SCIENCE & TECHNOLOGY POLICY INSTITUTE

Use of Grand Challenges in the Federal Government

Vanessa Peña
Chelsea A. Stokes

June 2019

Approved for public release;
distribution is unlimited.

IDA Document NS D-10699
Log: H 19-000291

IDA SCIENCE & TECHNOLOGY
POLICY INSTITUTE
1701 Pennsylvania Ave., NW, Suite 500
Washington, DC 20006-5805

The Institute for Defense Analyses is a nonprofit corporation that operates three Federally Funded Research and Development Centers. Its mission is to answer the most challenging U.S. security and science policy questions with objective analysis, leveraging extraordinary scientific, technical, and analytic expertise.

About This Publication

This work was conducted by the IDA Science and Technology Policy Institute. The views, opinions, and findings should not be construed as representing the official position of the National Science Foundation or the sponsoring office.

Acknowledgments

The authors are grateful to the numerous interviewees, including former and current Federal employees, who devoted their time to provide valuable input into this project and review the reports. In addition, the authors acknowledge the team at the Policy Design Lab for their support in helping develop early drafts of content for the reports.

For More Information

Vanessa Peña, Project Leader
vpena@ida.org, 202-419-5496

Mark S. Taylor, Acting Director, Science and Technology Policy Institute
mtaylor@ida.org, 202-419-5491

Copyright Notice

© 2019 Institute for Defense Analyses
4850 Mark Center Drive, Alexandria, Virginia 22311-1882 • (703) 845-2000.

This material may be reproduced by or for the U.S. Government pursuant to the copyright license under the clause at FAR 52.227-14 [Dec 2017].

Preface

In March 2016, the Office of Science and Technology Policy (OSTP) requested that the IDA Science and Technology Policy Institute (STPI) describe a set of approaches to improve innovation in and the effectiveness of the Federal Government. The innovative approaches identified create new processes, products, services, and methods of delivery; have been implemented or are in the initial stages of implementation; and have led to improvements in outcomes, efficiency, effectiveness, or quality related to Federal Government activities.

The objective of this project was to describe the lessons learned from the implementation of innovative approaches and identify opportunities for how to support the scaling up of these approaches throughout the Federal Government. The *Use of Grand Challenges in the Federal Government* report describes hallmark features of a Grand Challenge, how Federal employees are establishing Grand Challenges, including goal setting, design, and execution, and considerations for facilitating their use.

Prior to its publication online in 2019, this report was an internal Federal resource for Federal Government employees. It was published online to help benefit Federal and non-Federal communities alike. Because this report was written 3 years prior to its 2019 online publication, some of the URLs referenced may no longer be valid.

Contents

Use of Grand Challenges in the Federal Government

We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too.

—President John F. Kennedy,
Rice University, September 12, 1962

A. Overview

This report provides an overview of the use of Grand Challenges. It explains how Federal employees can determine if a goal warrants a Grand Challenge and provides considerations for designing and implementing Grand Challenges within their agencies. The report also describes ways non-government entities have used Grand Challenges. The information in this report is largely based on relevant literature, including articles from academic journals, news, and other outlets, as well as on interviews with Federal employees who have collaborated on Grand Challenges. In addition, appendices describe select examples of Grand Challenges (Appendix A) and additional resources (Appendix B).

B. Introduction

A Grand Challenge is an articulation of a desired objective that focuses attention and resources on specific, well defined problems and promotes innovative approaches, processes and solutions to solving them. The Grand Challenge approach does not define an immediately obvious solution. One of the values of the Grand Challenge approach lies in its ability to galvanize action from the public and private sectors. By using Grand Challenges to issue a call for new and audacious thinking, agencies can catalyze significant advances for national priorities. Grand Challenges have been used since the early 1980s for topics such as high-performance computing, global public health, and engineering.

The hallmarks of Grand Challenges include a pioneering vision, a large-scale collaborative effort, an ambitious but concrete target, and a flexible framework.

- **Grand vision**: Explicitly setting grand, ambitious targets—making solar energy as cheap as coal, understanding the human brain, or destroying cancerous tumors while

leaving healthy cells untouched—motivates the public and draws in new communities of potential solvers.

- **Collaboration across sectors**: Grand Challenges can accelerate the rate of progress on sticky problems by engaging a coordinated, "all-hands-on-deck" approach with multi-sector collaborations. Agencies can augment their impact by involving contributions from other agencies, foundations, research universities, companies, and citizens. Due to their scope and vision, Grand Challenges can encourage multi-sector and multi-disciplinary teams to form themselves in order to help solve the problem.
- **Ambitious yet achievable**: Grand Challenges can help agencies set bold, audacious goals. Historical examples include landing a human on the moon and the Human Genome Project. These examples have a definite and unambiguous outcome and do not articulate the solutions to achieve the outcome.
- **Flexible framework**: The Grand Challenge framework includes a variety of implementation mechanisms to engage new solvers, including, prize competitions,[1] crowdsourced innovations,[2] contracts,[3] organized commitments (e.g., for funding or other resources) across organizations and sectors, and partnerships.

1. Why

"A Grand Challenge can be a powerful tool to disrupt traditional thinking in a sector and industry and introduce, expand, and evolve what is possible in that industry," says Alexis Bonnell, Division Chief of Applied Innovation, from the U.S. Global Development Lab at the U.S. Agency for International Development (USAID).[4] By design, Grand Challenges can help achieve a large, seemingly unattainable goal for any agency. The development and execution of Grand Challenges can enable the Federal Government to:

- **Propel innovations that have a high return on investment for the public**: The Human Genome Project demonstrates the potential impact of ambitious research undertakings. From 1988 to 2003, the Federal Government invested $3.8 billion in the Human Genome Project. Between 1988 and 2010, the Human Genome Project

---

1 Challenge.gov, "Challenges and Prizes Toolkit," https://www.challenge.gov/toolkit

2 Citizenscience.gov, "Federal Crowdsourcing and Citizen Science toolkit," *Citizenscience.gov*, https://crowdsourcing-toolkit.sites.usa.gov

3 GSA, "Procurement toolkit," https://www.gsa.gov/portal/content/103364

4 A. Bonnell, in-person interview, November 14, 2016.

generated an estimated economic output of $796 billion; a return of $141 for every $1 invested.[5]

- **Marshal resources with an "all-hands-on-deck" approach**: The technological advancements made by participants in the Grand Challenge the Defense Advanced Research Projects Agency (DARPA) issued in 2002 for robotic ground vehicles helped spur private sector investment in autonomous vehicles, such as Google's self-driving car.[6] IBM's advances in artificial intelligence have been driven by Grand Challenge frameworks[7]—including Deep Blue,[8] which, in 1997, beat Gary Kasparov, world chess champion at the time; and Watson,[9] which, in 2011, defeated two Jeopardy champions. Universities can also create and launch learning opportunities, research initiatives, and capital campaigns that support Grand Challenges.
- Align with the modern collaborative research environment, while offering a new language and framework for research and problem-solving: The Grand Challenge framing is in sync with the group effort approach that increasingly characterizes research. "In contrast to the tired categories of basic and applied, Grand Challenges offers a research agenda more appropriate to our times, one that combines intellectual and practical motives, generating excitement to address problems so big that they exceed the capacity of specialist communities."[10]
- **Inspire the next generation of scientists, engineers, and entrepreneurs to work on hard and important problems**: In the 2008 Grand Challenges for Engineering report,[11] a committee of world-class scientists and engineers issued a clarion call to the engineering field. The vision? For the engineering field, particularly within academia, to orient itself around solving the biggest challenges facing humanity in the 21st century, including long-term energy solutions, carbon sequestration, cyber security, and advancements in personalized medicine. Grand Challenges can help inspire the next

---

5 Simon Tripp and Martin Grueber, "Economic Impact of the Human Genome Project," Battelle Memorial Institute, May 2011, https://www.battelle.org/docs/default-source/misc/battelle-2011-misc-economic-impact-human-genome-project.pdf

6 DARPA, "The DARPA Grand Challenge: Ten Years Later," *DARPA*, March 2014, http://www.darpa.mil/news-events/2014-03-13

7 IBM, "The Next Grand Challenge," http://www-03.ibm.com/marketing/br/watson/what-is-watson/the-next-grand-challenge.html

8 IBM, "Deep Blue," http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/

9 IBM, "Watson," https://www.ibm.com/watson/

10 D. Hicks, "Grand Challenges in US Science Policy Attempt Policy Innovation," *International Journal of Foresight and Innovation Policy*, 11(1–3), 22–42.

11 National Academy of Engineering, "Grand Challenges for Engineering," 2008, http://www.engineeringchallenges.org/File.aspx?id=11574&v=ba24e2ed

generation of scientists, engineers, and entrepreneurs to devote their lives' work to solving these challenges. A genuine shift in the engineering field has begun to coalesce. In 2015, deans of 122 engineering programs announced their commitment to integrate Grand Challenge programs into their undergraduate curriculums, pledging that in a decade, 20,000 more engineers would be trained to tackle these complex challenges.[12]

2. How

Grand Challenges may be best suited for confronting open-ended, sticky problems with no pre-defined solutions, where "what if?" ambitious thinking can generate new approaches. It is an appropriate tool to consider for solving national or global problems that need to be worked at scale and with a multidisciplinary approach. Grand Challenge deployments are unique to each agency, but there are commonly three phases for their design and implementation:

Goal Setting: The goal of a Grand Challenge is what sets it apart from other prize and challenge competitions. The goal is the rallying statement that should help convene the necessary communities around solving a Grand Challenge. Goal setting is such a key component of instituting a Grand Challenge that agencies need to consider it as its own process—with its own timeline, budget, and project management plan. Grand Challenge goals should be compelling and audacious, but still achievable, measurable, and time-bound.

