

Re-assessing the science – society relation: The case of the US National Science Foundation’s broader impacts merit review criterion (1997 – 2011)

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Abstract

In 2005, I published the first scholarly article on the US National Science Foundation’s Broader Impacts Merit Review Criterion.¹ In the intervening years, much has happened, both in terms of scholarship on the Broader Impacts Criterion and in terms of the Broader Impacts Criterion itself. Here, I revisit that original article, answering some questions, filling in some blanks, expanding some bits, contracting others, updating and generally rethinking the whole thing. The National Science Board has also rethought the Broader Impacts Criterion, and 2011 marks the gestation, if not the birth, of a much different criterion, a sort of Broader Impacts 2.0. Now, then, seems like the perfect time to think once again about NSF’s Broader Impacts Criterion and about the dialectic between the values of autonomy and accountability in the science – society relation.



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1. Introduction

Since its early modern origins, modern natural science has struggled to develop appropriate standards for quality assessment. In particular, one of the main issues has been the extent to

¹ “Assessing the Science – Society Relation: The Case of the U.S. National Science Foundation’s Second Merit Review Criterion,” in *Technology in Society* Volume 27, Issue 4, November 2005, Pages 437-451.

which science ought to be judged only on its own terms.² The history of science provides extensive literature on the effort to establish science as an autonomous human activity independent especially of religious or political manipulation. The experience of Galileo Galilei (1564-1642) and efforts to break free of church criticism of the heliocentric theory is perhaps the most well known case in the religious arena. The Soviet effort to promote the genetic theories of T.D. Lysenko (1898-1976) is an oft-cited case in the political arena. Such historical events are evoked as lessons that should have taught us, we are told, to espouse the Enlightenment ideal of a science that exists independently of religious or political influence for the ultimate benefit of society as a whole.

From the very beginning, however, questions have occasionally been raised about whether scientific autonomy might be carried so far as to create an imbalance in the science-society relation. The Romantic response to Enlightenment science, for instance, questioned whether science could indeed stand on its own. Are there not times when scientific knowledge distorts lived reality? Is technological power not only a boon but also a danger to human welfare? This debate may be seen in terms of a conflict between advocates of internal and external criteria for evaluating science, with internalists championing scientific autonomy while externalists argue for more societal accountability and control over the direction and scope of scientific research.

In post World War II America, the debate surrounding the formation of the US National Science Foundation (NSF) also reflected this ambivalence. The strong autonomy advocacy of Vannevar Bush's *Science – The Endless Frontier* (1945) was moderated by the more pragmatic arguments of the Steelman Report (Steelman, 1947), which advocated more limited scientific autonomy in the name of public benefit. Although by the time NSF was actually created in 1950 many of Bush's specific proposals for its formation were abandoned, his notion of the strong autonomy necessary for basic scientific research was institutionalized with the creation of NSF and the development of protocols for the internal peer review of proposals to be funded by the federal government.³ Tension persists between advocates of internal criteria of scientific merit and advocates of broader external criteria for assessing science (Frodeman and Holbrook, 2011a, 2011b; Holbrook, 2010b; Holbrook and Frodeman, 2011; Smith et al., 2011; Von Schomberg, 2011).

With the 1997 formulation of two basic merit review criteria for the assessment of NSF proposals, this tension between science and society, internal autonomy and external accountability, took on a unique institutional expression that has yet to work itself out into a well-accepted balance of complementary interests (Holbrook and Frodeman, 2011).⁴ This article examines some of the issues associated especially with NSF's Broader Impacts Criterion (sometimes also unofficially known as 'Criterion 2') in an effort to contribute to the further

² See, for instance, Weinberg (1969), Chubin and Hackett (1990), Guston (2000), Biagioli (2002), Donovan (2009), Holbrook (2009, 2010a, and 2010b), and Smith et al. (2011).

³ For a brief historical account of merit review at NSF, see Rothenberg (2010).

⁴ This is not meant to suggest that other agencies are not also dealing with the tension between autonomy and accountability. Indeed, the premise of the Comparative Assessment of Peer Review (CAPR) study of which I am co-Principal Investigator is that many agencies around the world are dealing with the issue of how best to incorporate impact considerations into their peer review processes. For further information on CAPR, see <http://csid-capr.unt.edu/>.

evolution of a discussion of a distinctive issue in the philosophy of science policy.⁵

2. Background

In October 1997 (FY 1998) NSF introduced two new generic merit review criteria that had been approved by the National Science Board (NSB), NSF's policy branch, to replace the four that had been in effect since 1981.⁶ The two criteria used to evaluate all NSF proposals for fourteen years (FY 1998 – FY 2011) are:

- *What is the intellectual merit of the proposed activity?*
 - How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields?
 - How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.)
 - To what extent does the proposed activity suggest and explore creative, original, or potentially transformative⁷ concepts?
 - How well conceived and organized is the proposed activity? Is there sufficient access to resources?

- *What are the broader impacts of the proposed activity?*
 - How well does the activity advance discovery and understanding while promoting teaching, training, and learning?
 - How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?
 - To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks and partnerships?
 - Will the results be disseminated broadly to enhance scientific and technological understanding?
 - What may be the benefits of the proposed activity to society?

It is tempting to assign an 'internalist' label to the Intellectual Merit Criterion, which was chiefly concerned with scientific merit as judged by scientists, while assigning the 'externalist' label to the Broader Impacts Criterion, which was concerned with issues of education, infrastructure, diversity, and societal benefit. However, no such simple division of labels will do. For, insofar

⁵ For an outline of the philosophy of science policy, see Frodeman and Mitcham (2004).

⁶ For a detailed comparison of the two 1997 criteria to the four 1981 criteria, see the report of the National Academy of Public Administration (NAPA, 2001, p.p. 6 and 17-8). Hereafter, this report shall be referred to as the 'NAPA Report'.

⁷ On September 24, 2007, NSF issued *Important Notice No. 130: Transformative Research*, which announced a change to NSF's Intellectual Merit Review Criterion effective January 5, 2008 (Bement, 2007). Reviewers would now be asked: "To what extent does the proposed activity suggest and explore creative, original, **or potentially transformative** concepts" ('bold' indicates addition of "potentially transformative" to the criterion)? This is the only change to the merit review criteria over the fourteen years from FY 1998 – FY 2011.

as both criteria were part of NSF's peer review process, that is, insofar as both criteria were criteria for scientists to be judged by scientists, the Broader Impacts Criterion was *also* meant to be an internal criterion. Nevertheless, NSF's introduction of broader impacts also introduced what many took to be considerations external to science into the (internal) peer review process (see, for instance, NAPA, 2001; APSN, 2007; *Times Higher Education*, 2009; Lok, 2010).

