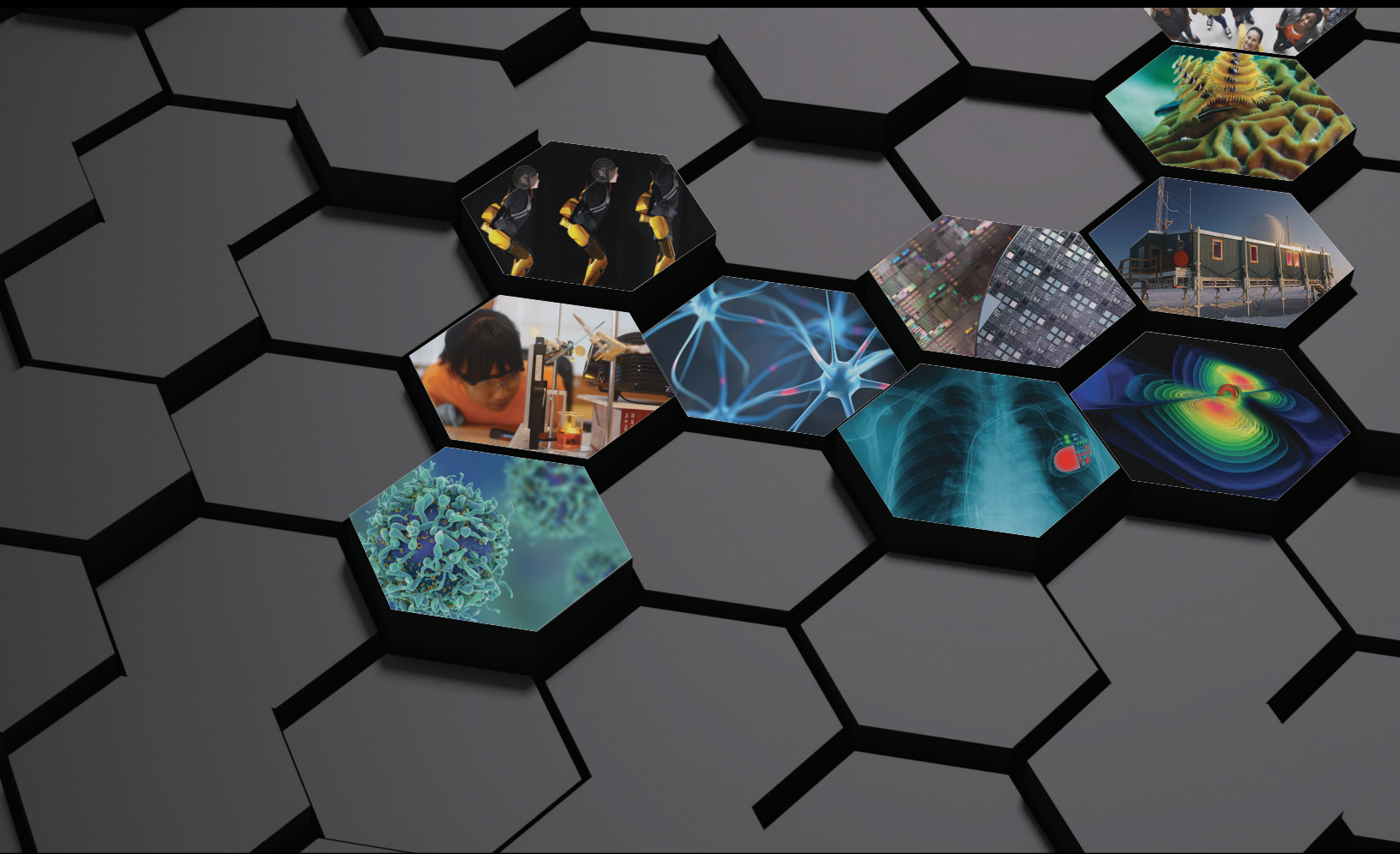


# IMPACT ASSESSMENTS OF NSF AWARDS TO THE NATIONAL ACADEMIES OF SCIENCE, ENGINEERING, AND MEDICINE



National Science Foundation



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## EXECUTIVE SUMMARY

The National Science Foundation (NSF) is interested in understanding the impacts of its investments in study reports, workshops, symposia, and other activities developed by the National Academies of Science, Engineering, and Medicine (NASEM). A team of NSF staff (NASEM Team), consisting of representatives from all the Directorates, the Office of Integrative Activities, the Office of International Science and Engineering, and the Office of Budget, Finance, and Award Management, made two different types of assessments. One developed an initial set of outcomes based on a small number of reports using quantitative, objective impact scores routinely used by NASEM as well as new ones developed by NSF for this analysis; the other provided a subjective understanding of the factors that contribute to high-level impacts of study reports, workshops, symposia, and other activities, as perceived by NSF Program Officers.

### IMPACT METRICS

To determine the feasibility of assessing the objective impact of reports funded by NSF, the NASEM Team decided to compare metrics from the reports from two different disciplinary Boards (from over 40) that appeared to be highly productive for NSF, the Board on Science Education (BOSE) and the Computer Science and Telecommunications Board (CSTB). First, the Team used a set of quantitative metrics developed by NASEM to determine report impacts. For each report, it looked at: (a) the number of copies distributed<sup>1</sup>; and (b) the report's Altmetric Score<sup>2</sup>. Next, the NASEM Team experimented with quantitative metrics developed by NSF. For each report, the Team looked at (c) the number of report citations in NSF program descriptions and solicitations<sup>3</sup>; and (d) the number of mentions in WhiteHouse.gov and Congress.gov documents.

