completed the development of theories of action for all its programs. ENG initiated a data collection effort for all IIP programs.
- In FY 2017, ENG will utilize the developing business intelligence platform and the output data available from the Research Performance Progress Report (RPPR) and public access to create dashboards and automated reports aimed at visualizing the output of programs, clusters, divisions, and the directorate, and their relationships with other factors and variables.

Workshops and Reports

- With support from CMMI, a two-day workshop[1] was held at the University of Florida from October 14 – 15, 2014, to explore the environmental and human health implications of the emerging field of additive manufacturing. This workshop was designed to build on a previous NSF-funded workshop held in July 2013, Frontiers of Additive Manufacturing Research and Education. The October 2014 workshop explored five areas of additive manufacturing, including lifecycle impacts (supply chain footprint from material extraction to finished product); energy use (quantification of energy use of additive vs conventional manufacturing); waste (minimizing end-of-life impacts); occupational health impacts (design to minimize emissions and exposure control); and cross-cutting/policy issues (associated environmental and occupational health issues to communicate to agencies such as the National Institute for Occupational Safety & Health, the Environmental Protection Agency, or the National Institutes of Health. The workshop informed the NSF program directors and the research community of emerging needs and opportunities in associated research.

- With support from CMMI, a three-day workshop on Advanced Manufacturing for the Oil and Gas Energy Industry[2] was held in Houston, Texas, from November 2 – 4, 2014. Attendees included representatives of industry; researchers, educators; and administrators and decision-makers who support and facilitate research, education, and technology transfer. Workshop attendees identified research needs to advance drilling processes; development of advanced material processing technologies such as nano-structured coatings that are resistant to fatigue, corrosion damage, extreme temperature and pressures; development of decision tools to relate various system design parameters to performance metrics; development and deployment of sensors, high temperature electronics and telemetrics to collect data; and advances in data analytics to bridge information gaps to improve performance control. The role of public–private partnership was stressed, as was the continuing challenge of workforce development.

- CBET sponsored a study by the National Academies on Industrialization of Biology. The National Academies Press published a report in 2015, titled "The Industrialization of Biology: A Roadmap to Accelerate the Advanced Manufacturing of Chemicals."[3] Major biotechnology advances have been made in the past decade, such as rapid, low-cost DNA sequencing, metabolic engineering, and high-throughput screening. The report puts forth a proactive strategy through the development of a technical roadmap to help realize the widespread benefits of accelerating the industrialization of biology.

- ECCS supported a March 2015 workshop, Rebooting the IT Revolution: A Call to Action,[4] in collaboration with the Semiconductor Industry Association (SIA), Semiconductor Research Corporation (SRC), the National Institute of Standards and Technology (NIST) and the Defense Advanced Research Projects Agency (DARPA). The purpose of this two-day workshop involving leaders from the tech industry and academia was to define Grand Challenges that will identify long-term research priorities in support of the upcoming IT revolution. Increasing societal expectations to access information anywhere, anytime, and deepening infusion of information technology in the physical world demand the development of a robust information technology infrastructure that connects the physical and virtual worlds. To determine ways to meet this demand, to fully realize Internet of Things breakthroughs, and to sustain America's technology leadership, workshop participants discussed needs for fundamental research for energy-efficient sensing and computing, data storage, real-time communication ecosystem, multi-level and scalable security, a new fabrication paradigm and insight computing. Many of these areas align with federal research initiatives, including the NSCI, the BRAIN

[1] www.wilsoncenter.org/sites/default/files/nsf_am_env_final_red.pdf
[2] ise.tamu.edu/nsf2014/PDFs/NSF-OGWorkshop-Report_Feb_2015.pdf
[3] nap.edu/catalog/19001/industrialization-of-biology-a-roadmap-to-accelerate-the-advanced-manufacturing
[4] src.org/newsroom/rebooting-the-it-revolution.pdf

Initiative, and the National Nanotechnology Initiative Grand Challenges.

Committees of Visitors (COV)

- In 2015, COVs reviewed CBET and CMMI. The COVs presented their reports to the ENG Advisory Committee, which convened in April and October of 2015. Both COV reports were approved by the ENG Advisory Committee.
- In 2016, COVs will review EEC and IIP.
- In 2017, COVs will review ECCS and EFMA.

