DIRECTORATE FOR ENGINEERING (ENG)

$940,280,000
+$175,850,000 / 23.0%

ENG Funding[1]
(Dollars in Millions)

	FY 2021 Actual	FY 2021 ARP Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Change over FY 2021 Actual Percent
Chemical, Bioengineering, Environmental and Transport Systems (CBET)	$199.87	-	-	$226.17	$26.30	13.2%
Civil, Mechanical, and Manufacturing Innovation (CMMI)	241.58	3.00	-	265.86	24.28	10.1%
Electrical, Communications, and Cyber Systems (ECCS)	124.00	-	-	137.20	13.20	10.6%
Engineering Education and Centers (EEC)	127.23	-	-	144.46	17.23	13.5%
Emerging Frontiers and Multidisciplinary Activities (EFMA)	71.76	-	-	166.59	94.83	132.1%
Total	**$764.44**	**$3.00**	**-**	**$940.28**	**$175.84**	**23.0%**

[1] The Division of Industrial Innovation and Partnerships (IIP) was 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.

About ENG

In FY 2023, 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 economic 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, Industry–University Cooperative Research Centers (IUCRC), Grant Opportunities for Academic Liaison with Industry (GOALI)). Working with the new TIP directorate, ENG will spur the engineering research community to follow existing well-established pathways towards technology translation, including I-Corps™, Partnerships for Innovation (PFI), and Small Business Innovation Research and Small Business Technology Transfer (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 2023 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 2023 investments will build future prosperity through essential contributions to research on advanced manufacturing and supply chains, new materials and semiconductor technologies, and clean energy and climate change adaptation and mitigation. 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 microelectronics and 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.

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.

ENG will also emphasize support for 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.

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 engineering 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, and opportunities for mid-size, interdisciplinary team research. ENG investments in academic partnerships and professional development opportunities with industry will help bring new ideas from lab to market and fortify the Nation’s innovation ecosystem.

ENG provides 42 percent of 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 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Change over FY 2021 Actual Percent
Advanced Manufacturing	$123.65	-	$174.37	$50.72	41.0%
Advanced Wireless Research	25.83	-	27.75	1.92	7.4%
Artificial Intelligence	85.86	-	95.80	9.94	11.6%
Biotechnology	86.77	-	101.50	14.73	17.0%
Climate: Clean Energy Technology[3]	143.38	-	223.57	80.19	55.9%
Improving Undergraduate STEM Education	-	-	5.15	5.15	N/A
Microelectronics/Semiconductors	43.07	-	46.00	2.93	6.8%
Postdoctoral Fellows	-	-	15.00	15.00	N/A
Quantum Information Science	21.31	-	32.89	11.58	54.3%
Secure & Trustworthy Cyberspace	3.25	-	3.25	-	-

[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.

[3] Funding includes resources for agency-wide initiatives.

- 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 2023 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, engineered living systems, 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, capacity, and workforce 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.
- Postdoctoral Fellowships: The Engineering Postdoctoral Fellowships Program (eFellows) places early-career PhDs in engineering fields in university research postdoctoral fellowships. In addition to hands-on academic research with a faculty advisor, each fellowship cohort will participate in professional development and mentoring activities designed to prepare them for future research careers. The eFellows program will focus support on postdoctoral Fellows who will broaden the participation of groups that are underrepresented in ENG fields in the U.S. including women,

Blacks or African Americans, Hispanics, Latinos, Native Americans, Alaska Natives, Native Hawaiians, and other Native Pacific Islanders as future leaders in ENG fields.

- 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. QIS activities will also address education and workforce development needs.
- 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.

ENG Funding for Centers Programs

ENG Funding for Centers Programs
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Change over FY 2021 Actual Percent
National Artificial Intelligence Research Institutes (Multiple)	$8.18	-	$9.20	$1.02	12.5%
Engineering Research Centers (ERC)	56.26	-	71.50	15.24	27.1%
STC: Emergent Behaviors for Integrated Cellular Systems (CBET)	-	-	5.00	5.00	N/A
STC: Engineering Mechano-Biology (CMMI)	2.74	-	5.00	2.26	82.7%

For detailed information on individual centers programs, please see the Cross Theme Topics section of the NSF-Wide Investments chapter.