Specific insights that the Team gleaned from this analysis include:

**Insight 1: Impact metrics do not appear to depend on award size.** Some smaller awards had impact metrics greater than many of the largest awards.

**Insight 2: Impact metrics vary by audience size.** Broad reports of interest to large audiences typically had higher impact metrics than more narrowly focused reports.

**Insight 3: The timing and resilience of topics appears to affect impact metrics.** Reports released when policy interest in the topic was high typically have greater impact metrics. Reports on topics of ongoing policy interest also appeared to have higher impact metrics.

### IMPACT MECHANISMS

The Team then asked its representatives in each of the Directorates to identify five to ten highly impactful study reports, workshops and/or symposia and three to five minimally impactful activities and to describe the factors that contributed to the reports' success or lack thereof.

<sup>1</sup> NASEM gave NSF the distribution numbers for all reports covered in this analysis.

<sup>2</sup> Altmetric is a private company that provides digital tools to track online activity around research outputs. NASEM provided NSF with the Altmetric score for each report. This is based on the number of times a report is mentioned or cited online in news outlets, social media, etc.

<sup>3</sup> NSF staff developed its own web-scraping tools to determine the outcomes of analysis #3 and #4.

Based on this analysis, the Team found the following factors were most instrumental in creating impact:

**Insight 4: Novel or insightful recommendations can spur change.** Recommendations that offer new insights or novel solutions can help trigger program changes, influence new research portfolios, secure new funding, guide long-term investment strategies, or result in new funding opportunities.

**Insight 5: Specific, actionable recommendations create impact.** Report recommendations that are concrete, specific, and sensitive to the current policy or scientific contexts enable action and more frequently lead to greater impact.

**Insight 6: Product timing is very important.** Greater impact is achieved when reports are released or workshops are held at a time when interest is high and actions can be taken.

**Insight 7: Strong, distinguished, and engaged chairs and committee members help create impact.** Committee leadership and members who are fully committed to the project can both help ensure a strong, timely product and can facilitate outreach necessary to achieve impact.

**Insight 8: Projects with clear, focused project descriptions and charges tended to be more impactful.** Awards in which the project description and committee charge clearly articulate a scope of work that is appropriately bounded and provides a specific and detailed project plan are often the most impactful. In many cases, high-impact awards also include a detailed plan to disseminate the report to ensure that it reaches audiences who can use and act on the findings.

**Insight 9: Significant community interest improves the likelihood of impact.** Community interest and “buy-in” into a NASEM activity at the outset helps ensure that the products will be used and the intended impacts achieved.

**Insight 10: Collaboration between communities or joint funding can indicate broad interest.** Co-funding with other agencies can help indicate strong community interest, so long as NSF interests are not eclipsed by partner-agency priorities.

**Insight 11: NASEM reports that complement other reports can add weight to specific arguments and spur change.** Building a portfolio of findings and/or recommendations across several external stakeholders can help set future directions in more powerful ways.

## **RECOMMENDATIONS - SEIZE OPPORTUNITIES**

Well-planned, well-situated activities that take advantage of opportunities to make change create impact. Therefore, the NASEM Team recommends that NASEM projects should be scoped and managed to take best advantage of the opportunities available to create impact. To accomplish this, the NASEM Team advises that NASEM and NSF consider the following recommendations:

**Recommendation 1: NASEM should explore models for more nimble projects so they can produce high-impact results more quickly.** Project models that could produce high-quality results or recommendations in 6 months to 1 year will help make NASEM projects more useful in situations where the opportunities for impact are near-term or short-lived.

**Recommendation 2: NASEM proposals should describe the intended impact, include an assessment of the opportunities available for achieving the intended impact, and include an appropriately scoped work-plan.** Proposals should also include a detailed impact plan that outlines intentions for distributing products to ensure target audiences are reached. NSF reviewers and program staff should consider these factors when evaluating proposals.

**Recommendation 3: NASEM and NSF program staff should remain cognizant of the timelines for potential opportunities and work to ensure that NASEM projects are scoped and managed appropriately.** NASEM and NSF need to consider the tradeoffs inherent in balancing speed with depth when scoping projects. NASEM and NSF program staff should jointly review the progress of projects and make mid-course adjustments to ensure timely delivery of products as needed.

**Recommendation 4: NASEM and NSF should ensure that study committees receive a clear and focused charge.** Spending time on crafting a well-defined charge is time well spent in the very beginning. In addition, it is important that NSF staff attends the first study report meeting and clarifies the charge with the committee.

**Recommendation 5: NASEM report recommendations should be insightful, specific, and actionable.** Care should be taken to ensure that recommendations suggest specific actions that are tailored to and achievable within the relevant policy contexts.

# IMPACT ASSESSMENTS OF NSF AWARDS TO THE NATIONAL ACADEMIES OF SCIENCE, ENGINEERING, AND MEDICINE

NSF is interested in understanding the impacts of its investments in study reports, workshops, symposia and other activities developed by the National Academies of Science, Engineering, and Medicine (NASEM). NSF typically supports NASEM work because their processes produce authoritative products. The societal impacts of NASEM products vary widely. Some inform NSF's strategic thinking and program planning, while others help communicate scientific consensus more broadly on important policy issues and some help to catalyze new scientific approaches to address particular challenges. Measuring the societal impact of scientific investments is an active area of scientific study and proven quantitative methodologies have yet to emerge. A team of NSF staff (NASEM Team), consisting of representatives from all the Directorates, the Office of Integrative Activities, the Office of International Science and Engineering, and the Office of Budget, Finance, and Award Management, experimented with a few strategies to explore the impact of NSF's investments in NASEM. This report outlines two methods that were applied, and the insights obtained from each analysis.