Design: Once a Grand Challenge goal is defined, program managers can move on to the design planning process. By their nature, Grand Challenges cannot be specific in their analogous design phase. Grand Challenges may require advances in fundamental scientific knowledge, tools, and infrastructure for successful completion. The general development of Grand Challenge initiatives, however, can follow the basic design recommendations from the General Services Administration (GSA) for incentive prize and challenge competitions, which includes defining the problem, identifying partners, developing communication and implementation plans, and iterating on the goal and outcome measures. The design of a Grand Challenges can include a range of activities, including grant programs, public-private partnerships, workshops, among other informal convening, that help to organize and induce action towards the specified goal. Through these varied mechanisms for engagement, Federal agencies can publicize and incentivize broad multi-disciplinary participation and support necessary to execute a Grand Challenge.

Execution: After a Grand Challenge goal has been defined and a program has been designed to achieve that goal, the next step is to execute the design plan. In this phase, discoveries may be made that require program managers to re-evaluate the original goal and adjust the original objective. This innately iterative process differentiates Grand Challenges from other prize and

---

[12] NAE Grand Challenges, "US Engineering School Deans' Response to President Obama on Educating Engineers to Meet the Grand Challenges," 2015, http://www.engineeringchallenges.org/File.aspx?id=15680&v=c29105cb

challenge competitions, which do not typically reassess their goals in the midst of the competition.

Detailed guidelines for implementing each of these phases are provided in section E. Implementation Guidelines.

C. Background

The understanding of Grand Challenge frameworks has evolved considerably over the past 35 years from a narrow technical discipline to a broad call that extends beyond the scientific and research community. The formal language surrounding the use of Grand Challenges as mechanisms for innovation by the Federal Government appeared as part of the advancement for high-performance computing. The High Performance Computing Act of 1991 narrowly defined Grand Challenges as "a fundamental problem in science or engineering, with broad economic and scientific impact, whose solution will require the application of high-performance computing resources and multidisciplinary teams of researchers."[13]

Soon after the passage of the High Performance Computing Act, Peter Diamandis adapted the Grand Challenge framework for the private sector when he introduced the first XPRIZE in 1996. Diamandis offered $10 million to the team that produced a "reliable, reusable, privately financed manned spaceship capable of carrying three people to 100 kilometers above the Earth's surface twice within two weeks."[14] The challenge was completed in 2004 when the XPRIZE Foundation awarded the Mojave Aerospace Ventures team led by Burt Rutan with $26 million in financial backing from Paul Allen. Since its inception, the XPRIZE Foundation has expanded to pursue Grand Challenges financed by the private sector in the areas of exploration, life science, energy, and global development.[15]

The Bill & Melinda Gates Foundation recognized the power and potential of the Grand Challenge framework, setting the stage for its Grand Challenges in Global Health in 2003.[16] The elevation of the term by the Gates Foundation was a milestone in the broader application of the concept of Grand Challenges. The Gates Foundation use the Grand Challenge framework to set an agenda and articulate specific scientific or technological innovations to solve important global health challenges.

---

[13] Public Law 102-194, Section 4, "Definitions," 102d Congress, December 9, 1992, https://history.nih.gov/research/downloads/PL102-194.pdf

[14] XPrize. "Ansari XPrize." *XPrize*. http://ansari.xprize.org/

[15] J. Harris, "Peter Diamandis, Founder of the XPRIZE Foundation," March 20, 2015, https://www.npr.org/2015/03/20/394292234/peter-diamandis-founder-of-the-xprize-foundation

[16] Bill and Melinda Gates Foundation, "Grand Challenges in Global Health Announced," Bill and Melinda Gates Foundation, January 2003, http://gcgh.grandchallenges.org/announcement/grand-challenges-global-health-announced

A fourth, concurrent milestone in the development of the Grand Challenge framework was the first DARPA Grand Challenge from 2002–2004.[17] The DARPA Grand Challenge challenged contestants to build driverless vehicles that could withstand long-distance trials. Since its first Grand Challenge, DARPA has gone on to sponsor the Spectrum Collaboration Challenge,[18] the Robotics Challenge,[19] and the Cyber Grand Challenge.[20]

At the request of the National Science Foundation (NSF), the National Academy of Engineering (NAE) published the Grand Challenges for Engineering report in 2008.[21] The NAE Grand Challenges follow the framework set up by the Gates Foundation by proposing a list of 14 Grand Challenges derived from discussions among experts and the public intended to galvanize broad public engagement towards solving the most pressing engineering problems of the 21st century.[22] As previously mentioned, in 2015, deans of 122 U.S. undergraduate engineering programs delivered a letter of intent to strengthen their degree programs to better align with NAE's Grand Challenges under a scholars program.[23]

The development of Grand Challenges in the public and private sectors culminated in the Federal Government's release in 2009 of the "A Strategy for American Innovation," which was updated in 2011 and 2015.[24] In the original 2009 and updated 2011 versions, Grand Challenges appear in the priority, "Catalyze Breakthroughs for National Priorities." In this section, eight examples of Grand Challenges are provided that are defined as "ambitious goals that will improve our quality of life and establish the foundation for industries and jobs of the future." The definition of Grand Challenges was updated by the Administration in the 2015 Strategy as "ambitious but achievable goals that harness science, technology, and innovation to solve important national or global problems and that have the potential to capture the public's imagination."[25]

---

17 DARPA, "Grand DARPA challenge: autonomous ground vehicles," 2003, http://archive.darpa.mil/grandchallenge04/index.htm

18 DARPA, "The Spectrum Collection Challenge," DARPA, https://spectrumcollaborationchallenge.com/

19 Christopher Orlowski, "DARPA Robotics Challenge (DRC), DARPA, http://www.darpa.mil/program/darpa-robotics-challenge

20 M. Walker, "Cyber Grand Challenge (CGC)," DARPA, http://www.darpa.mil/program/cyber-grand-challenge

21 National Academy of Engineering, "Grand Challenges for Engineering," 2008, http://www.engineeringchallenges.org/File.aspx?id=11574&v=ba24e2ed

22 NAE Grand Challenges for Engineering, "14 Grand Challenges for Engineering in the 21st Century," *NAE Grand Challenges for Engineering*, http://www.engineeringchallenges.org/challenges.aspx

23 NAE, "NAE Grand Challenges Scholars Program," http://www.engineeringchallenges.org/14365/GrandChallengeScholarsProgram.aspx

24 National Economic Council and Office of Science and Technology Policy, "A Strategy for American Innovation," October 2015, https://obamawhitehouse.archives.gov/sites/default/files/strategy_for_american_innovation_october_2015.pdf

25 White House, "21st Century Grand Challenges," https://obamawhitehouse.archives.gov/administration/eop/ostp/grand-challenges

Similarly, the President's Council of Advisors on Science and Technology (PCAST) describe Grand Challenges as large, outward-facing efforts with specific, measurable goals in their fifth assessment of the National Nanotechnology Initiative.[26] Drawing from PCAST's definition, in a June 2015 Request for Information (RFI) to seek suggestions for *Nanotechnology-Inspired Grand Challenges for the Next Decade* OSTP defines an effective Grand Challenge as an initiative that has the following characteristics:

- A measurable end-point that is highly ambitious but achievable.
- Requires advances in fundamental scientific knowledge, tools, and infrastructure for successful completion.
- Has clear intermediate milestones (measurable and valuable in their own right) that will be achieved en route to the final goals.
- Drives the need for collaboration between multiple disciplines, some of which do not normally interact, causing multiple organizations to come together to collaborate and to share resources and information to solve the challenge.
- Spans efforts from discovery and fundamental science to engineering demonstration and commercialization; *i.e.*, catalyzes the transition of technologies from laboratory to market.
- Is too big to be undertaken by one or even a few organizations.
- Is exciting enough to motivate decision makers to provide funding and resources and multiple organizations to collaborate, share resources, and information to solve the challenge.
- Captures the imagination of the public, thereby facilitating strong support for the resources required to achieve the goals.[27]

D. Considerations for Use

Conditions and contexts may be optimal for a Grand Challenge when officials are looking to raise the profile of a specific issue; garner multiple and diverse ideas for solving or understanding the problem; and promote collaboration among the private sector, universities, researchers, and other organizations.

---

[26] President's Council of Advisors on Science and Technology, "Report to the President and Congress on the Fifth Assessment of the National Nanotechnology Initiative," October 2014, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_fifth_nni_review_oct2014_final.pdf

[27] "Nanotechnology-Inspired Grand Challenges for the Next Decade; Notice of request for information," 80 *Federal Register* 34713 (June 17, 2015), pp. 34713-34715.