Ironically, NSB restructured the merit review criteria largely to respond to increased demand for an account of the societal benefits achieved by NSF funded projects.⁸ Congress had passed the Government Performance Results Act (GPRA) in 1993, the purpose of which was to increase the focus of Federal agencies on improving and measuring "results." These results would provide congressional decision makers with the data they require to assess the "relative effectiveness and efficiency of Federal programs and spending." The message that "results" are tied to funding was reinforced when President George W. Bush took office by the President's Management Agenda (PMA), as well as the establishment of the Program Assessment Rating Tool (PART), designed specifically to tie GPRA to budget formation. As the National Academy of Public Administration (NAPA) Report (2001) notes, "The immediate effect of this restructuring [of the merit review criteria] is to make the broader impact and societal objectives more visible – both to the scientific and engineering communities and to Congress" (17).

The added visibility of broader societal impacts also produced additional effects: (1) in 1997 Congress directed NSF to contract with NAPA to review the new criteria, and (2) questions arose within the scientific and engineering communities as to how to interpret and apply the new criteria, *especially* the Broader Impacts Criterion. NSF's new merit review criteria were being challenged on two fronts: on the external front, by members of Congress seeking immediate feedback on the "results" of the new criteria, and on the internal front, by scientists and engineers who questioned the criteria's validity. These challenges focused in particular on the issue of broader impacts.

3. A Brief Historical Outline of Issues Surrounding the Broader Impacts Criterion

One of the main reasons behind the 1997 restructuring of NSF's generic merit review criteria was the desire to link public investment in science with societal benefits, to demonstrate, in other words, that the people were getting a good return on their investment.⁹ Congress had passed GPRA in 1993, and it was partly in response to such demands for demonstrable results that in 1995 NSF had adopted a new strategic plan, according to which "the promotion of the discovery, integration, dissemination, and employment of new knowledge in service to society" (NSF 95-24) was among the long-term goals of the Foundation. The goal of "knowledge in service to society" was meant to link NSF's goal of world leadership in science and engineering with

⁸ Daryl Chubin (2007) suggests: "This [broader impacts] criterion can be traced to NSF's congressional mandate (the Science and Engineering Equal Opportunities Act of 1980, last amended in December 2002) to increase the participation of underrepresented groups (women, minorities, and persons with disabilities) in STEM (science, technology, engineering, and mathematics)."

⁹ For a brief description of the motivations behind the re-examination of NSF's merit review criteria, see NSF 2, Section I. Context of the Report. For a more detailed history of the development of NSF's new merit review criteria, including a "Key Events and Decisions Timeline," see NAPA (2001, p.p. 23-31).

contributions to the national interest.

3.1 NSB-NSF Task Force on Merit Review

Also in 1995, NSB stated its desire to re-examine the merit review criteria that had been in effect since 1981 in light of NSF's new strategic plan. In 1996 the Board established the NSB-NSF Task Force on Merit Review to examine and evaluate the old criteria. In its Discussion Report (NSB/MR 96-15) the Task Force recommended two generic criteria to replace the four 1981 criteria: (1) What is the intellectual merit and quality of the proposed activity? and (2) What are the broader impacts of the proposed activity? Among the perceived advantages of the proposed new criteria were that they would be helpful in connecting NSF investments to societal value while preserving NSF's ability to select proposals on the basis of scientific excellence, and that the new criteria were more clearly related to the goals and strategies of the new strategic plan. NSF published the recommendations of the Task Force on the Web, through press releases, and through direct contact with universities and professional associations and received around 300 responses from the scientific and engineering community.

In light of these responses, in 1997 the Task Force published its Final Recommendations (NSB/MR 97-05). The responses raised several concerns about the new criteria, including what the Task Force termed the issue of "weighting" the criteria: intellectual merit was perceived by respondents as more important than broader impacts, or the Broader Impacts Criterion was perceived as irrelevant, ambiguous, or poorly worded. Moreover, respondents expressed concern that for much of basic research it is impossible to make meaningful statements about its potential usefulness. The Task Force noted that "respondents may be interpreting this question too narrowly. While it may not be possible to predict specific potential applications for one's research, one should be able to discuss the value or applicability of the line of inquiry or research area."

In response to the issue of "weighting," the Task Force recommended stating that "the criteria need not be weighted equally." Ultimately, the Task Force judged the criteria to be flexible enough "to be useful and relevant across NSF's many different programs," and recommended that the new criteria be adopted. Later in 1997, NSF issued Important Notice No. 121, which announced NSB approval of the new merit review criteria, effective October 1 (Lane, 1997).

With the approval of the new merit review criteria, NSB had effectively increased the profile of the importance of the societal benefits of NSF-funded projects. Yet in doing so, they had also laid the foundation for a continuing philosophical conflict. At stake for NSB was thoroughly integrating the merit review process with their new strategic plan, which had been designed to increase the profile of the societal benefit derived from NSF-funded research. This makes perfect sense, since NSB's purpose is to set policy for NSF. At stake for the Task Force on Merit Review was finding a way to carry out this process of integration by means of revising the merit review criteria. Again, this makes sense, since this is precisely what the Task Force was tasked to do. Yet less attention was paid to what was at stake for the respondents to the Task Force's proposed new criteria: what was at stake for the scientific and engineering communities? While NSB approached the issue from a larger policy perspective, and while the Task Force

focused on producing the most generic, flexible criteria that would integrate intellectual merit and societal benefit, members of the scientific and engineering communities expressed diverse reservations about the proposed new criteria: some did not understand the Broader Impacts Criterion, some did not find it very important, some claimed it was irrelevant, some claimed it was impossible to address. Is the Broader Impacts Criterion unclear? Is it relatively unimportant? Is it irrelevant? Is it impossible to answer?

By recommending that “the criteria need not be weighted equally,” a recommendation that certainly allowed for the flexibility of the criteria, the Task Force also left the door open for broader impacts opponents – whoever claimed that the Broader Impacts Criterion was irrelevant was effectively given *carte blanche* to ignore it.¹⁰ This freedom also allowed discussion of the fundamental differences surrounding the Broader Impacts Criterion to be postponed.