## I. IMPACT METRICS

The NASEM Team experimented first with quantitative, objective metrics to assess the impact of study reports developed by NASEM. To test the efficacy of these metrics, the Board on Science Education (BOSE) and the Computer Science and Telecommunications Board (CSTB) were used as analytical test cases. Both were selected because they each receive substantial funding from NSF and they conduct work that is typical of the bulk of the projects NSF funds at NASEM.

For both boards, NASEM provided a list of all the Boards' published reports that were developed using NSF funds and the total number of copies of each that they had distributed. Each report was matched to the NSF award that provided funding and the following quantitative metrics were gathered for each report:

### Number of Copies Distributed

NASEM provided the total number of downloads and total number of print copies sold as of September 6, 2016 for each report. These numbers were summed for a single distribution metric. While distribution does not translate directly to impact, greater distribution does indicate greater interest in a topic or report, which is an important element behind impact.

### Altmetric Score

Altmetric is a private company that provides digital tools to "track and analyze the online activity around scholarly research outputs."<sup>4</sup> The National Academies Press uses this tool to provide an Altmetric score for each of its reports. It describes the score as follows:

*The Altmetric score is based on the amount of attention the report receives from social media and mainstream news media. As more people mention it, the score rises. However, each source contributes a different base amount to the final score. For instance, a newspaper article contributes more than a tweet. These data give valuable insight as to who is reading these reports and how they are being shared. This information then reveals the scope of the report's reach and influence and allows researchers to learn more about their audience.<sup>5</sup>*

<sup>4</sup> <https://www.altmetric.com/about-us> - Accessed 2/27/18

<sup>5</sup> <https://www.nap.edu/content/about-altmetrics> - Accessed 2/27/18

This score is not static and will increase as additional mentions of a report are made and captured. Using a web-scraping algorithm, staff from the Office of Integrative Activities (OIA) obtained the Altmetric score for each report as of September 2016. The Altmetric score is like the report distribution metric in that it predominantly measures interest rather than impact. However, the Altmetric score weights the citation count by source, giving more weight to sources with a greater likelihood of having impact, so it is more specific than a straight distribution count.

### Number of Report Citations in NSF Program Descriptions and Solicitations

To determine which NASEM reports have influenced NSF programs, OIA staff used text-mining algorithms to identify all instances in which the NASEM reports from BOSE and CSTB were cited or mentioned by name in NSF’s database of solicitations, as of November 2016. Additionally, this database was searched for reference to the National Academies and the surrounding text was read to discern whether a specific NASEM report could be identified.

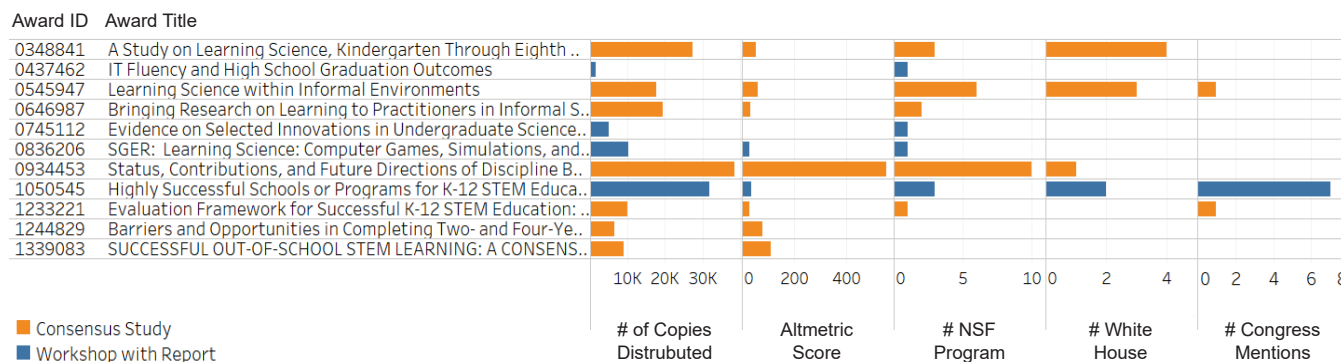
### Number of Mentions in WhiteHouse.gov and Congress.gov Documents

Using similar web-scraping and text-mining algorithms, OIA staff searched all documents found on WhiteHouse.gov and Congress.gov in November 2016 for mention of the BOSE and CSTB reports by title.