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

Number of People Involved in ENG Activities

	FY 2015 Actual Estimate	FY 2016 Estimate	FY 2017 Estimate
Senior Researchers	9,220	9,300	10,000
Other Professionals	1,856	1,900	2,100
Postdoctoral Associates	539	550	600
Graduate Students	7,523	7,600	8,200
Undergraduate Students	3,968	4,000	4,200
Total Number of People	**23,106**	**23,350**	**25,100**

DIVISION OF CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, AND TRANSPORT SYSTEMS (CBET) $198,420,000 +$14,600,000 / 7.9%

CBET Funding

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, CBET	**$180.40**	**$183.82**	**$198.42**	**$14.60**	**7.9%**
Research	**174.47**	**178.98**	**193.58**	**14.60**	**8.2%**
CAREER	33.26	27.19	27.56	0.37	1.4%
Centers Funding (total)	6.24	5.33	5.33	-	-
Nanoscale Science & Engineering Centers	1.24	0.33	0.33	-	-
STC: Center for Emergent Behavior of Integrated Cellular Systems	5.00	5.00	5.00	-	-
Education	**2.25**	**1.15**	**1.15**	**-**	**-**
Infrastructure	**3.68**	**3.69**	**3.69**	**-**	**-**
NNCI	3.68	3.69	3.69	-	-

Totals may not add due to rounding.

The FY 2017 Budget Request for CBET is $198.42 million, of which $187.18 million is discretionary funding and $11.24 million is new mandatory funding. The mandatory funding is within the research line in the above table.

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, including 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, civil, and aerospace engineering disciplines. To serve these communities and achieve its goals, CBET is organized into four thematic clusters: Chemical and Biochemical Systems; Bioengineering and Engineering Healthcare; Environmental Engineering and Sustainability; and Transport, Thermal, and Fluid Phenomena.

In general, 76 percent of the CBET portfolio is comprised of new research grants, and 24 percent supports continuing grants.

FY 2017 Summary

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

Research

- CAREER funding increases by $370,000, to a total of $27.56 million in FY 2017. This increase is consistent with CBET's emphasis on supporting early-career researchers.

- Support for NSF-wide INFEWS increases by $3.0 million, to a total of $8.0 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.
- Support for UtB research totals $7.0 million, equal to the FY 2016 Estimate. 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 enhance support of 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 enhance support for research in advanced biomanufacturing 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. This program will leverage the Biomedical Engineering and the Biotechnology and Biochemical Engineering programs in CBET.
- The division will provide $2.0 million in support of the national Materials Genome Initiative (MGI), through a collaborative effort with the Directorate for Mathematical and Physical Sciences (MPS) in Designing Materials to Revolutionize and Engineer our Future (DMREF) under the NSF-wide CEMMSS initiative.
- STC funding remains $5.0 million, equal to the FY 2016 Estimate, to continue support for the STC on Emergent Behaviors of Integrated Cellular Systems, led by the Massachusetts Institute of Technology.
- CBET support for the NSEC program totals $330,000, as the program continues to sunset as planned.

Education

- CBET contributes to a number of education and diversity activities, including REU and NSF's Career Life Balance (CLB) activities. Total CBET funding for these activities in the FY 2017 Request is $1.15 million.

Infrastructure

- CBET continues support for infrastructure in FY 2017 through investments in the NNCI at the FY 2016 Estimate level.

DIVISION OF CIVIL, MECHANICAL, AND MANUFACTURING INNOVATION (CMMI) — $233,920,000 / +$17,530,000 / 8.1%

CMMI Funding

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, CMMI	**$225.55**	**$216.39**	**$233.92**	**$17.53**	**8.1%**
Research	**203.07**	**200.24**	**217.82**	**17.58**	**8.8%**
CAREER	24.20	21.12	21.40	0.28	1.3%
Centers Funding (total)	1.04	0.31	0.31	-	-
Nanoscale Science & Engineering Centers	1.04	0.31	0.31	-	-
Education	**2.35**	**1.75**	**1.70**	**-0.05**	**-2.9%**
Infrastructure	**20.14**	**14.40**	**14.40**	**-**	**-**
NHERI	18.24	12.50	12.50	-	-
NNCI	1.90	1.90	1.90	-	-

Totals may not add due to rounding. FY 2015 Actual includes $11.32 million in carryover from prior fiscal year.

The FY 2017 Budget Request for CMMI is $233.92 million, of which $220.67 million is discretionary funding and $13.25 million is new mandatory funding. The mandatory funding is within the research line in the above table.

