Opportunities in Engineering Research, Education and Innovation: A Perspective from NSF

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Outline

• Context, Drivers, and Trends
• NSF Engineering Budgets and Priorities
• Conclusions
“to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…” NSF Act, 1950

Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.
Size of circle reflects the relative amount of annual R&D spending by the indicated country.

Scientists and Engineers per Million People

R&D as a percentage of Gross Domestic Product

Source: Battelle, R&D Magazine, International Monetary Fund, World Bank, CIA Fact Book, OECD

North America
South America
Europe
Middle East & Africa
Asia-Pacific
Russia - CIS
Global R&D Forecast

Long-Term Outlook for R&D Expenditures

Even if the historic stability of the U.S. and European commitment to research intensity (i.e., spending as a percent of GDP) continues, growth in China’s economy is likely to propel it to the top position in absolute R&D spending by the early 2020s.

Source: Battelle and R&D Magazine
Trend across Scientific Fields

Basic and applied research only

In billions of constant FY 2015 dollars

Source: AAAS Report: Research & Development series. FY 2015 figures are latest estimates, FY 2016 is the President's request. © 2015 AAAS
# NSF Budget 2016

## Table 1: National Science Foundation R&D and Total Budget

(budget authority in millions of dollars)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total NSF R&amp;D</td>
<td>5,800</td>
<td>5,999</td>
<td>6,309</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conduct of R&amp;D</td>
<td>5,403</td>
<td>5,562</td>
<td>5,864</td>
<td>302</td>
</tr>
<tr>
<td>R&amp;D Facilities</td>
<td>397</td>
<td>437</td>
<td>445</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>1.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total NSF Budget</td>
<td>7,131</td>
<td>7,344</td>
<td>7,724</td>
<td>379</td>
</tr>
<tr>
<td></td>
<td>5.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>721</td>
<td>731</td>
<td>748</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>2.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comp and Info Sci and Eng</td>
<td>893</td>
<td>922</td>
<td>954</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>3.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>833</td>
<td>892</td>
<td>949</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>6.4%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geosciences</td>
<td>1,321</td>
<td>1,304</td>
<td>1,365</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>4.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math and Physical Sci</td>
<td>1,268</td>
<td>1,337</td>
<td>1,366</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social, Behav and Econ Sci</td>
<td>257</td>
<td>272</td>
<td>291</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>7.1%</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Source: OMB R&D data, agency budget justification and Quantitative Data Tables.

All figures rounded to the nearest million. Changes calculated from unrounded figures.
Case for Science and Engineering Research

- Science and engineering advances are important drivers of economy, health, security, quality of life, and sustainability
- Fundamental research requires public sector support
- NSF has a unique role among Federal agencies in supporting long-term fundamental research

Important to connect research discoveries and inventions to real-world deployment
NSF Foundation-wide Priorities

- Innovations at the Nexus of Food, Water and Energy Systems (INFEWS)
- Risk and Resilience
- Understanding the Brain (UtB)
- Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES)
- Clean Energy
- Cyber-enabled Materials, Manufacturing and Smart Systems (CEMMSS)
- Cyber-infrastructure for 21st Century Science, Engineering, and Education (CIF21)
- Secure and Trustworthy Cyberspace
- Research at the Interface of Biology, Mathematical and Physical (BioMAPS)
- NSF Innovation Corps
NSF Engineering Directorate (ENG)

Investing in engineering research and education and fostering innovations to benefit society
Major Trends and Forces

• Ubiquitous computing and communications
  – Computational modeling, data, simulation, optimization pervasive in all fields of engineering
  – Networks and computation deeply integrated into engineered systems
  – Machine intelligence (AI)
  – New platforms for computing

• Systems science and engineering
  – Multi-scale analysis, design, and optimization
  – Integration of physical and cyber components
  – Range: nano- to micro- to macro-scale
  – Scale and complexity: large numbers of components
  – Safety, robustness, resilience, …
Major Trends and Forces

• Nanoscale science and technologies
  – Understanding and new tools at the atomic and molecular scales
  – Wide range of applications – biomed, energy, water, materials, electronics
  – From passive components to active systems, design, and manufacturing

• Biological/Medical Frontier
  – Interaction of engineered systems and biology at all scales – DNA to cells to organs to organisms to eco-systems
  – Engineering for neuroscience and brain
  – Synthetic biology
  – Plants, food, and agriculture
  – Advanced biomanufacturing
  – Biologically inspired engineering
Major Trends and Forces

• Behavioral/economic/social sciences
  – Human behavior and game theory in engineered systems and technology design
  – Prominent role in infrastructure systems such as electric grid, transportation, water, gas
  – Economic, regulatory, policy issues

• Design, creativity, aesthetics, …
ENG Budget ($M)

FY14 - $833M
FY15 - $892M
FY16(request) - $949M

- ENG
- SBIR/STTR
- ENG ARRA
- SBIR/STTR ARRA
ENG Research Awards to New and Prior NSF Researchers

<table>
<thead>
<tr>
<th>Year</th>
<th>ENG Awards - prior</th>
<th>ENG Awards - new</th>
<th>ENG Funding Rate - new</th>
<th>ENG Funding Rate - all</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY 2009</td>
<td>24% new</td>
<td>28% new</td>
<td>28%</td>
<td>28%</td>
</tr>
<tr>
<td>FY 2010</td>
<td>25% new</td>
<td>25% new</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>FY 2011</td>
<td>24% new</td>
<td>24% new</td>
<td>24%</td>
<td>24%</td>
</tr>
<tr>
<td>FY 2012</td>
<td>26% new</td>
<td>26% new</td>
<td>26%</td>
<td>26%</td>
</tr>
<tr>
<td>FY 2013</td>
<td>25% new</td>
<td>25% new</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>FY 2014 Est.</td>
<td>21% new</td>
<td>21% new</td>
<td>21%</td>
<td>21%</td>
</tr>
</tbody>
</table>
ENG Initiatives and Priorities Address National Interests

• Innovations at the Nexus of Food, Energy, and Water Systems
• Risk and Resilience – Resilient Infrastructure Systems
  – Urban Science – Smart and Connected Communities
• Clean Energy Technology
• Cyber-Enabled Materials, Manufacturing, and Smart Systems
  – Advanced Manufacturing
• National Nanotechnology Initiative
• Communications and Cyberinfrastructure
• Optics and Photonics

• Understanding the Brain
• Education and Broadening Participation
  – Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science (NSF INCLUDES)
  – IUSE:RED – Improving Undergraduate Science and Engineering: Revolutionizing Engineering Departments
• Innovation Corps
Concluding Comments

- Intense competition among universities
- NSF committed to supporting long-term fundamental research
- Public understanding of importance of science and engineering research
QUESTIONS?

IDEAS, SUGGESTIONS!

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