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

Funding Profile

ENG Funding Profile

	FY 2021 Actual Estimate	FY 2022 (TBD)	FY 2023 Estimate
Statistics for Competitive Awards:			
Number of Proposals	7,270	-	8,100
Number of New Awards	1,471	-	1,750
Regular Appropriation	1,466	-	1,750
ARP	5		
Funding Rate	20%	-	22%
Statistics for Research Grants:			
Number of Research Grant Proposals	6,877	-	7,500
Number of Research Grants	1,337	-	1,600
Regular Appropriation	1,332	-	1,600
ARP	5		
Funding Rate	19%	-	21%
Median Annualized Award Size	$127,582	-	$130,000
Average Annualized Award Size	$161,514	-	$165,000
Average Award Duration, in years	3.4	-	3.4

ENG investments support fundamental engineering research, engineering education, and innovation, as well as research infrastructure such as facilities. In FY 2023, funding for centers accounts for over nine percent of ENG's Request.

People Involved in ENG Activities

Number of People Involved in ENG Activities

	FY 2021 Actual Estimate	FY 2021 ARP Actual Estimate	FY 2022 (TBD)	FY 2023 Estimate
Senior Researchers	7,274	15	-	8,500
Other Professionals	739	-	-	850
Postdoctoral Associates	371	-	-	430
Graduate Students	7,376	24	-	8,850
Undergraduate Students	4,507	12	-	5,400
Total Number of People	**20,267**	**51**	**-**	**24,030**

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

$226,170,000
+$26,310,000 / 13.2%

CBET Funding
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over Amount	Change over Percent
Total	**$199.87**	**-**	**$226.17**	**$26.30**	**13.2%**
Research	**194.91**	**-**	**220.98**	**26.07**	**13.4%**
CAREER	43.59	-	45.60	2.01	4.6%
Centers Funding (total)	2.73	-	7.00	4.27	156.8%
Artificial Intelligence Research Institutes	2.73	-	2.00	-0.73	-26.6%
STC: Emergent Behaviors for Integrated Cellular Systems	-	-	5.00	5.00	N/A
Education	**1.12**	**-**	**1.50**	**0.38**	**33.4%**
Infrastructure	**3.83**	**-**	**3.69**	**-0.14**	**-3.7%**
National Nanotechnology Coordinated Infrastructure (NNCI)	3.68	-	3.69	0.01	0.3%

About CBET

CBET supports research and education to enhance and protect U.S. national health, energy, food, water, environment, process manufacturing, and security, by investing in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. Through CBET, the physical, chemical, and biological sciences are integrated in engineering research and education, resulting in advances in the rapidly evolving fields of biotechnology, bioengineering, biomanufacturing, advanced materials, environmental engineering, climate adaptation and mitigation, and sustainable clean energy. 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, materials for advanced manufacturing, natural gas and petroleum production, food, textiles, utilities, and microelectronics.

CBET investments support research in three priority areas:

- Climate change-related research increases understanding of climate change impacts and accelerates the creation and use of mitigation and adaptation strategies. Understanding the impacts of climate change includes wildfire, agricultural resilience, urban heat, and water sustainability research. Mitigating climate change includes research on reducing greenhouse gas emissions in the chemical, environmental and energy sectors, as well as carbon capture, utilization, storage, and conversion to useful products. Engineering adaptation to climate change includes research on catalytic remediation of emission process streams, the water-energy nexus, and sustainable systems.
- Clean energy research advances understanding of new energy options (such as hydrogen production, photovoltaics, wind/ocean energy harvesting), methods to decarbonize fuels, energy storage and electricity systems, and sustainability of critical mineral extraction and use.
- Biomanufacturing and biotechnology research supports new understanding and emerging technologies for microphysiological systems, biomaterials, tissue engineering, neuro-engineering, biosensors, and bio-photonic systems.

