DIRECTORATE FOR ENGINEERING (ENG) **$916,790,000**
+ $154,940,000 / 20.3%

ENG Funding[1]
(Dollars in Millions)

	FY 2020 Actual	FY 2020 CARES Act Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Chemical, Bioengineering, Environmental and Transport Systems (CBET)	$197.92	$7.70	$199.96	$241.05	$41.09	20.5%
Civil, Mechanical, and Manufacturing Innovation (CMMI)	238.58	3.75	241.13	290.50	49.37	20.5%
Electrical, Communications, and Cyber Systems (ECCS)	122.86	1.50	124.05	149.52	25.47	20.5%
Engineering Education and Centers (EEC)	124.06	1.30	125.02	149.30	24.28	19.4%
Emerging Frontiers and Multidisciplinary Activities (EFMA)	70.88	0.75	71.69	86.42	14.73	20.5%
Total	**$754.31**	**$15.00**	**$761.85**	**$916.79**	**$154.94**	**20.3%**

[1] The Division of Industrial Innovation and Partnerships (IIP) will be dissolved in FY 2022, with the bulk of its programs moving to the new Directorate for Technology, Innovation, and Partnerships (TIP) and the remainder to EEC. Funding above is presented in the new structure across all fiscal years for comparability. See the R&RA Overview for more details.

About ENG

In FY 2022, ENG will spur engineering breakthroughs to help ensure America's security, prosperity, health, and technological leadership in the future. ENG will invest in groundbreaking fundamental engineering research and in key Administration and NSF-wide research priorities. Substantial directorate investments—in cross NSF priority areas as well as the fourth generation of NSF Engineering Research Centers (ERCs)—will emphasize convergence research approaches to help address grand challenges and achieve societal impact. In addition, to advance U.S. global competitiveness, strategic ENG support will strengthen the engineering workforce and accelerate the translation of technological innovations.

To accelerate the translation of research results towards commercial and societal benefits, ENG will build on its long tradition of partnerships, with industry and other government agencies and laboratories, including both direct and indirect partnerships (e.g., ERC, IUCRC, GOALI). Working together with the new TIP directorate, ENG will spur the engineering research community to follow existing well-established pathways towards technology translation, including I-Corps, PFI, and SBIR/STTR. In addition, ENG will work closely with TIP to develop new translation pathways, building on and enhancing existing successes in our center programs (ERC and IUCRC). Research results coming out of mid-size ENG research awards create new opportunities that are ripe for translational impact.

ENG funding in FY 2022 will help protect Americans through the continuation of its long-term support for engineering research to improve resilience to hurricanes, earthquakes, and other disasters, including the Natural Hazards Engineering Research Infrastructure (NHERI). ENG will help secure and advance communications, computing, and sensing through investments in QIS-related programs for quantum technologies and systems. Other ENG-funded research will investigate methods and technologies for protecting the electric grid, understanding online influence and misinformation, detecting biological threats, and disrupting illicit supply networks.

ENG FY 2022 investments will build future prosperity through essential contributions to research on advanced manufacturing and supply chains, new materials and semiconductor technologies, and clean energy. The directorate will support advances in robotics, AI, and smart and autonomous systems, and will

continue stewardship of the FW-HTF Big Idea. ENG will also invest in disruptive technologies in support of HDR, energy-efficient computing and spectrum-efficient advanced wireless systems. Funding for NNA and other programs across ENG will help ensure sustainable and reliable infrastructure systems through, for example, sensor systems to understand soil dynamics, complex models of food-energy-water systems, and eco-friendly building materials and designs.

There will also be great emphasis placed on supporting racial equity efforts. ENG, together with other NSF directorates and offices, will invest in research, education, and workforce development that remove barriers, build capacity, and foster partnerships. ENG will increase investment in the Broadening Participation in Engineering program, grow mentoring and professional development activities, support collaborations with MSIs, and promote systemic changes that enhance diversity, equity, and inclusion in engineering.

ENG support will advance health technologies and systems through investment in fundamental research to observe nanoscale cellular processes and changes, engineering biology to reverse disease and produce therapies, and synthetic biology to advance URoL and a wide array of biotechnologies. The directorate also will support research on the transport of contaminants and pathogens (bacteria, viruses, or other microbes) in natural and built environments, methods to detect and monitor their presence, and the prevention and understanding of their impacts on the community and ecology. Engineering investments will continue advances in prosthetic and assistive technologies for veterans, senior citizens, and people with disabilities.