Grand Challenges can be implemented in a variety of ways (see Resource Box 1: How is a Grand Challenge Different from a Prize Competition?). For example, USAID implemented Grand Challenges with a variety of tools for sourcing and funding. Seema Patel, Division Chief, Innovation Design and Advisory, at the U.S. Global Development Lab, reflected on how Grand Challenges have been used in the laboratory's work to tackle critical international development challenges:

> The Grand Challenge [framework] allows us to deploy multiple types of methodologies that hit on different parts of that problem; not just the supply of an innovation, but how do we catalyze more of an ecosystem approach, how do we bring more investment to the table? How do we adopt or apply that innovation into a more traditional programming approach? We have different approaches beyond prize and challenge funds to do that in this systems approach. The Grand Challenge gives us that galvanizing force to bring the partners together around the broader goal between this one innovation and the presidential priority. It allows us to play that middle ground of continuing to catalyze and connect these two dots.[28]

Resource Box 1. How Is a Grand Challenge Different from a Prize Competition?

"Unlike prizes, where there are well-defined types of incentive prizes for particular types of problems, Grand Challenge programs so far have been designed in a very custom way, based on the goal itself, as well as available resources," explains Cristin Dorgelo, former Chief of Staff at the Office of Science and Technology Policy and former head of prize operations at the XPRIZE Foundation. In other words, a Grand Challenge program manager may choose to encompass a prize competition element as one aspect of a Grand Challenge program, but not necessarily.

Successful challenges demonstrate the array of possible approaches: all-in funding commitments that fund and scale solutions, offers to match funding from private and philanthropic sectors, commitments to source a prize without funding the resulting solutions, and high-level commitments that create the space for other stakeholders to develop and fund implementation.

Agency practitioners report that one of the most crucial ingredients for designing a Grand Challenge is articulating a grand vision to the public and stakeholders. The framing of a Grand Challenge vision helps shift thinking from "Why would we do that?" to "Why *aren't* we doing that?" The grand vision also justifies why *now* is the moment for action. Other common ingredients—imaginative framing, public-private collaborations, and competitive funding approaches—encourage novel solutions and remain agnostic about the best solutions or who the best performers will be. Agencies may wish to convene with relevant communities to encourage progress towards the goal and identify next steps or needs. Dorgelo notes, "Not all federal agencies use all of those ingredients in pursuing their Grand Challenge goals either because the goal being

[28] S. Patel, in-person interview, July 29, 2016.

pursued didn't call for it, they haven't thought of it, or they don't have enough resources for those activities."[29]

Grand Challenges can be viewed as operating under a spectrum of activities. At one end, a minimal deployment of the approach entails internal problem definition and goal framing, with the agency then issuing a compelling goal challenge to the public and allowing further action to develop organically. One example is the National Nanotechnology Initiative's Nanotechnology-Inspired Grand Challenge for Future Computing, in which the goal for nanotechnology Grand Challenges was announced via blog posts.[30] A public request for information and follow-on engagement work at industry-specific meetings spurred active discussion on what it would take to pursue such a goal, leading to the development of a white paper and statements of support from various agencies and organizations.[31] At the mid-point of the spectrum are efforts like the DARPA Grand Challenges[32]—including its most recent Cyber Grand Challenge[33]—which all have Grand Challenge goals, but primarily rely on an incentive prize model, with additional opportunities for funding and community convening. At the far and most developed end of the spectrum, goals can be defined through a rigorous process with stakeholder input. For the Department of Energy's (DOE) SunShot[34] and EV Everywhere Grand Challenges,[35] the process of internal problem definition was followed by an additional year of soliciting input from stakeholders (e.g., through workshops around the country regarding additions or revisions to the stated goal definition). See Appendix A for select examples of Grand Challenges from the DOE, the National Aeronautics and Space Administration (NASA), and USAID.

E. Implementation Guidelines

As previously noted, Grand Challenges can be implemented through the three broad phases depicted in Figure 1.

---

29 C. Dorgelo, in-person interview, August 3, 2016.

30 National Nanotechnology Initiative, "Nanotechnology-Inspired Grand Challenges," http://www.nano.gov/grandchallenges

31 National Nanotechnology Initiative, "A Federal Vision for Future Computing: A Nanotechnology-Inspired Grand Challenge," https://www.nano.gov/sites/default/files/pub_resource/federal-vision-for-nanotech-inspired-future-computing-grand-challenge.pdf

32 DARPA, "Urban Challenge," http://archive.darpa.mil/grandchallenge/

33 DARPA, "The World's First All-Machine Hacking Tournament," https://www.cybergrandchallenge.com/

34 DOE, "SunShot Initiative," https://energy.gov/eere/sunshot/sunshot-initiative

35 DOE, 2013, "EV Everywhere Grand Challenge Blueprint," https://energy.gov/sites/prod/files/2016/05/f31/eveverywhere_blueprint.pdf

Figure 1. Phases of Grand Challenge Implementation

1. Goal Setting

Grand Challenges may be referred to as "moonshot" goals because of their scale and audacity, referring to the broad Federal support in the 1960s to place an American on the moon. Chris Gerdes, former Chief Technology Officer at the Department of Transportation, comments that the term has "become shorthand notation for everything innovative: 'I'm doing a moonshot,' [but] a moonshot is not just a moonshot," he argues. Transformative breakthroughs may be achieved through a series of incremental and additive steps.[36]

Defining the goal is fundamental to organizing a Grand Challenge. Dorgelo emphasizes that problem definition is such a key component of instituting a Grand Challenge that agencies need to consider it as its own process—with its own timeline, budget, and project management plan. "Just to get to the place where you have the goal you want to pursue is, in itself, its own project," she notes.

In the initial part of the goal setting phase of a Grand Challenge, having only a general idea of the area for the Grand Challenge is typical. Once a Grand Challenge area has been identified, the next step is to seek input from program directors, outside experts, and possibly the public to define the overarching goal of the Grand Challenge. It may be important to invest time in breaking the goal down into component parts that can be addressed by different segments of the public so that experts can all contribute in different ways. This is particularly true for Grand Challenges focused around technical research questions, where segmenting can help identify the contributions non-experts can still make.

According to Dorgelo, Grand Challenge goals should be:

- **Compelling**: Grand Challenges should inspire people to devote their work to achieving the goal. Overall, the goal should be capable of attracting its own cohort of problem solvers from inside and outside the government.
- **Audacious**: A Grand Challenge goal should be expansive. It should require multiple disciplines of professionals to cooperate and solve. Grand Challenges should also have the potential for high impact, partly in order to attract multiple funding sources. Grand Challenges may require government funding, and should also be able to galvanize support from the private sector in collaboration with the government.

---

[36] C. Gerdes, in-person interview, July, 1, 2016.

- **Achievable**: A Grand Challenge goal should be defined in such a way that it is obvious when it has been achieved. For instance, when Apollo 11 successfully landed on the moon and Neil Armstrong took his first steps it was clear that the original moonshot goal had been achieved.
- **Measurable**: While the solution space may be unclear for Grand Challenges, there should be defined metrics that the agency can use to measure the progress towards a Grand Challenge. In the goal-setting phase of designing a Grand Challenge, it is a good idea to reach out to experts to define the criteria to measure the success of a Grand Challenge. Subject matter experts, academic experts, and foundations can advise and critique the proposed criteria in an iterative process until a consensus is reached among the Grand Challenge administrative team.
- **Time Bound**: Typically, Grand Challenge goals are to be solved within 5–10 years, sometimes extending up to 20 years. It is important that the scope of a Grand Challenge goal not be too far reaching that it cannot be attained within this timeframe.[37]

The moonshot goal of a Grand Challenge is what sets it apart from other prize and challenge competitions. The goal should be a rallying statement that helps convene the necessary communities around solving the Grand Challenge. As such, in the design and deployment phases of the Grand Challenge, it may be necessary to adjust the goal as new information, discoveries, and innovations in technology are presented. It may also be useful to conduct a barrier analysis to assess the anticipated challenges in the surrounding environment regarding the goal and incorporate feedback into the goal definition as these change over time.

2. Design

Once a Grand Challenge goal is defined, program managers can move on to the design process. Essentially, this portion of implementing a Grand Challenge requires program managers to work backwards to determine the resources already available and identify the resources necessary to see a Grand Challenge through to achievement. Dorgelo advises that this phase is very similar to the equivalent phase of designing a prize competition.[38] However, incentive prize and challenge competitions typically prescribe or confine the approach to a solution. Grand Challenges may require advances in fundamental scientific knowledge, tools, and infrastructure for successful completion. By their nature, Grand Challenges should be specific in their analogous design. The general development of Grand Challenge initiatives, however, can still follow the basic program design recommendations from the General Services Administration (GSA), for example:[39]

---

[37] C. Dorgelo, in-person interview, August 3, 2016.

[38] Ibid.

[39] Challenge.gov, "Challenges and Prizes Toolkit," https://www.challenge.gov/toolkit/

Identify goal and relevant outcome metrics: For Grand Challenges, this step can occur in the goal-setting portion of implementation.

Design the challenge structure: The challenge structure is made up of potential competition phases aligned with milestones, setting a general timeline, determining a setting, deciding on how to incentivize challenge participants, and designing a Grand Challenge to enable the implementation of successful contributions.