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, 83 percent of the CBET portfolio is available to support new research grants. The remaining 17 percent supports research grants made in prior years.

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

$265,860,000
+$24,280,000 / 10.1%

CMMI Funding
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Change over FY 2021 Actual Percent
Total	**$241.58**	**-**	**$265.86**	**$24.28**	**10.1%**
Research	**221.78**	**-**	**246.16**	**24.38**	**11.0%**
CAREER	60.52	-	33.60	-26.92	-44.5%
Centers Funding (total)	5.74	-	8.00	2.26	39.4%
Artificial Intelligence Research Institutes	3.00	-	3.00	-	-
STC: Engineering Mechano-Biology	2.74	-	5.00	2.26	82.7%
Education	**3.26**	**-**	**2.40**	**-0.86**	**-26.4%**
Infrastructure	**16.54**	**-**	**17.30**	**0.76**	**4.6%**
Natural Hazards Engineering Research Infrastructure (NHERI)	13.71	-	14.60	0.89	6.5%
Center for High Energy X-ray Science (CHEXS)	0.93	-	0.80	-0.13	-13.5%
National Nanotechnology Coordinated Infrastructure(NNCI)	1.90	-	1.90	-	-

About CMMI

CMMI funds fundamental research and education that advances civil, design, 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 on the built environment and in the context of a socio-technical system. 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, clean manufacturing technology that does not exist today (such as future manufacturing); enable the design and analysis of complex engineered systems; enhance the sustainability, security, and resilience of U.S. infrastructure (for example, buildings, transportation, and communication networks); help protect the Nation from extreme natural disasters and human-induced events; and apply engineering principles to improve the Nation's service and manufacturing enterprise systems, such as healthcare. CMMI also funds research that builds transparency and access to data and data infrastructure to build a robust and accessible cyberinfrastructure for engineering communities.

CMMI invests in the diverse human capital to ensure that high-risk/high-reward research is submitted, recognized, funded, and performed by a research community that reflects the diversity of the Nation. Important division support for this effort includes formal development opportunities for merit review panelists to learn about cognitive biases that affect appreciation for diverse scientific approaches, and special opportunities for researchers to pursue new directions for transformative and equitable advances in engineering.

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

In general, 82 percent of the CMMI portfolio is comprised of new research grants and 12 percent supports continuing grants.

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

$137,200,000
+$13,200,000 / 10.6%

ECCS Funding
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Change over FY 2021 Actual Percent
Total	**$124.00**	**-**	**$137.20**	**$13.20**	**10.6%**
Research	**117.62**	**-**	**130.94**	**13.32**	**11.3%**
CAREER	31.27	-	18.60	-12.67	-40.5%
Centers Funding (total)	1.70	-	2.70	1.00	58.8%
Artificial Intelligence Research Institutes	1.70	-	2.70	1.00	58.8%
Education	**0.88**	**-**	**0.92**	**0.04**	**4.3%**
Infrastructure	**5.49**	**-**	**5.34**	**-0.15**	**-2.8%**
Center for High Energy X-ray Science (CHEXS)	0.10	-	0.10	-	-
National Nanotechnology Coordinated Infrastructure	5.39	-	5.24	-0.15	-2.8%

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, including energy-efficient 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), sensing, energy and power, healthcare, transportation, robotics, advanced manufacturing, and other systems-related areas.