While fundamental engineering research fuels U.S. technological innovation and competitiveness, ENG support for workforce development and innovation speeds and strengthens the translation of discoveries. The directorate will invest in research on education, broadening participation, equity, and inclusion in engineering, as well as in student experiences with industry. ENG will maintain its commitment to talented students and faculty through programs supporting transitions between career stages, investment in CAREER, and opportunities for mid-size, interdisciplinary team research. ENG investments in academic partnerships with industry will help bring new ideas from lab to market and fortify the Nation's innovation ecosystem.

As part of the FW-HTF Big Idea, and in partnership with the other research directorates and offices, ENG will support convergence activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. While financial stewardship for this investment will be the responsibility of ENG, the convergence activities will be overseen and managed collaboratively by the multi-directorate/office FW-HTF leadership team. These activities will enable pursuit of fundamental research on advancing cognitive and physical capabilities in the context of human-technology interactions and the development of a 21st-century workforce capable of adapting to a changing employment landscape.

ENG provides 39 percent of the federal funding for basic research at academic institutions in the engineering disciplines.

Major Investments

ENG Major Investments

(Dollars in Millions)

Area of Investment[1,2]	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Advanced Manufacturing	$127.99	$117.37	$174.37	$57.00	48.6%
Advanced Wireless Research	24.36	23.45	25.80	2.35	10.0%
Artificial Intelligence	91.47	87.15	95.80	8.65	9.9%
Biotechnology	92.76	90.94	101.50	10.56	11.6%
Climate: Clean Energy Technnology	113.54	123.03	178.57	55.54	45.1%
Improving Undergraduate STEM Education	7.14	5.00	5.15	0.15	3.0%
Microelectronics & Semiconductors	30.43	34.77	40.00	5.23	15.0%
Quantum Information Science	23.83	27.89	32.89	5.00	17.9%
Secure & Trustworthy Cyberspace	3.25	3.25	3.25	-	-
NSF's Big Ideas					
FW-HTF Stewardship	*30.00*	*30.00*	*30.00*	-	-

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

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

- Advanced Manufacturing: ENG research accelerates advances in manufacturing with emphasis on multidisciplinary research that fundamentally alters and transforms manufacturing capabilities, methods, and practices. The FY 2022 Request includes $24.0 million in support of Future Manufacturing research under the advanced manufacturing umbrella. Future manufacturing is defined as fundamental research to enable manufacturing that (a) does not exist or is not possible today or (b) exists or is possible only at such small scales that it is not viable for mass production. Continued investments in advanced manufacturing include research on highly connected cyber-physical systems in smart processing and cyber manufacturing systems, and activities that develop new methods, processes, analyses, tools, or equipment for new or existing manufacturing products, supply chain components, or materials. ENG's investments will enable new functionalities that will increase the efficiency and sustainability of the production of the next generation of products and services. These developments will yield advantages such as reduced time to market, new performance attributes, improved small-batch production, cost and energy savings, and reduced environmental impact from the manufacturing of products.
- Advanced Wireless: ENG, together with other NSF directorates and offices, will invest in fundamental research, infrastructure, and education to advance knowledge gaps and innovate in areas critical to future generations of wireless technologies and networks beyond 5G to help make wireless communication faster, smarter, more responsive, and more robust. ENG funding will enable new wireless sensors, devices, circuits, protocols, networks, and systems; artificial intelligence and inference on mobile devices; human-machine-network interactions; dynamic spectrum allocation and sharing; and the integration of future wireless with energy, transportation, manufacturing, and other systems involving the internet-of-things.
- AI: ENG, together with other NSF directorates and offices, will increase support for AI research and development. A key focal point will be support for AI Institutes, a center-scale activity that will span (a) foundational areas of machine learning, computer vision, natural language processing, and autonomy, along with safety, security, robustness, and explainability of AI systems; (b) translational research at the intersection of AI and various science and engineering domains supported by NSF as

well as sectors such as agriculture, advanced manufacturing, transportation, and personalized medicine; (c) workforce development, including growing human capital and institutional capacity to nurture a new generation of ethical AI researchers and practitioners; and (d) advanced computing infrastructure, including access to data and computing capabilities.