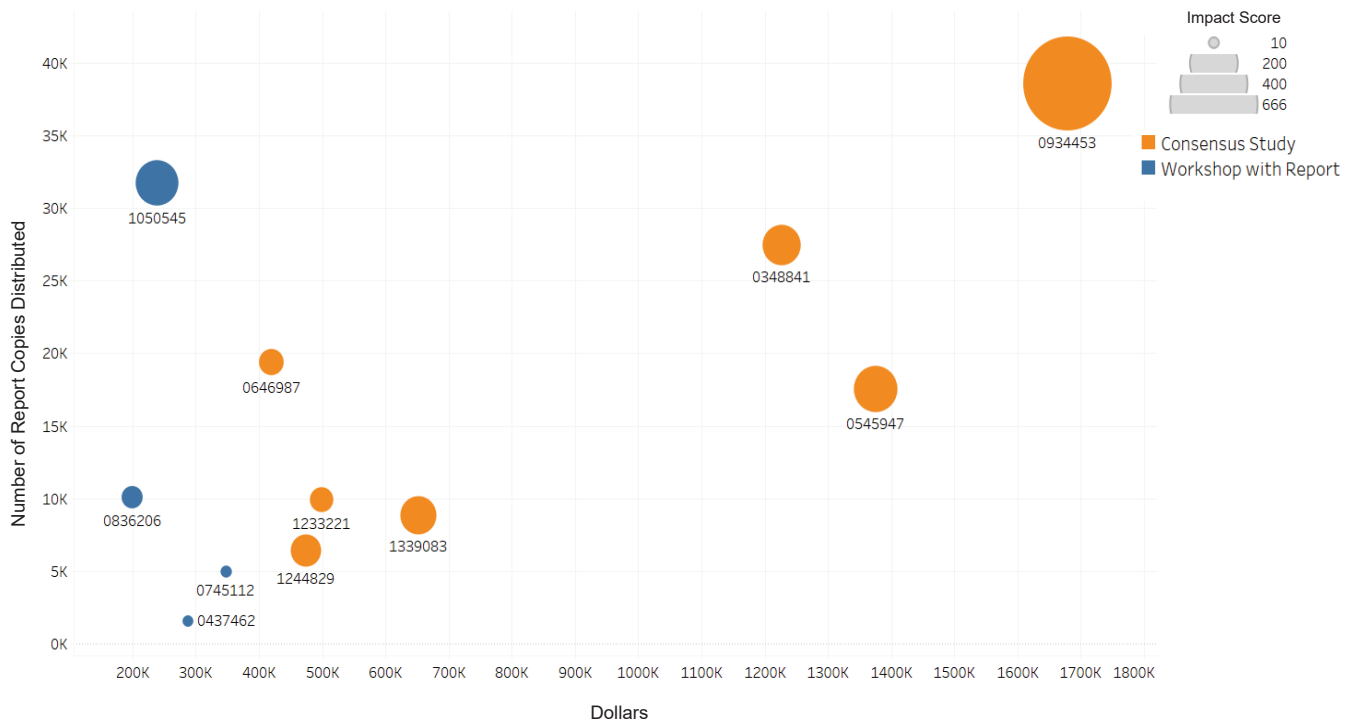
While it can be inferred that NASEM reports cited in NSF program descriptions and solicitations and in WhiteHouse.gov and Congress.gov documents have contributed to policy dialogues and/or outcomes, these metrics underestimate actual contributions. Many policy documents do not use formal citations, and NASEM reports not referenced by title were not captured with this method.

These metrics for NSF awards made to BOSE and CSTB are presented below. Tables 1 and 2 present the individual metrics on a per award basis in tabular form. On occasion, awards resulted in more than one report. In these cases, the metrics for each report were summed so that the total reflects the overall impact of the award. In Tables 1 and 2, it can be inferred that awards with longer and more numerous bars reading across were more influential. Note the difference in the scales for each metric.