3.2 2001 NAPA Report

Yet these issues would resurface in the 2001 NAPA Report. External pressure from Congress had not gone away: in 1998 the Senate directed NSF to contract with NAPA to review the effects of changes in the merit review criteria (Senate Report 105-53), a direction they reiterated in 1999 (Senate Report 105-216). In 2000, NSF commissioned the NAPA study. Among the “Major Conclusions and Recommendations” of the NAPA Report is that “there is a need to improve the conceptual clarity of the objectives of the new criteria as well as the language used in stating them.” The report continues:

Asking scientists to speculate about the possible future *broader or societal impacts* of a proposal raises a distinct level of discomfort for many reviewers. This discomfort is increased when precise definitions of some of the objectives of the new criteria remain ambiguous. The conceptual clarity of the new review criteria, therefore, needs to be improved so the criteria better reflect the intentions of NSF for instituting them. This is true of the language of Criterion 2, in particular. (NAPA, 2001, p. 8)

It is interesting to notice that the NAPA Report does not claim that the discomfort caused by Criterion 2 is due to lack of clarity. Rather, it suggests that the discomfort caused by Criterion 2 is *increased* by a lack of conceptual clarity. A good case can be made (Holbrook and Frodeman, 2011; Holbrook and Hrotic, under review), moreover, that such complaints about clarity are actually a proxy for an unwillingness to address the issue of impact.

As the Report goes on to suggest, “Rewriting the language of the review criteria and restructuring their order is essentially treating only surface-level symptoms and not addressing underlying issues, about which there is considerable diversity of views within the scientific and academic communities. *The ultimate differences about issues raised by Criterion 2 are not those of language but of belief*” (NAPA, 2001, p. 9, emphasis added). Ultimately, the NAPA Report

¹⁰ NSF did not *intend* to give proposers and reviewers *carte blanche*, however, as NSF 99-172 and NSF Important Notice No. 125 indicate: NSF requested that proposers and reviewers consider both intellectual merit and broader impacts in preparing and evaluating proposals for NSF (Colwell, 1999).

asserts, “the concept of *broader social impact* raises philosophical issues for many reviewers – in particular, reviewers who see their task as exclusively one of assessing the intellectual merit of proposals” (NAPA, 2001, p.14, emphasis added). In drawing attention to the fundamental issues surrounding Criterion 2, the NAPA Report provided yet another opportunity for discussion of those issues.

Yet in its FY2000 Report on its Merit Review System, NSF describes the recommendations of the 2001 NAPA Report as follows:

The key finding was that it is too soon to make valid judgements [*sic*] about the impact and effectiveness of the new criteria. The NAPA report also highlighted the need to (1) improve the conceptual clarity of the criteria, (2) better communicate with proposers, reviewers and NSF staff about how the criteria are to be used, and (3) improve quantitative measures and performance indicators to track the objectives and implementation of the new criteria. NSF is implementing these suggestions beginning in FY 2001. (NSF 10, p. 14)

The NAPA Report did indeed conclude that it was too early to make a valid judgment about the effectiveness of the new criteria. However, to characterize this conclusion as “the key finding” of the report is a bit misleading: it was one of five “Major Conclusions and Recommendations,” including also the need for quantitative measures to track the new criteria, the need for improving the conceptual clarity of the criteria, using targeted programs to address broader impact, and the need to move beyond simply modifying the language of the new criteria (NAPA, 2001, pp. 7-9).

The NAPA Report also offered four additional “Recommendations to Expand NSF’s Merit Review process Improvement Initiatives,” among which was included a recommendation to address the “intellectual and philosophical issues” raised by the new criteria (2001, p.p. 13-14). By emphasizing as “the key finding” the NAPA Report’s conclusion that it was too early to make a valid judgment about the effectiveness of the new criteria, and by agreeing to implement three so-called ‘highlighted suggestions’, the FY 2000 Report on the Merit Review System effectively gave the impression that, at least with regard to the NAPA Report, everything was under control. Moreover, by downplaying or even omitting other key findings of the NAPA Report, the FY2000 Report on Merit Review effectively allowed discussion of the fundamental differences surrounding the Broader Impacts Criterion to be postponed once again.

This is not to suggest that NSF had no interest in or intention of improving the merit review process. On the contrary, NSF has expended a great deal of time and resources on improving merit review. One of the key areas on which NSF has focused in terms of improving the merit review process is increasing reviewer and program officer attention to *both* merit review criteria.¹¹ The FY2001 Report on Merit Review details the actions undertaken to insure that both criteria are addressed, including, but not limited to, (1) developing and disseminating a draft set of examples of activities that address the Broader Impacts Criterion – in order to ‘improve the conceptual clarity’ of the criterion – (2) drafting revisions to the Grant Proposal Guide that instruct proposers that they *must* clearly address broader impacts in their proposals – in order

¹¹ In fact, this was incorporated as one of the GPRA performance goals for the foundation in FY 1999.

better to ‘communicate with proposers, reviewers and NSF staff about how the criteria are to be used’ – and (3) designing activities to increase program officer attention to the broader impacts criterion through training of new program officers and through electronic tracking of program officer use of both criteria in making recommendations to fund or decline proposals – in order to ‘improve quantitative measures and performance indicators to track the objectives and implementation of the new criteria’ (NSB 02-21). In other words, NSF attempted to follow the suggestions of the NAPA Report *as described in NSF’s FY2000 Report on Merit Review*.

Later in 2002, NSF issued Important Notice No. 127, which informed proposers that, effective October 1, 2002, NSF would return without review proposals that did not separately address both merit review criteria within the Project Summary (Colwell, 2002). Important Notice No. 127 therefore rescinded the notion that proposers and reviewers have *carte blanche* to ignore broader impacts. In sum, NSF was taking great pains to insure that the Broader Impacts Criterion was being addressed throughout the merit review process.

3.3 The Clarity of Broader Impacts

The NAPA Report notes that “many reviewers either ignore Criterion 2 [broader impacts] or in some cases regard it as irrelevant in the review of proposals,” that many reviewers “perceive Criterion 1 (scientific merit) and Criterion 2 (broader or societal impact) as in competition with each other,” and that many reviewers either “disregard Criterion 2 altogether or simply merge social value into scientific merit” (NAPA, 2001, p. 13). Among the major recommendations of the NAPA panel is that “there is a need to improve the conceptual clarity of the objectives of the new criteria as well as the language used in stating them This is true of the language of Criterion 2, in particular” (NAPA, 2001, p. 8).

After the February 2001 NAPA Report, there were repeated calls for clarification of the Broader Impacts Criterion.¹² Such calls for clarification rest on the assumption that *if those involved in NSF’s merit review process exhibit difficulties with the interpretation and application of the Broader Impacts Criterion, then the criterion itself must be unclear*. However, this is a questionable premise: there are many other possible explanations for the difficulties surrounding the Broader Impacts Criterion expressed by proposers and reviewers alike. As the NAPA Report states, “Reviewers who tried to apply Criterion 2 as a matter of course in their own evaluation process, generally found its language reasonably clear” (NAPA, 2001, p. 71). This suggests that reviewers who already took broader impacts seriously had little difficulty understanding the language of the second criterion.