- Biotechnology: ENG, together with other NSF directorates and offices, will invest in fundamental research, infrastructure, and education to understand and harness biological processes for societal benefit. ENG investment areas related to biotechnology include synthetic biology, engineering biology, metabolic engineering, tissue engineering, biomechanics, the microbiome, and the development of new types of biomaterials, bio-based microelectronics, and biomanufacturing. ENG also supports research on the social and environmental implications of synthetic biology and other biotechnologies. ENG investments will enable future innovations in the health therapeutics, biopharmaceutical, biochemical, and biotechnology industries.
- Clean Energy Technology: ENG, together with other NSF directorates and offices, will invest in fundamental research to advance clean energy technologies that are sustainable, reduce or mitigate the impacts of climate change, and improve human and community resiliency. ENG supports research on renewable and alternative energy sources, manufacturing, storage, distribution, and management, including smart grids, transmission and conversion systems, grid-scale energy storage, and carbon capture. ENG also supports the development of energy materials, use and efficiency, including low-power and green electronics, energy-intelligent and sustainable computing and communication systems, eco-manufacturing of materials and chemicals, and the remediation and reduction of legacy pollution, as well as societal and environmental aspects of clean energy.
- IUSE: ENG's investment in the NSF-wide IUSE initiative, which integrates the agency's investments in undergraduate education, will continue as support for the IUSE/Professional Formation of Engineers: Revolutionizing Engineering Departments (PFE:RED) solicitation. PFE:RED enables research and innovations leading to and propagating interventions that improve both the quality and quantity of engineering graduates.
- Microelectronics and Semiconductors: ENG, together with other NSF directorates and offices, will support research to address fundamental science and engineering questions on the concepts, materials, devices, circuits, and platforms necessary to sustain progress in semiconductor and microelectronic technologies. Research in semiconductors and microelectronics is critical to future advances and security in information technology, communications, sensing, smart electric grid, transportation, health, advanced manufacturing, and other areas. The investment will strengthen U.S. capabilities and capacity for revolutionary microelectronics design, architecture, and fabrication, as well as high-performance computing. New discoveries will enable the nation to overcome crucial scientific barriers for emerging technologies such as artificial intelligence, quantum technologies, and interconnected autonomous systems, and they will strengthen U.S. scientific leadership, economic prosperity, and national security.
- QIS: ENG, together with other NSF directorates and offices, will increase support for quantum information science and engineering research. ENG's QIS investments strongly align with the *National Quantum Initiative Act* (P.L. 115-368) to consolidate and expand U.S. global leadership in fundamental quantum research. QIS research will deliver proof-of-concept devices, applications, tools, or systems with a demonstrable quantum advantage over their classical counterparts. Research in QIS examines uniquely quantum phenomena that can be harnessed to advance information processing, transmission, measurement, and fundamental understanding in ways that classical approaches can only do much less efficiently, or not at all. Current and future QIS applications differ from prior applications of quantum mechanics, such as the laser, transistor, and magnetic resonance imaging, by using distinct quantum phenomena—superposition and entanglement—that do not have classical counterparts. QIS research activities will also address education and workforce development needs, with specific investments in Minority Serving Institutions (MSIs), broadening research collaborations, promoting innovative team-building activities, and stimulating cross-disciplinary curriculum development and training to provide a quantum-smart workforce.

- SaTC: ENG support for SaTC will focus on the engineering aspects of the NITRD Strategic Plan for the Federal Cybersecurity Research and Development Program.[1] NITRD's research thrusts cover a set of interrelated priorities for U.S. government agencies that conduct or sponsor research and development in cybersecurity.
- FW-HTF: ENG will continue to steward the FW-HTF Big Idea. While financial stewardship for this Emerging Frontiers and Multidisciplinary Activities (EFMA) investment will be the responsibility of ENG, the convergence activities will be overseen and managed collaboratively by the multi-directorate/office FW-HTF leadership team. ENG will work closely with OIA's Convergence Accelerator (CA) for the area of FW-HTF, building on collaborative design of the CA model that draws on ENG experience in technology translation and partnerships.

ENG Funding for Centers Programs

ENG Funding for Centers Programs

(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Engineering Research Centers (EEC)	$54.61	$56.90	$68.70	$11.80	20.7%
National Artificial Intelligence Research Institutes (Multiple)	5.00	9.05	9.25	0.20	2.2%
STC: Emergent Behaviors for Integrated Cellular Systems (CBET)[1]	1.30	-	-	-	N/A
STC: Engineering Mechano-Biology (CMMI)	4.95	5.00	5.00	-	-
STC: Energy Efficient Electronics Sytems (ECCS)[1]	1.30	-	-	-	N/A
Total	**$67.16**	**$70.95**	**$82.95**	**$12.00**	**16.9%**

[1] NSF's support for 2010 class of STCs concluded in FY 2020 as planned.