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, including healthcare.

In general, 82 percent of the CMMI portfolio is comprised of new research grants and 18 percent supports continuing grants.

FY 2017 Summary

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

Research

- CAREER funding increases by $280,000, to a total of $21.40 million, in FY 2017. This increase is consistent with CMMI's emphasis on supporting early-career researchers.
- Fundamental core research in support of advanced manufacturing will increase by $2.0 million, to a total of $52.90 million, 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 research, smart manufacturing, and design and manufacturing of complex engineered systems.

- Research to support NRI will be maintained at $5.0 million as part of the NSF-wide CEMMSS activity to help ensure continued U.S. leadership in the robotics field.
- The division will maintain funding of $7.0 million in support of the national MGI through the DMREF effort under the NSF-wide CEMMSS investment area.
- Support for the agency's Risk and Resilience focus through the CRISP program will increase $2.0 million, to a total of $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.
- Leveraging NSF's long-standing investment in Cyber–Physical Systems (CPS), CMMI will continue to support research in smart and connected communities to enable innovative applications and services for more livable, workable, and sustainable communities.
- Support for CIF21 is reduced by $1.00 million, to a total of $2.60 million, in FY 2017 as focus shifts to investments in NSCI. Within CIF21 and NSCI, CMMI will continue to support research on computationally-based approaches for engineering design, analysis, and predictive modeling, particularly under high degrees of uncertainty. Efforts will support research in the areas of data-enabled science and engineering, with emphasis on complex systems design and analysis, and methods to utilize disparate and distributed data sets for CMMI-relevant research. Linkages between CEMMSS-related research programs and elements of the CIF21 and NSCI activity will be strengthened, as researchers make greater use of modeling and simulation, and data-enabled capabilities made possible by CIF21 investments.
- CMMI support for the NSEC program totals $310,000, equal to the FY 2016 Estimate, as the program continues to sunset as planned.

Education

- CMMI contributes to a number of education and diversity activities, including REU and CLB. Total CMMI funding for these activities in the FY 2017 Request is $1.70 million.

Infrastructure

- Support for NHERI is maintained at $12.50 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 reduction in overall operations costs from the previous facility follows recommendations from numerous studies that indicated a need for a leaner and more focused facilities program for earthquake engineering simulation. The reduction in facilities and operational costs enables additional investments to be made in research that addresses engineering strategies to design for and mitigate against multiple hazards including earthquakes, wind, storm surge, and combinations of these and other potential hazards.
- ENG continues support for infrastructure through investments in the NNCI at the FY 2016 Estimate level.

DIVISION OF ELECTRICAL, COMMUNICATIONS, AND CYBER SYSTEMS (ECCS) — $122,770,000 / +$8,820,000 / 7.7%

ECCS Funding
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, ECCS	**$118.97**	**$113.95**	**$122.77**	**$8.82**	**7.7%**
Research	**112.70**	**107.71**	**116.58**	**8.87**	**8.2%**
CAREER	16.77	15.07	15.27	0.20	1.3%
Centers Funding (total)	5.68	5.11	5.11	-	-
Nanoscale Science & Engineering Centers	0.68	0.11	0.11	-	-
STC: Center for Energy Efficient Electronics	5.00	5.00	5.00	-	-
Education	**1.56**	**1.00**	**0.95**	**-0.05**	**-5.0%**
Infrastructure	**4.71**	**5.24**	**5.24**	**-**	**-**
NNCI	4.71	5.24	5.24	-	-

Totals may not add due to rounding. FY 2015 Actual includes $6.48 million in carryover from prior fiscal years.

The FY 2017 Budget Request for ECCS is $122.77 million, of which $115.80 million is discretionary funding and $6.97 million is new mandatory funding. The mandatory funding is within the research line in the above table.

ECCS addresses fundamental research issues underlying electronic and photonic devices and component technologies, radio frequency through terahertz circuit integration, nanoelectronics, bioelectronics, energy (including alternate energy sources), power, smart-grid, controls, computation, networking, communications, control, sensing, robotics, and cyber–physical technologies. The division supports fundamental research of novel electronic and photonic devices, the integration of these devices into circuit and system environments, and the networking of intelligent systems at multiple scales for applications in energy, healthcare, disaster mitigation, telecommunications, environment, 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 the next generation of innovative devices and systems.