Identify partners to leverage the stakeholder community: Grand Challenges can inspire participation in the public and private sectors, and across multiple disciplines. Grand Challenges can leverage resources across these sectors as well as encourage partners and networks to plan follow-on activities around the goal. It is important to identify potential partners as part of the engagement strategy and communication plan (see below). If developing participation requirements, these should be explicit and not overly constraining. Alongside partner identification, this portion of the design phase can also align the activities and mechanisms that can be used to engage with relevant stakeholders, such as tiered grant programs, public-private partnerships, informal workshops, summits, and the like to induce public action, publicize the goal, and organize stakeholders around the Grand Challenge.

Develop a communications plan: A well-defined communications plan can include definitions of desired audience segments, modes of communication, and content of messages to be shared with the appropriate audience segments. Grand Challenge coordinators can seek to acknowledge and, where appropriate, reward the efforts and achievements of partners and participants. In addition, Grand Challenge coordinators may seek to maintain communication with and among the community of interested partner organizations and participants.[40]

Create an implementation plan: Also called a project management plan, the plans can combine everything defined in steps 1–4 into a concise, trackable plan for carrying out the Grand Challenge.

Prepare to announce: Verify the readiness of the communications plan, implementation plan, and Grand Challenge team before publicly announcing the Grand Challenge.

Obtain agency clearance: Verify senior agency leadership's support of the Grand Challenge and ensure that all legal requirements have been properly addressed before moving on to Grand Challenge execution.

3. Execution

Once all of the elements of the program design phase have been satisfied, the next phase in conducting a Grand Challenge is to execute the communications and implementation plan. By definition, Grand Challenges can be more unwieldly and less constricted to a hard schedule than

---

[40] U.S. Government Accountability Office, Open Innovation: Executive Branch Developed Resources to Support Implementation, but Guidance Could Better Reflect Leading Practices, GAO-17-507 (Washington, DC, 2017), 17, https://www.gao.gov/products/GAO-17-507.

other prize and challenge competitions. It is important that in the execution phase the agency leaders of a Grand Challenge are constantly making sure the overarching goal behind the Grand Challenge is being reflected by the work of challenge participants.

At times, it may be necessary to tweak the Grand Challenge goal and outcome metrics.[41] Dorgelo offered some advice on enabling flexibility in the Grand Challenge approach (Resource Box 2: Enabling Flexibility).

[41] C. Dorgelo, in-person interview, August 3, 2016.

Resource Box 2. Enabling Flexibility

Dorgelo offers the following advice for enabling flexibility in goal setting, designing, and executing Grand Challenges: "There are some proven approaches that I think Grand Challenge program designers should use when it comes to problem definition, and they all focus on the concepts of ever increasing circles of input. It is unlikely that a single individual in a room could conceive of a Grand Challenge goal that could check all those boxes I described as being compelling, of being audacious, of being achievable et cetera.

…And so, the ways that program managers have approached this that has worked is to engage in a brainstorming process with a diverse set of participants. Often this happens, as I said, in an ever expanding way, where first, they're doing this problem definition within their organization.

NASA for example hosted what they called Big Think sessions where they brought people within the agency, from different aspects of the agency, together to start brainstorming about what those audacious goals might be, where their leadership team then down-selected that list of audacious goals to the most compelling, where some feasibility assessment was done (meaning, how much does this goal match with what Congress is telling us to, what do we have money for already, what is already going to happen without our help). And then they take that more limited set of goals and start expanding their circle to external advisory bodies, to the general public, to get input and reactions. And they are flexible and willing to adjust course, and willing to tweak their concept for their Grand Challenge goal based on feedback received.

Also, you can look to what DOE did with EV-Everywhere Grand Challenge. They used that internal process that I was describing—of coming up with the idea, vetting the ideas to figure out how feasible they are, and getting input from key internal stakeholders. And when they went public with their goal, they issued essentially what I think of as their top bullet—we want to make electric vehicle as affordable and cost-effective and convenient to own as gas-powered vehicles. But at the start, they didn't publish any what I think of as the sub-bullets to that overarching goal, because they wanted more input…they went out and they talked to tons of stakeholders and said 'What would we need to do this?' And they learned things, and they changed the definition of how they were going to pursue that goal as a result of that input.

If I think back to XPRIZE and to how DARPA also has tried to define the goals that they were going to use for their Grand Challenge prize competitions to pursue their Grand Challenge goals, they did similar things. They talked to a lot of experts. They narrowed down the range of how you might measure success, because like any smart goal, you need it to be measurable, you need it to be time bound, and you need to be realistic. And so they asked, "what are the criteria we're going to use to measure success?" They came up with a few potential framings for how to go after that envisioned future of success.

They usually included in that a few different types of criteria that could be used to measure whether the goal had been reached. So, for example, if you're looking at radically improving the cleanup of oil from water, you could be looking at efficiency of cleanup oil from water or the total volume of oil collected. You could be looking at the diversity of environments in which that new technology can operate, et cetera. They then took all those potential criteria; they aired them in front of a large number of experts. The experts told them, "Right criteria, wrong criteria. A bar too high. A bar too low." They listened to that and then they set the goal.

And so, if there's one secret sauce, it's that increasing feedback loop until you heard that feedback so frequently that you think you got it right. And then there's the willingness to put that goal out there publicly and get input on how to define the next level, the next sub bullets down, in terms of how you get there, how you achieve that Grand Challenge goal."

Source: C. Dorgelo, in-person interview, August 3, 2016; See Appendix A for further descriptions of select DOE and NASA Grand Challenges.

F. Lessons Learned

Implementation of Grand Challenges can be facilitated by the following attributes:

- **Thoughtful program design to appropriately adapt the framework**. There is a wide variation in program structures for Grand Challenges, including a significant degree of difference in terms of funding levels, formality, and roles and responsibilities. "That level of variation has been a real challenge—no pun intended!—for Federal agencies and other organizations that say, 'Hey, I think I want to launch a Grand Challenge goal or Grand Challenge program for X…What do I do next?' That wide variation has rightfully been a roadblock because it means that the onus is on the program manager to figure out what structure makes the most sense," comments Dorgelo, adding, "while that's a challenge, I actually think it's the right thing: When you're thinking about a Grand Challenge—an ambitious, yet achievable goal—[…] it makes sense that in each given sector or industry that […] the means to reach that goal are going to be different, based on the state of the market and based on who the actors are. It requires very savvy and thoughtful program design."[42]
- **Open-minded approach to goal definition and redefinition**. Appropriately defining the scope and boundaries of the challenge goal can impact success. It may be important not only to invest adequate time and resources in the problem definition process, but to remain receptive to further refining the target based on feedback. "It is essential," says Dorgelo, "that agency staff retain the flexibility and willingness to adjust the goal if needed—if you're learning that what you put forth to the public either isn't achievable, or it's too hard…may mean you need to change it."[43] She observes that in some Grand Challenges, the initial problem definition turned out to need further adjustment—and savvy Federal program managers can change the Grand Challenge framing in order to orient solutions to meet the intended goals.
- **High-level support and receptivity for new problem-solving approaches**. A Grand Challenge requires the support of high-level authority, which can facilitate access to and convening of diverse stakeholders. Top leadership can help create a space for program managers to feel comfortable imagining how they might do their job differently, and how to engage with innovative approaches like challenges to deliver on those objectives. While this holds true for nearly any innovation approach, Grand Challenges in particular require this top cover to reimagine how to frame, engage with, and solve problems.
- **Right team in place to break down silos**. Grand Challenges inherently require multi-sectoral collaboration, which also brings organizational challenges. But overcoming

[42] Ibid.

[43] Ibid.

barriers to collaboration is essential for Grand Challenges to succeed, and may require eschewing conventional arrangements and breaking down silos to bring different stakeholders together. Implementing a Grand Challenge can also be facilitated by assembling a team of creative, non-linear thinkers with the ambition to see beyond what will happen next year, and who can instead target longer time horizons.

- **Advanced planning and alignment within budget cycles**. Grand Challenges may require budget authority. The reality of the budget and solicitation cycles can be a tough obstacle for Grand Challenge deployment. Program managers and agency leadership may wish to consider how to structure Grand Challenges budgets within 1–2 years. For instance, if solicitation planning cycles begin 8 months before publishing, it may be difficult to adjust content two months before its launch. Additionally, budget planning could consider resources that may be needed over the long-term for integration into agency processes and follow-on activities.
- **Deploying in an appropriate context, or, what a Grand Challenge is not.** Too much deviation from the common understanding of a Grand Challenge dilutes the power and efficacy of the approach. While there's great flexibility in how Grand Challenge goals can be pursued, there are bright lines around what it is, and isn't. "There are goals that simply are not Grand Challenge goals. […] They are not compelling, they are not ambitious, or they're a pipedream and you're highly unlikely to achieve them based on current capabilities and trends in science, technology, and society. Or, they're not understandable to the person on the street who would want to know why an engineer is devoting his life to that goal, or why a scientist is devoting her research to that goal," comments Dorgelo.[44]

G. Future Considerations

Grand Challenges have been employed in public and private sectors to innovate in highly technical fields since their inception. The future implications of the Grand Challenge framework include identifying ways of applying the Grand Challenge framework to non-science and engineering disciplines, including ways to apply the problem-solving technique to rally public support behind solving popular social policy issues of the 21st century. Agencies concerned about the bottom half of the income distribution have had less connection, historically, to the entrepreneurial, scientific, and technical communities where Grand Challenges have arisen. The framework could be used to accelerate progress on domestic and societal challenges that relate to poverty alleviation and social mobility, as demonstrated by USAID's development of internationally-focused challenges. The use of Grand Challenges for social policy could lead to questions like:

- Can we shift the unemployment rate by ½ percent? What would that look like?