Yet this also suggests other possibilities: perhaps the language of the Broader Impacts Criterion is not in and of itself conceptually unclear (Frodeman and Parker, 2009; Holbrook and

¹² The most persistent calls for clarification of the language of the Broader Impacts Criterion come from the reports of Committees of Visitors (COVs), which are made up of outside experts who provide feedback to NSF on various aspects of program-level operations and outcomes of NSF-funded research. However, such calls for clarification of the Broader Impacts Criterion also appear in the reports of NSF’s Advisory Committee for GPRA Performance Assessment (AC/GPA). AC/GPA provides advice to the Director regarding NSF’s performance vis-à-vis GPRA.

Frodeman, 2011; Holbrook and Hrotic, under review). Perhaps there exist some reviewers who simply do not want to address broader impacts (Holbrook and Hrotic, under review). In fact, the NAPA Report supports this latter possibility:

Some scientific communities have found Criterion 2 hard to accept. NSF received approximately 300-400 emails on the new criteria that showed a strong bifurcation of opinion. Approximately half saw NSF as having been too elitist and therefore welcomed the change to the new criteria. Half remained purists and didn't like the new criteria. Mathematicians, for example, were against the new criteria. Geophysicists have been for them. (NAPA, 2001, p. 83)

The issue of clarity would become a persistent problem with the Broader Impacts Criterion that itself had broader impacts (see §4, below).

3.4 Quantity and Quality in the Application of the Broader Impacts Criterion

Given the attention now being paid by NSF to the use and abuse of the Broader Impacts Criterion, one would expect an improvement in its application; and to some extent this is true. The 2004 Report of the Advisory Committee for GPR Performance Assessment (AC/GPA) notes that NSF's merit review process is, on the whole, "impressive" (NSF 04-216). The AC/GPA Report also notes some improvement in the application of the Broader Impacts Criterion:

One of NSF's original GPR goals was to increase reviewer and program officer (PO) attention to *both* of the merit review criteria. It was noted in the two previous AC/GPA reports that consideration of the broader impact of the research continued to be somewhat inadequate. In 2003, 90 percent of the reviewers commented on both merit review criteria, up from 84 percent in 2002 and 69 percent in 2001. Thus, there has been considerable progress on addressing the two criteria. (NSF 04-216, p. 46)

That is, there had been considerable progress in the *quantity* of reviewers who address Criterion 2.¹³

"However," the FY 2004 AC/GPA Report continues,

the quality of response to the broader impacts criterion is still an issue. Several COV [Committees of Visitors] reports as well as comments from the AC/GPA indicate that the discussions of this criterion frequently lack substance and appear

¹³ This trend has generally continued, marked by a steady decline in the number of proposals returned without review for failing to address both criteria. However, the latest available Report on the NSF's Merit Review Process (FY 2010) notes a departure from that trend: in FY 2008, 124 proposals were returned without review, up from 117 in FY 2007; and in FY 2009, 147 proposals were returned without review for failure to address broader impacts (NSB-11-41). FY 2010, however, marks "a historical low" of 131 proposals returned without review (NSB-11-41, p. 22).

to be cursory at best, even though NSF now requires a one page discussion of both criteria in the project summary of the proposal. In 2003, 276 proposals were returned because this discussion was missing completely. The AC/GPA finds that the review of the broader impacts criterion remains a challenge for most reviewers. We noted some inconsistency in the completeness and quality of this part of the review and we recommend that NSF continue to focus on this issue. (NSF 04-216, p.p. 46-7)

NSF's attention to the criterion had produced improvement in terms of the *quantity* of proposers and reviewers who address broader impacts; yet the *quality* of responses to the Broader Impacts Criterion remained a persistent problem.

The lack of quality responses to broader impacts issues points to a severe limitation in NSF's use of quantitative analyses of the application of the criterion: even if 100% of proposers and reviewers were to address broader impacts in their proposals and reviews, if they do so in a manner that lacks substance, then the question of the broader impacts of the proposal will remain unanswered.¹⁴ This also pointed to an area of vulnerability as regards NSF's Organizational Excellence goal of operating a credible, efficient merit review system.¹⁵ Unless the quality of responses to the Broader Impacts Criterion improved, the credibility of the merit review system would suffer. Moreover, a lack of substance in reviewer responses to the Broader Impacts Criterion would decrease the efficiency of the merit review process: determinations of the broader impacts of proposals would essentially be left to NSF staff.

NSF has since avoided such difficulties. In its 2006-2011 Strategic Plan, NSF changed its strategic outcome goals to Discovery, Learning, and Research Infrastructure, with broader impacts 'highlights' used to evaluate the goal of Learning (see FY 2009 AC/GPA Report). The strategic outcome goal of Learning involves "cultivating a world-class, broadly inclusive science and engineering workforce, and expanding the scientific literacy of all citizens" (FY 2009 AC/GPA Report, p. 1). Highlights represent the best of the best outcomes of NSF support. They are identified by Committees of Visitors (COVs)¹⁶ who review specific NSF programs every three years, and then they are written up by Program Directors and passed along to AC/GPA, among others, in order to highlight NSF-sponsored achievements.

3.5 America COMPETES 2007 and 2010

¹⁴ Prior to 2004, NSF's GPRA Performance Plans addressed merit review in terms of a "Management Goal," as opposed to a "Strategic Outcome Goal," and set the specific goal on the use Criterion 2 at 70% usage. That is, NSF would be "successful" in its Management Goal relating to the use of Criterion 2 if at least 70% of reviewers commented on Criterion 2 in their reviews. NSF was "not successful" in FY2001, as only 69% of reviewers addressed both criteria; in FY2002 and FY2003, NSF was "successful," since 84% and 90% (respectively) of reviewers addressed both criteria (NSF 04-10, p. II-47). After 2004, "Management Goals" became "Organizational Excellence," a fourth "Strategic Outcome Goal." NSF's "Organizational Excellence" goal vis-à-vis merit review became to "operate a credible, efficient merit review system" (NSF 05-01, see also NSF 04-216, p. 45).

¹⁵ See [13], p. 45.

¹⁶ Among the program-level operations about which COVs provide feedback is a program's adherence to the merit review process, including its use of *both* merit review criteria, with special focus on the extent of each program's use of the Broader Impacts Criterion.