**Table 1: BOSE – Impact Metrics**



**Figure 1: BOSE – Combined Impact Metrics**

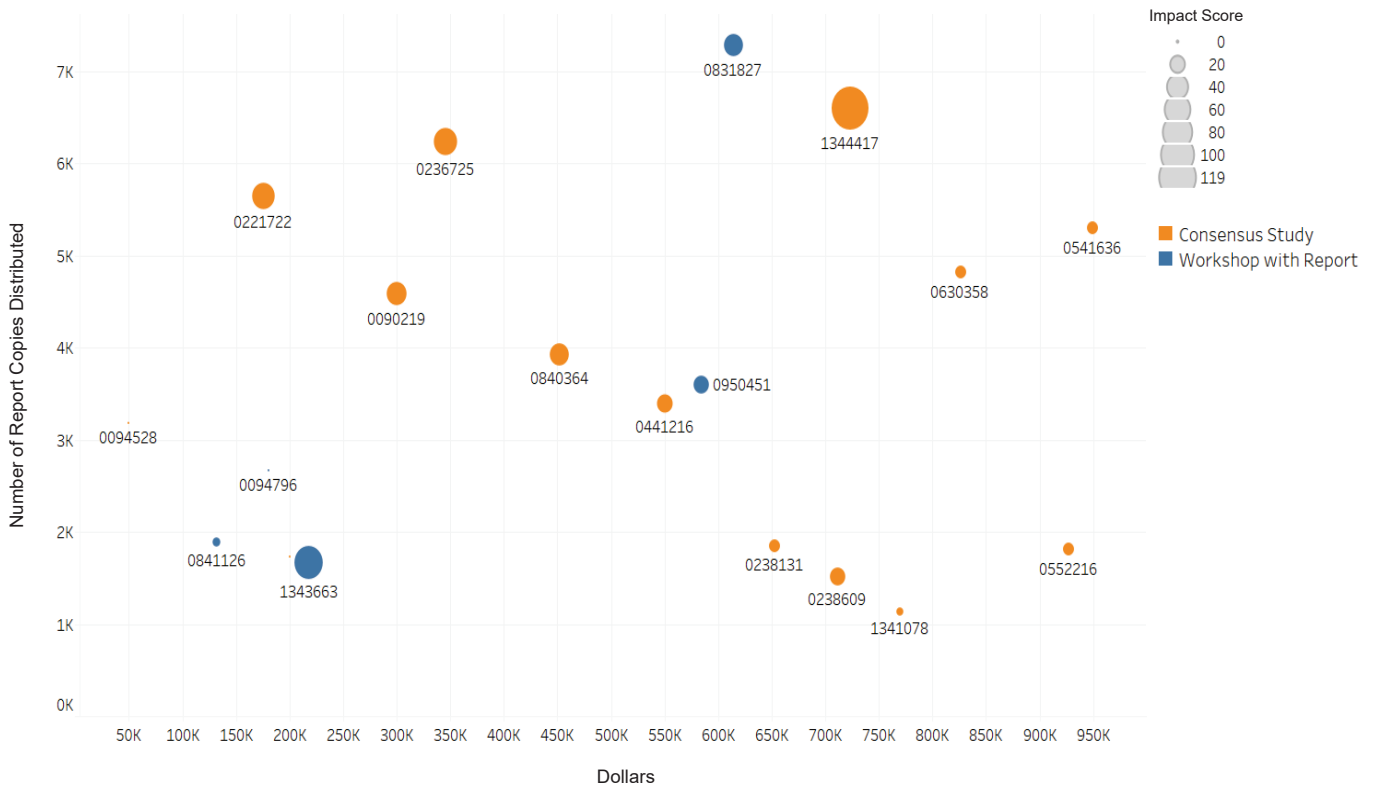


**Table 2: CSTB – Impact Metrics**

Award ID	Award Title	# of Copies Distributed	Altmetric Score	# NSF Program Citations	# White House Mentions	# Congress Mentions
0090219	Authentication Technologies and Their Privacy I..	10K	1	0	10K	0
0094528	Computing Frontiers: Prospects from Biology	8K	0	0	0	0
0094796	Workshop on Intersections Between Geospatial I..	5K	0	0	0	0
0221722	Improving Cybersecurity Research in the United ..	10K	1	0	10K	5K
0236725	Sufficient Evidence? Building Certifiably Depend..	10K	1	0	15K	0
0238131	Wireless Technology Prospects and Policy	5K	0	0	5K	0
0238609	Telecommunications Research and Development	5K	0	0	10K	0
0436133	A Framework for Understanding Electronic Voting	5K	0	0	0	0
0441216	Policy and Technical Dimensions of Large-Scale G..	8K	1	0	0	0
0541636	Advancing Software Producibility	10K	0	0	5K	0
0552216	Assessing the Information Technology Research ..	5K	0	0	5K	0
0630358	Sustaining Growth in Computing Performance an..	10K	1	0	0	0
0831827	Computational Thinking For Everyone: A Works..	15K	15	0	0	0
0840364	Depicting Innovations in Information Technology	10K	10	0	0	0
0841126	Usability, Security, and Privacy of Information Sy..	5K	1	0	0	0
0950451	Computing Research for Environmental and Soc..	10K	1	10K	0	0
1341078	Toward 21st Century Cyber-Physical Systems Ed..	5K	1	0	0	0
1343663	Continuing Innovation in Information Technology..	5K	15	0	15K	0
1344417	Future Directions for NSF Advanced Computing I..	10K	10	10K	5K	10K



**Figure 2: CSTB – Combined Impact Metrics**



In Figures 1 and 2, the Altmetric score was combined with the numbers of citations in NSF’s solicitation database and mentions in the documents found at Whitehouse.gov and Congress.gov using the following weighted sum.

$$\text{Altmetric Score} + 10 * (\# \text{ Citations in NSF funding opportunities} + \# \text{ WhiteHouse.gov mentions} + \# \text{ Congress.gov mentions})$$

The number of citations in NSF’s solicitation database and on the Whitehouse.gov and Congress.gov websites were weighted in this manner because: a) Altmetric scores were consistently much larger than the other metrics (note scale differences in Tables 1 and 2); and b) citations in an NSF funding opportunity and mentions on the Whitehouse.gov and Congress.gov websites may denote greater societal impact than the social media and news mentions counted by the Altmetric score. The combined metrics were then plotted against the award amount and the number of NASEM report copies that were distributed (see Figures 1 and 2).

While these metrics are crude proxies for actual impact, they give a sense of the relative interest in and reach of the various reports. Specific insights the Team gleaned from this analysis include:

**Insight 1: Impact metrics do not appear to depend on award size.** Some smaller awards had impact metrics greater than many of the largest awards. For example, the \$200,000 workshop titled “Highly Successful Schools or Programs for K-12 STEM Education” (1050545) produced a report that was cited in 3 NSF program solicitations, 2 WhiteHouse.gov documents, and 7 Congress.gov documents.

**Insight 2: Impact metrics vary by audience size. Broad reports of interest to large audiences typically had higher impact metrics than more narrowly focused reports.** The Board on Science Education (BOSE), for example, produces reports relevant to all the sciences. These reports had higher overall impact metrics than the discipline-focused reports of the Computer Science and Telecommunications Board (CSTB).

**Insight 3: The timing and resilience of topics appears to affect impact metrics. Reports released when policy interest in the topic was high typically have greater impact metrics.** For example, the report “Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017-2020” (1344417) was published in 2016 very shortly before this analysis was completed and the report had already been cited in 1 NSF program solicitation, 1 WhiteHouse.gov document and 2 Congress.gov mentions. Similarly, reports on topics of ongoing policy interest also appear to have higher impact metrics. The report “Discipline-Based Education Research” was published in 2012 and continues to be frequently downloaded and is regularly cited in NSF program solicitations.