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

[1] www.nitrd.gov/pubs/FY2019-Cybersecurity-RD-Roadmap.pdf

Funding Profile

ENG Funding Profile

	FY 2020 Actual Estimate	FY 2021 Estimate	FY 2022 Estimate
Statistics for Competitive Awards:			
Number of Proposals	6,358	6,400	7,400
Number of New Awards	1,633	1,520	1,750
Regular Appropriation	1,516	1,520	1,750
CARES Act	117		
Funding Rate	26%	24%	24%
Statistics for Research Grants:			
Number of Research Grant Proposals	5,852	5,900	6,800
Number of Research Grants	1,460	1,360	1,560
Regular Appropriation	1,343	1,360	1,560
CARES Act	117		
Funding Rate	25%	23%	23%
Median Annualized Award Size	$134,479	$134,500	$135,000
Average Annualized Award Size	$164,737	$165,000	$166,000
Average Award Duration, in years	3.1	3.1	3.1

ENG investments support fundamental engineering research, engineering education, and innovation, as well as research infrastructure such as facilities. In FY 2022, funding for centers accounts for approximately nine percent of ENG's Request.

Program Monitoring and Evaluation

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

People Involved in ENG Activities

Number of People Involved in ENG Activities

	FY 2020 Actual Estimate	FY 2020 CARES Act Actual Estimate	FY 2021 Estimate	FY 2022 Estimate
Senior Researchers	7,066	183	7,100	8,200
Other Professionals	662	22	670	800
Postdoctoral Associates	411	28	420	450
Graduate Students	7,044	136	7,100	8,200
Undergraduate Students	3,899	26	4,000	4,600
Total Number of People	**19,082**	**395**	**19,290**	**22,250**

DIVISION OF CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, AND TRANSPORT SYSTEMS (CBET) **$241,050,000 +$41,090,000 / 20.5%**

CBET Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Total	**$197.92**	**$199.96**	**$241.05**	**$41.09**	**20.5%**
Research	**193.45**	**194.87**	**235.76**	**40.89**	**21.0%**
CAREER	46.74	38.00	45.60	7.60	20.0%
Centers Funding (total)	2.30	1.30	1.30	-	-
Artificial Intelligence Research Institutes	1.00	1.30	1.30	-	-
STC: Emergent Behaviors for Integrated Cellular Systems	1.30	-	-	-	N/A
Education	**0.79**	**1.40**	**1.60**	**0.20**	**14.3%**
Infrastructure	**3.68**	**3.69**	**3.69**	**-**	**-**
National Nanotechnology Coordinated Infrastructure (NNCI)	3.68	3.69	3.69	-	-

About CBET

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.

CBET also contributes to the directorate's annual operations support of NSF facilities such as NNCI.

In general, 84 percent of the CBET portfolio is available to support new research grants. The remaining 16 percent supports research grants made in prior years.

DIVISION OF CIVIL, MECHANICAL, AND MANUFACTURING INNOVATION (CMMI) **$290,500,000**
+$49,370,000 / 20.5%

CMMI Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Total	**$238.58**	**$241.13**	**$290.50**	**$49.37**	**20.5%**
Research	**219.95**	**224.58**	**273.30**	**48.72**	**21.7%**
CAREER	46.22	28.00	33.60	5.60	20.0%
Centers Funding (total)	6.75	8.75	8.75	-	-
Artificial Intelligence Research Institutes	1.80	3.75	3.75	-	-
STC: Engineering Mechano-Biology	4.95	5.00	5.00	-	-
Education	**2.90**	**2.10**	**2.50**	**0.40**	**19.0%**
Infrastructure	**15.74**	**14.45**	**14.70**	**0.25**	**1.7%**
Natural Hazards Engineering Research Infrastructure (NHERI)	13.04	11.75	12.00	0.25	2.1%
Center for High Energy X-ray Science (CHEXS)	0.80	0.80	0.80	-	-
National Nanotechnology Coordinated Infrastructure (NNCI)	1.90	1.90	1.90	-	-

About CMMI

CMMI funds fundamental research that advances 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 cross-cutting technologies such as adaptive systems, artificial intelligence, robotics, nanotechnology, and high-performance computational modeling and simulation.

The division supports cross-disciplinary research partnerships at the intersections of traditional research disciplines to achieve transformative research results. CMMI investments create innovative manufacturing technology that does not exist today (such as future manufacturing); 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.