Continued questions regarding the quality of responses to the Broader Impacts Criterion once again led to Congressional action. On August 9, 2007, the America COMPETES Act (H.R. 2272) was signed into law (Public Law 110-69). Section 7022 of the act required the Director of NSF to issue a report to Congress “on the impact of the broader impacts grant criterion used by the Foundation” within one year of the date of enactment of the Act.¹⁷ This report was issued in 2008, though it was not posted on the NSF website.¹⁸

On January 4, 2011, the America COMPETES Reauthorization Act of 2010 (H.R. 5116) was signed into law (Public Law 111-358). Sec. 526 of the law deals explicitly with NSF's Broader Impacts Criterion. It is divided into two subsections titled “Goals” and “Policy.” The first outlines eight specific national needs that NSF's Broader Impacts Criterion is well-suited to address, including increasing the economic competitiveness of the United States, developing a globally competitive workforce, increasing partnerships between academia and industry, increasing the participation of underrepresented groups in science and engineering, increasing national security, improving science education, and enhancing scientific literacy.

As the House report (111-478) language makes clear, these eight national goals were not an imposition of the will of Congress on NSF or those members of the scientific community who apply for NSF funding or review its grant proposals. In fact, these goals are lifted directly from NSF's report to Congress requested in the original America COMPETES Act of 2007. Nevertheless, this first subsection is an attempt by Congress to help clarify the Broader Impacts Criterion for those scientists and engineers who claim to be confused by it (Holbrook, 2010c; see Lok, 2010; Hand, 2011).

The subsection on “Policy” is more directive than the first, indicating both to NSF and to members of the scientific community that they must enhance the quality of their approaches to satisfying and reviewing the Broader Impacts Criterion. As the report language puts the point: “the [House] Committee [on Science and Technology] is concerned that this criterion has been in place for more than 10 years now with little effort put toward evaluation of its impact or toward holding anyone, including NSF funded investigators, accountable for their efforts to satisfy the criterion.” The committee even raises the rather complicated issue of broader impacts expertise: “The Committee believes that if a broader impacts review criterion is to be applied at all, it should be treated with the same rigor as the scientific merit review criterion.”

The “Policy” subsection of Sec. 526 directs the NSF director to implement a policy that, among other things:

- requires grant recipients to employ “proven strategies and models” for addressing broader impacts;
- allows for grant funding to be used for “assessment and evaluation of the broader impacts activity;”

¹⁷ For a discussion of Section 7022, see Holbrook and Frodeman, 2007.

¹⁸ The *Report in Response to America COMPETES Act SEC. 7022* is available, however, from the CAPR Digital Repository: <http://csid-capr.unt.edu/fedora/repository/capr:15/-/Report%20in%20Response%20to%20America%20COMPETES%20Act:%20SEC.%207022>.

- encourages the development of institutional support for researchers to help them address broader impacts in their research and grantmaking; and
- has NSF require investigators to provide evidence of having received such institutional support, either from their own or another university or from someone with BIC-relevant expertise

As of December 2011, this policy had yet to be implemented. Nor had NSB changed NSF's Broader Impacts Criterion. However, proposed changes to the criterion were released in 2011.

4. Broader Impacts 2.0?

NSB-11-42, released June 14, 2011, announced new draft criteria for the review of proposals submitted to NSF. The proposed new Broader Impacts Criterion would ask, "which national goal (or goals) is (or are) addressed in the proposal?" The complete list of goals is:

- Increased economic competitiveness of the United States
- Development of a globally competitive STEM [science, technology, engineering, and mathematics] workforce
- Increased participation of women, persons with disabilities, and underrepresented minorities in STEM
- Increased partnerships between academia and industry
- Improved pre-K-12 STEM education and teacher development
- Improved undergraduate STEM education
- Increased public scientific literacy and public engagement with science and technology
- Increased national security
- Enhanced infrastructure for research and education, including facilities, instrumentation, networks, and partnerships

There is certainly some holdover from the 1997 formulation of the Broader Impacts Criterion. However, there is even more resemblance to the list of goals contained in the America COMPETES Reauthorization Act of 2010, which itself repeats the list of national needs the Broader Impacts Criterion is best suited to meet provided to Congress in NSF's *Report in Response to America COMPETES Act SEC. 7022*.¹⁹

4.1 NSF Questions

Six months prior to the release of the draft criteria, on January 21, 2011, NSB had announced it was seeking feedback on NSF's Merit Review criteria (NSB-11-8). This feedback was sought to inform the deliberations of a new Task Force on Merit Review, which had been formed at the February 3-4, 2010 meeting of the NSB and had been charged "to consider all options when developing their final recommendations, from keeping the criteria just as they are to completely

¹⁹ For discussion of the proposed criteria, see Frodeman and Holbrook, 2011a and 2011b.

rewriting them, or anything in between” (NSB-11-8).²⁰ In addition to collecting responses from a website, members of the Task Force on Merit Review made contact with a variety of stakeholders in NSF’s Merit Review process:²¹

Members of NSF’s senior leadership and representatives of a small set of diverse institutions were interviewed; surveys about the criteria were administered to NSF’s program officers, division directors, and advisory committee members and to a sample of 8,000 of NSF’s Principal Investigators (PIs) and reviewers; and the NSF community at large was invited to provide comments and suggestions for improvements through the NSF web site (http://www.nsf.gov/nsb/publications/2011/01_19_mrtf.jsp). The stakeholder responses were very robust—all told, the Task Force considered input from over 5,100 individuals. (NSB-11-42)

NSB Chairman Ray Bowen and NSF Director Subra Suresh described this input as remarkably consistent:

One of the most striking observations that emerged from the data analyses was the consistency of the results, regardless of the perspective. All of the stakeholder groups identified similar issues, and often offered similar suggestions for improvements. It became clear that the two review criteria of Intellectual Merit and Broader Impacts are in fact the right criteria for evaluating NSF proposals, but that revisions are needed to clarify the intent of the criteria, and to highlight the connection to NSF’s core principles. (NSB-11-42)

As a result, in addition to the list of goals outline above (§4), the proposed new merit review criteria were preceded by a statement of merit review principles.