ECCS's investments include three priority areas:

- Sustainable microelectronics research will advance semiconductors for recyclable, green, and secure micro-electronics, quantum engineering, novel photonics, electronic materials and fabrication at the device, chip, wafer, and system levels. Applications include future computing, AI, power electronics, sensing, and communications.
- Secure and resilient power systems research will enable a clean energy future with autonomous, continuous, and secure electric power grids using new advancements in power electronics technologies, machine learning, optimization, and control. It will enable the seamless integration of renewables and electric vehicles with the grid and the use of fair, accountable, and ethical AI for energy-efficient smart homes, smart buildings, and smart transportation.
- Advanced wireless research for 6G communications and beyond will enable high-speed, ubiquitous wireless communications with fundamental research in semiconductor devices, radio-frequency circuits, millimeter wave and terahertz communications, advanced signal processing, and quantum communication. Applications include the internet of things, augmented and virtual reality, smart and connected communities, and smart health.

The division also provides funding, in partnership with other NSF directorates, and management of the NNCI and contributes to the directorate's annual operations support of the CHEXS facility.

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

DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC) $144,460,000
+$17,230,000 / 13.5%

EEC Funding
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Change over FY 2021 Actual Percent
Total	**$127.23**	**-**	**$144.46**	**$17.23**	**13.5%**
Research	**110.35**	**-**	**125.26**	**14.91**	**13.5%**
CAREER	0.62	-	-	-0.62	-100.0%
Centers Funding (total)	57.01	-	73.00	15.99	28.0%
Artificial Intelligence Research Institutes	0.75	-	1.50	0.75	100.0%
Engineering Research Centers (ERC)	56.26	-	71.50	15.24	27.1%
Education	**16.89**	**-**	**19.20**	**2.31**	**13.7%**

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 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 2023 funding level supports 15 centers. The total includes funding to support up to five additional 4th-generation (Gen-4) ERCs 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. EEC's increased investment in center-based research will enhance center research outcomes, expand the engineering community, and grow its tremendous societal impact.

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; EEC participates in IUSE and advances the professional development of engineers through the Revolutionizing Engineering Departments program.

Engineering Workforce Development includes programs such as Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET), as well as support for 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.

The Broadening Participation in Engineering program 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 NSF INCLUDES, which integrates the agency's investments to build on and scale up what works in broadening participation programs.

EEC will engage the groups traditionally underrepresented in the field across the country by increasing investment in equity and broadening participation and supporting initiatives that find, recruit, educate, retain, and graduate a larger, more-diverse engineering population. EEC will take an integrated approach—with innovative efforts that expand engineering education to pre-college and informal settings and with partnerships that develop a diverse and inclusive engineering workforce—to enable engineering careers and advances in emerging technologies.

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)

$166,590,000
+$94,830,000 / 132.1%

EFMA Funding
(Dollars in Millions)

	FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Change over FY 2021 Actual Percent
Total	**$71.76**	**-**	**$166.59**	**$94.83**	**132.1%**
Research	**71.44**	**-**	**166.37**	**94.93**	**132.9%**
Education	**0.10**	**-**	**0.12**	**0.02**	**15.4%**
Infrastructure	**0.22**	**-**	**0.10**	**-0.12**	**-55.1%**
Center for High Energy X-ray Science (CHEXS)	0.23	-	0.10	-0.13	-55.6%

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.

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 GERMINATION program supports development of innovative pedagogical approaches to scientific problem formulation, including fostering convergence. REM and REU supplements underwrite capacity-building toward an expanded and diverse STEM workforce.

In the area of Clean Energy Technology, EFMA will invest $45.0 million specifically related to convergent approaches across scale, with attention to workforce training and foundational climate and clean energy research that emphasizes innovation, sustainability, resilience, equity and social

justice, and engagement of local communities in formulating problems and translating promising research. This is in addition to other important clean energy investments across ENG.

The EFMA office also supports special activities such as the Engineering Research Visioning Alliance (ERVA), which convenes the engineering community to identify important engineering research challenges and opportunities. ERVA provides a mechanism for the engineering research community to coalesce around research priorities and speak with a unified voice. EFMA also contributes to the directorate's annual operations support of NSF facilities such as CHEXS.

Funding for the FW-HTF Big Idea 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, 85 percent of the EFMA portfolio is comprised of new research grants, and about 15 percent supports continuing increments for grants made in previous years.