## II. IMPACT MECHANISMS

The Team then asked each of the Directorates to identify five to ten highly impactful awards and three to five minimally impactful NASEM awards and to describe the factors that contributed to the awards’ success or lack thereof. The primary intent of this qualitative exercise was to understand what factors NSF staff believe to have contributed to the success or failure of investments in NASEM activities, not to quantify impact.

The Team asked the Directorates to rely on their staff’s experiential knowledge of NSF’s NASEM portfolio to identify a set of highly and minimally impactful awards. The Team did not constrain the Directorates to identifying NASEM awards that produced reports (e.g., consensus studies or workshop reports), since some Team members felt that other types of NASEM activities (e.g., workshops that did not produce a report, symposia) have had significant impact as well. The Team also did not constrain the Directorates to selecting awards that resulted in products intended to inform NSF activities, since many NSF awards to NASEM result in products or activities that inform the broader scientific communities and/or policy, too.

The Directorates identified a total of 49 awards – 33 of which were identified as highly impactful awards and 12 as minimally impactful awards. Staff disagreed about whether the impact of the 4 remaining awards was high or low. The discrepancy of opinion and the rationale provided to support the different positions offered interesting insight in this context and so these awards were retained in this analysis. NSF staff disagreed, for example, on whether the award “Future Research Goals and Directions for Foundational Science in Cybersecurity, Phase Two” (1400278) was impactful or not. One Program Director felt that the award was highly successful because: a) the NASEM report was very widely read, as indicated by the number of worldwide downloads; and b) the report inspired several additional studies at both NASEM and outside of government. Another Program Director strongly disagreed, noting that the report was six years late and that the findings were not insightful and fairly obvious. In this instance, the report may not have had the specific intended impact due to its tardiness but proved to be valuable to a broader audience.

Table 3 lists by impact level and type of NASEM activity the number of awards identified, the average award budget, and the average award duration in months. Most awards identified for this analysis supported NASEM consensus studies, although a couple of workshops and other activities were also identified. Note that the average budget and average award duration for highly impactful consensus studies are both lower than the same numbers for low impact consensus studies, and the average award duration for high impact workshops is less than for low impact workshops.

**Table 3: Award Characteristics<sup>6</sup>**

Type of NASEM Activity	High Impact			Low Impact			Uncertain Impact		
	Number Awards	Average Budget	Average Award Duration (Months)	Number Awards	Average Budget	Average Award Duration (Months)	Number Awards	Average Budget	Average Award Duration (Months)
Core Support	3	\$811,389	46	1	\$48,848	12	1	\$983,154	36
Consensus Study	20	\$475,733	22	8	\$543,221	30	3	\$433,118	26
Workshop with Report	5	\$220,621	17	1	\$99,999	36			
Workshop without Report	1	\$80,326	12						
Letter Report <sup>7</sup>				1	\$91,445	12			
Other	2	\$814,744	12						

For each of the identified awards, the Directorates provided a statement that answered the following two questions:

- a) Why is this award one of the most/least impactful NASEM awards in your portfolio?
- b) What factors contributed to this award having/not having impact?

Table 4 outlines the most frequently mentioned factors that staff felt affected whether awards were successful. For each factor, statements for high-impact awards typically noted that the factor was present and enhanced impact; while statements for low impact awards, typically noted that the factor was not present and the absence lowered or prevented impact. For example, the statements for 12 high impact awards mentioned that the product was timely, while the statements for 4 low impact awards noted that the product was not timely or delayed.

**Table 4: Impact Mechanisms**

Factor	High Impact	Low Impact	Uncertain Impact	Total
Novel or insightful recommendations	24	8	1	33
Specific, actionable recommendations	22	6	0	28
Product timing	12	4	1	17
High quality chair or committee	7	2	1	10
Clear and focused charge	3	6	0	9
Significant community interest	6	1	0	7
Collaboration between communities / joint funding	6	0	0	6
Complements other reports	3	0	0	3

<sup>6</sup> The award jackets were unavailable for 3 of the 49 awards identified for this analysis – due to conflicts of interest or age of the award. These 3 awards were excluded from this table to ensure the averages were calculated accurately.

<sup>7</sup> NASEM reports for which the evidence provided is abbreviated, typically by referring to earlier National Research Council (NRC) work that provides more detailed evidence.

Each of these impact mechanisms is explained in more detail below. Included under each mechanism are examples of the input the Team received from the Directorates that illustrate the factor described.

**Insight 4: Novel or insightful recommendations can spur change.** Recommendations that are particularly insightful or offer novel solutions can help trigger program changes, influence research portfolios, secure new funding, guide long-term investment strategies, or result in new funding opportunities, while recommendations that reiterate or affirm existing knowledge often support the status quo. Novel or insightful recommendations was the most frequently cited reason why reports were considered highly impactful.