4.2 Proposed Merit Review Principles

The first proposed merit review principle states: “All NSF projects should be of the highest intellectual merit with the potential to advance the frontiers of knowledge” (NSB-11-42). In

²⁰ At the time of its formation, the Task Force included the following: NSB members: Dr. Alan Leshner, Chairman, Dr. Ray Bowen, Dr. John Bruer, Dr. Esin Gulari, Dr. Lou Lanzerotti, Dr. Douglas Randall, Dr. Diane Souvaine, Dr. Thomas Taylor, and NSF Liaison members on the Task Force, Dr. Lance Haworth, Dr. Tim Killeen, and Mr. Jeff Nesbit (http://www.nsf.gov/nsb/committees/tskforce_mr_charge.jsp). There was some turnover, and the latest available list of members included the following: Co-Chairmen: Dr. John T. Bruer and Dr. Alan I. Leshner; Members: Dr. Douglas D. Randall, Dr. Diane L. Souvaine, Dr. Thomas N. Taylor; Consultant: Dr. Louis J. Lanzerotti; NSF Members: Dr. Timothy L. Killeen; Executive Secretary: Dr. Joanne S. Tornow (http://www.nsf.gov/nsb/committees/tskforce_mr.jsp).

²¹ For instance, on March 26, 2010, Joanne Tornow, Executive Secretary of the Task Force on Merit Review, contacted Warren Burgren, a member of the CAPR Team, to discuss procuring multiple copies of a special issue of *Social Epistemology* devoted to NSF’s Broader Impacts Criterion (Holbrook, 2009) to distribute to the Task Force. NSF purchased 25 copies in April, 2010. On July 22, 2010, Tornow also met with CAPR PI Robert Frodeman and co-PI J. Britt Holbrook. Tornow later participated in a workshop co-organized by CAPR and the European Commission in Brussels in December, 2010 (<http://csid-capr.unt.edu/research/capr-workshop-brussels-december-2010>).

other words, broader impacts alone would be insufficient to guarantee funding. This does not indicate a change from previous NSF practice, but it does make this practice explicit.

The Task Force also recommended adding the following principle:

Broader impacts may be achieved through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by the project but ancillary to the research. All are valuable approaches for advancing important national goals. (NSB-11-42)

By allowing for “ancillary” broader impacts activities, those who insisted that their research had no broader impacts would be freed from thinking that their proposed broader impacts activities would have to be integrated with their research.

This is an interesting shift away from a longstanding principle listed in NSF’s Grant Proposal Guide (NSF 11-1) immediately following a description of the Merit Review criteria:

NSF staff will give careful consideration to the following in making funding decisions:

Integration of Research and Education

One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects and activities it supports at academic and research institutions. These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students, and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learning perspectives. (Chapter III-1)

This Humboldtian principle of the integration of research and education was not considered to be an official merit review criterion that would be considered by reviewers. However, it was presented as a principle that proposers knew would be considered by the NSF program officer and Division Director.²²

The final proposed new merit review principle was designed to answer Congress’s demand for improved quality of broader impacts:

Ongoing application of these criteria should be subject to appropriate assessment developed using reasonable metrics over a period of time. (NSB-11-42)

In other words, NSB agreed that merit review ought to be subject to assessment, as long as the assessment was “appropriate,” the metrics developed were “reasonable,” and time was allowed by Congress for NSF to figure out the details.

²² For a discussion of the role of the program officer in the funding decision process, see Holbrook and Frodeman, 2011.

4.3 Proposed New Merit Review Criteria

The proposed new Intellectual Merit Criterion was largely unchanged (NSB-11-42):

Intellectual merit of the proposed activity

The goal of this review criterion is to assess the degree to which the proposed activities will advance the frontiers of knowledge. Elements to consider in the review are:

1. What role does the proposed activity play in advancing knowledge and understanding within its own field or across different fields?
2. To what extent does the proposed activity suggest and explore creative, original, or potentially transformative concepts?
3. How well conceived and organized is the proposed activity?
4. How well qualified is the individual or team to conduct the proposed research?
5. Is there sufficient access to resources?

Two changes are notable, however. First, the proposed new Intellectual Merit Criterion is preceded by a statement of the goal of the criterion that was not present in the 1997 criterion. Second, the order of the elements to consider under the rubric of intellectual merit had been changed. Whether the proposed activity were “potentially transformative” had been moved up in the list to second from third; and the qualifications of the individual or team had been moved down from second to fourth.

The proposed new Broader Impacts Criterion, however, was fairly radically different from the 1997 criterion (NSB-11-42):

Broader impacts of the proposed activity

The purpose of this review criterion is to ensure the consideration of how the proposed project advances a national goal(s). Elements to consider in the review are:

1. Which national goal (or goals) is (or are) addressed in this proposal? Has the PI presented a compelling description of how the project or the PI will advance that goal(s)?
2. Is there a well-reasoned plan for the proposed activities, including, if appropriate, department-level or institutional engagement?
3. Is the rationale for choosing the approach well-justified? Have any innovations been incorporated?
4. How well qualified is the individual, team, or institution to carry out the proposed broader impacts activities?

5. Are there adequate resources available to the PI or institution to carry out the proposed activities?

The most glaringly obvious change is the connection to national goals. Although the proposed criterion does not explicitly state that the list of national goals provided in the peer review principles is exhaustive, it is certainly plausible that many proposers and reviewers would assume that the question “which national goal” the proposal addresses would be answered with reference to that list of national goals. Economic competitiveness, national security, partnerships with industry, and a globally competitive workforce are added. Education activities, enhancing infrastructure, and broadening participation of underrepresented groups remain.

Notably missing from the proposed new criterion, however, was the question of the potential benefits of the proposed activity to society. Potential benefits to society seemed to be limited to the list of national goals provided in the proposed principles. In taking away the vagueness of the “benefit to society” clause, however, the proposed new criterion would also limit the freedom of proposers and reviewers to suggest and judge novel and creative ideas not included on the list (Holbrook and Frodeman, 2011; Frodeman and Holbrook, 2011a and 2011b).

Somewhat reminiscent of the Research Councils UK approach known as “Pathways to Impact,” the proposed criterion featured a new emphasis on *how* the proposed broader impacts are to be achieved. Once one chooses the national goal advanced through the research, the focus turns toward questions of implementation and strengthens the parallel between the Broader Impacts Criterion and the Intellectual Merit Criterion. Such parallelism could help dispel the illusion that “predicting” impacts is somehow more difficult than “predicting” intellectual success (Holbrook and Frodeman, 2011; Holbrook and Hrotic, under review).