CMMI also provides funding and management of NHERI and contributes to the directorate's annual operations support of the NNCI and CHEX/S facilities.

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

DIVISION OF ELECTRICAL, COMMUNICATIONS, AND CYBER SYSTEMS (ECCS) **$149,520,000**
+$25,470,000 / 20.5%

ECCS Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Total	**$122.86**	**$124.05**	**$149.52**	**$25.47**	**20.5%**
Research	**116.27**	**117.91**	**143.21**	**25.30**	**21.5%**
CAREER	21.77	15.50	18.60	3.10	20.0%
Centers Funding (total)	2.75	2.70	2.70	-	-
Artificial Intelligence Research Institutes	1.45	2.70	2.70	-	-
STC: Energy Efficient Electronics Systems	1.30	-	-	-	N/A
Education	**1.15**	**0.80**	**0.97**	**0.17**	**21.3%**
Infrastructure	**5.44**	**5.34**	**5.34**	**-**	**-**
Center for High Energy X-ray Science (CHEXS)	0.10	0.10	0.10	-	-
National Nanotechnology Coordinated Infrastructure (NNCI)	5.34	5.24	5.24	-	-

About ECCS

ECCS supports enabling and transformative research at the nano, micro, and macro scales that fuels progress in engineering system applications with high societal impacts. The division's programs encompass novel electronic, photonic, quantum, and magnetic devices (such as low-power and secure semiconductor technologies) and the integration of these devices into circuit and system environments, intelligent systems, control, and networks.

ECCS investments in artificial intelligence research for real-time learning and decision-making will help enable safe, reliable, and efficient data-enabled engineering systems. Breakthroughs in devices and systems advance applications spanning quantum, cyber and communications technologies (such as advanced wireless networks, spectrum efficiency and security), energy and power, healthcare, transportation, robotics, advanced manufacturing, and other systems-related areas.

The division also provides funding, in partnership with other NSF directorates, and management of the National Nanotechnology Coordinated Infrastructure (NNCI) and contributes to the directorate's annual operations support of the CHEX/S facility.

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

DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC) **$149,300,000**
+$24,280,000 / 19.4%

EEC Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Total	**$124.06**	**$125.02**	**$149.30**	**$24.28**	**19.4%**
Research	**107.89**	**109.02**	**130.10**	**21.08**	**19.3%**
CAREER	0.83	-	-	-	N/A
Centers Funding (total)	55.36	58.20	70.20	12.00	20.6%
Artificial Intelligence Research Institutes	0.75	1.30	1.50	0.20	15.4%
Engineering Research Centers (EEC)	54.61	56.90	68.70	11.80	20.7%
Education	**16.17**	**16.00**	**19.20**	**3.20**	**20.0%**

About EEC

EEC integrates disciplinary basic research and education conducted in other ENG divisions and across NSF into strategic frameworks that address societal grand challenges and promote innovation. Research included in the EEC portfolio spans engineering and involves the physical, life, and social and behavioral sciences. Applications range across a wide spectrum, such as energy and the environment; health and biotechnology; communications, quantum, and computer systems; nano- and microelectronics; manufacturing; civil infrastructure; and others.

The complex, integrative role of EEC requires a comprehensive set of programs for centers, networks, and people. EEC funds formal scholarly studies in the professional formation of engineers, which can lead to innovations in engineering education and career development, and in broadening participation in engineering. Creative and effective approaches to developing a diverse and inclusive engineering workforce are vital, as a lack of properly prepared engineers is a critical barrier to a robust U.S. economy. EEC invests in faculty, graduate and undergraduate students, post-doctoral scholars, and K–12 teachers. As nontraditional students comprise more than 70 percent of the general undergraduate population, EEC is also defining alternative pathways for these students, especially veterans, to successfully earn degrees in engineering.

The programs in EEC are managed within four clusters: (1) Centers and Networks; (2) Engineering Education Research; (3) Engineering Workforce Development; and (4) Broadening Participation in Engineering. The Centers and Networks cluster includes the signature Engineering Research Centers (ERC) and Industry–University Cooperative Research Centers (IUCRC) programs.