- ***“The Current Status and Future Direction of High Magnetic Field Study in the United States” 1108705:*** This report gave recommendations that were very forward looking with short, medium, and long-range targets. It also made clear the need for focused research efforts in both fundamental science and technology development that go beyond current limitations of materials and systems used in high field magnets. The report outlined a coherent and cogent framework for high field magnet technology development for future magnets. The charge was concise, outlining only three main questions to be explored.
- ***“The Future of Center-Based, Multidisciplinary Engineering Research” 1539798:*** This award will affect the future of the largest awards the ENG Directorate makes. The key recommendations are the focus on convergence and a call for a substantial increase in the annual budgets of the awards. This will potentially change the way these Centers do research, the kinds of projects they will focus on, and the kinds of technologies they will create in the future.

**Insight 5: Specific, actionable recommendations create impact.** Report recommendations that are concrete, specific, and attentive to the current policy or scientific contexts enable action and more frequently lead to greater impact. Recommendations that are too broad or general can hinder impact, even if the advice is timely.

- ***“Basic Research Opportunities in the Earth Sciences” 9809585:*** This report triggered major program changes in the Division of Earth Sciences, including Critical Zone Observatories and EarthScope. The report pointed to foundational activities in the community that could be built upon to establish new science, such as the study of the “critical zone” between the top of bedrock and the top of the vegetation canopy, and study of the 4-dimensional structure of the North American continent.
- ***“Sea Change: 2015-2025 Decadal Survey of Ocean Sciences” 1341391:*** Operations and maintenance costs of ships and the Ocean Observatories Initiative were eating into the core research budgets of the division. This report had significant impact in clearing the way for adjustments to the budget that still allowed for the facilities to remain in operation. The resulting report had specific, actionable recommendations.

**Insight 6: Product timing is very important.** Greater impact is achieved when reports are released or workshops are held at a time when interest is high and actions can be taken. Reports released after the policy and/or scientific communities have moved on have limited impact.

- ***“Information Technology, Automation, and the U.S. Workforce” 1449410:*** This project was very well timed. The co-chairs were involved and did a lot of work to make the report accessible and to highlight the outcomes. The timing was right as technology impacts became a part of broad societal discussions on benefits and equity of technologies. The report, which emphasizes the need to

understand and track trends and develop strategies to respond, also provides open questions and promising research pathways. The report was one of the key inputs to The Future of Work at the Human-Technology Frontier, one of NSF's 10 Big Ideas.

**Insight 7: Strong, distinguished, and engaged chairs and committee members help create impact.** Committee leadership and members who are fully committed to the project can both help ensure a strong, timely product and can facilitate outreach necessary to achieve impact.

- **“Envisioning the Data Science Discipline: The Undergraduate Perspective” 1626983:** This is a current consensus study, but impacts are already being seen in the data science community. Beyond the focus on producing MS degrees, where Data Science initially had impact in education, there are now new programs that provide training for faculty from a range of institutions, with a focus on state universities and community colleges. This will significantly leverage the insights on undergraduate curriculum developed in the study. The Academy selected strong and engaged members for the Committee and the time frame was restricted to a minimum, encouraging focus. CISE, DMS, EHR, and SBE jointly funded it at NSF.
- **“Study on the Future of NSF Supported Social Science Surveys” 1518978:** The goal of this activity was to develop a vision for the future of the “Big Three” surveys supported by SBE: a) American National Election Studies; b) the General Social Survey; and c) the Panel Study of Income Dynamics. The committee was able to raise awareness among members of the community interested in the Big Three surveys regarding NSF's interest in understanding the trade-offs between efficiency and data quality. It also raised awareness regarding NSF's interest in learning to what extent the “Big Three” investigators exchange ideas, etc.

**Insight 8: Projects with clear, focused project descriptions and charges tended to be more impactful.** Awards in which the project description and committee charge clearly articulate a scope of work that is appropriately bounded and provides a specific and detailed project plan are often the most impactful. In many cases, high impact awards also include a detailed plan to disseminate the report to ensure that it reaches audiences who can use and act on the findings. Awards lacking specificity to guide the project rarely have an impact.

- **“Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science in 2017-2020” 1344417:** Some of the motivation for NSF 17-558 (Towards a Leadership-Class Computing Facility), released in FY 17, was based on the recommendations and findings of this project report. The report also provided support for many of the other current programs that are being pursued in CISE/OAC, e.g., the Software Infrastructure for Sustained Innovation program. Factors that contributed to the report's impact included the specificity of the charge, the distinguished panel members, and the current global context.
- **“The Mathematical Sciences in 2025” 0911899:** The specific charge to the committee included producing a “forward-looking assessment of the current state of the mathematical sciences and of emerging trends that will affect the discipline and its stakeholders as they look ahead to the quarter-century mark.” The Mathematical Sciences in 2025 report made a compelling case for the importance of, and critical role of, the mathematical sciences in a number of disciplines, including biology, medicine, social sciences, business, advanced design, climate, finance, and advanced materials. The report noted the importance of NSF's support for core research in the mathematical sciences and urged mathematics and statistics departments to increase efforts to attract and retain students. The report included a number of recommendations to NSF, other funding agencies, and the broader mathematical sciences community.

**Insight 9: Significant community interest improves the likelihood of impact.** Community interest and “buy-in” into a NASEM activity at the outset helps ensure that the products will be used and the intended impacts achieved.

- **“Future of Atmospheric Chemistry Research” 1449200:** This report highlighted ways that the community could move forward, especially in relation to how the National Center for Atmospheric Research (NCAR) should interact with the university community. There were acknowledged challenges in the atmospheric chemistry community; the development of a community-wide report was seen as the best way to move forward.
- **“Challenges and Opportunities in the Hydrologic Sciences” 0938578:** This report laid out a roadmap for the hydrologic sciences community. The community has followed it and has been very successful in executing ambitious projects to understand the hydrologic system.