In general, 81 percent of the ECCS portfolio is comprised of new research grants and 19 percent supports continuing grants.

FY 2017 Summary
All funding decreases/increases represent change over the FY 2016 Estimate.

Research

- CAREER funding increases by $200,000, to a total of $15.27 million, in FY 2017. This increase is consistent with ECCS's emphasis on supporting early-career researchers.
- Support for CIF21 activities will decrease $400,000, to a total of $400,000 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 device and hardware systems era.
- The division's investment in NRI ($2.50 million, unchanged from the FY 2016 Estimate) is part of the NSF-wide CEMMSS portfolio and will support the integration of electronic, mechanical, computing,

sensing devices and systems, controls, and intelligent systems that enable ubiquitous, advanced robotics to be realized.

- In an ongoing collaboration with the Directorate for Computer and Information Science and Engineering (CISE), the division will support research on CPS totaling $4.50 million, unchanged from the FY 2016 Estimate. The ECCS investment is part of the NSF-wide CEMMSS portfolio and will be directed towards the integration of intelligent decision-making algorithms and hardware into physical 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 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.
- Formal support for EARS ends in FY 2016. Building on previous EARS investments through its core and crosscutting programs, ECCS will continue to support and emphasize 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.
- ECCS funding of $5.0 million maintains support for the STC for Energy Efficient Electronics Science, led by the University of California at Berkeley and awarded in FY 2010.
- ECCS support for the NSEC program is maintained at the FY 2016 Estimate, as the program continues to sunset as planned.

Education

- ECCS contributes to a number of education and diversity activities, including REU and CLB. Total ECCS funding for these activities in the FY 2016 Request is $950,000, a reduction of $50,000 from the FY 2016 Estimate.

Infrastructure

- ENG maintains support for infrastructure through investments in the NNCI at the FY 2016 Estimate.

DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC) — $120,320,000 / +$12,710,000 / 11.8%

EEC Funding

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, EEC	**$117.95**	**$107.61**	**$120.32**	**$12.71**	**11.8%**
Research	**91.59**	**82.87**	**95.39**	**12.52**	**15.1%**
Centers Funding (total)	61.57	56.50	61.00	4.50	8.0%
Engineering Research Centers	59.68	56.50	61.00	4.50	8.0%
Nanoscale Science & Engineering Centers	1.04	-	-	-	N/A
Science of Learning Centers	0.85	-	-	-	N/A
Education	**26.36**	**24.74**	**24.93**	**0.19**	**0.8%**

Totals may not add due to rounding. FY 2015 Actual includes $200,000 in carryover from prior fiscal year.

The FY 2017 Budget Request for EEC is $120.32 million, of which $113.50 million is discretionary funding and $6.82 million is new mandatory funding. The mandatory funding is within the research line in the above table.

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 and life sciences and engineering, from nanostructured materials to new device concepts, subsystems, and systems. Applications range across a wide spectrum, including energy, medicine, telecommunications, nanoelectronics, manufacturing, civil infrastructure, the environment, computer networks, cybersecurity, and others. Also included are formal scholarly studies in engineering education and on professional formation of engineers.

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 three categories: (1) Major Centers and Facilities; (2) Engineering Education Research; and (3) Engineering Career Development. The Major Centers and Facilities category is comprised of the signature ERC program and NSECs. They provide the framework for interdisciplinary research and education, development, and technology transfer in partnership with academia, industry, and government. The Engineering Education Research category 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. The Engineering Career Development category includes programs such as REU and Research Experiences for Teachers (RET).

In general, 28 percent of the EEC portfolio is comprised of new research grants. The remaining 72 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 2017 Summary
All funding decreases/increases represent change over the FY 2016 Estimate.

Research

- Support for the ERC program increases by $4.50 million, to a total of $61.0 million. This funding level provides support for 14 existing centers and the addition of four new ones through the FY 2017 competition. 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 device and hardware systems era. EEC's ERC portfolio includes four Nanosystems ERCs: three that were first supported in FY 2012 and one funded as part of the Class of FY 2015.