5. Broader Impacts: their Present and Future State

Once the proposed new criteria were released in June, 2011, NSB received more feedback.²³ According to an entry on the *Nature News Blog* from December 13, 2011, the task force had settled on a “non-prescriptive, big-tent definition” of broader impacts:

Since 1997, the NSF has required all grant proposers to justify their requests not just on intellectual merit, but also on this notion of broader impacts. Yet researchers have found the requirements distressingly vague. Legislation passed by Congress in 2010 confirmed the importance of broader impacts, and also tried to be more specific, listing some of the activities that would count as having societal benefit. But when the task force’s May 2011 draft report dutifully repeated some of these examples, some critics worried that the NSF’s criteria would end up being too specific. Bruer’s team has since removed the list. “It raised problems about why some things were on the list and others not,” says Bruer. (Hand, 2011)

²³ Several relevant publications followed the release of the proposed new criteria, including AAAS, 2011; Frodeman and Holbrook 2011a and 2011b; Holbrook and Frodeman, 2011; Mervis, 2011a; and Sarewitz, 2011.

Although critics of the Broader Impacts Criterion had consistently claimed that it was unclear or “distressingly vague,” NSB seemed to have realized that intentional vagueness can actually be a good thing: it allows for maximum autonomy on the part of proposers and peer reviewers to provide content for broader impacts (Holbrook and Frodeman, 2011; Frodeman and Holbrook, 2011a and 2011b). “As a result, the task force stripped down its recommendations and kept the wording for the two criteria essentially the same as before” (Hand, 2011).

In addition, the list of national goals has been removed from the merit review principles:

Instead of four principles, with the list of national goals featured prominently, there are three governing ideas, none as controversial as the goals list. The first declares that all NSF projects “should be of the highest quality.” The second says that, in the aggregate, projects should contribute more broadly to advancing societal goals. The third states that any assessment of a project’s broader impacts should be “scaled” to the size of the activity. (Mervis, 2011a: 171)

The Task Force on Merit Review met with NSB on December 13-14, 2011. On December 16, 2011, NSF Director Suresh was quoted as follows (Mervis, 2011b: 1493):

One thing the NSB task force on broader impacts has looked at closely is metrics for success. And these are inherently long term. The time frame in which you assess the impact is much longer than the duration of the grant itself. That makes it much harder to say, at the end of 3 years, whether you've had an impact or not. So one thing we've been grappling with is how to put quantifiable, verifiable, and accessible metrics into everything we do, including broader impacts.

Ironically, peer review is not included in this list of metrics for broader impacts – though one might expect that anything as difficult to quantify as broader impacts might be ideally suited to being judged by peer review.

On January 9, 2012, NSB released its report (NSB/MR-11-22): *National Science Foundation's Merit Review Criteria: Review and Revisions*. Highlights of the report include the following:

- Retaining freedom for researchers to posit their own broader impacts, rather than relying on a predetermined list of “National Needs,” which was abandoned in the revision.
- Treating broader impacts more like intellectual merit.
- A call for developing better metrics for broader impacts activities.
- Noting that broader impacts may be better measured at levels beyond the individual project — at the institutional level, for instance.

It is obviously too early to say what these changes will mean. However, it is possible to say that NSB acted to keep NSF on the course of allowing members of the science and engineering community the freedom and creativity to give an account of their broader impacts. Whether scientists and engineers will embrace this freedom or continue to resist such calls for accountability remains to be seen.

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References

AAAS 2011. <http://www.aaas.org/spp/cstc/docs/11_07_13nsfmeritreview.pdf>, last accessed January 26, 2011.

APSN 2007. NSF's Broader Impacts Criterion gets mixed reviews. *American Physical Society News* 16(6), June.

Bement Jr., A. 2007. Important Notice No. 130: Transformative Research. National Science Foundation. <<http://csid-capr.unt.edu/fedora/repository/capr:1152>>, last accessed January 26, 2012.

Biagioli, M. 2002. From Book Censorship to Academic Peer Review. *Emergences*, Volume 12, Number 1, 2002, p.p. 11-45.

Blanpied, W.A. 1999. "Science and Public Policy: The Steelman Report and the Politics of Post-World War II Science Policy," in *AAAS Science and Technology Policy Yearbook*, 1999, p.p. 305-20.

Bush, V. 1945. *Science – The Endless Frontier* (Washington, D.C.: United States Government Printing Office, 1945). <<http://csid-capr.unt.edu/fedora/repository/capr:1156>>, last accessed January 26, 2012.

Colwell, R. 1999. Important Notice No. 125: Merit Review Criteria. National Science Foundation. <<http://csid-capr.unt.edu/fedora/repository/capr:1150>>, last accessed January 26, 2012.

Colwell, R. 2002. Important Notice No. 127: Implementation of new Grant Proposal Guide Requirements Related to the Broader Impacts Criterion. National Science Foundation. <<http://csid-capr.unt.edu/fedora/repository/capr:1138>>, last accessed January 26, 2012.

Chubin, D. 2007. <http://www.issues.org/24.1/forum.html>.

Chubin, D. and Hackett, E. 1990. *Peerless Science: Peer Review and US Science Policy*. (Albany: State University of New York Press).

Donovan, C. 2009. Gradgrinding the Social Sciences: The Politics of Metrics of Political Science. *Political Studies Review*: 2009 Volume 7, p.p. 73–83.

Frodeman, R. and Holbrook, J.B. 2011a. NSF's Struggle to Articulate Relevance. *Science*, vol. 333, July 8, 2011, p.p. 157-58. < <http://www.peerevaluation.org/read/libraryID:27861>>, last accessed January 26, 2012.

Frodeman, R. and Holbrook, J.B. 2011b. NSF and Public Accountability: New, More Prescriptive 'Merit Criteria' May Hinder Science Progress. *Science Progress*. June 27, 2011. <http://scienceprogress.org/2011/06/nsf-and-public-accountability/>, last accessed January 26, 2012.

Frodeman, R. and Mitcham, C., 2004. Eds. Special Issue of *Philosophy Today*: Toward a Philosophy of Science Policy: Approaches and Issues, 48: 5.

Frodeman, R. and Parker, J. 2009. Intellectual Merit and Broader Impact: The National Science Foundation's Broader Impacts Criterion and the Question of Peer Review. *Social Epistemology* 23 (3):337-345.

Guston, D. 2000. [Between Politics and Science: Assuring the Integrity and Productivity of Research](#) (Cambridge U. Press, 2000).

Hand, E. 2011. NSF takes broad look at broader impacts, Nature News Blog, December 13, 2011: <http://blogs.nature.com/news/2011/12/nsf-takes-broad-look-at-broader-impacts.html>.

Holbrook, J. B. 2009. Ed. *Social Epistemology: A Journal of Knowledge, Culture and Policy. Special Issue: US National Science Foundation's Broader Impacts Criterion*. 23 (3-4), July – December.

Holbrook, J.B. 2010a. "Peer Review," in *The Oxford Handbook of Interdisciplinarity*, R. Frodeman, J.T. Klein, and C. Mitcham, eds. Oxford: Oxford University Press, 2010, 321-32.