[44] Ibid.

- Our current workforce development investment programs, on average, increase wages of beneficiaries by $1,800; how do we increase that by a factor of 10*?*

More reflection is needed to assess lessons learned as agencies continue to iterate and refine their Grand Challenge operations. “We must share information insight and resources so that we can make informed decisions around what challenges are needed, what solutions already exist and how they are performing. It doesn’t make sense to keep doing Challenges without being transparent and efficient about what is coming out of them, not just the winners, but all of the ideas, funded or not,” shares Grace Kim, Global Innovation Exchange Project Manager, U.S. Global Development Lab at USAID.

In addition, more could be done by external stakeholders to further maximize the power of Grand Challenges. The private sector could rally around the Grand Challenge framework and formally partner with Federal or local governments in public-private partnerships to address prominent public policy issues. This partnership could lead to innovative Grand Challenge topics, such as transportation and automotive companies investing in self-driving cars using that technology to reduce traffic fatalities by a certain percentage by the year 2030.

Appendix A.
Select Examples of Grand Challenges

Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) SunShot Initiative[45]

Launched in 2011, the Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy's (EERE) SunShot Initiative is a Grand Challenge effort to make solar energy cost-competitive with conventional forms of electricity generation by the end of the decade (2020). The goal—to drive down the cost of solar electricity to $0.06 per kilowatt-hour or ~$1 per watt—arose from one question: What would it take for solar to become a large portion of the nation's energy supply mix? Through SunShot, DOE has partnered with more than 450 awardees, funding cooperative research and development (R&D), demonstration, and deployment projects led by private companies, universities, state and local governments, nonprofit organizations, and national laboratories.[46]

Five years into the decade-long initiative, the solar industry is already more than 70% of the way to achieving SunShot's cost target.[47] Longer-term goals are now being set, and one important lesson from SunShot is how Grand Challenges can be used to push the research community towards a common goal.[48]

Key accomplishments

SunShot has contributed to making solar-generated electricity price competitive with traditional energy sources in 14 states across the United States. Increased deployment of affordable and accessible solar energy continues to grow quickly across the country. Two key points deserve emphasis:

- Return on Federal Investment: SunShot has been a catalytic focusing lens, generating significant economic and job growth in the solar industry. DOE has spent roughly $2.3 billion on R&D, but net economic benefits total more than $15 billion to date.[49]

---

45 Information derived from in-person interview with C. Dorgelo on August 3, 2016.

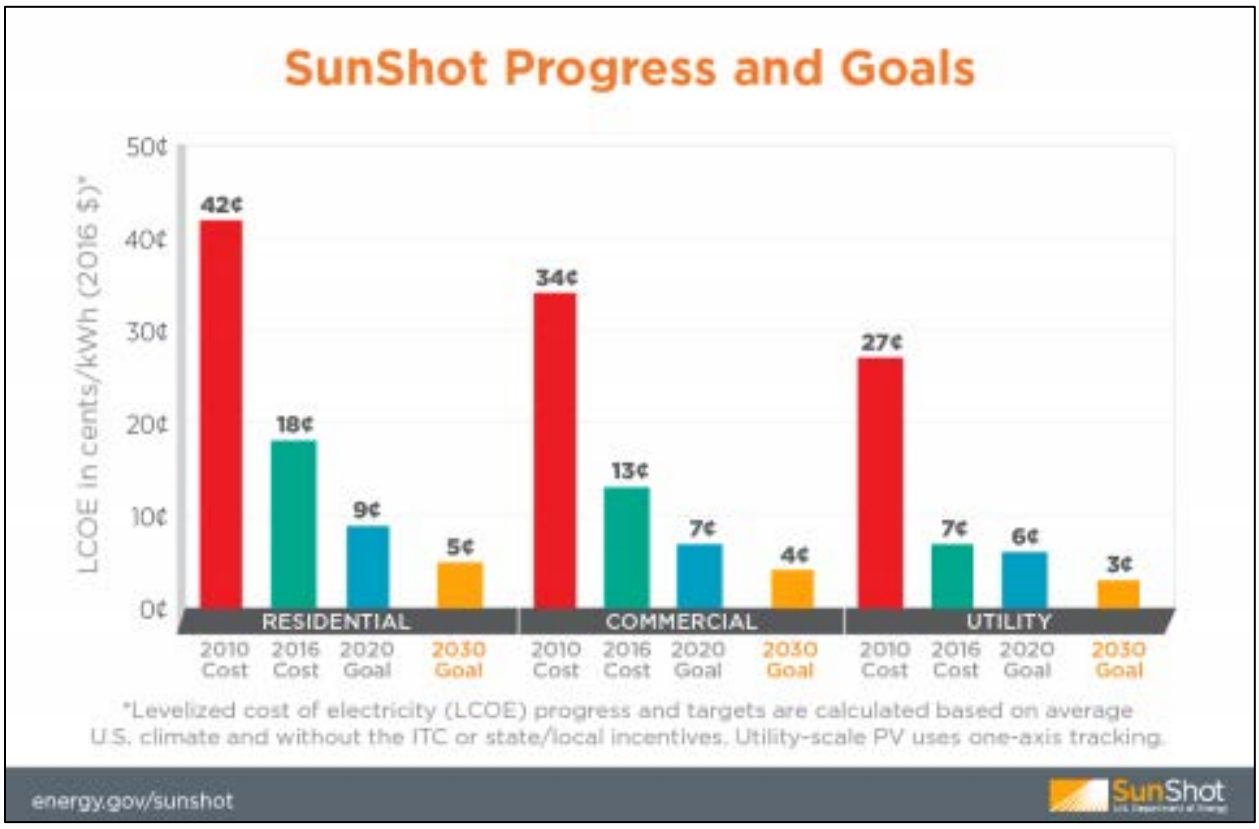
46 DOE, "About the Sunshot Initiative," https://www.energy.gov/eere/sunshot/about-sunshot-initiative

47 Ibid.

48 DOE, "Sunshot Initiative Goals," https://www.energy.gov/eere/sunshot/sunshot-initiative-goals

49 DOE, "The Sun Shot Initiative: Making Solar Energy Affordable for All Americans," June 2016, https://www.energy.gov/sites/prod/files/2016/06/f32/SunShot-factsheet-6-10_final-508.pdf

- Leapfrog Technical Advancement: There is more than 10 times more solar installed today in the United States than in 2011 when the SunShot Initiative was first launched. Meanwhile, the overall costs of solar have dropped by over 65 percent (Figure A-1).



Source: DOE, "About the Sunshot Initiative," https://www.energy.gov/eere/sunshot/about-sunshot-initiative

Figure A-1. Solar Costs Fall towards the SunShot Initiative Goal

How they did it

The appeal of using a Grand Challenge framework for SunShot was its cost-effective ability to promote scale and impact under a broad umbrella. For SunShot, DOE held an annual summit; released research papers regarding technical milestones needed to achieve the goal; funded nearly 300 cooperative R&D, demonstration, and deployment projects from 2011 to 2015; and also offered open prize competitions to fuel entrepreneurship and drive innovation in solar technology. SunShot's broad articulation and interagency coordination also enabled a systems-level perspective to emerge during implementation, which highlighted the importance of certain aspects that needed increased attention. For example, prior to SunShot, DOE had an overall cost goal for solar technology that emphasized the cost of cells and modules. The learning gained through

SunShot indicated that even if the solar modules were free, the cost goal could not be met without addressing other important areas, such as grid integration and soft costs.[50]

Effective messaging has also been essential to the program's success. The program wasn't originally launched as SunShot; the name came later. Building a brand identity was a central part of establishing the program's narrative.

Lessons for Agencies

Some key lessons from implementing SunShot include:

- **Using Grand Challenges to spur holistic impact:** SunShot exemplifies how systems-level perspectives can emerge from Grand Challenge frameworks, and how investing in holistically understanding the problem can lead to more effective problem-solving to advance technology *and* integrate it into the marketplace. SunShot program staff spent a year soliciting feedback from stakeholders to develop SunShot's goals, identifying five areas where innovation was needed: photovoltaics, concentrating solar power, systems integration, soft costs, and technology-to-market. After integrating stakeholder feedback and developing technology white papers, Dorgelo explains, DOE "took their existing solar-technology funding streams and oriented them towards what they had heard would be needed to achieve the overall goal through advances in those five technology areas." The integrated portfolio approach across multiple technology paths and stages, coupled with collaboration across Federal agencies, helped SunShot make impacts across the U.S. solar value chain. Iterative assessment of the state of the industry, market and existing programs helped SunShot remain agile to the market and changing conditions that could impact SunShot's goals.
- **Setting a big (and timely) goal that can be sufficiently funded:** Big ideas evolve from issues of our time. A Grand Challenge needs to inspire people to want to propose solutions and be incentivized enough to make it worth their time. Considerable research and industry consultation went into the $1 goal, which fell just outside of what industry felt at the time was feasible. One billion dollars was allocated in pursuit of the goal.
- **Using a wide variety of funding mechanisms:** "In SunShot's case, they used a wide variety of funding mechanisms, including prize competitions as well as funding awards for cooperative R&D, demonstration, and deployment projects," notes Dorgelo. "They looked holistically about what type of funding would make most sense for certain aspects of pursuing the goal, and deployed standard funding mechanisms such as grants and contracts, but also incentive prizes where appropriate." Prize competitions, for instance, were a good fit for driving entrepreneurship and meeting software needs that could reduce solar soft costs—by using short timeframes and smaller funding rates, it

[50] DOE, "Soft Costs," http://energy.gov/eere/sunshot/soft-costs

encouraged software companies to lower hurdle rates. The variety of funding approaches also recognized the other kinds of value the program could bring to the table through data and information assets, analyses, training, convenings, and by working with stakeholders to identify the right questions to answer that would keep the industry moving forward.