Education

- In FY 2014, NSF adopted a comprehensive agency-wide framework — IUSE — that consolidates NSF's investments in undergraduate education. While the majority of funding for IUSE is provided through the Directorate for Education and Human Resources (EHR), other NSF directorates contribute directly to this effort, ensuring an enduring connection to established discipline-based activities and expertise. In FY 2017, EEC will contribute $6.0 million towards IUSE-related activities, equal to the FY 2016 Estimate.
- In FY 2017, EEC will continue to support IUSE/Professional Formation of Engineers: REvolutionizing engineering and computer science Departments (IUSE/PFE:RED) to enable 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.
- Funding for the REU Sites program increases by $250,000, 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, who 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 increases by $100,000, 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 to support the agency's broadening participation program NSF INCLUDES.
- Support of NRT, a modernization of the IGERT program, decreases by $90,000, to a total of $2.50 million. The FY 2017 decrease reflects funding of the remaining commitments to IGERT awards.

DIVISION OF INDUSTRIAL INNOVATION AND PARTNERSHIPS (IIP) **$268,900,000**
+$28,970,000 / 12.1%

IIP Funding
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, IIP	**$227.26**	**$239.93**	**$268.90**	**$28.97**	**12.1%**
Research	**226.66**	**239.78**	**268.75**	**28.97**	**12.1%**
SBIR/STTR	177.11	188.56	213.26	24.70	13.1%
Education	**0.60**	**0.15**	**0.15**	**-**	**-**

Totals may not add due to rounding.

The FY 2017 Budget Request for IIP is $268.90 million, of which $254.17 million is discretionary funding and $14.73 million is new mandatory funding. $3.14 million of the mandatory funding is within the research line in the above table. $11.59 million is provided for SBIR/STTR, consistent with the levels specified in the SBIR/STTR Reauthorization Act of 2011 (P.L 112-81), which stipulates 3.0 percent and 0.45 percent of NSF's FY 2017 extramural research funding be allocated to the SBIR and STTR programs, respectively.

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 Federal small business research programs, the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. These innovation research programs leverage academic research findings and build partnerships among small businesses, academia, large companies, and/or other stakeholders with the goal of achieving technology commercialization and enabling new products, processes, or services. SBIR and STTR technology topics draw upon the breadth of NSF scientific and engineering research disciplines and are aligned with national and societal priorities.

IIP supports academic research through three research programs: the Industry/University Cooperative Research Center (I/UCRC) program, the Partnerships for Innovation (PFI) program, and the Grant Opportunities for Academic Liaison with Industry (GOALI) program. 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.

The division also administers, and is a strong intellectual contributor to, the I-Corps™ program. The NSF I-Corps™ program 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, 93 percent of the IIP portfolio is comprised of new research grants and 7 percent supports continuing grants.

FY 2017 Summary
All funding decreases/increases represent change over the FY 2016 Estimate.

Research

- Funding for SBIR/STTR increases by $24.70 million, to a total of $213.26 million, consistent with the levels specified in the SBIR/STTR Reauthorization Act of 2011 (P.L 112-81), which stipulates 3.0 percent and 0.45 percent of NSF's FY 2017 extramural research funding be allocated to the SBIR and STTR programs, respectively. Increased support for SBIR/STTR will (1) provide more resources to the small business community to embark on cutting-edge, high-risk, and high-impact research projects; and (2) provide an opportunity for greater collaboration with the disciplinary divisions across NSF in the spirit of catalyzing technology commercialization of discovery research.
- Funding for the PFI program increases by $500,000, to a total of $22.0 million. The PFI program is an umbrella for two complementary components. The Building Innovation Capacity (BIC) component supports academic–industry partnerships that are led by an interdisciplinary academic research team with at least one industry partner. Through partnerships, BIC partners collaborate in the integration of technologies inspired by breakthrough discoveries into a specified human-centered smart service system with the potential to achieve transformational change in an existing service system or to spur an entirely new service system. The Accelerating Innovation Research (AIR) component is designed to enable research discoveries to be translated along a path toward commercial reality while engaging faculty and students in entrepreneurial and market-oriented thinking, leveraging prior NSF investments, and providing NSF-funded research alliances the opportunity to develop academic-based innovation ecosystems.
- Funding for the I-Corps™ program is maintained at $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, 534 Teams have completed this experiential education, and approximately 45 percent of these Teams have started their own companies, and two of these companies have been acquired.
- Funding for I/UCRC increases by $500,000, to a total of $12.50 million. Support will emphasize topics related to advanced manufacturing, clean energy, and cyberinfrastructure, in line with NSF investments in CEMMSS, clean energy technology, and CIF21. Funding will also support REU, which will further enhance the educational impact of I/UCRCs by preparing students for innovation leadership in a globally competitive marketplace through opportunities to work closely with industry.
- IIP's support for GOALI increases by $130,000, to a total of $5.0 million. The program promotes university–industry partnerships by making project funds or fellowships/traineeships available to support an eclectic mix of industry–university linkages across the Foundation.