Holbrook, J.B. 2010b. The use of societal impacts considerations in grant proposal peer review: A comparison of five models. *Technology and Innovation*, Vol. 12, 2010, pp. 213–224. DOI: 10.3727/194982410X12895770314078. Available via open access at <<http://www.ingentaconnect.com/content/cog/ti/2010/00000012/00000003/art00005>>, last accessed January 26, 2012.

- Holbrook, J. B. 2010c. Accountable science: the COMPETES Act needs to demonstrate an accountability attitude. *Science Progress*, September 16. <<http://scienceprogress.org/2010/09/accountable-science/>>, last accessed January 26, 2012.
- Holbrook, J.B. and Frodeman, R. 2007. "Answering NSF's Question: What Are the Broader Impacts of the Proposed Activity?" *Professional Ethics Report XX* (3), Summer 2007. <http://www.aaas.org/spp/sfrr/per/newper50.shtml#NSF>, last accessed January 26, 2011.
- Holbrook, J.B. and Frodeman, R. 2011. "Peer review and the *ex ante* assessment of societal impacts." *Research Evaluation*, 20(3), September 2011, pp. 239–246. DOI: 10.3152/095820211X12941371876788. <<http://rev.oxfordjournals.org/content/20/3/239.full.pdf+html>>, last accessed January 26, 2012.
- Holbrook, J.B. and Hrotic, S. Under review. Blue skies, impacts, and peer review: Results of a survey.
- Lane, N. 1997. Important Notice 121: New Criteria for NSF Proposals. National Science Foundation. <<http://csid-capr.unt.edu/fedora/repository/capr:1148>>, last accessed January 26, 2012.
- Lok, C. 2010. Science funding: science for the masses. *Nature* **465**, 416-18. <<http://www.nature.com/news/2010/100526/full/465416a.html>>, last accessed 30 June 2011.
- Mervis, J. 2011a. Peer Review: Beyond the Data. *Science* 14 October 2011: Vol. 334 no. 6053 pp. 169-171 DOI: 10.1126/science.334.6053.169
- Mervis, J. 2011b. U.S. Science Policy: Suresh Expects Low-Cost Ideas Will Mean a Big Payoff for NSF. *Science* 16 December 2011: Vol. 334 no. 6062 pp. 1492-1493 DOI: 10.1126/science.334.6062.1492 <http://www.sciencemag.org/content/334/6062/1492.full>
- NAPA 2001. National Academy of Public Administration. *A Study of the National Science Foundation's Criteria for Project Selection: A Report by the National Academy of Public Administration for the National Science Foundation*. <<http://csid-capr.unt.edu/fedora/repository/capr:1098>>, last accessed January 26, 2012.
- NSB 01-36. FY2000 Report on the NSF Merit Review System. <<http://csid-capr.unt.edu/fedora/repository/capr:1139>>, last accessed January 26, 2012.
- NSB 02-21. FY2001 Report on the NSF Merit Review System. <<http://csid-capr.unt.edu/fedora/repository/capr:1140>>, last accessed January 26, 2012.
- NSB-11-8. http://www.nsf.gov/nsb/publications/2011/01_19_mrtf.jsp.
- NSB/MR 96-15. *Task Force on Merit Review's Discussion Report*. <<https://csid-capr.unt.edu/fedora/repository/capr:1146>>, last accessed January 26, 2012.

- NSB/MR 97-05. *Task Force on Merit Review's Final Recommendations*. <<http://csid-capr.unt.edu/fedora/repository/capr:1149>>, last accessed January 26, 2012.
- NSB/MR-11-22. *National Science Foundation's Merit Review Criteria: Review and Revisions*. <https://csid-capr.unt.edu/fedora/repository/capr:1176>.
- NSF 95-24. *NSF in a Changing World*. <<http://csid-capr.unt.edu/fedora/repository/capr:1147>>, last accessed January 26, 2012.
- NSF 99-172. "Dear Colleagues" letter to PIs and reviewers. <<http://csid-capr.unt.edu/fedora/repository/capr:1151>>, last accessed January 26, 2012.
- NSF 04-216. *FY2004 Report of the Advisory Committee for GPRA Performance Assessment*. <<http://csid-capr.unt.edu/fedora/repository/capr:1145>>, last accessed January 26, 2012.
- NSF 04-10. *FY2003 Performance and Accountability Report*. <<http://csid-capr.unt.edu/fedora/repository/capr:1141>>, last accessed January 26, 2012.
- NSF 05-01. *FY2004 Performance and Accountability Report*. <<http://csid-capr.unt.edu/fedora/repository/capr:1142>>, last accessed January 26, 2012.
- Rothenberg, M. 2010. Making Judgments about Grant Proposals: A Brief History of the Merit Review Criteria at the National Science Foundation, *Technology and Innovation*, Vol. 12, pp. 189–195, 2010. DOI: 10.3727/194982410X.
- Sarewitz, D. 2011. The dubious benefits of broader impact. *Nature* 475, 141. DOI:10.1038/475141a.
- Senate Report 105-53. <<http://csid-capr.unt.edu/fedora/repository/capr:1153>>, last accessed January 26, 2012.
- Senate Report 105-216. <<http://csid-capr.unt.edu/fedora/repository/capr:1154>>, last accessed January 26, 2012.
- Smith, S., Ward, W., House, A. 2011. 'Impact' in the proposals for the UK's Research Excellence Framework: Shifting the boundaries of academic autonomy. *Research Policy*, Vol. 40, Issue 10, December, 2011, p.p. 1369-1379.
- Steelman, J.R. 1947. *Science and Public Policy: A Program for the Nation*. US Government Printing Office.
- Times Higher Education* 2009 Petition decries 'impact' agenda in research. *Times Higher Education*, 11 June. <<http://www.timeshighereducation.co.uk/story.asp?storyCode=406931§ioncode=26>>, last accessed 30 June 2011.

Unlocking Our Future: Toward a New National Science Policy, A Report to Congress by the House Committee on Science, September 24, 1998. <<http://csid-capr.unt.edu/fedora/repository/capr:1155>>, last accessed January 26, 2012.

Von Schomberg, R. 2011. Prospects for Technology Assessment in a framework of responsible research and innovation, in M. Dusseldorp and R. Beecroft (eds). *Technikfolgen abschätzen lehren: Bildungspotenziale transdisziplinärer Methoden*, Wiesbaden: Vs Verlag, *in print*.

Weinberg, A.M. 1969. *Reflections on Big Science*. (Boston: The MIT Press).