- **Hiring the right people—and have senior leadership support:** SunShot required a highly trained technical team for active management of the grants. A concerted push was made with grantees to assess whether projects would yield results competitive with forward looking estimates for current technologies and approaches, with an overarching emphasis on the quantitative cost goal. (This meant that if it would take 10 years for a solution to mature and gain market acceptance, it would have to be competitive with cost reduction curves on current technologies in that same 10 year horizon.) Leadership from the top was also key for ensuring continued, unwavering support for these goals. The Secretary of Energy was integrally involved in the effort.
- **Continually iterating and refining processes:** Internal process improvements piloted within the SunShot program led to updates to how all grants and cooperative agreements were selected and managed within EERE. The time from announcement to award was reduced from about 18 months, to 6 months to keep up with the rapidly changing technology and market environment.

National Aeronautics and Space Administration's Asteroid Grand Challenge[51]

The National Aeronautics and Space Administration's (NASA) Asteroid Grand Challenge (AGC) aims to find and address all asteroid threats to human populations. The Challenge statement is "find all asteroid threats to human populations and know what to do about them."[52] With estimates suggesting less than 10% of objects smaller than 300 meters in diameter and less than 1% of objects smaller than 100 meters in diameter have been discovered, NASA's AGC aimed to accelerate the completion of the survey of potentially hazardous asteroids.[53]

Launched in June 2013, the AGC is an extensive, international effort drawing on experts from academia, the private sector, and other U.S. government agencies made up of the following sub-tasks:

---

[51] Information derived from in-person interviews with J. Gustetic on July, 26, 2016 and J. Kessler on November 11, 2016.

[52] Dennis Bonilla, "What Is the Asteroid Grand Challenge?" NASA, March 2015, https://www.nasa.gov/feature/what-is-the-asteroid-grand-challenge

[53] Ibid.

1. Detect: Find the asteroid objects;[54]
2. Track: Figure out how to quickly and accurately measure the object's orbit;[55]
3. Characterize: Once the orbit is known, learn more about the asteroid's composition; [56] and
4. Mitigate: Study mitigation solutions, so we'll know what to do if a threat is identified.[57]

Key accomplishments

The AGC is an example of how Grand Challenges can seed and sustain continued work in critical mission areas. Marrying science and public engagement, the ACG drew significant public attention to help accelerate NASA's cataloging capabilities for near-earth objects. In fiscal year 2012, President Obama proposed and Congress appropriated $20.4 million, up from an annual budget of $4 million. That budget more than doubled in fiscal year 2016 to include $50 million for NASA's near-Earth object observations and planetary defense.[58]

How they did it

NASA heavily invested in problem definition at the outset in order to broaden engagement with potential solvers. NASA first used a brainstorming technique ("Big Think") to select a Grand Challenge focus. From there, deconstructing the chosen problem area through a process of problem decomposition was essential: "We wanted to see if there was a way to engage a broader audience and bring a new community to think about this problem in a different way," explains Jason Kessler, formerly NASA's Asteroid Grand Challenge Program Executive.[59] With the help of researchers at George Washington University's systems engineering program, NASA was also able to leverage insights from third-party academic participants.[60] Their observations were useful for decomposing the problem so that "non-expert" groups could meaningfully participate—for instance, citizen

---

54 Dennis Bonilla, "How Do We Detect Asteroids," NASA, September 2015, https://www.nasa.gov/content/asteroid-grand-challenge/detect/how-do-we-detect-asteroids/

55 Ibid.

56 Dennis Bonilla, "How Do We Characterize Asteroids," NASA, September 2015, https://www.nasa.gov/content/asteroid-grand-challenge/characterize/how-do-we-characterize-asteroids

57 Dennis Bonilla, "How Do We Mitigate the Hazard of Possible Asteroid Impacts," NASA, March 2015, https://www.nasa.gov/content/asteroid-grand-challenge/mitigate/how-do-we-mitigate-the-hazard-of-possible-asteroid-impacts

58 Jet Propulsion Laboratory, "NASA Office to Coordinate Asteroid Detection, Hazard Mitigation," January 2016, https://www.jpl.nasa.gov/news/news.php?feature=4816

59 Launch.org, "Our Process," http://www.launch.org/process

60 George Washington University, "Department of Engineering Management and Systems Engineering," https://www.seas.gwu.edu/department-engineering-management-systems-engineering

solvers could volunteer labor for pattern recognition, and "distant experts" (experts in other fields) could contribute specialized knowledge.

Lessons for Agencies

Some key lessons from implementing AGC include:

- **Engaging with citizen solvers in problem definition**: The overriding message of the AGC was that asteroid hunting is an activity everyone can get involved in. "With projects like Asteroid Data Hunter, NASA proved that it could think through 'NASA-hard' programs and find places where the crowd can meaningfully contribute," observes Jennifer Gustetic, program executive for NASA's Small Business Innovation Research/ Small Business Technology Transfer (SBIR/STTR) division.[61] Dividing the problem into four parts made it possible to ask for engagement from every level, from deep technical experts to motivated citizens willing to write computer code, build hardware, observe through a telescope, tell stories, and publicize the issue. At the same time, observes Kessler, program managers should recognize the cultural challenges as well as the time and energy required to engage with technical experts in the problem definition process. It is essential to find technical experts that can describe the problems without explaining how they would solve the problems. Collaboration with experts can enable Grand Challenge owners to better understand how a problem could be examined by others in a new light.
- **Developing powerful narratives and segmented messaging to drive engagement:** The idea of "everyone as an asteroid hunter" was a way to further involve the public in NASA's work. Asking for the public's help was a compelling narrative; by framing the call as, "We can't do this alone, we need you," it drew in motivated citizen scientists and experts alike. At the same time, segmented messaging that is appropriate and sensitive to different groups and communities is required. An existing small community of scientists had been doing "amazing work on a shoestring," recounts Kessler, but some of the initial public messaging seemed to discount the technical challenges they had managed to overcome on a daily basis. A targeted communications plan was embedded in program implementation, with the goal of ensuring that all relevant constituencies were engaged and motivated. It is especially important to engage expert communities early, to build relationships and ensure that public engagement outcomes can be more easily integrated into existing systems and processes.
- **Co-creating and developing collaborative partnerships:** NASA's AGC is also an example of agency-driven co-creation, where the agency played a key role in coordinating discussions among global partners. Concerted efforts were made by the

[61] NASA, "Asteroid Data Hunter Challenge," https://www.nasa.gov/content/asteroid-data-hunter-challenge-0/

agency to think through which aspects of the Grand Challenge could involve not just the general public, but also international actors and other Federal agencies. The program enabled NASA to partner with industry and academia in new ways, and gave the Near-Earth Object Observations Program office the ability to quickly form partnerships with entities they had not worked with before.

- **Integrating follow-on engagement into program implementation:** While resource constraints can be a limiting factor, sustaining follow-on engagement can continue to accrue value. The AGC motivated a great deal of interest and potential for continued engagement from the newly formed community of participants. "There were connections made by people who had never talked together, but could really benefit from collaboration," notes Kessler.

U.S. Agency for International Development Grand Challenges for Development[62]

The U.S. Agency for International Development's (USAID) Grand Challenges for Development (GCDs) are programmatic frameworks that focus global attention and resources on specific, well-defined international development problems and promote the innovative approaches, processes, and solutions to solving them.

Conceived, launched, and implemented in coordination with public and private sector partners, GCDs emphasize the engagement of non-traditional solvers around critical development problems. The GCDs complement USAID's current programming methods, with each GCD led by experts in USAID's bureaus. These experts work directly with partners to implement the day-to-day activities of the program.

Furthermore, the GCDs show how implementation can combine a variety of modalities, including partnerships, incentive prizes, crowdsourcing, hack-a-thons,[63] and massive online open courses.[64] To date, USAID launched nine Grand Challenges with 20 public and private sector partners to address critical challenges in development (see box "USAID's Eight Grand Challenges for Development").

---

62 Information derived from email correspondence with L. Kavanaugh-Ulku on November 10, 2016 and in-person interview with USAID program managers on November 14, 2016.