Education

- Support for the REU program, at $150,000, remains the same as the FY 2016 Estimate.

OFFICE OF EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES (EFMA) **$58,400,000 +$3,910,000 / 7.2%**

EFMA Funding

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate Amount	Change Over FY 2016 Estimate Percent
Total, EFMA	**$53.41**	**$54.49**	**$58.40**	**$3.91**	**7.2%**
Research	**45.09**	**46.13**	**50.04**	**3.91**	**8.5%**
Centers Funding (total)	0.02	-	-	-	N/A
Engineering Research Centers	0.02	-	-	-	N/A
Education	**3.32**	**3.36**	**3.36**	**-**	**-**
Infrastructure	**5.00**	**5.00**	**5.00**	**-**	**-**
CHESS	5.00	5.00	5.00	-	-

Totals may not add due to rounding. FY 2015 Actual includes $3.19 million in carryover from prior fiscal year.

The FY 2017 Budget Request for EFMA is $58.40 million, of which $55.09 million is discretionary funding and $3.31 million is new mandatory funding. The mandatory funding is within the research line in the above table.

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 Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE) and 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 will 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 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.

In FY 2014 – FY 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 (2D) 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, EFRI is investing in two new topic areas. The first topic, Advancing Communication Quantum Information Research in Engineering (ACQUIRE), aims to enhance secure, scalable, and efficient data communication. ACQUIRE researchers will investigate 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 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.

EFMA launched a consortium in FY 2015 to identify emerging areas of advanced manufacturing that would benefit from shared public–private investment in research and development, education, and training: the Alliance for Manufacturing Foresight. As recommended by the President's Council of Advisors on Science and Technology in its 2014 report, *Accelerating U.S. Advanced Manufacturing*,[5] the consortium will provide a channel for rapid input from industrial, academic and other private sectors on future manufacturing technologies. It will help align advanced manufacturing research with national priorities and challenges to ensure efficient use of federal and private funding for the greatest possible return on investment.

In FY 2015, EFMA also awarded a two-year grant to the National Academies of Science to study what future models for center-based, multidisciplinary engineering research, education and innovation could be most effective in a shifting global landscape. The study will encompass potential future opportunities, missions, measures and models for engineering research centers, and will evaluate center designs and features, such as partnerships, for their ability to achieve breakthrough discoveries and innovations and to prepare an inclusive, innovative engineering workforce.

In FY 2015, EFMA funded the Exploring Innovation Frontiers Initiative (EIFI), a two-year study to identify the emerging models of technological innovation that will propel U.S. competitiveness through rapid change in the coming decades. EIFI will also explore methods for tapping into the Nation's innovation capacity, nurturing new talent and ideas, translating innovation into widespread prosperity, and growing national and regional economies.

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 2017 Summary
All funding decreases/increases represent change over the FY 2016 Estimate.

Research

- FY 2017 EFRI support increases by $500,000, to a total of $31.75 million, and will provide support for up to 16 interdisciplinary team projects aimed at addressing national challenges such as renewable energy, advanced manufacturing, and secure communication systems.
- An increase of $3.41 million, to a total of $15.63 million, is provided to support new and ongoing NSF-wide multidisciplinary investments and other important national priorities. This amount includes $2.50 million to enable researchers to formulate high-impact research ideas with the potential for transformative impacts on national needs and grand challenges. In FY 2016, ENG announced a Dear

[5] www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/amp20_report_final.pdf

Colleague Letter through EFMA for Germination of Research Ideas for Large Opportunities and Critical Societal Needs (GERMINATION). The DCL seeks EAGER (EArly-concept Grants for Exploratory Research) proposals with exploratory ideas to design learning frameworks, platforms and/or environments to enable early- and mid-career faculty, as well as graduate students and post-doctoral fellows to conceive research ideas and questions with potentially transformative outcomes. In FY 2017, ENG will continue to enable researchers to expand the long-term impacts of ENG's basic research investment.

Education

- EFMA support for the ADVANCE and REU programs are maintained at the FY 2016 Estimate of $3.26 million and $10,000, respectively.

Infrastructure

- EFMA maintains support for infrastructure through investment in CHESS.