**Insight 10: Collaboration between communities or joint funding can indicate broad interest.**

Co-funding with other agencies can help indicate strong community interest, so long as NSF interests are not eclipsed by partner-agency priorities.

- **“Developing a Sustainable Chemistry Basic Research Program” 1132553:** This activity brought together leaders to provide guidance on sustainable chemistry alternatives to the chemical, pharmaceutical, electronics and consumer products sectors. This workshop contributed to Dear Colleague Letters in Sustainable Chemistry, Engineering, and Materials (SusChEM) from FY 2014-2017. Researchers supported by the following NSF Divisions benefited from the SusChEM Dear Colleague Letters: CHE, CBET, DMR, EAR, and CMMI.
- **“A National Strategy for Advancing Climate Modeling” 0809051:** This report resulted in implementation of a Common Infrastructure for Modeling the Earth, a national modeling forum, and provided backing to the development of the NCAR/Wyoming supercomputer center. This was a collaborative effort across agencies (NOAA, NSF, NASA, DOE, Defense) to produce a strategic framework to guide progress in the nation’s climate modeling enterprise. A strong committee helped to guide the process.

**Insight 11: NASEM reports that complement other reports can add weight to specific arguments and spur change.** Building a portfolio of findings and/or recommendations across several external stakeholders or venues can help set future directions in more powerful ways.

- **“Status, Contributions, and Future Directions of Discipline Based Education Research” 0934453:** This award funded a consensus study of the research literature about undergraduate learning in the sciences. As a major study emphasizing research in subject-matter learning and teaching, the study built upon previous National Academies reports such as “How People Learn” (2000). The study explored the strengths and weaknesses of discipline-based education research (DBER).
- **“Building a National STEM Workforce Strategy: A Workshop for Researchers and Other Stakeholders” 1449332:** This award responded to a recommendation of the EHR Advisory Committee to solicit input from stakeholders about ideas that could help frame the workforce development core research theme for the Directorate. It also complemented the release of the National Science Board (NSB) “Revisiting the STEM Workforce” report and guided the assumptions in the current NAS revitalizing STEM graduation study. It is considered impactful because of its relevance to a long-term Directorate-wide investment strategy and its influence on a growing new research portfolio.

### III. RECOMMENDATIONS - SEIZE OPPORTUNITIES

The Team recognizes that NASEM reports and studies have different audiences and functions. The audiences include the public, specific scientific disciplines, NSF, and other US Government agencies. The functions include educating the public, informing science disciplines, and guiding public/science policy. The value and impacts of NASEM reports vary similarly. And, in some cases, some studies evolve so that the realized impact is not the intended impact. There is no one place to look or single metric to measure the value of NASEM projects. There appears to be relatively little correlation between award size and impact, for example. Instead, well-planned, well-situated activities that take advantage of opportunities to make change create impact. **Therefore, the NASEM Team recommends that NASEM projects should be scoped and managed to take best advantage of the opportunities available to create impact.** To accomplish this, the NASEM Team advises that NASEM and NSF consider the following recommendations to ensure that NSF's investments in NASEM have the highest impact:

**Recommendation 1: NASEM should explore models for more nimble projects so they can produce high-impact results more quickly. In many cases, opportunities to affect change and create impact are relatively fleeting.** Project models that could produce high-quality results or recommendations in 6 months to 1 year will help make NASEM projects more useful in situations where the opportunities for impact are near-term or short-lived. NSF should expedite the processing of NASEM proposals when rapid results are required. NASEM has been working to transform their processes and is experimenting with novel consensus study models to produce high-quality results that are timely and reasonably priced.

**Recommendation 2: NASEM proposals should describe the intended impact, include an assessment of the opportunities available for achieving the intended impact, and include an appropriately scoped work-plan.** Proposals should also include a detailed impact plan that outlines plans for distributing products to ensure target audiences are reached. NSF reviewers and program staff should consider these factors when evaluating proposals and funding them.

**Recommendation 3: NASEM and NSF program staff should remain cognizant of the timelines for targeted opportunities and work to ensure that NASEM projects are scoped and managed appropriately.** When NSF has a specific need for a NASEM product, NSF staff should be clear about when such a product must be received to be useful. NASEM and NSF need to consider the tradeoffs inherent in balancing speed with depth when scoping projects. Multi-year consensus studies should be reserved for more durable topics that receive sustained policy attention or are frequently revisited. NASEM and NSF program staff should jointly review the progress of projects and make mid-course adjustments to ensure timely delivery of products as needed. No-cost extensions should be rarely used if a project extension would severely limit the intended impact.

**Recommendation 4: NASEM and NSF should ensure that study committees receive a clear and focused charge.** Committee leadership and members must also understand the policy contexts and opportunities, so that they can work to produce results appropriately. Spending time on crafting a well-defined charge is time well spent in the very beginning. In addition, it is important that NSF staff attends the first study report meeting and clarifies the charge with the committee.

**Recommendation 5: NASEM report recommendations should be insightful, specific, and actionable.** Report authors should be cognizant of the relevant policy contexts and available opportunities to effect change. While recommendations do not always need to be novel (e.g. there is value in restating a position), care should be taken to ensure that recommendations suggest specific actions that are tailored to and achievable within the relevant policy contexts. Recommendations for increased funding, for example, are not useful or actionable if the opportunity to increase a budget is not available or has passed.