63 NASA, "The Power of Hackathons in Government," http://open.nasa.gov/blog/2012/06/29/the-power-of-hackathons-in-government/

64 Powering Agriculture, "MOOC: Powering Agriculture—Sustainable Energy for Food," https://poweringag.org/mooc

USAID's Nine Grand Challenges for Development

- Saving Lives at Birth a partnership of USAID, Grand Challenges Canada, The Bill and Melinda Gates Foundation, the Government of Norway, UKAid, and the Korean International Cooperation Agency, was designed to increase access to groundbreaking prevention and treatment approaches for pregnant women and newborns in poor, low-resource communities around the 48 hours of delivery. See http://www.savinglivesatbirth.org/.
- All Children Reading brings together USAID, World Vision, and the Australian government to dramatically increase the number of children in low-income countries who leave primary school with basic reading skills. See http://www.allchildrenreading.org/.
- Powering Agriculture: An Energy Grand Challenge for Development is a partnership between USAID, the Swedish International Development Cooperation Agency (SIDA), the German Ministry for Economic Cooperation and Development (BMZ), Duke Energy, and OPIC, that supports clean energy innovations that (1) enhance agricultural yields and productivity; (2) decrease post-harvest losses; (3) improve farmer and agribusiness income; and (4) increase energy efficiency within the operations of farms and agribusinesses to help end extreme poverty and extreme hunger. See. http://www.poweringag.org/.
- Making All Voices Count supports citizens and governments use of innovation, web, and mobile technologies to improve government performance and accountability. See http://www.makingallvoicescount.org/.
- Securing Water for Food helps farmers around the world grow more food using less water, enhance water storage, and improve the use of saline water and soil to produce food by ensuring that the entrepreneurs and scientists behind groundbreaking new approaches are getting the support they need to apply and expand their solutions around the world. See http://www.securingwaterforfood.org/.
- Fighting Ebola seeks to address key gaps in the response to the largest Ebola epidemic in history. See http://www.ebolagrandchallenge.net/.
- Combating Zika and Future Threats, aims to generate cutting-edge approaches to fight the current Zika outbreak and help strengthen the world's ability to prevent, detect, and respond to future infectious disease outbreaks. See https://www.usaid.gov/grandchallenges/zika.
- Scaling Off-Grid Energy, a partnership between Power Africa, USAID, the U.K. Department for International Development, and the Shell Foundation, which aims to accelerate growth in the off-grid energy market with a goal to provide 20 million households in sub-Saharan Africa with access to modern, clean and affordable electricity by 2030. See http://www.scalingoffgrid.org/.
- Ensuring Effective Health Supply Chains, partners with the Bill & Melinda Gates Foundation to uncover innovative and transformative solutions that can overcome key roadblocks and build more effective supply chains in low- and middle-income countries around the world. See https://www.usaid.gov/grandchallenges/supplies.

Key accomplishments

Some accomplishment for several of the GCDs:

- Saving Lives at Birth has reached 1.5 million women and newborns, saved nearly 10,000 lives, and catalyzed more than $70 million in private funding for its grantees.
- Securing Water for Food has saved more than 2 billion liters of water for agriculture and produced nearly 290,000 tons of food for more than 1 million farmers and other customers.
- Scaling Off-Grid Energy, launched in June 2016, has facilitated a projected 4.8 million connections in sub-Saharan Africa, bringing over $213 million to support the scaling of

the off-grid household sector. Its first round of investments leveraged more than $22 million in private funding.

Grand Challenges allow USAID and its partners to be a driver of innovation in markets that are underserved or perceived to be high risk. They signal demand and also allow for risk-sharing of investments across a number of donors. This strategy resulted in:

- **Leveraging Resources**: GCD's leverage the expertise, resources, and assets of public and private sector partners. Across the GCD portfolio, partners have jointly committed over $508 million (of which $148 million from USAID) in grants and technical assistance to over 450 innovators. In addition, some innovators supported by GCDs are then recognized and supported by others. They also use the power of the partners' networks to help innovators access investment and financing and help them connect with potential customers and partners. To date, GCD investments have catalyzed more than $154 million in follow-on funding from external sources.
- **Democratizing Innovation**: The GCD approach makes it easier for USAID to engage with those who have not previously worked with the agency. From 2011 to 2016, USAID received more than 8,500 applications and awarded more than 270 seed, validation, and transition grants (staged funding) to innovators in more than 60 countries. These results suggest outreach in sourcing new solutions from those closest to the problems, new ideas from non-traditional actors, and providing new opportunities for small and local businesses. For example, Powering Agriculture released two Global Calls for Innovations in December 2012 and November 2014. The first call received 473 applications (55% from developing countries) and the second call received 871 applications (62% from developing countries.) Securing Water for Food's fourth round call for applications in 2016 yielded 555 applications. Of those applications, 89 percent were from organizations that had not previously applied for funding from USAID, and 76 percent were from developing countries.

In addition, USAID's experience demonstrates the substantial benefit of highly visible market signaling. "Grand Challenges drive value, with outcomes that often are difficult to measure. We tend to measure innovator impact as that helps us determine our immediate progress," notes Patel, "but there's impact through formulating new partnerships and creating a market signal that motivates additional R&D."[65] There are also other kinds of spillover and returns on investments.

The positive media attention of the GCDs also helped to drive mission progress forward. It not only reflected well contributing to a positive "brand" of the Federal Government for the general public, but crucially, it focused attention around problems worth solving and worth thinking about. For example, GCDs generated significant press coverage for its innovators that helped socialize and promote the adoption of solutions. Some key wins include the significant coverage for Fighting

[65] S. Patel, in-person interview, July 29, 2016.

Ebola, which has helped reduce production timelines to market. Saving Lives at Birth's Odon Device, which provides a simplified way to deliver babies during prolonged labor, received widespread press attention.[66] Securing Water for Food's Adaptive Symbiotic Technologies raised $3.4 million of Series A round venture capital funding based on coverage in press of its microbial seed treatment innovation.

How they did it

Each GCD is its own unique prototype. The overriding theme is one of active engagement with stakeholders and a reliance on partnerships—financial sponsors, program managers, social media and public relations are all different kinds of partnerships that run GCDs. The emphasis on partnership carries into how USAID engaged issues of problem definition, where a fundamental principle is finding a partner who also wants to tackle that problem.

Because Grand Challenges take considerable talent and resources for effective execution, USAID has found it most effective to complement agency resources by sourcing external partners in a range of areas, from process managers, partners for communications and outreach, and partners to help run acceleration and pitch training for innovators.

Lessons for Agencies

Some key lessons from implementing GCDs include:

- **Defining the problem with stakeholder input:** Each GCD required a significant investment in problem identification to frame the challenge. This step was essential. It takes the right problem, right partners, and right activities to catalyze global action and create an opportunity for problem-solving. Problem definition work began broadly, with additional criteria added as the GCD goals and framing were refined. The development phase focused not just on understanding the problem but also the market of potential solvers. Partnership was critical even in the early stage of iterative problem definition. Barrier analysis and state of innovation assessments were key parts to the problem definition process; first identifying what the barriers were to solving a particular challenge, and next taking stock of the existing landscape to understand what kind of questions must be addressed. For instance, is there a technology gap? Or do solutions exist that need further support in order to be viable and reach scale? Early conversations with partners enhanced understanding of the technical obstacles.
- **Committing resources to multi-year engagement strategies:** GCDs invested a range of resources in bringing new solvers to the table. "You don't just put the call out there and expect people will come; you don't motivate new solvers that way," explains Patel.

---

[66] D. G. McNeil Jr, "Car Mechanic Dreams Up a Tool to Ease Births," *The New York Times*, November 13, 2013, http://www.nytimes.com/2013/11/14/health/new-tool-to-ease-difficult-births-a-plastic-bag.html

If you want to broaden the community base of problem-solvers, you must have a constant drumbeat through activities and communications. Planning an engagement and communications strategy on a multi-year trajectory, time was needed to build momentum and catalyze enough activity that a self-sustaining marketplace emerged.

- **Leveraging flexibility:** Each GCD was uniquely structured by USAID technical staff in a way that most appropriately addressed the identified problems. The variations in GDC design illustrate how agencies can mix and match modalities for solving within the Grand Challenges framework. In some GCDs, it was most appropriate to leverage private sector partnerships, while in others, a Request for Applications (RFA) was used to solicit grant proposals. "There's been a lot of range of experimentation of methodology under the Grand Challenge framework," explains Patel, "all of the teams have experimented under the Grand Challenge blueprint to address different parts of the systemic barriers to source innovations to integrate and scale."
- **Scaling innovations:** "Uncovering an innovation is inconsequential if it is not going to be used or adopted, or if that innovative organization cannot overcome their barriers to success," notes Bonnell. GCDs evolved to include acceleration services (support to innovators other than grant funding) to help innovators overcome organizational barriers and help their solutions reach end-users. This was achieved through customized technical assistance that helped innovators establish and meet aggressive targets. "When we fund innovation, it isn't just writing a check. We agree very specifically on the targets and performance growth path of that innovation, and we stage our funding to align with those targets. Innovation must ultimately be accountable for impact. But we don't leave innovators hanging. We provide assistance and support beyond just the money," said Dave Ferguson, Director for the Center for Development Innovation, Global Development Lab at USAID. Further, GCDs leverage the power of USAID's networks to support innovators' long-term goals by helping them connect with commercial investment and financing opportunities, companies and organizations interested in their solutions, and public sector and non-governmental organizations seeking similar solutions. "Innovation must be tied back to the traditional business of the Agency. If we source an incredible innovation but no one uses it, then it doesn't matter. We complement our innovation sourcing work through approaches like [GCDs] with thoughtful matchmaking to integrate and incorporate the innovations that are discovered into USAID's programs both with players inside the organization and outside. If you stop at discovery, the vision goes unrealized," said Bonnell.
- **Continuously learning and refining:** USAID's experience in deploying Grand Challenges reflects a process of continuous learning and refinement. Patel noted, "Saving Lives at Birth, USAID's first Grand Challenge for Development, helped set the stage and build a framework for Grand Challenges for Development across the Agency. The programs that followed have incorporated new elements such as crowdfunding,

incentive prizes, and diverse acceleration service offerings. Further, even within a GCD, each subsequent call for innovations incorporates lessons learned from previous calls. Powering Agriculture and Securing Water for Food, for example, revised requirements for later calls based on learnings from earlier rounds to bring in higher-quality, later-stage innovations. Scaling Off-Grid Energy, a Grand Challenge for Development founded by USAID, Power Africa, the U.K. Department for International Development and Shell Foundation is the culmination of lessons learned. This Grand Challenge is not like any of our other Grand Challenges. If you look at our previous Grand Challenges, they have mostly been about sourcing innovations and then scaling them. It's about how to come up with ideas to solve the problem. This Grand Challenge is really about scaling the solar household energy sector in sub-Saharan Africa."[67] Using the Grand Challenge model, USAID is bringing together different partners to concentrate on scaling solutions. "This focus on adoption and application of the innovations into USAID's larger programming and commercial sustainability is an evolution of what a Grand Challenge can truly be," said Dave Ferguson.