The ERC program provides a framework for interdisciplinary research and education, development, and technology transfer in partnership with academia, industry, and government. The FY 2022 funding level supports 15 centers. The total includes funding to support four 4th-generation (Gen-4) that advance convergence engineering research to tackle high-impact challenges that have the potential to benefit U.S. security, prosperity, health, and society. Gen-4 ERCs implement strategies for effective team formation, diversity and inclusion, and engagement with stakeholder communities to maximize their impacts. The IUCRC program develops long-term partnerships among industry, academe, and government. IUCRCs are catalyzed by NSF investment and are primarily supported by membership fees from industry and government labs, with NSF taking a supporting role in the development of the Center. Each Center conducts fundamental research that is of interest to both the members and the Center faculty. IUCRCs contribute to the nation's research infrastructure base and enhance the intellectual capacity of the engineering and science

workforce through the integration of research and education.

Engineering Education programs advance new productive engineering pedagogy and learning strategies in traditional and non-traditional environments. This cluster also includes EEC's participation in the NSF-wide activity, IUSE, which integrates the agency's investments in undergraduate education.

Engineering Workforce Development includes programs such as Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET), as well as support for Grant Opportunities for Academic Liaison with Industry (GOALI)/Non-Academic Research Internships for Graduate Students (INTERN), which stimulate university partnerships with non-academic organizations, including small and large companies, other government agencies, and non-profit organizations, and enable professional development.

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 cluster also includes EEC's engagement with the NSF INCLUDES Big Idea, which integrates the agency's investments to build on and scale up what works in broadening participation programs.

In general, 24 percent of the EEC portfolio is comprised of new research grants. The remaining 76 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.

OFFICE OF EMERGING FRONTIERS AND MULTIDISCIPLINARY ACTIVITIES (EFMA) **$86,420,000**
+$14,730,000 / 20.5%

EFMA Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Percent
Total	**$70.88**	**$71.69**	**$86.42**	**$14.73**	**20.5%**
Research	**70.72**	**71.49**	**86.20**	**14.71**	**20.6%**
CAREER	0.04	-	-	-	N/A
Education	**0.06**	**0.10**	**0.12**	**0.02**	**20.0%**
Infrastructure	**0.10**	**0.10**	**0.10**	**-**	**-**
Center for High Energy X-ray Science (CHEXS)	0.10	0.10	0.10	-	-

About EFMA

EFMA strategically pursues and supports projects in important emerging areas. The office has the necessary flexibility to target long-term challenges and to adapt as new challenges arise.

A central activity of EFMA is the Emerging Frontiers in Research and Innovation (EFRI) program. Each year EFRI funds interdisciplinary projects at the frontiers of engineering with potential for major impacts on national needs and/or grand challenges, 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.

In FY 2020 and FY 2021, EFMA invested in two EFRI topics: Distributed Chemical Manufacturing (DCheM) to enable the development of modular process plants that take advantage of distributed feedstocks and product delivery needs or address environmental remediation problems at the source; and Engineering the Elimination of End-of-Life Plastics (E3P) to create a scientific foundation for viable solutions to the capture, management, and elimination of end-of-use plastics. In FY 2022 and FY 2023, EFMA will invest in two new EFRI topics:

- Brain-Inspired Dynamics for Engineering Energy-Efficient Circuits and Artificial Intelligence (BRAID) will build on recent advances in neuroscience to stimulate and transform innovations in AI and engineered learning systems.
- Engineered Living Systems (ELiS) will foster research to advance the design, fabrication, manufacturing and modeling of engineered systems that incorporate living materials in order to address societal needs, with a focus on sustainable engineering.

EFMA invests in high-impact multidisciplinary education and learning platform programs, such as Germination of Research Ideas for Large Opportunities and Critical Societal Needs (GERMINATION), Research Experience and Mentoring (REM) and REU supplements. The office also supports special activities such as the Engineering Research Visioning Alliance, which convenes the engineering community to identify important engineering research challenges and opportunities. EFMA also contributes to the directorate's annual operations support of NSF facilities such as CHEX/S.

Funding for the FW-HTF Big Idea ($30.0 million) supports convergence activities that transcend the traditional disciplinary boundaries of individual NSF directorates and offices. Financial stewardship for this NSF investment is the responsibility of ENG and is managed by EFMA. The convergence activities are overseen and managed collaboratively by the multi-directorate/office FW-HTF leadership team. These ongoing activities are designed to enable pursuit of fundamental research on advancing cognitive and

physical capabilities in the context of human-technology interactions, and the development of a 21st century workforce capable of adapting to a changing employment landscape.

In general, 92 percent of the EFMA portfolio is comprised of new research grants, and about 8 percent supports continuing increments for grants made in previous years.