- **Building a community:** GCDs are also integrating ways to identify and share successes and lessons learned with the broader community of relevant funding organizations. For example, the Saving Lives at Birth Development Xchange is an annual meeting of investors, partners, and innovators with the purpose of evaluating Saving Lives at Birth award finalists.[68] The event is interactive and hosts over 500 attendees each year. Securing Water for Food and Powering Agriculture partnered to host the Agricultural Innovation Investment Summit, which will bring together investors and agriculture innovators. The Global Innovation Exchange was created to serve as a marketplace of development relevant innovations, funding, partners, and resources.[69] USAID, Gates Foundation, the Governments of Australia and South Korea, along with 80 other partners committed to share innovations in a central place so the larger ecosystem of innovation in development could be represented. The Global Innovation Exchange helps strengthen understanding of what innovations exist, where they are being used, and which organizations and partners support them. As of October 2016, the Exchange has over 4,500 innovations, nearly $100 million in active innovation funding, and more than 15,000 collaborators.

---

67 S. Patel, in-person interview, July 29, 2016.

68 USAID, "Saving Lives at Birth: The DevelopmentXChange," https://www.usaid.gov/news-information/videos/saving-lives-birth-developmentxchange

69 Global Innovation Exchange, "Funding Opportunities," https://www.globalinnovationexchange.org/funding

Appendix B.
Additional Resources Related to Grand Challenges

This appendix provides additional resources on topics—including existing communities of practice as well as further reading on developing Grand Challenges and the modern origins of Grand Challenges—to support would-be adopters of Grand Challenges.

Community of Practice

Federal agencies interested in participating in communities of practice may wish to learn more about or participate in the following group:

- Challenges and Prizes Community [https://www.digitalgov.gov/communities/challenges-prizes-community/] works to increase the use of challenges across the Federal Government, which includes increasing training and guidance among community members, to identify new and more effective methods for running challenges, and to establish a common knowledge base for all Federal managers.

Further Reading

Developing Grand Challenges

Atkins, D., and S. Baker. "National Science Foundation Advisory Committee for Cyberinfrastructure Task Force on Data and Visualization Final Report." National Science Foundation (2011).

"Identify and Define the Problem." Problem Definition Toolkit from Tools for Innovative Programming, U.S. Global Development Lab at USAID. https://www.globalinnovationexchange.org/resources/tools-innovation-programming

Kallerud, Egil, Effie Amanatidou, Paul Upham, Mika Nieminen, Antje Klitkou, Dorothy Sutherland Olsen, Maria Lima Toivanen, Juha Oksanen, and Lisa Scordato. "Dimensions of research and innovation policies to address grand and global challenges." (2013).

Kuhlmann, Stefan, and Arie Rip. "The challenge of addressing Grand Challenges." (2014).

Leijten, J., M. Butter, J. Kohl, M. Leis, and D. Gehrt. "Investing in research and innovation for grand challenges." Joint Institute for Innovation Policy (2012).

"Moving from a Culture of "Problem Solving" to a Culture of "Problem Definition." *Youtube*. DigitalGov, 19 Oct. 2015. Web. https://youtu.be/5AFGV9oPOR0?list=PLd9b-GuOJ3nHmi8ezudkvqyEtZ3r7WB5Q

Mowery, David C. “Defense-related R&D as a model for “Grand Challenges” technology policies.” *Research Policy* 41, no. 10 (2012): 1703-1715.

Spradlin, Dwayne. “Are you solving the right problem?” Harvard Business Review, September 2012.

Tripp, Simon, and Martin Grueber. “Economic impact of the human genome project.” Battelle Memorial Institute (2011): 4-7.

Modern Origins of Grand Challenges

“A strategy for American innovation: Driving towards sustainable growth and quality jobs.” Washington, DC: Executive Office of the President, National Economic Council, Office of Science and Technology Policy, The White House, (2009).

“A strategy for American innovation: Securing our economic growth and prosperity.” Appendix C. National Economic Council, Council of Economic Advisors, and Office of Science and Technology Policy, (2011).

Huray, Paul G. A research and development strategy for high performance computing. Executive Office of the President, Office of Science and Technology Policy, 1987.

Wilson, K. G. “Science, industry, and the new Japanese challenge.” Proceedings of the IEEE 72, no. 1 (1984): 6-18.

Wilson, K. G. (1983) Views on Science Policy of the Nobel Laureates for 1982, Hearing before the Committee on Science and Technology, U.S. House of Representatives, 98th Congress, 1st Session, February 23, 1983, USGPO, Washington D.C., pp. 10-25.

Wilson, K. G. “Grand challenges to computational science.” Future Generation Computer Systems 5, no. 2-3 (1989): 171-189.

Zients, J. D. “Guidance on the use of challenges and prizes to promote open government.” Office of Management and Budget (2010).

Abbreviations

ABLE	Adolescent Behavioral Learning Experience
ACF	Administration for Children and Families
ARRA	American Recovery and Reinvestment Act
CEO	Chief Evaluation Officer
CEP	Commission on Evidence-Based Policymaking
CLEAR	Clearinghouse for Labor Evaluation and Research
CLI	Children's Literacy Initiative
CNCS	Corporation for National and Community Service
DHHS	Department of Health and Human Services
DIV	Development Innovation Ventures
DOJ	Department of Justice
DOL	Department of Labor
ED	Department of Education
EIR	Education and Innovation Research
ESSA	Every Student Succeeds Act
FY	fiscal year
GAO	Government Accountability Office
GHHI	Green and Healthy Homes Initiative
HHS	Health and Human Services
HUD	Housing and Urban Development
i3	Investing in Innovation
IES	Institute of Education Sciences
IWG	Interagency Working Group
MBK	My Brother's Keeper
MRT	Moral Reconation Therapy
NCEE	National Center for Education Evaluation and Regional Assistance
NCLB	No Child Left Behind
NFP	Nurse Family Partnership
OAH	Office of Adolescent Health
OMB	Office of Management and Budget
PAF	Pregnancy Assistance Fund
PART	Program Assessment Rating Tool
PFS	Pay for Success
RCT	randomized control trial
SFA	Success for All
SIF	Social Innovation Fund
SSIR	Social Spending Innovation Research
STEM	science, technology, engineering, and mathematics
TANF	Temporary Assistance for Needy Families

TFA	Teach For America
TPP	Teen Pregnancy Prevention
USAID	U.S. Agency for International Development
WIOA	Workforce Innovation and Opportunity Act
WWC	What Works Clearinghouse

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
XX-06-2019	Final	

4. TITLE AND SUBTITLE

Use of Grand Challenges in the Federal Government

5a. CONTRACT NUMBER

NSFOIA-0408601

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Peña, Vanessa
Stokes, Chelsea A.

5d. PROJECT NUMBER

TP-20-1005.73

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

IDA Science and Technology Policy Institute
1899 Pennsylvania Avenue, NW, Suite 520
Washington, DC 20006-3602

8. PERFORMING ORGANIZATION REPORT NUMBER

IDA Document NS D-10699

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited (22 August 2019).

13. SUPPLEMENTARY NOTES

14. ABSTRACT

In March 2016, the Office of Science and Technology Policy (OSTP) requested that the IDA Science and Technology Policy Institute (STPI) describe a set of approaches to improve innovation in and the effectiveness of the Federal Government. The innovative approaches identified create new processes, products, services, and methods of delivery; have been implemented or are in the initial stages of implementation; and have led to improvements in outcomes, efficiency, effectiveness, or quality related to Federal Government activities. The objective of this project was to describe the lessons learned from the implementation of innovative approaches and identify opportunities for how to support the scaling up of these approaches throughout the Federal Government. The Use of Grand Challenges in the Federal Government report describes hallmark features of a Grand Challenge, how Federal employees are establishing Grand Challenges, including goal setting, design, and execution, and considerations for facilitating their use.

15. SUBJECT TERMS

grand challenges, innovation; innovative approaches

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Whitman, Lloyd J.
Unclassified	Unclassified	Unclassified	Same as Report	38	19b. TELEPHONE NUMBER *(Include area code)* 202-456-4444

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18